Working document

Cluster 5 "Climate, Energy and Mobility"

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Introduction

The overarching driver for this cluster is to accelerate the twin green and digital transitions and associated transformation of our economy, industry and society with a view to achieving climate neutrality in Europe by 2050. This encompasses the transition to greenhouse gas neutrality of the energy and mobility sectors by 2050 at the latest (as well as that of other sectors not covered by this cluster), while boosting their competitiveness, resilience, and utility for citizens and society. Europe has been at the forefront of climate science and is committed to keep delivering the knowledge for enabling efficient pathways to climate neutrality.

Activities of this work programme support the implementation of the Paris Agreement and the United Nations Sustainable Development Goals[1]. By creating more jobs, accelerating economic and social transformation, faster digitalisation and by generating innovation-based and inclusive growth, activities will aid Europe's recovery[2] in the wake of the Covid-19 crisis, contributing directly to the Commission priorities of a European Green Deal, a Europe fit for the digital age, and an economy that works for the people.

The European Commission's strategic vision "A Clean Planet for All"[3] outlines that the move to climate neutrality – along with faster digitalisation and accelerated economic and societal changes – will transform the energy and mobility sectors in the coming decades making them increasingly intertwined. Research and Innovation will heavily influence the speed at which these transitions can take place, directly affecting the associated costs, impacts and co-benefits, such as better air and water quality, increased employment, social inclusion, sustainable resource management (including the circular economy and biodiversity), and reduced dependency on fossil fuels. A key contribution to success is the development of a wide portfolio of – from a life-cycle perspective – cost-effective climate neutral alternatives for emitting activities, based on often in combination with enhanced sector coupling, digitalisation, system integration and leveraging, whenever appropriate, the existing Earth observation and monitoring programme Copernicus. The twin green and digital transitions require instilling profound changes in social practices and, as a result, engaging society in the co-design, co-development, and co-implementation of innovations through social innovation[4].

The rate at which European research and innovation actions succeed in developing, upscaling, implementing, and commercialising such innovative solutions will steer EU's future competitiveness of its existing and newly emerging industries in European and global markets.

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1 Activities in this cluster will contribute to multiple SDGs, with the most direct impact on SDG 7 (Affordable and clean energy), SDG 9 (Industry, Innovation and Infrastructure), SDG 11 (Sustainable Cities and Communities), and SDG 13 (Climate Action). In addition, SDG 3 (Good health and well-being), SDG 6 (Clean Water and Sanitation), SDG 8 (Decent work and economic growth), and SDG 12 (Responsible production and consumption) will be positively impacted.

2 Europe's moment: Repair and Prepare for the Next Generation, EC COM (2020) 456 final

3 A Clean Planet for all A European strategic long-term vision for a prosperous, modern, competitive and climate neutral economy; COM/2018/773 final

4 Social innovation concerns the development of new products, methods, and services for and with society involving citizens, public authorities, business and industry, and academia—the "Quadruple Helix"—in their design, development, and implementation.

Cluster 5 supports the EU's strategic objectives through activities included in this work programme and through the support of Institutional European Partnerships [5] which are implemented through dedicated structures. Although the latter activities are not included in this work programme, it is of great importance to maximise synergy and coherence between activities regardless of their implementation mode[6].

Activities in this work programme will contribute to all **Key Strategic Orientations (KSOs)** of the Strategic Plan (KSO C being the one with the most direct contribution):

A. Promoting an open strategic autonomy by leading the development of key digital and enabling technologies, sectors and value chains to accelerate and steer the digital and green transitions through human-centred technologies and innovations;

B. Restoring Europe's ecosystems and biodiversity, and managing sustainably natural resources to ensure food security and a clean and healthy environment;

C. Making Europe the first digitally led circular, climate-neutral and sustainable economy through the transformation of its mobility, energy, construction and production systems;

D. Creating a more resilient, inclusive and democratic European society, prepared and responsive to threats and disasters, addressing inequalities and providing high-quality health care, and empowering all citizens to act in the green and digital transitions.

To contribute to these programme-level KSOs, cluster 5 will deliver on six specific **expected impacts**. In this work programme, each expected impact has been transformed into a specific **Destination** (see table below). This Destination-based work programme structure follows a thematic centre-of-gravity approach, but activities in a given Destination can of course have a cross-cutting character and will often contribute to multiple expected impacts. The specific contribution to the overall expected impacts is explained in the introductory text of each Destination.

Expected Impact (Strategic Plan)	**Destination (Cluster 5 work programme)**
Transition to a climate-neutral and resilient society and economy enabled through advanced climate science, pathways and responses to climate change (mitigation and adaptation) and behavioural transformations.	1. Climate sciences and responses for the transformation towards climate neutrality
Clean and sustainable transition of the energy and transport sectors towards climate neutrality facilitated by innovative crosscutting solutions.	2. Cross-sectoral solutions for the climate transition

[5] Clean Hydrogen, Transforming Europe's rail system, Integrated Air Traffic Management, Clean Aviation

[6] Activities specifically targeting fuel cells and hydrogen are primarily supported through calls for proposals of the European Partnership on Clean Hydrogen. However, in justified cases and in line with topic descriptions, specific aspects of hydrogen and fuel cells can be supported outside of the Clean Hydrogen Partnership

More efficient, clean, sustainable, secure and competitive energy supply through new solutions for smart grids and energy systems based on more performant renewable energy solutions.	3. Sustainable, secure and competitive energy supply
Efficient and sustainable use of energy, accessible for all is ensured through a clean energy system and a just transition.	4. Efficient, sustainable and inclusive energy use
Towards climate-neutral and environmental friendly mobility through clean solutions across all transport modes while increasing global competitiveness of the EU transport sector.	5. Clean and competitive solutions for all transport modes
Safe, seamless, smart, inclusive, resilient, climate neutral and sustainable mobility systems for people and goods thanks to user-centric technologies and services including digital technologies and advanced satellite navigation services.	6. Safe Resilient Transport and Smart Mobility services for passengers and goods

According to the **intervention logic** of this work programme, Destination 1 fosters climate science and thus helps to identify effective and efficient pathways and responses to climate change. Destination 2 supports different cross-cutting technologies and solutions for climate, energy and mobility applications. Destination 3 and 4 focusses mainly on energy issues – Destination 3 on making energy supply more sustainable, secure and competitive; Destination 4 on reducing energy demand of buildings and industry and enabling their more active role in a smart energy system. Destination 5 and 6 improve the performance of transport modes and mobility solutions – Destination 5 increases the competitiveness and climate/environmental performance of different transport modes; Destination 6 advances mobility services and solutions at system level for passengers and goods.

Horizon Europe is the research and innovation support programme in a system of European and national funding programmes that share policy objectives. Through the programme, special attention will be given to ensuring cooperation between universities, scientific communities and industry, including small and medium enterprises, and citizens and their representatives, in order to bridge gaps between territories, generations and regional cultures, especially caring for the needs of the young in shaping Europe's future. Project applicants should consider and actively seek **synergies with**, and where appropriate possibilities for further funding from, **other R&I-relevant EU, national or regional programmes** (such as European Regional Development Fund (ERDF)[7], European Social Fund Plus (ESF+)[8], Just Transition Fund[9],

[7] https://ec.europa.eu/regional_policy/en/funding/erdf/
[8] https://ec.europa.eu/esf/main.jsp?catId=62&langId=en
[9] https://ec.europa.eu/info/strategy/priorities-2019-2024/european-green-deal/actions-being-taken-eu/just-transition-mechanism/just-transition-funding-sources_en

LIFE[10], Innovation Fund[11], InvestEU[12]), where appropriate, as well as private funds or financial instruments. The ERDF focuses amongst others on the development and strengthening of regional and local research and innovation ecosystems and smart economic transformation, in line with regional/national smart specialisation strategies. It can support building research and innovation capacities and uptake of advanced technologies and roll-out of innovative solutions from the Framework Programmes for research and innovation through the ERDF.

The EU's Recovery and Resilience Facility (RRF)[13] [currently available in all Member States] aims at financing projects that directly tackle the economic and social impacts from the Coronavirus crisis and support the green and digital transition. For project ideas that directly contribute to these objectives and that have a strong focus in one Member State it is advisable to check access to the RRF for a fast and targeted support.

This work programme contributes to Europe's recovery from the COVID19-crisis by investing resources from the **European Recovery Instrument (ERI)** into innovation activities that will help hard-hit sectors to embrace the business opportunities of the twin digital and green transition and thus develop sustainable and viable business opportunities.

In order to encourage multi-actors approaches and to be more effective in achieving impact, proposals are expected to synergize with other relevant initiatives funded at EU level, including the Knowledge and Innovation Communities (KICs) of the European Institute of Innovation and Technology (EIT)[14]. The innovation ecosystems created and nurtured by the EIT KICs can in particular contribute to building communities or platforms for coordination and support actions, sharing knowledge or disseminating and fostering the exploitation of the project results. Where relevant, and without prejudice to the direct participation of the EIT KICs in the R&I activities under this destination, proposals are encouraged to explore other forms and means of service provisions distinct from the EIT KICs that can be complementary to the considered proposals and their activities. Collaboration with other innovation communities that can well support the project implementation and impact is also encouraged.

In line with the European Green Deal objectives, research and innovation activities should comply with the **'do no significant harm' principle**[15]. Compliance needs to be assessed both for activities carried out during the course of the project as well as the expected life cycle impact of the innovation at a commercialisation stage (where relevant). The robustness of the compliance must be customised to the envisaged TRL of the project. In this regard, the potential harm of Innovation Actions contributing to the European Green Deal will be monitored throughout the project duration.

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10 https://ec.europa.eu/environment/archives/life/index.htm

11 https://ec.europa.eu/inea/en/innovation-fund

12 https://ec.europa.eu/commission/priorities/jobs-growth-and-investment/investment-plan-europe-juncker-plan/whats-next-investeu-programme-2021-2027_en

13 https://ec.europa.eu/info/strategy/recovery-plan-europe_en

14 https://eit.europa.eu/our-communities/eit-innovation-communities

15 **as per Article 17 of Regulation (EU) No 2020/852 on the establishment of a framework to facilitate sustainable investment (EU Taxonomy Regulation)**

Horizon Europe's approach to **international cooperation** consist of multilateralism and purposeful openness, combined with targeted actions with key third-country partners. Actions focus on aligning national, European and global efforts and investments in research and innovation areas that contribute towards achieving key European Commission priorities. With regard to cluster 5, the Commission pushes the acceleration of clean energy innovation through the Mission Innovation[16] Initiative, which was launched at COP21 and currently comprises 24 countries and the European Commission. International cooperation of EU Member States and Associated Countries in the context of Mission Innovation in relevant topics in this work programme is encouraged. In addition, this work programme specifically addresses cooperation with African countries on renewable energies[17], in line with the spirit of the Paris Agreement which emphasises the need for global cooperation on technology development and transfer.

For the purpose of technology monitoring and progress against the state-of-art and helping to indicate project contributions towards the targets of the European Commission's Green Deal all actions related to **hydrogen and fuel cells** funded under this work programme shall report directly or indirectly on an annual basis in a secure online data collection platform managed by the Clean Hydrogen Joint Undertaking and The European Commission during the course of Horizon Europe. The reporting shall consist of filling in the template questionnaire(s) relevant to the project content (and the technology development and TRL).

Activities included in this work programme have been **designed together** with EU Member States, EEA Countries and the European Parliament, as well as stakeholders and interested citizens.

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16 http://mission-innovation.net/our-work/innovation-challenges/

17 Topics HORIZON-CL5-2021-ESS-02-01 and HORIZON-CL5-2022-ESS-02-02

Destination – Climate sciences and responses for the transformation towards climate neutrality

Europe has been at the forefront of climate science and should retain its leadership position to support EU policies as well as international efforts for a global uptake of climate action in line with the Paris Agreement and the Sustainable Development Goals (SDGs), including biodiversity objectives. Advancing climate science and further broadening and deepening the knowledge base is essential to inform the societal transition towards a climate neutral and climate resilient society by 2050, as well as towards a more ambitious greenhouse gas reduction target by 2030. It will involve research that furthers our understanding of past, present and expected future changes in climate and its implications on ecosystems and society, closing knowledge gaps, and develops the tools that support policy coherence and the implementation of effective mitigation and adaptation solutions.

The activities implemented under this section will enable the transition to a climate-neutral and resilient society and economy through improving the knowledge of the Earth system and the ability to predict and project its changes under different natural and socio-economic drivers, including a better understanding of society's response and behavioural changes, and allowing a better estimation of the impacts of climate change and the design and evaluation of solutions and pathways for climate change mitigation and adaptation and related social transformation.

This Destination contributes directly to the Strategic Plan's **Key Strategic Orientation** D *"Making Europe the first digitally led circular, climate-neutral and sustainable economy through the transformation of its mobility, energy, construction and production systems"* and the **impact area** "Climate change mitigation and adaptation".

In line with the Strategic Plan, the overall **expected impact** of this Destination is to contribute to the *"Transition to a climate-neutral and resilient society and economy enabled through advanced climate science, pathways and responses to climate change (mitigation and adaptation) and behavioural transformations"*, notably through:

a. Advancing knowledge and providing solutions in the any of following areas: Earth system science; pathways to climate neutrality; climate change adaptation including climate services; social science for climate action; and better understanding of climate-ecosystems interactions.

b. Contributing substantially to key international assessments such as those of the Intergovernmental Panel on Climate Change (IPCC) or the European Environment Agency (e.g. European environment state and outlook reports, SOER).

c. Strengthening the European Research Area on climate change.

d. Increasing the transparency, robustness, trustworthiness and practical usability of the knowledge base on climate change for use by policy makers, practitioners, other stakeholders and citizens.

When considering their impact, proposals also need to assess their compliance with the "Do No Significant Harm" principle[18] according to which the research and innovation activities of the project should not be supporting or carrying out activities that make a significant harm to any of the six environmental objectives of the EU Taxonomy Regulation.

Coordination and synergies between activities supported under Destination 1, as well as in other Destinations and Clusters, and in particular complementarities with Cluster 4 and Cluster 6 should be taken into account by planning for adequate resources for co-ordination and clustering activities. Following a systemic approach, Destination 1 concentrates on activities related to climate science and modelling, whereas Cluster 6 supports R&I in the areas covered by Cluster 6, notably on the implementation of climate change mitigation and adaptation solutions.

The following call(s) in this work programme contribute to this destination:

Call	Budgets (EUR million)		Deadline(s)
	2021	2022	
HORIZON-CL5-2021-D1-01	136.00		07 Sep 2021
HORIZON-CL5-2022-D1-01-two-stage		51.00	10 Feb 2022 (First Stage) 27 Sep 2022 (Second Stage)
HORIZON-CL5-2022-D1-02		87.00	10 Feb 2022
Overall indicative budget	136.00	138.00	

[18] as per Article 17 of Regulation (EU) No 2020/852 on the establishment of a framework to facilitate sustainable investment (EU Taxonomy Regulation)

Call - Climate sciences and responses

HORIZON-CL5-2021-D1-01

Conditions for the Call

Indicative budget(s)[19]

Topics	Type of Action	Budgets (EUR million) 2021	Expected EU contribution per project (EUR million)[20]	Number of projects expected to be funded
Opening: 15 Apr 2021 Deadline(s): 07 Sep 2021				
HORIZON-CL5-2021-D1-01-01	RIA	24.00	Around 8.00	3
HORIZON-CL5-2021-D1-01-02	RIA	15.00	Around 5.00	3
HORIZON-CL5-2021-D1-01-03	CSA	8.00	3.00 to 5.00	2
HORIZON-CL5-2021-D1-01-04	RIA	15.00	Around 5.00	3
HORIZON-CL5-2021-D1-01-05	RIA	20.00	6.00 to 7.00	3
HORIZON-CL5-2021-D1-01-06	CSA	10.00	Around 10.00	1
HORIZON-CL5-2021-D1-01-07	RIA	6.00	Around 3.00	2
HORIZON-CL5-2021-D1-01-08	RIA	20.00	6.00 to 7.00	3
HORIZON-CL5-2021-D1-01-09	RIA	18.00	Around 6.00	3
Overall indicative budget		136.00		

General conditions relating to this call

[19] The Director-General responsible for the call may decide to open the call up to one month prior to or after the envisaged date(s) of opening.
The Director-General responsible may delay the deadline(s) by up to two months.
All deadlines are at 17.00.00 Brussels local time.
The budget amounts are subject to the availability of the appropriations provided for in the general budget of the Union for years 2021 and 2022.

[20] Nonetheless, this does not preclude submission and selection of a proposal requesting different amounts.

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Admissibility conditions	The conditions are described in General Annex A.
Eligibility conditions	The conditions are described in General Annex B.
Financial and operational capacity and exclusion	The criteria are described in General Annex C.
Award criteria	The criteria are described in General Annex D.
Documents	The documents are described in General Annex E.
Procedure	The procedure is described in General Annex F.
Legal and financial set-up of the Grant Agreements	The rules are described in General Annex G.

Proposals are invited against the following topic(s):

HORIZON-CL5-2021-D1-01-01: Improved understanding of greenhouse gas fluxes and radiative forcers, including carbon dioxide removal technologies

Specific conditions	
Expected EU contribution per project	The EU estimates that an EU contribution of around EUR 8.00 million would allow these outcomes to be addressed appropriately. Nonetheless, this does not preclude submission and selection of a proposal requesting different amounts.
Indicative budget	The total indicative budget for the topic is EUR 24.00 million.
Type of Action	Research and Innovation Actions
Eligibility conditions	The conditions are described in General Annex B. The following exceptions apply: If projects use satellite-based earth observation, positioning, navigation and/or related timing data and services, beneficiaries must make use of Copernicus and/or Galileo/EGNOS (other data and services may additionally be used).
Procedure	The procedure is described in General Annex F. The following exceptions apply:

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	To ensure a balanced portfolio covering all three areas, grants will be awarded to applications not only in order of ranking but at least also to one project that is the highest ranked within each area, provided that the applications attain all thresholds.

Expected Outcome: Project results are expected to contribute to all of the following expected outcomes:

- Improved knowledge in the addressed areas, also through increasing the use of high quality data, leading to a better understanding of the processes driving climate change.
- Improved projections of climate change (including in relation to climate change-related extreme events).
- Improve our understanding of how innovative mitigation actions can help stabilise global temperature.
- Improved understanding from these actions should be fed into improvements in Earth system models, climate services and other forms of downstream use.

Scope: This topic aims at filling fundamental gaps in our understanding of Earth system, focussing on greenhouse gas (GHG) fluxes and Earth system feedbacks, the behaviour of radiative forcers (including their pre-cursors), and efforts to stabilise global temperature through deployment of carbon dioxide (CO_2) removal approaches.

Beneficiaries are encouraged to take advantage of the relevant national and/or European research infrastructures (e.g. ICOS, ACTRIS etc.).

Actions should improve scientific understanding in only one of the following areas:

a) Greenhouse gas fluxes and Earth system feedbacks

Actions should target a better understanding of key processes related to the life cycles of GHGs, other climate forcers and associated feedbacks affecting the Earth's climate over different time horizons, including the effect of climate variability from inter-annual to multi-decadal and longer time scales. Actions should focus on elements of the climate system, such as terrestrial ecosystems, hydrological cycles, ocean circulation changes, atmosphere-ocean gas exchanges, coastal zones or the biogeochemical cycles, which have an important influence on climate change and its impacts but are not sufficiently understood by the latest science.

b) Global warming contribution of different, non-CO_2 radiative forcers

Actions should improve knowledge concerning the individual and cumulative contribution of short- and long-lived radiative forcers, including GHGs other than CO_2 and their precursors, aerosols, refrigerants and other climate forcers, to climate change, including their impact on atmospheric and ocean circulation, as well as other environmental issues. Actions may focus on a subset of forcers, and should concentrate on those where the relationship between

emissions, atmospheric lifecycle, climate system feedbacks, and global warming is least well understood. Actions should also assess the climate and non-climate impacts, over multiple time scales, of policies and measures targeting forcers other than CO_2. Moreover, the action should examine the application of this knowledge in relevant sectors (such as transport, industry, agriculture and health) with a view to better understand co-benefits and trade-offs of mitigation policies with other societal benefits, including human health.

c) Climate and Earth system responses to climate neutrality and net negative emissions

Actions should improve understanding of the environmental consequences of reducing net greenhouse gas emissions to levels consistent with the aim of stopping global warming. Actions should focus on the response of global temperatures and other key properties of the Earth system to sustained reductions in greenhouse gas emissions to net zero and below. This should include, but not be limited to, pathways consistent with the Paris Agreement goals of limiting warming to well below 2°C and pursuing efforts to limit it to 1.5°C above pre-industrial levels, including scenarios with and without temperature overshoot. The action should pay particular attention to climate-related challenges at different temporal scales, including potential benefits, risks and feedbacks (e.g. effects of surface albedo changes) of using carbon dioxide removal strategies, whether nature-based or technological, to stabilise global temperature. In this context, interaction with actions dedicated to carbon dioxide removal (like ongoing EU projects, NEGEM, LANDMARC and OceanNETs, as well as HORIZON-CL5-2022-D1-01-01-two-stage: Carbon Dioxide Removal approaches and Carbon Capture Utilisation and Storage) is encouraged.

The Joint Research Centre (JRC) may participate as a member of the consortium but is not eligible for funding.

International cooperation on the above areas is encouraged.

HORIZON-CL5-2021-D1-01-02: Modelling the role of the circular economy for climate change mitigation

Specific conditions	
Expected EU contribution per project	The EU estimates that an EU contribution of around EUR 5.00 million would allow these outcomes to be addressed appropriately. Nonetheless, this does not preclude submission and selection of a proposal requesting different amounts.
Indicative budget	The total indicative budget for the topic is EUR 15.00 million.
Type of Action	Research and Innovation Actions
Legal and financial set-up of the Grant Agreements	The rules are described in General Annex G. The following exceptions apply:

	Beneficiaries will be subject to the following additional obligation regarding open science practices: • Open access to any new modules, models or tools developed from scratch or substantially improved with the use of EU funding under the action must be ensured through documentation, availability of model code and input data developed under the action.

Expected Outcome: Project results are expected to contribute to all of the following expected outcomes:

- Improve existing European and/or global climate mitigation models by better representation of basic industrial value chains (including reliable data) and potential mitigation technologies including the impact of circular economy.
- Improve the quantification of the impacts and potentials of the circular economy for climate change mitigation.
- Support the integration of the circular economy into climate action, policies and their evidence base, including externalities.
- Support the integration of the GHG emission reduction / mitigation in the circular economy criteria.

Scope: Projects are to advance the understanding and modelling of the current and future potential contribution of the circular economy in Europe to GHG emissions reductions. The scope of the modelling activities has to go beyond the state-of-the-art, in particular in terms of sectors covered and their interrelations, be as comprehensive as possible (e.g. covering also the blue economy), and include citizen's behaviours and engagement.

This action should look beyond the specific measures needed to deliver a circular economy and propose a framework for revealing, demonstrating and quantifying the circular economy's potential contribution to climate goals, as well as improving the coverage of basic industry value and supply chains in models (or suites of models) used to analyse mitigation pathways. While focusing on the linkages between circular economy measures and climate goals, the action can also improve the understanding of the connections between climate action and other environmental areas and issues as well as social and health issues, in line with the systemic approach that the European Green Deal promotes.

Collaboration between the scientific community and policy- and decision-makers in order to integrate the circular economy into integrated assessment frameworks and other comprehensive climate policy visions is highly recommended. Actions should also ensure collaboration with industry stakeholders and civil society, including, for example, sharing best-practices, data, models and other knowledge required to analyse mitigation pathways to ensure the input of - and alignment with - the needs, values and expectations of society.

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When dealing with models, actions should promote the highest standards of transparency and openness, as much as possible going well beyond documentation and extending to aspects such as assumptions, code and data that is managed in compliance with the FAIR principles[21]. In particular, beneficiaries are strongly encouraged to publish results data in open access databases and/or as annexes to publications. In addition, full openness of any new modules, models or tools developed from scratch or substantially improved with the use of EU funding is expected.

HORIZON-CL5-2021-D1-01-03: Maximising the impact and synergy of European climate change research and innovation

Specific conditions	
Expected EU contribution per project	The EU estimates that an EU contribution of between EUR 3.00 and 5.00 million would allow these outcomes to be addressed appropriately. Nonetheless, this does not preclude submission and selection of a proposal requesting different amounts.
Indicative budget	The total indicative budget for the topic is EUR 8.00 million.
Type of Action	Coordination and Support Actions
Procedure	The procedure is described in General Annex F. The following exceptions apply: To ensure a balanced portfolio covering both areas, grants will be awarded to applications not only in order of ranking but at least also to one project that is the highest ranked within each area, provided that the applications attain all thresholds.

Expected Outcome: Project results are expected to contribute to some of the following expected outcomes:

- Raising awareness of citizens, business, policy-makers and other relevant audiences towards climate change, based on more efficient, transparent and engaging communication of authoritative and timely science-based information originating from EU-funded climate change research projects.
- Better coordination of both on-going and future EU-funded climate change research initiatives and a more efficient use of resources.
- Enhanced impact of research investments and accelerated transfer of knowledge to inform policy and climate actions in Europe.

[21] FAIR (Findable, Accessible, Interoperable, Reusable). Further information: https://www.go-fair.org/fair-principles/; and Final Report and Action Plan from the European Commission Expert Group on FAIR Data, "TURNING FAIR INTO REALITY" (https://ec.europa.eu/info/sites/info/files/turning_fair_into_reality_0.pdf)

- Increased robustness, coherence and visibility of the results of EU-funded climate change research and innovation leading to increased uptake of the knowledge and solutions and more robust decisions by the public sector, businesses, industry and society.

- Curation of research and innovation project results related to climate change, such that stakeholders can discover and understand what EU-funded research is ongoing in their area of interest.

- Innovative and tailor-made tools and strategies to communicate the results of EU-climate change research leading to improved science – civil society interface, while considering drivers for active citizen engagement in climate action and more sustainable behaviours, including social innovations.

- Better coordination of climate change research, innovation and technology initiatives within the European Research Area, facilitating complementarity and coherence between EU-level, national and regional efforts and a more efficient use of resources.

- Identification of complementary research and innovation activities among the past, present and future work supported by national and regional R&I programmes on climate change, facilitating coherence between EU-level and national efforts and a more efficient use of resources, and taking into account international developments where relevant.

- Showcasing national and regional research and innovation activities and findings that could be of interest for cooperation between countries.

- Improving prioritisation of European climate change research by identifying priority topics (in terms of knowledge gaps and/or societal needs), and taking stock of national and EU-level climate change R&I research activities, in order to enhance the ability of existing and future European R&I to respond to societal needs.

- Accelerating the transfer of knowledge on climate change research to policy-makers, practitioners and the society.

- Implementation of collaborative activities to enhance the market, regulatory or societal uptake of R&I solutions related to climate change across Europe, for example by replicating national or local success stories in Europe.

- Identify good practices at European, national and regional level on communication, dissemination and exploitation of climate change research findings and projects results and facilitate their scaling up.

Scope: Actions should cover one of the following areas:

a) Maximising the impact of EU-funded climate change research

The action should deliver effective mechanisms to strengthen the science-policy and science-civil society interface on the state-of-the-art climate change research in order to increase Europe's capacity to accelerate the response to the climate crisis and, biodiversity and other

environmental challenges. Climate change research is understood here as projects dealing with climate, mitigation and adaptation science that will result mainly from Destination 1 of Cluster 5 - "Climate sciences and responses"- of Horizon Europe as well as relevant legacy projects of Horizon 2020[22]. Other relevant projects, in particular from Cluster 3 and 6, as well as other Destinations in Cluster 5 should also be considered where relevant and possible. Synergies with the topic HORIZON-CL5-2021-D1-01-06: Supporting and standardising climate services should be established as necessary.

Knowledge synthesis and valorisation of results across EU funded projects and initiatives are expected to constitute an important element of work and should lead to integrated policy briefs and (joint) scientific publications that consolidate findings from different projects on priority issues and challenges that are central to climate action at all scales. To deliver these objectives, the action should consider activities such as curating, clustering, co-ordinating and supporting the creation of synergies between EU-funded climate change research and innovation activities, where relevant also considering national as well as international initiatives such as Global Covenant of Mayors and Mission Innovation.

The actions should identify and systematically update research needs emerging from science and/or policy discussions, and, where possible, match these needs against the themes that are addressed (or could be addressed) by ongoing EU-funded research projects.

The action should build on the knowledge and tools accumulated during previous and existing EU-funded initiatives. It should provide for adequate resources to take over and manage selected knowledge curation platforms, including the EU climate change mitigation portal[23]. It is also expected to facilitate exploitation and maintenance of selected decision support tools developed by other EU-funded climate change research projects in close cooperation with the Commission services.

Communication, dissemination and cross-fertilisation of research results will be an important component of the action and should include support to upscaling the efforts of individual projects under Destination 1. These activities are expected to account for the majority of the action's budget and should be accordingly substantiated in the proposal. Activities should go beyond standard (passive) practices and could include, for example, Massive Online Open Courses, videos, mobile apps, festivals, citizen debates and other forms of active outreach, where possible and appropriate building on existing tools and materials developed by EU-funded projects. They should address a broad range of audiences, including policy makers, business and civil society with particular emphasis on young people, taking into account each audience's specific needs and paying attention to gender differences, with a view to increase awareness about the state of climate science, build support for climate action and trigger broader societal transformation. National, regional and local level initiatives should be an important component of the outreach. Innovative approaches, such as, for example, UNEP's "Earth

[22] In particular relevant projects financed under the 2018-2020 H2020 work programme Call - Building a low-carbon, climate resilient future: climate action in support of the Paris Agreement, notably under areas: Decarbonisation, Climate adaptation, impacts and services; the Cryosphere and the Knowledge gaps. The final list is to be agreed with the European Commission.

[23] https://climatechangemitigation.eu

School"[24], podcasts or TED talks[25], fully leveraging digital and social media opportunities, are strongly encouraged. The action should mobilise and promote direct interaction between the scientific community and civil society/practitioners. In addition, it should also support efforts to counter misconceptions, fake news and conspiracy theories regarding climate change.

The action is also expected to contribute to the objectives and activities of the European Climate Pact[26].

This topic requires the effective contribution of SSH disciplines and the involvement of SSH experts, institutions as well as the inclusion of relevant SSH expertise, notably as regards exploration of the most effective techniques of communication, dissemination and engagement, in order to produce meaningful and significant effects enhancing the societal impact of the related research activities. Social innovations should also be considered, notably as new tools, ideas and methods leading to active citizen engagement and as drivers of social change, social ownership and new social practices.

b) Maximising the synergy of climate change research and innovation in Europe

This action will help strengthen the European Research Area by ensuring coordination, cooperation and synergies between research, innovation and technology policies and programmes in the area of climate change research, including mitigation and adaptation, at European, national and regional level.

Maximising the societal impact of climate change research in Europe requires coordination among European, national and regional initiatives and research programmes. For example, climate services, mitigation and adaptation options pioneered in one location may be deployable in another. In basic climate science, coordination among programmes avoids duplications, and ensures optimal use of resources (like IT infrastructure or data).

The action is expected to help prioritise investments in climate change R&I and to add value to current and future R&I occurring across the ERA by exploiting potential synergies in R&I planning and activities, and opportunities for partnerships or complementary activities. To achieve this objective, the action should facilitate dialogue and exchange of information among the relevant scientific communities and funding bodies at European, national and regional level. It should identify and systematically update research needs emerging from science, policy discussions and the society, and enable the inclusion of these priorities in national and regional research strategies and agendas to finance ongoing and future projects.

A science-policy and science-society dialogue should be established, when possible in coordination with similar initiatives organised by other projects or entities, to improve access to and communication and dissemination of excellent climate change research and innovation.

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24 https://www.unenvironment.org/explore-topics/education-environment/what-we-do/earth-school

25 See, for example, https://countdown.ted.com/

26 In the context of the European Green Deal which sets ambitious goals towards achieving climate neutrality by 2050, the objective of the Climate Pact is to raise awareness on climate change, to engage citizens and communities in action for climate and environment and to build on and amplify existing initiatives in Europe.

Activities will enhance cooperation between climate research scientist, professionals and all relevant stakeholders (e.g. universities, business and other research and innovation actors), accelerate the transfer of knowledge to inform policy and climate actions in Europe.

Activities should identify, analyse and support the scaling up of good practices at European, national and regional level on communication, dissemination and exploitation of climate change R&I projects results and solutions, as well as on climate change policies and strategies (e.g. comparative reports on national and regional R&I policies addressing climate change).

Coordination should be ensured with relevant European, national and regional initiatives (e.g. Joint Programming Initiatives, EIT Climate-KIC…).

The activities should build links with relevant EU programmes such as Copernicus, as well as build upon and link to global structures like the IPCC, the Global Carbon Project and the Global Covenant of Mayors.

Projects funded under this topic should ensure coordination between their activities.

HORIZON-CL5-2021-D1-01-04: Enhanced integrated assessment in pursuit of global climate goals

Specific conditions	
Expected EU contribution per project	The EU estimates that an EU contribution of around EUR 5.00 million would allow these outcomes to be addressed appropriately. Nonetheless, this does not preclude submission and selection of a proposal requesting different amounts.
Indicative budget	The total indicative budget for the topic is EUR 15.00 million.
Type of Action	Research and Innovation Actions
Eligibility conditions	The conditions are described in General Annex B. The following exceptions apply: If projects use satellite-based earth observation, positioning, navigation and/or related timing data and services, beneficiaries must make use of Copernicus and/or Galileo/EGNOS (other data and services may additionally be used).

Expected Outcome: Under the Paris Agreement, Parties to the UNFCCC have to pursue policies and measures to reduce their greenhouse gas emissions, including by preparing and implementing successive Nationally Determined Contributions (NDCs) towards the Agreement's objectives. By 2025, countries are expected to produce new NDCs covering the post-2030 period, informed during the 2022-23 period by the 6th Assessment Report of the IPCC and the Paris Agreement Global Stocktake.

Project results are expected to contribute to all of the following expected outcomes:

- Provision of information for the preparation of climate policies and national planning for the post-2030 period, in light of the Paris Agreement goals and the need to reduce global net greenhouse emissions to zero by 2050.

- Enhanced international cooperation among the modelling community and other relevant stakeholders to expand the provision of robust in-country advice to decision-makers around the world.

- Enhanced mutual learning among the modelling, social science and policy communities to ensure coherence between different tools used to inform climate action, and consistency with the best available and open science.

Scope: Proposals should:

- Ensure that Integrated Assessment Models enable the assessment of Paris Agreement-compatible mitigation policies to which policymakers around the world have access.

- Deliver advice and insights that can inform climate action and sustainable development policy design, including biodiversity preservation, at global and national level, based on the best available science.

- Support comparability of model results e.g. between national and global scenarios, and between Integrated Assessment Models and other models used to inform climate action at different geographical scales.

- Identify milestones, drivers and barriers towards achieving climate neutrality in an economically and environmentally responsible and socially inclusive way, including where appropriate by examining implementation of previous or existing climate policies.

- Consider the role of major sectors including energy, water, transport, industry and land use, as well as the sequence of individual, social, economic, structural, and technological changes that could lead to climate neutrality.

- Support the use of model-based and data/driven analysis for climate-policy in the context of sustainable development and recovery from the economic and social impacts of the COVID-19 pandemic.

- Share best practices and build capacities to support the production of national scenarios and to inform domestic stakeholders during and after the lifespan of the action.

Reflecting the nature of climate change as a global challenge, actions should be able to provide insights at global level and of relevance to major emitters and countries from different regions, with different levels of economic development and in-country scientific and institutional capacity.

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International cooperation is encouraged, in particular with one or more of the top ten emitters[27] and with non-high-income countries[28] requiring support for the design and implementation of current and future NDCs.

This topic requires the effective contribution of SSH disciplines and the involvement of SSH experts, institutions as well as the inclusion of relevant SSH and gender expertise, in order to produce meaningful and significant effects enhancing the societal impact of the related research activities.

When dealing with models, actions should promote the highest standards of transparency and openness, as much as possible going well beyond model documentation and extending to aspects such as assumptions, code and data that is managed in compliance with the FAIR principles[29]. In particular, beneficiaries are strongly encouraged to publish results data in open access databases and/or as annexes to publications.

HORIZON-CL5-2021-D1-01-05: Better understanding of the interactions between climate change impacts and risks, mitigation and adaptation options

Specific conditions	
Expected EU contribution per project	The EU estimates that an EU contribution of between EUR 6.00 and 7.00 million would allow these outcomes to be addressed appropriately. Nonetheless, this does not preclude submission and selection of a proposal requesting different amounts.
Indicative budget	The total indicative budget for the topic is EUR 20.00 million.
Type of Action	Research and Innovation Actions
Eligibility conditions	The conditions are described in General Annex B. The following exceptions apply: If projects use satellite-based earth observation, positioning, navigation and/or related timing data and services, beneficiaries must make use of Copernicus and/or Galileo/EGNOS (other data and services may additionally be used).
Legal and financial set-up of the Grant Agreements	The rules are described in General Annex G. The following exceptions apply: Beneficiaries will be subject to the following additional obligation regarding open science practices:

[27] For a ranking, see e.g. here: http://www.globalcarbonatlas.org/en/CO2-emissions orhttps://www.climatewatchdata.org/data-explorer/ .

[28] As defined by the World Bank.

[29] FAIR (Findable, Accessible, Interoperable, Reusable). Further information: https://www.go-fair.org/fair-principles/; and Final Report and Action Plan from the European Commission Expert Group on FAIR Data, "TURNING FAIR INTO REALITY" (https://ec.europa.eu/info/sites/info/files/turning_fair_into_reality_0.pdf)

	• Open access to any new modules, models or tools developed from scratch or substantially improved with the use of EU funding under the action must be ensured through documentation, availability of model code and input data developed under the action.

Expected Outcome: Project results are expected to contribute to some of the following expected outcomes:

- Enhanced understanding, supported by quantitative and qualitative analysis, of the interaction, complementarity and trade-offs between adaptation and mitigation measures and policies helping to overcome the silo approach within and between them and leading to more effective climate action policies.
- Better knowledge about the risk and impacts of climate change and their interaction with mitigation pathways, including their feasibility across various scenarios of global warming.
- Enhanced legitimacy and robustness of integrated assessment frameworks based on more realistic representation of climate processes and their impacts.
- Contribution to enhanced collaboration among Working Groups I, II, and III of the Intergovernmental Panel on Climate Change.
- Support and interaction with the activities of Horizon Europe Mission "Adaptation to climate change including societal transformation".

Scope: Actions should deliver progress in integrating the analysis of the impacts and risks of climate change, mitigation pathways and adaptation strategies into a single framework to help understand and quantify their numerous interactions.

Progress is needed to better reflect the economic damages and reduced well-being due to climate change in mitigation pathway analysis. Actions should integrate state of the art climate science stemming from Earth System Models, Reduced Complexity Models and similar into a common integrated assessment framework. This could include climate change impacts, biodiversity and ecological considerations, Earth system feedbacks and extreme events, and their interaction with mitigation pathways.

Actions should also improve the general understanding of the synergies, conflicts and trade-offs between mitigation and adaptation strategies. For example, many adaptation actions that need to be deployed at a large scale in the short to medium term (in parallel to ambitious mitigation efforts) can have negative impact in terms of emissions. This includes flood and coastal (hard) protection, irrigation and desalination measures as well as increased demand for cooling/air conditioning that are typically highly energy intensive and may put additional stress on energy systems. Another example of an interaction between adaptation and mitigation strategies is the shift towards regenerative and organic agriculture that provides adaptation

benefits, but may require expansion of food production areas to compensate for lower productivity with the consequence of more deforestation. Any such potential conflicts and interdependencies should be investigated, taking into account cross-sectorial cascading effects and temporal differences.

Actions should formulate a set of technical and policy recommendations, including sector-specific ones, targeting both public and private stakeholders, to reduce the tensions between mitigation and adaptation strategies. Given that the interactions between mitigation and adaptation often occur at regional and local scale, research should also aim at finding solutions to reconcile the different scales at which mitigation and adaptations strategies are implemented, including improving the territorial resolution of relevant tools. In addition, actions should evaluate the impact on the costs of mitigation and adaptation strategies in Europe when they are treated in an integrated manner. In order to achieve the above-mentioned objectives actions may work on improvements in the modelling of adaptation, particularly in the sectors where adaptation strongly interacts with mitigation (such as energy and agriculture).

Actions should explore effective ways for bridging the gap between modelling theory and practical applications, including through active involvement of and co-creation with stakeholders and end-users from various relevant fields and social categories, including through case studies in order to test and replicate the results. This should include outreach activities to general public to better explain the trade-offs and interactions between mitigation and adaptation strategies and measures.

Synergies with relevant projects funded under this Work Programme as well those originating from Horizon 2020 should be explored and established during the course of the project. In particular, projects resulting from the topic HORIZON-CL5-2022-D1-01-02-two-stage: Socio-economic risks of climate change in Europe and from Cluster 3 on Disaster Resilient Societies should be foreseen.

When dealing with models, actions should promote highest standards of transparency and openness, as much as possible going well beyond documentation and extending to aspects such as assumptions, code and data that is managed in compliance with the FAIR principles[30]. In particular, beneficiaries are strongly encouraged to publish results data in open access databases and/or as annexes to publications. In addition, full openness of any new modules, models or tools developed from scratch or substantially improved with the use of EU funding is expected.

Projects funded under this topic should ensure the coordination of their activities.

This topic requires the effective contribution of SSH disciplines and the involvement of SSH experts, institutions as well as the inclusion of relevant SSH expertise, in order to produce

[30] FAIR (Findable, Accessible, Interoperable, Reusable). Further information: https://www.go-fair.org/fair-principles/; and Final Report and Action Plan from the European Commission Expert Group on FAIR Data, "TURNING FAIR INTO REALITY" (https://ec.europa.eu/info/sites/info/files/turning_fair_into_reality_0.pdf)

meaningful and significant effects enhancing the societal impact of the related research activities.

HORIZON-CL5-2021-D1-01-06: Supporting and standardising climate services

Specific conditions	
Expected EU contribution per project	The EU estimates that an EU contribution of around EUR 10.00 million would allow these outcomes to be addressed appropriately. Nonetheless, this does not preclude submission and selection of a proposal requesting different amounts.
Indicative budget	The total indicative budget for the topic is EUR 10.00 million.
Type of Action	Coordination and Support Actions
Eligibility conditions	The conditions are described in General Annex B. The following exceptions apply: If projects use satellite-based earth observation, positioning, navigation and/or related timing data and services, beneficiaries must make use of Copernicus and/or Galileo/EGNOS (other data and services may additionally be used).

Expected Outcome: Project results are expected to contribute to all of the following expected outcomes:

- Support to the implementation of the EU Adaptation Strategy and the Mission on adaptation to climate change, including societal transformation e.g. by providing standardised tools for climate proofing and increasing resilience.
- Improved relevance of data, information and knowledge on climate change impacts and adaptation, as well as mitigation for users both in the private and public sectors.
- Enhanced value of climate services through standards and quality assurance procedures and communication.
- The generation of trust across supply and demand of knowledge and services, supporting the development of a market for climate services and the European climate service sector.
- Enhanced quality, impact, equity and performance of European climate services.
- Enhanced data and analytical tools for climate impacts, risks (including extremes, longer trends, and the combination of trends and extremes) and transition risks, as well as actionable knowledge for the formulation of recommendations, identification and appraisal of adaptation options addressing the needs of all stakeholders.
- Enhanced coordination and visibility of climate services activities.

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Scope: This topic is intended to improve the delivery of quality control and standards (including open and licensed) for climate services and to guarantee suitability, quality, and performance of digital solutions to manage climate risks and enhance adaptive capacities.

The scope of activities under this topic should cover the following aspects:

- Uncertainty analysis and quality control with supportive case studies at various levels (national to European and global), and delivery domains (public and private).
- Preparation of metadata guidelines to document in a comparative and transparent manner climate service data sources and processing methodologies, as well as decision-making based on these services, and support FAIR[31] data management practices.
- Development of good practices, guidance, and standardization of climate information and verification methods for long-term forecast products.
- Definition of verification and certification methods to enhance quality and usability of climate services, including methods for the evaluation of their effectiveness.
- Coordination and promotion of European climate service activities, encouraging open exchange of knowledge, expertise and data and providing a science-user communication platform and improving synergies between regional, national, European and international activities.
- Development of appropriate business models and knowledge brokerage activities to support scale-up and replication of climate services.
- Organisation of the European Climate Change Adaptation (ECCA) Conferences and contribution to other international conferences on climate change adaptation.

Actions should develop interdisciplinary and transdisciplinary activities. Regular engagement with stakeholders should be foreseen to consider applications in case studies, and to test, benefit and allow replication and upscaling of the results.

These standards and schemes will also require supportive governance and other measures, such as training and capacity building, to promote and sustain their use and continued development. This includes the development of common terminology between user, provider, and purveyor communities.

Synergies should be explored with relevant activities under other Clusters, in particular clusters 3 and 4 and standardization efforts internationally and in Europe (e.g. the Climate Services partnership, the European Open Science Cloud (EOSC), Digital Europe Programme and the Copernicus Programme, amongst others). The action should build on the achievements of the H2020 ClimatEurope project and the ERA4CS.

[31] FAIR (Findable, Accessible, Interoperable, Reusable).

This topic requires the effective contribution of SSH disciplines and the involvement of SSH experts, institutions as well as the inclusion of relevant SSH and gender expertise, in order to produce meaningful and significant effects enhancing the societal impact of the related research activities.

HORIZON-CL5-2021-D1-01-07: Improved economic methods for decision-making on climate and environmental policies

Specific conditions	
Expected EU contribution per project	The EU estimates that an EU contribution of around EUR 3.00 million would allow these outcomes to be addressed appropriately. Nonetheless, this does not preclude submission and selection of a proposal requesting different amounts.
Indicative budget	The total indicative budget for the topic is EUR 6.00 million.
Type of Action	Research and Innovation Actions

Expected Outcome: Project results are expected to contribute to all of the following expected outcomes:

- Enhanced operational capacities of the methods of economic analysis for climate and environmental policies, leading to their increased usage in the preparation of decision-making on climate and environmental policies. This includes, but is not limited to, improved cost-benefit, multi-criteria and cost-effectiveness analysis.
- Practical recommendations and conceptual guidelines for improved, methodologically transparent economic approaches and practices for public policy design and evaluation in the domain of climate and environment.
- Proposals on ways to produce a better reflection of the specificities and risks of environmental challenges in public policy and promoting precautionary responses.
- Enhanced efficiency, effectiveness and legitimacy of European regulatory and policy decisions by providing decision-makers, stakeholders and the public with more realistic ability to systematically assess the options and their consequences.
- Improved capacity for decision making under the conditions of (extreme) uncertainty.
- New evidence on the effectiveness of various regulatory strategies, instruments and approaches for climate and environmental policies.
- Factual evidence and insights for the design and evaluation of the implementation of major European policies such as in the domain of the European Green Deal, New Generation Europe, national recovery plans, and other relevant policies.

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Scope: Actions should focus on the improvement of methodologies, practices and techniques for conducting economic appraisal of environmental policies, taking into account the progress in relevant sciences and in the understanding of the limitations of the methodologies and tools used so far, notably in impact studies. The key environmental policies of interest under this topic are those addressing climate change and biodiversity loss and actions should foster integrated approaches for addressing these interdependent challenges. Innovative and out-of-the-box approaches are strongly encouraged.

Actions are expected to investigate limitations of mainstream economic theory and models used for environmental policy assessment, including the evaluation of appropriateness of cost-benefit and cost-effectiveness analyses. They should also consider alternative approaches that could be applied to assess environmental policies. Issues such as measurement of environmental/climate damages and the treatment of uncertainty, including overreliance on average and most likely outcomes as well as the non-linear features of climate-related risks are expected to be addressed. Other aspects that could be explored include short-termism, treatment of unpriced values, irreversibility, discounting, inclusiveness and socio-economic inequalities, and broader ethical issues such as inter-generational fairness.

The work should encompass in-depth ex-post evaluation of the actual performance of selected climate and environmental policies at European[32], national or regional level in order to identify their strengths and weaknesses and propose possible improvements in the underpinning methodologies for ex-ante assessments. Alternative approaches derived from the measurement of actual, realised costs and benefits of a representative sample of cases can also be considered.

Actions should also examine the performance of different types of regulatory strategies such as a comparison of market-based vs traditional (command and control) regulation, a comparison among different types of market-based approaches (taxes, emissions trading, green certificates, subsidies, etc.), evaluation of the performance of information-based mechanisms (such as labelling) for purposes of environmental policy-making. The analysis should take into account public acceptance dimension. Consortia should also explore innovative policy interventions (such as various types of incentive) that could be applied to encourage the adoption of more sustainable technologies and behaviours.

Applicants should take into account not only the advances in economic thinking, but also the evolution in behavioural insights, study of public and political acceptance, as well as progress in other relevant fields such as sociology, natural and political sciences, humanities, gender and intersectional studies, public health and disaster risk reduction, as well as key trends that have influenced the evolution of the European environmental policy-making. Lessons from the COVID-19 crisis should also be taken into account. Participation of and co-creation with relevant stakeholders and key actors should be part of the action, including in-depth

[32] For European Commission's impact assessments please refer to https://ec.europa.eu/smart-regulation/impact/ia_carried_out/cia_2016_en.htm (Note: initiatives included in this data base may not be exhaustive and applicants are free to choose other case studies).

contribution from social sciences and humanities to advance the understanding of the dynamics and the factors impacting the policy and political decision-making processes.

Finally, actions should formulate and implement strong dissemination plan towards key actors in relevant decision-making processes with an aim to testing the proposed methods in real conditions and towards educational institutions in order to facilitate broad cross-fertilisation of the insights created.

In response to this topic actions are expected to address the broader framework and methodologies for economic analysis of environmental policies and thus go well beyond the economic aspects of Integrated Assessment Models.

Synergies with other topics, in particular from Cluster 6 with respect to relevant biodiversity insights, should be explored and established over the duration of the project.

This topic requires the effective contribution of SSH disciplines and the involvement of SSH experts, institutions as well as the inclusion of relevant SSH expertise, in order to produce meaningful and significant effects enhancing the societal impact of the related research activities.

HORIZON-CL5-2021-D1-01-08: Restoration of natural wetlands, peatlands and floodplains as a strategy for fast mitigation benefits; pathways, trade-offs and co-benefits

Specific conditions	
Expected EU contribution per project	The EU estimates that an EU contribution of between EUR 6.00 and 7.00 million would allow these outcomes to be addressed appropriately. Nonetheless, this does not preclude submission and selection of a proposal requesting different amounts.
Indicative budget	The total indicative budget for the topic is EUR 20.00 million.
Type of Action	Research and Innovation Actions
Eligibility conditions	The conditions are described in General Annex B. The following exceptions apply: If projects use satellite-based earth observation, positioning, navigation and/or related timing data and services, beneficiaries must make use of Copernicus and/or Galileo/EGNOS (other data and services may additionally be used).

<u>Expected Outcome</u>: Project results are expected to contribute to some of the following expected outcomes:

- Support the EU Nature Restoration Plan of the EU Biodiversity Strategy for 2030.

- Improved assessment of the added value of wetland, peatland and floodplain restoration approaches under different scenarios and monitor their benefits and trade-offs in terms of greenhouse gas (GHG) emissions and removals, climate change adaptation and disaster risk reduction, a wide range of ecosystem services and biodiversity.

- Improve the knowledge base on the status of European wetlands beyond the current state of the art on extent, location, condition, spatio-temporal trends, type of management and pressures (including climate change), as well as restoration potential to understand their capacity as carbon sinks or GHG sources to support climate mitigation and adaptation plans/solutions.

- Introduction of the quantified greenhouse gas abatement potential of wetland restoration in models and scenarios, for climate and biodiversity.

- Analyse the degree to which these approaches related to wetlands are affected by different scenarios of climate change (i.e. effectivity under global warming of 2°C and higher).

- Support the implementation of the Land Use, Land Use Change and Forestry (LULUCF) Regulation with respect to the inclusion of wetland restoration activities by developing robust and transparent methodologies, data provision and analysis.

- Contribute to the evidence on ecosystem services provided by restored wetlands and their long-term management as an investment with significant net societal benefits.

- Contribute to scientific assessments such as the IPCC, IPBES and International Resource Panel reports.

Scope: Projects are expected to assess the current extent and state of European wetlands, their current and potential GHG profile (with or without protection/restoration measures) and their medium to long-term mitigation capacity through restoration or other measures. As a minimum, the assessment should take into account key greenhouse gases (CO_2, CH_4 and N_2O), the carbon value of services (such as production) in the baseline (e.g., food production) and restoration scenarios (e.g., paludiculture or non-productive uses, like agritourism) and estimate the abatement cost for different policy-relevant time periods. Assessments should therefore look at assessing any trade-offs of restoring wetlands primarily for climate and biodiversity benefits with the delivery of their wide range of other services, and on methods to avoid, and if not possible, to mitigate them.

Projects are expected to develop or identify workable tools and approaches for the sound estimation of GHG performance as well as impacts on biodiversity and a wide range of ecosystem services. The GHG emission during restoration (e.g. due to disturbance of soils, dredging of sediments, methane from rewetting) should be considered, including trade-offs and benefits of passive restoration and following succession of water bodies. The evidence collected may contribute to the related policies, like LULUCF, and the implementation of the Biodiversity Strategy commitments.

Projects are expected to go beyond the state-of-the-art of the different restoration and management techniques and knowledge and provide guides and recommendations about the scaling up of the solutions. In particular, the projects should capitalise on the evidence provided by LIFE, Horizon 2020 and ERDF projects addressing wetland, floodplains and peatland restoration and protection.

Actions should envisage clustering activities with other relevant selected for cross-projects co-operation, consultations and joint activities on cross-cutting issues and share of results as well as participating in joint meetings and communication events. To this end, proposals should provide for a dedicated work package and/or task, and earmark the appropriate resources accordingly.

This topic requires the effective contribution of SSH disciplines and the involvement of SSH experts, institutions as well as the inclusion of relevant SSH expertise, in order to produce meaningful and significant effects enhancing the societal impact of the related research activities.

HORIZON-CL5-2021-D1-01-09: The contribution of forest management to climate action: pathways, trade-offs and co-benefits

Specific conditions	
Expected EU contribution per project	The EU estimates that an EU contribution of around EUR 6.00 million would allow these outcomes to be addressed appropriately. Nonetheless, this does not preclude submission and selection of a proposal requesting different amounts.
Indicative budget	The total indicative budget for the topic is EUR 18.00 million.
Type of Action	Research and Innovation Actions
Eligibility conditions	The conditions are described in General Annex B. The following exceptions apply: If projects use satellite-based earth observation, positioning, navigation and/or related timing data and services, beneficiaries must make use of Copernicus and/or Galileo/EGNOS (other data and services may additionally be used).

Expected Outcome: Project results are expected to contribute to some of the following expected outcomes:

- A comprehensive assessment of the climate mitigation potential of European forests and forest-based sector through modelling of different policy pathways, taking into account climate change related risks, physiological and biogeochemical responses to environmental change and management practices, adaptation needs, biodiversity goals, and the provision of other ecosystem services. The effects analysed have to include

changes in carbon sequestration, forest health, productivity, substitution and biophysical factors, including the causes and time dynamics of these changes. The assessment of the potential and limits of forest-based products and biomass for energy in delivering climate benefits will inform public authorities on the most suitable approach to forest policy and forest bioeconomy.

- Development and improvement of robust and transparent methodologies for high-resolution monitoring and reporting of forest carbon pools and their interactions through a combination of in-situ data collection and remote sensing methods to be used to advance land use, land-use change and forestry (LULUCF) reporting under the UNFCCC and compliance under EU legislation. Methods developed under this action will additionally feed into the development of the Forest Information System for Europe (FISE).

Scope: Proposals under this topic should develop a comprehensive assessment of different pathways of the European forest GHG balance in view of the reviewed 2030 and 2050 climate targets and other relevant EU environmental legislation and objectives incorporating:

- Biodiversity goals consistent with the EU Green Deal objectives and Biodiversity Strategy 2030 goals. Issues considered include the use non-native tree species, intensive thinning, transition between intensive and close-to-nature silviculture, and strict protection of forests.
- Uncertainties related to climate change and natural disturbances risks.
- Adaptation needs of existing and future forests, including factors determining their adaptation potential.
- Mitigation potential of afforestation and other forest activities including their opportunity costs.
- GHG impact of forest bioeconomy, including substitution effect of forest-based products and energy against realistic counterfactuals and with appropriate time dynamics.
- Renewable energy targets and the needs of forest-based bioeconomy for sustainable domestically-sourced feedstock.
- Biophysical effects, including changes in air temperature and precipitation associated to changes in surface albedo, land-surface properties, emissions of biogenic volatile organic compounds, transpiration and heat flux.
- Assessment of trade-offs and synergies between climate-oriented forest management, and other objectives, for example recreational and amenity values;

Having such models/assessment at their disposal and understanding their time dynamics, uncertainties and system boundaries, policy-makers will be better suited to incorporate forests in the design and evaluation of possible solutions and pathways for climate change mitigation and adaptation.

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Monitoring and reporting on changes to forest carbon stocks is essential for policymakers (both national and European) in order to be informed of trends in the forest sink evolution and to develop annual approximated greenhouse gas inventories. Actions should support the use of higher tier (and higher accuracy) methodologies and geographically explicit land-use data in accordance with the 2006 IPCC Guidelines for National Greenhouse Gas Inventories[33] and its 2019 Refinement[34]. Especially needed are actions to fill existing gaps resulting from inventory bias towards the most economically relevant tree species and carbon pools.

Proposals under this topic should therefore aim to develop knowledge, tools, models, databases and country- and region-specific values available to Member States and Associated Countries, where possible integrating with Integrated Assessment Models (IAMs) and climate models to improve monitoring and reporting of forest carbon pools. Remote sensing data sets can be helpful in estimating or verifying forest living biomass gains and losses, forest area changes, forest health status and in identifying carbon-rich old-growth forests or natural disturbances. Sample-based systems, on the other hand, should support mapping changes in other forest carbon pools such as soil organic carbon in mineral and organic soils, and dead organic matter. More robust estimation of fluxes among these forest carbon pools, which are often neglected in greenhouse gas inventories, will assist in estimating their importance as carbon reservoirs and the role that forest management can play in enhancing them, taking into account biodiversity needs and resilience. Considering biophysical effects will improve the understanding of trade-offs among climate objectives and their articulation with forest management practices.

The Joint Research Centre (JRC) may participate as a member of the consortium but is not eligible for funding.

Actions should envisage coordinating activities with other relevant actions, initiatives and programmes, including Horizon 2020 Work Programmes and the LIFE Programme, COPERNICUS and relevant research infrastructures to promote synergies, integration and co-operation. They should make use and contribute to knowledge exchange and networking European platforms and consider devising a novel decision-making platform to ensure effective dissemination of the results to the target stakeholders (i.e. policy-makers and relevant national competent authorities). Cooperation and planning for further exploitation of actions results during and after the project end is strongly encouraged.

Call - Climate sciences and responses

HORIZON-CL5-2022-D1-01-two-stage

Conditions for the Call

Indicative budget(s)[35]

[33] https://www.ipcc-nggip.iges.or.jp/public/2006gl/vol4.html
[34] https://www.ipcc-nggip.iges.or.jp/public/2019rf/vol4.html
[35] The Director-General responsible for the call may decide to open the call up to one month prior to or after the envisaged date(s) of opening.
The Director-General responsible may delay the deadline(s) by up to two months.

Topics	Type of Action	Budgets (EUR million)	Expected EU contribution per project (EUR million)[36]	Number of projects expected to be funded
		2022		
Opening: 12 Oct 2021 Deadline(s): 10 Feb 2022 (First Stage), 27 Sep 2022 (Second Stage)				
HORIZON-CL5-2022-D1-01-01-two-stage	RIA	21.00	Around 7.00	3
HORIZON-CL5-2022-D1-01-02-two-stage	RIA	10.00	Around 5.00	2
HORIZON-CL5-2022-D1-01-03-two-stage	RIA	20.00	6.00 to 7.00	3
Overall indicative budget		51.00		

General conditions relating to this call	
Admissibility conditions	The conditions are described in General Annex A.
Eligibility conditions	The conditions are described in General Annex B.
Financial and operational capacity and exclusion	The criteria are described in General Annex C.
Award criteria	The criteria are described in General Annex D.
Documents	The documents are described in General Annex E.
Procedure	The procedure is described in General Annex F.
Legal and financial set-up of the Grant Agreements	The rules are described in General Annex G.

Proposals are invited against the following topic(s):

All deadlines are at 17.00.00 Brussels local time.
The budget amounts are subject to the availability of the appropriations provided for in the general budget of the Union for years 2021 and 2022.
36 Nonetheless, this does not preclude submission and selection of a proposal requesting different amounts.

HORIZON-CL5-2022-D1-01-01-two-stage: Carbon Dioxide Removal (CDR) approaches

Specific conditions	
Expected EU contribution per project	The EU estimates that an EU contribution of around EUR 7.00 million would allow these outcomes to be addressed appropriately. Nonetheless, this does not preclude submission and selection of a proposal requesting different amounts.
Indicative budget	The total indicative budget for the topic is EUR 21.00 million.
Type of Action	Research and Innovation Actions
Eligibility conditions	The conditions are described in General Annex B. The following exceptions apply: If projects use satellite-based earth observation, positioning, navigation and/or related timing data and services, beneficiaries must make use of Copernicus and/or Galileo/EGNOS (other data and services may additionally be used).

Expected Outcome: Project results are expected to contribute to some of the following expected outcomes:

- Support climate policies through an enhanced understanding of existing and emerging carbon dioxide removal options in terms of their technical readiness, key requirements (land and other resource needs, geographical and geological constraints, primary energy needs, etc.), short- and long-term sequestration potential, permanence, impacts (environmental, social, health, resource depletion, etc.) including potential co-benefits.

- Support climate models and integrated assessment models through an improved parametrisation of these technologies and solutions, allowing their better integration into pathways and strategies and broadening the carbon dioxide removal technology options that can be numerically modelled.

- A harmonised, comprehensive and transparent methodology for the characterisation and comparison of such technologies and the barriers to their deployment, which can facilitate public discourse on their role and impacts.

- Gain better insight into the extended, system-level impacts of these technologies by considering ripple effects (e.g. extended impacts, land benefits foregone, opportunity costs, and rebound effects).

- Develop abatement cost estimates in function of time profile as well as factors like scale of deployment, key input factors (e.g., land/sea space, energy, reservoirs).

- Exploration and demonstration of business/ policy/ MRV (Monitoring, reporting and verification) frameworks for CDR uptake at scale, ranging from plant level to

incorporation of CDR in international MRV and accounting (for example in the case of bioenergy trade).

Scope: Projects under this topic should identify an extended range of nature-based and technical CDR methods, analyse and characterise them in a consistent and transparent assessment framework. In this way, projects should:

- Deliver realistic estimates of each approach's potential scale, cost, and effectiveness: on the basis of factors such as technical readiness, key land and other resource needs, geographical and geological constraints, primary energy needs (and associated impacts, including emissions), short- and long-term sequestration potential (including risk of non-permanence), key impacts (environmental, social, health, resource depletion, etc.) and risks.

- Allow the better parametrisation of integrated assessment models with respect to removals as well a better design of forward-looking policies. Develop abatement cost estimates in function of time profile as well variables like scale of deployment and key input factors.

- Explore efficient incentive and governance frameworks to facilitate CDR uptake at scale, including social acceptance, ethical and regulatory considerations, as well as identifying major issues and options for establishing MRV and accounting systems associated with CDR in general and specific technologies where applicable.

Analysis under this action should be based on practical experiences (in particular with a range of land-based projects), existing pilot and experimental projects, technical and theoretical analysis and review, including system-level impacts by considering ripple effects through consequential analysis, including land benefits foregone, opportunity costs and rebound effects, key barriers to deployment and governance challenges.

Interactions with CCUS topics under Destination 3 and HORIZON-CL5-2021-D2-01-08: Emerging technologies for a climate neutral Europe under Breakthrough Technologies are encouraged.

Projects investigating the use of CDR technologies for enhanced oil recovery are not eligible.

Where appropriate, interaction with the topics related to climate-ecosystem interaction (HORIZON-CL5-2021-D1-01-08, HORIZON-CL5-2021-D1-01-09, HORIZON-CL5-2022-D1-02-05) as well as marine topics (Cluster 6) is encouraged in order to foster integrative and system approaches including different scientific communities and disciplines, as well as different sectors of the society.

This topic requires the effective contribution of SSH disciplines and the involvement of SSH experts, institutions as well as the inclusion of relevant SSH expertise, in order to produce meaningful and significant effects enhancing the societal impact of the related research activities.

HORIZON-CL5-2022-D1-01-02-two-stage: Socio-economic risks of climate change in Europe

Specific conditions	
Expected EU contribution per project	The EU estimates that an EU contribution of around EUR 5.00 million would allow these outcomes to be addressed appropriately. Nonetheless, this does not preclude submission and selection of a proposal requesting different amounts.
Indicative budget	The total indicative budget for the topic is EUR 10.00 million.
Type of Action	Research and Innovation Actions
Eligibility conditions	The conditions are described in General Annex B. The following exceptions apply: If projects use satellite-based earth observation, positioning, navigation and/or related timing data and services, beneficiaries must make use of Copernicus and/or Galileo/EGNOS (other data and services may additionally be used).
Legal and financial set-up of the Grant Agreements	The rules are described in General Annex G. The following exceptions apply: Beneficiaries will be subject to the following additional obligations regarding open science practices: • Open access to any new modules, models or tools, which are developed from scratch or substantially improved with the use of EU funding under the action must be ensured through documentation, availability of model code and input data developed under the action.

<u>Expected Outcome</u>: Project results are expected to contribute to some of the following expected outcomes:

- A comprehensive socio-economic evaluation of future climate change impacts across sectors, countries/regions, timescales and climate building on socio-economic scenarios with improved sectoral, cross-sectoral and spatial resolution of impact projections.

- Improved climate change related decision support based on better understanding (and quantification) of the socio-economic risks (and opportunities), associated with climate change impact, for both sudden onset extreme events and slow onset processes.

- Better evidence for ambitious climate policy response, both in terms of mitigation and adaptation measures, based on a better understanding of socio-economic risks in the absence of adequate mitigation and adaptation efforts (or when limits to adaptation are reached), leading to a more secure and more certain socio-economic future.

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- Actionable insights based on data at the appropriate level of geographical scale and spatial resolution for decision-makers in public and private sectors, including national and regional level estimations, leading to enhanced adaptation efforts and to a more resilient Europe.

- Better integration of climate change risks in public and private sectors' investment decisions - from property, through infrastructure up to regional and national supply chains - leading to increased long-term resilience.

- Enhanced coordination with European Commission's Joint Research Center on research concerning climate impacts and adaptation modelling.

- Provision of authoritative knowledge to inform the activities of the Horizon Europe Mission on Adaptation to climate change including societal transformation.

Scope: Actions should improve the understanding of the nature and extent of physical risks from a changing climate and their integrated socio-economic implications in Europe in 2030, 2050 and 2100 timeframes. The analysis should evaluate the costs of inaction / "business as usual" by extrapolating current policies with different social and climatological scenarios. It should seek to capture the range of possible socio-economic climate-related risks including both those most likely to occur as well as those associated with low-probability high-impact climate events with potentially catastrophic outcomes. Indirect impacts should be part of the analysis as well as the impacts in the rest of the world with relevant spill over effects in Europe should also be considered.

A comparison with scenarios with lower degrees of warming (with ambitious mitigation measures) should be included as well as the analysis of the costs and benefits of ambitious adaptation measures. Research should also improve the understanding of climate-related risks that are unlikely to be avoided through mitigation and/or adaptation and require urgent/specific response. The work could encompass improvements in adaptation modelling, in particular in impact areas with the highest potential damages. Actions should also take into account the impact of radical transformations envisaged in the context of the post-COVID recovery.

The impacts of climate risks should be assessed and monetised across various economic sectors aiming at an expansion of the existing impact categories and combining them into a coherent framework. Cross-sectorial impacts taking into account the interactions between various sectors should also be addressed. This research should equally encompass impact categories that cannot be directly monetised, but with either economy-wide implications or of critical importance for future human well-being, such as health (including the spread of infectious diseases), social justice, and biodiversity/ecosystems. The development of appropriate tools and methodologies that are able to address these kinds of non-market based impacts is part of the scope. In addition, actions should aim at accounting for the various sources of uncertainty in a systematic way.

A national, and as much as possible regional, resolution should be aimed at in order to account for heterogeneity in terms of hazards, exposure, vulnerability (including adaptive capacities) and ability to manage risks across countries and regions. Distributional and further equity

considerations, including gender, associated with climate change impacts should also be investigated in order to inform the formulation of just mitigation and adaptation strategies. Development and testing of rapid analysis and assessment techniques using open data, tools and methodologies as well as work on an economy-wide damage function relating GDP losses or other metrics of public welfare and human wellbeing with temperature increase, could be part of the research, too.

Actions should identify and formulate recommendations for measures that should be implemented by various stakeholders groups to minimise the climate risks across Europe as well as the needs for future research. They should explore effective ways for bridging the gap between science, policy and practice. The needs of the private sector in order to prepare for and adapt to climate change impacts should be an integral part of the work and could include development of approaches for better integration of climate risks into financing principles of the investment community.

This topic calls for a truly interdisciplinary approach combining a wide range of disciplines including economics, climate science, bio-geophysical modelling, data engineering, risk analysis, political and behavioural science etc. as well as for an active involvement of and co-creation with people and communities at risk. As much as possible, it should integrate the results of the existing studies and evidence-base, including from previously funded projects such as COACCH and other projects from call SC5-06-2016-2017[37].

When dealing with models, actions should promote the highest standards of transparency and openness, as much as possible going well beyond documentation and extending to aspects such as assumptions, code and data that is managed in compliance with the FAIR principles[38]. In particular, beneficiaries are strongly encouraged to publish results data in open access databases and/or as annexes to publications. In addition, full openness of any new modules, models or tools developed from scratch or substantially improved with the use of EU funding is expected.

Synergies with topic HORIZON-CL5-2021-D1-01-05: Better understanding of the interactions between climate change impacts, mitigation and adaptation options, as well as with relevant topics in Cluster 3: Civil security for Society – Destination Area DRS02 on Support to improved disaster risk management and governance, should be explored and established. In addition, coordination with existing relevant initiatives on climate impacts and adaptation modelling should also be sought, in particular in the context of the PESETA assessment[39].

The Joint Research Centre (JRC) may participate as member of the consortium but is not eligible for funding.

This topic requires the effective contribution of SSH disciplines and the involvement of SSH experts, institutions as well as the inclusion of relevant SSH expertise, in order to produce

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37 A list of other relevant projects can be found here: https://cordis.europa.eu/project/id/776479

38 FAIR (Findable, Accessible, Interoperable, Reusable). Further information: https://www.go-fair.org/fair-principles/; and Final Report and Action Plan from the European Commission Expert Group on FAIR Data, "TURNING FAIR INTO REALITY" (https://ec.europa.eu/info/sites/info/files/turning_fair_into_reality_0.pdf)

39 https://ec.europa.eu/jrc/en/peseta-iv

meaningful and significant effects enhancing the societal impact of the related research activities.

HORIZON-CL5-2022-D1-01-03-two-stage: Social science for land-use strategies in the context of climate change and biodiversity challenges

Specific conditions	
Expected EU contribution per project	The EU estimates that an EU contribution of between EUR 6.00 and 7.00 million would allow these outcomes to be addressed appropriately. Nonetheless, this does not preclude submission and selection of a proposal requesting different amounts.
Indicative budget	The total indicative budget for the topic is EUR 20.00 million.
Type of Action	Research and Innovation Actions

Expected Outcome: Project results are expected to contribute to all of the following expected outcomes:

- A characterisation of future expected land use patterns consistent with long-term objectives (especially on climate, biodiversity and renewable energy) and its comparison with the current situation and trends.
- A comprehensive understanding of the key motivations and drivers (economic, regulatory, legal, cultural, environmental, etc.) behind land-use related decisions in Europe at levels ranging from land owners to public authorities at local, regional and national level, including their relative importance.
- A better understanding of the awareness of key actors (land owners, managers, local authorities, regulatory agencies) about climate change and biodiversity challenges and their willingness to contribute addressing them, including the adoption of new or different practices consistent with long-term expectations.

Support to climate (mitigation, adaptation) and biodiversity policy design and implementation through economic and behavioural insights allowing the efficient targeting of incentives and engagement of stakeholders in a cost-effective manner, taking into account telecoupling (displacement effects through changes in imports and exports).

Scope: Actions should aim to gain a realistic understanding of the factors behind land-use decisions and how they can be best oriented towards the efficient and socially responsible pursuit of multiple policy objectives on various scales (from the individual field/farm to region to national to continental scale). They should develop a toolbox of instruments and approaches deployable at different levels consistent with long-term goals and strategies considering, inter alia:

- The need for land to provide net sequestration and biomass flows consistent with the demands of various mitigation pathways, on different timescales.
- The continued need for land to provide food, feed and raw materials under increasing climate change and other pressures and needs (e.g., water availability, climate change resilience).
- The potential for demand-side measures that can contribute to long-term objectives (such as sustainable and healthy dietary change) and how they can be deployed.
- The crucial need for halting and, if possible, reversing biodiversity loss in Europe and globally.
- The socioeconomic dynamics, behavioural patterns and inertia related to land ownership, management and policies.
- The considerable diversity of land use patterns, approaches and biogeographic conditions in Europe, including land-related resources such as water.
- The need to make the instruments and approaches, including collective learning and negotiation processes at local and landscape scale, widely and practically available to the key actors, to enable sustainable change.
- The need to avoid rebound (detrimental displacement effects).

Actions should focus on one or more of the following issues:

a. Development of realistic scenarios and workable models for optimising the contribution of land to climate change mitigation, adaptation and biodiversity objectives, where possible integrating with Integrated Assessment Models (IAMs), consistent with expectations while reducing conflicts, exploiting synergies and managing risks (agroforestry can be one example of a system that allows higher productivity, more resilience and more biodiversity at the same time).

b. Economic and behavioural insights into land use related decisions, barriers to change, efficient design of incentives. This should explore the relative merits of instruments (regulatory, market-based, education, soft policy).

c. Explore a range of delivery mechanisms that could best incentivise the upscaling of the required changes under real-life situations in multiple settings (countries, biogeographical regions).

d. Develop workable models for effective and efficient monitoring and incentivising public goods benefits (such as emissions reductions, biodiversity protection and water services).

e. Contribute to the better quantification of land-related greenhouse gas flux trajectories for integrated assessment models on relevant scales (including displacement effects).

Participation of and co-creation with relevant societal stakeholders should be part of the action, including interdisciplinary and transdisciplinary research and the contribution from social sciences and humanities and other relevant disciplines.

Synergies should be ensured with topics related to land-use, biodiversity and ecosystems in Cluster 5 and in other Clusters, with the implementation of the Mission on Adaptation to climate change including societal transformation, as well as with other relevant actions, programmes and initiatives[40].

This topic requires the effective contribution of SSH disciplines and the involvement of SSH experts, institutions as well as the inclusion of relevant SSH and gender expertise, in order to produce meaningful and significant effects enhancing the societal impact of the related research activities.

Social innovation is recommended when the solution is at the socio-technical interface and requires social change, new social practices, social ownership or market uptake.

Call - Climate sciences and responses

HORIZON-CL5-2022-D1-02

Conditions for the Call

Indicative budget(s)[41]

Topics	Type of Action	Budgets (EUR million)	Expected EU contribution per project (EUR million)[42]	Number of projects expected to be funded
		2022		
Opening: 12 Oct 2021 Deadline(s): 10 Feb 2022				
HORIZON-CL5-2022-D1-02-01	RIA	15.00	Around 5.00	3
HORIZON-CL5-2022-D1-02-02	RIA	20.00	Around 10.00	2
HORIZON-CL5-2022-D1-02-03	RIA	15.00	Around 5.00	3

40 E.g. UN Decade on Ecosystem Restoration.

41 The Director-General responsible for the call may decide to open the call up to one month prior to or after the envisaged date(s) of opening.
The Director-General responsible may delay the deadline(s) by up to two months.
All deadlines are at 17.00.00 Brussels local time.
The budget amounts are subject to the availability of the appropriations provided for in the general budget of the Union for years 2021 and 2022.

42 Nonetheless, this does not preclude submission and selection of a proposal requesting different amounts.

HORIZON-CL5-2022-D1-02-04	RIA	20.00	Around 10.00	2
HORIZON-CL5-2022-D1-02-05	RIA	17.00	8.00 to 9.00	2
Overall indicative budget		87.00		

General conditions relating to this call	
Admissibility conditions	The conditions are described in General Annex A.
Eligibility conditions	The conditions are described in General Annex B.
Financial and operational capacity and exclusion	The criteria are described in General Annex C.
Award criteria	The criteria are described in General Annex D.
Documents	The documents are described in General Annex E.
Procedure	The procedure is described in General Annex F.
Legal and financial set-up of the Grant Agreements	The rules are described in General Annex G.

Proposals are invited against the following topic(s):

HORIZON-CL5-2022-D1-02-01: Verification and reconciliation of estimates of climate forcers

Specific conditions	
Expected EU contribution per project	The EU estimates that an EU contribution of around EUR 5.00 million would allow these outcomes to be addressed appropriately. Nonetheless, this does not preclude submission and selection of a proposal requesting different amounts.
Indicative budget	The total indicative budget for the topic is EUR 15.00 million.
Type of Action	Research and Innovation Actions
Eligibility conditions	The conditions are described in General Annex B. The following exceptions apply:

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	If projects use satellite-based earth observation, positioning, navigation and/or related timing data and services, beneficiaries must make use of Copernicus and/or Galileo/EGNOS (other data and services may additionally be used).

Expected Outcome: Project results are expected to contribute to all of the following expected outcomes:

- Enhancing the ability to ascertain whether and to what extent emission reduction efforts are producing the desired atmospheric signals for key greenhouse gases on relevant spatial and temporal scales.
- Better understanding of apparent discrepancies between reported greenhouse gas (GHG) emissions and removals (in national inventories and other schemes), measured atmospheric signals and modelled levels, with the aim of reducing and/or reconciling them on the long run.
- Reduced uncertainty of national GHG inventories through improved comparability with models and observations and piloting top-down approaches recognised in the 2019 refinement of the IPCC 2006 Guidelines for National Greenhouse Gas Inventories.
- Contribution to improving the attribution of GHG fluxes (anthropogenic vs natural) as well as non-GHG atmospheric climate forcers (such as aerosols), including feed-backs.
- Support the Paris Agreement, in particular the Global Stocktake, and the implementation and monitoring of EU climate policy instruments.
- Provide input (such as open data, models, methods and protocols) and contributions to international programmes and assessments (such as IPCC, Global Carbon Project).

Scope: Actions should aim at reconciling national greenhouse gas inventories with relevant assessment and monitoring systems in Europe (in particular EU and Horizon Europe Associated Countries) including observations from a wide range of monitoring networks, in-situ and remote-sensed) at a range of scales by comparing their results. Aerosols and their precursors should also be included in the analysis, as well as other air pollutants where relevant (e.g., co-emitted species).

Special attention should be given to establishing how the use of top-down techniques that can support the verification of national greenhouse gas inventories and other regulated estimates of emissions and removals, in order to improve or supplement the methods/approaches currently used. Ideally case studies in collaboration with one or more national inventory compilers should be organised for this purpose.

Proposals should aim to develop scientifically robust methodologies, building on achievements from previous research activities in order to decrease to acceptable levels uncertainties associated with emission estimates, identify and constrain irreducible differences and improve the attribution of emissions and removals to their sources (in particular the separation of natural

versus anthropogenic fluxes). They should also explore and support the development and implementation of top-down approaches for use in national inventories, as recognised in the 2019 Refinement of the IPCC 2006 Guidelines for National Greenhouse Gas Inventories.

The development and improvement of methodologies should also address the need for versatility of applications, including mobile sources, individual point sources, land, management actions etc. relevant to current and potential future reporting and compliance systems. Furthermore, issues such as open data and metadata standards, transfer of information and tools, and replicability of methodologies and tools outside Europe (mainly in developing countries) should also be addressed.

Beneficiaries are encouraged to take advantage of the relevant national and/or European research infrastructures (e.g. ACTRIS, ICOS etc.).

HORIZON-CL5-2022-D1-02-02: Development of high-resolution Earth system models for global and regional climate change projections

Specific conditions	
Expected EU contribution per project	The EU estimates that an EU contribution of around EUR 10.00 million would allow these outcomes to be addressed appropriately. Nonetheless, this does not preclude submission and selection of a proposal requesting different amounts.
Indicative budget	The total indicative budget for the topic is EUR 20.00 million.
Type of Action	Research and Innovation Actions
Eligibility conditions	The conditions are described in General Annex B. The following exceptions apply: If projects use satellite-based earth observation, positioning, navigation and/or related timing data and services, beneficiaries must make use of Copernicus and/or Galileo/EGNOS (other data and services may additionally be used).
Legal and financial set-up of the Grant Agreements	The rules are described in General Annex G. The following exceptions apply: Beneficiaries will be subject to the following additional obligations regarding open science practices: • Open access to any new modules, models or tools, which are developed from scratch or substantially improved with the use of EU funding under the action must be ensured through documentation, availability of model code and input data developed under the action.

Expected Outcome: Proposals should improve European high-resolution, fully coupled atmosphere-ocean-land Earth System Models, able to robustly simulate key climate processes, their variability and future trends for this and well into the next century in order to enhance the quality, robustness and versatility of climate projections on a range of temporal and spatial scales (global and regional) to (1) support policies implementing the goals of the Paris Agreement and (2) address the societal need to assess and respond to the adverse impacts of climate change.

Project results are expected to contribute to all of the following expected outcomes:

- Improved climate projections with sound uncertainty estimates under different scenarios on different temporal and spatial scales.
- Improved understanding and modelling of tipping points in the climatic systems, such as the ice shields at both poles and ocean circulation.
- Advances in attribution of climate change and its phenomena to anthropogenic forcers.
- Support to the evaluation of mitigation policies through improved linkages with Integrated Assessment Models.
- Pave the way for the next cycle of the IPCC Assessment reports by a leading role in the WCRP Coupled Model Intercomparison Programme (CMIP).
- Sustain and enhance European cooperation and leadership in climate sciences.

Scope: Projects should foster a fully coupled atmosphere-ocean-land-ice Earth-system model approach that contribute to a better understanding and representation of the processes, including for that drive and influence climate change on global and regional scale. Arctic and Antarctic regions should be considered as key elements in global climate changes.

Projects should make efficient use of available and high quality observational data (e.g. space-based and not space based, including in-situ and paleoclimatic data) for the development of robust model validation, verification, and improve uncertainty estimation methodologies.

Where relevant, high-resolution model development and evaluation should be properly connected with major programmes in the domain of Earth Observation such as the Copernicus Programme, the ESA science satellite missions in Europe, as well as the Group on Earth Observations (GEO) and the Global Earth Observation System of Systems (GEOSS) at global level.

They should also strive to reduce uncertainty of key parameters of climate and hydrological systems. Projects should advance methods for assessing and attributing model outputs and climate change impact on regional scales with the support of advanced digital technologies, such as artificial intelligence methodologies.

The advanced climate modelling activities should support the attribution of observed and projected climatic hazards to climate change or climate variability.

The activities should build on the experiences from and results of other European projects contributing to the development of a new generation of climate models[43].

Beneficiaries are encouraged to take advantage of the emerging ICT infrastructures (e.g. EuroHPC and other high performance computing, cloud-based facilities) that will be made available through the Destination Earth initiative under the Digital Europe Programme[44].

If adding value to the project outcomes, coordination with the Destination Earth initiative can be proposed to ensure the timely development of "climate replicas" building on the new state-of-the-art IT infrastructure, including access to European high performance computing resources and an operational platform to upload and integrate the models and data developed in the course of the projects. Connection to the European Open Science Cloud (EOSC) should be considered where relevant.

When dealing with models, actions should promote the highest standards of transparency and openness, as much as possible going well beyond documentation and extending to aspects such as assumptions, code and data that is managed in compliance with the FAIR principles[45]. In particular, beneficiaries are strongly encouraged to publish results data in open access databases and/or as annexes to publications. In addition, full openness of any new modules, models or tools developed from scratch or substantially improved with the use of EU funding is expected.

International cooperation is encouraged, in particular with countries such as Japan, Canada, Australia, India, or African Countries.

Projects are expected to co-operate with other projects funded under this call, as well as other relevant projects under Destination 1 and Cluster 6, Destination 5.

HORIZON-CL5-2022-D1-02-03: Improvement of Integrated Assessment Models in support of climate policies

Specific conditions	
Expected EU contribution per project	The EU estimates that an EU contribution of around EUR 5.00 million would allow these outcomes to be addressed appropriately. Nonetheless, this does not preclude submission and selection of a proposal requesting different amounts.
Indicative budget	The total indicative budget for the topic is EUR 15.00 million.

43 E.g., H2020 CRESCENDO (Coordinated Research in Earth Systems and Climate: Experiments, kNowledge, Dissemination and Outreach) https://cordis.europa.eu/project/id/641816 , H2020 PRIMAVERA (PRocess-based climate sIMulation: AdVances in high resolution modelling and European climate Risk Assessment) https://cordis.europa.eu/project/id/641727, or projects funded from the call topic H2020-LC-CLA-18-2020.

44 https://ec.europa.eu/digital-single-market/en/europe-investing-digital-digital-europe-programme

45 FAIR (Findable, Accessible, Interoperable, Reusable). Further information: https://www.go-fair.org/fair-principles/; and Final Report and Action Plan from the European Commission Expert Group on FAIR Data, "TURNING FAIR INTO REALITY" (https://ec.europa.eu/info/sites/info/files/turning_fair_into_reality_0.pdf)

Type of Action	Research and Innovation Actions
Legal and financial set-up of the Grant Agreements	The rules are described in General Annex G. The following exceptions apply: Beneficiaries will be subject to the following additional obligations regarding open science practices: • Open access to any new modules, models or tools, which are developed from scratch or substantially improved with the use of EU funding under the action must be ensured through documentation, availability of model code and input data developed under the action.

Expected Outcome: Project results are expected to contribute to all of the following expected outcomes:

- Improved adequacy of Integrated Assessment Models (IAMs) to effectively contribute to international, European, national and regional climate policy processes in support of the implementation of the European Green Deal, the Paris Agreement, COVID-19 recovery and broader sustainability goals

- Contributions to major international scientific assessments such as the reports of the Intergovernmental Panel on Climate Change (IPCC), the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) and the International Resource Panel (IRP).

- Increased robustness, legitimacy, relevance, usability and transparency of IAMs leading to increased uptake and better awareness of their results across various end-user groups, developing, where possible, new business models for IAMs transparency (for example, open source and open code options).

- Enhanced coherence between climate action (mitigation, understanding of impacts, climate risks and adaptation) and other environmental/sustainability objectives, notably biodiversity, based on a more realistic representation of their interactions, including co-benefits and trade-offs.

- More active involvement of citizens in climate action based on better understanding and demonstration of how small scale actions contribute to the achievement of large-scale climate policy objectives including through socially innovative approaches, and better understanding of which actions/policies are more effective.

- Ultimately, accelerated transition towards climate neutrality based on improved knowledge and better designed policies that are more integrated, greener, healthier, more inclusive.

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Scope: Actions should improve the state-of-the-art of IAMs by tackling their existing weaknesses and lack of/limited capabilities of the current generation of models in order to provide robust, credible and transparent evidence-base in support of design and evaluation of multiscale (global, European, national, regional) mitigation policies at various time horizons.

An important goal of this call is to address multiple challenges in a coherent and consistent manner using an integrated framework. To achieve this goal, it is not compulsory to incorporate all issues into a single IAM. Combinations of hard linking, soft linking and other ways of insuring a coherent approach between models and experts can be considered.

Actions should address developments and improvements, such as:

- Sectorial detail and (transformative/structural) changes across various sectors of the economy such as those resulting from increased circularity and digitalisation.
- Temporal resolution and technological detail.
- Spatial resolution with outputs suitable for national/regional level analysis.
- Behavioural and lifestyle changes.
- Distributional and equity effects of climate policies.
- Interactions with the relevant sustainable development goals (such as co-benefits due to avoided impacts and trade-offs in areas such as health, biodiversity, food security etc.).
- Climate change impacts, including the extent to which they can be avoided through mitigation action, synergies and trade-offs between climate mitigation and adaptation policies.
- Financial sector and investment needs, including information in support of investment risk-reduction strategies to mobilise capital to finance the transition towards a climate-neutral economy.
- Uncertainties and risk-management strategies for supporting mitigation policies.

The above list is non-exhaustive and actions also may propose new avenues of research, while duly justifying their choice and keeping in mind the impact on IAMs' relevance and adequacy as a decision-support tool. Actions should also explore options for making models more capable of responding to external shocks such as the COVID-19 pandemic or similar. While addressing the improvements, actions should take into account the modelling requirements and learnings resulting from the COVID-19 crisis.

Actions should build on the knowledge base developed by previous initiatives and are encouraged to establish links with other relevant projects financed from this work programme (e.g. circular economy, climate adaptation modelling) and by Horizon 2020. In order to avoid duplication of efforts, proposals should clearly demonstrate how they will go beyond the modelling state of art.

Actions are encouraged to explore alternative approaches to the mainstream economic assumptions typically underlying the models (such as fully functioning markets and perfect information) and aim at striking the right balance between model complexity and usability.

In order to maximise the impact, active involvement of the end-users (policy makers, business, civil society) in the co-design of models and validation of the outputs should be considered. Applicants should investigate and apply communication tools and strategies for improved interaction with stakeholders and dissemination of model results, duly accounting for the needs of non-technical audiences. They should further develop the thinking around the best ways to apply modelling insights to policies, including by building on the learnings from the COVID-19 pandemic. Consortia should also explore ways for better bridging the gap between modelling theory and practical applications, including in support of behavioural change and societal transformation.

It is recommended to include capacity-building efforts to lower the entrance barriers to the established IAM community by involving research teams in EU Member States and Associated Countries that are less advanced in terms of modelling capabilities.

When dealing with models, actions should promote the highest standards of transparency and openness, as much as possible going well beyond documentation and extending to aspects such as assumptions, code and data that is managed in compliance with the FAIR principles[46]. In particular, beneficiaries are strongly encouraged to publish results data in open access databases and/or as annexes to publications. In addition, full openness of any new modules, models or tools developed from scratch or substantially improved with the use of EU funding is expected.

This topic requires the effective contribution of SSH disciplines and the involvement of SSH experts, institutions as well as the inclusion of relevant SSH expertise, in order to produce meaningful and significant effects enhancing the societal impact of the related research activities.

HORIZON-CL5-2022-D1-02-04: Supporting the formulation of adaptation strategies through improved climate predictions in Europe and beyond

Specific conditions	
Expected EU contribution per project	The EU estimates that an EU contribution of around EUR 10.00 million would allow these outcomes to be addressed appropriately. Nonetheless, this does not preclude submission and selection of a proposal requesting different amounts.
Indicative budget	The total indicative budget for the topic is EUR 20.00 million.

[46] FAIR (Findable, Accessible, Interoperable, Reusable). Further information: https://www.go-fair.org/fair-principles/; and Final Report and Action Plan from the European Commission Expert Group on FAIR Data, "TURNING FAIR INTO REALITY" (https://ec.europa.eu/info/sites/info/files/turning_fair_into_reality_0.pdf)

Type of Action	Research and Innovation Actions
Eligibility conditions	The conditions are described in General Annex B. The following exceptions apply: If projects use satellite-based earth observation, positioning, navigation and/or related timing data and services, beneficiaries must make use of Copernicus and/or Galileo/EGNOS (other data and services may additionally be used).

Expected Outcome: Project results are expected to contribute to all of the following expected outcomes:

- Support to the implementation of the new EU Adaptation Strategy and the Mission on adaptation to climate change, including societal transformation, through better access to improved knowledge about climate impacts and fit-for-purpose data on individual and collective climate risks for all levels of government and stakeholders.
- Reduced vulnerability to climate change impacts based on decadal predictions which are a key source of information for better planning of adaptation options.
- Improved assessment of risks for people and systems exposed to extreme weather and climate events.
- Enhanced scientific collaboration and exploitation of synergies across the EU and Associated Countries for the provision of climate information to stakeholders engaged with the implementation of the EU Adaptation Strategy.
- Enhanced European cooperation and leadership in climate sciences e.g. in the frame of the Euro-CORDEX initiative, a part of WCRP's Coordinated Regional Climate Downscaling Experiment project (CORDEX).

Scope: Proposals should aim at improving seasonal to decadal prediction to boost their quality at regional to local scale in particular for Europe and for variables of high societal relevance. Actions will enable progress in closing the gap between current skill and potential predictability estimates, as well as better aligning with immediate adaptation needs of end-users and making those predictions actionable. Ultimately, methodologies need to be developed to merge simulations from long-term weather forecast to climate predictions and projections, resulting in seamless climate information from sub-seasonal to seasonal and decadal predictions for the next 30 years.

Proposals should also improve assessments of risk through extreme climate-related events on a range of temporal and spatial scales, as well as early detection of tipping points. Tackle uncertainties regarding regional patterns and magnitude of changes and improve understanding of how existing model biases affect the representation of extremes regarding the intensity and frequency of hazards, including the co-variability of different risk factors, and ultimately reducing the biases.

Better exploiting climate variables can enhance consistency with impact models and avoid potential mismatches, leading to better understanding of interactions between climate system and other natural and socio-economic systems (e.g. insurance practices) as well as feedbacks related to land use and cover, urban dynamics, air quality, etc., which are very relevant for model simulations at regional scale. Actions should explore novel ways of coupling existing impact models with climate models to provide quality forecast at the local scale, focussing for example on cities. Actions are encouraged to develop guidance on selection or aggregation of model data for local impact assessments, with clear justification of the procedures, allowing transformation of uncertainty into a manageable package of information.

Coordination with the Destination Earth initiative can be proposed to ensure the timely development of "climate replicas" building on the new state-of-the-art IT infrastructure, including access to European high performance computing resources and an operational platform to upload and integrate the models and data developed in the course of the projects. Data should be FAIR[47] and based on standards. Models should also be fully documented in terms of assumptions, architecture, code and data.

Participants should also ensure synergies with relevant projects and initiatives (e.g. Digital Twin of the Ocean under the EU Green Deal call LC-GD-9-3-2020: Transparent & Accessible Seas and Oceans: Towards a Digital Twin of the Ocean and the Digital Europe Programme).

Model development should be properly connected with major programmes in the domain of Earth Observation such as the Copernicus Programme and the ESA science satellite missions in Europe, as well as the Group on Earth Observations (GEO) and the Global Earth Observation System of Systems (GEOSS) at global level.

Actions should ensure the dissemination of project results to policy-makers and stakeholders to support long-term planning. International cooperation is encouraged with the aim to ensure the sharing of knowledge and experience between Europe and third countries on climate change impact and adaptation option modelling and assessment.

This topic requires the effective contribution of SSH disciplines and the involvement of SSH experts, institutions as well as the inclusion of relevant SSH and gender expertise, in order to produce meaningful and significant effects enhancing the societal impact of the related research activities.

HORIZON-CL5-2022-D1-02-05: Let nature help do the job: Rewilding landscapes for carbon sequestration, climate adaptation and biodiversity support

Specific conditions

[47] FAIR (Findable, Accessible, Interoperable, Reusable). Further information: https://www.go-fair.org/fair-principles/; and Final Report and Action Plan from the European Commission Expert Group on FAIR Data, "TURNING FAIR INTO REALITY" (https://ec.europa.eu/info/sites/info/files/turning_fair_into_reality_0.pdf)

Expected EU contribution per project	The EU estimates that an EU contribution of between EUR 8.00 and 9.00 million would allow these outcomes to be addressed appropriately. Nonetheless, this does not preclude submission and selection of a proposal requesting different amounts.
Indicative budget	The total indicative budget for the topic is EUR 17.00 million.
Type of Action	Research and Innovation Actions
Eligibility conditions	The conditions are described in General Annex B. The following exceptions apply: If projects use satellite-based earth observation, positioning, navigation and/or related timing data and services, beneficiaries must make use of Copernicus and/or Galileo/EGNOS (other data and services may additionally be used).

Expected Outcome: Project results are expected to contribute to some of the following expected outcomes:

- Contribution to IPBES and IPCC, to the achievement of objectives of reaching net zero carbon emissions, enhancing climate change adaptation, and to the EU Biodiversity Strategy.
- Support the implementation of the Horizon Europe Mission on Adaptation to climate change including societal transformation.
- Identify low cost/benefit ratio options to restore natural and semi-natural ecosystems for carbon sequestration and biodiversity conservation.
- Assess the value of restoring ecosystem for adaptation to and/or mitigation of climate change and identify potential rebound effects and trade-offs.
- Demonstrate the degree to which these approaches are affected by climate change itself and if they can still be effective under global warming of 2°C and higher.
- Demonstrate the potential contribution of European abandoned land and protected areas systems for carbon sequestration, adaptation to and/or mitigation of climate change.
- Develop strategies to minimize the increasing risk of wildfires due to the changing climate.
- Provide operational methods for low cost, low human intervention options for ecosystems restoration optimising the contributions to climate and biodiversity objectives and managing trade-offs.

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- Help generate FAIR[48]data and well-documented, robust and transparent methodologies for better integration of land-use management systems into IAMs and ESMs.
- Assess the perception and acceptability of citizens and stakeholders on rewilding and rewilding options and identify potential conflicts and trade-offs in governance and decision-making.

Scope: The biodiversity crisis and the climate crisis are intrinsically linked and the contribution of Nature-based Solutions (NBS) to the global climate objectives is pivotal. A better understanding of how the use of ecosystems natural capacity, with minimal help from humans, can contribute to carbon sequestration and biodiversity conservation is urgently needed to make the use of NBS operational.

Actions should foster interdisciplinary research with a focus on the climate-biodiversity nexus, advancing our knowledge to further promote integrated approaches to better address these interdependent challenges.

Actions, taking stock of previous and ongoing experience, including associated uncertainty, should provide a robust assessment of the potential contribution that restoring ecosystems, including trophic chains restoration, with a "let nature do the job", also called "rewilding", approach can provide in terms of carbon sequestration and storage, climate change mitigation and adaptation and biodiversity conservation. "Rewilding" is meant here as passive management of ecological succession with the goal of restoring natural ecosystem processes and reducing human control of landscapes, although some intervention may be required in the early restoration stages.

Actions can address specific ecosystems and/or landscapes on land, freshwater, coastal and marine ecosystems while providing a clear contribution to define the potential use of the "rewilding" approach at regional, national and continental levels.

Actions should build on an updated and detailed picture of the status and trends of ecosystems change, (including, where applicable, land abandonment) in Europe to assess where, at which ecological conditions and at what scale the "rewilding" approach can significantly improve carbon sequestration together with habitats reinforcement and biodiversity conservation.

Actions should investigate how "rewilding" can be complemented with other approaches (for example active restoration and conservation, low intensity farming, forestry and pasture management, fishing), taking into account specific regional conditions, to increase carbon sequestration, improve biodiversity conservation and ensure provision of goods and ecosystem services.

Actions should provide scientific insights, tools, methodologies and innovative solutions including social innovations to assist national governments, regions and communities in embedding the "rewilding" approach, as far as feasible, in their own plans to reach carbon

[48] FAIR (Findable, Accessible, Interoperable, Reusable).

neutrality. Actions should also advance the integration of land use options for carbon sequestration into IAMs and ESMs.

Actions should significantly advance knowledge on the role and relevance of restoring fully functional trophic chains, for instance through the conservation, management and reintroduction of apex predators, grazers and scavengers, in the "rewilding" process, with a special focus on the functioning of trophic cascades on landscape processes and the ability of ecosystems to act as carbon sinks. Challenges and barriers to this aim should be analysed and the involvement of Social Sciences and Humanities is recommended.

Actions should ensure appropriate multi-stakeholder collaboration and interdisciplinarity to embed socio-economic aspects, including opportunities for economic development, existing barriers (ecological, social, gender-related…) and potential synergies and drawbacks.

Actions should envisage clustering activities with other relevant actions, initiatives and programmes, including Horizon 2020 and the LIFE Programme to promote synergies, integration and co-operation. They should make use and contribute to knowledge exchange and networking European platforms (e.g. Climate-ADAPT, Network Nature, OPPLA, BiodivERsA). Cooperation and planning for further exploitation of actions results during and after the project end is strongly encouraged.

Synergies should be ensured with projects addressing wildfires (for example under the EU Green Deal call LC-GD-1-1-2020, Horizon 2020 Societal Challenge 5).

This topic requires the effective contribution of SSH disciplines and the involvement of SSH experts, institutions as well as the inclusion of relevant SSH and gender expertise, in order to produce meaningful and significant effects enhancing the societal impact of the related research activities.

Social innovation is recommended when the solution is at the socio-technical interface and requires social change, new social practices, social ownership or market uptake.

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Destination – Cross-sectoral solutions for the climate transition

This Destination covers thematic areas which are cross-cutting by nature and can provide key solutions for climate, energy and mobility applications. In line with the scope of cluster 5 such areas are batteries, hydrogen, communities and cities, early-stage breakthrough technologies as well as citizen engagement. Although these areas are very distinct in terms of challenges, stakeholder communities and expected impacts, they have their cross-cutting nature as a unifying feature and are therefore grouped together under this Destination.

This Destination contributes to the following Strategic Plan's **Key Strategic Orientations (KSO)**:

- *C: Making Europe the first digitally led circular, climate-neutral and sustainable economy through the transformation of its mobility, energy, construction and production systems,*
- *A: Promoting an open strategic autonomy by leading the development of key digital and enabling technologies, sectors and value chains to accelerate and steer the digital and green transitions through human-centred technologies and innovations;*
- *D: Creating a more resilient, inclusive and democratic European society, prepared and responsive to threats and disasters, addressing inequalities and providing high-quality health care, and empowering all citizens to act in the green and digital transitions.*

It covers the following **impact areas**:

- Industrial leadership in key and emerging technologies that work for people
- Affordable and clean energy
- Smart and sustainable transport

The **expected impact**, in line with the Strategic Plan, is to contribute to the *"Clean and sustainable transition of the energy and transport sectors towards climate neutrality facilitated by innovative cross-cutting solutions"*, notably through:

a. Nurturing a world-class European research and innovation eco-system on **batteries** along the value chain based on sustainable pathways. It includes improvement of technological performance to increase application user attractiveness (in particular in terms of safety, cost, user convenience, fast charging and environmental footprint), in parallel supporting the creation of a competitive, circular, and sustainable European battery manufacturing value chain (more detailed information below).

b. Increased efficiency of Europe's **cities' and communities'** energy, resource use and mobility patterns and cities' and communities' overall sustainability, thereby improving their climate-resilience and attractiveness to businesses and citizens in a holistic fashion. This also includes improved air and water quality, resilience of energy supply, intelligent mobility services and logistics, liveability and accessibility of cities, public health,

comfortable, affordable zero emissions housing as well as the exploitation of relevant European technologies and knowledge (more detailed information below).

c. Facilitating the transformation to a climate neutral society, in line with the EU's 2050 climate targets, through more effectively **engaging and empowering citizens** to participate in the transition, from planning to decision-making and implementation (more detailed information below).

d. Nurturing the development of **emerging technologies** with high potential to enable zero-greenhouse gas and negative emissions in energy and transport (more detailed information below).

When considering their impact, proposals also need to assess their compliance with the "Do No Significant Harm" principle[49] according to which the research and innovation activities of the project should not be supporting or carrying out activities that make a significant harm to any of the six environmental objectives of the EU Taxonomy Regulation.

A competitive and sustainable European battery value chain

Batteries will enable the rollout of zero-emission mobility and renewable energy storage, contributing to the European Green Deal and supporting the UN SDGs by creating a vibrant, responsible and sustainable market. Besides climate neutrality, batteries also contribute to other UN SDGs directly and indirectly such as enabling of decentralized and off-grid energy solutions.

The strategic pathway is, on the one hand, for Europe to rapidly regain technological competitiveness in order to capture a significant market share of the new and fast growing rechargeable battery market, and, on the other hand, to invest in longer term research on future battery technologies to establish Europe's long term technological leadership and industrial competitiveness

The Partnership "Towards a competitive European industrial battery value chain for stationary applications and e-mobility", to which all battery-related topics under this Destination will contribute, aims to establish world-leading sustainable and circular European battery value chain to drive transformation towards a carbon-neutral society.

The main impacts to be generated by topics targeting the battery value chain under this Destination are:

a. Increased global competitiveness of the European battery ecosystem through generated knowledge and leading-edge technologies in battery materials, cell design, manufacturing and recycling;

[49] as per Article 17 of Regulation (EU) No 2020/852 on the establishment of a framework to facilitate sustainable investment (EU Taxonomy Regulation)

b. Accelerated growth of innovative, competitive and sustainable battery manufacturing industry in Europe;

c. Accelerated roll out of electrified mobility through increased attractiveness for citizens and businesses, offering lower price, better performance and safety, reliable operation of e-vehicles. Increased grid flexibility, increased share of renewables integration and facilitated self-consumption and participation in energy markets by citizens and businesses;

d. Increased overall sustainability and improved Life Cycle Assessment of each segment of the battery value chain. Developed and established innovative recycling network and technologies;

e. Increased exploitation and reliability of batteries though demonstration of innovative use cases of battery integration in stationary energy storage and vehicles/vessels/aircrafts (in collaboration with other partnerships);

Communities and cities

This work programme contains only a few activities. The bulk of activities related to communities and cities will be introduced during 2021 as an update to the Horizon Europe work programme 2021, once the preparatory phase of the Horizon Europe Missions has been concluded.

Emerging breakthrough technologies and climate solutions

Although the contribution of a wide range of technologies to reach climate neutrality is already foreseeable, EU R&I programming should also leave room for emerging and break-through technologies with a high potential to achieve climate neutrality. These technologies can play a significant role in reaching the EU's goal to become climate neutral by 2050.

Relevant topics supported under this Destination do not duplicate activities supported under Pillars I or III, but focus on emerging technologies that can enable the climate transition and follows at the same time a technology-neutral bottom up approach and the support of key technologies that are expected to support achieving climate neutrality. Research in this area is mostly technological in nature but should also where relevant be accompanied by assessments of environmental impact, social and economic impacts, and possible regulatory needs as well as activities to support the creation of value chains and to build up new ecosystems of stakeholders working on breakthrough technologies.

The main expected impacts to be generated by topics targeting breakthrough technologies and climate solutions under this Destination are:

- Emergence of unanticipated technologies enabling emerging zero-greenhouse gas and negative emissions in energy and transport;

- Development of high-risk/high return technologies to enable a transition to a net greenhouse gas neutral European economy;

Citizens and stakeholder engagement

The transition to climate-neutral economies and societies by 2050 is the defining challenge of this century. The challenge is not just technical: it calls for wide-ranging societal transformations and the adaptation of lifestyles and behaviours. Engaging citizens and stakeholders is therefore critical for the success of the European Green Deal, as is making greater recourse to the Social Sciences and Humanities (SSH), alongside the Scientific, Technical, Engineering and Mathematical (STEM) disciplines.

The topics under this section do not stand alone but aim to complement and support the broader integration ("mainstreaming") of citizen and stakeholder engagement as well as the social sciences and humanities (SSH) across the whole Horizon Europe programme map and particularly Cluster 5.

The main expected impacts to be generated by topics targeting citizen and stakeholder engagement under this Destination are:

- A better understanding of the societal implications of the climate transition, including its distributional repercussions;
- More effective policy interventions, co-created with target constituencies and building on high-quality policy advice;
- Greater societal support for transition policies and programs, based on greater and more consequential involvement of those most affected.

The following call(s) in this work programme contribute to this destination:

Call	Budgets (EUR million)		Deadline(s)
	2021	2022	
HORIZON-CL5-2021-D2-01	231.00	18.50	19 Oct 2021
HORIZON-CL5-2022-D2-01		138.00	06 Sep 2022
Overall indicative budget	231.00	156.50	

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Call - Cross-sectoral solutions for the climate transition

HORIZON-CL5-2021-D2-01

Conditions for the Call

Indicative budget(s)[50]

Topics	Type of Action	Budgets (EUR million)		Expected EU contribution per project (EUR million)[51]	Number of projects expected to be funded
		2021	2022		
Opening: 15 Apr 2021 Deadline(s): 19 Oct 2021					
HORIZON-CL5-2021-D2-01-01	RIA	21.00		6.00 to 7.00	3
HORIZON-CL5-2021-D2-01-02	RIA	24.00		6.00 to 8.00	3
HORIZON-CL5-2021-D2-01-03	RIA	36.00		8.00 to 9.00	4
HORIZON-CL5-2021-D2-01-04	RIA	20.00		Around 5.00	4
HORIZON-CL5-2021-D2-01-05	RIA	26.00		6.00 to 7.00	3
HORIZON-CL5-2021-D2-01-06	RIA	30.00		9.00 to 10.00	3
HORIZON-CL5-2021-D2-01-07	CSA	3.00		Around 3.00	1
HORIZON-CL5-2021-D2-01-08	RIA	20.00		Around 2.50	8
HORIZON-CL5-2021-D2-01-09	RIA	15.00		2.00 to 3.00	2
HORIZON-CL5-2021-D2-01-10	RIA			2.00 to 3.00	2
HORIZON-CL5-2021-D2-01-11	RIA			2.00 to 3.00	2
HORIZON-CL5-2021-D2-01-12	RIA	10.00		3.00 to 4.00	3

50 The Director-General responsible for the call may decide to open the call up to one month prior to or after the envisaged date(s) of opening.
The Director-General responsible may delay the deadline(s) by up to two months.
All deadlines are at 17.00.00 Brussels local time.
The budget amounts are subject to the availability of the appropriations provided for in the general budget of the Union for years 2021 and 2022.

51 Nonetheless, this does not preclude submission and selection of a proposal requesting different amounts.

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HORIZON-CL5-2021-D2-01-13	CSA	3.00		2.00 to 3.00	1
HORIZON-CL5-2021-D2-01-14	CSA	2.00		2.00 to 3.00	1
HORIZON-CL5-2021-D2-01-15	CSA	2.50		Around 2.50	1
HORIZON-CL5-2021-D2-01-16	COFUND	18.50	18.50	Around 130.00	1
Overall indicative budget		231.00	18.50		

General conditions relating to this call	
Admissibility conditions	The conditions are described in General Annex A.
Eligibility conditions	The conditions are described in General Annex B.
Financial and operational capacity and exclusion	The criteria are described in General Annex C.
Award criteria	The criteria are described in General Annex D.
Documents	The documents are described in General Annex E.
Procedure	The procedure is described in General Annex F.
Legal and financial set-up of the Grant Agreements	The rules are described in General Annex G.

A competitive and sustainable European battery value chain

Proposals are invited against the following topic(s):

HORIZON-CL5-2021-D2-01-01: Sustainable processing, refining and recycling of raw materials (Batteries Partnership)

Specific conditions	
Expected EU contribution per project	The EU estimates that an EU contribution of between EUR 6.00 and 7.00 million would allow these outcomes to be addressed appropriately. Nonetheless, this does not preclude submission and selection of a proposal requesting different amounts.

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Indicative budget	The total indicative budget for the topic is EUR 21.00 million.
Type of Action	Research and Innovation Actions
Technology Readiness Level	Activities are expected to achieve TRL 4-5 by the end of the project – see General Annex B.

Expected Outcome: Raw materials need to be competitively processed and refined in Europe in a sustainable way, including reduced environmental footprint, and improved social aspects and competitiveness.

Project results will contribute to decreasing dependency of Europe on imported battery chemicals and raw materials. As a result new business opportunities and jobs will be created for the European industry.

Projects are expected to coordinate with projects funded under *Cluster 4 RESILIENCE Green and Sustainable Materials topics.* Projects are expected to contribute to European Raw Materials Alliance objectives.

Project results are expected to contribute to all of the following expected outcomes:

- European low-grade deposits and secondary material sources such as tailings as source of nickel, cobalt and lithium are taken into use, reducing the European dependency on important materials by increasing refining capacity to battery grade materials in Europe. This requires innovative, cost-effective and safe extraction technologies;
- Battery grade intermediates such as lithium hydroxide and precursor materials are competitively produced and refined in Europe in a sustainable and socially acceptable way, improving the competitiveness and value of European battery and mobility industries;
- Reduced carbon emissions, increased energy efficiency, and more efficient resource use and yield, for example by increasing the capacity to re-process recycled lithium from spent batteries integrated in primary lithium processing;
- New business opportunities and models for the European industry (e.g. joint processing, centralised Lithium refinery) creating additional jobs from increased processing and refining capacity.

Scope: In order to secure a competitive battery industry in Europe, innovations in chemical and metallurgical production are required. The focus is at improved yield, better process control, flowsheet flexibility, improved product purity and quality, improved impurity removal, and improved recovery from secondary streams. These innovations are in some cases complementary unit processes to existing process flow sheets, while in others, such as European lithium or precursor production, completely new flowsheets. These advancements are expected to bring the European battery metal and chemical production to a global leadership. The activities are expected to cover one or several bullets:

- Solutions to a sustainable Lithium value chain, such as:
    - Novel sorting technologies, new comminution method and alternative energy sources to improve energy efficiency, CO_2 emissions and reduce water use in lithium processing and refining.
    - Selective methods for lithium extraction from pegmatites and other Lithium bearing minerals and refining of lithium materials to battery grade chemicals or even to lithium metal. Improvement of stability of refined LiOH. Cross-connections to other relevant WP parts which cover raw materials issues (e.g. Cluster 4) will be established.
    - Specification of physical-chemical properties for Lithium deposits, to foresee how the mineral mix could be better processed.
- New refining processes to increase value and yield from European mines and sustainably sourced and imported (nickel and cobalt) raw materials, but also from process waste, side streams, recycled materials, mine tailings and other non-conventional sources.
- Improvements in performance and efficiency of existing (nickel and cobalt) refining processes in Europe, e.g. by implementing new methodologies to reduce carbon emissions, increasing energy and resource efficiency, raw material flexibility and substitution of fossil fuels.
    - Development of new recoverable reagents and processes and real-time composition analysis for battery metal leaching and extraction to reduce waste and improve material efficiency
    - New smelting and slag engineering technologies to address Ni and Co losses in smelting
- Development of continuous processes for precursor materials (pCAM) to replace the currently used batch processing, including:
    - Process control solutions for different cathode active material recipes
    - Complete process design concepts including filtration, gas supply, mixing ratios, flow control, fluidised process solutions, and process automation
    - Process optimisation to minimise and/or recover off-specification battery metals and compounds.
- Zero Liquid Discharge processing in battery chemical and precursor material processing, including energy cascading and waste valorisation
- New business models for co-processing and process integration

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- Process modelling competence combined with environmental impact evaluation (incl. LCA) for individual primary processes, in collaboration with a project funded under HORIZON-CL5-2021-D5-01-04.

This topic implements the co-programmed European Partnership on 'Towards a competitive European industrial battery value chain for stationary applications and e-mobility'.

HORIZON-CL5-2021-D2-01-02: Advanced high-performance Generation 3b (high capacity / high voltage) Li-ion batteries supporting electro mobility and other applications (Batteries Partnership)

Specific conditions	
Expected EU contribution per project	The EU estimates that an EU contribution of between EUR 6.00 and 8.00 million would allow these outcomes to be addressed appropriately. Nonetheless, this does not preclude submission and selection of a proposal requesting different amounts.
Indicative budget	The total indicative budget for the topic is EUR 24.00 million.
Type of Action	Research and Innovation Actions
Technology Readiness Level	Activities are expected to achieve TRL 6 and higher by the end of the project – see General Annex B.

Expected Outcome: Projects are expected to contribute to the following outcomes:

- Advanced Li-ion batteries delivering on cost, performance, safety, sustainability and recyclability, with clear prospects for cost-competitive large-scale manufacturing and uptake by the electro mobility as well as other application sectors.
- Increase in energy density and hence increasing driving distance at reduced cost on module and pack level, inducing a broader customer's acceptance.
- Broader user acceptance leading to a significantly broader market penetration, helping to reduce GHG emissions of the transport and industry sectors to support EU's efforts to become climate-neutral by 2050: demonstrated for recyclability.

Translating these outcomes into indicative KPIs to guide the R&I efforts, it is recommended to target the following for impact by 2025 and beyond:

- Gravimetric, volume energy density at cell level of 350-400 Wh/kg, 750-1000 Wh/l respectively.
- Power density at cell level of 700 W/kg, 1500+ W/L.
- For high voltage application, operation at 4.7+ Volt.
- 3000+ and 2000+ deep cycles for high capacity and high voltage applications respectively.

- Cost at pack level < 100 euro/kWh.

Scope: The overarching R&I challenges lie in the development of advanced materials enabling higher energy / power density thanks to higher capacity (voltage range 4.3-4.5V) and/or operating at higher voltage (4.7+V). Focus is on adapting the cathode materials (high-nickel NMCs for capacity, spinels / Li-rich Mn NMCs for voltage), the anode materials (graphite-containing Si(Ox)), the electrolytes (stabilised formulations) and their interplay.

- **For the higher capacity approach, focusing on maximising energy and power density should address topics such as**
    - High-capacity cathode materials operating in 4.3-4.5 Volt range while delivering on cycle life, protective coatings for safety improvements;
    - High-performance anodes with advanced graphite and silicon materials (increase Si content in Si/C anodes to achieve capacities ideally at 1000 mAh/g), - Other option is to, develop complete Si or other alloying anode solutions in nanostructured form;
    - Suitable inactive materials (binders, conductive carbons, current collectors, separators);
    - Electrolytes stable in 4.3-4.5 Volt (new additives and/or solvent systems), advanced processing routes for the novel materials and advanced electrode and cell/module designs.
- **For the higher voltage approach, focusing on maximising energy and power density should address topics such as**
    - High-voltage stable electrolyte systems (new electrolytes and/or new formulations);
    - High-voltage stable cathode active materials (e.g. HV spinels, Li-rich Mn NMCs, phosphates, disordered materials etc. with lowered content in critical and high price elements, protective coatings);
    - Tailoring and operando monitoring of the electrochemical interplay between the cathode active material and the electrolyte formation of stable SEI interfaces;
    - Advanced high performance anodes matching these high-voltage cathodes and electrolytes;
    - Structuring of the cathode and anode electrodes for among others their competition and electric conductivities.

This topic implements the co-programmed European Partnership on 'Towards a competitive European industrial battery value chain for stationary applications and e-mobility'.

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HORIZON-CL5-2021-D2-01-03: Advanced high-performance Generation 4a, 4b (solid-state) Li-ion batteries supporting electro mobility and other applications (Batteries Partnership)

Specific conditions	
Expected EU contribution per project	The EU estimates that an EU contribution of between EUR 8.00 and 9.00 million would allow these outcomes to be addressed appropriately. Nonetheless, this does not preclude submission and selection of a proposal requesting different amounts.
Indicative budget	The total indicative budget for the topic is EUR 36.00 million.
Type of Action	Research and Innovation Actions
Technology Readiness Level	Activities are expected to achieve TRL 5 by the end of the project – see General Annex B.

Expected Outcome: Project results are expected to contribute to all of the following expected outcomes:

- Advanced Li-ion batteries delivering on cost, performance, safety, thermal stability, sustainability with clear prospects for cost-competitive large-scale manufacturing and uptake by electro mobility sector.
- Increase in energy density and hence increasing driving distance at reduced costs on module and pack level, positively affecting the customer's acceptance.
- Broader user acceptance will help to reduce GHG emissions of the transport sector and support EU's efforts to become climate-neutral by 2050.

Translating these outcomes into indicative KPIs to guide the R&I efforts, it is recommended to target the following for impact by 2030 and beyond:

- Gravimetric energy density at cell level of 400+ Wh/kg volumetric energy density at cell level of 800+ Wh/l (Gen 4a) progressing to 1000+ Wh/l (Gen 4b).
- Cycle life up to 3000 and beyond and ability to operate at charging rate of 3-5C (for aviation up to 10C).
- Cost at pack level down to below 75 euro/kWh.
- High-power variants for fast charging, airborne, heavy-duty, hybrid segments targeting >500W/kg and >700 W/l.

Scope: The overarching R&I challenges lie in the development of solid-state electrolytes, cathode materials and anode materials enabling higher thermal and electrochemical stability while targeting higher energy / power densities, fast charging, cyclability and improved safety.

These new materials should contribute in the control of thermal runaway at early stage, and create non-propagation designs. Developments should range from using conventional materials to using Li metal-based anode materials. Projects should be aligned with ongoing H2020 projects on the subject, especially from H2020-LC-BAT-2020 call and their publicly-available results.

- **For Generation 4a (solid state with conventional materials) projects are expected to cover all bullets:**
    - Developing low direct current resistance active materials;
    - Reducing thickness of the anode;
    - Developing thin solid electrolyte with high ionic conductivity;
    - Developing concepts/strategies for manufacturing new solid electrolyte interlayers;
    - Improving interface design to ensure efficient charge-transfer and electrochemical stability and improved cell mechanical stability;
    - Proposed approach is expected to have no negative impact on energy densities, safety, and cyclability;
    - Development of coating strategies for current collectors.
- **For Generation 4b (solid state with Li metal-based anode materials) projects are expected to cover one or several bullets:**
    - New materials and/or chemistries to increase the energy densities beyond the state of the art of batteries used in electro mobility applications.
    - At the anode side, lithium metal appears as the most appealing choice in terms of gravimetric energy density.
    - Improved reversibility, homogeneity and density of electrodeposition process by doping or coating strategies.
    - Solutions for manufacturing and handling Li metal sheet in dry atmosphere.
    - Novel solutions for low cost manufacturing strategies such as solvent-free electrode manufacturing and solid electrolyte deposition.
    - Another technology (anode-less), could also be developed by designing current collectors for reversible electrodeposition of lithium. Current collector coating strategies which regulate lithium deposition and improve cycling performance can also be developed.
    - Solid-state electrolytes and lithium metal anodes open the way to new cathode chemistries reaching high energy density such as lithium-free cathode in combination

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with lithium metal or Li-excess cathode exhibiting high irreversible capacity in the anode-less configuration.

- Improving interface design to ensure efficient charge-transfer and electromechanical stability and improved cell mechanical stability.
- Bipolar cell design concepts and processing.

This topic implements the co-programmed European Partnership on 'Towards a competitive European industrial battery value chain for stationary applications and e-mobility'.

HORIZON-CL5-2021-D2-01-04: Environmentally sustainable processing techniques applied to large scale electrode and cell component manufacturing for Li ion batteries (Batteries Partnership)

Specific conditions	
Expected EU contribution per project	The EU estimates that an EU contribution of around EUR 5.00 million would allow these outcomes to be addressed appropriately. Nonetheless, this does not preclude submission and selection of a proposal requesting different amounts.
Indicative budget	The total indicative budget for the topic is EUR 20.00 million.
Type of Action	Research and Innovation Actions
Technology Readiness Level	Activities are expected to achieve TRL 5-6 by the end of the project – see General Annex B.

Expected Outcome: Project results are expected to contribute to all of the following expected outcomes:

- Provide European a leadership position in production of batteries with lower carbon footprint.
- New sustainable electrode and cell manufacturing techniques are with reduced energy consumption, lower carbon footprint and no Volatile Organic Compounds (VOCs) emissions. Electrode and cell manufacturing processes are scalable, safer, cheaper, cleaner and less energy consuming compared to state-of-the-art technologies, ultimately reinforcing an internationally competitive European battery manufacturing industry.
- Electrode coating production techniques completely eliminate organic solvents as slurry dispersing media leading to avoid the large capital costs associated to the solvent recovery system Implementation of dry manufacturing techniques such as 3D patterning of active electrode layers, and/or hydrophobic surface treatment of electrodes with next generation materials.

- Industrialising closed loops and process design to return low-value chemicals from manufacturing processes to high-value and necessary inputs for the battery manufacturing industry.

Scope: Industrial scale fabrication of Li-ion battery (LIB) porous electrodes imply casting of a slurry over a thin metallic current collector according to conventional coating procedures. This is the technology used also for advanced LIBs with high energy electrode materials and liquid electrolyte (Gen3a/b). The slurry to be coated is prepared by mixing the active material, conductive agent and binder in a solvent, typically N-Methyl-2-pyrrolidone (NMP). Since NMP is toxic in nature, an expensive recovery system should be placed to collect the evaporated NMP in the drying process.

Less expensive and environmentally friendly solvents, such as water are already employed for anode manufacturing, which eliminates the large capital cost of the solvent recovery system. Wet coating technologies can still be further optimised and benefit from reducing the solvent fraction, thus, reducing the energy demand of the drying step. Moreover, completely dry processing techniques could completely remove the need for energy consuming drying, hence reducing the CO_2 footprint of the electrode fabrication process.

This may also apply for example to protective interface coatings for both advanced anode –e.g. lithium metal- and cathode – e.g. HV spinel materials. Also, there are other new concepts that can benefit from the implementation of dry manufacturing techniques such as 3D patterning of active electrode layers, or hydrophobic surface treatment of electrodes with next generation materials. The process should be scalable, safer, cheaper, cleaner and less energy consuming compared to state-of-the-art technologies. The proposed/developed processes are expected to address the notion of "Design to Manufacture", which should reduce production cost and increase battery performance resulting in increased efficiency and better cycle life. As the manufacturing techniques may benefit from digitalization, and moreover be ready to be integrated in digitally-driven larger production lines, project proposals should address digitalization within their scope..It should also propose innovative technical solutions and/or standardized approaches to ensure workers and users safety, particularly in the field of handling new materials during processing – such as in the case of nano-materials. The challenge is proposed for Li-ion up to generation 3.

Focus is into manufacturing technology development, up to pilot-level proof of concept. Activities to be aligned/feeding into the specific machinery development topic – industrial machinery development is beyond the scope of this topic.

Projects are expected to be aligned with H2020 project LiPLANET initiative – The EU network of R&D Li cell manufacturing pilot lines.

This topic implements the co-programmed European Partnership on 'Towards a competitive European industrial battery value chain for stationary applications and e-mobility'.

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HORIZON-CL5-2021-D2-01-05: Manufacturing technology development for solid-state batteries (SSB, Generations 4a - 4b batteries) (Batteries Partnership)

Specific conditions	
Expected EU contribution per project	The EU estimates that an EU contribution of between EUR 6.00 and 7.00 million would allow these outcomes to be addressed appropriately. Nonetheless, this does not preclude submission and selection of a proposal requesting different amounts.
Indicative budget	The total indicative budget for the topic is EUR 26.00 million.
Type of Action	Research and Innovation Actions
Technology Readiness Level	Activities are expected to achieve TRL 5-6 by the end of the project – see General Annex B.

Expected Outcome: Project results are expected to contribute to all of the following expected outcomes:

- Position Europe at the industrial production lead in the international race for next generation, SSB technologies all through the value chain.
- Generation of an indigenous technological knowledge portfolio of industrially scalable manufacturing solutions for the different approaches to SSB including all core components: electrolytes, anodes –either carbon or Li(m) based - and their ad hoc composites cathodes.
- Contribute to climate neutral transport via the development of breakthrough technology in SSB batteries.
- Enable cost effective, low carbon footprint and low-emission mass production of Gen4 technology in Europe.

Scope: Lithium ion battery cells with conventional active materials are reaching their limits in terms of energy densities. Also, safety issues arise with the utilisation of liquid organic electrolyte which are becoming even more critical with the nearly introduction of advanced materials made to increase cell voltage and fast-charging rates. Hence, there is an urgent need for the development of innovative scalable manufacturing technologies based on of new solid electrolytes that can be also combined with metallic lithium at the anode, leading to significantly enhanced energy density. In that context, solid-state electrolytes enable overcoming current battery cells limitations in terms of voltage and safety (reducing dendrites formation risk) leading to and increased intrinsic thermal and electrochemical stability.

As a consequence, in parallel to the progress in new materials developments, there is a growing need of Research and Innovation addressed to develop appropriate processing techniques for assemble cells based on solid type electrolytes including all current foreseen technological

options: polymer-based, hybrid polymeric, inorganic and other alternatives such as gel-like semisolid electrolytes.

Also, processing, handling and integration of lithium metal anodes into cells, with special attention to solid-solid interfaces and protection layers need to be tackled (Generation 4b). As an alternative route, advanced Si/C composite-based anodes (Generation 3b) may come as a possible solution, and their specific manufacturing approach and interface requirements towards solid state electrolytes should be covered as well. Thus, appropriate processing techniques should be developed, optimised, adapted or reinvented for the preparation of dense electrode and electrolyte layers, to enable scale up of solid-state battery cells (Generation4a and Generation4b) towards industrial GWh mass production.

Cathodic electrodes making use of advanced materials – e.g. high Ni content oxides- combined with electrolyte material to enhance interfacial compatibility may pose specific manufacturing challenges involving innovative dry and/or extrusion coating techniques.

Projects funded under this topic should make provisions to establish adequate coordination schemes with related materials running projects, with special focus in HORIZON-CL5-2021-D2-01-03: Advanced high-performance Generation 4a, 4b (solid-state) Li-ion batteries.

The new manufacturing techniques for the SSB Gen 4a/4b batteries should focus on cost, performance, safety and sustainability with clear prospects for cost-competitive large-scale manufacturing and uptake by the electro mobility sector. Also, as the manufacturing techniques may benefit from digitalization, and moreover be ready to be integrated in digitally-driven larger production lines, project proposals should address digitalization within their scope. Manufacturing and cell assembly processes to be developed should be more sustainable compared to the current LIB manufacturing. In order to demonstrate cost reduction and improvement in other parameters projects are expected to provide comparison with baseline manufacturing techniques.

Focus is into manufacturing technology development, up to pilot-level proof of concept. Activities to be aligned/feeding into the specific machinery development topic –industrial machinery development is beyond the scope of this topic.

This topic implements the co-programmed European Partnership on ‘Towards a competitive European industrial battery value chain for stationary applications and e-mobility’.

HORIZON-CL5-2021-D2-01-06: Sustainable, safe and efficient recycling processes (Batteries Partnership)

Specific conditions	
Expected EU contribution per project	The EU estimates that an EU contribution of between EUR 9.00 and 10.00 million would allow these outcomes to be addressed appropriately. Nonetheless, this does not preclude submission and selection of a proposal requesting different amounts.

Indicative budget	The total indicative budget for the topic is EUR 30.00 million.
Type of Action	Research and Innovation Actions
Technology Readiness Level	Activities are expected to achieve TRL 5-6 by the end of the project – see General Annex B.

Expected Outcome: Projects are expected to contribute to the following outcomes:

- Improved access to battery materials and strengthened European raw material independency by increased circularity of material flows and use of the secondary raw materials in new batteries produced in Europe.
- Increased European competitiveness offering sustainable, safe, energy efficient and low carbon footprint battery recycling technologies and upscaleable solutions.
- Reduced recycling cost and environmental impacts through new and disruptive concepts for very high efficiency recycling.
- Improved health and safety aspects of recycling.
- The industry is prepared to meet the new regulatory targets for the recycling.

Scope: In order to effectively exploit the vast amounts of EV and stationary battery waste emerging in the next decades, as well as the increasing amounts of production scrap resulting from larger manufacturing, it is important to create innovative feasible and holistic recycling processes in Europe.

Newly developed recycling processes are expected to be more flexible and adaptive, to be able to meet a wide variety of battery waste or production scrap resulting from cross different Li-battery chemistries (i.e. with and without transition metals). It is desirable to implement intelligent process design through integrating selected fractions into existing industrial infrastructure, or other innovative integration of fractions or processes. The recycling processes may partially utilise existing metallurgical infrastructure of the primary materials to support feasible processing and explore ways to support industrial transition towards green technologies.

Newly developed recycling processes are expected to aim at recovering the highest amount of resources (e.g. metals, graphite, fluorinated compounds and polymers, active materials) present within secondary raw materials which result from spent Li-batteries with and without transition metals and focus on the reuse of these materials in batteries.

Low-value chemicals from manufacturing processes should be returned to high-value and necessary inputs for the battery manufacturing industry. Focus should, however, be on developing materials recycling routes which as directly as possible target next-generation battery cathode and anode materials. Vertical integration to component/cell manufacturing should be improved.

Proposals are expected to aim at the outmost recovery rates and recovered material purity, meeting industrial requirements for their integration in the loop of cell manufacturing, in line with values reflected in Partnership Strategic Research Agenda (SRA).

Recovery/re-use/re-purposing/reconditioning of battery materials/electrodes/components should also be maximised and recycling discharge minimised.

Proposals are expected to develop new unit processes, or innovative combinations of optimised unit processes, including, but not limited to mechanical pre-processing, leaching, precipitation, solvent extraction, ion exchange, centrifuging, crystallisation, electrowinning, roasting, smelting, pyrolysis, shock wave disruption and direct reuse of materials and components.

Proposals are expected to identify and address health risks, environmental impacts, safety hazards and new safety practices related to developed processes.

The environmental impacts and benefits are to be quantified through life cycle thinking approach (e.g. LCA/SLCA), also in collaboration with the project funded under the joint topic HORIZON-CL5-2021-D5-01-04.

The co-operation with projects funded under topics HORIZON-CL5-2021-D2-01-01, HORIZON-CL5-2022-D2-01-01 should be established.

International collaboration is strongly encouraged.

This topic implements the co-programmed European Partnership on 'Towards a competitive European industrial battery value chain for stationary applications and e-mobility'.

HORIZON-CL5-2021-D2-01-07: Support for establishment of R&I ecosystem, developing strategic forward-looking orientations to ensure future skills development, knowledge and technological leadership for accelerated disruptive technology exploration and uptake (Batteries Partnership)

Specific conditions	
Expected EU contribution per project	The EU estimates that an EU contribution of around EUR 3.00 million would allow these outcomes to be addressed appropriately. Nonetheless, this does not preclude submission and selection of a proposal requesting different amounts.
Indicative budget	The total indicative budget for the topic is EUR 3.00 million.
Type of Action	Coordination and Support Actions

Expected Outcome: In order to succeed in the development of a thriving innovative battery industry, pan-European cooperation on research and innovation is essential. It is not only essential to work across geographical boarders and institutional levels but it is also crucial that stakeholders from all parts of the battery value chain pull together in a strategic coordinated

manner to ensure our collective research efforts are efficiently translated into sustainable technologies and products economically, environmentally and socially.

Europe has an extensive landscape of battery R&I stakeholders. Thus there is a need to continuously consolidate the Battery R&I community across the EU and associated countries and across Battery-related networks, projects and initiatives (including European, national, regional – HEU Partnerships, IPCEIs, Interregional partnership on advanced battery materials, European Battery Alliance and coordination actions including BATTERY 2030+, LiPLANET).

Project results are expected to contribute to all/ of the following expected outcomes:

- Consolidated Battery R&I community across the EU and associated countries and across Battery-related networks, projects and initiatives (including European, national, regional – HEU Partnerships, IPCEIs, Interregional partnership on advanced battery materials, European Battery Alliance and coordination actions including BATTERY 2030+, LiPLANET, and other initiatives established until the project end). Exceptional participation of third country participants is therefore not foreseen.

- Facilitated access to information for all – enabled European "one-stop shop" on Battery R&I information, including information on national programmes, events, battery projects and national battery networks (via website and other communication channels) reaching as many as possible battery stakeholders.

- Reduced time to market of technologies and improved European competitiveness through established research-industry collaborations, information sharing and expert group work.

- Synergies and research results efficiently shared along the whole value chain, thus mobilizing R&I efforts.

- Attracted talent and competences necessary to achieve the technical goals and to support European industry.

- Provided scientific evidence for policymakers.

- Increase and reinforce international collaboration within the geographical scope outlined above..

<u>Scope</u>: Proposals are expected to:

- Develop, consolidate and communicate a strategic research approach for all stakeholders throughout the entire European Battery Value Chain.

- Develop and/or update coherent Strategic Research and Innovation agenda (SRIA) and corresponding detailed roadmaps covering all aspects of the battery value chain through expert group work.

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- Facilitate and support work of experts from a different field in a cross-collaboration manner, identify the challenges and opportunities and so create guidelines and recommendations on how best to develop synergies.
- Establish and continuously update Key performance indicator (KPI's) values for current state-of-art battery technology, as collected from stakeholders across the battery value chain correlated and communicated via SET Plan progress monitoring.
- Establish Target Key performance indicators (Target KPI's) values for future battery R&I as collected from all relevant forums, correlated and communicated via SET Plan progress monitoring and the Strategic Research and Innovation agenda (SRIA) to the entire R&I community in general.
- Implement and foster the adoption of uniform standards and methodologies for the reporting of battery research developments across EU and national projects building on existing European and national work/efforts.
- Execute a clear communication plan describing the hosting and updating website, organising events and facilitating networking. Communicate results and progress in Battery R&I on both a European and International level.
- Cooperate with ETIPs and similar stakeholders fora, provide support to existing SET Plan Implementation Plans and advancement towards more interconnected activities, both in terms of contents and implementation mechanisms (see topic HORIZON-CL5-2021-D3-01-17)
- Promote and facilitate international collaborative actions, where necessary.
- Perform additional activities which are relevant to reach the expected outcomes.
- In order to ensure high quality coordination and technical outputs from the proposals should possess both technical and operative expertise.

The overarching European R&I platform should build on previous efforts and continue to foster pan-European active cooperation and maintain up-to-date clear realistic strategic research and innovation agenda for Europe.

The project's main governance (e.g. Steering Group, Advisory Board) is expected to provide for direct involvement of European Commission services for collaboration on relevant policy activities, incl. further supporting SET plan.

This topic implements the co-programmed European Partnership on 'Towards a competitive European industrial battery value chain for stationary applications and e-mobility'.

Emerging breakthrough technologies and climate solutions

Proposals are invited against the following topic(s):

HORIZON-CL5-2021-D2-01-08: Emerging technologies for a climate neutral Europe

Specific conditions	
Expected EU contribution per project	The EU estimates that an EU contribution of around EUR 2.50 million would allow these outcomes to be addressed appropriately. Nonetheless, this does not preclude submission and selection of a proposal requesting different amounts.
Indicative budget	The total indicative budget for the topic is EUR 20.00 million.
Type of Action	Research and Innovation Actions
Technology Readiness Level	Activities are expected to achieve TRL 4 by the end of the project – see General Annex B.

Expected Outcome: Project results are expected to contribute to all of the following expected outcomes:

- Available high-risk/high return technologies for a transition to a net greenhouse gas neutral EU economy by 2050.
- Knowledge and scientific proofs of the technological feasibility of the concept.
- Environmental, social and economic benefits to contribute to R&I strategy and policy forecast.
- Establishing a solid long term dependable European innovation base.

Scope: The proposal is expected to address one of the following areas:

- Decarbonised, efficient, effective, and safe Transport;
- Fuel cells;
- Efficient energy generators;
- Energy distribution;
- Energy storage;
- Negative GHG emissions.

The following areas should not be covered as they fall within either partnerships or other calls:

- Material research;
- Renewable energy technologies and renewable hydrogen production are addressed under HORIZON-CL5-2021-D3-02-02;

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- Batteries.

The proposal should address the validation of its concept to TRL 4, presenting a robust research methodology and activities, establishing the technological feasibility of the proposed concept. The methodology should include proper assessment of the environmental, social and economic benefits, and consider transfers of developments in sectors other than energy whenever relevant. These interdisciplinary aspects may provide ideas, experiences, technology contributions, knowledge, new approaches, innovative materials and skills. The applications of those concepts can also be proposed for various sectors. Economic benefits could be for example technology cost reduction, job creations, new businesses and more efficient motors and generators.

Proposals may consider the following areas:

- Technologies providing the possibility of multi-fuel integration and/or the potential for the transversal;
- Intersectorial decarbonization;
- Concepts targeting hard-to-decarbonize sectors and energy-intensive applications, such as road/rail/maritime transport or energy generation though thermal power generators;
- Flexibility in terms of its scalability to different power/energy demands;
- Compatibility with local or distributed energy production layouts;
- Use of already available industrial processes and raw materials for easy TRL upgrading and final transfer to mass production.

In developing its concept the proposal is expected to address the following related aspects:

- Lower environmental impact (e.g. on climate change, pollution and biodiversity);
- Better resource efficiency (materials, geographical footprints, water, etc…) than current commercial technologies;
- Barriers to the deployment of such technologies, including issues related to social acceptance or resistance to new energy technologies, related socioeconomic and livelihood issues globally;
- Life cycle approach to be done with the relevant information that can be gathered at such TRL level.

HORIZON-CL5-2021-D2-01-09: Methane cracking to usable hydrogen and carbon

Specific conditions

Expected EU contribution per project	The EU estimates that an EU contribution of between EUR 2.00 and 3.00 million would allow these outcomes to be addressed appropriately. Nonetheless, this does not preclude submission and selection of a proposal requesting different amounts.
Indicative budget	The total indicative budget for the topic is EUR 15.00 million.[52]
Type of Action	Research and Innovation Actions
Procedure	The procedure is described in General Annex F. The following exceptions apply: To ensure a balanced portfolio, grants will be awarded to applications not only in order of ranking but at least also to those that are the highest ranked within set topics, provided that the applications attain all thresholds.
Technology Readiness Level	This topic focusses on technological concepts at low TRLs (TRL 3 or lower). Activities are expected to achieve TRL 5 by the end of the project – see General Annex B.

Expected Outcome: Project results are expected to contribute to at least one of the following expected outcomes:

- Replacement of the unabated use of natural gas by climate-neutral (or negative, in case of cracking of biogenic methane) hydrogen.
- Reduction of emissions by hard to decarbonise sectors, also considering the use of eventual by-products.
- Faster reduction of GHG emissions by economies heavily relying on natural gas export or use (provided they reduce their upstream emissions).
- Production of economically usable by-product solid carbon (in tires, batteries, etc.).

Scope: A potential breakthrough technology is represented by the development of processes allowing the use of available fossil and renewable methane to economically generate hydrogen without any release of CO_2 or other GHGs (as in current processes). To be advantageous on a life cycle basis, however, this requires a higher efficiency than in current processes and that the used natural or renewable gas is supplied by a chain with low upstream leakage.

This requires the development of innovative methodologies to deliver high performance hydrogen production from methane by directly splitting the molecule in its components (hydrogen and solid carbon). Proposals are expected to demonstrate significant advances with respect to already achieved results in Europe and outside, delivering a minimum of 50% efficiency (i.e. energy from hydrogen recovery vs energy from original methane, for instance

[52] This budget is shared with topic HORIZON-CL5-2021-D2-01-10, HORIZON-CL5-2021-D2-01-11

by reducing reaction temperatures and improving catalysts), and demonstrating the potential to achieve mass production and a competitive hydrogen cost and an improved climate performance with respect to current methane based, CO_2 releasing hydrogen production methods including CCS. Due consideration should be given to the management of impurities in the source stream, and to the development of the economic potential of the carbon particles delivered by the specific technology which could have a valuable end-use (e.g. synthetic graphite or carbon black) or the development of side-streams of other carbon-rich chemical compounds (excluding uses which would re-release the carbon as CO_2). Each project will dedicate part of its work programme to technology assessment to consider environmental, resource and economic aspects of the deployment of the technology).

HORIZON-CL5-2021-D2-01-10: Technologies for non- CO2 greenhouse gases removal

Specific conditions	
Expected EU contribution per project	The EU estimates that an EU contribution of between EUR 2.00 and 3.00 million would allow these outcomes to be addressed appropriately. Nonetheless, this does not preclude submission and selection of a proposal requesting different amounts.
Indicative budget	The total indicative budget for the topic is EUR 15.00 million.[53]
Type of Action	Research and Innovation Actions
Procedure	The procedure is described in General Annex F. The following exceptions apply: To ensure a balanced portfolio, grants will be awarded to applications not only in order of ranking but at least also to those that are the highest ranked within set topics, provided that the applications attain all thresholds.

<u>Expected Outcome</u>: Project results are expected to contribute to at least one of the following expected outcomes:

- Increase knowledge on the plausibility of removing non-CO_2 greenhouse gases from the atmosphere.
- Raise awareness on the effects of non-CO_2 greenhouse gases on earth warming.
- Develop technologies for addressing the effects of non-CO_2 greenhouse gas emissions.
- Investigate techno-economic aspects of technologies and physical properties of emissions striving to match both into market-ready solutions.

[53] This budget is shared with topic HORIZON-CL5-2021-D2-01-09, HORIZON-CL5-2021-D2-01-11

Scope: Development of technologies for removing non-CO_2 greenhouse gases CH4, N_2O and fluorinated gases.

This topic focusses on technological concepts at low TRLs (TRL 3 or lower).

In the case of methane, the scope of possible applications is further constrained: Methane emissions stemming from the supply chain of fossil fuels are excluded, considering that such emissions are meant to be addressed through emission avoidance. Other emissions with a methane concentration higher than 1% are also excluded, considering that economic interests should drive their mitigation.

Technologies are expected to contribute to the capture, concentration, use and/or disposal of emissions, either from or at natural sources (if more concentrated) or in the atmosphere. Carbon dioxide may be considered, though only if any synergy can be found with processing it in combination with other greenhouse gas(es) which should be the prime focus. The state-of the art of technology development will be clearly presented in the proposal with global potential for emission reductions, cost figures and versatility and economic viability of use where appropriate.

HORIZON-CL5-2021-D2-01-11: Direct atmospheric carbon capture and conversion

Specific conditions	
Expected EU contribution per project	The EU estimates that an EU contribution of between EUR 2.00 and 3.00 million would allow these outcomes to be addressed appropriately. Nonetheless, this does not preclude submission and selection of a proposal requesting different amounts.
Indicative budget	The total indicative budget for the topic is EUR 15.00 million.[54]
Type of Action	Research and Innovation Actions
Procedure	The procedure is described in General Annex F. The following exceptions apply: To ensure a balanced portfolio, grants will be awarded to applications not only in order of ranking but at least also to those that are the highest ranked within set topics, provided that the applications attain all thresholds.
Technology Readiness Level	This topic focusses on technological concepts at low TRLs (TRL 3 or lower). Activities are expected to achieve TRL 4-5 by the end of the project – see General Annex B.

Expected Outcome: Project results are expected to contribute to at least one of the following expected outcomes:

[54] This budget is shared with topic HORIZON-CL5-2021-D2-01-09, HORIZON-CL5-2021-D2-01-10

- Increase knowledge of existing/develop new materials for direct atmospheric carbon capture and conversion technologies; or
- Address potential barriers to incorporation of direct air capture in existing CC(U)(S) concepts; or
- Make direct atmospheric carbon capture and conversion technologies a viable technology to make the EU carbon neutral by increasing the TRL levels of the different technological options.

Scope: This topic focusses on Direct Atmospheric Carbon Capture and Conversion, which is a technology that can help reaching climate neutrality by 2050 by i) creating the carbon sinks required to balance out residual emissions in 2050 and/or ii) using carbon captured from the air as a raw material to replace other fossil raw materials.

The scope of this topic is to establish the technological feasibility of Direct Atmospheric Carbon Capture and Conversion, including the environmental, social and economic benefits with the goal of establishing this concept as a viable technology to fight climate change the potential technologies require major technological breakthroughs, for example by

- Increasing knowledge of existing/develop new oxygen-tolerant catalysts for photo/electro-reductive conversion of carbonates/carbamates; or
- Developing thermal chemical conversion technologies for direct atmospheric carbon capture and conversion; or
- Developing photo(electro)chemical conversion technologies for direct conversion of atmospheric CO_2 to direct atmospheric carbon capture and conversion.

Technological concepts supported under this topic should i) combine capture and conversion in a single step, eliminating the need to regenerate absorbents or adsorbents and/or ii) be able to enable decentralised production of chemicals and fuels using solar energy devices.

Projects that include research into the use of direct air capture for enhanced oil recovery will not be considered.

Citizens and stakeholder engagement

Proposals are invited against the following topic(s):

HORIZON-CL5-2021-D2-01-12: Fostering a just transition in Europe

Specific conditions	
Expected EU contribution per project	The EU estimates that an EU contribution of between EUR 3.00 and 4.00 million would allow these outcomes to be addressed appropriately.

	Nonetheless, this does not preclude submission and selection of a proposal requesting different amounts.
Indicative budget	The total indicative budget for the topic is EUR 10.00 million.
Type of Action	Research and Innovation Actions

Expected Outcome: Projects are expected to contribute to one or several of the following outcomes:

- A better understanding of the distributional repercussions of the transition to climate neutrality across sectors, social groups, countries, regions, cities, and in the labour market that will help implement the commitment to "leaving nobody behind".
- A better understanding of the trade-offs and synergies between climate action, climate-change impacts and equity and justice considerations, such as social inequality, gender equalities, as well as their interaction with other transformations that underpin the transition to climate neutrality.
- Addressing procedural justice concerns in the transition to carbon neutrality, via deeper and more consequential involvement of stakeholders from all parts of society in the transition process, for instance via co-design and co-production processes, social innovations, citizen science, user-led innovation type activities, or upstream multi-stakeholder debates or mechanisms for citizen deliberation and engagement.
- New scientific evidence to inform EU, national and regional policies in designing inclusive, socially fair, gender-sensitive and economically viable transition plans and post-COVID recovery packages that take due care of the most affected regions, cities, sectors and parts of society, including vulnerable individuals and households.
- Increased societal and political acceptance for climate transition strategies, including renewable energy projects and more sustainable mobility concepts, based on greater involvement of those most affected, leading to better capacity for co-designing policy frameworks that enhance inclusiveness while minimising adverse distributional effects and inequalities.
- Improved insights into socio-economic and socio-political barriers that impede a just transition towards climate neutrality and identification of strategies to overcome these barriers on different temporal and spatial scales across Europe.

Scope: Actions should enhance the understanding of the challenges of the "just transition" to climate-neutral and environmentally sustainable economies and societies, as envisaged in the European Green Deal and Next Generation EU. They should analyse various dimensions of inequality arising from climate change impacts, climate policies and transition pathways including their distributional implications associated with changes in GDP, industrial competitiveness and trade, employment and skills, taxation, incomes and wealth, vulnerabilities and human health, structure of sectors, business models and relative prices etc. Further equity

aspects associated with climate change impacts and climate policy, such as differential vulnerabilities as well as intergenerational fairness or justice should also be studied, taking into consideration social and geographic circumstances and paying due attention to most vulnerable parts of the society (poor, elderly, children etc.). The gender dimension should also be explored. Research should integrate learnings from the COVID-19 pandemic in terms of the evolution of inequality in Europe and analyse potential implications for climate action and green recovery.

Actions should identify policy options and measures that combine climate and environmental benefits with intra- and intergenerational justice, e.g. by a reduction of poverty and inequality across different sectors of society, as well as within and between countries and regions. They should explore links between and combinations of climate-focused policies and social, taxation, employment and other relevant measures. Recommendations as to the most effective levers for enacting an inclusive, fair and just ecological transition should be formulated.

Beyond climate action, links to Sustainable Development Goals should be considered as many of them are centred on reducing poverty, inequality and meeting basic human needs.

Improving tools and methodologies for addressing intra- and intergenerational equity, equality and justice concerns in the context of the transition to climate neutrality is part of the action's scope, but should take into account the work by projects in other parts of the work programme, notably those addressing the improvement of Integrated Assessment Models under Destination 1 on Climate Science. Research should comprise a strong empirical component, including field experiments, and meaningfully involve stakeholders to collect evidence, test proposals and discuss relevant issues.

Actions are expected to mobilise and build on the knowledge from across a broad range of social sciences (including behavioural science, political science, sociology, economics, law, gender studies etc.) and humanities and involve all parts of the quadruple helix (public bodies, industry/SMEs, academia/research, citizens/civil society) in a meaningful transdisciplinary manner and across activities[55]. Synergies with the topic HORIZON-CL5-2021-D2-01-15 on Transition Super-Labs should be explored, given that equity and fairness considerations will play a very important role in that context, too.

This topic requires the effective contribution of SSH disciplines and the involvement of SSH experts, institutions as well as the inclusion of relevant SSH expertise, in order to produce meaningful and significant effects enhancing the societal impact of the related research activities.

HORIZON-CL5-2021-D2-01-13: Strengthening Social Sciences and Humanities (SSH) research communities in climate, energy and mobility disciplines

Specific conditions

[55] Projects focused on Responsible Research and Innovation (RRI) may be particularly relevant in this regard; a large number of these can be found in the Science with and for Society part of Horizon 2020: https://op.europa.eu/s/oeby.

Expected EU contribution per project	The EU estimates that an EU contribution of between EUR 2.00 and 3.00 million would allow these outcomes to be addressed appropriately. Nonetheless, this does not preclude submission and selection of a proposal requesting different amounts.
Indicative budget	The total indicative budget for the topic is EUR 3.00 million.
Type of Action	Coordination and Support Actions

Expected Outcome: Projects are expected to contribute to the following outcomes:

- Research and innovation communities focusing on Social Science and Humanities (SSH) approaches to climate, energy and mobility as well as on citizen engagement and empowerment are less fragmented and better networked across Europe, including with respect to Eastern and Southern Europe.
- A targeted strategy for intensifying collaboration between Scientific, Technical, Engineering and Mathematical (STEM) and Social Science and Humanities (SSH) research and innovation communities has led to more and more in-depth interdisciplinary work.
- Dedicated outreach and engagement activities (e.g. co-creation processes and greater dissemination of best practices and challenges), have produced strong links to principal stakeholder communities, including policymakers at various levels, the private sector, academia, civil society, and citizens at large.
- Project activities have lowered social and behavioural barriers and contributed to greater citizen engagement in the context of the SET Plan, Horizon Europe Missions, Horizon Europe Partnerships, or other research and innovation actions supported by the EU's framework programme, in collaboration with or building on other EU-funded projects in these areas.
- Policy advice to policy communities, including at European and other levels, is based on the latest research, including work prepared in the context of this project, actionable, and supported by communication and dissemination resources as well as practical guidelines.

Scope: Confronting the threat of global warming and transitioning to carbon neutrality by mid-century requires research and innovation in a number of distinct but interconnected areas, notably in climate science, energy, and mobility. Along with technological innovations, successful solutions need to factor in changing lifestyles, social innovation, forms of behaviour, value structures, governance arrangements at institutional or corporate levels, as well as forms of social organisation. This calls for concerted, multi-disciplinary approaches that are rooted in a variety of academic disciplines but also draw in and engage policymakers at various levels, the private sector, civil society and citizens at large.

To develop and enact such approaches, more extensive networks connecting relevant communities of researchers and practitioners are required, to facilitate and enable deeper and

more consequential forms of collaboration. In particular, Scientific, Technical, Engineering and Mathematical (STEM) communities in climate science, energy and climate need to work more closely with those in the Social Sciences and Humanities (SSH) disciplines, ensuring adequate outreach especially to the eastern and southern parts of Europe. At the same time, methods and mechanisms for lowering social and behavioural barriers and engaging citizens and stakeholders need further refinement, more extensive application and improvement via co-creation and co-production processes, including gender-sensitive ones, and greater dissemination. Focus areas requiring specific attention include prosumers, renewable energy and mobility communities, resource efficiency and the circular economy, as well as digital platforms and technologies.

Developing novel, multi-disciplinary perspectives, strengthening SSH research communities while encouraging collaboration with the STEM disciplines, and nurturing linkages with stakeholder communities, civil society and citizens at large are important preconditions for providing targeted, high-quality advice on how to confront the manifold challenges surrounding the transition to climate neutrality. Policymakers at European and other levels have obvious need for such advice, in delivering the European Green Deal and other high-profile policy initiatives.

Projects under this topic are expected to work towards these goals, while also producing novel research and concrete applications that can inform policymaking, notably at EU-level including with respect to the European Green Deal.

This topic requires the effective contribution of SSH disciplines and the involvement of SSH experts, institutions as well as the inclusion of relevant SSH expertise, in order to produce meaningful and significant effects enhancing the societal impact of the related research activities.

HORIZON-CL5-2021-D2-01-14: Accelerating the climate transition in difficult contexts: transition super-labs (pilot)

Specific conditions	
Expected EU contribution per project	The EU estimates that an EU contribution of between EUR 2.00 and 3.00 million would allow these outcomes to be addressed appropriately. Nonetheless, this does not preclude submission and selection of a proposal requesting different amounts.
Indicative budget	The total indicative budget for the topic is EUR 2.00 million.
Type of Action	Coordination and Support Actions

Expected Outcome: Projects are expected to contribute to the following outcomes:

- A mapping exercise has identified which settings across Europe – such as non-sustainable business complexes, mining regions or polluted metropolitan areas – would benefit the

most from the transition super-labs approach, and which settings could serve to demonstrate the utility of this approach more generally.

- Feasibility studies have been carried out in a select number of these settings, yielding programmatic, actionable blueprints with a view of launching actual transition super-labs at a subsequent stage.
- Enabling coalitions for the practical delivery of transition super-labs have been assembled, with the participation of policymakers at local, regional and other levels, business, finance, civil society organisations, individual citizens, as well as academia.
- A program outline for the practical delivery of a number of transition super-labs in several contexts across Europe, comprising at least three EU Member States and/or Associated Countries, has been prepared, including an assessment of the contribution of different funding instruments (European, national regional and private funds).

Scope: First suggested by the High-Level Panel of the European Decarbonisation Pathways Initiative, Transition Super Labs are a novel way of linking research and innovation with policy. They are particularly relevant for challenges that defy purely technocratic solutions and require fundamental transformations in economies and societies, including lifestyle and behavioural changes or forms of social innovation. Anchored in the EU's research and innovation framework program, they provide ample room for co-creation with Member States/Associated Countries, stakeholders and citizens.

Transition Super Labs are real-life laboratories where a rapid shift to climate neutrality is conceptualised, implemented, monitored and revised in an integrated way. Similar to "living labs" but operating at a much larger scale, they spur the transformation of whole entities – such as non-sustainable business complexes, mining regions and polluted metropolitan areas – in an economically, socially and environmentally sustainable manner.

Designed as flagship demonstrators, Transition Super Labs involve a broad range of actors – businesses and industry, different levels of government, academia, civil society, citizens at large – working closely with communities and regions directly affected by climate change. They provide an ideal complement to mission-driven innovation in that they test systemic innovations at scale and in real-world conditions. Confronting concepts and ideas with technical, environmental and socioeconomic realities, they identify and help to overcome critical bottlenecks and cultural resistance while avoiding false ecological trade-offs.

This topic supports a set of pilot activities designed to prepare the launch of several fully-fledged transition super-labs at a subsequent stage.

This topic requires the effective contribution of SSH disciplines and the involvement of SSH (including gender) experts, institutions as well as the inclusion of relevant SSH expertise, in order to produce meaningful and significant effects enhancing the societal impact of the related research activities.

HORIZON-CL5-2021-D2-01-15: Fostering cooperation between Horizon Europe cluster 5 National Contact Points (NCPs)

Specific conditions	
Expected EU contribution per project	The EU estimates that an EU contribution of around EUR 2.50 million would allow these outcomes to be addressed appropriately. Nonetheless, this does not preclude submission and selection of a proposal requesting different amounts.
Indicative budget	The total indicative budget for the topic is EUR 2.50 million.
Type of Action	Coordination and Support Actions
Eligibility conditions	The conditions are described in General Annex B. The following exceptions apply: Applicants must be Horizon Europe national support structures (e.g. NCP) responsible for cluster 5 and officially nominated to the Commission, from a Member State or Associated Country. Only in case and as long as Horizon Europe structures would not yet be officially nominated, national support structures responsible for cluster 5 nominated for Horizon 2020 would be eligible.
Procedure	The procedure is described in General Annex F. The following exceptions apply: The granting authority can fund a maximum of one project.

Expected Outcome: Project results are expected to contribute to all of the following expected outcomes:

- Improved professionalization/skills of NCPs across Europe, helping to simplify access to Horizon Europe calls, lowering the entry barriers for newcomers, and raising the average quality of proposals submitted.
- Enhanced integration of all the cross-cutting issues throughout Horizon Europe.
- Connection with the NCP-network dealing with horizontal activities.
- Increased cooperation of NCPs with the Enterprise Europe Network. Harmonised and improved trans-national cooperation between NCPs.

Scope: The project should:

- Aim to facilitate trans-national co-operation between National Contact Points (NCPs) with a view to identifying and sharing good practices and raising the general standard of support to programme applicants;

- Give special attention to enhancing the competence of NCPs, including helping less experienced NCPs rapidly acquire the know-how built up in other countries;
- Have a good representation of experienced and less experienced NCPs and reflect the diversity of the areas covered under cluster 5. Countries not participating as beneficiaries of the action may benefit from the activities carried out by the network.
- Establish close cooperation and exploit synergies with other relevant NCP support structures;
- Aim to facilitate trans-cluster cooperation in the areas covered by Pillar 2, with a view to identifying synergies, to make possible to share good practices and tools. A close coordination and cooperation will be essential to achieve the objectives and impact of the NCPs networks.
- Built on the knowledge and tools generated by the NCP networks developed under H2020 program;
- Cover the whole duration of Horizon Europe.

Communities and cities

Proposals are invited against the following topic(s):

HORIZON-CL5-2021-D2-01-16: Co-Funded Partnership: Driving Urban Transitions to a sustainable future (DUT)

Specific conditions	
Expected EU contribution per project	The EU estimates that an EU contribution of around EUR 130.00 million would allow these outcomes to be addressed appropriately. Nonetheless, this does not preclude submission and selection of a proposal requesting different amounts.
Indicative budget	The total indicative budget for the topic is EUR 37.00 million.
Type of Action	Programme Co-fund Action
Total indicative budget	The total indicative budget for the topic is EUR 130 million committed in annual instalments over the 7 years, 2021-2022 (EUR 18.5 million from the 2021 budget and EUR 18.5 million from the 2022 budget).
Legal and financial set-up of the Grant Agreements	The rules are described in General Annex G. The following exceptions apply: Beneficiaries may provide financial support to third parties. Financial support provided by the participants to third parties is one

	of the primary activities of this action to allow the partnership to achieve its objectives. Therefore, the EUR 60 000 threshold provided for in Article 204 (a) of the Financial Regulation No 2018/1046 does not apply.

Expected Outcome: To enable the EU to achieve targets set out by the EU Green Deal and fulfil its commitments related to the UN Agenda 2030 for sustainability, the Urban Agenda for the EU, the Habitat III New Urban Agenda and the Paris Agreement, European cities need to engage in sustainability and climate-neutrality transitions.

The partnership is expected to contribute to all of the following expected outcomes:

- Enhanced multi-level cooperation and alignment on R&I on sustainable urban development across and within cities, regions and countries, including international outreach and cooperation with other networks and initiatives.
- Strengthen Europe as a role model for R&I on sustainable urban development.
- Innovative, cross-sectoral and inclusive governance, policy and decision-making harnessing the full potential of social science and citizens' engagement in city making process.
- Sustainable, safe, resilient, socially inclusive, liveable and attractive neighbourhoods, towns and cities with reduced environmental footprint and enhanced well-being and quality of life for citizens.
- Local authorities, municipalities, business, civil society, knowledge institutions and citizens empowered with necessary knowledge, skills and tools to actively engage in sustainability and climate-neutrality transitions.
- Cities fully empowered to play their critical role in providing solutions to global challenges thanks to enhanced technological, institutional, digital, nature-based and social innovation capacity.
- Science and evidence based implementation of the European Green Deal, the Urban Agenda for the EU and other European, national, regional and local urban-relevant policies and strategies.

Scope: Cities are the home of complex, inter-dependent challenges related to resource depletion, climate change impacts, environmental degradation, water, air and soil pollution, health issues and social exclusion. Although they occupy about 3% of the Earth's land, they consume over 65% of the world energy, 75% of natural resource and account for more than 70% of the global CO_2 emission. Today, more than 70% of EU citizens live in urban areas and it is expected that more than two thirds of the global population will be living in cities by 2030. Cities are also the engines of the European economy generating about 85% of the EU's GDP and hubs of technological and social innovation. As such, they are key players in shaping and

providing solutions to these challenges and need to urgently engage in unprecedented systemic transformational and bold transition towards sustainability and climate neutrality.

Important gaps in knowledge, evidence, innovation, technology, data, capacity and skills, lack of integrated approaches and deficit in applying research and innovation results to actions exist that prevent successful implementation of such transitions. Also institutional fragmentation, non-inclusive and non-participatory governance structures lead to a lack of shared vision, goal and direction regarding the transition process, incoherence in policies and strategies, uncoordinated planning and decision-making, ineffective measures and inefficient use of resources. Public utilities and enterprises in municipal ownership are an often overseen link between the political ambition and innovative activities on the ground supporting a transformation.

A co-funded partnership on Urban Transitions to a sustainable future is expected to make a considerable contribution towards filling up these gaps. By aligning, mobilising and leveraging EU, national and regional R&I agendas, programmes, priorities, activities and investments, including from the private sector and associating to the extent possible, the totality of EU Member States and Associated Countries, it should create a pan-European critical mass and invest on challenge-driven R&I to underpin urban sustainability transitions.

It should focus as priority on critical urban sectors such as Positive Energy Districts, accessible, connected urban mobility and urban greening and circularity, their inter-relations and interplay with cross-sectoral issues such as governance, digitisation, resilience, land use, infrastructures and public spaces for sustainable, liveable, inclusive and resilient cities. In doing so, the partnership should develop holistic, integrated, systemic and cross-sectorial approaches, foster co-creation processes involving all relevant urban stakeholders and actors and harness the potential of social innovation and citizen's engagement to deliver place-based portfolios of solutions, measures and tools, facilitate their replication, upscaling, up-taking and mainstreaming and foster market accessibility to increase the return to investments.

It should experiment and promote technological, nature-based, social, economic, cultural, planning and governance innovation and new business and finance models.

In line with the European Commission's political vision of leaving no one behind, the partnership should harness the outreach potential provided by the national research and innovation funding agencies and involve, as necessary, international cities network to mobilise cities, including small and medium size ones, enterprises including those in municipal ownership, stakeholders, societal actors and research institutions across Europe, including widening countries, and empower them in designing and rolling out sustainability and climate neutrality transitions. This way it will establish itself as a European urban R&I platform serving the sustainability transition needs of the wide diversity and heterogeneity among cities across Europe regarding their socio-economic, technological, institutional, innovation and skills potential.

Major efforts should be invested in facilitating replication, upscaling and up-taking of technologies, solutions, tools and practices and fostering accessibility to knowledge and

evidence, individual and collective behavioural changes, knowledge sharing, dialogues, peer-learning, awareness raising, communities and capacity building and skills enhancement to enable urban actors, practitioners, society and citizens to become drivers for transformative transitions towards urban sustainability.

Emphasis should be given to place-based approaches and experimentation capitalizing on citizens' engagement, social innovation, user-led and citizen science, for shared ownership of human-centred and just solutions and transitions pathways that are tailored to local specificities.

The European Partnership for 'Driving Urban Tradition to Sustainable Future' is expected to present a joint programme of activities implemented through a series of joint calls for research and innovation projects and a comprehensive management and implementation plan promoting coordination, networking, training, demonstration and dissemination. Activities could potentially be structured along the following building blocks:

- Implementing joint calls for challenge-driven R&I;
- Setting-up of a multi-stakeholder community of practice to facilitate science-policy-business-society dialogues and sharing of experiences;
- Pursuing communication and dissemination measures to make R&I results accessible for all stakeholder groups;
- Preparation of methodologies, guidelines, references and tools for replication and mainstreaming of good "practice";
- Clustering of projects and synthesising of R&I results;
- Setting-up a knowledge hub, organising training activities, fostering ULLs and experience sharing on new approaches and solutions to support capacity building among urban actors;
- Addressing standardisation, certification or, wherever necessary, legislative issues;
- Setting-up rigorous monitoring to assess progress towards achieving the objectives of the Partnership and its contribution to relevant EU policies;

To ensure coherence and complementarity of activities and leverage of knowledge and investment possibilities, the partnership is expected to foster close collaboration and synergies with other ongoing EU and nationally funded R&I actions, the mission on 'Climate-neutral and Smart Cities' as well as other relevant Horizon Europe European Partnerships (e.g. Clean Energy Transitions; Built environment and construction, Rescuing biodiversity, Safe and Sustainable Food System, 2ZERO, Cooperative, Connected and Automated Mobility (CCAM), EIT Urban Mobility and Water4All. Applicants are expected to describe in details the way to implement such collaborations. To this end, proposals should provide for a dedicated work package and/or task to describe the aims to be achieved through these collaborations, the way to implement them and earmark the appropriate resources accordingly.

Interfaces to public procurement and investment programmes and links with Urban Innovative Actions (UIA) under the Urban Agenda for the EU, European Urban Initiative (EUI) under cohesion policy, ESIF, private funds, etc. should be explored to support take-up and larger scale implementation of tested approaches and solutions.

Mutually benefitting international outreach, collaboration and cooperation with global and international cities and research funding networks should be pursued to align strategies and research agenda and promote scientific evidence and good practice for urban policy on international level.

Financial commitments and in-kind contributions are expected to be provided by the partners of the consortium for the governance structure, the joint calls and other dedicated implementation actions and efforts for national coordination.

It is expected that the partnership will organise joint calls on an annual base from 2022-2027 and will consider ample time for the implementation of the co-funded projects.

Call - Cross-sectoral solutions for the climate transition

HORIZON-CL5-2022-D2-01

Conditions for the Call

Indicative budget(s)[56]

Topics	Type of Action	Budgets (EUR million)	Expected EU contribution per project (EUR million)[57]	Number of projects expected to be funded
		2022		
Opening: 28 Apr 2022 Deadline(s): 06 Sep 2022				
HORIZON-CL5-2022-D2-01-01	IA	10.00	Around 5.00	2
HORIZON-CL5-2022-D2-01-02	RIA	10.00	Around 5.00	2
HORIZON-CL5-2022-D2-01-03	RIA	20.00	Around 20.00	1

56 The Director-General responsible for the call may decide to open the call up to one month prior to or after the envisaged date(s) of opening.
The Director-General responsible may delay the deadline(s) by up to two months.
All deadlines are at 17.00.00 Brussels local time.
The budget amounts are subject to the availability of the appropriations provided for in the general budget of the Union for years 2021 and 2022.

57 Nonetheless, this does not preclude submission and selection of a proposal requesting different amounts.

HORIZON-CL5-2022-D2-01-04	IA	15.00	7.00 to 8.00	2
HORIZON-CL5-2022-D2-01-05	RIA	15.00	Around 5.00	2
HORIZON-CL5-2022-D2-01-06	RIA	15.00	Around 5.00	3
HORIZON-CL5-2022-D2-01-07	RIA	15.00	Around 5.00	3
HORIZON-CL5-2022-D2-01-08	CSA	3.00	Around 3.00	1
HORIZON-CL5-2022-D2-01-09	RIA	15.00	Around 5.00	3
HORIZON-CL5-2022-D2-01-10	RIA	15.00	Around 5.00	3
HORIZON-CL5-2022-D2-01-11	CSA	5.00	4.00 to 5.00	1
Overall indicative budget		138.00		

General conditions relating to this call	
Admissibility conditions	The conditions are described in General Annex A.
Eligibility conditions	The conditions are described in General Annex B.
Financial and operational capacity and exclusion	The criteria are described in General Annex C.
Award criteria	The criteria are described in General Annex D.
Documents	The documents are described in General Annex E.
Procedure	The procedure is described in General Annex F.
Legal and financial set-up of the Grant Agreements	The rules are described in General Annex G.

A competitive and sustainable European battery value chain

Proposals are invited against the following topic(s):

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HORIZON-CL5-2022-D2-01-01: Sustainable processing and refining of battery grade graphite (Batteries Partnership)

Specific conditions	
Expected EU contribution per project	The EU estimates that an EU contribution of around EUR 5.00 million would allow these outcomes to be addressed appropriately. Nonetheless, this does not preclude submission and selection of a proposal requesting different amounts.
Indicative budget	The total indicative budget for the topic is EUR 10.00 million.
Type of Action	Innovation Actions
Legal and financial set-up of the Grant Agreements	The rules are described in General Annex G. The following exceptions apply: The funding rate is up to 60% of the eligible costs. This funding rate applies both to members and non-members of the partnership, except for non-profit legal entities, where the funding rate is up to 100% of the total eligible costs.
Technology Readiness Level	Activities are expected to achieve TRL 6-7 by the end of the project – see General Annex B.

Expected Outcome: For graphite, both natural and synthetic graphite production for the EV market take place almost exclusively in China. Although there is some existing mining of Natural graphite in Europe, scaling these sources for the active anode material needs within Europe will be very challenging as (i) extensive graphite exploration and mining would be needed, and (ii) almost all of the refining capacity is based in China. The main challenges in refining are low yield in the spheronisation and the use of large amounts of hydrofluoric acid in the refining step.

For synthetic graphite, by-products of oil distillation are used as the starting point, followed by calcining, milling, shaping and graphitisation. This process produces high quality anode graphite (enabling long lifetimes and fast charging) but is energy intensive and causes environmental emissions (CO_2, PAH). Opportunities to overcome all these problems exist already in Europe but need further development and investment to reach the required scale.

Project results are expected to contribute to all of the following expected outcomes on either natural or synthetic graphite production respectively:

- Decreased dependency of Europe on imported battery grade graphite and decreased risk in European Battery supply chains.
- Graphite (both natural and synthetic) competitively produced and refined in Europe in a sustainable and socially acceptable way improving the competitiveness of European batteries.

- Graphite leveraging the potential for fast charging of batteries, one of the key factors for the user acceptance of electric vehicles.
- Reduced carbon and environmental emissions from the anode material supply chain.
- Projects should contribute to European Raw Materials Alliance objectives.

The Synthetic graphite projects are expected to focus additionally on:

- System prototype demonstration of battery grade anode graphite material with high energy density, long lifetime and quality enabling fast charging, produced with increased yield and lower environmental footprint.
- As a longer-term option, biocarbon alternatives to petroleum coke are expected to be developed to ensure long term sustainable supply.

The Natural graphite projects are expected to focus additionally on:

- Advanced refining of Natural graphite to improve the yield of battery grade products and lower the environmental footprint.

Scope:

- Enabling European graphite production – with vertical integration into the European battery production. Resource efficient sustainable production of both synthetic and natural graphite emphasising reduction of energy consumption, CO_2 emissions, chemical use and the optimisation of recovery yield and raw material consumption. Enhance versatility regarding products and usable primary/secondary raw materials.
- Development of solutions for combined use of natural and synthetic graphite.
- For natural graphite: improving purification, milling, shaping and coating technologies that improve the performance characteristics of natural graphite.
- Improving the yield of spheronised products from natural graphite concentrate.
- Development of a non-HF purification technology to produce battery-grade anode material from spheronised natural graphite.
- Developing improved coating technologies for natural graphite that will increase the performance characteristics of natural compared to synthetic.
- For synthetic graphite: Improving graphitisation, calcining, milling, shaping and coating that improve the performance characteristics of synthetic graphite.
- The use of other available European carbon options like biobased anode carbon and by-products from anode material production as raw materials for synthetic graphite are expected to be developed.

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- Development of new processes for synthetic graphite production from natural gas pyrolysis.
- Reduction of process discharge and emissions in synthetic graphite production.

This topic implements the co-programmed European Partnership on 'Towards a competitive European industrial battery value chain for stationary applications and e-mobility'.

HORIZON-CL5-2022-D2-01-02: Interface and electron monitoring for the engineering of new and emerging battery technologies (Batteries Partnership)

Specific conditions	
Expected EU contribution per project	The EU estimates that an EU contribution of around EUR 5.00 million would allow these outcomes to be addressed appropriately. Nonetheless, this does not preclude submission and selection of a proposal requesting different amounts.
Indicative budget	The total indicative budget for the topic is EUR 10.00 million.
Type of Action	Research and Innovation Actions
Technology Readiness Level	Activities are expected to achieve TRL 3-4 by the end of the project – see General Annex B.

Expected Outcome: State-of-the-art in experimental and computational techniques for characterisation of battery materials and interfaces are targeting the scale of the atoms and ions. There is still a lack of understanding hampering the engineering of new and emerging battery technologies,, due to the complexity of interface formation and evolution as a function of time, temperature, battery cycling conditions and chemical composition of the electrolytes consisting of different salts, additives and liquid solvents and/or solid components,. Going into more depth, at process level, the time and the length scale of the electron transfer reactions remain almost completely underexplored.

Pushing the frontiers of present in situ analytical techniques is a must to more efficiently pursue research on sustainable materials and to develop greener Li-ion as well as future battery chemistries. Improvements in analytical techniques that would allow to follow the movement of interfacial reactions at the molecular scale all the way to the role of electrons at the nanoscale and sub-nanoscale, at relevant timescales and on relevant systems and interfaces, will have great impact beyond the sole battery field and would benefit to the electrochemistry field as a whole, including electrocatalysis and others. It will contribute to open up a new era for the study of transport at interfaces, which remains one of the greatest challenges of research for any electrochemist. For researchers exploring new storage concepts and engineering new interfaces, it will also provide insight into how to control the movement and redox processes of atoms. It can lead to an increased control of the electronic wiring of electrodes and a deeper understanding of the redistribution of electronic charge during redox processes.

Project results are expected to contribute to all of the following expected outcomes:

- New methods for studying electrode/electrolyte interfaces for liquid-based electrolytes and batteries and for studying solid-state and buried interfaces.
- Models for explaining the degradation of battery interfaces.
- Deeper understanding of the formation and evolution of battery interfaces, leading to new insights on how to increase the lifetime and safety of new and emerging battery technologies, and therefore contributing to the long-term competitiveness of the European battery industry.

Scope: This topic should support the development of novel experimental and computational techniques targeting the time and length scales of interface reactions in a battery cell including electron and ion localisation, mobility and transfer reactions.

This targets the development of novel analytical techniques, supported by modelling and simulation, able to follow interface, electron and ion dynamics in battery materials and battery cells, and carefully selecting controlled model systems to implement those novel techniques.

Examples of experimental tools include operando Transmission Electron Microscope (TEM), Electron Paramagnetic Resonance (EPR), operando ambient pressure photoelectron spectroscopy techniques, operando X-ray scattering techniques, NMR, soft X-ray spectroscopy with RIXS, neutron spectroscopy, ultra-fast spectroscopic methods as well as Free Electron Laser (FEL) facilities. Other synchrotron and neutron scattering and ion-beam techniques leading to development of new understanding of interfaces can also to be suggested and implemented. The goal is to give advice and new insights on how to increase the life time and safety of new emerging technologies.

Building upon the BATTERY 2030+: this call topic addresses the need of increasing the fundamental understanding of processes in batteries at a level that will accelerate the development of more stable chemistries adapted for their specific purpose. The proposal should also cover the contribution and collaboration to the BATTERY 2030+ large scale initiative.

This topic implements the co-programmed European Partnership on 'Towards a competitive European industrial battery value chain for stationary applications and e-mobility'.

HORIZON-CL5-2022-D2-01-03: Furthering the development of a materials acceleration platform for sustainable batteries (combining AI, big data, autonomous synthesis robotics, high throughput testing) (Batteries Partnership)

Specific conditions	
Expected EU contribution per project	The EU estimates that an EU contribution of around EUR 20.00 million would allow these outcomes to be addressed appropriately. Nonetheless, this does not preclude submission and selection of a proposal requesting different amounts.

Indicative budget	The total indicative budget for the topic is EUR 20.00 million.
Type of Action	Research and Innovation Actions
Technology Readiness Level	Activities are expected to achieve TRL 3-4 by the end of the project – see General Annex B.

Expected Outcome: Batteries have complex and dynamic processes taking place in and between materials and at the interfaces/interphases within a battery cell. For each new battery chemistry explored, new challenges in understanding these processes are revealed. To accelerate the finding of new material's and their combinations for both existing and future battery chemistries the iterative and fragmented trial and error approach used today needs to be replaced since it is slow and insufficient.

To accelerate the discovery of battery interfaces, materials and new sustainable concepts with high energy and/or power performance there is a need to develop a fully autonomous and chemistry neutral Materials Acceleration Platform (MAP) for battery materials and interfaces. This is a key and long-term challenge for European battery community. The aim is to integrate advanced multi-scale computational modelling, materials synthesis, characterisation and testing to perform closed-loop autonomous materials findings and interphase engineering that would accelerate by at least a factor of five the discovery of new battery chemistries with ultra-high performances.

Building upon the shared data infrastructure, standards and protocols developed in the BATTERY 2030+ initiative, this call topic addresses the need of increasing the level of autonomy in the MAP-based discovery and development process. The proposal should also cover the contribution and collaboration to the BATTERY 2030+ large scale initiative.

Project results are expected to contribute to all of the following expected outcomes

- Develop new tools and methods for significantly accelerating the development and optimisation of battery materials and interfaces, in order to increase the competitiveness of the battery material and cell industry in Europe.

- Demonstrate a fully autonomous battery-MAP capable of integrating computational modelling, materials synthesis and characterisation of both Li-ion and beyond Li-ion chemistries.

- Scale-bridging, multi-scale battery interface models capable of integrating data from embedded sensors in the discovery and prediction process, e.g. to orchestrate proactive self-healing.

- Community wide state-of-the-art collaborative environment to access data and utilise automated workflows for integrated simulations and experiments on heterogeneous sites, e.g., exploiting European HPC architectures and Large-scale facilities in collaboration with LENS and LEAPS.

- Demonstrate a robotic system that is capable of material synthesis for inorganic, organic or hybrid compounds following standard synthesis routes via automated characterisation of intermediate and final products and autonomous decision-making.

- Deploy predictive hybrid physics- and data-driven models for the spatio-temporal evolution of battery interfaces and demonstrate inverse design of a battery material/interface.

Scope:

- Infrastructure tools for secure remote data access, data analysis and predictive modelling: Develop a FAIR[58] data infrastructure for raw and curated experimental and modelling data, which can be accessed remotely and securely by relevant stakeholders, including industry. Develop the software infrastructure required to operate this platform, also with regard to future reproducibility and further exploitation of the results of the research activities. The software should provide specific access right and allow remote data access, complemented by distributed workflows using software-agnostic workflow engines that provide rapid-prototyping. Inverse materials design using hybrid physics- and data-driven battery interface genome models should also be demonstrated.

- Automated high throughput characterisation and integrated experimental and computational workflows: High throughput, multimodal operando experimental techniques using standardised battery cells and established protocols should be optimised to perform effective screening of new materials and on-line diagnosis of realistic devices. A central objective is to establish, structure, operate and dynamically refine such facility platform to harmonise, mutualise and optimise the global demand for battery characterisation. This includes automated experimental and computational workflows and modules for data acquisition and multimodal/multiscale analysis. Particular attention should be paid to battery interfaces and direct observation of interfaces under dynamic conditions, which are key to improve the performances and the lifetime of batteries.

- Autonomous synthesis robotics and orchestration software: The transition from low/no automated robotics for the synthesis of battery materials requires several R&I steps towards fully autonomous systems. Within the scope of this proposed call are partially autonomous systems following standard synthesis routes for inorganic and organic battery materials, especially also multi-step and high-temperature synthesis, that so far are challenging to automate for high throughput. AI-based orchestration and optimisation software modules and packages specifically targeting battery materials and interfaces are also central to the scope.

- Inverse design and AI-assisted scale-bridging models for multiple time- and length-scale processes: To develop scale-bridging models correctly describing the multiple mechanisms occurring at atomistic scale and the mesoscopic scale on the cell level. The new model approaches should be able to incorporate data from the advanced sensing in

[58] FAIR (Findable, Accessible, Interoperable, Reusable)

virtual design optimisation and battery control algorithms for SoX estimation. Sensitivity analysis and uncertainty quantification of the developed SoX models is also a requirement to assess the robustness of the developed models. These models should achieve a challenge based rational balance of accuracy and computational effort. They should accurately describe the actual state of the system, but also enable diagnosis and prediction, e.g., when self-healing procedures should be initiated. Multiscale Modelling approaches should be developed for the control of safety between BOL (Beginning Of Life) and EOL (End of Life) of a battery system by different uses and diagnosing the safety state of a battery system by innovative methods.

This topic implements the co-programmed European Partnership on 'Towards a competitive European industrial battery value chain for stationary applications and e-mobility'.

HORIZON-CL5-2022-D2-01-04: Towards creating an integrated manufacturing value chain in Europe: from machinery development to plant and site integrated design (Batteries Partnership)

Specific conditions	
Expected EU contribution per project	The EU estimates that an EU contribution of between EUR 7.00 and 8.00 million would allow these outcomes to be addressed appropriately. Nonetheless, this does not preclude submission and selection of a proposal requesting different amounts.
Indicative budget	The total indicative budget for the topic is EUR 15.00 million.
Type of Action	Innovation Actions
Legal and financial set-up of the Grant Agreements	The rules are described in General Annex G. The following exceptions apply: The funding rate is up to 60% of the eligible costs. This funding rate applies both to members and non-members of the partnership, except for non-profit legal entities, where the funding rate is up to 100% of the total eligible costs.
Technology Readiness Level	Activities are expected to achieve TRL 6 (for machinery development) and TRL 7 (integration of manufacturing plant supply chain) by the end of the project – see General Annex B.

Expected Outcome: Project results are expected to contribute to all of the following expected outcomes:

- Strengthening Europe's battery cell industrial manufacturing value chain by building-up its Giga scale manufacturing capabilities distributed in the member states territories.

- Development of new battery cell manufacturing machinery, with priority on minimising energy needed for cells production, enhancement of plant efficiency rates and integration of intelligent control processes to minimise scrap.

- Enabling deeper collaboration between (i) battery process equipment companies (ii) industrial-scale cell manufacturing, (iii) material, energy and other supply chain sectors benefitting from sector coupling.

- To stimulate and intensify the collaboration between pilot line operators, industrial-scale academia, cell manufacturing companies and European equipment companies to push innovations with regard to an economically and ecologically sustainable cell production in Europe.

Scope: In order to build globally competitive Li ion battery (LIB) cell production plants in Europe, all the production value chain from machinery to plant and site development and optimisation is expected to be considered holistically, from machinery development to plant and site integration and optimisation. This topic intents to cover both areas.

In recent years Europe has developed strong competences in Li ion battery technology with regard to academic research, material development and Battery system design. However, there is still a lack of knowledge and competence regarding the economically and ecologically production of LIB cells in both high volumes in Giga-factories or in much smaller batches for specialised applications as developed in Mega-factories. From this perspective, the scope of this topic is two-fold:

- From one side, to be able to supply machinery which is developed and built locally, Europe has to develop a leading position in the production of resource efficient, intelligent electrode and cell manufacturing machinery.

In the development of such battery manufacturing machinery, important aspects for success include: minimising energy consumption, eliminating air and water pollution and integration of intelligent control processes to minimise scrap thus reducing costs and environmental impact of the production process. In addition, such machinery is expected to operate at very high productivity levels with incorporate intelligent quality control systems. Moreover, strategies of industry 4.0 should be intensively integrated in new European cell production plants to yield economic success.

Activities under this topics would cover from TRL 3 (start) to TRL 6 (target).

- From the other side, battery cell production as a whole is currently confronted with enormous cost pressure. One major factor in the cost structure of European Giga-scale battery cell production is related to highly energy consuming manufacturing processes. A significant reduction and/or utilisation of low-carbon and low-emission energies would not only bring economic benefits, but would also provide clear advantages in terms of the ecological footprint. For sustainable success, the horizontal integration of the European

supply chain for battery process equipment into the growing production of giga-scale battery cells is a major challenge.

Activities under this topic would cover from TRL 6 (today) to TRL 7 (target).

Hence, this topic aims at closing a gap and enabling deeper collaboration between industrial-scale cell manufacturing, battery process equipment companies, and material and other industrial sectors potentially benefitting from sector coupling with cell manufacturing (e.g. grid power or material suppliers)**.**

Therefore, existing cell production lines and their material and energy flow internally and externally interaction with other companies at the site should be investigated and evaluated. Based on this, the network should investigate the ecological impact of different machinery, production line configurations and factory designs to come to best practice proposals. Another challenge is to implement ecological standards along the production chain together with material suppliers and factory operators.

One additional target to achieve these goals is to stimulate and intensify the collaboration between pilot line operators (e.g. which should be organised within the LiPLANET network), industrial-scale academia, cell manufacturing companies and European equipment companies to push innovations with regard to an economically and ecologically sustainable cell production in Europe. This includes the support from running activities including for example IPCEI's on batteries.

This topic implements the co-programmed European Partnership on 'Towards a competitive European industrial battery value chain for stationary applications and e-mobility'.

HORIZON-CL5-2022-D2-01-05: Next generation technologies for High-performance and safe-by-design battery systems for transport and mobile applications (Batteries Partnership)

Specific conditions	
Expected EU contribution per project	The EU estimates that an EU contribution of around EUR 5.00 million would allow these outcomes to be addressed appropriately. Nonetheless, this does not preclude submission and selection of a proposal requesting different amounts.
Indicative budget	The total indicative budget for the topic is EUR 15.00 million.
Type of Action	Research and Innovation Actions
Technology Readiness Level	Activities are expected to achieve TRL 5 by the end of the project – see General Annex B.

Expected Outcome: Project results are expected to contribute to all of the following expected outcomes:

- Next-generation battery system technologies for electrification of a broad range of transport and mobile applications (including road, waterborne, airborne, and rail transport, as well as non-road mobile machinery).
- Demonstrating increased performances (energy density, power density, lifetime) and safety of battery systems, to improve the competitiveness of the European battery industry in the transport market.
- Novel design and process to reduce manufacturing, refurbishment, dismantling and recycling costs of battery systems.

Scope: Batteries are key for a climate neutral transport sector, which represents around 25% of the total CO_2 emissions in the EU. The electrification of transport and mobile applications require high-performance and safe battery systems. In particular, fire is a critical safety risk for several transport modes.

Projects are expected to develop innovative battery systems technologies that will benefit several transport and mobile applications, by significantly improving performances and safety, as well as environmental sustainability and cost.

In order to leverage the full potential of the research ongoing in Europe at the battery material and cell levels, projects should consider the adaptation of battery system design to novel cell chemistries that will reach the market in the short-to-medium term (e.g., advanced lithium-ion or solid-state cells). Enhancing the cell-on-system volume ratio and/or weight ratio will increase the energy density and/or power density at the battery system level. More generally, projects should consider new technologies (battery system materials, mechanical design, electrical architectures, thermal management strategies, etc.) for enhancing performances and safety (for example, novel lightweight materials with optimum thermal characteristics to decrease battery module and pack weight and simultaneously enhancing safety; new dielectric cooling liquids with enhanced fire-retardant properties; etc.).

Manufacturability and recyclability should be explicitly addressed, in order to reduce the manufacturing, refurbishment, dismantling and recycling costs as well as the carbon footprint of the new battery systems.

Furthermore, the projects are expected to develop and assess methodologies to ensure the safety.

The projects should focus on the battery system level, i.e., on the integration of battery cells into a battery system (e.g., a battery pack), considering mechanical, electrical and thermal aspects.

The integration of battery systems into larger systems of application (e.g., into vehicles) is out of scope for this topic, but obviously projects are expected to provide for requirements of the chosen use cases.

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Project outcomes should be applicable to one or several use cases among the main transport or mobiles applications (such as road, waterborne, airborne and rail transport, as well as non-road mobile machinery and industrial applications), with the aim to maximise the impact on the European industry and on CO_2 emission reduction. Projects may consider the key performance indicators proposed by Batteries Europe or by the dedicated Partnerships, reflected in the Partnership Strategic Research Agenda (SRA), to guide the technology developments on the application segments and use cases that will be selected. Some of the project results can also be relevant for stationary energy storage applications.

This topic implements the co-programmed European Partnership on 'Towards a competitive European industrial battery value chain for stationary applications and e-mobility'.

HORIZON-CL5-2022-D2-01-06: Embedding smart functionalities into battery cells (embedding sensing and self-healing functionalities to monitor and self-repair battery cells) (Batteries Partnership)

Specific conditions	
Expected EU contribution per project	The EU estimates that an EU contribution of around EUR 5.00 million would allow these outcomes to be addressed appropriately. Nonetheless, this does not preclude submission and selection of a proposal requesting different amounts.
Indicative budget	The total indicative budget for the topic is EUR 15.00 million.
Type of Action	Research and Innovation Actions
Technology Readiness Level	Activities are expected to achieve TRL 2-4 by the end of the project – see General Annex B.

Expected Outcome: Batteries are operating in different conditions and although preventive approach during battery operation is a must, we need to develop curative functionalities which would enable battery operation in different non-ideal conditions while being transparent through the nasty chemical environment of the cell. Smart functionalities with sensing developed to detect irreversible reactions and self-healing functionalities designed to repair damage occurred within the cell, Europe can develop cells with much higher quality, better reliability and longer cycle life. This call is building on the long-term research roadmap of BATTERY 2030+. The proposal should also cover the contribution and collaboration to the BATTERY 2030+ large scale initiative.

Project results are expected to contribute to all of the following expected outcomes:

- Increased quality, reliability and life (QRL) of the battery system by integrating both sensing and self-healing functionalities at the battery cell level.
- Disruptive battery cell and battery management system technologies, to support a competitive and sustainable battery manufacturing industry in Europe.

Scope: The target of this call is to embed sensors and self-healing functionalities into single battery cell, with sensors being capable to detect defective operation and trigger self-repairing functionalities via the Battery Management System (BMS).

Proposal should aim at a combined approach with the development of sensors capable of continuous, long term operation within the cell and on the development of self-healing functionalities which can be triggered by external stimulus. Sensors and self-healing functionalities need to be adapted to detection of the critical degradation processes during cell electrochemical or chemical ageing. Different battery chemistries can be addressed with a focus on most critical degradation processes.

Proof of concept of coupling sensors and self-healing agents via BMS should be demonstrated. Clear benefit of embedding smart functionalities into battery cells should be demonstrated and approach needs to be adaptable to battery cells mass production processes and not hinder subsequent recycling process. Estimation of QRL over the life span should be assessed and the competitive advantage over alternative approaches like replacement or recycling or second-use should be demonstrated.

Building upon the BATTERY 2030+ roadmap, this call topic addresses the need to develop new sensors and self-healing functionalities which can give the batteries of the future increased life-time, efficient re-use and better commercial success. The benefit of these innovation on the global battery safety should be demonstrated. The proposal should also cover the contribution and collaboration to the BATTERY 2030+ large scale initiative.

This topic implements the co-programmed European Partnership on 'Towards a competitive European industrial battery value chain for stationary applications and e-mobility'.

HORIZON-CL5-2022-D2-01-07: Digitalisation of battery testing, from cell to system level, including lifetime assessment (Batteries Partnership)

Specific conditions	
Expected EU contribution per project	The EU estimates that an EU contribution of around EUR 5.00 million would allow these outcomes to be addressed appropriately. Nonetheless, this does not preclude submission and selection of a proposal requesting different amounts.
Indicative budget	The total indicative budget for the topic is EUR 15.00 million.
Type of Action	Research and Innovation Actions
Technology Readiness Level	Activities are expected to achieve TRL 5-6 by the end of the project – see General Annex B.

Expected Outcome: Project results are expected to contribute to all of the following expected outcomes:

- Competitiveness of the European battery industry across the value chain (from cell manufacturers to cell integrators);
- Shorter time-to-market;
- Reduced time and/or cost of battery development by at least 20% to 30%;
- Improved battery design, for longer lifetime, and better reliability and safety;
- Reduced investment and operational costs of battery systems.

Scope: The current way of developing batteries is mainly based on trial-and-error processes, which are time consuming, costly, and do not always lead to the best product design. It is particularly the case when it comes to testing batteries to assess their performance, lifetime, reliability and safety. Existing methods and tools lead to high costs, because of long test durations, and/or the high number of required test samples, and/or the use of costly test infrastructures. There is a significant room for improvement, by relying on digital methods and tools to minimise the use of standard trial-and-error processes. Digitalisation of battery testing will lead to an acceleration of the battery development time, a higher quality of the battery assessment (better evaluation of battery performances, lifetime, reliability and safety), and an improvement of the battery design itself (by better adapting the design to the application requirements and production capabilities) and a better estimation lifetime (by better modelling of battery ageing). Improvement in battery testing will result in major cost savings, in particular in the development phase (test before invest).

Projects are expected to provide novel methods and tools to accelerate and improve the battery testing process. A multi-scale approach should be used, by covering the value chain from battery cells to battery systems (here, a battery system refers to an energy storage unit integrating battery cells, excluding power converters). Projects should propose and validate a new paradigm based on intelligent design of experiment (to avoid duplicated experiments, or experiments that give low-quality information), the smart combination of physical and virtual testing, hardware in the loop solutions, and the development and use of advanced models describing battery cells and systems (physics-based models, data-driven models, or hybrid models) and the relevant expected evolution in multiple different conditions of usage. In turn, this requires full documentation of new modules, models or tools developed from scratch or substantially improved. Particular attention should be paid to the assessment of battery lifetime, reliability and safety, including the development of innovative methods for testing of safety in transport and safety in usage, based on representativeness of the method for the various potential failures (failure initiation, propagation control, mitigation means, etc…).Projects should have an ambition for cross-sectorial applications, and should focus on battery chemistries currently on the market or that will reach the market in the short term (i.e., advanced lithium-ion chemistries), with the potential to quickly adapt to next-generation battery chemistries (i.e., solid-state lithium-based chemistries).

This topic implements the co-programmed European Partnership on ‘Towards a competitive European industrial battery value chain for stationary applications and e-mobility’.

HORIZON-CL5-2022-D2-01-08: Coordination of large-scale initiative on future battery technologies (Batteries Partnership)

Specific conditions	
Expected EU contribution per project	The EU estimates that an EU contribution of around EUR 3.00 million would allow these outcomes to be addressed appropriately. Nonetheless, this does not preclude submission and selection of a proposal requesting different amounts.
Indicative budget	The total indicative budget for the topic is EUR 3.00 million.
Type of Action	Coordination and Support Actions

Expected Outcome: Project results are expected to contribute to all of the following expected outcomes:

- Fostering the scientific, technological, economic and societal impact of the initiative and paving the way to industrial exploitation of future battery technologies in key energy and transport application domains.
- Well-coordinated European research initiative on future battery technologies gathering excellent scientists and innovators as well as involving other relevant stakeholders and linked with relevant international, national and regional programmes.
- Spreading of excellence in future battery technologies across Europe, increased awareness of European activities and availability of European curricula in the field.
- Increased synergies and collaboration between the relevant research and innovation stakeholders in Europe as well as with major initiatives that already exist or are under preparation.

Scope: This call topic aim to network and coordinate the BATTERY 2030+ large scale research initiative on Future Battery Technologies and its contribution to the broader efforts of the European research and innovation stakeholders in battery technologies foreseen at European level and in the Strategic Energy Technology (SET) Plan and to tackle long-term research challenges expected to result in 'game changing' impacts on future battery technologies paving the way for providing a technological competitive advantage to the European battery industry. Because of their ambition, their scale and their interdisciplinary nature, these challenges can only be realised through a long-term, coordinated and sustained effort at European level, by building on large scale research cooperation across academia and industry and with other research initiatives at regional, national and European level, and by mobilising Europe's best researchers around an ambitious long-term research agenda.

Proposals are expected to coordinate the research activities and the stakeholders participating in the initiative; to facilitate communication, dialogue and cooperation on crosscutting topics; to monitor the initiative's progress and maintain its roadmap; to provide support for its

governance; to establish a robust and reliable knowledge base including key methodologies and established results; to promote and communicate the objectives of the initiative and its achievements, including by ensuring media presence and public visibility, by engaging with industry and society and by participating or organising outreach events; to identify training and education needs and promote European curricula in future battery technologies. In particular, proposals should identify and coordinate relevant efforts for modelling and data sharing, standardisation, intellectual property rights in cooperation with other relevant initiatives at European level. They should also help networking and collaboration with other relevant national and international activities in the field. They should cooperate with Batteries Europe, the ETIP on battery announced in the EU Strategic Action Plan on Batteries.

It is expected that such an activity is driven by representatives of the relevant actors of the field (e.g., from academia, RTOs and industry).

This topic implements the co-programmed European Partnership on 'Towards a competitive European industrial battery value chain for stationary applications and e-mobility'.

HORIZON-CL5-2022-D2-01-09: Physics and data-based battery management for optimised battery utilisation (Batteries Partnership)

Specific conditions	
Expected EU contribution per project	The EU estimates that an EU contribution of around EUR 5.00 million would allow these outcomes to be addressed appropriately. Nonetheless, this does not preclude submission and selection of a proposal requesting different amounts.
Indicative budget	The total indicative budget for the topic is EUR 15.00 million.
Type of Action	Research and Innovation Actions
Technology Readiness Level	Activities are expected to achieve TRL 4 by the end of the project – see General Annex B.

Expected Outcome: Project results are expected to contribute to all of the following expected outcomes:

- New physics and data-based approaches for battery management, with the potential to enhance performances, lifetime, reliability and safety of battery systems for transport and stationary applications.
- New physics and data-based approaches for battery management facilitating predictive maintenance, and/or knowledge-driven end-of-life management of battery systems, and/or the development of more accurate degradation models.

Scope: Battery management plays an essential role by ensuring an efficient and safe battery operation. However, current battery management systems (BMS) typically rely on semi-

empirical battery models (such as equivalent-circuit models) and on a limited amount of measured data. Consequently, there is currently a lack of knowledge about the overall state of the battery in operation, resulting in suboptimal utilisation.

Projects are expected to substantially advance the state of the art in the field of battery management, by developing innovative physics and data-based approaches, both at the software and hardware levels to ensure an optimised and safe utilisation of the battery system during all modes of operation.

Projects should pave the way towards next-generation BMS, which will leverage on an increased computational capability enabling the execution of advanced software, and on the ability to acquire, communicate and analyse large amount of data. Those next-generation BMS will lead to significantly enhanced performances, lifetime, reliability and safety of the battery system, by a dynamic update of battery usage limitations and the possibility to widen the battery operating range in a controlled manner. Moreover, they will provide open access to an increased amount of FAIR[59] data (which can possibly be processed offline), enabling the development of effective degradation models (thus reducing the investments costs of storage systems by mean of improved sizing during the design phase), and facilitating predictive maintenance and end-of-life management.

Projects are expected to develop technologies at both the software and hardware levels, with a validation through a lab-scale prototype at TRL 4. Several of the following items should be addressed: the development and implementation of physics-based battery models (e.g., ageing phenomena models); adaptable battery models (e.g., based on operation data); sensor-based solutions at the battery system level (e.g., with respect to sensor integration, communication with the battery management, data fusion, data analysis); advanced state estimators (e.g., state of health, state of function, state of energy, state of power, state of safety); methods for the prognosis of remaining useful lifetime and ageing; methods for the early detection or prediction of failures; solutions for the management of special situations (e.g., unbalanced or dysfunctional cells). Project results should be applicable to a broad range of transport or stationary applications.

This topic implements the co-programmed European Partnership on 'Towards a competitive European industrial battery value chain for stationary applications and e-mobility'.

HORIZON-CL5-2022-D2-01-10: Streamlined collection and reversed logistics, fully automated, safe and cost-efficient sorting, dismantling and second use before recycling (Batteries Partnership)

Specific conditions	
Expected EU contribution per project	The EU estimates that an EU contribution of around EUR 5.00 million would allow these outcomes to be addressed appropriately.

[59] FAIR (Findable, Accessible, Interoperable, Reusable)

	Nonetheless, this does not preclude submission and selection of a proposal requesting different amounts.
Indicative budget	The total indicative budget for the topic is EUR 15.00 million.
Type of Action	Research and Innovation Actions
Technology Readiness Level	Activities are expected to achieve TRL 5-7 by the end of the project – see General Annex B.

Expected Outcome: Project results are expected to contribute to all of the following expected outcomes:

- Achieving the objectives of the Circular Economy Action Plan by enabling second life of batteries and increasing rates for recycling and recovery, in line with upcoming regulatory requirements.
- Revolutionize and re-freshen recycling industry, by applying best-in-world innovations based on automatisation, efficiency and sustainability.
- Create new circular business models, such as second life, to reduce the need for primary raw materials, and to maximize the use of battery cells reducing the cost per cycle.
- Develop a community for actors involved in the management of the recycling value chain for batteries (including second life) for sharing best practices (health and safety, transport, dismantling, refurbishing, recycling).
- Improve safety, through automatisation and reducing accidents.

Scope: Today the amount of end-of-life (EoL) batteries from e-mobility and stationary applications is still limited. Moreover, EoL batteries are not standardised (form, chemical composition, etc.) and consequently, their management and recycling are mainly based on manual process. This increases risk of accidents as the integrity of the batteries / cells is no longer guaranteed.

Within next several years, the amount of EoL batteries will surge, transforming the recycling and battery value chain in general. It is important to develop efficient recycling chain and processes able to meet these upcoming amounts of diversified waste streams. A general approach to recycling should thus be reconsidered and new sustainable recycling chain for batteries should be established, in terms of introducing novel approaches to products, processes and keeping in mind their socio-economic viability and environmental impact.

It will require new upscaleable techniques and concepts for collection, logistics, and automatisation in sorting, dismantling and second use before recycling.

Proposals are expected to cover all aspects below:

- Development of standardized common diagnostics protocols and cut-off criteria between product (2nd life application) and waste (recycling).
- Elaborate critical stage of diagnosis of batteries as a waste-prevention measure in order to define which batteries or components of batteries are still considered fit for a second life application.
- Automate the dismantling of E-mobility and stationary batteries, reducing costs by avoiding manual work and improving sorting of parts for their replacement or preparation for recycling allowing the selective extraction of materials including the cathode and anode materials which for certain Li-chemistries lead to a higher value creation for the downstream recyclers.
- Development of novel safe dismantling processes and safety procedures along all steps of EoL management chain with focus on battery burning process (thermal runaway), identification of Limiting Oxygen Index (LOI) and Lower Explosive Limits (LEL).
- Development of technologies preventing or reducing thermal runaway during transportation, storage and dismantling of batteries.
- Design and demonstration of standardized and cost-efficient storage and transportation containers with visual and thermal load monitoring systems and, if necessary, inert atmosphere or other measures reducing risk of fire or thermal runaway.
- Development of technologies for fast and efficient discharge of used batteries, connected with energy recovery, possibly integrated with SoH diagnostic equipment, with flexible connectivity and adjustable to various kinds of batteries.
- Development of standardized battery labelling system enabling all interested parties to automatically obtain necessary data on each battery. Potential integration of labelling system with battery passport database project and with labelling systems from other regions of the world (e.g. China). Identification of necessary data that should be included into labelling and battery passport projects.
- Research on batteries sorting and dismantling technologies, particularly automated sorting including machine learning applicable to small and EV batteries.
- Identify all potential risks and develop safe processes and safety procedures to reduce accidents.

This topic implements the co-programmed European Partnership on ‘Towards a competitive European industrial battery value chain for stationary applications and e-mobility’.

Communities and cities

Proposals are invited against the following topic(s):

HORIZON-CL5-2022-D2-01-11: CIVITAS 2030 – Coordination and support for EU funded urban mobility innovation

Specific conditions	
Expected EU contribution per project	The EU estimates that an EU contribution of between EUR 4.00 and 5.00 million would allow these outcomes to be addressed appropriately. Nonetheless, this does not preclude submission and selection of a proposal requesting different amounts.
Indicative budget	The total indicative budget for the topic is EUR 5.00 million.
Type of Action	Coordination and Support Actions

Expected Outcome: Projects are expected to contribute to the following outcomes:

- Increasing the extent and speed of the take up of innovative, replicable urban mobility solutions in Europe, targeting responsible authorities and other stakeholders, in order to contribute to the priorities of the European Green Deal, which stresses that ‘’transport should become drastically less polluting, especially in cities. A combination of measures should address emissions, urban congestion, and improved public transport’’:
    - Develop, and put in place a communication, dissemination and promotion strategy that will clearly distinguish the identity of the CIVITAS initiative amongst other European city initiatives.
    - Provide a common communication and dissemination framework for the projects funded, including providing a common corporate identity and producing a monthly newsletter that includes project results as well as wider developments in the field of sustainable urban mobility.
    - Reach out to national transport press correspondents and relevant European media, the Horizon project community and a wider European and international audience of cities and professionals with the aim of increasing the visibility of the network and urban mobility projects.
- Providing coordination, monitoring and support activities to the living lab cities and projects funded under CIVITAS, among others by formalising the collaboration with each project through an Memorandum of Understanding, and by providing a common realistic and user-friendly evaluation framework with dedicated support to the projects:
    - Facilitating exchanges among the CIVITAS projects and living labs and with the European Commission with the aim of disseminating project results, key milestones and achievements.

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- Organising capacity building, training sessions and three site visits per year, based on latest results and best practices from the CIVITAS or other European projects, to support the take up of innovative mobility solutions.
- Organise a CIVITAS Forum to share results and best practice from urban mobility projects.
- Collaborate on the organisation of the Urban Mobility Days (flagship conference on innovative, clean and integrated urban mobility and transport).
- Looking at project results as well as wider developments in the field of sustainable urban mobility, European media outlets, of cities and professionals.
- Update and increase the database of subscribers of CIVITAS newsletters by 20% every year.
- Offer liaison activities, collaboration and synergy building with the different urban mobility communities and initiatives at European level, such as the ELTIS, EIP SCC, Driving Urban Transitions Partnership, EIT Urban Mobility and the Climate Neutral and Smart Cities Mission.
- Maintaining, optimising and promoting the CIVITAS website through usability tests, and improving its functionality, to ensure that it remains the main platform for the dissemination of relevant European urban mobility innovation results increasing the minimum of unique visitors with 10% every year.
- Increase the CIVITAS twitter followers by 20% every year.
- Preparing two policy papers per year on innovative solutions, good practices, and their replication, putting in place ad-hoc three Thematic Groups (based on the thematic areas of CIVITAS) to analyse developments and prepare recommendations, and organising two meetings per year of the CIVITAS Policy Advisory Committee, with one policy paper issued per year, to facilitate a continued dialogue between cities, businesses and civil society.
- Prepare policy recommendations and key learnings addressed to cities, Member States/Associated Countries and the European Commission based on research and innovation as well as results from ongoing projects.
- Updating, promoting and enlarging the CIVITAS cities network, with at least 20 new European cities added per year, providing support and funding to CIVINETS, maintaining the secretariat for the CIVITAS initiative, and actively engaging with local, regional or national stakeholders, aiming to overcome language and other barriers.

Scope: Together with initiatives of ELTIS and the European Mobility Week, CIVITAS is part of the EU policy on urban mobility as a key flagship encouraging innovation at local level.

Since 2002 it acts as an open platform that facilitates research, the uptake of innovative solutions, the validation of research results, the exchange of knowledge and best practices, and common learning in the area of urban mobility and transport. The project selected under this topic will help to ensure the long-term support for the CIVITAS projects offering governance, and an organisational and logistical framework that guarantees the wide dissemination and take up of urban mobility project results.

Proposals should aim at focusing activities on communication and event organisation and coordination of living lab activities continuing and enhancing the operation of the platform, to facilitate the continued coordination and knowledge exchange between the urban mobility projects that have been, or that will be funded under the CIVITAS initiative. These projects will deliver solutions that help achieve climate neutrality in cities, covering both personal mobility and goods/urban logistics using all transport modes.

Proposals should aim at putting in place a common communication and dissemination strategy to maximise the impact of the CIVITAS initiative. Proposals should ensure the monitoring of activities, events and results of the urban mobility projects and communicate about their progress and achievements. Applicants should also consolidate the common 'CIVITAS Process and Impact Evaluation Framework' and ensure the continuity of the CIVINETs. They should ensure continuity and provide a smooth transition from the previous Coordination and Support Action, CIVITAS ELEVATE.

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Destination – Sustainable, secure and competitive energy supply

This Destination includes activities targeting a sustainable, secure and competitive energy supply. In line with the scope of cluster 5, this includes activities in the areas of renewable energy; energy system, grids and storage; as well as Carbon Capture, Utilization and Storage (CCUS).

The transition of the energy system will rely on reducing the overall energy demand and making the energy supply side climate neutral. R&I actions will help to make the energy supply side cleaner, more secure, and competitive by boosting cost performance and reliability of a broad portfolio of renewable energy solutions, in line with societal needs and preferences. Furthermore, R&I activities will underpin the modernisation of the energy networks to support energy system integration, including the progressive electrification of demand side sectors (buildings, mobility, industry) and integration of other climate neutral, renewable energy carriers, such as clean hydrogen. Innovative energy storage solutions (including chemical, mechanical, electrical and thermal storage) are a key element of such energy system and R&I actions will advance their technological readiness for industrial-scale and domestic applications. Carbon Capture, Utilisation and Storage (CCUS) is a CO_2 emission abatement option that holds great potential and R&I actions will accelerate the development of CCUS in electricity generation and industry applications.

This Destination contributes to the following Strategic Plan's **Key Strategic Orientations (KSO)**:

- *C: Making Europe the first digitally led circular, climate-neutral and sustainable economy through the transformation of its mobility, energy, construction and production systems,*
- *A: Promoting an open strategic autonomy by leading the development of key digital and enabling technologies, sectors and value chains to accelerate and steer the digital and green transitions through human-centred technologies and innovations;*

It covers the following **impact areas**:

- Industrial leadership in key and emerging technologies that work for people;
- Affordable and clean energy.

The **expected impact**, in line with the Strategic Plan, is to contribute to *"More efficient, clean, sustainable, secure and competitive energy supply through new solutions for smart grids and energy systems based on more performant renewable energy solutions"*, notably through

i. Fostering European global leadership in affordable, secure and sustainable **renewable energy technologies** and services by improving their competitiveness in global value chains and their position in growth markets, notably through the diversification of the renewable services and technology portfolio (more detailed information below).

ii. Ensuring cost-effective uninterrupted and affordable supply of energy to households and industries in a scenario of high penetration of variable renewables and other new low carbon energy supply. This includes more efficient approaches to managing **smart and cyber-secure energy grids** and optimisation the interaction between producers, consumers, networks, infrastructures and vectors (more detailed information below).

iii. Accelerating the development of **Carbon Capture, Use and Storage (CCUS)** as a CO_2 emission mitigation option in electricity generation and industry applications (including also conversion of CO_2 to products) (more detailed information below).

When considering their impact, proposals also need to assess their compliance with the "Do No Significant Harm" principle[60] according to which the research and innovation activities of the project should not be supporting or carrying out activities that make a significant harm to any of the six environmental objectives of the EU Taxonomy Regulation.

Fostering the European global leadership in affordable, secure and sustainable renewable energy technologies

Renewable energy technologies provide major opportunities to replace or substitute carbon from fossil origin in the power sector and in other economic sectors such as heating/cooling, transportation, agriculture and industry. Their large scale and decentralised deployment is expected to create more jobs than the fossil fuel equivalent. Renewable energy technologies are the baseline on which to build a sustainable European and global climate-neutral future. A strong global European leadership in renewable energy technologies, coupled with circularity and sustainability, will pave the way to increase energy security and reliability.

It is imperative to enhance affordability, security, sustainability and efficiency for more established renewable energy technologies (such as wind energy, photovoltaics or bioenergy), and to further diversify the technology portfolio. Furthermore, advanced renewable fuels, including synthetic and sustainable advanced biofuels, are also needed to provide long-term carbon-neutral solutions for the transport and energy-intensive industrial sectors, in particular for applications where direct electrification is not a technically and cost efficient option.

Synergies with activities in cluster 4 are possible for integrating renewable energy technologies and solutions in energy consuming industries. Complementarities with cluster 6 concern mainly biomass-related activities.

In line with the "do not harm" principle for the environment, actions for all renewable energy technologies aim to also improve the environmental sustainability of the technologies, delivering products with reduced greenhouse gas emissions and improved environmental performance regarding water use, circularity, pollution and ecosystems. In particular, for biofuels and bioenergy improving the environmental sustainability is associated to the biomass

[60] as per Article 17 of Regulation (EU) No 2020/852 on the establishment of a framework to facilitate sustainable investment (EU Taxonomy Regulation)

conversion part of the value chain and the quality of the product, while air pollution associated to combustion in engines falls in the scope of other parts of the WP.

The main impacts to be generated by topics targeting the renewable energy technologies and solutions under this Destination are:

a. Availability of disruptive renewable energy and renewable fuel technologies and systems in 2050 in order to accelerate the replacement of fossil-based energy technologies.

b. Reduced cost and improved efficiency of renewable energy and renewable fuel technologies and their value chains.

c. De-risking of renewable energy and fuel technologies with a view to their commercial exploitation and net zero greenhouse gas emissions by 2050.

d. Better integration of renewable energy and renewable fuel-based solutions in energy consuming sectors.

e. Reinforced European scientific basis and European export potential for renewable energy technologies through international collaboration (notably with Africa in renewable energy technologies and renewable fuels and enhanced collaboration with Mission Innovation countries).

f. Enhanced sustainability of renewable energy and renewable fuels value chains, taking fully into account social, economic and environmental aspects in line with the European Green Deal priorities.

g. More effective market uptake of renewable energy and fuel technologies.

Energy systems, grids and storage

Efficient and effective network management is the key to the integration of renewables in an efficient way that ensures cost-effectiveness and affordability, security of supply and grid stability. Real time monitoring and optimisation are necessary to increase the flexibility, through solutions such as storage, demand response or flexible generation among others, to integrate higher shares of variable renewable energy. Exploiting synergies between electricity, heating and cooling networks, gas networks, transport infrastructure and digital infrastructure will be crucial for enabling the smart, integrated, flexible, green and sustainable operation of the relevant infrastructures. Besides hydrogen and batteries (addressed elsewhere), R&I in other storage technologies, in particular thermal storage but also electrochemical, chemical, mechanical and electrical storage solutions is necessary to create a set of flexibility options.

Activities on energy systems, grids and storage under this Destination will primarily focus on the systemic aspects to enhance the flexibility and resilience of the system, in particular: integrated energy system planning and operation, engaging consumers and providing new services, electricity system reliability and resilience, storage development and integration and green digitalisation of the energy system.

Moreover, the role of citizens and communities is key when it comes to making the flexibility at appliance level available for the grid. Related to this, the inclusion of social sciences and humanities (SSH) where relevant is essential to build the social acceptance of new energy technologies and increase participation of consumers in energy markets.

All projects will contribute to an increased capacity of the system to integrate renewable energy sources and less curtailment at transmission and distribution level. The main expected impacts are:

a. Increased resilience of the energy system based on improved and/or new technologies to control the system and maintain system stability under difficult circumstances.

b. Increased flexibility and resilience of the energy system, based on technologies and tools to plan and operate different networks for different energy carriers simultaneously in a coordinated manner that will also contribute to climate neutrality of hard-to-electrify sectors.

c. Enhance consumer satisfaction and increased system flexibility thanks to enabling consumers to benefit from data-driven energy services and facilitating their investment and engagement in the energy transition, through self-consumption, demand response or joint investments in renewables (either individually or through energy communities or micro-grids).

d. Improved energy storage technologies, in particular heat storage but also others such as electrochemical, chemical, mechanical and electrical.

e. Foster the European market for new energy services and business models as well as tested standardised and open interfaces of energy devices through a higher degree of interoperability, increased data availability and easier data exchange among energy companies as well as companies using energy system data.

f. More effective and efficient solutions for transporting off-shore energy thanks to new electricity transmission technologies, in particular using superconducting technologies, power electronics and hybrid Alternate Current – Direct Current grid solutions as well as MT HVDC (Multi Terminal High Voltage Direct Current) solutions.

Carbon capture, utilisation and storage (CCUS)

CCUS will play a crucial role in the EU Green Deal for the transition of energy-intensive industries and the power sector towards climate neutrality. Supporting R&I for CCUS will be particularly important in those industries where other alternatives do not yet exist like the cement industry. This will be highly relevant towards 2050, when most electricity will be coming from renewables, but the need to tackle the process emissions from industry will continue. If CCUS is combined with sustainable biomass, it could create negative emissions.

Low carbon hydrogen from natural gas with CCUS could also play a significant role in industrial climate neutrality, in the transition towards full use of hydrogen from renewable

sources, in particular in industries such as steel making, chemicals, or refining where large quantities of hydrogen are needed. CCUS would enable early, clean hydrogen at scale. The hydrogen infrastructure built for clean hydrogen with CCUS could be also shared by hydrogen from renewable sources. It is thus important to develop CCUS for industrial clusters, including aspects of system planning, shared infrastructure solutions such as buffer storage, shared CO_2 and hydrogen transportation and infrastructure optimisation for CCS and CCU.

Demonstration of the full CCUS chain is needed in the EU, with special emphasis on the reduction of the energy penalty and cost of capture and on ascertaining safe storage. Under the EU Strategic Energy Technology Plan (SET Plan) ambitious R&I targets have been set in agreement with the sectorial stakeholders. The focus is on CO_2 storage appraisal, cost-reductions, new technologies and proliferation of pilots and demonstrators.

Synergies with cluster 4 exist on the use of CO_2 (please see topic "HORIZON-CL4-2022-TWIN-TRANSITION-01-11: Valorisation of CO/ CO_2 streams into added-value products of market interest (IA)").

The main impacts to be generated by topics targeting the renewable energy technologies and solutions under this Destination are:

a. Accelerated rollout of infrastructure for CCUS hubs and clusters.

b. Updated authoritative body of knowledge on connecting industrial CO_2 sources with potential 'bankable storage sites, providing greater confidence for decision makers and investors.

c. Proven feasibility of integrating CO_2 capture, CO_2 storage and CO_2 use in industrial facilities. Demonstrating these technologies at industrial scale shall pave the way for subsequent first-of-a-kind industrial projects.

d. Reduced cost of the CCUS value chain, with CO_2 capture being still the most relevant stumbling block for a wider application of CCUS.

e. Adequate frameworks for Measurement, Monitoring and Verification (MMV) for storage projects, to document safe storage and for public acceptance of the technology.

The following call(s) in this work programme contribute to this destination:

Call	Budgets (EUR million)		Deadline(s)
	2021	2022	
HORIZON-CL5-2021-D3-01	303.80	35.00	26 Aug 2021
HORIZON-CL5-2021-D3-02	280.00		05 Jan 2022
HORIZON-CL5-2022-D3-01		381.00	23 Feb 2022

HORIZON-CL5-2022-D3-02		99.00	27 Oct 2022
HORIZON-CL5-2022-D3-03		127.50	10 Jan 2023
Overall indicative budget	583.80	642.50	

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Call - Sustainable, secure and competitive energy supply

HORIZON-CL5-2021-D3-01

Conditions for the Call

Indicative budget(s)[61]

Topics	Type of Action	Budgets (EUR million)		Expected EU contribution per project (EUR million)[62]	Number of projects expected to be funded
		2021	2022		
Opening: 15 Apr 2021 Deadline(s): 26 Aug 2021					
HORIZON-CL5-2021-D3-01-01	IA	15.00		Around 15.00	1
HORIZON-CL5-2021-D3-01-02	CSA	10.00		Around 2.50	4
HORIZON-CL5-2021-D3-01-03	CSA	10.00		Around 2.00	5
HORIZON-CL5-2021-D3-01-04	RIA	20.00		Around 5.00	4
HORIZON-CL5-2021-D3-01-05	IA	30.00		9.00 to 10.00	3
HORIZON-CL5-2021-D3-01-06	IA	25.00		Around 8.00	3
HORIZON-CL5-2021-D3-01-07	IA	15.00		7.00 to 8.00	2
HORIZON-CL5-2021-D3-01-08	RIA	15.00		7.00 to 8.00	2
HORIZON-CL5-2021-D3-01-09	IA	15.00		Around 15.00	1
HORIZON-CL5-2021-D3-01-10	IA	10.00		Around 5.00	2
HORIZON-CL5-2021-D3-01-11	CSA	1.00		Around 1.00	1
HORIZON-CL5-2021-D3-01-12	IA	32.00		Around 8.00	4

61 The Director-General responsible for the call may decide to open the call up to one month prior to or after the envisaged date(s) of opening.
The Director-General responsible may delay the deadline(s) by up to two months.
All deadlines are at 17.00.00 Brussels local time.
The budget amounts are subject to the availability of the appropriations provided for in the general budget of the Union for years 2021 and 2022.

62 Nonetheless, this does not preclude submission and selection of a proposal requesting different amounts.

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HORIZON-CL5-2021-D3-01-13	CSA	4.00		Around 4.00	1
HORIZON-CL5-2021-D3-01-14	CSA	5.00		Around 5.00	1
HORIZON-CL5-2021-D3-01-15	CSA	2.00		Around 2.00	1
HORIZON-CL5-2021-D3-01-16	RIA	30.00		10.00 to 15.00	2
HORIZON-CL5-2021-D3-01-17	CSA	20.00		Around 20.00	1
HORIZON-CL5-2021-D3-01-18	CSA	9.80		Around 1.00	10
HORIZON-CL5-2021-D3-01-19	COFUND	35.00	35.00	Around 210.00	1
Overall indicative budget		303.80	35.00		

General conditions relating to this call	
Admissibility conditions	The conditions are described in General Annex A.
Eligibility conditions	The conditions are described in General Annex B.
Financial and operational capacity and exclusion	The criteria are described in General Annex C.
Award criteria	The criteria are described in General Annex D.
Documents	The documents are described in General Annex E.
Procedure	The procedure is described in General Annex F.
Legal and financial set-up of the Grant Agreements	The rules are described in General Annex G.

Global leadership in renewable energy

Proposals are invited against the following topic(s):

HORIZON-CL5-2021-D3-01-01: Demonstration of wave energy devices to increase experience in real sea condition

Specific conditions

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Expected EU contribution per project	The EU estimates that an EU contribution of around EUR 15.00 million would allow these outcomes to be addressed appropriately. Nonetheless, this does not preclude submission and selection of a proposal requesting different amounts.
Indicative budget	The total indicative budget for the topic is EUR 15.00 million.
Type of Action	Innovation Actions
Eligibility conditions	The conditions are described in General Annex B. The following exceptions apply: In order to achieve the expected outcomes, and safeguard the Union's strategic assets, interests, autonomy, or security (namely to keep a European competitive advantage and establish a strong European supply chain, considering that the EU currently holds a first mover advantage and is globally well positioned - see State of the Energy Union report 2020 and accompanying Competitiveness Progress Report), participation is limited to legal entities established in Member States and associated countries. Proposals including entities established in countries outside the scope specified in the topic will be ineligible.

Expected Outcome: Project results are expected to contribute to all of the following expected outcomes:

- Demonstrated performance and reliability of wave energy devices producing comparable and public results using international metrics
- Improved knowledge on how to operate wave energy devices, their availability maintainability and to increase the impact it is expected that projects are sharing project data.
- Reduction of the LCOE in line with the SET Plan targets (actions should clearly justify estimated LCOE at project start and end, using a recognised calculation methodology).
- Reinforced industrial supply chain.
- Attraction of private investors to the sector and reduction of the cost of their investment by presented evidences and credible key performance indicators.

Scope: The action is expected to:

- Demonstrate wave energy devices in real sea conditions for long periods of time (12-24 months) providing invaluable learnings regarding performance, reliability, availability, maintainability, survivability and environmental impact.

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- Utilise verified key subsystems by comprehensive dry testing to reduce risks in the implementation of the project. Alternatively, the project action is expected to finalise the dry testing in the first year of the project. The onshore testing of key subsystems need to have been carried out prior to any at-sea deployment of complete devices.

Proposals are expected to address also all the following:

- Industrial design and manufacturing processes, circularity of (critical) raw materials, scalability, installation methods, transport, operation & maintenance, supply chains and the related digital infrastructures.

- Projects are requested to demonstrate the technologies at sea while respecting existing environmental regulatory framework. Present an environmental monitoring plan to be implemented during the demonstration action.

The project has to include a clear go/no go moment ahead of entering the deployment phase. Before this go/no-go moment, the project has to deliver the detailed engineering plans, a techno-economic assessment, including key performance indicators based on international recognized metrics, a complete implementation plan, a plan to achieve certification by an independent certification body before the end of the action, and all needed permits for the deployment of the project. The project proposal is expected to clearly demonstrate a proposed pathway to obtaining necessary permits for the demonstration actions and allow for appropriate timelines to achieve these. The project is expected also to demonstrate how it will get a financial close for the whole action. Independent experts will assess all deliverables and will advise for the go/no-go decision.

The selected projects are expected to contribute and participate to the activities of the project BRIDGE[63] when relevant.

HORIZON-CL5-2021-D3-01-02: Sustainability and educational aspects for renewable energy and renewable fuel technologies

Specific conditions	
Expected EU contribution per project	The EU estimates that an EU contribution of around EUR 2.50 million would allow these outcomes to be addressed appropriately. Nonetheless, this does not preclude submission and selection of a proposal requesting different amounts.
Indicative budget	The total indicative budget for the topic is EUR 10.00 million.
Type of Action	Coordination and Support Actions

Expected Outcome: The EU has ambitious goals to tackle the ongoing climate crisis, noteworthy being the aim to be a fully climate-neutral continent by 2050. Thus a framework

[63] https://www.h2020-bridge.eu/

needs to be established where sustainability and educational aspects for renewable energy and fuel technologies is addressed. Further, these actions need to engage with stakeholders at different levels (policymakers, regulators, innovators, industry, trade associations, universities and local communities) in order to align priorities and needs, while also identifying possibly overlooked challenges.

In this context, and taking into consideration circularity and sustainability, project results are expected to contribute to all of the following expected outcomes:

- Enhance and promote sustainability by addressing social and environmental aspects (air pollution, waste management, job opportunities, wildlife concerns, etc.) of renewable energy and renewable fuel technologies at a global level, thus ensuring the European Green Deal priorities are met.

- Support the development of training and reskilling efforts in the renewable energy and renewable fuel technology sectors, while also identifying (global and local) challenges, to realise the large deployment ambitions of the European Green Deal, and the various sectorial strategies under it (such as the recent Offshore Renewable Energy Strategy) and its external dimension.

- Support and promote circularity concepts and approaches (such as circular- and/or recyclable-by-design) in line with the Circular Economy Action Plan and the Action Plan on Critical Raw Materials.

Scope: In this topic, sustainability is meant in environmental, social and economic terms. The proposal is expected to address all the following aspects:

- Coordinate the stakeholder community and propose concrete actions to promote and accelerate the development of sustainable solutions for renewable energy and renewable fuel technologies, encompassing 'circularity-by-design' (with special attention to life cycle assessment of the entire value chain, including critical raw materials and gradual substitution of fossil fuels), and identifying and assessing relevant externalities.

- Set up and initiate a structured programme to promote an innovative multi-disciplinary approach on teaching and engaging with the sustainability of all forms of renewable energy. The proposal should also actively engage with European universities in this matter. Special consideration to gender balance issues should also be given. A clear post-project life for such programme should also be addressed.

- Develop and run an industry-academia programme focused on hands-on training. This programme should identify the required skills needed for the sustainability of renewable technologies, identify and act on knowledge gaps, and identify retraining opportunities based on revamped training curricula and course content. These concerted actions are expected to develop human capital in innovative new technologies through education and training.

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This topic requires the effective contribution of SSH disciplines and the involvement of SSH experts, institutions as well as the inclusion of relevant SSH expertise, in order to produce meaningful and significant effects enhancing the societal impact of the related research activities.

HORIZON-CL5-2021-D3-01-03: Market Uptake Measures of renewable energy systems

Specific conditions	
Expected EU contribution per project	The EU estimates that an EU contribution of around EUR 2.00 million would allow these outcomes to be addressed appropriately. Nonetheless, this does not preclude submission and selection of a proposal requesting different amounts.
Indicative budget	The total indicative budget for the topic is EUR 10.00 million.
Type of Action	Coordination and Support Actions

Expected Outcome: Project results are expected to contribute to some of the following expected outcomes:

- Facilitate the wider uptake of renewable energy systems in the energy, industrial and residential sectors leading to an increased share of renewable energy in the final energy consumption by 2030 and beyond.
- Contribute to provide a basis for policy-makers and stakeholders for developing more informed RES policy and for analysing about the market dynamics when including all renewable energies.
- Contribute to the development of markets and respective financial frameworks that can operate efficiently and incentive-compatible while accommodating massive shares of renewables.
- Increase societal acceptance of renewable energy facilities and installations through science-based evidence and tools addressing misperception phenomena from citizens.

Scope: The proposal is expected to develop solutions addressing at least 2 of the expected outcomes either for the entire renewable energy market or focusing on a specific energy sector, such as electricity, heating, cooling or renewable fuels. Proposals can also address issues within a specific geographical region such as urban and peri-urban areas. Issues related to acceptance of RES technologies due to cultural heritage landscape particularities can be addressed. Self-consumption issues can be addressed too. International aspects, such as collaboration with third countries and promoting solution in new markets, can be addressed as well.

The proposed solution can be developed to address a local challenge but needs to have wide potential for reapplication. The solution should have a long term viability and not be limited to

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an ad-hoc fix. The methodologies applied may be inspired by successful approaches already tested in other fields or contexts.

For all actions, the consortia have to involve and/or engage relevant stakeholders (e.g. businesses, public authorities, civil society organisations) and market actors who are committed to adopting/implementing the results. The complexity of these challenges and of the related market uptake barriers may call for multi-disciplinary approaches, which should include contributions from the social sciences and humanities. Where relevant, regional specificities, socio-economic, gender-related, spatial and environmental aspects will be considered from a life-cycle perspective.

Where relevant, proposals are expected to also assess the legal, institutional and political frameworks at local, national and European level and examine how, why and under what conditions these could act as a barrier or an enabler.

HORIZON-CL5-2021-D3-01-04: Novel tandem, high efficiency Photovoltaic technologies targeting low cost production with earth abundant materials

Specific conditions	
Expected EU contribution per project	The EU estimates that an EU contribution of around EUR 5.00 million would allow these outcomes to be addressed appropriately. Nonetheless, this does not preclude submission and selection of a proposal requesting different amounts.
Indicative budget	The total indicative budget for the topic is EUR 20.00 million.
Type of Action	Research and Innovation Actions
Technology Readiness Level	Activities are expected to achieve TRL 5 by the end of the project – see General Annex B.

Expected Outcome: Photovoltaic power generation is pivotal in the transition to a clean energy system and the achievement of the zero-emissions target. To that end, it is important to enhance affordability, security of supply and sustainability of PV technologies along with further efficiency improvements. Consequently, project results are expected to contribute to all of the following outcomes:

- Demonstrate tandem technologies for efficiencies beyond the single-junction Shockley–Queisser limit (~29%).
- Increase the potential of tandem technologies with earth abundant materials for mass production at low manufacturing cost.
- Minimise the impact of PV on landscape and environment by increasing its energy yield/m2.

- Contribute towards establishing a solid European innovation base and a competitive, continuous and coherent PV value chain.

Scope: Tandem-junction cell architectures present a path towards higher module efficiencies over single-junction designs, because of the ability to absorb more efficiently the different wavelength regions of the solar spectrum by means of separate devices (monolithically integrated and bonded/mechanically stacked). This enables surpassing the limiting efficiency of single-junction Si (~29%), which has neared its theoretical limit. As module costs drop, balance-of-systems costs dominate the cost of PV installations, and gains in efficiency could influence more the overall system costs, the energy yield/m2 and hence the land use or the integration potential of the technology. The aim is to develop tandem cells and modules that will reach efficiencies >30%, offer the same lifetime and degradation rate as standard crystalline panels at only marginally higher cost, creating thus a viable economic pathway for commercialisation of these technologies.

The proposal should address all of the following:

- Develop novel concepts based on earth abundant materials that optimise PV cell and module architecture, increase durability, decrease losses and target very high efficiencies, taking also into consideration specific applications.
- Employ simple, scalable and low cost processing techniques; deliver proof-of-concept for equipment development to support novel layer deposition.
- Ensure compliance with the relevant standards at laboratory scale, also considering the specific applications targeted.
- Perform device/module real –life (under actual outdoor operating conditions) characterisation for reliability and energy yield assessment.
- Perform a life cycle analysis to bring evidence of the lower environmental impact, better resource efficiency than current commercial PV technologies, and circularity potential.

Energy systems, grids and storage

Proposals are invited against the following topic(s):

HORIZON-CL5-2021-D3-01-05: Energy Sector Integration: Integrating and combining energy systems to a cost-optimised and flexible energy system of systems

Specific conditions	
Expected EU contribution per project	The EU estimates that an EU contribution of between EUR 9.00 and 10.00 million would allow these outcomes to be addressed appropriately. Nonetheless, this does not preclude submission and selection of a proposal requesting different amounts.

Indicative budget	The total indicative budget for the topic is EUR 30.00 million.
Type of Action	Innovation Actions
Technology Readiness Level	Activities are expected to achieve TRL 6-8 by the end of the project – see General Annex B.

Expected Outcome: Project results are expected to contribute to most of the following expected outcomes:

- Demonstrated benefits of sector integration in different geographic, climate and economic conditions.
- Improved planning of integration of power, heat, gas, industry with a production site(s) of renewable energy.
- Optimised operations of coupled networks (e.g. electricity vs. heating).
- Validated tools and platforms enabling effective sector coupling as tested in large demonstration projects.
- Consolidated methodology to evaluate the impacts on OPEX, CAPEX and overall value creation connected to the integration of flexibility from storage and other energy flexibility solutions.

Scope: Projects should demonstrate the benefits of the integration of different elements. This includes in particular electricity and gas networks, district heating and cooling, and long term energy storage systems (for example Hydrogen, power-to-X, thermal storage, hydro-storage). It can also include mobility systems (e.g. e-mobility infrastructure) and energy-intensive industry and/or industrial clusters or sites. Projects should demonstrate the integration at local (i.e. distribution networks) and at national level (i.e. transmission networks), and the interactions between them.

- Develop 2 or 3 pilots in different Member States/Associated Countries that demonstrate of solutions for energy system integration based on integrated management of various networks and infrastructures. The pilots could include for example:
    - Electricity and gas networks;
    - Implementation of solutions for district heating and cooling as sector integration for energy storage and flexible operation at different energy carriers;
    - E-mobility infrastructure;
    - Solutions for industry and industrial clusters for integrated flexible generation, consumption and energy storage;

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- Flexible stand-alone systems and tools for living quarters and small and medium sized businesses and industries based on renewable generation, sector-coupling and storage technologies;
- Integrated systems to allow for long term (weekly, seasonal) energy storage.

- Demonstrations can be build up based on a combination and integration of various locally optimised grids into overall system management.

Projects should provide a preliminary analysis including country-specific challenges, a sustainability assessment for the environmental impact, social acceptance, as well as economic feasibility.

The participation of inter- and trans-disciplinary consortia combining expertise and capacity from public authorities, urban stakeholders, infrastructure providers, knowledge institutions, planners, entrepreneurs, societal actors and citizens is advised to address the challenges of this topic.

Projects should develop a consolidated methodology to evaluate interaction of coupled networks and the impact on OPEX and CAPEX connected to the integration of flexibility from storage and other energy vectors as well as to build upon integrating knowledge on cost reduction for the relevant conversion processes.

Projects should develop innovative tools for:

- Assessment of technical and operational challenges, including environmental impact and social acceptance.
- System planning toolboxes to determine the optimal sizing, location and distribution of energy storage systems and technologies to facilitate their optimal use at different grid levels, as well as system planning toolboxes to determine the optimal location and utilisation rate of available energy conversion plants.
- Aging models' definitions for several storage technologies according to the operating conditions and required regulation services.
- Communication, platforms and devices for increased observability/controllability of the generation, consumption and storage resources and the measurement acquisition.
- Tools to quantify the flexibility provided by sector integration.

Where relevant, projects should collaborate with the Clean Hydrogen Joint Undertaking on aspects that require integration of hydrogen.

Activities in relation to production of hydrogen are excluded, as all production aspects are covered through calls of the Clean Hydrogen Institutional Partnership. Fuel Cell Micro Boilers technology is also excluded due to technology development through the Clean Hydrogen

Partnership. Cooperation with the Clean Hydrogen Partnership, for example through joint projects, is however welcomed.

The selected projects are expected to contribute to relevant BRIDGE[64] activities.

HORIZON-CL5-2021-D3-01-06: Increasing energy system flexibility based on sector-integration services to consumers (that benefits system management by DSOs and TSOs)

Specific conditions	
Expected EU contribution per project	The EU estimates that an EU contribution of around EUR 8.00 million would allow these outcomes to be addressed appropriately. Nonetheless, this does not preclude submission and selection of a proposal requesting different amounts.
Indicative budget	The total indicative budget for the topic is EUR 25.00 million.
Type of Action	Innovation Actions
Technology Readiness Level	Activities are expected to achieve TRL7-8 by the end of the project – see General Annex B.

Expected Outcome: Projects are expected to contribute to most of the following outcomes:

- New business models for market parties based on energy services and revenue streams for consumers (across energy sectors and beyond, based on valorisation of the flexibility in their energy consumption).
- Enable market parties to provide flexibility services to network operators and the wholesale market based on competitive markets that are easily accessible and at low transaction costs.
- Increased application of digital technologies to support consumers and market parties to market their flexibility.
- Increased consumer engagement and acceptance.
- Increased availability of flexibility sources for TSOs and DSOs and enable them to develop markets for flexibility and interact with many distributed resources at the same time (via intermediaries such as energy suppliers or aggregators) based on seamless data exchange and interoperability.
- Facilitate scaling up the platforms and markets to spread its use by making it as easy as possible for suppliers, aggregators or consumers directly to offer grid services based on other or new small-scale and large-scale assets/devices on these markets, if necessary through as easy and automated pre-qualification processes as possible.

[64] https://www.h2020-bridge.eu/

- Better understanding of market models and regulatory measures that can promote new business models.
- Contribution to better informed investment decisions by network operators and tariff setting models by NRAs, as flexibility markets and new business models can postpone or avoid new investments making better use of existing assets.

Scope: The projects will test and develop further already demonstrated solutions for data-driven energy services for consumers, in cooperation with various actors in the energy system (such as prosumers, aggregators, TSOs, DSOs, owners of assets that can provide flexibility like batteries, heating/cooling systems, charging point operators, gas systems):

- Replicate them in as many different geographies as possible having different system needs, consumer needs, economic conditions or different climates. They will be adapted to the local energy requirements and they will aim at increasing consumer acceptance and participation. Focus is expected to be in the facilitation of different services.
- Integrate energy services with other services for citizens and/or consumers (e.g. health, safety, mobility):
    - focus on business models that combine energy services with other services, such as health, security, home automation or mobility services taking into account experiences and practice from social science and humanities;
    - focus on business models for households that combine energy services focused on flexibility with investments in assets at consumer level that contribute to long-term changes in electricity production or consumption, such as RES generation, energy storage, deep renovations, new, more efficient and intelligent appliances that form a major part of household energy consumption (e.g. heating).

The development and testing of business models will contribute to a better understanding of the ways to promote such models and to address their impact in the design, modelling and planning of energy markets at all-time horizons and at all geographical scales, from the pan-European cross-border wholesale electricity and gas markets, products, services and businesses, down to local level. In the latter, without precluding other options, we are considering neighbourhood, aggregated, retail, centralized local flexibility markets or peer-to-peer market of energy products and services (flexibility, ancillary services, electricity, gas and heating/cooling).

The solutions are expected to be aligned with already existing markets. The projects will therefore be asked to cooperate to jointly provide detailed analyses and studies that address possible regulatory measures related to the implementation of the Clean Energy for All Europeans Package.

Specific demonstrators will make use of operational end-to-end architectures, digital platforms and other data exchange infrastructure being developed under ongoing Horizon 2020, Horizon Europe as well as under other EU programs such as the Digital Europe Program.

The selected projects are expected to contribute to relevant BRIDGE[65] activities.

HORIZON-CL5-2021-D3-01-07: Reliability and resilience of the grid: Measures for vulnerabilities, failures, risks and privacy

Specific conditions	
Expected EU contribution per project	The EU estimates that an EU contribution of between EUR 7.00 and 8.00 million would allow these outcomes to be addressed appropriately. Nonetheless, this does not preclude submission and selection of a proposal requesting different amounts.
Indicative budget	The total indicative budget for the topic is EUR 15.00 million.
Type of Action	Innovation Actions
Technology Readiness Level	Activities are expected to achieve TRL5-6 by the end of the project – see General Annex B.

Expected Outcome: Project results are expected to contribute to the following expected outcome: Demonstration of increased energy system reliability and resilience, preventing or ensuring rapid recovery following disturbances such as faults, cyberattacks, terrorism or similar at all relevant levels (infrastructure, hardware, software, organisational, etc.).

Scope: Proposals are expected to include all of the following 4 points:

- Demonstration of measures to minimize TSO and DSO risks, vulnerabilities and of priority strategies and measures against nature and man-made hazards, terrorism, weather, migration, etc. for:
    - substation systems security and design;
    - HV, MV, LV grid infrastructures including platforms for TSO and DSO interaction;
    - automatic control of decentralized flexibility solutions;
    - Events resulting in cascading failures, their mitigation and prevention.
- Application of advanced information technologies (e.g. probabilistic safety assessment, quantitative risk analysis) in system development, operation and asset management.
- Application of digital technologies for ensuring operational data quality and demand patterns recognition improving data access and information acquisition for maintenance operators.

[65] https://www.h2020-bridge.eu/

- Development of shared knowledge basis within European area concerning threats, vulnerabilities, methods, not only for components but for entire systems and energy system technologies.

From the following four, proposals should include at least two:

- Development and application of technology (e.g. blockchain) for the identification and authentication of energy IoT devices, authentication of origin in spare part management, trading certificate infrastructures, protection relay configuration and micro grid management.
- Development, testing and demonstration of advanced intrusion detection and prevention systems for energy infrastructures including security-related data and deep learning methods.
- Dedicated strategies for enhanced security and resilience at DSO and TSO level, including demonstration of TSO/DSO security data sharing.
- Development and application of methodologies for automation of grid maintenance (for example through robotics), advanced human-machine interfaces, and of data validation processes automation by applying emerging technologies.

The selected projects are expected to contribute to relevant BRIDGE[66] activities.

HORIZON-CL5-2021-D3-01-08: Electricity system reliability and resilience by design: High-Voltage, Direct Current (HVDC)-based systems and solutions

Specific conditions	
Expected EU contribution per project	The EU estimates that an EU contribution of between EUR 7.00 and 8.00 million would allow these outcomes to be addressed appropriately. Nonetheless, this does not preclude submission and selection of a proposal requesting different amounts.
Indicative budget	The total indicative budget for the topic is EUR 15.00 million.
Type of Action	Research and Innovation Actions
Technology Readiness Level	Activities are expected to achieve TRL5-6 by the end of the project – see General Annex B.

Expected Outcome: Project results are expected to contribute to all of the following expected outcomes:

[66] https://www.h2020-bridge.eu/

- HVDC technologies contribution achieving climate neutrality of the electricity generation sector allowing the integration of large share of renewables while concurrently addressing the security of supply.

- HVDC interconnections can act as a firewall blocking the spread of disturbances while permitting the interchange of power.

- Mastering HVDC technologies will open new business horizons for European companies in the global clean energy markets.

- Increased electricity system reliability and resilience throughout the overall interconnection system, which includes High Voltage cables. Furthermore, the use of buried HVDC cables reduces the visual impact and improves the social acceptance compared to the classical AC overhead lines.

Scope: Proposals will explore concepts and propose solutions to foster the development of large HVDC based transmission grid infrastructures, able to bring benefits to the existing electrical system and capable of integrating the fore coming large amount of renewable energy.

Proposals should demonstrate the reliability and resilience of the energy system through HVDC interconnections integrated in the AC grid while coping with faster dynamics, in particular by addressing at least two of the following topics:

- Proposals of optimal grid architecture concepts using HVDC (e.g. multi terminal, hub operation, etc.) and related demonstrated advantages, with a careful overview of planning aspects and deployment methodologies. Proposals should investigate and identify the technological (e.g. coordination between HVDC converters in close vicinity, modelling of HVDC submarine cables for transient phenomena, etc.), contractual and regulatory barriers for the deployment and present solutions to remove them.

- Real-time monitoring and assessment of the level of system stability and vulnerability against disturbances of future AC systems characterised by more HVDC and less conventional power generation.

- Reliability model for HVDC and its impact on the overall transmission system reliability with the HVDC link acting as ‘firewall‘ within the synchronous AC transmission system.

- Technical-economic benefits of the HVDC interconnection solution with the “firewall” functionality as well as in combination of other advantages contributing to the system security such as relieving heavily loaded AC corridors, etc.

- Simulation, real time demonstration of the avoidance or containment of cascading effects and resilience to cyberattacks or faults of the HVDC connection in the AC network.

- Simulation, real time demonstration of the co-ordinated use of HVDC-connected RES for containment of cascading faults and contribution to system restoration.

- Evaluation of the impact on system reliability of an increasing number of HVDC links incorporated in the transmission system through modelling and quantification of the dynamic "firewall" properties of the HVDC links incorporated in the transmission system.
- Evaluation of the use of HVAC fault location and monitoring systems for cables in HVDC (e.g. fibre optic distributed temperature sensing, online PD detection and location and time domain reflectometer (TDR) measurements for faults pre-location and fingerprinting).
- Development of novel pre-fault monitoring systems for the evaluation of the actual status of the HVDC cables and accessories, with the aim to improve the reliability of the DC links.
- Development and validation of new dielectric materials for the insulation of HVDC cables and accessories aiming at achieving higher capacity transfer capabilities. The proposed materials should have reduced ageing due to space charge accumulation phenomena.
- Proposals for highly reliable design and manufacturing of HVDC cables and accessories and related demonstrated advantages. Proposals should investigate the sustainability of the identified procedures through LCA.

The selected projects are expected to contribute to relevant BRIDGE[67] activities.

HORIZON-CL5-2021-D3-01-09: Demonstration of superconducting systems and elpipes

Specific conditions	
Expected EU contribution per project	The EU estimates that an EU contribution of around EUR 15.00 million would allow these outcomes to be addressed appropriately. Nonetheless, this does not preclude submission and selection of a proposal requesting different amounts.
Indicative budget	The total indicative budget for the topic is EUR 15.00 million.
Type of Action	Innovation Actions
Technology Readiness Level	Activities are expected to bring long distance DC Superconductors to TRL 8 in Europe by the end of the project – see General Annex B.

Expected Outcome: The Superconducting Transmission Lines (SCTL) main advantages are higher transmission efficiency and ability to use lower operating voltages while still preserving the total capacity. Potential applications for transport of high amounts of energy or in European congested grid context is then key for the development of the grid and to increase its efficiency.

Elpipes are polymer-insulated underground HVDC conductors based on low cost extruded metal conductors. The technology could potentially be used to transfer massive capacities in identified corridors. An elpipe installed at the surface could go to at least 30 GW with passive

[67] https://www.h2020-bridge.eu/

cooling. Actively (but non-cryogenically) cooled elpipe designs can theoretically go to transfer capacities above 200 GW.

Project results are expected to contribute to all of the following expected outcomes:

- New SCTL technologies to upgrade and expand the electric grid to meet the requirements imposed by the increasing penetration of renewables.
- Use of different superconductor technologies (e.g. HTS, MgB_2) with different cooling medium, power rating and lengths.
- Increased power transfer capability within existing right of ways.
- Test and validate the transmission of bulk power not achievable with current cable technologies.

Scope: The activities will concur to demonstrate the reliability of the technology and its applicability in the grid network.

- Demonstration of up to ±100kV, up to 1 GW power, superconducting system (HTS) up to 5 km onshore.
- Demonstration of ±100 kV, up to 1 GW power, superconducting system up to 100 km, offshore.
- Demonstration of a SCTL based on MgB_2 LH_2 cooled, for DC with a length up to 1 km and above, onshore. The voltage level and the cable section should be designed to have the maximum benefits in terms of insulation requirements and conductor section for a capacity transfer of 10 kA and above.
- Cable design and simulation of kA range faults, power reversal response, loss calculation and demonstration for protections of SCTL.
- Technical-economic benefits of the SCTL demonstrated compared with traditional (overhead lines, XLPE cable).
- Investigate the feasibility and applicability of elpipes with technical economic analysis, use cases, etc. for high transfer rates in identified corridors.

The selected projects are expected to contribute to relevant BRIDGE[68] activities.

HORIZON-CL5-2021-D3-01-10: Demonstration of advanced Power Electronics for application in the energy sector

Specific conditions

[68] https://www.h2020-bridge.eu/

Expected EU contribution per project	The EU estimates that an EU contribution of around EUR 5.00 million would allow these outcomes to be addressed appropriately. Nonetheless, this does not preclude submission and selection of a proposal requesting different amounts.
Indicative budget	The total indicative budget for the topic is EUR 10.00 million.
Type of Action	Innovation Actions
Technology Readiness Level	Activities are expected to achieve TRL5-6 by the end of the project – see General Annex B.

Expected Outcome: Wide Bandgap-based (WBG) semiconductors such as Silicon Carbide (SiC) enable higher power density, operation voltages, temperatures, and frequencies while reducing heat dissipation of power electronics. This enables the development of more efficient and smaller size converter stations affecting considerably on grid distribution generally and logistics, cost, etc. and the deployment of the offshore energy grid. Right now SiC allows for sufficient reduction on converter footprint, but it is far too expensive, and its cost has a negative impact on overall system cost.

Project results are expected to contribute to all of the following expected outcomes:

- Production, test and validation of WBG-based switching semiconductors such as Silicon Carbide (SiC) for HVDC – MVDC converter applications in converter stations.
- Reduced size of components and equipment for offshore / onshore applications.
- Reduced cost of WBG-based semiconductors such as Silicon Carbide (SiC).

Scope: The activities are intended to produce, test and validate WBG-based based switching semiconductors such as Silicon Carbide (SiC) for converter station application.

The activities include, but are not limited to:

- Production of SiC based semiconductors for HVDC – MVDC converter applications (example for HVDC: MMC cells with SiC 3.3 kV and above, 1,5 kA and above with optimal increased switching frequency to reduce losses).
- Converter board design and production (power and control parts installation and soldering of all components, hardware and software testing, etc.).
- Simulation and analysis of the impact of the actual passive components used in WBG components circuitry in the above mentioned conditions; development of strategies and innovative techniques to upgrade them for better adaptation to the afore-mentioned working conditions.
- Analysis of the impact of fast transients from power electronics on other electrical components that were not originally designed to endure such stresses.

- Series modules assembly for converter application.
- Simulation and real time testing and validation of the converter with WBG-based switching semiconductor.
- Technical-economic assessment of the benefits provided by WBG-based compared to Silicon-based switching semiconductor of converters.

The consortium is expected to involve DG ENER and ECSEL JU where considered relevant

The selected projects are expected to contribute to relevant BRIDGE[69] activities.

HORIZON-CL5-2021-D3-01-11: Laying down the basis for the demonstration of a Real Time Demonstrator of Multi-Vendor Multi-Terminal HVDC with Grid Forming Capability: Coordinated action

Specific conditions	
Expected EU contribution per project	The EU estimates that an EU contribution of around EUR 1.00 million would allow these outcomes to be addressed appropriately. Nonetheless, this does not preclude submission and selection of a proposal requesting different amounts.
Indicative budget	The total indicative budget for the topic is EUR 1.00 million.
Type of Action	Coordination and Support Actions

Expected Outcome: The call is intended to support all the preparatory phases among all stakeholders (HVDC systems manufacturers, TSOs, wind turbine manufacturers and windfarm developers) leading to a demonstration project to de-risk the technology to enable the installation in Europe of the first Multi-Vendor Multi-Terminal HVDC system with Grid Forming Capability. The HVDC system should guarantee at least the technological capabilities needed for advanced grid management capabilities and the deployment of the offshore grid (active and reactive power controlled separately, support to weak AC grids, black start, etc.). HVDC systems are applicable and can be planned, designed and integrated in any part of the AC grid, i.e. onshore as well as offshore. Following the Commission adoption of the "Strategy on Offshore Renewable Energy", attention is presently focused to offshore grid application.

The demonstration project deriving from the action will pave the way to the deployment of the offshore energy system, which will enable the integration of increasing amounts of RES in the energy system.

Project results are expected to contribute to all of the following expected outcomes:

[69] https://www.h2020-bridge.eu/

- Solid foundation to ensure investments in DC technologies for the European electricity network needed for the energy transition.
- Agreement among stakeholders (HVDC systems manufacturers, TSO, Regulators, Standardisation bodies, wind turbine manufacturers, windfarm developers etc.) and planning for the demonstration of a Real Time Demonstrator of Multi-Vendor Multi-Terminal HVDC with Grid Forming Capability, which will lead to the first real-life full scale installation in Europe.
- New way of framing the European energy system (on- off-shore) architecture and topology.
- Provide new pathways to offshore energy and development.

Scope: The supports all the multiple preparatory tasks, which will lead to a global agreement among stakeholders and define the detailed planning for the full-scale industrial demonstrator. These include, but are not limited to:

- Coordination and organization of a platform involving all stakeholders (HVDC system manufacturers, TSOs, third-party HVDC system integrators, wind turbine manufacturers, offshore wind farm developers).
- Compatibility of modelling tools towards interoperability.
- Model sharing between TSOs: legal framework.
- Roles and responsibilities on interoperability issues.

The selected projects are expected to contribute to relevant BRIDGE[70] activities.

HORIZON-CL5-2021-D3-01-12: Establish the grounds for a common European energy data space

Specific conditions	
Expected EU contribution per project	The EU estimates that an EU contribution of around EUR 8.00 million would allow these outcomes to be addressed appropriately. Nonetheless, this does not preclude submission and selection of a proposal requesting different amounts.
Indicative budget	The total indicative budget for the topic is EUR 32.00 million.
Type of Action	Innovation Actions
Technology Readiness Level	Activities are expected to achieve TRL 5-7 by the end of the project – see General Annex B.

[70] https://www.h2020-bridge.eu/

Expected Outcome: Project results are expected to contribute to all of the following expected outcomes:

- Higher degree of interoperability between data platforms.
- Energy data made available and re-usable.
- Enable new market roles, market participants and energy communities.
- Demonstrated implementations of Energy Data Spaces, exploiting open standards related to data-packages, interfaces, protocols, platforms and procedures.
- Enabling new digital solutions and services supporting the energy transition.
- Increased acceptance and participation of consumers on data sharing for energy services.

Scope: Develop, validate, demonstrate an Energy Data Space that enables access to and use of energy data, comparison with different solutions and that has the following features:

- Interfaces for the exchange of information (i.e. APIs, connectors), and interoperable open standards.
- Pilot innovative solutions for a Common European Energy Data Space[71], to promote a stronger availability and cross-sector sharing of data, in a customer-centric, secure and trustworthy manner.
- Support the establishment a common European Energy Data Space providing the tools and standards to connect and to make accessible as much data as possible covering the full energy value chain.
- Support the ability to accommodate Digital Twins at different levels of the grid (and outside the grid) and facilitate real-time operations.
- Create a market place for data-driven energy services on top of this energy related data space that are attractive for consumers and operators, increase the potential for investing in green energy and provide innovative services which are not possible w/o these Data Spaces.
- All projects together need to come forward with and test individually the minimum requirements on data governance and data interoperability, where applicable, exploring data source certification schemes.
- All projects together need to demonstrate interoperability of their respective Energy Data Space with those of the other projects in this call. A joint analysis of the solutions is expected as part of this exercise (learnings, best practices, barriers to implementation ...).

[71] https://ec.europa.eu/info/sites/info/files/communication-european-strategy-data-19feb2020_en.pdf

- Protection of personal data, cybersecurity and data rights (e.g. right for a fair remuneration) are to be specifically considered, with a final aim to increase the trust of data subjects and data providers in the energy data space.

- Projects should reserve one work package for the activities requiring collaboration, namely demonstration of interoperability, with the other projects of this call.

The selected projects are expected to contribute to relevant BRIDGE[72] activities.

This topic will benefit from the effective contribution of SSH disciplines and the involvement of SSH experts, institutions as well as the inclusion of relevant SSH expertise, in order to produce meaningful and significant effects enhancing the societal impact of the related research activities. The Commission will make sure that projects benefit from SSH expertise through the cooperation in Bridge.

HORIZON-CL5-2021-D3-01-13: Reinforcing digitalisation related know how of local energy ecosystems

Specific conditions	
Expected EU contribution per project	The EU estimates that an EU contribution of around EUR 4.00 million would allow these outcomes to be addressed appropriately. Nonetheless, this does not preclude submission and selection of a proposal requesting different amounts.
Indicative budget	The total indicative budget for the topic is EUR 4.00 million.
Type of Action	Coordination and Support Actions

Expected Outcome: Project results are expected to contribute to all of the following expected outcomes:

- Increased autonomy of local ecosystems to participate in the decentralisation of energy systems and energy transition.

- Increase the number of participants in flexibility markets.

- Cover the gap on knowledge around digitalisation of energy services and contribute to the reskilling & upskilling of individuals and organizations.

- Facilitate the creation of a network of parties interested in joining forces for public procurement of energy related digital services.

Scope: The digitization of the future will not be created only by leading digital technologies, but also by knowledge on and from the application areas of these technologies as well as a range of methods and strategic tools. The creation/reinforcement of local digitalisation-of-energy

[72] https://www.h2020-bridge.eu/

ecosystems as a way to support a competence cluster for digital energy concepts affecting to operators, consumers/prosumers, and authorities, which enable them being autonomous to react to local energy transition needs.

The project should create an upskilling and reskilling training program, centred on the digitalisation of energy and covering needs of local ecosystems centred on, among others, DSOs, city operators, connected active consumers (energy communities or potential new entrants) and local/regional authorities.

The training program should also contribute to capacity building of energy community members and to the support of citizens in understanding the steps to follow to create an energy community.

The project should seek to establish a cluster organization at local level **for energy relevant** digital technologies such as, but not only, Artificial Intelligence, Internet of Things, cybersecurity, big data, edge computing, data communications or blockchain.

After identifying the needs and engaging on a local level, the project should provide extensive training in all Member States/Associated Countries and make the developed/used training material available as broadly as possible.

The project should take into account, and collaborate with, where considered necessary, the ongoing EDDIE [73] project from the Erasmus + program, relevant initiatives by Digital Innovation Hubs, EC Digital Education action plan and any other initiative geared in the same direction.

At the same time the project should investigate, and if the reaction is positive, create a network of parties interested in joining forces for public procurement of digital services. One example could be tools for cities to participate in energy flexibility markets that are interoperable, where already present, with their Smart City Platforms)

The selected projects are expected to contribute to relevant BRIDGE[74] activities.

This topic will benefit from the effective contribution of SSH disciplines and the involvement of SSH experts, institutions as well as the inclusion of relevant SSH expertise, in order to produce meaningful and significant effects enhancing the societal impact of the related research activities. The Commission will make sure that projects benefit from SSH expertise through the cooperation in Bridge.

HORIZON-CL5-2021-D3-01-14: Interoperability community

Specific conditions

[73] http://www.eddie-erasmus.eu/
[74] https://www.h2020-bridge.eu/

Expected EU contribution per project	The EU estimates that an EU contribution of around EUR 5.00 million would allow these outcomes to be addressed appropriately. Nonetheless, this does not preclude submission and selection of a proposal requesting different amounts.
Indicative budget	The total indicative budget for the topic is EUR 5.00 million.
Type of Action	Coordination and Support Actions

Expected Outcome: Project results are expected to contribute to all of the following expected outcomes:

- Ensure continuity of the ongoing interoperability of energy services related activities.
- Ensure horizontal coordination and support, sustainable up-take of the energy services related to interoperability, data spaces and digital twins.
- Support and disseminate a common framework for testing interoperability across running projects. Harmonise interoperability testing procedures[75].
- Increased interoperability of energy services, data and platforms, both at the function and business layers.

Scope: Facilitate the coordination and alignment of projects and support interaction between the various related initiatives happening at European and National level.

- The project should support a community of practice that includes interoperability expertise relevant to the energy transition that keeps track and maintains an expertise around changes in requirements, emerging use cases and regulatory condition.
- development of IT/ICT, evolution of relevant standards and all activities impacting interoperability, virtualisation and digital twins, data spaces.
- industrial and working groups' efforts towards interoperability (including ontologies, core models etc.).

Maintain an overview of what is happening, create a repository of best practices and use cases, indicate what is needed to keep this interoperability and provide a forum to support agreements on open standards, convergence on reference architectures and broad dissemination.

Increased interoperability of energy services, data and platforms, both at the function and business layers of the Smart Grid Architecture Model. Where relevant consider including also smart energy systems models going beyond Smart Grids.

[75] The Smart Grid Interoperability testing methodology developed by JRC of the EC is one such methodology https://ec.europa.eu/jrc/en/publication/smart-grid-interoperability-testing-methodology

Develop an Interoperability Maturity Model (IMM) to indicate the level of maturity in organisations, and the further effort/ actions need to be made to reach higher levels of interoperability.

Create a network of interested parties, and eventually, setting up a distributed European ecosystem of centres for the Interoperability testing of data driven energy solutions. This should take into account existing initiatives like living labs, digital innovation hubs, JRCs Interoperability testing lab related ERA-Net program calls and Clean Energy Transition Partnership, and should aim at supporting a European knowledge base of use cases, interoperability profiles test cases, and results of tests.

Establishing a cross-fertilisation of existing regional testing infrastructures, explore best practice of local sand-boxing and link with existing networks. Demonstrate with the testing of a set of real life cases where new interoperability requirements are to be tested, how the activities would be organised.

The networks should agree on a common testing methodology and a common test reporting methodology to be used.

The selected projects are expected to contribute to relevant BRIDGE[76] activities.

Carbon capture, utilisation and storage (CCUS)

Proposals are invited against the following topic(s):

HORIZON-CL5-2021-D3-01-15: Integration of CCUS in hubs and clusters, including knowledge sharing activities

Specific conditions	
Expected EU contribution per project	The EU estimates that an EU contribution of around EUR 2.00 million would allow these outcomes to be addressed appropriately. Nonetheless, this does not preclude submission and selection of a proposal requesting different amounts.
Indicative budget	The total indicative budget for the topic is EUR 2.00 million.
Type of Action	Coordination and Support Actions

Expected Outcome: The continuation of investigating CCUS possibilities in hubs and clusters, including knowledge sharing activities, is urgently needed as it could help to identify infrastructure needs. Furthermore, it could also lead to identifying potential new CO_2 Projects of Common Interest in the sense of the TEN-E regulation[77]. Early planning will enable and accelerate the roll-out of a CCUS infrastructure consisting of capture points and clusters,

[76] https://www.h2020-bridge.eu/

[77] REGULATION (EU) No 347/2013 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL on guidelines for trans-European energy infrastructure.

intermediate hubs, CO_2 conversion facilities, safe and cost-effective CO_2 transport and storage. Comprehensive information concerning the integration of CCUS in hubs and clusters will facilitate the development of operational sites as from the early 2020's. The project is expected to demonstrate the necessary requirements for CCUS integration in carbon-intensive industries and will promote knowledge sharing activities.

Scope: The EU Green Deal underlines that the transition to climate neutrality requires smart infrastructure and defines CCUS among the innovative infrastructures whose deployment in key industrial sectors will be necessary before 2030. Integration of CCUS in high emission industrial hubs and clusters is expected to be the most cost-efficient approach. Sharing, eventually across borders, CO_2 transport, use and/or storage infrastructure will help with achieving economies of scale, and improving the business case. The complexity of CCUS projects requires the inclusion of a great number of stakeholders, transparency, information and knowledge sharing, and forward looking, joint planning.

The project is expected to include the elaboration of detailed plans for the integration of CCUS in hubs and clusters linked to CO_2 storage sites via hubs, pipeline networks and shipping routes, with due attention to national and border-crossing permitting and regulatory issues. Mapping and understanding the nature and longevity of emission sources, identification of transport corridors and modalities, and performing initial impact assessments, and developing local business models for delivery of CO_2 capture, transport, utilisation and/or storage (including the separation of responsibilities across the CO_2 value chain), within promising regions is important. Industrial clusters may include, for example, power generation, cement and steel factories, chemical plants, refineries, waste-to-energy plants, and hydrogen production facilities. In its initial phase, this topic could include the use of natural gas (for the production of low carbon hydrogen, in power plants and refineries). The assessment of cost-effective ('bankable') storage capacity in the selected regions is important. This can be sites for onshore or offshore storage capabilities. Interaction between CCUS hubs-and-clusters on the one hand, and renewables-based integrated energy systems, and/or circular production modes on the other; will need to be studied.

Close cooperation across the CCUS value chain, as well as engagement with local stakeholders, is paramount and so is knowledge exchange across CCUS projects. This includes identifying and involving relevant end users, public authorities and societal stakeholders and analysing their concerns and needs using appropriate techniques and methods from the social sciences and humanities. The exchange of knowledge and know how across CCUS projects needs to be continued and facilitated: therefore the successful project will be expected to continue the activities of the existing European CCUS project network[78].

HORIZON-CL5-2021-D3-01-16: Cost reduction of CO2 capture (new or improved technologies)

Specific conditions

[78] https://www.ccusnetwork.eu/

Expected EU contribution per project	The EU estimates that an EU contribution of between EUR 10.00 and 15.00 million would allow these outcomes to be addressed appropriately. Nonetheless, this does not preclude submission and selection of a proposal requesting different amounts.
Indicative budget	The total indicative budget for the topic is EUR 30.00 million.
Type of Action	Research and Innovation Actions
Technology Readiness Level	Activities are expected to achieve TRL 6 by the end of the project – see General Annex B.

Expected Outcome: Significant step-change advances in CO_2 capture rates, reductions in energy penalty and cost of CO_2 capture as well as facilitating safe and economic integration into industrial clusters - which will in a short timeframe allow the uptake of CCUS in the power sector and energy intensive industries.

Scope: The high cost of carbon capture is still the most relevant stumbling block for a wider application of CCUS. Commercial deployment of CCUS requires a significant reduction of the energy intensity of the CO_2 capture process for power plants or other energy-intensive industries, and a substantial decrease of the cost of capture. A continuous effort is needed to develop and demonstrate new or improved capture technologies.

The objective is the pilot demonstration of advanced CO_2 capture technologies that have a high potential for increasing capture rates and efficiency, while reducing energy penalty and improving cost-efficiency of the whole capture process. Projects will test operating conditions and operational flexibility, and provide proof of the reliability and cost-effectiveness of these concepts, whilst at the same time evaluating the cost, technical requirements and operational and safety impacts on the industrial facility and the associated transport and storage infrastructure. The proposal should state credible and clearly defined targets and key performance indicators (KPIs) for the energy penalty reduction, the capture rate and the relative capital and operating costs of the capture process. Environmentally benign technologies have to be pursued and their environmental impact addressed in the project also in view of future scaling up.

Technology development should be balanced by an assessment of the societal readiness towards the proposed innovations, including by identifying and involving relevant end users and societal stakeholders (such as civil society organisations, non-governmental organisations, and local associations) in deliberative processes and analysing their concerns and needs using appropriate techniques and methods from the social sciences and humanities. Proposals are expected to include aspects of circularity and best use of resources.

Cross-cutting issues

Proposals are invited against the following topic(s):

HORIZON-CL5-2021-D3-01-17: Support to the activities of the European Geological Services

Specific conditions	
Expected EU contribution per project	The EU estimates that an EU contribution of around EUR 20.00 million would allow these outcomes to be addressed appropriately. Nonetheless, this does not preclude submission and selection of a proposal requesting different amounts.
Indicative budget	The total indicative budget for the topic is EUR 20.00 million.
Type of Action	Coordination and Support Actions
Eligibility conditions	The conditions are described in General Annex B. The following exceptions apply: If projects use satellite-based earth observation, positioning, navigation and/or related timing data and services, beneficiaries must make use of Copernicus and/or Galileo/EGNOS (other data and services may additionally be used).

Expected Outcome: Project results are expected to contribute to all of the following expected outcomes:

- An improved evidence-based decision-making and long-term sustainable management of Europe's subsurface, including offshore, needed to build a climate neutral continent.
- Comprehensive inventory of harmonised data on primary raw materials in Europe, with a focus on applications of critical raw materials[79] for energy storage and power generation, resulting in a higher level of independence for Europe.
- Comprehensive inventory of information on geothermal energy resources and subsurface storage capacities for sustainable energy carriers (hydrogen, heat and cold) and sequestration of CO_2, based on common and national scale assessment criteria and standardised reporting.
- Improved appraisal, protection and sustainable use – including appraisal of capacities for temporary storage - of Europe's groundwater resources, which are under increasing pressure because of climate change and competing uses of the subsurface. Improved adaptation of coastal zones to the effects of climate change and sea level rise.
- A strong and sustainable network of national Geological Survey organisations in order to provide geological knowledge and services on a Pan-European level.

[79] COM(2020) 474 - Critical Raw Materials Resilience: Charting a Path towards greater Security and Sustainability

Scope: The growing demand for energy, raw materials and water is a key challenge for Europe, requiring a more integrated, efficient and sustainable use of these resources. Europe is increasingly dependent on global supply of mineral resources, in particular on those needed for application in power generation, energy storage and transport, for the transition to climate neutrality. However, until now there is no complete and harmonised data at European level on mineral resources and reserves. There is a need for standardised reporting and uniform appraisal of subsurface capacities for CO_2 sequestration and temporary storage of sustainable energy carriers (including hydrogen and heat/cold) in order to support a secure, affordable and low-carbon energy supply. Groundwater resources are under increasing pressure as a result of climate change, as well as competing subsurface uses, including for mineral and energy resources. An up-to-date body of knowledge with high quality, policy-relevant geoscientific information and expertise, aggregated at the EU-level, at the service of European citizens, enterprises and institutions. This topic calls for concerted action to structurally address this challenge at European level, which is expected to ultimately lead to a Geological Service for Europe as a point of entry into a permanent collaborative network of National Geological Survey organisations.

For achieving these objectives, the action is expected to address the following issues:

- Re-evaluation of European resources in primary raw materials and mining waste, with a focus on critical raw materials needed for climate transition, filling the currently existing gaps in data and information at European level.
- Developing a database with FAIR[80] and harmonised data on mineral resources and reserves (excluding fossil fuels) according to United Nations Framework Classification for Resources (UNFC)[81], integrated in or linked to the EC managed geoportals (EU Open data portal[82] and EU INSPIRE Geoportal.
- Developing an EU International Centre of Excellence on Sustainable Resource Management focused on promoting and building capacity on United Nations Framework Classification for Resources (UNFC) for mineral resources (primary and secondary) and supporting the United Nations Resource Management System (UNRMS) in line with the UN 2030 Agenda for Sustainable Development.
- Building and maintaining an integrated European geothermal resources database based on uniform appraisal techniques and resource classification standards. Extend the geothermal database with assessed storage options for heat and cold.

80 FAIR (Findable, Accessible, Interoperable, Reusable). Further information: https://www.go-fair.org/fair-principles/; and Final Report and Action Plan from the European Commission Expert Group on FAIR Data, "TURNING FAIR INTO REALITY" (https://ec.europa.eu/info/sites/info/files/turning_fair_into_reality_0.pdf)

81 https://www.unece.org/energywelcome/areas-of-work/unfc-and-resource-management/about-unfc-and-sustainable-resource-management.html

82 https://data.europa.eu/euodp/en/home

- Deploying and maintaining a European storage atlas for CO_2 and sustainable energy carriers like hydrogen and compressed air. Develop the knowledge for the subsurface management and planning of storage sites for CO_2 and sustainable energy carriers.

- Transnational, harmonised data gathering, managing under the FAIR [83] principles, monitoring and evaluation of groundwater dynamics and groundwater quality.

- Collating and integrating geological and climate related information and data to assess and map coastal vulnerability, and to optimise siting of offshore windfarms (as well as associated infrastructure), in support of multifunctional use of pan-European marine space.

- Developing - and partly implementing strategic within the CSA - a research agenda, which includes the piloting of innovative cross-country data generation methods, to help achieve the expected impacts. Coordinating, integrating and aligning R&I programmes of European geological surveys.

- Developing a user-friendly digital Europe geological information system providing permanent data access, based on FAIR, and disseminating accurate, up-to-date, relevant and impartial data, information and knowledge developed by the partnership.

- Transformation of these data into decision support information and intelligence, including the use of innovative modelling and visualisation in multiscale digital products.

- Dissemination and communication of information and knowledge to stakeholders, including the general public.

- Create a strong network of geological surveys, and develop a permanent structure in the form of a Geological Service for Europe able to sustain this network and the geological information system after the end of the programme.

The use of own resources, for example for implementing the proposed research agenda, will increase the potential impact of the action, and is strongly encouraged.

HORIZON-CL5-2021-D3-01-18: Support to the activities of the ETIPs and technology areas of the SET Plan

Specific conditions	
Expected EU contribution per project	The EU estimates that an EU contribution of around EUR 1.00 million would allow these outcomes to be addressed appropriately. Nonetheless, this does not preclude submission and selection of a proposal requesting different amounts.
Indicative budget	The total indicative budget for the topic is EUR 9.80 million.

[83] FAIR (Findable, Accessible, Interoperable, Reusable)

Type of Action	Coordination and Support Actions
Award criteria	The criteria are described in General Annex D. The following exceptions apply: Only up to one project will be funded in each of the following sectors: • carbon capture storage and use; • geothermal systems; • hydropower; • ocean energy; • photovoltaics; • renewable fuels & bioenergy; • concentrated solar thermal energy (CSP & STE); • renewable heating and cooling; • wind energy; • energy efficiency in industry; • energy efficiency in buildings.

Expected Outcome: Engagement of stakeholders is pivotal in the transition to a clean energy system and the achievement of the zero-emissions target.

Project results are expected to contribute to both of the following outcomes:

- Consolidation of strong and sustainable networks in the different technology areas covered through the Strategic Energy Technology (SET) Plan and its integrated roadmap.
- Cooperation among ETIPs and similar stakeholders fora, support to existing SET Plan Implementation Plans and advancement towards more interconnected activities, both in terms of contents and implementation mechanisms.

Scope: In 2015, the launch of the Energy Union saw the SET Plan incorporated as the Energy Union's fifth pillar on 'Research, Innovation and Competitiveness'. Through the Communication "Towards an Integrated Strategic Energy Technology (SET) Plan", the Integrated SET Plan set ambitious R&I targets which remain relevant and essential in the new context of the European Green Deal and the Recovery Plan for Europe.

Depending on the sector, European Technology and Innovation Platforms (ETIPs), and/or SET Plan Implementation Working Groups (IWG) and/or similar stakeholders fora support the development and implementation of the SET Plan R&I priorities by bringing together relevant stakeholders in key areas from industry, research organisations and, where applicable, SET Plan Countries' government representatives. They develop research and innovation agendas and

roadmaps, industrial strategies, analysis of market opportunities and funding needs, understanding of innovation barriers and exploitation of research results, which are in line with the Recovery Plan for Europe and latest EU climate and energy related policies. They also provide consensus-based strategic advice to the SET Plan initiative covering technical and non-technological aspects.

Considering the overarching aim of the clean energy transition, ETIPs, IWGs and/or similar fora are encouraged to align and coordinate their activities, defining cross-cutting aspects for accelerating the clean energy transition and contribute to the development of a European Research Area in the field of Energy. Proposals should support ETIPs and/or IWGs and/or stakeholders fora of one of the above-listed sectors, taking into consideration the specific needs of the sector they address and the emerging policy priorities for their implementation as well as the coordination with other initiatives/projects, in order to avoid overlaps.

ETIPs, IWGs and stakeholders fora should ensure the participation of companies (industry and SMEs), research and civil society organisations, universities and European associations representing relevant sectors (as applicable) from a representative number of SET Plan countries establishing links with national authorities. To maximise their impact and widen participation, they are encouraged to develop and implement robust outreach approaches and societal engagement actions to span across the EU and associated countries**.**

Special attention should be given to the key challenges of the European Green Deal, including, but not limited to, technological pushback, industrial production, societal transformation, and just transition. Likewise, contributions to the goals of the European Research ERA in the field of energy, in particular regarding how to incentivise investing in research and innovation should be addressed.

Furthermore, proposals should develop a dissemination and exploitation strategy and implement dissemination and networking activities with other existing ETIPs and IWGs (e.g. joint workshops, thematic conferences, webinar series, regular exchanges, etc.). Relevant outputs of these CSAs will feed into the SET Plan information system (SETIS).

This topic requires the effective contribution of SSH disciplines and the involvement of SSH experts, institutions as well as the inclusion of relevant SSH expertise, in order to produce meaningful and significant effects enhancing the societal impact of the related research activities.

Proposals should address one of the following sectors: carbon capture storage and use, geothermal systems, hydropower, ocean energy, photovoltaics, renewable fuels & bioenergy, concentrated solar thermal energy (CSP & STE), renewable heating and cooling, wind energy, energy efficiency in industry, energy efficiency in buildings.

Proposals submitted under this topic are encouraged to include actions designed to facilitate cooperation, across Europe, with other projects and to ensure the accessibility and reusability of data produced in the course of the project. Proposals should include a finance and sustainability plan for future continuation beyond the lifetime of the proposal.

The indicative project duration is 3 years.

The requested budget for actions in the areas of concentrated solar thermal energy, energy efficiency in industry and energy efficiency in buildings should be around EUR 0.6 million because in these sectors there is no ETIP, only a SET Plan IWG with lighter structure and activities. Nonetheless, this does not preclude submission and selection of a proposal requesting different amounts.

HORIZON-CL5-2021-D3-01-19: Clean Energy Transition

Specific conditions	
Expected EU contribution per project	The EU estimates that an EU contribution of around EUR 210.00 million would allow these outcomes to be addressed appropriately. Nonetheless, this does not preclude submission and selection of a proposal requesting different amounts.
Indicative budget	The total indicative budget for the topic is EUR 70.00 million.
Type of Action	Programme Co-fund Action
Total indicative budget	The total indicative budget for the topic is EUR 210 million committed in annual instalments over the 7 years, 2021-2027, EUR 35 million from the 2021 budget and EUR 35 million from the 2022 budget).
Legal and financial set-up of the Grant Agreements	The rules are described in General Annex G. The following exceptions apply: Beneficiaries may provide financial support to third parties. Financial support provided by the participants to third parties is one of the primary activities of this action to allow the partnership to achieve its objectives. Therefore, the EUR 60 000 threshold provided for in Article 204 (a) of the Financial Regulation No 2018/1046 does not apply.

<u>Scope</u>: The partnership is expected to contribute to all of the following expected outcomes:

a. Increased directionality of clean energy transition research and innovation in Europe in line with the SET Plan by a shared pan-European vision regarding the goal and direction of the required system transformation processes adapted to regional needs and availability of renewable energy resources

b. Evidence based energy and climate policy formulation

c. A wider systemic transition and energy supply required for the climate transition in all sectors of society; enabling the transition of the built environment, transport, industry and other sectors to clean, low carbon energy;

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d. An innovation ecosystem for Europe's transition to clean energy and contribute to a resource-efficient energy system, both from an ecological and economic standpoint;

e. A building block to a zero-emission energy system for the decarbonisation of transport, buildings, industry, agriculture in the specific European environment;

f. Increased engagement of consumers and prosumers and in appropriate demand-response mechanisms and its integration in the energy system;

g. And finally, an energy system that meets the needs of different parts of society, in different geographical locations (urban and rural) and different groups.

Expected Impact: The European Green Deal aims to transform Europe into a fair and prosperous society with a modern, resource-efficient and competitive economy, with no net emissions of greenhouse gases in 2050. To decarbonise Europe, renewables must become the main energy source, while keeping the stability and resilience of the European energy system. Research and Innovation is needed to be able to achieve the Clean Energy Transition, while realizing also the ambitions of other EU policies like the New Circular Economy Strategy and the new Biodiversity Strategy and delivering on the objectives of the European Green Deal. It will also contribute to the Sustainable Development Goals of the United Nations (in particular SDG 7 Affordable and Clean Energy and SDG 9 Industry, Innovation and Infrastructure). At national level, policies and measures in clean energy research and innovation will support the achievement of the energy and climate targets, as outlined in the National Energy and Climate Plans.

The Clean Energy Transition Partnership (CETP) aims to empower the energy transition and contribute from a R&I perspective to the EU's goal of becoming the first climate-neutral continent by 2050. To achieve this ambitious goal, Europe needs to embark into a transformative process of both the energy system and its supporting technologies, as well as of the society. Key enabling and disruptive technologies, as well system innovation are essential for this transition. With robust investment in innovation and technology development, the energy transition turns into an opportunity for sustainable growth and competitiveness, creating high-quality jobs and leaving nobody behind.

The Clean Energy Transition partnership is expected to contribute to the overarching goal of transitioning to a clean energy system by pooling national and regional resources/funding programmes thus overcoming a fragmented approach. In its Strategic Research and Innovation Agenda, the Clean Energy Transition Partnership will address the following areas: Development of clean and affordable energy production and conversion technologies; development of a climate neutral, flexible and robust energy system; storage and its integration in the energy system; resource and energy efficiency and circular flows in the energy sector for an ecologically sustainable energy system; a just and inclusive energy transition; sector integration and coupling; and digital transformation.

The partnerships actions are expected to contribute to:

- a better cost performance by improving efficiency, sustainability, reliability and circularity of a broad portfolio of clean energy technologies and solutions;
- the integration of a wide range of new energy solutions and 'first of a kind' technologies on all levels of the energy system to give flexibility, promote and efficiently manage self-generation and consumption profiles and new holistic solutions for energy storage (surplus energy, peak load supply, inter-seasonal storage);
- the acceleration of the sustainable energy transition and societal development by the use of opportunities arising from the digital transformation and from data and information from the Copernicus programme, as well as the European Union's Earth Observation programme.

The partner composition is expected to at least include a geographically representative distribution of national and regional research and innovation authorities and funding agencies from EU Member States, associated countries and their regions. The number of partners and their contribution should be enough to attain a critical mass in the field. The partnership should be open to the addition of new partners during the lifetime of the partnership. The partnership should pool the necessary financial resources from the participating national (or regional) research programmes with a view to implementing joint calls for transnational proposals resulting in grants to third parties and in accordance to the ambition of activities proposed.

The CETP will have to overcome the transnational challenges in the clean energy transition following the ambition of the European Green Deal via a joint, shared, transnational approach, engaging a wide variety of stakeholders including industry and research institutes.

The partnership has to provide a platform that makes research results available for the best use and implementation for all stakeholders and to support capacity building in areas requiring specific resources and expertise. By doing this, public and private investments in clean energy technologies development and deployment can be leveraged and capitalised to ensure adequate exploitation of results across Europe as needed.

Based on priorities identified in the Clean Energy Transition Strategic Research and Innovation Agenda, proposals should pool together the necessary financial resources from the participating national (or regional) research programmes with a view to implementing annual joint calls for proposals resulting in grants to third parties with EU co-funding. National efforts should reflect the ambitions outlined in the National Energy and Climate Plans, including on Member States/Associated Countries participation in the SET Plan work streams. Participation of legal entities from international partner countries and/or regions including those not automatically eligible for funding in accordance with General Annex A is encouraged in the joint calls.

The partnership should envisage clustering activities with other relevant selected projects for cross-projects co-operation, consultations and joint activities on cross-cutting issues. To this end, proposals should provide for a dedicated work package and/or task, and earmark the appropriate resources accordingly. The partnership should also present and implement a joint

programme of activities focussed on communication (participation in joint meetings and communication events), dissemination and exploitation.

The partnership is expected to collaborate closely with the following European Partnerships:

- Clean Hydrogen, Built Environment and construction, European industrial battery value Chain and Driving Urban Transition within the Cluster Climate, Energy and mobility;
- Smart Networks and services, Clean Steel –Low carbon steelmaking, Carbon Neutral and Circular Industry and Geological Services for Europe within the Cluster Digital, Industry and Space;
- Circular Bio-based Europe within the cluster Food, Bioeconomy, Natural Resources, Agriculture and Environment;
- And the Climate-KIC and InnoEnergy EITs;

in order to ensure coherence and complementarity of activities. Applicants are expected to describe in their proposal the methodology for their collaboration and the aims they want to achieve with this kind of collaboration.

It is expected that the partnership will organise joint calls on an annual base from 2022 to 2027 and will consider ample time for the implementation of the co-funded projects.

Call - Sustainable, secure and competitive energy supply

HORIZON-CL5-2021-D3-02

Conditions for the Call

Indicative budget(s)[84]

Topics	Type of Action	Budgets (EUR million)	Expected EU contribution per project (EUR million)[85]	Number of projects expected to be funded
		2021		
Opening: 02 Sep 2021 Deadline(s): 05 Jan 2022				

[84] The Director-General responsible for the call may decide to open the call up to one month prior to or after the envisaged date(s) of opening.
The Director-General responsible may delay the deadline(s) by up to two months.
All deadlines are at 17.00.00 Brussels local time.
The budget amounts are subject to the availability of the appropriations provided for in the general budget of the Union for years 2021 and 2022.

[85] Nonetheless, this does not preclude submission and selection of a proposal requesting different amounts.

HORIZON-CL5-2021-D3-02-01	RIA	5.00	Around 2.50	2
HORIZON-CL5-2021-D3-02-02	RIA	33.00	Around 3.00	11
HORIZON-CL5-2021-D3-02-03	RIA	10.00	Around 3.30	3
HORIZON-CL5-2021-D3-02-04	RIA	18.00	Around 6.00	3
HORIZON-CL5-2021-D3-02-05	RIA	10.00	Around 3.00	3
HORIZON-CL5-2021-D3-02-06	RIA	9.00	Around 3.00	3
HORIZON-CL5-2021-D3-02-07	RIA	15.00	Around 5.00	3
HORIZON-CL5-2021-D3-02-08	RIA	10.00	3.00 to 5.00	2
HORIZON-CL5-2021-D3-02-09	RIA	15.00	Around 5.00	3
HORIZON-CL5-2021-D3-02-10	RIA	10.00	Around 3.50	3
HORIZON-CL5-2021-D3-02-11	RIA	10.00	3.00 to 5.00	2
HORIZON-CL5-2021-D3-02-12	IA	50.00	Around 16.00	3
HORIZON-CL5-2021-D3-02-13	IA	45.00	Around 15.00	3
HORIZON-CL5-2021-D3-02-14	IA	10.00	Around 10.00	1
HORIZON-CL5-2021-D3-02-15	RIA	10.00	Around 5.00	2
HORIZON-CL5-2021-D3-02-16	IA	20.00	Around 10.00	2
Overall indicative budget		280.00		

General conditions relating to this call	
Admissibility conditions	The conditions are described in General Annex A.
Eligibility conditions	The conditions are described in General Annex B.
Financial and operational capacity and exclusion	The criteria are described in General Annex C.
Award criteria	The criteria are described in General Annex D.
Documents	The documents are described in General Annex E.

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Procedure	The procedure is described in General Annex F.
Legal and financial set-up of the Grant Agreements	The rules are described in General Annex G.

Global leadership in renewable energy

Proposals are invited against the following topic(s):

HORIZON-CL5-2021-D3-02-01: AU-EU Water Energy Food Nexus

Specific conditions	
Expected EU contribution per project	The EU estimates that an EU contribution of around EUR 2.50 million would allow these outcomes to be addressed appropriately. Nonetheless, this does not preclude submission and selection of a proposal requesting different amounts.
Indicative budget	The total indicative budget for the topic is EUR 5.00 million.
Type of Action	Research and Innovation Actions
Eligibility conditions	The conditions are described in General Annex B. The following exceptions apply: In addition to the conditions described in General Annex B, at least three partners from three different African countries must be part of the consortium.
Technology Readiness Level	Activities are expected to achieve TRL 4 by the end of the project – see General Annex B.

<u>Expected Outcome</u>: Project results are expected to contribute to all of the following expected outcomes:

- Reinforce the activities in the long term the AU-EU HLPD CCSE Partnership.
- Provide knowledge and scientific modelling as evidence base of the water-energy-food-nexus including the environmental, social and economic trade-offs to contribute to R&I strategy and policy making.
- Increase clean energy generation in the African energy systems.
- A sustained network of African experts and expertise in this area.
- Improve in the long-term governance to advance knowledge and scientific modelling of the water energy food nexus including the environmental, social and economic trade-offs

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(governance aspects should be included since they are under-represented in the current research works).

Scope: The topic is contributing to the activities of the AU-EU High Level Policy Dialog (HLPD) Climate Change and Sustainable Energy (CCSE) partnership. Climate changes and increase usage of water in all economic activities create more stresses on water use for energy generation. Energy generation covers in this context energy from renewable sources and energy vectors such as electricity, heat and fuels. Therefore the needs for African countries of having their own dedicated models to simulate and estimate the stresses on the water-energy nexus are crucial for their policy decision and energy planning. International agreement and trade issues can be considered in the model. Most of the current models are based on developed country standard and usage.

The proposal should then develop and test models for decision makers and planners to implement energy infrastructures and energy supply in Africa which safeguard a systemic approach to the water-energy food nexus. These models can be based on existing reliable source codes and models. The test should be made on the case of an existing African water basin. Participation of societal stakeholders is considered important

Actions should promote the highest standards of transparency in model adoption, going beyond documentation and extending to aspects such as assumptions, architecture, code and data. The outcome of the project should be widely disseminated and the source code of the model should be open access to stimulate future development. To ensure future uses, African experts in water-energy nexus and in model development should be full partners in the project. The project should identify further local training needs.

The project should also link with existing European activities to create synergies and cross-fertilisation. The project should participate in the activities of the HLPD CCSE partnership.

HORIZON-CL5-2021-D3-02-02: Next generation of renewable energy technologies

Specific conditions	
Expected EU contribution per project	The EU estimates that an EU contribution of around EUR 3.00 million would allow these outcomes to be addressed appropriately. Nonetheless, this does not preclude submission and selection of a proposal requesting different amounts.
Indicative budget	The total indicative budget for the topic is EUR 33.00 million.
Type of Action	Research and Innovation Actions
Technology Readiness Level	Activities are expected to achieve TRL 3-4 by the end of the project – see General Annex B.

Expected Outcome: Project results are expected to contribute to all of the following expected outcomes:

- Available breakthrough and game changing renewable energy technologies enabling a faster transition to a net-zero greenhouse gas emissions EU economy by 2050.
- Knowledge and scientific proofs of the technological feasibility of the concept including the environmental, social and economic benefits to contribute to R&I strategy and policy forecast.
- Establishing a solid long term dependable European innovation base.

Scope: The proposal is expected to address high-risk/high return technology developments for game changing renewable energy technologies including catalyst development, dedicated storage systems and integration of renewable energy technologies into a single energy generation system, heating & cooling systems, fuels production systems, hybrid electricity generation solutions between different renewable energy sources, direct utilization of renewable energy sources.

The following areas should not be covered as they fall within the scope of partnerships or other calls:

- Pure material research;
- Conventional hydrogen production and fuel cells;
- Batteries.

However the production of renewable hydrogen directly from renewable energy sources is within the scope of the topic.

The proposal should validate its concept to TRL 3 or TRL 4 through a robust research methodology and activities, establish the technological feasibility of its concept, consider transfer developments in sectors other than energy whenever relevant, as they may provide ideas, experiences, technology contributions, knowledge, new approaches, innovative materials and skills.

In developing its concept the proposal is expected to address the following related aspects: lower environmental impact, better resource efficiency (materials, geographical footprints, water, etc…) than current commercial renewable technologies, issues related to social acceptance or resistance to new energy technologies, related socioeconomic and livelihood issues. Considerations should be given to the regulatory frameworks for their adequate integration.

The project should also document the research process thoroughly - methods, data, results - to ensure that future research and deployment builds on lessons from positive and negative attempts made, through for example public deliverable, ORDP, etc. in order to ensure that the final results and data are actually available after the project end.

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HORIZON-CL5-2021-D3-02-03: Hybrid catalytic conversion of renewable energy to carbon-neutral fuels

Specific conditions	
Expected EU contribution per project	The EU estimates that an EU contribution of around EUR 3.30 million would allow these outcomes to be addressed appropriately. Nonetheless, this does not preclude submission and selection of a proposal requesting different amounts.
Indicative budget	The total indicative budget for the topic is EUR 10.00 million.
Type of Action	Research and Innovation Actions
Technology Readiness Level	Activities are expected to achieve TRL 3-4 by the end of the project – see General Annex B.

Expected Outcome: Carbon-neutral fuels can provide breakthrough solutions towards a fossil-free economy responding to longer-term future demands for high energy density carriers in sectors relying on liquid fuels if making their synthesis more efficient and technically sound. This will contribute to advance the European scientific basis, leadership and global role in the area of renewable fuels by moving forward the supra-national actors, and to reinforce the European potential to export European renewable fuel technologies through international collaboration.

Project results are expected to contribute to all of the following expected outcomes:

- Foster availability of synergetic catalytic systems for carbon-neutral renewable fuels.
- Improve performance of carbon-neutral renewable fuels and European competitiveness.
- Accelerate development of efficient carbon-neutral renewable fuels.

Scope: Proposals will develop hybrid catalytic conversion processes, combining chemical, electrochemical, biological, biochemical and thermochemical catalytic processes to convert renewable energy to carbon-neutral renewable fuels of biological or non-biological origin (other than hydrogen), and which respond to longer-term future demands for high energy density carriers in sectors relying on liquid fuels. The development and combination of novel catalysts and linked lab-scale components and/or systems which improve significantly the performance regarding conversion efficiency for best atomic economy and specific marginal cost reduction should be addressed. Development of catalysts and/or systems with dual function, e.g. catalyst/sorbent or other, may be included. Combination of at least two different catalysts types into a single multicatalytic material as appropriate should be addressed. Improvements as regards the conversion of a broader variety of molecules from the same feedstock and the broader application of hybrid catalytic systems in up-scaled processes should be examined. Maximizing GHG emissions abatement in the conversion process should be

aimed. International cooperation is encouraged. Combination of H2 production by electrolysis and its separate use for catalytic conversion of CO_2 is not covered by this topic.

HORIZON-CL5-2021-D3-02-04: Physics and aerodynamics of atmospheric flow of wind for power production

Specific conditions	
Expected EU contribution per project	The EU estimates that an EU contribution of around EUR 6.00 million would allow these outcomes to be addressed appropriately. Nonetheless, this does not preclude submission and selection of a proposal requesting different amounts.
Indicative budget	The total indicative budget for the topic is EUR 18.00 million.
Type of Action	Research and Innovation Actions
Eligibility conditions	The conditions are described in General Annex B. The following exceptions apply: In order to achieve the expected outcomes, and safeguard the Union's strategic assets, interests, autonomy, or security (namely to keep a European competitive advantage and establish a strong European supply chain), considering that the EU currently holds a first mover advantage and is globally well positioned (State of the Energy Union report 2020 and accompanying Competitive Progress Report) participation is limited to legal entities established in Member States and associated countries. Proposals including entities established in countries outside the scope specified in the topic will be ineligible. If projects use satellite-based earth observation, positioning, navigation and/or related timing data and services, beneficiaries must make use of Copernicus and/or Galileo/EGNOS (other data and services may additionally be used).
Technology Readiness Level	Activities are expected to achieve TRL 5 by the end of the project – see General Annex B.

Expected Outcome: As wind turbines grow bigger and taller, the blade tips are increasing more affected by turbulent atmospheric flow features, while airborne wind energy systems operate at even higher altitudes. This zone of the atmosphere currently lays between the current numeric models at the microscale and the mesoscale. Further, the data integration of the models of these different altitudes is still scarce. Thus, there is a need for an improved understanding of atmospheric flow physics, particularly regarding wind power production forecasting and the design of wind energy technology components.

It is expected that better predictions of wind patterns should:

- Support improved wind farm design, location choice, distribution and operation thus bridging the gap between small-scale controlled experiments and full-scale deployment;
- Enhance system reliability and power production;
- Decrease economic uncertainties related to farm design and power production, as well as wind technology components design and durability;
- Lead to the development of numerical models capable of accurately forecasting high wind flow and power production. It will also improve wakes modelling and the integration of models with real condition wind farm data;
- Use open access of Big Data storage and usage for the testing and performance tracking of the numeric models.

Scope: The proposal is expected to address all of the following aspects:

- Develop an open access knowledge hub for experimental data, based on the principles of open data sharing.
- Develop and validate numeric models to accurately forecast wind flow in low, medium and high altitudes in onshore and offshore scenarios. These models should address how external factors, such as wind conditions, and different climate affect power production and loads on target and neighbouring wind power systems;
- Integrate these different developments (knowledge hub and forecasting models) into a tool able to be readily absorbed by the sector. This integrated approach need to be applicable to at least 2 of these different wind energy conversion technologies: onshore wind, offshore wind (fixed bottom or floating), and high altitude wind systems;
- Validate and promote how such tools could be used to improve the design and deployment of wind farms, through case studies;
- Address and test how such integrated tools can be used for design development of wind technology components (for example blades, towers, substructures, kites, etc.), in particular on the issue of energy efficiency and material durability.

Further indirect impacts on decreased material usage, system efficiency, and social issues should also be made explicit. In order to optimise impact and enhance synergies, cooperation with projects from the Horizon 2020 LC-SC3-RES-31-2020 call is particularly encouraged.

Synergies are possible with topic: HORIZON-CL4-DIGITAL-EMERGING-2022-01-18: 2D materials-based devices and systems for energy storage and/or harvesting (RIA).

HORIZON-CL5-2021-D3-02-05: Wind energy in the natural and social environment

Specific conditions

Expected EU contribution per project	The EU estimates that an EU contribution of around EUR 3.00 million would allow these outcomes to be addressed appropriately. Nonetheless, this does not preclude submission and selection of a proposal requesting different amounts.
Indicative budget	The total indicative budget for the topic is EUR 10.00 million.
Type of Action	Research and Innovation Actions
Procedure	The procedure is described in General Annex F. The following exceptions apply: To ensure a balanced portfolio, grants will be awarded to applications not only in order of ranking but at least also to the highest ranking proposal addressing offshore wind farms and the highest ranking proposal addressing onshore wind farms, provided they attain all thresholds. This condition to ensure a balanced portfolio will also considered to be met if one project addressing both aspects is funded.
Technology Readiness Level	Activities are expected to achieve TRL 5 by the end of the project – see General Annex B.

Expected Outcome: Renewable energy technologies will be evermore present in the lives of European citizens, thus a harmonious co-existence is essential. Wind turbines are particularly susceptible to the NIMBY effect (Not In My BackYard), and hence it is facing opposition despite being a high-potential clean energy source. In order to achieve the European goals on climate neutrality, dedicated actions in this context are needed to ensure that large turbines retain a low environmental impact and gain more popular support. A particular focal point should be how to best engage with different communities to identify actions toward the co-existence goal.

Project results are expected to contribute to all of the following expected outcomes:

- Develop and promote the use of modelling tools and objective holistic assessment metrics for realistic in-depth analysis of cumulative impacts of wind installations on the environment and on local communities;
- Develop guidelines to enhance energy citizenship[86]of (onshore or offshore) wind energy and farms, promoting a harmonious co-existence between the local population, other sectors (e.g. fishing communities, tourism) and the wind farms;
- Realise outreach activities to promote social awareness and engagement on wind energy, and develop guidelines for participatory processes in wind farm development to reach interactive and mutually value-enhancing outcomes;

[86] Creating energy citizenship through material participation

- Facilitate both the identification of future areas for deployment, notably of offshore wind farms, and the consenting process.

Scope: The proposal is expected to address all the following aspects:

- Develop and promote the use of validated models and guidelines as a tool for enhanced societal engagement. Further, it should also demonstrate how participatory processes can enhance value creation and achieve higher social acceptability of wind energy;

- Assess through validated models how wind turbines impact the local environment (noise, impact on soil or sea beds, visual effect, effects on animal life and other species). In addition, it should also assess, if applicable, how offshore wind turbines (and fixed or floating substructures) impact the local marine environment (currents, waves, upwelling, and sediment transport). Finally, it should help to identify the best areas for deployment and to develop new designs and/or enhanced control strategies of wind turbines to address potential impacts;

- Develop a forum where regulators, industry, and local communities can exchange information and provide input to one another. Further, it should also identify the effect that the implemented models have on promoting wind energy;

- Address how the impact of different wind energy innovations and applications (onshore, offshore, floating, and airborne) is seen by the general public and the local actors.

This topic requires the effective contribution of Social Science and Humanities (SSH) disciplines and the involvement of SSH experts, institutions as well as the inclusion of relevant SSH expertise, in order to produce meaningful and significant effects enhancing the societal impact of the related research activities. Social innovations should also be considered, notably as new tools, ideas and methods leading to active citizen engagement and as drivers of social change, social ownership, and new social practices.

HORIZON-CL5-2021-D3-02-06: Novel approaches to concentrated solar power (CSP)

Specific conditions	
Expected EU contribution per project	The EU estimates that an EU contribution of around EUR 3.00 million would allow these outcomes to be addressed appropriately. Nonetheless, this does not preclude submission and selection of a proposal requesting different amounts.
Indicative budget	The total indicative budget for the topic is EUR 9.00 million.
Type of Action	Research and Innovation Actions
Eligibility conditions	The conditions are described in General Annex B. The following exceptions apply:

	If projects use satellite-based earth observation, positioning, navigation and/or related timing data and services, beneficiaries must make use of Copernicus and/or Galileo/EGNOS (other data and services may additionally be used).

Expected Outcome: Concentrating solar power (CSP) plants supply renewable, dispatchable power and can therefore be an important element of the evolving energy system. Project results are expected to contribute to all of the following expected outcomes:

- Higher shares of variable output renewables in the energy system.
- Future, higher-efficiency CSP plants.
- Reduced levelized cost of electricity of future CSP plants.
- Significant performance regarding start-up, shutdown and load variation of future CSP plants.
- Improved environmental profile of future CSP plants.

Scope: Support will be given to novel solutions that use concentrating solar thermal energy to generate power.

In terms of power dispatchability, the novel solutions will have to ensure a performance at least equivalent to current commercial installations.

Solutions that cogenerate power and heat are also in the scope. Moreover, solutions that support the concentrating solar thermal technology with photovoltaic technology are also in the scope.

Projects should assess the sustainability of the proposed solutions in environmental and socio-economic terms. Applicants are encouraged to consider a 'circularity by design' approach.

HORIZON-CL5-2021-D3-02-07: Stable high performance Perovskite Photovoltaics

Specific conditions	
Expected EU contribution per project	The EU estimates that an EU contribution of around EUR 5.00 million would allow these outcomes to be addressed appropriately. Nonetheless, this does not preclude submission and selection of a proposal requesting different amounts.
Indicative budget	The total indicative budget for the topic is EUR 15.00 million.
Type of Action	Research and Innovation Actions
Technology Readiness Level	Activities are expected to achieve TRL 5 by the end of the project – see General Annex B.

Expected Outcome: Photovoltaic power generation is pivotal in the transition to a clean energy system and the achievement of the zero-emissions target. To that end, it is important to enhance affordability, security of supply and sustainability of PV technologies along with further efficiency improvements. Consequently, project results are expected to contribute to all of the following outcomes:

- Increase the efficiency and stability and minimise the environmental impact of Perovskite PV.
- Enlarge with bandgap tuneable perovskites and corresponding device architectures the integration and application possibilities of PV technology.
- Increase the potential for commercialisation of perovskite PV, creating a competitive technological know-how for the European PV industrial base.

Scope: Perovskite PV are welcomed as an emerging technology for solar energy conversion, as today they afford high power conversion efficiency (PCE), higher than 25%. At the same time, perovskite semiconductors are based on abundant and low-cost starting materials and can be processed using simple and economic methods. The tuneable bandgap of the perovskite materials opens a lot of applications in a wide range of optoelectronic devices, even beyond solar cells. To ensure however economic feasibility and competitive levelized cost of electricity, the technology should offer long-term stability alongside high power conversion efficiency to match the reliability of silicon-wafer-based modules (the lifetime expectation for a PV module in a power plant is 20–25 years). At present, the long-term stability of lead halide perovskite modules does not meet this target and improvements are hampered by a lack of understanding of the cell and module failure modes. In addition to the intrinsic cell stability issues of perovskite PV, the usage of lead and scaling-up are the main challenges towards bringing perovskite technologies to the market.

The proposal should address all of the following:

- Research and resolve the degradation issues/mechanisms encountered from material to module and produce stable and highly efficient perovskite PV architectures/modules by optimizing the constituent materials, the architecture of the cell, the interfaces, the interconnections between cells, the environment conditions during the fabrication steps of cells and modules, the encapsulation of cells and modules, etc.
- Propose new device concepts and new materials (improved lead-halide perovskites or Pb-free perovskite analogues) to deal with any toxicity issues.
- Ensure compliance with the relevant protocols (ISOS) at laboratory scale.
- Develop adequate stability assessment methods/measurements; propose and perform device/module real –life (under actual outdoor operating conditions) characterisation for reliability and energy yield assessment.

- Identify environmental "hotspots" and how to address them. Perform a life cycle analysis (including decommissioning and disposal) to bring evidence of the low environmental impact, better resource efficiency than current commercial PV technologies, and circularity potential.

HORIZON-CL5-2021-D3-02-08: Cost-effective micro-CHP and hybrid heating systems

Specific conditions	
Expected EU contribution per project	The EU estimates that an EU contribution of between EUR 3.00 and 5.00 million would allow these outcomes to be addressed appropriately. Nonetheless, this does not preclude submission and selection of a proposal requesting different amounts.
Indicative budget	The total indicative budget for the topic is EUR 10.00 million.
Type of Action	Research and Innovation Actions
Technology Readiness Level	Activities are expected to achieve TRL 5 by the end of the project – see General Annex B.

Expected Outcome: Project results are expected to contribute to some of the following expected outcomes:

- Increased technical performance, robustness, feasibility and penetration of renewables at household level
- Increase technology leadership and competitiveness of European industry
- Increased production share of renewables at consumer level
- Increased socioeconomic and environmental sustainability of renewables based energy systems at household level.

Scope: Develop new technologies for biomass micro-CHP systems, including e.g. high efficiency supercritical CHP systems with embedded integration of other renewables into hybrid heating systems for maximizing the overall share of renewables at household and/or multifamily level and emission reduction.

Improve the integration of compatible renewable technologies in household and/or multifamily generators of heat and power making them attractive by addressing technological bottlenecks, efficiency, cost-effectiveness and socio-economic as well as environmental sustainability.

HORIZON-CL5-2021-D3-02-09: Carbon-negative sustainable biofuel production

Specific conditions

Expected EU contribution per project	The EU estimates that an EU contribution of around EUR 5.00 million would allow these outcomes to be addressed appropriately. Nonetheless, this does not preclude submission and selection of a proposal requesting different amounts.
Indicative budget	The total indicative budget for the topic is EUR 15.00 million.
Type of Action	Research and Innovation Actions
Technology Readiness Level	Activities are expected to achieve TRL 4-5 by the end of the project – see General Annex B.

Expected Outcome: Reusing or inhibiting biogenic effluent gases from biofuel production in the same process, increases the biomass conversion efficiency and sustainability potential and the overall resource and energy efficiency of the biomass utilization. Improving such integration will contribute to increase the biofuel technology competitiveness and acceptance and advance the European leadership and global role in the area of sustainable biofuels.

Project results are expected to contribute to all of the following expected outcomes:

- Increase bioenergy efficiency and sustainability.
- Increase sustainable biomass resource utilization.
- Generate negative emissions from biofuel production.

Scope: Proposals should develop cost-effective solutions to minimize carbon waste in sustainable biofuel production processes by inhibiting biogenic effluent gas emissions or incorporating biological and/or chemical/other capture of the biogenic effluent gas emissions from the process and use it as appropriate either for separate in-situ downstream synthesis of renewable fuels of biological origin, or integrate it in the sustainable biofuel production through recycling. Proposals should also include an innovative approach for biogenic carbon storage, through for example integrating production of biochar and using it as soil amendment to enhance organic carbon content and functionality of soil, as well as a means to sequester carbon into the soil. Synergies with renewable hydrogen production should be developed by incorporating it as appropriate in the sustainable biofuel production to compensate for additional needs in hydrogen, increase overall biomass conversion efficiency, minimize the biogenic carbon waste and reduce the fossil carbon footprint of the biofuel production. The overall GHG emissions should be assessed on the basis of a Life Cycle Analysis for proving negative GHG emissions and higher sustainability potential of biofuel production when reusing biogenic effluent gases in-situ, along with addressing socioeconomic aspects.

HORIZON-CL5-2021-D3-02-10: Innovative foundations, floating substructures and connection systems for floating PV and ocean energy devices

Specific conditions

Expected EU contribution per project	The EU estimates that an EU contribution of around EUR 3.50 million would allow these outcomes to be addressed appropriately. Nonetheless, this does not preclude submission and selection of a proposal requesting different amounts.
Indicative budget	The total indicative budget for the topic is EUR 10.00 million.
Type of Action	Research and Innovation Actions
Eligibility conditions	The conditions are described in General Annex B. The following exceptions apply: In order to achieve the expected outcomes, and safeguard the Union's strategic assets, interests, autonomy, or security (namely to keep a European competitive advantage and establish a strong European supply chain), considering that the EU currently holds a first mover advantage and is globally well positioned (State of the Energy Union report 2020 and accompanying Competitive Progress Report) participation is limited to legal entities established in Member States and associated countries. Proposals including entities established in countries outside the scope specified in the topic will be ineligible.
Technology Readiness Level	Activities are expected to achieve TRL 4-5 by the end of the project – see General Annex B.

Expected Outcome: Project results are expected to contribute to all of the following expected outcomes:

- Improved overall life time, reliability, installability, operability and maintainability of marine substructures, mechanical joints and energy connection systems for ocean energy devices and/or offshore floating PV to reduce degradation and failure rates and thus investment risk.
- Better understanding of the device's real life performance allowing a safe reduction in the over-engineering of devices' specifications.
- Reduction of LCOE in line with the SET Plan targets (actions should clearly justify estimated LCOE at project start and end, using a recognised calculation methodology).
- Contribution to the objectives of the Mission Healthy oceans, seas, coastal and inland waters.

Scope: The action is expected to:

- Test and validate the potential benefits of new circular materials in offshore floating PV and/or ocean energy substructures, foundations and if relevant mooring and anchoring systems whilst ensuring structural integrity and durability considering very high wind

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(speed >25 m/s), current (>1.2 m/s) and wave (height >14 m) loads and corrosion and biofouling on all elements of the ocean energy systems.

- Test and validate new prototype components and materials used in offshore floating PV and/or ocean energy devices and verify that they are compatible with and resistant to the marine environment**.**
- Research material properties and behaviour in combination with the use of improved predictive computational modelling tools.
- Research, develop and validate improved predictive computational modelling tools for material properties.

The use of existing test facilities and related research infrastructures for the purposes of the project should be considered.

This topic requires the effective contribution of SSH disciplines and the involvement of SSH experts, institutions as well as the inclusion of relevant SSH expertise, in order to produce meaningful and significant effects enhancing the societal impact of the related research activities.

The selected projects are expected to contribute and participate to the activities of the project BRIDGE[87] when relevant.

HORIZON-CL5-2021-D3-02-11: Development of hydropower equipment for hidden hydropower

Specific conditions	
Expected EU contribution per project	The EU estimates that an EU contribution of between EUR 3.00 and 5.00 million would allow these outcomes to be addressed appropriately. Nonetheless, this does not preclude submission and selection of a proposal requesting different amounts.
Indicative budget	The total indicative budget for the topic is EUR 10.00 million.
Type of Action	Research and Innovation Actions
Technology Readiness Level	Activities are expected to achieve TRL 5 by the end of the project – see General Annex B.

Expected Outcome: Project results are expected to contribute to some of the following expected outcomes:

- Advance the European scientific basis, leadership and global role in the area of sustainable hydropower while creating evidence for policy making.

[87] https://www.h2020-bridge.eu/

- Create additional sustainable hydropower capacity to the existing fleet, maintain and advance European technological competitiveness in the sector, thus supporting the EU goals for climate protection, energy independence and economic growth.
- Enhance sustainability of added hydropower capacities by addressing social, economic and environmental aspects and by promoting prosumer renewable energy in cities and communities.

Scope: Development of hydropower equipment for hidden and therefore unrealised hydropower by developing novel technologies which allow for increased techno-economic feasible and sustainable hydropower production in non-hydropower hydraulic systems with low head and/or small reservoir or water body size and/or impaired water quality (e.g. saltwater), that may also involve prosumer solutions.

HORIZON-CL5-2021-D3-02-12: Innovation on floating wind energy deployment optimized for deep waters and different sea basins (Mediterranean Sea, Black Sea, Baltic Sea, North-east Atlantic Ocean)

Specific conditions	
Expected EU contribution per project	The EU estimates that an EU contribution of around EUR 16.00 million would allow these outcomes to be addressed appropriately. Nonetheless, this does not preclude submission and selection of a proposal requesting different amounts.
Indicative budget	The total indicative budget for the topic is EUR 50.00 million.
Type of Action	Innovation Actions
Eligibility conditions	The conditions are described in General Annex B. The following exceptions apply: In order to achieve the expected outcomes, and safeguard the Union's strategic assets, interests, autonomy, or security (namely to keep a European competitive advantage and establish a strong European supply chain), considering that the EU currently holds a first mover advantage and is globally well positioned (State of the Energy Union report 2020 and accompanying Competitive Progress Report) participation is limited to legal entities established in Member States and associated countries. Proposals including entities established in countries outside the scope specified in the topic will be ineligible.
Procedure	The procedure is described in General Annex F. The following exceptions apply: To ensure a balanced portfolio covering multiple geographical areas, grants will be awarded to applications not only in order of ranking but

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	priority will be given to high-ranking proposals addressing each of the different sea basins, provided that the proposals attain all thresholds.
Technology Readiness Level	Activities are expected to achieve TRL 7 by the end of the project – see General Annex B.

Expected Outcome: Floating offshore wind has the potential to unleash a new European industrial sector able to deliver clean and sustainable energy. Building from European technological and industrial know-how and harnessing the natural resources of the different sea basins around the European Union, namely the Mediterranean Sea, the Black Sea, the Baltic Sea and the North-east Atlantic Ocean, there is an opportunity to leverage these conditions into technological leadership, while supporting the goal of climate neutrality.

In this context, project results are expected to contribute to all of the following expected outcomes:

- Development or significant improvement of designs that reduce both CAPEX and OPEX;
- Deployment and demonstration of advanced full-scale floating wind turbines prototypes, and auxiliary equipment, in operational environment;
- Allow development of cost-efficient scalable solutions supporting exploitation of the renewable energy offshore potential in challenging conditions, while building upon innovative designs of floating structures and auxiliary equipment;
- Contribute to LCOE reduction in line with the SET Plan targets (actions should clearly justify an estimated LCOE at project start and end).

Scope: The proposal is expected to deploy in one of the possible sea basins[88] in Europe. Further, the proposal should:

- Demonstrate how innovations (materials, technologies, designs,…) on floating wind turbines, substructures, dynamic cables, control systems and moorings positively affect production;
- Demonstrate in real use scenario the improvements that the identified solutions contribute in terms of life expectancy, cost reductions, as well as operation and maintenance of a floating offshore wind installation;
- Demonstrate how the proposed innovations positively increase rate of deployment of offshore wind in deep seas, reducing capital, operational and maintenance costs, as well as present an industrial roadmap for a floating energy industrial sector, with focus on mass production;

[88] The boundaries between the sea basins as defined in the Directive 2008/56/EC.

- Document all demonstrations fully and transparently, to ensure replicability, up-scaling and to assist future planning decisions;
- Demonstrate a modular design suited to large-scale deployment in various environments, with special focus on industrial mass production;
- Ensure minimal environmental impact of these innovations, and address how Maritime Spatial Planning can be used to facilitate the identification and optimal use of suitable locations for floating wind platforms.

The proposal has to include a clear go/no go moment ahead of entering the deployment phase. Before this go/no-go moment, the project will have to deliver the detailed engineering plans, a complete business and implementation plan and all needed permits for the deployment of the project. The proposal is expected to clearly demonstrate a proposed pathway to obtaining necessary permits for the demonstration actions and allow for appropriate timelines to achieve these. The proposal is expected to also demonstrate how it will get a financial close[89] for the whole action. Independent experts will assess all deliverables and will advise for the go/no-go decision.

The proposal should take a multi-disciplinary and multi-stakeholder approach, to ensure that different viewpoints and interests are taken into account in development and deployment processes and to help avoid foreseeable externalities. Thus, it requires the effective contribution of SSH disciplines and the involvement of SSH experts, institutions as well as the inclusion of relevant SSH expertise, in order to produce meaningful and significant effects enhancing the societal impact of the related research activities

The selected projects are expected to contribute and participate to the activities of the project BRIDGE[90] when relevant.

HORIZON-CL5-2021-D3-02-13: Demonstration pilot lines for alternative and innovative PV technologies (Novel c-Si tandem, thin film tandem, bifacial, CPV, etc.)

Specific conditions	
Expected EU contribution per project	The EU estimates that an EU contribution of around EUR 15.00 million would allow these outcomes to be addressed appropriately. Nonetheless, this does not preclude submission and selection of a proposal requesting different amounts.

89 Financial close occurs when all the project and financing agreements have been signed and all the required conditions contained in them have been met. It enables funds to start flowing so that project implementation can actually start. It includes, but it is not limited to, permitting and planning approvals, outstanding technical design issues, remaining key project and financing documents, and funding approvals. More information can be found at: https://www.eib.org/epec/g2g/iii-procurement/32/323/index.htm

90 https://www.h2020-bridge.eu/

Indicative budget	The total indicative budget for the topic is EUR 45.00 million.
Type of Action	Innovation Actions
Eligibility conditions	The conditions are described in General Annex B. The following exceptions apply: In order to achieve the expected outcomes and safeguard the Union's strategic assets, interests, autonomy or security (namely to create a European competitive advantage and re-establish a strong European photovoltaic supply chain, as stipulated in the Competitiveness Progress Report accompanying the 2020 State of the Energy Union Report), participation is limited to legal entities established in Member States and associated countries. Proposals including entities established in countries outside the scope specified in the topic will be ineligible.
Technology Readiness Level	Activities are expected to achieve TRL 7 by the end of the project – see General Annex B.

Expected Outcome: Photovoltaic power generation is pivotal in the transition to a clean energy system and the achievement of the zero-emissions target. To that end, it is important to enhance affordability, security of supply and sustainability of PV technologies along with further efficiency improvements. To insure security of supply, retaining the whole value chain in Europe is essential; technology de-risking is a necessary step towards this direction. Consequently, project results are expected to contribute to all of the following outcomes:

- Promote a considerable pipeline of new and advanced versions of existing technologies from lab to fab production, enabling robust continued performance increase, opening up new applications and facilitating further cost reduction.
- Reinforce the European PV value chain, support local companies to develop and sell differentiated and high value PV products and create local jobs.
- Demonstrate the feasibility and cost-competiveness of the novel PV technologies.
- Contribute towards establishing a solid European innovation base.
- Enable and facilitate large-scale deployment of PV and generation of renewable electricity.
- Minimise the impact of PV on landscape and environment by increasing its energy yield/m2.

Scope: Net-zero scenarios modelled by the JRC[91] show that Europe needs to install up to 600 GW PV generation capacity by 2030 and over 1 TW by 2050 to reach its climate and energy

[91] https://doi.org/10.1016/j.rser.2020.109836

objectives. The European market will grow 10-15% per year and reach close to 80 GW by 2030. In this race, Europe has a unique opportunity to develop and deploy new generation PV modules. A considerable number of new and advanced/innovative technologies is in the pipeline but the concrete application on pilot manufacturing lines is lagging behind. The aim is therefore to advance those technologies that offer the potential for much higher efficiency and/or higher energy yield, the same lifetime and degradation rate and comparable cost to standard crystalline technologies, opening-up possibilities for largescale 4.0 factories to drive down costs, allowing large relocation of production to Europe.

The proposal should address all of the following:

- Develop and demonstrate at pilot line level innovative or alternative and advanced versions of existing PV technologies: the pilot lines should show the feasibility and cost-competitiveness of industrial production of cells and modules.
- Develop corresponding manufacturing equipment.
- Implement Industry 4.0 concepts.
- Test and validate the performance characteristics of manufactured products (efficiency, durability, reliability, etc.).
- Demonstrate a business case for manufacturing plants of individual output capacity in the GW range and a market introduction strategy.
- Address the following related aspects: lower environmental impact, better resource efficiency than current commercial renewable technologies, circularity potential (including recycling and sustainability by design).
- Document all demonstrators fully and transparently to ensure replicability and up scaling, to assist future planning decisions.

The proposal should involve multidisciplinary consortia including industrial partners.

HORIZON-CL5-2021-D3-02-14: Demonstration of large-scale CHP technologies for a shift to the use of biogenic residues and wastes

Specific conditions	
Expected EU contribution per project	The EU estimates that an EU contribution of around EUR 10.00 million would allow these outcomes to be addressed appropriately. Nonetheless, this does not preclude submission and selection of a proposal requesting different amounts.
Indicative budget	The total indicative budget for the topic is EUR 10.00 million.
Type of Action	Innovation Actions

Eligibility conditions	The conditions are described in General Annex B. The following exceptions apply: The following additional eligibility criteria apply: Proposals that include 'Hybrid' approaches that combine the use of renewable energy with the continued use of fossil fuels, are not eligible.
Technology Readiness Level	Activities are expected to achieve TRL 7 by the end of the project – see General Annex B.

Expected Outcome: Project results are expected to contribute to some of the following expected outcomes:

- Advance the European scientific basis and increase technology competitiveness in the area of bioenergy, in particular increase penetration of renewables, regional development, cost reduction and feedstock enlargement thus supporting the EU goals for climate protection, energy independence and economic growth;
- Technology de-risk retrofitting of large-scale fossil CHP to bioenergy as a necessary step before scaling up at commercial level;
- Allow high penetration in the energy system, ensure stability and security of energy supply and gain efficiency and costs in transforming the energy system on a decarbonised basis, in particular by reducing CAPEX for bioenergy capacity and base-load capability;
- Enhance sustainability of renewable energy and fuel value chains by addressing social, economic and environmental aspects.

Scope: Demonstration of cost-effective and efficient technologies for retrofitting of fossil CHP systems to the complete use of regionally sourced sustainable biogenic residues and wastes or derived intermediate bioenergy carriers for continuous, cost-effective and low-emission operation. Proposals are expected to address long-term scenarios for flexible and modular operation within the energy system network and document all demonstrators fully and transparently, to ensure replicability, up-scaling and to assist future planning decisions.

HORIZON-CL5-2021-D3-02-15: Solutions for more sustainable geothermal energy

Specific conditions	
Expected EU contribution per project	The EU estimates that an EU contribution of around EUR 5.00 million would allow these outcomes to be addressed appropriately. Nonetheless, this does not preclude submission and selection of a proposal requesting different amounts.
Indicative budget	The total indicative budget for the topic is EUR 10.00 million.

Type of Action	Research and Innovation Actions
Technology Readiness Level	Activities are expected to achieve TRL 5 by the end of the project – see General Annex B.

Expected Outcome: Project results are expected to contribute to all of the following expected outcomes:

- Performance and reliability improvement of shallow and/or deep geothermal systems;
- Reduced environmental impact of geothermal plants;
- Reduced risk of seismicity;
- Increased citizen engagement for geothermal energy;
- Reduction of LCOE approaching SET Plan targets (actions should clearly justify estimated LCOE at project start and end);
- Energy efficient, environmentally sound, and economically viable generation of electricity, and/or heating and cooling from geothermal resources in a wide range of geological settings, enabling geothermal energy development in new regions and supporting application concepts for local energy supply.

Scope: The proposal is expected to develop and validate innovative sustainable circular-by-design solutions that can reduce environmental impact and increase the overall circularity of geothermal energy. The following can be considered:

- Capture of greenhouse gases, storage or reinjection schemes for the development and exploitation of geothermal reservoirs, in particular those with high content of non-condensable gases (NCGs), and the use of alternative fluid to brine.
- Techniques for reservoir development and exploitation in a wider range of geological settings, including complex and/or untested geological conditions.
- Potential introduction and demonstration of the innovative technologies as part of existing geothermal plants in Europe and abroad.
- Novel methods and technologies to find and develop productivity from near magmatic, superhot/supercritical zones that are currently unexploitable and non-commercial.

This topic requires the effective contribution of SSH disciplines and the involvement of SSH experts, institutions as well as the inclusion of relevant SSH expertise, in order to produce meaningful and significant effects enhancing the societal impact of the related research activities.

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HORIZON-CL5-2021-D3-02-16: Innovative biomethane production as an energy carrier and a fuel

Specific conditions	
Expected EU contribution per project	The EU estimates that an EU contribution of around EUR 10.00 million would allow these outcomes to be addressed appropriately. Nonetheless, this does not preclude submission and selection of a proposal requesting different amounts.
Indicative budget	The total indicative budget for the topic is EUR 20.00 million.
Type of Action	Innovation Actions
Technology Readiness Level	Activities are expected to achieve TRL 6-7 by the end of the project – see General Annex B.

Expected Outcome: Biomethane is a renewable substitute of natural gas, which can provide energy storage capability and be a flexible renewable energy carrier to be fed to the existing gas grid if reaching quality standards at an affordable price.

Project results are expected to contribute to all of the following expected outcomes:

- Increase cost-effectiveness of the conversion in biomethane production.
- Diversify the conversion technology basis for biomethane production.
- Contribute to market up-take of biomethane related technologies in the gas market.
- Contribute to the priorities of the SET Plan Action 8.

Scope: Proposals will demonstrate cost-effective and innovative biomethane production through thermochemical, biochemical, chemical, electrochemical, biological pathways including sustainable biomass and biogenic wastes gasification, CO_2 effluents from anaerobic digestion or fermentation processes combined with renewable hydrogen or water. The biomethane production should be optimized to improve production efficiency, reduce cost, minimize GHG emissions and increase sustainability in a circularity approach for energy and material above conventional technologies of biogas upgrading to biomethane. All demonstrators should be fully and transparently documented, to ensure replicability, up-scaling and to assist future planning decisions. Demonstrating advanced technologies for efficient production at scale of biomethane will contribute to facilitate the market introduction of the biomethane technologies and the substitution of natural gas in the gas grid. This is the basis for penetration of biomethane in the energy and the transport energy systems, in particular for gas consuming sectors. It supports the European Green Deal and climate and energy targets for 2030 and the net zero greenhouse gas emissions by 2050, while supporting the EU goals for energy independence and competitive sustainable growth.

Call - Sustainable, secure and competitive energy supply

HORIZON-CL5-2022-D3-01

Conditions for the Call

Indicative budget(s)[92]

Topics	Type of Action	Budgets (EUR million)	Expected EU contribution per project (EUR million)[93]	Number of projects expected to be funded
		2022		
Opening: 14 Oct 2021 Deadline(s): 23 Feb 2022				
HORIZON-CL5-2022-D3-01-01	IA	20.00	Around 10.00	2
HORIZON-CL5-2022-D3-01-02	IA	40.00	Around 13.00	3
HORIZON-CL5-2022-D3-01-03	IA	32.00	Around 16.00	2
HORIZON-CL5-2022-D3-01-04	IA	20.00	Around 20.00	1
HORIZON-CL5-2022-D3-01-05	IA	10.00	Around 10.00	1
HORIZON-CL5-2022-D3-01-06	IA	10.00	Around 5.00	2
HORIZON-CL5-2022-D3-01-07	IA	10.00	Around 10.00	1
HORIZON-CL5-2022-D3-01-08	IA	18.00	5.00 to 6.00	3
HORIZON-CL5-2022-D3-01-09	IA	55.00	Around 55.00	1
HORIZON-CL5-2022-D3-01-10	IA	7.00	2.00 to 3.00	3
HORIZON-CL5-2022-D3-01-11	IA	30.00	7.00 to 8.00	4
HORIZON-CL5-2022-D3-01-12	IA	35.00	8.00 to 9.00	4
HORIZON-CL5-2022-D3-01-13	RIA	6.00	Around 6.00	1

92 The Director-General responsible for the call may decide to open the call up to one month prior to or after the envisaged date(s) of opening.
The Director-General responsible may delay the deadline(s) by up to two months.
All deadlines are at 17.00.00 Brussels local time.
The budget amounts are subject to the availability of the appropriations provided for in the general budget of the Union for years 2021 and 2022.

93 Nonetheless, this does not preclude submission and selection of a proposal requesting different amounts.

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HORIZON-CL5-2022-D3-01-14	IA	30.00	7.00 to 8.00	4
HORIZON-CL5-2022-D3-01-15	IA	58.00	Around 29.00	2
Overall indicative budget		381.00		

General conditions relating to this call	
Admissibility conditions	The conditions are described in General Annex A.
Eligibility conditions	The conditions are described in General Annex B.
Financial and operational capacity and exclusion	The criteria are described in General Annex C.
Award criteria	The criteria are described in General Annex D.
Documents	The documents are described in General Annex E.
Procedure	The procedure is described in General Annex F.
Legal and financial set-up of the Grant Agreements	The rules are described in General Annex G.

Global leadership in renewable energy

Proposals are invited against the following topic(s):

HORIZON-CL5-2022-D3-01-01: Demonstration of cost-effective advanced biofuel technologies utilizing existing industrial plants

Specific conditions	
Expected EU contribution per project	The EU estimates that an EU contribution of around EUR 10.00 million would allow these outcomes to be addressed appropriately. Nonetheless, this does not preclude submission and selection of a proposal requesting different amounts.
Indicative budget	The total indicative budget for the topic is EUR 20.00 million.
Type of Action	Innovation Actions

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Technology Readiness Level	Activities are expected to achieve TRL 6-7 by the end of the project – see General Annex B.

Expected Outcome: The cost-effective integration of advanced biofuel technologies in existing industrial plants will contribute to increase the competitiveness of these technologies and overcome the costly scaling-up of advanced biofuel production which requires heavy new infrastructure and investments and impedes their capacity building. It will thus allow high penetration of advanced biofuels in the transport energy system, in particular for hard to electrify sectors like aviation and maritime. Project results are expected to contribute to all of the following expected outcomes:

- Reduce capital and operational expenses (CAPEX and OPEX) of advanced biofuel production facilities.
- De-risk technology, boost scale-up of advanced biofuels and contribute to their market up-take.
- Contribute to the priorities of the SET Plan Action 8.
- Respond to short and medium term needs for renewable fuels in transport.
- Create win-win solutions for advanced biofuel production and conventional industrial phasing out plants, e.g., first generation biofuels, associated with socio-economic benefits.

Scope: Proposals should demonstrate cost-efficient advanced biofuel technologies which improve the economic viability of the advanced biofuel production. This should be done through innovative transformation of existing plants to incorporate production of advanced biofuels from non-food/feed sustainable biomass feedstock into existing processes, e.g., first generation biofuel plants, paper mill industry, waste treatment plants, oil-refineries, petrochemical industry, etc. Integration of advanced biofuel processing should be done with new and innovative installations and it should be optimized implementing a circularity approach for energy and material, as well as digitalization as appropriate, e.g. by using sensors, smarter equipment, algorithms etc., to increase the efficiency, cost-effectiveness and performance of the final plant. Economic advantages in terms of both capital and operational expenditure for commercialization of advanced biofuels through transformation, as well as socio-economic benefits for phasing-out industries including the impact on current first generation biofuel sites should be addressed. Proposals should provide information about the expected economic improvements and the potential of full transformation to advanced biofuel plants as appropriate. All demonstrators should be fully and transparently documented, to ensure replicability, up-scaling and to assist future planning decisions.

This topic requires the effective contribution of SSH disciplines and the involvement of SSH experts, institutions as well as the inclusion of relevant SSH expertise, in order to produce meaningful and significant effects enhancing the societal impact of the related research activities.

HORIZON-CL5-2022-D3-01-02: Demonstration of innovative materials, supply cycles, recycling technologies to increase the overall circularity of wind energy technology and to reduce the primary use of critical raw materials

Specific conditions	
Expected EU contribution per project	The EU estimates that an EU contribution of around EUR 13.00 million would allow these outcomes to be addressed appropriately. Nonetheless, this does not preclude submission and selection of a proposal requesting different amounts.
Indicative budget	The total indicative budget for the topic is EUR 40.00 million.
Type of Action	Innovation Actions
Eligibility conditions	The conditions are described in General Annex B. The following exceptions apply: In order to achieve the expected outcomes, and safeguard the Union's strategic assets, interests, autonomy, or security (namely to keep a European competitive advantage and establish a strong European supply chain), considering that the EU currently holds a first mover advantage and is globally well positioned (State of the Energy Union report 2020 and accompanying Competitive Progress Report) participation is limited to legal entities established in Member States and associated countries. Proposals including entities established in countries outside the scope specified in the topic will be ineligible.
Procedure	The procedure is described in General Annex F. The following exceptions apply: To ensure a balanced portfolio, grants will be awarded to applications not only in order of ranking but at least also the highest ranking proposal of each activity area as described in the topic will be funded, provided that the applications attain all thresholds.
Technology Readiness Level	Activities are expected to achieve TRL 6-7 by the end of the project – see General Annex B.

Expected Outcome: To achieve the goals of climate-neutrality by 2050, renewable energy sources installations will have an explosive growth. Wind energy, in particular, will play a large role on supplying clean energy to the electrical grid. Nevertheless, this growth must be done in a sustainable manner and following the principles set out in the Circular Economy Action Plan and the Action Plan on Critical Raw Materials. Thus, clear and decisive actions will need to be taken now to assure that the future wind farms are sustainable and circular, while also dealing with current wind farms and the recycling of their components, once they reach the end of their lifetime. The nature of this challenge involves different kinds of activities.

The first activity is on the development of large-scale industrial demonstration of composite material recycling technologies to increase the circularity of wind technology. This demonstration will focus on flexible approaches for composite recycling, and on the development of a knowledge hub involving other composite-heavy sectors, in order to share best practices and to identify common challenges.

Another activity is on the development of alternative solutions to replace/substitute critical raw materials. Further constraints linked to the availability of rare earths elements used in the wind sector, in particular for permanent magnets, are also relevant in this context.

The project results are expected to contribute to the promotion of the 'circularity by design' approach in the wind energy sector, and to support the adoption of life cycle assessment tools, demonstrating reduced carbon footprint on the wind turbine value chain.

Scope: The proposal is expected to address one of the following activity areas:

- On the development of large-scale industrial demonstration of composite material recycling technologies to increase the circularity of wind technology, proposals are expected to demonstrate recycling technologies at large-scale in an operating environment. The proposed solution will be a flexible production line, able to deal with a large amount of material (including, for example, coatings, paints, etc.) and applicable to several manufacturers and possibly to other sectors. The proposed solution should also have a long-term plan, with a business plan, beyond the life of the project. The proposals will also build a knowledge hub within the sector and with other sectors to transfer information and to promote recycling in the renewable energy sector and 'circularity by design' as a solution.

- On the development of alternative solutions to replace/substitute critical raw materials, proposals need to develop and demonstrate, in a relevant or operational environment, solutions and their supply cycles, improving efficiency of sourcing processes and effectively replacing the constrained materials. The development of advanced 'circular by design' materials should also be considered. The solutions proposed should be in line with the Action Plan on Critical Raw Materials [94]and the Foresight Study on Critical Raw Materials for Strategic Technologies and Sectors in the EU[95]. Finally, the proposals will indicate the effect that such proposed solutions have on promoting circularity and/or recyclability on wind energy, as well as their circularity potential, their financial feasibility, and their potential to be upscaled. Further, the proposals should address and support life cycle analysis as a tool to bring into evidence the environmental impact and resource efficiency of proposed solutions.

Independently of the activity tackled, the proposal has to include a clear go/no go moment ahead of entering the deployment phase. Before this go/no-go moment, the project will have to deliver the detailed engineering plans and all needed permits for the deployment of the project. In the

94 COM(2020) 474 - Critical Raw Materials Resilience: Charting a Path towards greater Security and Sustainability

95 Critical Raw Materials for Strategic Technologies and Sectors in the EU - A Foresight Study

case of the first activity, the project will also have to deliver a complete business and implementation plan. The proposal is expected to clearly demonstrate a proposed pathway to obtaining necessary permits for the demonstration actions and allow for appropriate timelines to achieve these. The proposal is expected to also demonstrate how it will get a financial close[96] for the whole action. Independent experts will assess all deliverables and will advise for the go/no-go decision.

Synergies are possible with topic: HORIZON-CL4-2021-RESILIENCE-01-23: Novel recycling technologies for composite materials (RIA).

The selected projects are expected to contribute and participate to the activities of the project BRIDGE[97] when relevant.

HORIZON-CL5-2022-D3-01-03: Advanced manufacturing of Integrated PV

Specific conditions	
Expected EU contribution per project	The EU estimates that an EU contribution of around EUR 16.00 million would allow these outcomes to be addressed appropriately. Nonetheless, this does not preclude submission and selection of a proposal requesting different amounts.
Indicative budget	The total indicative budget for the topic is EUR 32.00 million.
Type of Action	Innovation Actions
Eligibility conditions	The conditions are described in General Annex B. The following exceptions apply: In order to achieve the expected outcomes and safeguard the Union's strategic assets, interests, autonomy or security (namely to create a European competitive advantage and re-establish a strong European photovoltaic supply chain, as stipulated in the Competitiveness Progress Report accompanying the 2020 State of the Energy Union Report), participation is limited to legal entities established in Member States and associated countries. Proposals including entities established in countries outside the scope specified in the topic will be ineligible.
Technology Readiness Level	Activities are expected to achieve TRL 7 by the end of the project – see General Annex B.

96 Financial close occurs when all the project and financing agreements have been signed and all the required conditions contained in them have been met. It enables funds to start flowing so that project implementation can actually start. It includes, but it is not limited to, permitting and planning approvals, outstanding technical design issues, remaining key project and financing documents, and funding approvals. More information can be found at: https://www.eib.org/epec/g2g/iii-procurement/32/323/index.htm

97 https://www.h2020-bridge.eu/

Expected Outcome: Photovoltaic power generation is pivotal in the transition to a clean energy system and the achievement of the zero-emissions target. To that end, it is important to enhance affordability, sustainability and exploit the modularity and synergies of application of PV technologies. Consequently, project results are expected to contribute to all of the following outcomes:

- Demonstrate that automated manufacturing of integrated photovoltaics (IPV) can deliver cost competitive products assuming both the function of energy generators and of structural elements.
- Reinforce the European PV value chain, support local companies to develop and sell differentiated IPV products and create local jobs.
- Enable and facilitate large-scale integration of PV in buildings in line with the concept of "positive energy buildings", in infrastructure, transport, agriculture, etc.
- Minimise the impact of PV on landscape and environment exploiting its modularity and synergies of use.

Scope: "Integrated PV" stands for photovoltaics that are embedded into components fulfilling other functions. The most well-known and developed application currently is Building Integrated PV (BIPV), in which PV is integral part of construction elements (tiles, façades, cladding, …) and assembled to constitute a system replacing a conventional building envelope solution. However, other Integrated PV (IPV) solutions are markedly emerging, for example in infrastructure (IIPV), in the automotive industry (VIPV), in agriculture, etc. In addition to the overall PV goal of lowering the LCOE, IPV applications can bring the extra value of decentralized, point-of-use electricity generation and simultaneously fulfil another function such as of a roofing, facade or sound barrier. Progressively developing and having the potential for a world-wide market with huge opportunities for the European industry, manufacturing of customized IPV in series production concept needs to be developed to bring down the cost of Integrated PV allowing for largescale production and use.

The proposal should address all of the following:

- Demonstrate at pilot line level flexible automated manufacturing for:
    - differentiated product design (format, different thicknesses of substrate and variations in the solar cell matrix, encapsulation material, front sheet, etc.) respecting freedom of design and aesthetics for various applications;
    - integration of advanced robust techniques for inline process and quality control;
    - equipment design easily adaptable to rapidly emerging novel cell and module technologies;
    - high product efficiency and durability at competitive costs, in conformity with codes and standards of integrated photovoltaics (IPV) use.

- Implement Industry 4.0 concepts.
- Demonstrate a business case and a market introduction strategy.
- Facilitate the 'renovation wave' by establishing an active collaboration between the PV sector and the building industry for seamless industrial construction/renovation workflows.
- Address the following related aspects: low environmental impact, resource efficiency and circularity potential.

The proposal should involve multidisciplinary consortia including industrial partners.

HORIZON-CL5-2022-D3-01-04: Demonstrate the use of high temperature geothermal reservoirs to provide energy storage for the energy system

Specific conditions	
Expected EU contribution per project	The EU estimates that an EU contribution of around EUR 20.00 million would allow these outcomes to be addressed appropriately. Nonetheless, this does not preclude submission and selection of a proposal requesting different amounts.
Indicative budget	The total indicative budget for the topic is EUR 20.00 million.
Type of Action	Innovation Actions
Technology Readiness Level	Activities are expected to achieve TRL 7 by the end of the project – see General Annex B.

Expected Outcome: Project results are expected to contribute to all of the following expected outcomes:

- Performance and reliability improvement of geothermal systems.
- Reduced environmental impact of geothermal plants.
- Increased citizen engagement.
- Reduction of LCOE approaching SET Plan targets (actions should clearly justify the estimated LCOE at project start and end).

Scope: High-temperature underground thermal energy storage (HT-UTES) covers the 25-90°C temperature range, and the targets of interest can reach up to 2000 m in depth. The development of UTES is linked to a multidisciplinary understanding of the whole system, including waste-heat source, exploration and subsurface characterisation, production, implementation and distribution systems, as well as the adaptation of the regulatory framework and social acceptance. The main technical challenges are the adaptation of the return temperature from the surface site to the subsurface temperature and to the regulatory frameworks, identification,

characterisation and monitoring the reservoirs for UTES, the geo-mechanical effects of the reservoir linked to the seasonal injection/ production operations related to pressure and temperature changes, hydrogeochemical problems associated with scaling and corrosion of the piping system, circular design and optimisation of the distribution network.

The proposal is expected to:

- Develop and demonstrate appropriate control systems and infrastructure to manage geothermal heat and electricity production, heat demand and storage connected to the installation.
- Use the flexibility of geothermal reservoirs as thermal energy storage systems and flexibility in the network coping with daily, weekly and seasonal variations in heat demand.
- Demonstrate the innovative technologies in at least 2 different plants with different characteristics.

This topic requires the effective contribution of SSH disciplines and the involvement of SSH experts, institutions as well as the inclusion of relevant SSH expertise, in order to produce meaningful and significant effects enhancing the societal impact of the related research activities.

HORIZON-CL5-2022-D3-01-05: Demonstration of innovative plug-and play solutions for system management and renewables storage in off-grid applications

Specific conditions	
Expected EU contribution per project	The EU estimates that an EU contribution of around EUR 10.00 million would allow these outcomes to be addressed appropriately. Nonetheless, this does not preclude submission and selection of a proposal requesting different amounts.
Indicative budget	The total indicative budget for the topic is EUR 10.00 million.
Type of Action	Innovation Actions
Technology Readiness Level	Activities are expected to achieve TRL 8 by the end of the project – see General Annex B.

Expected Outcome: Project results are expected to contribute to some of the following expected outcomes:

- Advance the European innovative knowledge basis, technology base, technology leadership in the area of renewable energy-based off-grid energy systems, while creating evidence for policy making in the context of off-grid energy systems.

- Improve environmental and socio-economic sustainability of the renewable-energy off-grid systems, particularly on geographic energy islands and/or in Africa and/or Central Asia.
- Technology de-risk through prototype demonstration tested and validated in operational environment as a necessary step before scaling up at commercial level.
- Reinforce the European scientific and innovation basis through international collaboration on off-grid energy systems while increasing the potential to export European renewable energy technologies and ensuring political priorities.

Scope: Demonstration of innovative plug and play solutions for system management and renewables storage in off-grid applications, which allow for increase of renewables penetration for electricity and heating/cooling and are deployable under different climatic conditions, while also addressing cost-effectiveness, energy poverty and security of supply and by promoting prosumer renewable energy in off-grid cities and communities (including on geographic islands).

This topic requires the effective contribution of SSH disciplines and the involvement of SSH experts, institutions as well as the inclusion of relevant SSH expertise, in order to produce meaningful and significant effects enhancing the societal impact of the related research activities.

HORIZON-CL5-2022-D3-01-06: Novel Agro-Photovoltaic systems

Specific conditions	
Expected EU contribution per project	The EU estimates that an EU contribution of around EUR 5.00 million would allow these outcomes to be addressed appropriately. Nonetheless, this does not preclude submission and selection of a proposal requesting different amounts.
Indicative budget	The total indicative budget for the topic is EUR 10.00 million.
Type of Action	Innovation Actions
Eligibility conditions	The conditions are described in General Annex B. The following exceptions apply: In order to achieve the expected outcomes and safeguard the Union's strategic assets, interests, autonomy or security (namely to create a European competitive advantage and re-establish a strong European photovoltaic supply chain, as stipulated in the Competitiveness Progress Report accompanying the 2020 State of the Energy Union Report), participation to the topic is limited to legal entities established in Member

	States and associated countries. Proposals including entities established in countries outside the scope specified in the topic will be ineligible.
Technology Readiness Level	Activities are expected to achieve TRL 7 by the end of the project – see General Annex B.

Expected Outcome: Photovoltaic power generation is pivotal to a clean energy system and the achievement of the zero-emissions target. To that end, it is important to enhance affordability, sustainability and exploit the modularity and synergies of application of PV technologies. Consequently, project results are expected to contribute to all of the following outcomes:

- Harvesting of crops and photovoltaic electricity, providing sustainable solutions for energy production/use/efficiency, soil protection and water conservation.
- Reinforce the European PV value chain, introduce new business models and open new markets for novel Agro-Photovoltaic systems.
- Minimise the impact of PV on landscape and environment exploiting its modularity and synergies of use.

Scope: Agro-Photovoltaics (or Agrivoltaics) denotes approaches to use agricultural areas simultaneously to produce crops and to generate PV electricity. In this way, Agro photovoltaics increases land-use efficiency and enables PV capacity to be expanded solving the problem of energy poverty in the agricultural sector, while still retaining fertile arable areas for agriculture.

The proposal should address all of the following:

- Develop and demonstrate agro-photovoltaic systems or building integrated agro-photovoltaic systems for green houses employing PV cell technologies/systems that allow and are adapted to appropriate growth conditions (plant variety and local geography) and at the same time produce electricity covering all year-through energy needs (e.g. for cooling/heating, watering, etc.) and increased crop yield.
- Demonstrate feasibility, reliability, replicability, robustness and ease of maintenance of the system and its performance using relevant KPIs (for e.g. ground coverage ratio, energy and agricultural yield, spatial efficiency, etc.).
- Demonstrate a business case for the concept and market introduction strategy.
- Address the following related aspects: low environmental impact (avoiding or minimizing land impact from PV systems), resource efficiency and circularity potential.
- Include a strong involvement of citizens/civil society, together with academia/research, industry/SMEs and government/public authorities.

This topic requires the effective contribution of SSH disciplines and the involvement of SSH experts, institutions, as well as the inclusion of relevant SSH expertise, in order to produce

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meaningful and significant effects enhancing the societal impact of the related research activities.

HORIZON-CL5-2022-D3-01-07: Demonstration of innovative rotor, blades and control systems for tidal energy devices

Specific conditions	
Expected EU contribution per project	The EU estimates that an EU contribution of around EUR 10.00 million would allow these outcomes to be addressed appropriately. Nonetheless, this does not preclude submission and selection of a proposal requesting different amounts.
Indicative budget	The total indicative budget for the topic is EUR 10.00 million.
Type of Action	Innovation Actions
Eligibility conditions	The conditions are described in General Annex B. The following exceptions apply: In order to achieve the expected outcomes, and safeguard the Union's strategic assets, interests, autonomy, or security (namely to keep a European competitive advantage and establish a strong European supply chain), considering that the EU currently holds a first mover advantage and is globally well positioned (State of the Energy Union report 2020 and accompanying Competitive Progress Report) participation is limited to legal entities established in Member States and associated countries. Proposals including entities established in countries outside the scope specified in the topic will be ineligible.
Technology Readiness Level	Activities are expected to achieve TRL 7 by the end of the project – see General Annex B.

Expected Outcome: Project results are expected to contribute to all of the following expected outcomes:

- Demonstrated increased performance (>20%) and reliability of tidal energy devices.
- Improved knowledge on how to operate tidal energy devices, their availability, maintainability and survivability.
- Reduction of LCOE approaching SET Plan targets (actions should clearly justify the estimated LCOE at project start and end using a recognised calculation methodology).
- Reinforced industrial supply chain.

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- Attraction of private investors to the sector and reduce the cost of their investment to projects with evidences and credible key performance indicators.

Scope: There is a need for further technology investigation and demonstration for improved reliability and efficiency of tidal turbine rotor and blades, including control and condition monitoring systems. Failure in a blade can create long downtimes, for instance blade edges can erode rapidly, facilitating water ingress, accelerating fatigue and the risk of failure. There are different blade solutions under development in terms of shape and material. Improving the seaworthiness of rotor and blades will reduce the likelihood of failure, reduced annual energy production and increases in operating costs.

The proposal is expected to:

- Demonstrate innovative rotor and blade solutions including condition monitoring systems for tidal energy devices in real sea conditions for long periods of time (12-24 months) providing invaluable learnings regarding performance, reliability, availability, maintainability, survivability and environmental impact.

- Apply high performance computing and digitalisation (e.g. data processing, machine learning and data analytics methods for implementation in data driven design, digital twins and control and monitoring for O&M).

The selected projects are expected to contribute and participate to the activities of the project BRIDGE[98] when relevant.

Energy systems, grids and storage

Proposals are invited against the following topic(s):

HORIZON-CL5-2022-D3-01-08: Supporting the action of consumers in the energy market and guide them to act as prosumers, communities and other active forms of active participation in the energy activities

Specific conditions	
Expected EU contribution per project	The EU estimates that an EU contribution of between EUR 5.00 and 6.00 million would allow these outcomes to be addressed appropriately. Nonetheless, this does not preclude submission and selection of a proposal requesting different amounts.
Indicative budget	The total indicative budget for the topic is EUR 18.00 million.
Type of Action	Innovation Actions
Technology Readiness Level	Activities are expected to achieve TRL 6-8 by the end of the project – see General Annex B.

[98] https://www.h2020-bridge.eu/

Expected Outcome: Project results are expected to contribute to most of the following expected outcomes:

- Demonstrate in real life interactive communication and support tools to engage citizens in the energy transition and to support them throughout the process of creating, constituting and developing an energy community, that are developed and fine-tuned based on field-tests;
- Engagement of distributed active consumers and energy communities at broad scale, including through innovative incentive mechanisms;
- Enabled new market roles and market participants;
- Enabled automated participation;
- Residential and SME related Demand Response contributing to increased level of flexibility and to the development of new flexibility products;
- Identified drivers and rules beyond marginal pricing which can steer the transactions within the energy communities;
- Developing mechanisms to support the creation, growth and capacity building of energy communities.

Scope: The provisions of the Clean Energy Package have paved the way for a new, more active role of prosumers and energy communities in the electricity market. Innovative tools and tailored solutions should be developed and tested in order to fully enable new type of interactions between citizens as consumers, prosumers and (members of) energy communities and foster participation in energy (in particular electricity) markets.

To this aim, projects should link citizens, technologies, regulation and markets together.

Tools should be developed to support demonstration of the energy community paradigm shift within the mentioned context using suitable digital platforms for putting the citizens in direct contact with each other, suppliers, aggregators and other involved market stakeholders and to increase prosumers' satisfaction and participation.

Dedicated demonstrations should be set to demonstrate the use of these interactive tools to contribute to real-time optimization of Distributed Energy Resources and the facilitation of investment decisions at household or community level in RES or demand response.

To get the acceptance of different energy technologies in civil society, these demonstrations should be built on SSH approach to take into account the social and behavioural dimension at the stage of their design, also considering safety issues of electrical systems.

As a result, these demonstrations are expected to aim to increase the understanding of consumer's behaviour (e.g. by understanding how they are providing demand side flexibility as close as possible to real-time). They should also aim to create innovative tools and tailored

solutions to empower prosumers, to help them to realise energy communities and finally pave the way for the energy transition.

With these new insights the projects are expected to adapt the solution, test it again and compare the outcome of both iterations.

The tested solutions should be able to reconciling the top-down market developments with the bottom-up changes in the market arrangement and participation.

Solutions are expected to be as replicable as possible and to be demonstrated in a variety of geographical locations in different Member States/Associated Countries representing very different social and economic situations. In addition, regulatory / administrative barriers and possible solutions should be assessed as part of the projects.

To do so, projects are expected to design, develop and test incentives for market participants to react to system conditions according to location and time, while at the same time considering maximization of their economic benefit.

Projects should develop the entire functional chain from data collection and elaboration, to local flexibility needs and user-centric compensation enabling the active participation of prosumers.

Projects should take into account related ongoing activities under H2020 and Horizon Europe and are expected to contribute to relevant BRIDGE[99] activities.

HORIZON-CL5-2022-D3-01-09: Real Time Demonstrator of Multi-Vendor Multi-Terminal VSC-HVDC with Grid Forming Capability (in support of the offshore strategy)

Specific conditions	
Expected EU contribution per project	The EU estimates that an EU contribution of around EUR 55.00 million would allow these outcomes to be addressed appropriately. Nonetheless, this does not preclude submission and selection of a proposal requesting different amounts.
Indicative budget	The total indicative budget for the topic is EUR 55.00 million.
Type of Action	Innovation Actions
Technology Readiness Level	Activities are expected to achieve TRL 6-7 by the end of the project – see General Annex B.

Expected Outcome: Project results are expected to contribute to the following expected outcomes:

- Real Time Demonstrator of a Multi-Vendor Multi-Terminal HVDC (High Voltage Direct Current) with Grid Forming Capability to de-risk the technology and pave the way to the

[99] https://www.h2020-bridge.eu/

installation of the first installation in Europe of a Multi-Vendor Multi-Terminal HVDC system with Grid Forming capability. The Grid Forming capability in the demonstrator addresses the loss of inertia that the grid will incur with the huge integration of offshore RES.

- New way of framing the European energy system (on- off-shore) architecture and topology.
- Way opening to the offshore energy development. Provide new pathways to offshore energy and grid development.
- Involvement, best practice and acquired experience and confidence of all stakeholders (HVDC system manufacturers, TSOs, third-party HVDC system integrators, wind turbine manufacturers, offshore wind farm developers).

Scope: The real-time demonstrator is the preliminary step to de-risk the technology and enable a real life demonstrator application, which will pave the way to the exploitation of the offshore RES and the development of the offshore grid. Proposals will include all the necessary activities concurring to the implementation of a Real Time Demonstrator of a Multi-Vendor Multi-Terminal HVDC (Voltage Source Converter High Voltage Direct Current) with Grid Forming capability. HVDC systems are applicable and can be planned, designed and integrated in any part of the AC grid, i.e. onshore as well as offshore. Following the Commission's adoption of the "Strategy on Offshore Renewable Energy", attention is presently focused to offshore grid application. The HVDC system will guarantee at least the following capabilities or better:

- Independent and full control over the active and reactive power;
- Provide support to weak AC systems;
- Power flow reversal without the need of reversing the voltage polarities;
- Excellent response to AC faults;
- Black start capabilities.

These include, but are not limited to:

- Requirements for multi-vendor converter capabilities in all connection points (AC side, DC side).
- Definition of basic and detailed functional specifications, control and protection interoperability, readiness for future seamless system extension, standardization of HVDC models and replicas, model for interoperability assessment of grid forming converters, etc.).
- Definition of basic and detailed functional specifications, control and protection interoperability, and standardisation of wind power plant models and replicas for assessment of integration to HVDC grids.

- Development, integration, testing and validation of HV components and sub-systems guaranteeing interoperability. Evaluation of the technological challenges related to placing MT-HVDC systems subsea, e.g. at the sea bottom.

- Real-time physical demonstrator of a HVDC system connected to the AC grid with at least three terminals of three different manufacturers with power rating applicable in the current existing real life use cases.

- Contextually, proposals will address grid codes and standardisation issues for all European operators in close cooperation with the European Commission.

- Regulatory framework analysis, definition and application aspect.

The selected projects are expected to contribute to relevant BRIDGE[100] activities.

HORIZON-CL5-2022-D3-01-10: Interoperable solutions for flexibility services using distributed energy storage

Specific conditions	
Expected EU contribution per project	The EU estimates that an EU contribution of between EUR 2.00 and 3.00 million would allow these outcomes to be addressed appropriately. Nonetheless, this does not preclude submission and selection of a proposal requesting different amounts.
Indicative budget	The total indicative budget for the topic is EUR 7.00 million.
Type of Action	Innovation Actions
Technology Readiness Level	Activities are expected to achieve TRL 5-7 by the end of the project – see General Annex B.

Expected Outcome: Project results are expected to contribute to all] of the following expected outcomes:

- A new generation of energy management systems implemented to provide the capability of a hybrid energy storage systems (HESS) to work as a conventional battery energy storage system with enhanced performance. Hybrid energy storage systems can concern distributed sources of storage, such as EV Batteries, Home Batteries, or connection with the Heat Pumps.

- Agreeing in wide scope of stakeholders including EV community and other sources of storage (e.g. flexible heat pumps) on a common protocol that could connect different storage applications (Energy- Home management system, heat pumps, EVs).

[100] https://www.h2020-bridge.eu/

- Validation of user acceptance, and demonstrating concepts that ensure privacy, liability, security and trust in connected data spaces.

- To encourage European citizens and businesses, especially SMEs to deploy storage, the ease of use and consequently interoperability are a must.

Scope: The objective is to develop interoperable distributed storage technology to enable the seamless utilization and monetization of storage flexibility within a real life environment.

Pilots need to demonstrate innovative Battery Energy Storage Systems (BESS) and Hybrid Energy Storage Systems HESS solutions within the home, building, community and stand-alone and power grid connected together with TSO and/or DSO, including real-time data sharing and operation.

At least 2 pilots, with different use cases (overall covering both BESS and HESS systems), should present interoperable solutions involving different types of BESS.

The project(s) should facilitate HESS reaching a similar interoperability and Plug-and-Play capabilities of a BESS with extended performance by using virtualization techniques.

A new generation of hybrid energy storage systems (HESS) that can efficiently operate with the combined capacities of the individual energy storage systems (ESS) that conform it. Hybrid energy storage systems can concern distributed sources of storage, such as EV Batteries, Home Batteries, or connection with the Heat Pumps.

Real-time data sharing and operation should be ensured through aligning existing standards from the utility and ICT domains, across the devices and systems to enable innovative distributed storage services.

Deployment and adoption of IoT standards and platforms for distributed storage systems (stationary and electric vehicles) in Europe and development of cost-effective and sustainable European distributed storage ecosystems and related business models are expected. For example:

- Access of third parties to the minimum necessary data to perform aggregation functions should be looked at: which type of data could be made available for 3rd parties.

- Common solution between different stakeholder groups and different brands of devices should be looked at (for example storage from Heat Pumps requires coordination with several brands, so as to come up with a possible cross brands and cross sector solution).

- HESS dimensioning methodology depending on the application and integration conditions, including the selection of different European manufacturers ESS to conform the HESS, connection architecture, and control. Aspects of competition to be considered (include different manufacturers).

- Validation of the HESS integration in a real environment, demonstrating an efficient energy management, and the benefits of the combined capability of the individual ESS.

- Framework for use of data that may be considered as personal data generated by natural persons under the GDPR.

Common architecture models (Smart Grids Architecture Model - SGAM[101]) and implementing standards (such as CEN-CENELEC, SAREF etc.) should be taken into account to ensure interoperability and compatibility.

Highest (semantic) interoperability should be reached for alluse cases of storage and cost of deployment of distributed storage is decreased.

The need for standard harmonization across industry sectors should be explored, along with legislation and demonstration of scalability and stimulation of spill-over effects, for example towards applications beyond road transport.

Feedback mechanisms from the users should be envisaged to allow adaptation and optimisation of the technological and business approach to the particular use case. For all actions, the consortia have to involve and/or engage relevant stakeholders and market actors who are committed to adopting/implementing the results.

The selected projects are expected to contribute to relevant BRIDGE[102] activities. Projects should take into account existing interoperability related work of previous and ongoing H2020 and HE research projects such as INTERCONNECT[103].

Collaboration and synergies with the co-programmed European Partnership 2Zero are also expected. Areas will concern interoperable aspects of integration of storage from the EVs, including research on minimum data to be made ready for the third parties (for purpose of storage), e.g. HORIZON-CL5-2021-D5-01-03: System Approach for advanced Static Smart Charging: integration of EV with the infrastructure of the grid.

Similarly, collaboration and synergies are expected with European Partnership "Towards a competitive European industrial battery value chain for stationary applications and e-mobility". Areas concern battery management system and operation data (e.g. HORIZON-CL5-2021-D2-01-06: Physics and data-based battery management for optimised battery utilisation), and complementarities where integration of battery systems into larger systems is not tackled (e.g. HORIZON-CL5-2022-D2-01-05: Next generation technologies for High-performance and safe-by-design battery systems for transport and mobile applications), will also be expected.

This topic will benefit from the effective contribution of SSH disciplines and the involvement of SSH experts, institutions as well as the inclusion of relevant SSH expertise, in order to produce meaningful and significant effects enhancing the societal impact of the related research activities. The Commission will make sure that projects benefit from SSH expertise through the cooperation in Bridge.

101 https://ec.europa.eu/energy/sites/ener/files/documents/xpert_group1_reference_architecture.pdf
102 https://www.h2020-bridge.eu/
103 https://interconnectproject.eu/

HORIZON-CL5-2022-D3-01-11: Demonstration of innovative forms of storage and their successful operation and integration into innovative energy systems and grid architectures

Specific conditions	
Expected EU contribution per project	The EU estimates that an EU contribution of between EUR 7.00 and 8.00 million would allow these outcomes to be addressed appropriately. Nonetheless, this does not preclude submission and selection of a proposal requesting different amounts.
Indicative budget	The total indicative budget for the topic is EUR 30.00 million.
Type of Action	Innovation Actions
Eligibility conditions	The conditions are described in General Annex B. The following exceptions apply: In order to achieve the expected outcomes, and safeguard the Union's strategic assets, interests, autonomy, or security, namely for keeping maximum flexibility to preserve knowlegde and ownership on new energy storage technologies, as these are highly critical for European competitiveness and for the European energy system transformation, participation is limited to legal entities established in Member States and associated countries. Proposals including entities established in countries outside the scope specified in the topic will be ineligible. For duly justified and exceptional reasons, notably for keeping maximum flexibility to preserve knowlegde and ownership on new energy storage technologies, as these are highly critical for European competitiveness and for the European energy system transformation, and in order to guarantee the protection of the strategic interests of the Union and its Member States, legal entities established in a Member State or in countries associated to Horizon Europe that are directly or indirectly controlled by third countries not associated to Horizon Europe or by legal entities of non-associated third countries, are not eligible to participate. Proposals including entities that are controlled by third countries outside the scope specified in the topic/call/action will be ineligible.
Technology Readiness Level	Activities are expected to achieve TRL 6-7 by the end of the project – see General Annex B.

Expected Outcome: Project results are expected to contribute to most of the following expected outcomes:

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- Demonstration of innovative storage technologies which go beyond the state-of-the art of existing storage solutions in respect of sustainability, technical performance, lifetime, non-dependency on location geographical particularities and cost.
- Increased availability, robustness and safety of sustainable and efficient choices for energy storage to reduce energy losses and improve the environmental footprint of the energy system.
- Demonstrated availability and functionality of innovative energy storage systems developed for specific system designs and applications.
- Improvement of the already established European storage value chain able to contribute to the EU climate neutrality objectives.
- Creation and improvement of European technological value chains with the potential for international cooperation and market exploration
- Demonstration of successful business cases and systems designs for energy storage integration solutions in innovative and 'green' energy systems at different scales and timeframes.
- Demonstration of effective integration of innovative energy storage systems and value chains at the interface of renewable energies and specific demand sectors
- Ensuring the compatibility of systems and standards of distributed energy storage for participation in flexibility markets.

Scope: Demonstration of successful operation and integration of either standalone or combined innovative storage solutions (e.g. chemical, electrical, thermal, mechanical including e.g. compressed air/liquid, supercapacitors, innovative hydropower storage solutions) into innovative energy systems and grid architectures.

Solutions should in particular explore, how innovative storage solutions can enable and drive further the successful penetration of renewable into the European energy mix across several important demand sectors (industry, energy, transport, residential, agriculture) by delivering effectively at the interface of renewable energies and specific demand sector needs.

The solutions should show clear innovation with respect to the state of the art e.g. through use of new advanced materials or new design solutions, always bearing in mind the objective of sustainability and circular economy, minimizing the environmental footprint.

The demonstrated technologies should respond to energy storage flexibility requirements in form of technological requirements and expected future investment and operational costs and business cases in existing or emerging energy markets, by acknowledging existing system designs and energy grid architectures. The demonstrated technologies should include interfaces for connecting with existing infrastructure, e.g. of hydraulic systems for innovative hydropower

or the use of natural gas storage sites for hydrogen or biomethane storage, or abandoned infrastructure such as mines, or storage solutions in district heating networks.

When integrating the storage solution, common architecture models (Smart Grids Architecture Model - SGAM[104]) and implementing standards (such as CEN-CENELEC, SAREF etc.) should be taken into account to ensure interoperability and compatibility.

Highest interoperability should be reached ideally for all, but in any case for most of the use cases of storage, so that cost of deployment of distributed storage is decreased.

Technical and regulatory barriers, also including the market dimension, should be taken into account. This together with considering consumer acceptance of the solution as a prerequisite to increasing participation of consumers in the energy system.

The selected projects are expected to contribute to relevant BRIDGE[105] activities.

HORIZON-CL5-2022-D3-01-12: Replicable solutions for a cross sector compliant energy ecosystem

Specific conditions	
Expected EU contribution per project	The EU estimates that an EU contribution of between EUR 8.00 and 9.00 million would allow these outcomes to be addressed appropriately. Nonetheless, this does not preclude submission and selection of a proposal requesting different amounts.
Indicative budget	The total indicative budget for the topic is EUR 35.00 million.
Type of Action	Innovation Actions
Technology Readiness Level	Activities are expected to achieve TRL 6-7 by the end of the project – see General Annex B.

Expected Outcome: Project results are expected to contribute to most of the following expected outcomes:

- A catalogue of services and flexibility potential of appliances tailor-made for specific consumer groups, as well as the accompanying IT-tools that can help them providing flexibility services to the energy market and system.
- Increase participation of energy consumers in demand side flexibility markets by reducing entry barriers and transaction cost, in particular in relation to data exchange and market access.
- Provide viable interoperable solutions and products, available to all levels of the grid including within the home, which makes it simple to increase flexibility in energy

104 https://ec.europa.eu/energy/sites/ener/files/documents/xpert_group1_reference_architecture.pdf
105 https://www.h2020-bridge.eu/

consumption and have a positive impact in balancing demand/response with an increasing share of renewable energy sources.

- Create a vibrant cross-sector ecosystem, successfully mobilising demand-response and demonstrating opportunities for new services provided by SMEs and start-ups.
- Create sustainable marketplaces based on a comprehensive catalogue of energy smart appliances (home appliances including EV charging and distributed energy storage), services and hardware/software solutions compliant with a set of standards for Minimum Interoperability.
- Demonstrate the potential for a sustainable up-take (coordinated across all projects from the call) based on components and solutions piloted in real life.

Scope: Promote the adoption and usage of connected interoperable energy smart home appliances (including the EV charging and home storage) and solutions in order to accelerate the deployment of demand-side flexibility services, reduce the entry barrier and facilitate replication.

- Identify a set of open standards for Minimum Interoperability based on the results of multiple research and innovation projects and existing technological developments as well as already available open standards and/or open source solutions to enable energy smart appliances and solutions to participate in demand side flexibility.
- Provide new business models supported by innovative interoperable solutions enabled by connecting systems from different sectors.
- Test interoperable services/solutions based on a reference architecture and minimum interoperability mechanisms that can enable flexibility.
- The solutions initially developed in a pilot in one country will have to be tested, in real life, in at least two other countries, with different energy constraints, by different entities. The overall target is replication in as many Member States/Associated Countries as possible.
- Create and populate a commonly agreed catalogue of energy smart home appliances (including EV charging and storage), services and hardware/software solutions compliant to a set of standards for Minimum Interoperability.
- The call is open to all stakeholders. For instance, utilities, ESCO/aggregators, appliances manufacturers, energy cooperatives, retailers owning buildings (heating/cooling) in many cities, office building that in their parkings offer eV chargers, water treatment plants, public buildings, schools, ICT companies, system integrators, Data Centre operators, EV manufacturers, storage providers, industry and other relevant stakeholders with a role in the energy flexibility market.

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- The projects should support the proliferation of innovative energy and energy services markets building on interoperable solutions that can be tailored easily to the type or need of users. Therefore the projects should take into account the social and behavioural dimensions of consumer's participation and to get the acceptance of different energy technologies.

- The solutions are expected to adapt digital technologies to the specificities and requirements of the energy system (Artificial Intelligence, Big Data, 5G, cloud/edge computing, Internet of Things ...).

- While complying with cybersecurity requirements privacy issues are to be specifically considered. They have to be built on open architectures and commonly agreed standards derived from these technologies (such as SAREF) and relevant European and Global ICT and Energy Standards Development Organisation and associations

- The selected projects will cooperate among themselves and with other relevant projects through regular common workshops, exchange of non-confidential reports, etc.

The selected projects are expected to contribute to relevant BRIDGE[106] activities.

HORIZON-CL5-2022-D3-01-13: Energy system modelling, optimisation and planning tools

Specific conditions	
Expected EU contribution per project	The EU estimates that an EU contribution of around EUR 6.00 million would allow these outcomes to be addressed appropriately. Nonetheless, this does not preclude submission and selection of a proposal requesting different amounts.
Indicative budget	The total indicative budget for the topic is EUR 6.00 million.
Type of Action	Research and Innovation Actions

Expected Outcome: Projects are expected to contribute to all the following outcomes:

- Provide regional, national and European public authorities and network operators, with customisable open source models of the components of the energy system, as well as tools to assemble these component models into a model of the energy system integrating the infrastructure related to all energy carriers in a given geographical area, with static and dynamic modelling capabilities.

- Provide regional, national and European public authorities and network operators, with an open source tool to allow them to better plan and optimise the development of renewable and low emission energy sources and the enhancement of infrastructure (including

[106] https://www.h2020-bridge.eu/

storage) to meet the future energy needs in a geographical area, while minimising the total investment and operation cost, hence satisfying the future final uses of energy (sometimes used as a feedstock) by consumers, at lowest cost and with better quality of service.

Scope: Advanced modelling tools to perform regional / cross-border and cross-energy vector system planning and optimisation on a long time horizon, where cross-sectoral disruptive innovations in industry, mobility and building sector can be included

Building on existing open source models or on the opening of currently proprietary models, as far as they are available, the project should develop and validate open source models of the components of the energy system and provide tools to integrate these component models into a **system model** to satisfy the (future) needs in a geographical area, thereby providing a planning tool for cost and emissions optimisation **of the enhanced energy system at pan-European level**. The aim is to better plan and optimise the expansion of the energy generation and transmission and storage systems to meet the (future) energy needs aggregated at a granularity level finer or equal to the NUTS2 level; the distribution layer to individual energy users is not to be considered.

The open source modelling tool should be composed of the most relevant of the following modules:

The multi-physics **component models** is expected to model the cost (CAPEX, fixed and variable OPEX, economic lifetime) and technical performances (including GHG emissions) of the components, they should be parametrised to take into account the local climate and socio-economic characteristics of the geographical area where they will be located, as well as the time-dimension, such as the season and time of day. The component models should be capable of dynamic modelling with appropriate time steps (e.g. quarterly or hourly power profile of sources for intraday balance assessment; weekly or monthly profile for seasonal balance). The component models need to be described with standard modelling languages and be modular, so that each one can be updated without impact on the others and can be assembled with other models. They should cover most of the components in the following list, at the very least one component in each of the 9 categories below:

- **Renewable energy sources**: energy production units of several typical sizes, covering technologies, such as for example photovoltaic, concentrated solar power, solar thermal, geothermal, onshore wind, offshore wind, hydroelectric, tidal, wave, biogas, biomass … Modelling of their cost, GHG emissions, typical (average) production performance of the sources, taking into account (where applicable): the season (month of the year), time (hour of the day), geo-location (at NUTS-2 level), and other parameters that can affect cost/performance. Where applicable, the statistic variability of their performance should be given and power profiles should be generated, for running dynamic simulations when the component modules will be integrated into system modules. A large-scale source should have its own model, small-scale sources (such for example wind turbines or household PV) should be aggregated (e.g. households PV aggregated at the level of a city).

- **Non-renewable primary energy sources** (natural gas, coal, oil, uranium …): extraction, import; modelling of the cost, capacity, GHG emissions and geolocation.

- **Non-renewable energy conversion**: refineries producing fuels or hydrogen; modelling the cost and performance (including GHG emissions) of the conversion from the primary energy carrier to secondary energy carriers, including CCS where applicable.

- **Non-renewable electricity production** (coal, natural gas, oil, nuclear …): cost and performance of existing or new power plants, including CCS where applicable; modelling the transformation from the primary energy carrier to electricity (including GHG emissions).

- **Renewable energy conversion**: production of hydrogen and other renewable or low-emissions gaseous or liquid fuels; modelling of their cost and performances (power, efficiency …); modelling the conversion from the primary energy carrier to secondary energy carrier and by-products (O2, CO_2, including GHG emissions …).

- **Energy storage** models: stationary batteries (large scale and house), electric vehicle batteries, hydropower storage, thermal storage, methane storage, hydrogen storage … ; modelling of their cost and performances: power, efficiency, capacity, life expectancy, state-of-charge (for dynamic modelling), life cycle GHG emissions.

- **Transport pipelines** (including recompression stations): cost (per km) and performance (capacity, efficiency, GHG emissions) of existing and new natural gas, hydrogen, CO_2 pipelines, district heating/cooling pipelines or of upgrading pipelines to admixtures of renewable gasses or to pure hydrogen or to CO_2; as well as **other infrastructure (e.g. LNG terminals) or logistics** (e.g. transport by ship).

- **Transmission power lines**: cost (per km) and performance (capacity, efficiency), of existing or new power lines, or for upgrading existing power lines to higher voltage/capacity.

- **Energy consumers**: modelling of the energy use profile of typical consumers (industry, buildings, households, local heat networks, mobility and transport) for the different types of energy carriers, taking into account (where applicable): the season (month of the year, and associated average temperature), time (hour of the day), geo-location (at NUTS-2 level), and other parameters that can affect their energy use. Where applicable, the statistic variability of their performance should be given and power profiles should be generated, for running dynamic simulations when the component modules will be integrated into system modules. Where applicable, their capability to shift their consumption in time (demand response) and to store energy should be modelled, including the cost of this flexibility service. A large-scale user should have its own model; small-scale users, such for example household or eVehicle and (bi-directional) charging or refuelling stations, should be aggregated at the level of a city or NUTS2 region. New methods to take into accounts new types of assets connected to the grids (Electric

Vehicles (EV), microgrids, storage, small scale production, non-synchronous generators, etc.) and considering the cost-effective coupling with other energy networks.

System modelling, planning and optimisation tool:

- A **system modelling tool** should be developed to integrate the models of the components located in a geographical area into a system model. The models will use available data on the future needs of industry and other end-user sectors. The system modelling tool should allow both static and dynamic simulations, to assess the intraday, weekly and seasonal balances and associated grids stability. The modelling tool has to be modular and open to ensure coupling with other models, for example models including the exchange of resources and materials (enabling industrial-urban symbiosis and circularity), as well as socio-economic and market models.

- Based on the system model, an **optimisation and medium-long term grid planning tool** should be developed to optimise the development pathways for renewable energy and other low emissions sources, storage and the enhancement of infrastructure, to meet the future energy needs in a geographical area, while minimising the total investment and operation cost, hence satisfying the future final uses of energy vectors of consumers, at lowest cost and climate impact.

- **Visualisation tools** should be developed to support the system modelling, the optimisation process and their results, notably in the format of dynamic energy heat maps. The compatibility of the results format with the JRC visualisation tools should be ensured.

Validation of the models and tools:

- Methodologies and procedures should be developed for the **certification** of the components models and, if possible, system models.

- The component models, system modelling and optimisation tools need to be **validated** by using them in support of the planning of the energy transition of two real-life geographical areas: one macro-region (e.g. several small or large countries) and one large (possibly cross-border) industrial cluster. The validations should cover the range of models and tools developed, and should therefore include in particular the dynamic modelling of relevant energy sources (intermittent and dispatchable), different existing or new energy networks, conversion between different energy vectors, energy storage and energy consumers capable of demand response.

The component models and the system modelling/optimisation tools need to be a properly **documented and open source** development allowing the EC, the Member States and Associated Countries and other public authorities or private organisations to use the tools for their planning needs, or to develop additional add on modules. The models and tools, as well as the relevant documentation and user guides, should be published under an appropriate open license and made available to the modelling community on the Energy Modelling Platform for

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Europe[107]. The results of the project have to be **disseminated**, notably at the EMP-E annual conference. Upon completion of the projects presently supporting the EMP-E platform and conference, the selected project should take over supporting the platform and organising the annual conference.

The research should entail interviews with relevant grid operators and public administrations in all EU Member States/ Associated Countries, so as to collect their views on how the tools could best meet their needs. At least 2 interviews per MS/AC should be foreseen.

The development of the models, simulation, optimisation and visualisation tools will be closely coordinated with DG Energy, DG Research and Innovation and with the Joint Research Centre.

The selected projects are expected to contribute to relevant BRIDGE[108] activities.

HORIZON-CL5-2022-D3-01-14: Thermal energy storage solutions

Specific conditions	
Expected EU contribution per project	The EU estimates that an EU contribution of between EUR 7.00 and 8.00 million would allow these outcomes to be addressed appropriately. Nonetheless, this does not preclude submission and selection of a proposal requesting different amounts.
Indicative budget	The total indicative budget for the topic is EUR 30.00 million.
Type of Action	Innovation Actions
Eligibility conditions	The conditions are described in General Annex B. The following exceptions apply: For duly justified and exceptional reasons and in order to guarantee the protection of the strategic interests of the Union and its Member States, legal entities established in a Member State or in countries associated to Horizon Europe that are directly or indirectly controlled by third countries not associated to Horizon Europe or by legal entities of non-associated third countries, are not eligible to participate. Proposals including entities that are controlled by third countries outside the scope specified in the topic/call/action will be ineligible.
Technology Readiness Level	Activities are expected to achieve TRL 6-7 by the end of the project – see General Annex B.

Expected Outcome: Project results are expected to contribute to all of the following expected outcomes:

107 http://www.energymodellingplatform.eu/
108 https://www.h2020-bridge.eu/

- Develop and demonstrate novel modular, compact, high performances, thermal energy storage solutions (TES) for heating, hot tap water and cooling for electricity load shifting. The integration of the solution within the energy networks of the building and its system management should allow different functions, such as peak load reduction, energy saving, energy cost minimization.

- Develop and demonstrate a novel thermal energy storage system much more compact than state-of-the-art technologies, enabling the storage of heat and cold for domestic applications for periods typically of 4 weeks long.

Scope: The scope covers the whole spectrum of application of the thermal energy storage systems, ranging from short run to longer run, as well as from the smaller to bigger sizes:

- Thermal end-uses (space heating, hot tap water, cooling) represent a major share of the European electricity demand with consumption often at peak times. Integration into the building heating system and in the smart electricity grid is a key development aspect, next to the storage materials and technologies. Such storage devices reduces the demand for electricity from the grid at peak times during the day, allowing off peak electricity to be used in the building for satisfying cooling needs during summer and/or heating demand, for space heating and hot tap water at later times. The typical charging power is in the order of 3 kW, for periods of up to three hours. The TES system is conceived modularly. The high volumetric energy density is a basic requirement given its utilization.

- For buildings not connected to district heating and cooling network, a much more compact TES system is needed to optimize and to increase the integration of varying RES . Such systems need much less volume than state-of-the-art technologies, realized with materials that have extremely low heat losses and enable the storage of heat and cold for domestic applications for periods typically up to 4 weeks. *Cost reduction* is a very important target, as the present solutions are too expensive. The ideal thermochemical TES process should have high reaction heat; Good reversibility; Fast charging and discharging rates; Stable reaction products; Non-toxic, non-corrosive, non-flammable and non-explosive reactants and products; Large-scale availabilities and abundance, affordable price.

The nature of the activities concerns:

- The development of novel phase change materials (PCM) and components (Polymer liners, integrated thermal storage materials, low cost vacuum insulation technology, lid construction) of required characteristics for thermochemical and PCM TES, characterized by low starting TRL (4).

- The development & adaptation of available heat exchanger and novel reactor designs; design and development of controls and modelling for novel sensors for TCM and PCM, starting from a higher TRL (5).

- Ice cold storage having higher TRL (6).

The achievable storage density (kWh/m^3) depends on the technological approach (sensible heat, PCM and TCM) and decreases drastically moving from the component to the system level. Furthermore, with the exception of TCM, the charge of the store decreases with elapsed time. The expected system level storage density measured initially and after four weeks from the charge should be indicated.

The selected projects are expected to contribute to relevant BRIDGE[109] activities.

Carbon capture, utilisation and storage (CCUS)

Proposals are invited against the following topic(s):

HORIZON-CL5-2022-D3-01-15: Decarbonising industry with CCUS

Specific conditions	
Expected EU contribution per project	The EU estimates that an EU contribution of around EUR 29.00 million would allow these outcomes to be addressed appropriately. Nonetheless, this does not preclude submission and selection of a proposal requesting different amounts.
Indicative budget	The total indicative budget for the topic is EUR 58.00 million.
Type of Action	Innovation Actions
Technology Readiness Level	Activities are expected to achieve TRL 7-8 by the end of the project – see General Annex B.

Expected Outcome: Successful, safe and economic demonstration of integrated-chain CCUS from relevant industrial sources will pave the way for subsequent first-of-a-kind industrial projects. The scale of the proposals should permit obtaining relevant data and experience required so that up-scaling to a first-of-a-kind plant can be envisaged as a next step.

The impact of projects under this call will be determined by the extent to which the results will be extended to be used in further industrial facilities. In addition, it is important to demonstrate how the captured CO_2 will be utilised and/or stored in a sustainable way. Projects carried out in areas with a sufficient concentration of CO_2 emitting industries are considered prime sites for hub and cluster developments, and are expected to generate the highest impact on full-scale deployment of the results.

Scope: CCUS is one of the key promising technologies that can reduce CO_2 emissions in the carbon intensive industry and the only pathway for very stringent GHG emission reductions from those industries that generate CO_2 as part of their production processes. Relevant industrial sectors in which inclusion of CCUS could contribute to reaching climate neutrality are for example steel, iron and cement making, oil refining, gas processing, hydrogen production,

[109] https://www.h2020-bridge.eu/

sustainable biofuel production and waste-to-energy plants. However, CCUS in industrial applications faces significant challenges due to its high cost and the fierce international competition in the sectors concerned. These sectors currently account for up to 20% of global CO_2 emissions.

The focus of this topic lies in demonstrating the integrated chain of mature CO_2 capture technologies in industrial facilities with the perspective of geological storage and/or use. Based on a high TRL (7 – 8) CO_2 capture project a detailed plan on how to use the results, i.e. the subsequent transport, utilisation and/or underground storage of the captured CO_2 should be developed. Important aspects to address are of technical (e.g. the optimised integration of capture plant with industrial processes; flexibility, scalability; CO_2 purity), safety (e.g. during transportation and storage), financial (e.g. cost of capture; cost of integration) and strategic nature (e.g. business models; operation and logistics of industrial clusters and networks). The project should identify a detailed set of operational, environmental, technical and economic Key Performance Indicators (KPIs) to allow monitoring and assessing the progress achieved by the project.

Technology development has to be balanced by an assessment of the societal readiness towards the proposed innovations. Relevant end users and societal stakeholders (such as civil society organisations, non-governmental organisations, and local associations) will be identified in the proposal, and involved in deliberative activities, so as understand and address their concerns and needs. This will be analysed during the project using appropriate techniques and methods from the social sciences and humanities, in order to create awareness, gain feedback on societal impact and advancing society's readiness for the proposed solutions. Projects should also explore the socio-economic and political barriers to acceptance and awareness with a view to regulatory or policy initiatives and include aspects of circularity and best use of resources. Successful projects will be encouraged to join the EU CCUS knowledge sharing project network.

Cross-cutting issues

Call - Sustainable, secure and competitive energy supply

HORIZON-CL5-2022-D3-02

Conditions for the Call

Indicative budget(s)[110]

[110] The Director-General responsible for the call may decide to open the call up to one month prior to or after the envisaged date(s) of opening.
The Director-General responsible may delay the deadline(s) by up to two months.
All deadlines are at 17.00.00 Brussels local time.
The budget amounts are subject to the availability of the appropriations provided for in the general budget of the Union for years 2021 and 2022.

Topics	Type of Action	Budgets (EUR million)	Expected EU contribution per project (EUR million)[111]	Number of projects expected to be funded
		2022		
Opening: 26 May 2022 Deadline(s): 27 Oct 2022				
HORIZON-CL5-2022-D3-02-01	RIA	9.00	Around 3.00	3
HORIZON-CL5-2022-D3-02-02	RIA	5.00	Around 2.50	2
HORIZON-CL5-2022-D3-02-03	IA	10.00	Around 10.00	1
HORIZON-CL5-2022-D3-02-04	RIA	10.00	3.00 to 5.00	2
HORIZON-CL5-2022-D3-02-05	IA	20.00	Around 10.00	2
HORIZON-CL5-2022-D3-02-06	RIA	10.00	3.00 to 5.00	2
HORIZON-CL5-2022-D3-02-07	IA	15.00	Around 7.50	2
HORIZON-CL5-2022-D3-02-08	IA	20.00	Around 10.00	2
Overall indicative budget		99.00		

General conditions relating to this call	
Admissibility conditions	The conditions are described in General Annex A.
Eligibility conditions	The conditions are described in General Annex B.
Financial and operational capacity and exclusion	The criteria are described in General Annex C.
Award criteria	The criteria are described in General Annex D.
Documents	The documents are described in General Annex E.
Procedure	The procedure is described in General Annex F.

[111] Nonetheless, this does not preclude submission and selection of a proposal requesting different amounts.

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Legal and financial set-up of the Grant Agreements	The rules are described in General Annex G.

Global leadership in renewable energy

Proposals are invited against the following topic(s):

HORIZON-CL5-2022-D3-02-01: Digital solutions for defining synergies in international renewable energy value chains

Specific conditions	
Expected EU contribution per project	The EU estimates that an EU contribution of around EUR 3.00 million would allow these outcomes to be addressed appropriately. Nonetheless, this does not preclude submission and selection of a proposal requesting different amounts.
Indicative budget	The total indicative budget for the topic is EUR 9.00 million.
Type of Action	Research and Innovation Actions
Eligibility conditions	The conditions are described in General Annex B. The following exceptions apply: The consortium must include as a beneficiary at least one legal entity established in a Mission Innovation Country[112], not being Member State or Associated Country.
Technology Readiness Level	Activities are expected to achieve TRL 5 by the end of the project – see General Annex B.

Expected Outcome: Project results are expected to contribute to some of the following expected outcomes:

- Advance the European and global scientific basis, European leadership and global role in the area of renewable energy and renewable fuels and related energy value chains while creating evidence for policy making by developing novel digital solutions.
- Provide digital breakthrough solutions for promoting the increase of the global renewable energy share.
- Reinforce the European scientific basis through international collaboration while increasing the potential to export European renewable energy technologies and ensuring political priorities in the context of sustainable global energy value chains.

[112] http://mission-innovation.net/

- Improve reliability of system components, advanced and automated functions for data analysis, diagnosis and fault detection, forecasting and model-predictive control frameworks, ancillary services for the stability of the network; maintenance planning and/or reporting.

Scope: Development of novel real time and open data monitoring and/or simulation solutions (e.g. including digital twins) for sustainable energy production and consumption, predictive modelling and artificial intelligence for the analysis of international renewable energy value chains and for internationally aligned decision-making in cooperation with international partners from Mission Innovation Countries. To ensure trustworthiness, wide adoption by user communities and support EU policy-makers, actions should promote the highest standards of transparency and openness, going well beyond documentation and extending to aspects such as assumptions, models and data related to renewable energy and fuels.

HORIZON-CL5-2022-D3-02-02: AU-EU Energy System Modelling

Specific conditions	
Expected EU contribution per project	The EU estimates that an EU contribution of around EUR 2.50 million would allow these outcomes to be addressed appropriately. Nonetheless, this does not preclude submission and selection of a proposal requesting different amounts.
Indicative budget	The total indicative budget for the topic is EUR 5.00 million.
Type of Action	Research and Innovation Actions
Eligibility conditions	The conditions are described in General Annex B. The following exceptions apply: In addition to the conditions described in General Annex B, the consortium must include at least three legal entities from three different African countries.

Expected Outcome: Project results are expected to contribute to all of the following expected outcomes:

- Reinforce the activities in the long term the AU-EU HLPD CCSE Partnership.
- Provide knowledge and scientific energy system modelling as evidence base including the environmental, social and economic trade-offs to contribute to R&I strategy and policy making.
- Increase clean energy generation in the African energy systems.
- A permanent network of African experts and expertise in this area.

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Scope: The topic is contributing to the activities of the AU-EU High Level Policy Dialog (HLPD) Climate Change and Sustainable Energy (CCSE) partnership. Current models are based on developed country standard and usage. The development of energy system models tailored to the specific African social, economic and regulatory environment is crucial for energy generation system planning and for energy policy development. Today African countries are relying heavily on developed country models and expertise.

Therefore, the proposal should develop and test models for decision makers and planners to design and evaluate energy system(s) with a high penetration of renewable energy generation in African countries through a regional approach. Considerations are to be given to climate neutrality of cities and industries, using no fossil fuels. A focus should be made on the introduction of clean energy technologies. The tests should be done for at least two base cases.

Proposals should include activities to coordinate with the project(s) to be selected under the topic HORIZON-CL5-2021-D2-02-01.

Actions should promote the highest standards of transparency in model adoption, including assumptions, architecture, code and data. The outcome of the project should be widely disseminated and all the source codes of the whole model to be open source and open access to stimulate future development. To ensure future uses, African experts in energy and in models development should be full partners in the project. The project should identify further local training needs.

The project should make use of existing European activities to create synergies and cross-fertilisation.

The project will contribute to the work of the AU-EU HLPD CCSE partnership through networking activities with existing projects.

HORIZON-CL5-2022-D3-02-03: Innovative renewable energy carrier production for heating from renewable energies

Specific conditions	
Expected EU contribution per project	The EU estimates that an EU contribution of around EUR 10.00 million would allow these outcomes to be addressed appropriately. Nonetheless, this does not preclude submission and selection of a proposal requesting different amounts.
Indicative budget	The total indicative budget for the topic is EUR 10.00 million.
Type of Action	Innovation Actions
Technology Readiness Level	Activities are expected to achieve TRL 7 by the end of the project – see General Annex B.

Expected Outcome: Project results are expected to contribute to some of the following expected outcomes:

- Advance the European innovative knowledge basis and increase technology competitiveness in the area of energy carrier production and heating value chains, in particular increase of feedstock availability for renewable heating, thus supporting the EU goals for climate protection, energy independence and economic growth;
- Technology de-risk of renewable energy carrier value chains as a necessary step before scaling up at commercial level;
- Enhanced sustainability of renewable heating value and supply chains by improving techno-economic efficiency and minimising negative environmental effects.

Scope: Demonstrate cost-effective and energy-, catalyst and equipment material-efficient transformation of renewable energy into renewable energy carriers for heating, while ensuring very good combustion properties in respect of efficiency and avoidance of pollutants and environmental and socioeconomic sustainability of the respective heating supply and value chains.

HORIZON-CL5-2022-D3-02-04: Technological interfaces between solar fuel technologies and other renewables

Specific conditions	
Expected EU contribution per project	The EU estimates that an EU contribution of between EUR 3.00 and 5.00 million would allow these outcomes to be addressed appropriately. Nonetheless, this does not preclude submission and selection of a proposal requesting different amounts.
Indicative budget	The total indicative budget for the topic is EUR 10.00 million.
Type of Action	Research and Innovation Actions
Technology Readiness Level	Activities are expected to achieve TRL 4 by the end of the project – see General Annex B.

Expected Outcome: Project results are expected to contribute to some of the following expected outcomes:

- Advance the European scientific basis, technological leadership and global role in the area of renewable and solar fuels, while creating evidence for policy making;
- Provide breakthrough solutions towards a fossil-free economy and ecosystem by bridging solar energy and other renewables in boosting renewable fuel production and storage with the potential of strongly reducing CAPEX and OPEX/toe, high penetration in the energy system, ensuring stability and security of energy supply;

- Increase European technology competitiveness in solar and renewable fuel technologies, thus supporting the EU goals for climate protection, energy independence and economic growth.

Scope: Development of energy transmitting technological interfaces to couple solar fuel technologies to other renewables such as from e.g. biosources or directly connected renewable power generation, which allow for efficient feed in of other forms of renewable energy into solar fuel conversion technologies and allow for efficient and continuous renewable fuel production.

HORIZON-CL5-2022-D3-02-05: Renewable energy carriers from variable renewable electricity surplus and carbon emissions from energy consuming sectors

Specific conditions	
Expected EU contribution per project	The EU estimates that an EU contribution of around EUR 10.00 million would allow these outcomes to be addressed appropriately. Nonetheless, this does not preclude submission and selection of a proposal requesting different amounts.
Indicative budget	The total indicative budget for the topic is EUR 20.00 million.
Type of Action	Innovation Actions
Technology Readiness Level	Activities are expected to achieve TRL 7 by the end of the project – see General Annex B.

Expected Outcome: Project results are expected to contribute to some of the following expected outcomes:

- Advance the European scientific basis and increase technology competitiveness in the area of energy carrier production and integration with renewable electricity and carbon value and supply chains;
- Technology de-risk of renewable energy carrier value chains through demonstration as a necessary step before scaling up at commercial level;
- Enhanced sustainability of renewable energy carrier value and supply chains by improving techno-economic efficiency and avoidance of CO_2/GHG emissions and renewable electricity economic or curtailment losses and supported by a life cycle assessment.

Scope: Demonstration of renewable energy carrier synthesis from variable renewable electricity surplus and carbon emissions from energy consuming sectors, which is targeting improvement of the overall synthesis value chain efficiency and viability while making best use of the CO_2 emissions in synergy with renewable electricity generation. The incorporation of hybrids of renewable electricity with algal or synthetic renewable fuels in energy intensive sectors by integrating the conversion of surplus renewable electricity and carbon emissions from these

sectors to liquid renewable energy carriers by algal, artificial photosynthesis or homologous non-solar pathways will be demonstrated. Conversion technologies should be based upon biological, biochemical, thermochemical and or electrochemical processes.

Proposals should avoid curtailing of renewable electricity and carbon emissions and improve overall efficiency and viability of renewable electricity assemblies in synergy with reduction of carbon emissions.

HORIZON-CL5-2022-D3-02-06: Direct renewable energy integration into process energy demands of the chemical industry

Specific conditions	
Expected EU contribution per project	The EU estimates that an EU contribution of between EUR 3.00 and 5.00 million would allow these outcomes to be addressed appropriately. Nonetheless, this does not preclude submission and selection of a proposal requesting different amounts.
Indicative budget	The total indicative budget for the topic is EUR 10.00 million.
Type of Action	Research and Innovation Actions
Technology Readiness Level	Activities are expected to achieve TRL 4-5 by the end of the project – see General Annex B.

Expected Outcome: Project results are expected to contribute to some of the following expected outcomes:

- Advance the European scientific basis, technological leadership and global role in the area of renewable integration into the chemical industry, while creating evidence for policy making;
- Increase European technology competitiveness in renewable process energy technologies, thus supporting the EU goals for climate protection, energy independence and economic growth;
- Provide breakthrough solutions towards a fossil-free economy and ecosystem;
- Allow high penetration in the energy system, ensure stability and security of energy supply, including integration of local resources, and gain efficiency and costs in transforming the energy system on a fossil-free basis;
- Enable transformation of the energy supply to socio-economic and environmental fossil-free sustainable solutions across energy intensive chemical industry, targeting in particular process energy and its GHG emissions.

Scope: Development of the technology and the methodology of integrating renewable energy in chemical processing by substituting fossil process energy in chemical industry, which has a

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high carbon footprint due to processing relative to the mass of the final product. Pursued technology developments are expected to directly target renewable energy integration into process energy demands of the chemical industry beyond electricity (targeting e.g. electrochemical potential of artificial photosynthesis to chemical reduction processes and/or e.g. direct solar thermochemical conversion) and should improve GHG balance and sustainability of the targeted process.

Possible synergies exist with topic: HORIZON-CL4-2021-TWIN-TRANSITION-01-21: Design and optimisation of energy flexible industrial processes (IA).

HORIZON-CL5-2022-D3-02-07: Renewable energy incorporation in agriculture and forestry

Specific conditions	
Expected EU contribution per project	The EU estimates that an EU contribution of around EUR 7.50 million would allow these outcomes to be addressed appropriately. Nonetheless, this does not preclude submission and selection of a proposal requesting different amounts.
Indicative budget	The total indicative budget for the topic is EUR 15.00 million.
Type of Action	Innovation Actions
Technology Readiness Level	Activities are expected to achieve TRL 6-7 by the end of the project – see General Annex B.

Expected Outcome: Meeting local and seasonal energy demands in agriculture and forestry with optimum agricultural and forest waste management and use while reducing the associated emissions is essential. If not managed, agricultural waste is often burnt in the fields and forests suffer from fires, thus increasing the environmental footprint of agriculture and forests. Soil and biodiversity improvement in agriculture could also benefit from renewable energy technologies. Demonstrating incorporation of renewable energy technologies to attain heat, waste and land management needs in agricultural and forestry will contribute to increase the penetration of renewable sources in the energy system and enable transformation of the energy supply across critical energy-consuming sectors, thus accelerating the achievement of the European Green Deal and climate and energy targets for 2030 and of net zero greenhouse gas emissions by 2050, while supporting the EU goals for energy independence and economic growth. Furthermore, it will support achieving the specific objective of the post 2020 Common Agricultural Policy[113] regarding contribution to climate change mitigation and adaptation, as well as sustainable energy.

Project results are expected to contribute to some of the following expected outcomes:

[113] https://ec.europa.eu/info/sites/info/files/food-farming-fisheries/key_policies/documents/cap-post-2020-environ-benefits-simplification_en.pdf

- Promote decentralised renewable energy use and cost-efficient decentralized production of renewable energy carriers.
- Reduce agriculture and forestry carbon footprint from own energy consumption and agricultural/forest waste management.
- Increase sustainability and circularity in agriculture while creating positive effects on biodiversity.
- Increase sustainability and circularity in forestry.
- Foster regional development in rural areas.
- Support farmers' and foresters' engagement as prosumers of renewable energy.

Scope: Proposals should demonstrate incorporation of renewable energy technologies in agriculture or forestry to meet its electricity, heat, cold, waste and land management needs. Solutions should combine innovative renewable, circular and regional value chains from different renewables and adapted storage options to de-fossilize agricultural or forest processes trans-seasonally, taking into account hybridization compatibility. They should also address one of the two options:

- Transformation of agricultural or forest wastes to renewable energy carriers in situ, e.g. by modular slow pyrolysis units, using renewable energy for process energy needs. Solutions should improve the cost-effectiveness and the sustainability of agriculture or forest seasonal energy demand based on renewables.
- Development of renewable-based agricultural protocols for multiple and cover cropping and/ or mixed cropping which increase carbon sequestration and soil organic matter and reduce pesticides, combined with transformation to renewable energy carriers in situ, e.g. by biogas production, in a circular approach for soil nutrients and carbon. Positive effects on soil biodiversity/soil health and soil functionality as regards increasing soil organic matter, phosphorus and other nutrients and reducing the risk on groundwater contamination from nitrogen oxides should be assessed. Solutions should improve the cost-effectiveness and the sustainability (including biodiversity) of agricultural waste and land management through valorisation of wastes and secondary crops based on renewable energy technologies.

This topic requires the effective contribution of SSH disciplines and the involvement of SSH experts, institutions as well as the inclusion of relevant SSH expertise, in order to produce meaningful and significant effects enhancing the societal impact of the related research activities. The effective contribution of renewable energy and agronomy disciplines is also expected.

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HORIZON-CL5-2022-D3-02-08: Demonstration of complete value chains for advanced biofuel and non-biological renewable fuel production

Specific conditions	
Expected EU contribution per project	The EU estimates that an EU contribution of around EUR 10.00 million would allow these outcomes to be addressed appropriately. Nonetheless, this does not preclude submission and selection of a proposal requesting different amounts.
Indicative budget	The total indicative budget for the topic is EUR 20.00 million.
Type of Action	Innovation Actions
Technology Readiness Level	Activities are expected to achieve TRL 6-7 by the end of the project – see General Annex B.

Expected Outcome: Complete value chains for advanced biofuels and renewable fuels of non-biological origin provide a systemic understanding of the value created and the constraints in individual chain steps. Demonstrating such complete value chains will contribute to increase the competitiveness of their technologies and foster their commercialization to allow high penetration of advanced biofuels and renewable fuels of non-biological origin in the energy and transport energy system, in particular for hard to electrify sectors.

Project results are expected to contribute to all of the following expected outcomes:

- Build a portfolio of complete value chains for advanced biofuels and renewable fuels of non-biological origin.
- De-risk technology, boost the scale-up of advanced biofuels and non-biological origin renewable fuels.
- Contribute to the priorities of the SET Plan Action 8.
- Respond to short and medium term needs for renewable fuels in energy and transport.
- Improve sustainability and security of the value chains.

Scope: Proposals should demonstrate innovative and cost effective sustainable value chains for advanced biofuels or synthetic renewable fuels of non-biological origin (other than for hydrogen as a final product), over the entire cycle from feedstock to end use. Any sustainable biomass feedstock including residues and wastes, or biogenic CO2 or industrial CO2 and renewable hydrogen, as well as input energy to the conversion should be addressed. Pathways which are biochemical, thermochemical, biological, chemical, electrochemical or combinations of them should be considered. Proposals should aim at improved performance in terms of increasing the efficiency and sustainability and reducing the cost, while evidencing the value creation along the value chain steps. Complete value chains may address any relevant end use.

Call - Sustainable, secure and competitive energy supply

HORIZON-CL5-2022-D3-03

Conditions for the Call

Indicative budget(s)[114]

Topics	Type of Action	Budgets (EUR million)	Expected EU contribution per project (EUR million)[115]	Number of projects expected to be funded
		2022		
Opening: 06 Sep 2022 Deadline(s): 10 Jan 2023				
HORIZON-CL5-2022-D3-03-01	IA	16.50	Around 5.50	3
HORIZON-CL5-2022-D3-03-02	RIA	9.00	Around 3.00	3
HORIZON-CL5-2022-D3-03-03	RIA	10.00	3.00 to 5.00	2
HORIZON-CL5-2022-D3-03-04	RIA	18.00	Around 6.00	3
HORIZON-CL5-2022-D3-03-05	RIA	20.00	Around 5.00	4
HORIZON-CL5-2022-D3-03-06	RIA	10.00	3.00 to 5.00	2
HORIZON-CL5-2022-D3-03-07	RIA	15.00	Around 5.00	3
HORIZON-CL5-2022-D3-03-08	RIA	9.00	3.00 to 4.50	3
HORIZON-CL5-2022-D3-03-09	IA	20.00	6.00 to 7.00	3
Overall indicative budget		127.50		

General conditions relating to this call	
Admissibility conditions	The conditions are described in General Annex A.

114 The Director-General responsible for the call may decide to open the call up to one month prior to or after the envisaged date(s) of opening.
The Director-General responsible may delay the deadline(s) by up to two months.
All deadlines are at 17.00.00 Brussels local time.
The budget amounts are subject to the availability of the appropriations provided for in the general budget of the Union for years 2021 and 2022.

115 Nonetheless, this does not preclude submission and selection of a proposal requesting different amounts.

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Eligibility conditions	The conditions are described in General Annex B.
Financial and operational capacity and exclusion	The criteria are described in General Annex C.
Award criteria	The criteria are described in General Annex D.
Documents	The documents are described in General Annex E.
Procedure	The procedure is described in General Annex F.
Legal and financial set-up of the Grant Agreements	The rules are described in General Annex G.

Global leadership in renewable energy

Proposals are invited against the following topic(s):

HORIZON-CL5-2022-D3-03-01: Innovative components and/or sub-systems for CSP plants and/or concentrating solar thermal installations

Specific conditions	
Expected EU contribution per project	The EU estimates that an EU contribution of around EUR 5.50 million would allow these outcomes to be addressed appropriately. Nonetheless, this does not preclude submission and selection of a proposal requesting different amounts.
Indicative budget	The total indicative budget for the topic is EUR 16.50 million.
Type of Action	Innovation Actions
Technology Readiness Level	Activities are expected to achieve TRL 6-7 by the end of the project – see General Annex B.

Expected Outcome: Concentrating solar thermal technologies supply renewable, dispatchable energy and can therefore be an important element of the evolving energy system. Project results are expected to contribute to some of the following expected outcomes:

- Higher shares of variable output renewables in the energy system.
- Higher efficiency of concentrated solar power (CSP) plants and/or concentrating solar thermal installations.

- Reduced operation and maintenance costs of CSP plants and/or concentrating solar thermal installations.
- Achievement of the targets of the SET Plan Initiative for Global Leadership in CSP.

Scope: Support will be given to the demonstration of innovative, cost effective and more reliable components and/or sub-systems for CSP plants and/or concentrating solar thermal installations. The components and/or sub-systems will allow better efficiency in terms of solar energy conversion.

The demonstration should span a continuous interval of at least six months covering all possible incidence angles of the direct solar radiation.

Projects are expected to assess the sustainability of the proposed components and/or sub-systems in environmental, social and economic terms.

All demonstrators should be fully and transparently documented, to ensure replicability, up-scaling and to assist future planning decisions.

HORIZON-CL5-2022-D3-03-02: Best international practice for scaling up sustainable biofuels

Specific conditions	
Expected EU contribution per project	The EU estimates that an EU contribution of around EUR 3.00 million would allow these outcomes to be addressed appropriately. Nonetheless, this does not preclude submission and selection of a proposal requesting different amounts.
Indicative budget	The total indicative budget for the topic is EUR 9.00 million.
Type of Action	Research and Innovation Actions
Technology Readiness Level	Activities are expected to achieve TRL 4-5 by the end of the project – see General Annex B.

Expected Outcome: The need of including sustainable biofuels in a transformed integrated energy system is recognized worldwide. Enhancing the European global role in this area will increase the potential to export European renewable fuel technologies into global developing markets, and improve sustainability of biofuel value chains worldwide while supporting the EU goals for climate change mitigation in 2030 and 2050.

Project results are expected to contribute to some of the following expected outcomes:

- Build global knowledge for the scaling-up and the sustainability assessment of sustainable biofuels value chains.

- Contribute to cost-effective and more sustainable large-scale production of sustainable biofuels.
- Contribute to Mission Innovation Challenge n°4 Sustainable Biofuels[116].
- Contribute to the SET Plan Action 8 Bioenergy and Renewable Fuels for Sustainable Transport.
- Accelerate capacity building for sustainable biofuels in the world.
- Develop networks for skill development and knowledge sharing in sustainable biofuels value chains worldwide.

Scope: Proposals will aim at fostering international cooperation to develop best practices and concepts along the entire value chain for accelerating the scale-up of sustainable biofuels worldwide. Scaling up sustainable biofuels is a global challenge in terms of environmental, social, and economic sustainability, which can benefit from international collaboration and knowledge exchange. Proposals should address systemic constraints and opportunities for scaling up complete value chains of sustainable biofuels and propose solutions. Any sustainable non-food/feed biomass feedstock and any innovative technology or combinations of them should be considered. Proposals should enhance overall cost-effectiveness and sustainability of large scale production of sustainable biofuels based on Life Cycle Analysis addressing social, economic and environmental aspects. International cooperation with Mission Innovation countries is expected.

HORIZON-CL5-2022-D3-03-03: Efficient and circular artificial photosynthesis

Specific conditions	
Expected EU contribution per project	The EU estimates that an EU contribution of between EUR 3.00 and 5.00 million would allow these outcomes to be addressed appropriately. Nonetheless, this does not preclude submission and selection of a proposal requesting different amounts.
Indicative budget	The total indicative budget for the topic is EUR 10.00 million.
Type of Action	Research and Innovation Actions
Technology Readiness Level	Activities are expected to achieve TRL 5 by the end of the project – see General Annex B.

Expected Outcome: Project results are expected to contribute to some of the following expected outcomes:

[116] http://www.mission-innovation.net/our-work/innovation-challenges/sustainable-biofuels/

- Advance the European scientific basis, leadership and global role in the area of renewable and solar fuels, while creating evidence for policy making;
- Provide solar fuel breakthrough solutions towards a fossil-free economy and ecosystem by bridging solar energy and fuel needs with the potential of high penetration in the energy system, ensuring stability and security of energy supply;
- Increase European technology competitiveness in solar fuel technologies, thus supporting the EU goals for climate protection, energy independence and economic growth.
- Develop artificial photosynthesis solutions, which will minimize further downstream processing and increase their scalability and integration within the industrial value chain in respect of circularity.

Scope: Development of novel artificial photosynthesis technologies, which allow for improved efficiency of light harvesting, conversion to electrochemical potential and energy fixation to carriers with strictly implementing circularity by design and efficient use of carrier and (photo)catalyst materials through novel photoelectrochemical or bio-based (bio-hybrid) or biological pathways for solar fuel production with increased efficiency in comparison to light and dark reactions of natural photosynthesis. Production of hydrogen as a final product is not envisaged.

Synergies are possible with topic HORIZON-CL4-2021-RESILIENCE-01-16 Creation of an innovation community for solar fuels and chemicals (CSA) and respective cooperation activities are encouraged.

HORIZON-CL5-2022-D3-03-04: Integrated wind farm control

Specific conditions	
Expected EU contribution per project	The EU estimates that an EU contribution of around EUR 6.00 million would allow these outcomes to be addressed appropriately. Nonetheless, this does not preclude submission and selection of a proposal requesting different amounts.
Indicative budget	The total indicative budget for the topic is EUR 18.00 million.
Type of Action	Research and Innovation Actions
Eligibility conditions	The conditions are described in General Annex B. The following exceptions apply: If projects use satellite-based earth observation, positioning, navigation and/or related timing data and services, beneficiaries must make use of Copernicus and/or Galileo/EGNOS (other data and services may additionally be used).

	In order to achieve the expected outcomes, and safeguard the Union's strategic assets, interests, autonomy, or security (namely to keep a European competitive advantage and establish a strong European supply chain), considering that the EU currently holds a first mover advantage and is globally well positioned (State of the Energy Union report 2020 and accompanying Competitive Progress Report) participation is limited to legal entities established in Member States and associated countries. Proposals including entities established in countries outside the scope specified in the topic will be ineligible.
Procedure	The procedure is described in General Annex F. The following exceptions apply: In order to ensure a balanced portfolio, at least the highest ranking proposal addressing offshore wind farms and the highest ranking proposal addressing onshore wind farms will be funded, provided they attain all thresholds. This condition to ensure a balanced portfolio will also considered to be met if one project addressing both aspects is funded.
Technology Readiness Level	Activities are expected to achieve TRL 5 by the end of the project – see General Annex B.

Expected Outcome: The EU aims to be climate neutral in 2050, and to achieve this goal wind energy technologies will need to unlock its full potential on low-cost reliable clean energy generation. Thus, the next generation of wind farms will need to be supported by an even more innovative set of physical and digital tools as well as operational controls, collectively called wind farm control. Generally, wind farm control refers to the coordination of different wind turbines within a wind farm to better the overall farm power production, and to reduce the structural loading among wind turbines[117].

In this context, project results are expected to contribute to all of the following expected outcomes:

- Development of open source data-driven tools to decrease energy costs on operation, while increasing total wind farm output, and a parallel evaluation of operational risks arising from the chosen solution, including e.g. limitations from machine learning (AI) and resilience against third-party fraud, i.e. operational security.

- Development of digital and physical tools, as well as interoperable frameworks and controls, for enhanced data collection, analysis, and operation aimed at an improved performance at farm level.

[117] FarmConners. D1.5: Recommendations and best practices for testing and validation of wind farm control. 2020.

- Allow operators to make better informed decisions on farm-wide system optimisation, lifetime extension, decommissioning and/or recycling of components.
- Contribute to LCOE reduction in line with the SET Plan targets (actions should clearly justify the estimated LCOE at project start and end).

Scope: The proposal is expected to address all the following aspects:

- Address and validate how digital innovation on wind farm control are able to provide more stable, resilient, secure, reliable and affordable energy, while retaining high levels of cybersecurity. Focus on farm output maximization is expected. Additionally, focus on reduced component load is strongly encouraged.
- Address how these data-driven innovations reduce operational and maintenance costs, increase energy output, and their impact on (component, turbine, farm) lifetime;
- Address the role of such innovations as a prognostic tool, regarding failures and damages:
- Develop and release an open source digital/AI solution for sector uptake. This tool is expected to be built from concrete experiments and data measurements. Further, it should account for the advent of large wind turbines (up to 20 MW) and include those in the development of this tool.

In order to optimise impact and enhance synergies, cooperation with projects from the HORIZON-CL5-2021-D3-02-04 call is particularly encouraged.

The selected projects are expected to contribute and participate to the activities of the project BRIDGE[118] when relevant.

HORIZON-CL5-2022-D3-03-05: Novel Thin Film (TF) technologies targeting high efficiencies

Specific conditions	
Expected EU contribution per project	The EU estimates that an EU contribution of around EUR 5.00 million would allow these outcomes to be addressed appropriately. Nonetheless, this does not preclude submission and selection of a proposal requesting different amounts.
Indicative budget	The total indicative budget for the topic is EUR 20.00 million.
Type of Action	Research and Innovation Actions
Technology Readiness Level	Activities are expected to achieve TRL 5 by the end of the project – see General Annex B.

[118] https://www.h2020-bridge.eu/

Expected Outcome: Photovoltaic power generation is pivotal in the transition towards a clean energy system and the achievement of the zero-emissions target. To that end, it is important to enhance affordability, security of supply and sustainability of PV technologies along with further efficiency improvements. Consequently, project results are expected to contribute to all of the following outcomes:

- Increase the potential of thin-film technologies for mass production, low cost and/or specialised applications.
- Reinforce the European PV value chain, support local companies to develop and sell differentiated PV products.
- Allow for an efficient use of available areas for renewable energy generation/ reducing competition between different kinds of land use by further increasing PV energy yield/m2.
- Enable and facilitate large-scale deployment of PV and generation of renewable electricity.

Scope: An alternative to c-Silicon PV is thin-film solar cells, which can be fabricated on various and flexible substrates (including glass, metal foils and polymers). A benefit of thin-film PV is the lower direct semiconductor materials cost. Realising lower costs in production requires high input material utilisation and low raw materials conversion costs. Largescale thin-film module production can be more cost efficient when utilising rapid processing technologies. With further advances in scientific understanding, 25% efficiency devices are within reach as are even higher efficiencies in tandem architectures. Translating those device and process advances to manufacturing technology will dramatically reduce LCOE once sufficiently scaled in both module size and production volume. This will require adapting deposition processes for higher rates and to larger-scale equipment while developing suitable robust techniques for inline process and quality control.

The proposal should address all of the following:

- Develop novel environmentally benign thin-film technology concepts that optimise PV cell and module architecture, increase durability, decrease losses (minimising also the cell-to-module efficiency gap) and target very high efficiencies (>25%) with flexibility for specific applications.
- Employ simple, scalable and low cost/low energy consumption and higher rate deposition processes.
- Ensure compliance with all relevant standards, including those related to the specific applications targeted.
- Perform device/module real–life (under actual outdoor operating conditions) characterisation for reliability and energy yield assessment.

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- Perform a life cycle analysis to bring evidence of the lower environmental impact, better resource efficiency than current commercial PV technologies, and circularity potential.

HORIZON-CL5-2022-D3-03-06: Efficient and low-emission technologies for industrial use of combustion and gasification systems from low-value biogenic residues and wastes

Specific conditions	
Expected EU contribution per project	The EU estimates that an EU contribution of between EUR 3.00 and 5.00 million would allow these outcomes to be addressed appropriately. Nonetheless, this does not preclude submission and selection of a proposal requesting different amounts.
Indicative budget	The total indicative budget for the topic is EUR 10.00 million.
Type of Action	Research and Innovation Actions
Technology Readiness Level	Activities are expected to achieve TRL 5 by the end of the project – see General Annex B.

Expected Outcome: Project results are expected to contribute to some of the following expected outcomes:

- Advance the European scientific basis, technology base, leadership and global role in the area of bioenergy integration into industrial settings while creating evidence for policy making;
- Increased feedstock diversification and better technological performance leading to cost-reduction of bioenergy with positive effects on renewables' penetration, circularity and security of supply;
- Reduced emissions and increased environmental and socio-economic sustainability of biomass combustion and gasification and bioenergy value chains.

Scope: Development of technologies for optimization of advanced biofuel flexible systems regarding upstream multi-feedstock, logistics, feeding, ash management, combustion or gasification processes and effluent emissions and their effective integration into industrial process energy environment through efficient and low-emission technologies for industrial use of combustion and gasification systems from low-economic value, but fully sustainable biogenic residues and wastes.

HORIZON-CL5-2022-D3-03-07: Development of algal and renewable fuels of non-biological origin

Specific conditions

Expected EU contribution per project	The EU estimates that an EU contribution of around EUR 5.00 million would allow these outcomes to be addressed appropriately. Nonetheless, this does not preclude submission and selection of a proposal requesting different amounts.
Indicative budget	The total indicative budget for the topic is EUR 15.00 million.
Type of Action	Research and Innovation Actions
Eligibility conditions	The conditions are described in General Annex B. The following exceptions apply: If projects use satellite-based earth observation, positioning, navigation and/or related timing data and services, beneficiaries must make use of Copernicus and/or Galileo/EGNOS (other data and services may additionally be used).
Procedure	The procedure is described in General Annex F. The following exceptions apply: At least one algal fuel project, the highest scored from the above threshold proposals will be funded, provided that it passes all thresholds
Technology Readiness Level	Activities are expected to achieve TRL 4-5 by the end of the project – see General Annex B.

Expected Outcome: Renewable fuels of the future will be also based on algae and non-biological feedstock for sectors that depend on and operate with dense fuels. Improving these technologies will contribute to advance the European scientific basis and global technological leadership in the area of renewable fuels, increase their technology competitiveness and role in transforming the energy system on a fossil-free basis by 2050, in particular for hard to electrify sectors like aviation, while supporting the EU goals for energy independence.

Project results are expected to contribute to some of the following expected outcomes:

- Increase feedstock and technology basis for renewable fuels.
- Facilitate development of advanced and high-quality biofuels from algae vegetable lipids.
- Foster development of technological pathways for algal and non-biological renewable fuel production.
- Increase robustness of conversion and process sustainability for algal and non-biological renewable fuels.
- Contribute to the priorities of the SET Plan Action 8.
- Deliver technology for longer-term needs for renewable fuels in energy and transport.

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Scope: Proposals will develop and improve algal and/or non-biological renewable fuel technologies (other than for hydrogen as a final product), through developing synthetic pathways including biological, biochemical, thermochemical, electrochemical processes or combinations of them. Improving the performance of the conversion process by increasing the efficiency, reducing the cost and decreasing the GHG emissions from the production should be addressed beyond the current state of the art. Implementing and improving circularity for energy and material use should be considered, also as means to enhance sustainability and economic feasibility of the proposed concepts. Proposals should also address systemic constraints and opportunities for scaling-up algal and non-biological renewable fuel technologies.

HORIZON-CL5-2022-D3-03-08: Development of digital solutions for existing hydropower operation and maintenance

Specific conditions	
Expected EU contribution per project	The EU estimates that an EU contribution of between EUR 3.00 and 4.50 million would allow these outcomes to be addressed appropriately. Nonetheless, this does not preclude submission and selection of a proposal requesting different amounts.
Indicative budget	The total indicative budget for the topic is EUR 9.00 million.
Type of Action	Research and Innovation Actions
Technology Readiness Level	Activities are expected to achieve TRL 5 by the end of the project – see General Annex B.

Expected Outcome: Project results are expected to contribute to some of the following expected outcomes:

- Advance the European scientific basis, technology base, technology leadership in the area of hydropower in the context of digital transition and energy markets while creating evidence for policy making;
- Increase the technology competitiveness of the existing hydropower fleet in changing European power markets by increasing hydropower flexibility and decision-making in modern power markets;
- Facilitate market penetration of renewables and getting closer to the European Green Deal and climate and energy targets for 2030 by increasing the flexibility, sustainability and predictability of existing hydropower;
- Improve environmental and socio-economic sustainability of the existing hydropower fleet.

Scope: Development of novel sensor technologies and digital solutions for digitization of existing hydropower plants and improving their sustainable operation by addressing one or

more of the following: weather and flow forecast, biodiversity monitoring, predictive modelling and artificial intelligence for the analysis of sensor data for decision-making in operation and maintenance. Acknowledging eventual confidentiality of operational data, to ensure wide uptake and reliability, actions should promote the highest standards of transparency and openness of the digital solutions, extending to aspects such as assumptions, architecture, code and data.

HORIZON-CL5-2022-D3-03-09: Recycling end of life PV modules

Specific conditions	
Expected EU contribution per project	The EU estimates that an EU contribution of between EUR 6.00 and 7.00 million would allow these outcomes to be addressed appropriately. Nonetheless, this does not preclude submission and selection of a proposal requesting different amounts.
Indicative budget	The total indicative budget for the topic is EUR 20.00 million.
Type of Action	Innovation Actions
Eligibility conditions	The conditions are described in General Annex B. The following exceptions apply: In order to achieve the expected outcomes and safeguard the Union's strategic assets, interests, autonomy or security (namely to create a European competitive advantage and re-establish a strong European photovoltaic supply chain, as stipulated in the Competitiveness Progress Report accompanying the 2020 State of the Energy Union Report), participation is limited to legal entities established in Member States and associated countries. Proposals including entities established in countries outside the scope specified in the topic will be ineligible.
Technology Readiness Level	Activities are expected to achieve TRL 7 by the end of the project – see General Annex B.

Expected Outcome: Photovoltaic power generation is pivotal in the transition to a clean energy system and the achievement of the zero-emissions target. To that end, it is important to enhance its sustainability while creating wealth and additional employment opportunities in Europe. Consequently, project results are expected to contribute to all of the following outcomes:

- Demonstrate efficient, low-cost, emerging recycling technologies for PV modules/products.
- Increase recyclability and minimise the environmental impact of PV technology.
- Introduce new business models and open new markets in PV recycling.

- Reduce dependency on primary raw materials through the circular use of resources, sustainable products and innovation.
- Strengthen domestic sourcing of raw materials in the EU.

Scope: PV technology is undergoing a transition to a new generation of efficient, low-cost products based on various photoactive materials. PV technology has definite environmental advantages over competing electricity generation technologies, and the PV industry follows a pro-active life-cycle approach to prevent future environmental impact and to sustain these advantages. However, long-term sustainability of photovoltaics will be largely dependent on the effectiveness of the process solutions that will be adopted to recycle the unprecedented volume of end-of-life panels/products expected to be generated in the near future. Recycling is indispensable to avoid the loss of the valuable materials employed to produce photovoltaics and, at the same time, prevent harmful elements, including, for example, heavy metals, to be dispersed into the environment through improper disposal practices.

The proposal should address all of the following:

- Forecast the PV waste streams and estimate the market potentials.
- Develop and demonstrate flexible, high efficiency and throughput recycling technologies adapted to the large volumes of PV modules/products that will be disposed in the future, depending on the typologies of cells/modules/products and reverse logistics.
- Demonstrate re-use potential of high-value recycled material (maintaining its purity and/or integrity) in the PV sector.
- Demonstrate a business case for the concept and a market introduction strategy.
- Address the following related aspects: low environmental impact, resource efficiency and circularity potential.

The proposal should involve multidisciplinary consortia including industrial partners.

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Destination – Efficient, sustainable and inclusive energy use

This Destination addresses activities targeting the energy demand side, notably a more efficient use of energy as regards buildings and industry.

Demand side solutions and improved energy efficiency are among the most cost effective ways to support the transition to climate neutrality, reduce pollution and raw materials use, to create inclusive growth and employment in Europe, to bring down costs for consumers, to reduce our import dependency and redirect investments towards smart and sustainable infrastructure. The transition to a decentralised and climate neutral energy system will greatly benefit from the use of digital technologies which will enable buildings and industrial facilities to become inter-active elements in the energy system by optimising energy consumption, distributed generation and storage and vis-à-vis the energy system. They will also trigger new business opportunities and revenue streams for up-graded, innovative energy services which valorise energy savings and flexible consumption.

This Destination contributes to the following Strategic Plan's **Key Strategic Orientations (KSO)**:

- *C: Making Europe the first digitally led circular, climate-neutral and sustainable economy through the transformation of its mobility, energy, construction and production systems.*
- *A: Promoting an open strategic autonomy by leading the development of key digital and enabling technologies, sectors and value chains to accelerate and steer the digital and green transitions through human-centred technologies and innovations.*

It covers the following **impact areas**:

- Industrial leadership in key and emerging technologies that work for people;
- Affordable and clean energy;
- Circular and clean economy.

The **expected impact**, in line with the Strategic Plan, is to contribute to the *"Efficient and sustainable use of energy, accessible for all is ensured through a clean energy system and a just transition"*, notably through

a. Technological and socio-economic breakthroughs for achieving climate neutrality and the transition to zero pollution of the **building stock** by 2050, based on inclusive and people-centric R&I (more detailed information below).

b. Increased energy efficiency in **industry** and reducing industry's Greenhouse Gas (GHG) and air pollutant emissions through recovery, upgrade and/or conversion of industrial excess (waste) heat and through electrification of heat generation (more information below).

Other Horizon Europe Clusters include topics and activities that can be relevant to this Destination, e.g. in order to seek synergies. These include (but are not limited to) the following:

Cluster 2:

- Destination 2 – Innovative Research on the European Cultural Heritage and the Cultural and Creative Industries. That Destination is most relevant for the topics which scope addresses heritage buildings.
- Destination 3 - Innovative Research on Social and Economic Transformations. That Destination is most relevant for the social innovation items included in some of the topics.

Cluster 3:

- Destination 4 – Increased Cybersecurity. This potential link is most relevant for the topics that address smart buildings and digitalisation of buildings.
- Destination 5 – A Disaster-Resilient Society for Europe. This potential link can be relevant for the topics that address the resilience of the building stock.

Cluster 4: the whole cluster is relevant, in particular Destination 1 – Climate Neutral, circular and digitised production, which is highly relevant for all topics on buildings (e.g. for the digitalisation of construction / renovation workflows).

Cluster 6:

- Destination 3 – Circular economy and bioeconomy sectors and Destination 4 – Clean environment and zero pollution. This potential link is relevant for all topics, in particular those that address sustainable renovation of buildings.

Beyond Horizon Europe, other programmes include some components with which synergies and complementarities can be found. For instance, the Clean Energy Transition and Circular Economy sub-programmes under LIFE can contribute to the market uptake of the innovation delivered under this Destination. The Digital Europe programme includes actions that can be relevant to consider in relation to the topics that entail the development or use of (big) data approaches.

When considering their impact, proposals also need to assess their compliance with the "Do No Significant Harm" principle[119] according to which the research and innovation activities of the project should not be supporting or carrying out activities that make a significant harm to any of the six environmental objectives of the EU Taxonomy Regulation.

<u>Highly energy-efficient and climate neutral European building stock</u>

[119] as per Article 17 of Regulation (EU) No 2020/852 on the establishment of a framework to facilitate sustainable investment (EU Taxonomy Regulation)

Topics under this Destination targeting highly energy-efficient and climate-neutral European building stock focus on both, the energy challenge in buildings and, more broadly, the transformation of the built environment towards more sustainable living.

In line with the new European Bauhaus aiming to "bring the European Green Deal to life in an attractive, and innovative and human-centred way", the sustainable built environment should go beyond merely improving the energy and resource efficiency of buildings and also include a qualitative, aesthetic and human dimension. At the intersection of science, technology and the arts, new creative design and architectural solutions should be developed to ensure the sustainable renovation of the existing European building stock for the well-being of its users. In particular the renovation or adaptive reuse of historical and heritage buildings and sites needs to embrace quality principles to preserve the cultural values of Europe's historical environment and local architectural identity.

Topics targeting energy efficiency in buildings under this Destination seek to achieve the following impacts:

- More energy efficient building stocks supported by an accurate understanding of buildings performance in Europe and of related evolutions.
- Building stocks that effectively combine energy efficiency, renewable energy sources and digital and smart technologies to support the transformation of the energy system towards climate neutrality.

Addressing the broader transformation of the built environment, though, requires a larger involvement of all players across the built environment value chain and throughout building life cycle. To this end, a co-programmed European Partnership on a people-centric, sustainable built environment has been set up (Built4People) to develop holistic R&I for an effective transition to sustainability. All Horizon Europe R&I actions addressing the challenges related to the buildings and construction sector will contribute to achieving the Built4People Partnership goals and will benefit from the coordinated approach within the community of its partners and stakeholders. Topics contributing to the implementation of the Built4People European Partnership seek to achieve the following impacts:

- Higher buildings' performance with lower environmental impacts through increased rates of holistic renovations.
- Higher quality, more affordable built environment preserving climate, environment and cultural heritage and ensuring better living conditions.

<u>Industrial facilities in the energy transition</u>

Topics on industrial facilities in the energy transition supported under this Destination focus on thermal energy management in industry. The bulk of R&I activities related to industry is however supported under Cluster 4 "Digital, Industry and Space".

The following call(s) in this work programme contribute to this destination:

Call	Budgets (EUR million)		Deadline(s)
	2021	2022	
HORIZON-CL5-2021-D4-01	66.00		19 Oct 2021
HORIZON-CL5-2021-D4-02	38.00		25 Jan 2022
HORIZON-CL5-2022-D4-01		54.00	06 Sep 2022
HORIZON-CL5-2022-D4-02		86.00	24 Jan 2023
Overall indicative budget	104.00	140.00	

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Call - Efficient, sustainable and inclusive energy use

HORIZON-CL5-2021-D4-01

Conditions for the Call

Indicative budget(s)[120]

Topics	Type of Action	Budgets (EUR million)	Expected EU contribution per project (EUR million)[121]	Number of projects expected to be funded
		2021		
Opening: 15 Apr 2021 Deadline(s): 19 Oct 2021				
HORIZON-CL5-2021-D4-01-01	IA	10.00	3.00 to 5.00	2
HORIZON-CL5-2021-D4-01-02	IA	16.00	5.00 to 8.00	2
HORIZON-CL5-2021-D4-01-03	IA	10.00	3.00 to 5.00	2
HORIZON-CL5-2021-D4-01-04	IA	16.00	Around 8.00	2
HORIZON-CL5-2021-D4-01-05	IA	14.00	10.00 to 14.00	1
Overall indicative budget		66.00		

General conditions relating to this call	
Admissibility conditions	The conditions are described in General Annex A.
Eligibility conditions	The conditions are described in General Annex B.
Financial and operational capacity and exclusion	The criteria are described in General Annex C.

120 The Director-General responsible for the call may decide to open the call up to one month prior to or after the envisaged date(s) of opening.
The Director-General responsible may delay the deadline(s) by up to two months.
All deadlines are at 17.00.00 Brussels local time.
The budget amounts are subject to the availability of the appropriations provided for in the general budget of the Union for years 2021 and 2022.

121 Nonetheless, this does not preclude submission and selection of a proposal requesting different amounts.

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Award criteria	The criteria are described in General Annex D.
Documents	The documents are described in General Annex E.
Procedure	The procedure is described in General Annex F.
Legal and financial set-up of the Grant Agreements	The rules are described in General Annex G.

Highly energy-efficient and climate neutral EU building stock

Proposals are invited against the following topic(s):

HORIZON-CL5-2021-D4-01-01: Advanced energy performance assessment and certification

Specific conditions	
Expected EU contribution per project	The EU estimates that an EU contribution of between EUR 3.00 and 5.00 million would allow these outcomes to be addressed appropriately. Nonetheless, this does not preclude submission and selection of a proposal requesting different amounts.
Indicative budget	The total indicative budget for the topic is EUR 10.00 million.
Type of Action	Innovation Actions
Technology Readiness Level	Activities are expected to achieve TRL 6-7 by the end of the project – see General Annex B.

Expected Outcome: Project results are expected to contribute to all of the following expected outcomes:

- Improved construction quality and service life compliance.
- Improved accuracy of energy performance assessment and any other assessment conducted in parallel, reduced gap between assessment and actual performance.
- Improved and automated monitoring of energy performance of buildings, and other relevant life-cycle performance aspects with a direct link to the energy efficiency performance.

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- Improved user-friendliness of Energy Performance Certificates and post-occupancy performance data, in terms of clarity, accuracy, trade-offs and usability of the information provided.

- Increased uptake of design standards and practices based on actual performance.

- More reliable understanding of energy and environmental performance in the early stage of the building life cycle, and over service life, based on robust and consistent assessment practices across the buildings sector and across Member States and Associated Countries.

Scope: The next generation of energy performance assessment and certification schemes needs to support the transition towards a climate neutral building stock over the full life cycle, relying on technological innovations to improve speed and quality of as-built performance assessment and service life compliance checks, also linking to other instruments such as building logbooks, building renovation roadmaps, Level(s) and other datasets. Energy performance assessment and certification schemes should seek to work coherently, where relevant, with other performance data generated over the building's life cycle. This can include well-being, indoor air quality, noise and acoustic quality, daylight levels, pollutants and health related data, as well as data pertaining to other issues such as accessibility of buildings, and consumption of non-energy resources such as water.

The proposal should:

- Develop more reliable, cost-effective and highly replicable energy performance calculation methods also addressing, in parallel, relevant life-cycle performance aspects (e.g. well-being, indoor air quality and comfort, acoustics, water consumption, resilience, or whole life carbon) with a direct link to the energy efficiency performance.

- Address the definition and demonstration of advanced and innovative approaches for building energy performance and certification, and how these can interact with other relevant life cycle performance data and certification, focusing on a credible assessment of building intrinsic performance but also increasingly working towards output-based assessments using available building data; Investigate how such approaches can rely on automatic and semi-automatic assessment based on building digital models (e.g. BIM).

- Seek to incorporate in those approaches social and economic indicators.

- Develop dynamic energy and other relevant life-cycle performance assessment and certification databases as a unique source of information on individual buildings over their lifetime for home owners, investors, real estate agents and public authorities.

- Demonstrate how data from smart sensors can be included in assessments in a dynamic way, also exploring, where relevant, how to combine building asset rating with building operational rating, and how to use digital innovations for the assessment of energy and other relevant life-cycle performance.

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- Ensure the proposed solutions build on the results of previous projects dealing with building performance including Energy Performance Certificates (EPCs), also considering where relevant integrating building renovation passports or roadmaps in EPCs.
- Ensure the proposed solutions allow for synergies with other relevant instruments (e.g. the smart readiness indicator under Directive 2010/31/EU, building renovation passports and relevant parts of Level(s)).
- Seek to ensure from the design phase that the project is developed with a view to integrate its results/deliverables under a digital building logbook.
- Ensure that the proposed solutions comply with, and support a broad adoption of, relevant EU standards and codes in order to allow for an EU-wide deployment.
- Ensure the involvement of relevant stakeholders (including European, national and regional certification bodies and consumer organisations).

Clustering and cooperation with other relevant projects is strongly encouraged; in particular, liaison and synergies with the Horizon Europe Partnership on 'People-centric sustainable built environment'.

Proposals submitted under this topic should include a clear business case and exploitation strategy, as well as demonstration activities (at least three demonstration use cases) of an adequate scale.

This topic requires the effective contribution of SSH disciplines and the involvement of SSH experts, institutions as well as the inclusion of relevant SSH expertise, in order to produce meaningful and significant effects enhancing the societal impact of the related research activities.

HORIZON-CL5-2021-D4-01-02: Industrialisation of deep renovation workflows for energy-efficient buildings

Specific conditions	
Expected EU contribution per project	The EU estimates that an EU contribution of between EUR 5.00 and 8.00 million would allow these outcomes to be addressed appropriately. Nonetheless, this does not preclude submission and selection of a proposal requesting different amounts.
Indicative budget	The total indicative budget for the topic is EUR 16.00 million.
Type of Action	Innovation Actions
Technology Readiness Level	Activities are expected to achieve TRL 8 by the end of the project – see General Annex B.

Expected Outcome: Project results are expected to contribute to some of the following expected outcomes:

- Significant improvement in productivity of construction and renovation processes for energy-efficient buildings, supporting an increase in scale in the renovation process and streamlining resource efficient nearly zero-energy performance renovation: 30 % waste reduction; improved quality of renovation; at least 30% and towards 50% reduction of on-site construction / renovation work time and 25% costs reduction.

- More affordable renovation projects for owners, for all building types but with a specific focus on residential buildings.

- Enhanced quality of construction, backed up by post-occupancy evaluations, also supporting a better integration of design and construction activities, streamlining commissioning of buildings, in particular in relation to energy management but also taking into account cross-cutting issues such as accessibility of buildings.

- Reduced performance gap between as-built and as-designed (difference between theoretical and measured performance), allowing tracking performance across the life cycle.

- Increased trust towards construction and renovation processes, by allowing tracking energy performance across the life-cycle.

- Upskilled workforce for industrialised renovation workflows, including automated and robotised construction / renovation, relying on interoperable digital modelling data.

- Enhanced safety of the construction workforce and increased acceptance of robotic support for deep renovation.

- Innovative, tailored business models for deep renovation allowing increased scale of renovation, generating economies of scale and increasing the potential for attractive and affordable packages for end users including financing.

- Tailored access to building information across the life cycle for relevant stakeholders (owners, facility managers, contractors, public authorities).

- Integration with distributed renewable energy sources in neighbourhoods and districts, favouring the emergence of related initiatives (e.g. renewable energy communities).

- Enhanced synergies of renovation with local resources, e.g. district heating & cooling networks.

Scope: Several recent projects & calls have focused on prefabrication for deep renovation, but more work is needed to innovate seamless workflows from design through to offsite manufacture, installation, and compliance checking on site, also ensuring due consideration of life cycle performance. There is also a need for more demonstrations across the EU.

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Proposals should:

- Investigate innovative approaches for industrialised deep renovation, covering the whole workflow from design through to offsite manufacture, installation, compliance checking on site and end strategies for maintenance, operation and end of life.
- Make use of innovative processes and technologies, including those delivered by previous research such as design based on circularity principles, prefabricated components and digital tools, that allow to optimise workflows (cost, time, quality, resource use).
- Develop significantly improved integrated digital twin solutions that can support all stakeholders involved in the different phases of the construction or renovation processes, i.e. from concept to end-of-use, including design, construction, commissioning, operation (management and maintenance) and, where relevant, change of use.
- Demonstrate a seamless integration of the proposed approaches with state-of-the-art digital technologies for construction and renovation (Building Information Modelling, digital twins, etc.).
- Investigate the use of robotic systems and automation such as additive manufacturing, on-site automated and robotic systems (e.g. robots for building component assembly), drones and autonomous vehicles (e.g. for surveying, inspection and monitoring), and other types of automated support to augment workers' capability and safety (e.g. lift robots, exoskeletons) for deep renovation.
- Investigate the application of the proposed approaches at neighbourhood- and district-level, with the aim to maximise synergies in renovation work and processes, decrease costs, and to optimise the use of energy-related shared district resources (e.g. heating and cooling networks, renewable energy sources, energy storage facilities, etc.).
- Select processes and technologies that have a maximum potential for rapid and broad deployment at European level, with due consideration of the sector's practices.
- Ensure effective involvement of the buildings supply chain, in particular SMEs, as well as of building owners/tenants and other relevant stakeholders.
- Where relevant, investigate whether and how the proposed approaches could apply to cultural heritage buildings.
- Ensure the proposed approaches allow to reach the highest level of energy performance, also considering other relevant aspects (e.g. life cycle, accessibility), while keeping costs in an attractive range for owners.
- Seek to ensure from the design phase that the project is developed with a view to integrate its results/deliverables under a digital building logbook.
- Demonstrate, based on well-defined metrics and key performance indicators, that the innovative approaches proposed lead to fewer mistakes, less waste, higher resource

efficiency, higher quality in particular with regard to energy performance (reduced performance gap), increased replicability across sites, and other relevant life cycle aspects, enhanced safety of workers and their ability to work alongside robots, and faster construction.

- Investigate business models in view of mass deployment and EU-wide impact, seeking to address split of incentives between the owner and tenant of a building as a barrier to investments.

- Lead at least 3 large-scale demonstration to assess the proposed approaches for a variety of buildings typologies representative of the European building stock, ensuring the most adequate coverage of climatic conditions.

Clustering and cooperation with other relevant projects is strongly encouraged; in particular, liaison and synergies with the Horizon Europe Partnerships on 'People-centric sustainable built environment' and 'Driving Urban Transitions'.

HORIZON-CL5-2021-D4-01-03: Advanced data-driven monitoring of building stock energy performance

Specific conditions	
Expected EU contribution per project	The EU estimates that an EU contribution of between EUR 3.00 and 5.00 million would allow these outcomes to be addressed appropriately. Nonetheless, this does not preclude submission and selection of a proposal requesting different amounts.
Indicative budget	The total indicative budget for the topic is EUR 10.00 million.
Type of Action	Innovation Actions
Eligibility conditions	The conditions are described in General Annex B. The following exceptions apply: If projects use satellite-based earth observation, positioning, navigation and/or related timing data and services, beneficiaries must make use of Copernicus and/or Galileo/EGNOS (other data and services may additionally be used).
Technology Readiness Level	Activities are expected to achieve TRL 8 by the end of the project – see General Annex B.

Expected Outcome: Project results are expected to contribute to all of the following expected outcomes:

- More robust, improved and consistent monitoring of performance (energy and other relevant aspects, such as indoor environment quality and life cycle) of buildings across the European sectors and through the whole value chain.

- Better informed planning of building infrastructure (e.g. renovation roadmaps, heating & cooling systems, district heating networks, mobility infrastructures (EV charging, parking facilities, communication networks, strategies for whole life carbon reduction etc.) and better informed investment decision-making for designing future buildings and building processes.

- Successfully tested smart energy services on the basis of advanced, high-quality building stock performance data.

- Significant and measurable increase in the use of open, real-time and reliable building data from multiple sources.

- Development of accurate methods that facilitate collection of data from the building stock (e.g. to support policy making and policy impact assessment or to substantiate performance guarantee schemes and contribute to de-risking investments in a climate neutral building stock over the full life cycle).

- Better availability of big data and big data analysis facilities for real-life scale research, simulation and policy-making.

- More effective implementation of EU policies that drive the transition to a green, digital and sustainable economy, and contribute to enhance the quality of the building stock across the board (e.g. quality of life and working, inclusiveness and accessibility, etc.).

Scope: The proposal should:

- Enhance the collection and quality of energy and related (e.g. life cycle) data for buildings (including heating, ventilation and air-conditioning, indoor environment quality, all technical equipment, lighting and other appliances) through various sources such as manufacturers' data, BIM and digital twin models, surveys, digital logbooks, sensors, meters, interfaces (statistical, structured and big data) and Level(s).

- Explore approaches to integrate dynamic data from buildings (e.g. coming from sensors) with metering static data (e.g. data spaces, energy performance certificates databases), statistical data, and other types of data (e.g. qualitative feedback from building users).

- Ensure the proposed approaches build on interoperability and cloud-based solutions that and allow for seamless collection and use of data from the buildings, systems and subsystems.

- Develop new or enhance existing open source data analytics dashboards and prediction tools.

- Develop improved tools for digital simulation and digital twinning.

- Develop, enhance and integrate existing open data sharing platforms, including where relevant by refining and integrating building data reference architectures and making links with relevant data spaces.

- Contribute to the development of open access and standardised European buildings data repositories, also supporting the development of related EU initiatives (e.g. the EU Building Stock Observatory, JRC E3P Roadmap for whole life cycle carbon emissions reduction).
- Promote fair data management practices to ensure findability, accessibility, interoperability and re-usability of data.
- Seek to ensure from the design phase that the project is developed with a view to integrate its results/deliverables under a digital building logbook.
- Demonstrate digital data exchange platforms for building. The solutions should be interoperable and able to interact with grid management platforms.
- Demonstrate real use cases with business potential (e.g. smart energy services) valorising high quality building performance data, e.g. to accurately monitor energy consumption and production across different fuels (for instance integrated heating and cooling and hybrid systems) as well as other relevant performance criteria.
- Demonstrate that the proposed solutions allow to significantly improve the monitoring of the building stock performance, taking into consideration all relevant aspects (e.g. environmental, economic, and social ones).

Clustering and cooperation with other relevant projects is strongly encouraged; in particular, liaison and synergies with the Horizon Europe Partnerships on 'People-centric sustainable built environment' and 'Driving Urban Transitions'.

Industrial facilities in the energy transition

Proposals are invited against the following topic(s):

HORIZON-CL5-2021-D4-01-04: Full-scale demonstration of heat upgrade technologies with supply temperature in the range 90 - 160°C

Specific conditions	
Expected EU contribution per project	The EU estimates that an EU contribution of around EUR 8.00 million would allow these outcomes to be addressed appropriately. Nonetheless, this does not preclude submission and selection of a proposal requesting different amounts.
Indicative budget	The total indicative budget for the topic is EUR 16.00 million.
Type of Action	Innovation Actions
Technology Readiness Level	Activities are expected to achieve TRL 7-8 by the end of the project – see General Annex B.

Expected Outcome: Project results are expected to contribute to all of the following expected outcomes:

- Demonstration at full scale (0.5 – 10 MWth) of industrial heat upgrade systems to supply various industrial processes with useful heat in the (sink) temperature range of 90 – 160 °C, extracted from renewable heat sources (e.g. solar thermal), ambient heat or industrial waste heat.

- Scaling up and improvement of the economic and technical performances of heat upgrade in order to cover more industrial processes with special attention to integration and adaptation to existing/improved processes.

- Demonstration of business models and contractual agreements in the cases of use of the upgraded heat within the industrial plant, in other neighbouring plants or heating networks, as part of the Hubs4circularity approach, identifying also potential regulatory barriers.

- Better awareness of the challenges and benefits of heat upgrade in the relevant industrial sectors.

Scope: This topic aims to satisfy the need for low temperature heat in the relevant industrial sectors, by upgrading lower temperature heat flows, including from renewable heat sources, ambient heat or industrial excess (waste) heat, as a cost-efficient way to improve energy efficiency and reduce the GHG emissions.

Heat upgrade technologies exist, such as for example heat pumps, but their size needs to be scaled-up and their cost needs to be reduced, notably by improving their performances, and their operation needs to be demonstrated in various industrial contexts, in order to ensure their wide deployment. The optional integration of renewable heat sources (e.g. solar thermal) as the input heat flow to be further upgraded, is in scope.

In order to reach this goal all the following development areas need to be covered:

- Identify the target industrial processes which would benefit from this technology, as excess (waste) heat sources and as users (heat sinks); assess the impacts of these applications in terms of energy savings and GHG and air pollutant emissions reductions in the EU (and Associated States, if data are available), so as to maximise the impact and coverage of the most promising applications in the subsequent optimisation and demonstration steps. A preliminary analysis of the technico-economic feasibility and impact of the proposed heat upgrade process is expected already in the proposal.

- Optimise the heat upgrade system to improve its economic and technical performances in terms of: sink output temperature range (90 to 160°C); temperature increase between sink inlet and sink outlet temperatures; temperature spread between source and sink temperatures; flexibility to source input temperature variations; higher sink thermal power; higher coefficient of performance; bigger size; lower CAPEX (equipment) and operational costs (higher efficiency and lower maintenance).

- Development/improvement of design tools at components and system levels.
- Integration and long term full-scale demonstration of the system in an industrial application in at least one industrial sector.
- Technical and economical life cycle assessment of heat upgrade systems adapted for at least 4 industrial sectors, to demonstrate economic viability, define business cases and exploitation strategy.
- Assess the potential impact in CO_2 emissions reduction (Mton CO_2/a) and energy savings (TWh/a) in EU27 and (if data are available) in the Associated States, of using heat upgrade systems in the relevant industrial sectors, taking into account not only the thermal energy temperature and volumes needed by the relevant sectors but also the temperature lift capabilities, and the availability of ambient or waste heat sources. The supply temperature ranges to be considered for the impact assessment are: <100°C, 100-200°C and >200°C. Evaluate the potential impact at global level by extrapolation. In case several projects are funded under this call, the results of this assessment should be compared with the other projects and harmonised.
- Identify the potential barriers to the deployment of heat upgrade and use due to the local regulatory framework in the EU Member States and Associated Countries.
- Disseminate the technical and economic benefits, notably (but not only) to the communities of the relevant Horizon Europe private-public partnerships.
- Given the transversal nature of the technology, the potential for transferring the technology to the building heating sector, including district heat networks, should be assessed and disseminated.

HORIZON-CL5-2021-D4-01-05: Industrial excess (waste) Heat-to-Power conversion based on organic Rankine cycles

Specific conditions	
Expected EU contribution per project	The EU estimates that an EU contribution of between EUR 10.00 and 14.00 million would allow these outcomes to be addressed appropriately. Nonetheless, this does not preclude submission and selection of a proposal requesting different amounts.
Indicative budget	The total indicative budget for the topic is EUR 14.00 million.
Type of Action	Innovation Actions
Technology Readiness Level	Activities are expected to achieve TRL 6-7 by the end of the project – see General Annex B.

Expected Outcome: Project results are expected to contribute to all the following expected outcomes:

- Improved systems based on Organic Rankine Cycle (ORC) to achieve scalability to higher power levels, higher cost effectiveness, wider input temperature ranges, significantly reduced system size, allowing wider take up of heat recovery and its conversion to power from more industrial processes.

- Better awareness of the challenges and benefits of systems based on Organic Rankin Cycles.

Scope: Better use of process excess/waste heat represents a significant source of energy savings for industries. The conversion of excess heat back to electricity would also improve energy efficiency, mitigate the increase of electricity consumption due to industrial electrification and thereby reduce the load on the power grids. This will also facilitate balancing the grid due to intermittent supply of electricity from renewables and so contribute to reduce GHG emissions.

Accounting for the results of previous research[122], proposals are expected to integrate an industrial excess heat-to-power conversion system based on Organic Rankine Cycle (ORC) and demonstrate the system operation in industrial environment at an output power level of at least 2 MW, with improved cost efficiency compared to existing solutions

In order to reach this goal all the following development areas need to be covered:

- Optimisation of thermal cycles and mixtures of fluids or additives for different temperature levels of recovered heat and constrained industrial environment, in terms of efficiency and economics (CAPEX, OPEX).

- Development/improvement of design tools at components and system levels.

- Development/improvement of materials and components: heat exchangers, turbomachinery (including advanced sealing technologies), waste heat recovery unit, power generator and electronics, etc.

- Integration and demonstration of the system in industrial environment; optionally heat storage can be integrated as well in the system.

- Technical, and economical life cycle assessment of heat-to-power systems adapted for at least 4 energy intensive industrial sectors, to demonstrate economic viability, define business cases and exploitation strategy.

- Evaluation of the potential impacts in terms of primary energy savings (GWh/year) in industry (heat recovery) and potential primary energy savings in the power generation sector, assuming full deployment in EU Member States and (as far as data are available

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for the calculation of the impact) in Associated Countries, and at global level by extrapolation.

- Dissemination of the technical and economic benefits, notably (but not only) to the communities of the relevant Horizon Europe private-public partnerships.

Call - Efficient, sustainable and inclusive energy use

HORIZON-CL5-2021-D4-02

Conditions for the Call

Indicative budget(s)[123]

Topics	Type of Action	Budgets (EUR million)	Expected EU contribution per project (EUR million)[124]	Number of projects expected to be funded
		2021		
Opening: 02 Sep 2021 Deadline(s): 25 Jan 2022				
HORIZON-CL5-2021-D4-02-01	IA	15.00	5.00 to 7.50	2
HORIZON-CL5-2021-D4-02-02	IA	22.00	9.00 to 11.00	2
HORIZON-CL5-2021-D4-02-03	CSA	1.00	Around 1.00	1
Overall indicative budget		38.00		

General conditions relating to this call	
Admissibility conditions	The conditions are described in General Annex A.
Eligibility conditions	The conditions are described in General Annex B.

123 The Director-General responsible for the call may decide to open the call up to one month prior to or after the envisaged date(s) of opening.
The Director-General responsible may delay the deadline(s) by up to two months.
All deadlines are at 17.00.00 Brussels local time.
The budget amounts are subject to the availability of the appropriations provided for in the general budget of the Union for years 2021 and 2022.

124 Nonetheless, this does not preclude submission and selection of a proposal requesting different amounts.

Financial and operational capacity and exclusion	The criteria are described in General Annex C.
Award criteria	The criteria are described in General Annex D.
Documents	The documents are described in General Annex E.
Procedure	The procedure is described in General Annex F.
Legal and financial set-up of the Grant Agreements	The rules are described in General Annex G.

Highly energy-efficient and climate neutral EU building stock

Proposals are invited against the following topic(s):

HORIZON-CL5-2021-D4-02-01: Demonstrating integrated technology solutions for buildings with performance guarantees (Built4People)

Specific conditions	
Expected EU contribution per project	The EU estimates that an EU contribution of between EUR 5.00 and 7.50 million would allow these outcomes to be addressed appropriately. Nonetheless, this does not preclude submission and selection of a proposal requesting different amounts.
Indicative budget	The total indicative budget for the topic is EUR 15.00 million.
Type of Action	Innovation Actions
Legal and financial set-up of the Grant Agreements	The rules are described in General Annex G. The following exceptions apply: The funding rate is up to 60% of the eligible costs. This funding rate applies both to members and non-members of the partnership, except for non-profit legal entities, where the funding rate is up to 100% of the total eligible costs.
Technology Readiness Level	Activities are expected to achieve TRL 6-7 by the end of the project – see General Annex B.

Expected Outcome: Project results are expected to contribute to all of the following expected outcomes:

- Demonstrated viability of, and proven integrated technology solutions for, performance guarantees and performance-based contracts to increase buildings energy performance but including aspects going beyond energy towards a broader range of climate- and environment- relevant matters (e.g. resource efficiency, whole life carbon, etc.).

- Enhanced consumer trust in guarantees of performance and related contracts.

- Increased number of market actors, especially SMEs, offering performance-based business models.

- Enhanced awareness of end users and capacity building of businesses on performance-based contracts.

Scope: The proposal should:

- Design and demonstrate innovative integrated technology solutions based on state-of-the-art components (envelope, heating, ventilation and air-conditioning, cooling, automation and control, renewable energy, etc.) solutions for cost-effective buildings' overall performance enhancement with performance guarantees.

- Investigate the viability of performance-based business models combining those technology solutions with attractive and innovative contractual frameworks for performance guarantees and testing them with the relevant market players (e.g. energy suppliers, product manufacturer, technology/service providers).

- Develop business models that suit new industrialised design and production methods, and include enhanced energy and resource (based on suitable Level(s) indicators) performance guarantees with longer commissioning and condition-based maintenance to replace maintenance contracts.

- Develop performance contracts that work with industrialised solutions for the renovations in the residential sector, valorising energy and environmental performance, resource and energy efficiency, energy flexibility (through demand response) and comfort (Comfort Performance Contracts) for all building elements (e.g. building envelope, equipment & systems, energy storage).

- Build, where possible, on existing business approaches that have shown effectiveness for renovation (e.g. one-stop-shops, ESCOs).

- Ensure that those business models make use of digital tools (e.g. energy management systems, block chain, digital logbooks) to increase data availability for measurement and verification and therefore increase the traceability of performance (e.g. energy savings, energy generation, GHG emissions, location of components and substances in the buildings) and to ease the implementation of performance-based contracts.

This topic implements the co-programmed European Partnership on 'People-centric, Sustainable Built Environment' (Built4People).

HORIZON-CL5-2021-D4-02-02: Cost-effective, sustainable multi-functional and/or prefabricated holistic renovation packages, integrating RES and including re-used and recycled materials (Built4People)

Specific conditions	
Expected EU contribution per project	The EU estimates that an EU contribution of between EUR 9.00 and 11.00 million would allow these outcomes to be addressed appropriately. Nonetheless, this does not preclude submission and selection of a proposal requesting different amounts.
Indicative budget	The total indicative budget for the topic is EUR 22.00 million.
Type of Action	Innovation Actions
Legal and financial set-up of the Grant Agreements	The rules are described in General Annex G. The following exceptions apply: The funding rate is up to 60% of the eligible costs. This funding rate applies both to members and non-members of the partnership, except for non-profit legal entities, where the funding rate is up to 100% of the total eligible costs.
Technology Readiness Level	Activities are expected to achieve TRL 7 by the end of the project – see General Annex B.

Expected Outcome: Project results are expected to contribute to all of the following expected outcomes:

- Increased scale and productivity in the renovation process: demonstrated and quantified decrease of on-site construction / renovation work time (at least 30% and towards 50%).
- Benchmarked and quantified improvement of insulation and air-tightness compared to standard renovation solutions.
- Demonstrated improvement of indoor environment and user comfort and satisfaction, as well as accessibility, increasing attractiveness of renovation for buildings owners and users.
- Improved affordability of sustainable renovation and RES systems in buildings, in particular for households experiencing energy poverty issues.
- Demonstrated reduction of embodied energy and CO_2 of renovation, and emission of air pollutants over the life cycle.
- Increased deployment of built-in renewable energy generation solutions for on-site multi-purpose (heating, cooling, electricity) renewable energy generation.

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- Increased share of reused and /or recycled and/or biosourced construction materials / products used in building renovation to contribute to circular economy.

- Faster uptake of EU-wide standards or certification of reused and / or recycled construction materials / products.

Scope: Proposals are expected to deliver large-scale, real life demonstration of promising technology innovations already demonstrated at lab level. Proposals should cover all of the following:

- Develop renovation solutions for a range of needs (from renovations limited in scope to deep renovations) applying predominantly re-used and / or recycled and/or biosourced construction materials / products in a cradle-to-cradle approach, allowing for installation without significantly modifying the structure of the building (or without overloading existing structures) and demonstrating a high replication and industrial potential.

- Develop multi-functional (passive & active) and scalable renovation solutions to improve energy performance of buildings, applicable to different building types based on prefabricated components and integrated RES systems.

- Develop building envelope solutions with integral means for combined active/passive management of energy transfer, i.e., integrating RES for active heat and sound insulation and direct on-site renewable electricity generation.

- Seek to support the integration of local sources of reused components and secondary raw materials in the renovation packages relying, where relevant, on urban mining.

- Develop novel testing methodologies oriented towards assessing the long-term performance of the elements. This should include the estimation of durability and service life.

- Model and test in actual scale the materials and components selected.

- Benchmark energy and environmental performance (applying the appropriate Level(s) indicators), monitoring (at least one year) at real scale of the new solutions, also demonstrating compliance with project and regulatory requirements, and demonstrating cost-effectiveness of the renovation solutions over the lifetime.

- Assess the risks related to major disruptive events (such as flooding, heat waves, and/or other climate-driven events and/or earthquakes) that apply to the geographical zones targeted and, where relevant, include an analysis of resilience of the renovated building / infrastructure against those major disruptive events.

- Demonstrate, based on clear and thorough documentation of relevant activities, that the proposed solutions lead to reduced maintenance costs, lead to an improvement of indoor environment and user comfort and satisfaction, as well as accessibility, can be used in a wide range of environmental conditions, favour sustainable use of resources, respect

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sustainability life cycle principles, including end-of-life analysis involving the reuse of new and replaced elements at the end of service life.

- Consider renovation packages also integrating renewable energy sources for buildings with respect of the aesthetic, the historical value and/or the local architectural identity.

- Lead at least 3 large-scale demonstration of the solutions in diverse geographical areas, with various local environmental, social, and economic conditions, addressing both residential and non-residential buildings.

- Where relevant, contribute to standardisation (e.g. recycled concrete CEN standard) and certification activities (e.g. guides for non-standard hybrid component assessment).

This topic implements the co-programmed European Partnership on 'People-centric, Sustainable Built Environment' (Built4People).

HORIZON-CL5-2021-D4-02-03: Strengthening European coordination and exchange for innovation uptake towards sustainability, quality, circularity and social inclusion in the built environment as a contribution to the new European Bauhaus (Built4People)

Specific conditions	
Expected EU contribution per project	The EU estimates that an EU contribution of around EUR 1.00 million would allow these outcomes to be addressed appropriately. Nonetheless, this does not preclude submission and selection of a proposal requesting different amounts.
Indicative budget	The total indicative budget for the topic is EUR 1.00 million.
Type of Action	Coordination and Support Actions

Expected Outcome: Projects are expected to contribute to the following outcomes:

- Increased uptake of innovative solutions for a sustainable, digitalised, human-centric and inclusive, quality built environment, following circularity principles across the value chain;

- Intensified, cross-sectorial and interdisciplinary peer-learning from front runners;

- Increased awareness on benefits from technological and non-technological (social, cultural) innovation and the synergetic cross-border cooperation in the built environment sector, with due consideration of all relevant aspects such as sustainability, energy and resource efficiency, life-cycle perspective, digitalisation, inclusion and accessibility;

- (In line with the New European Bauhaus) better acknowledgement and integration of quality architecture and design principles, blending design and sustainability in innovative solutions to improve sustainability of the built environment, including cultural heritage, also ensuring compliance with the principles of circular economy, with due consideration

of relevant aspects such as style, human-centric inclusivity and accessibility for persons with disabilities;

- Improved visibility, more systematic adoption (including by users of the built environment) and uptake of innovative results, including from EU funded projects, in the field of sustainable built environment;
- Strengthened, long-lasting and multi-disciplinary networking in the field of innovative sustainable built environment;
- Scaled-up co-financing of innovation in the field of innovative sustainable built environment.

Scope: The proposal should:

- Develop business models to ensure co-financing options to foster innovation for sustainability, style, accessibility and quality of the built environment;
- Support the creation and operation of whole value chain Innovation Clusters linked to the 'Built4People' (B4P) partnership (People-centric sustainable built environment[125]).
- Link up the concept of whole value chain Innovation Clusters with regional/national innovation hubs and clusters, and, to relevant pilot projects of the New European Bauhaus, seeking to improve collaboration between those;
- Combine specialisation and advanced expertise with multi-disciplinary knowledge for cross-border value chains and offer the best possible R&I support to all actors of the European built environment ecosystem in particular for SMEs and mid-caps, as well as their stakeholders and clients;
- Put in place a long-term and multi-disciplinary network structure for those Innovation Clusters, along with an appropriate governance, to focus and nurture public investments that would serve several regions of Europe;
- Organise supporting dissemination actions, including workshops, conferences, peer-learning activities involving final end-users and relevant experts (e.g. accessibility), industrial fora, dissemination material, etc. and develop an organisation and business model for an effective collaboration among these Innovation Clusters, including after the end of the grant;

125 https://ec.europa.eu/info/sites/info/files/research_and_innovation/funding/documents/ec_rtd_he-partnerships-built4people.pdf

- Seek to cooperate with other coordination actions designed to support the New European Bauhaus, for instance in relation to education and dissemination, in the scope of Horizon Europe[126] and beyond;
- Cooperate closely with the leading partners of the B4P partnership.

This topic implements the co-programmed European Partnership on 'People-centric, Sustainable Built Environment' (Built4People).

Call - Efficient, sustainable and inclusive energy use

HORIZON-CL5-2022-D4-01

Conditions for the Call

Indicative budget(s)[127]

Topics	Type of Action	Budgets (EUR million) 2022	Expected EU contribution per project (EUR million)[128]	Number of projects expected to be funded
Opening: 28 Apr 2022 Deadline(s): 06 Sep 2022				
HORIZON-CL5-2022-D4-01-01	IA	12.00	4.00 to 6.00	2
HORIZON-CL5-2022-D4-01-02	IA	12.00	4.00 to 6.00	2
HORIZON-CL5-2022-D4-01-03	IA	12.00	4.00 to 6.00	2
HORIZON-CL5-2022-D4-01-04	RIA	10.00	3.00 to 5.00	2
HORIZON-CL5-2022-D4-01-05	RIA	8.00	3.00 to 4.00	2
Overall indicative budget		54.00		

126 E.g. actions funded under the HORIZON-CIT- 2021-01-02 topic, which should contribute to the New European Bauhaus movement and the objectives of the European Green Deal, in relation to the Mission on Climate Neutral and Smart Cities.

127 The Director-General responsible for the call may decide to open the call up to one month prior to or after the envisaged date(s) of opening.
The Director-General responsible may delay the deadline(s) by up to two months.
All deadlines are at 17.00.00 Brussels local time.
The budget amounts are subject to the availability of the appropriations provided for in the general budget of the Union for years 2021 and 2022.

128 Nonetheless, this does not preclude submission and selection of a proposal requesting different amounts.

General conditions relating to this call	
Admissibility conditions	The conditions are described in General Annex A.
Eligibility conditions	The conditions are described in General Annex B.
Financial and operational capacity and exclusion	The criteria are described in General Annex C.
Award criteria	The criteria are described in General Annex D.
Documents	The documents are described in General Annex E.
Procedure	The procedure is described in General Annex F.
Legal and financial set-up of the Grant Agreements	The rules are described in General Annex G.

Highly energy-efficient and climate neutral EU building stock

Proposals are invited against the following topic(s):

HORIZON-CL5-2022-D4-01-01: Demand response in energy-efficient residential buildings

Specific conditions	
Expected EU contribution per project	The EU estimates that an EU contribution of between EUR 4.00 and 6.00 million would allow these outcomes to be addressed appropriately. Nonetheless, this does not preclude submission and selection of a proposal requesting different amounts.
Indicative budget	The total indicative budget for the topic is EUR 12.00 million.
Type of Action	Innovation Actions
Technology Readiness Level	Activities are expected to achieve TRL 6-7 by the end of the project – see General Annex B.

Expected Outcome: Project results are expected to contribute to all of the following expected outcomes:

- Increased potential benefits, trust and acceptability of demand-response solutions for residential consumers.
- Advanced asset control and aggregation approaches that enable the participation of residential buildings in commercial demand response.
- Expanded pool of assets relevant for demand response in the residential sector.

Scope: Address the large but untapped potential of the residential sector for Demand Response with a view to support the energy transition at system level while respecting user privacy, comfort and ownership.

Proposals should:

- Investigate innovative demand response solutions for the residential sector, including new control modes and asset optimisation techniques involving as many devices as possible.
- Ensure that the proposed solutions comply with the principle of privacy by design and with best practices on data protection.
- Ensure that the proposed solutions allow to minimise the effort required to elicit user preferences, also investigating innovative approaches for user segmentation and engagement.
- Take due account the regulatory frameworks of the regions / countries in which the proposed solutions could be deployed in designing their innovation, and shaping related exploitation activities.
- Seek to the best consideration of social and economic enablers in the design of the innovative solutions.
- Consider social innovations, notably as new tools, ideas and methods leading to active citizen engagement and as drivers of social change, social ownership, and new social practices.
- Demonstrate that the proposed solutions lead to reducing costs of small demand response assets e.g. through improved models and faster data processing and, are scalable and replicable.
- Demonstrate that the proposed solutions are suitable for explicit demand response, or a combination of both explicit and implicit residential demand response.

Each project is expected to include at least three demonstration sites located in different climatic regions.

Clustering and cooperation with other relevant projects is strongly encouraged; in particular, liaison and synergies with the European Partnership on ‘People-centric sustainable built environment’.

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HORIZON-CL5-2022-D4-01-02: Renewable-intensive, energy positive homes

Specific conditions	
Expected EU contribution per project	The EU estimates that an EU contribution of between EUR 4.00 and 6.00 million would allow these outcomes to be addressed appropriately. Nonetheless, this does not preclude submission and selection of a proposal requesting different amounts.
Indicative budget	The total indicative budget for the topic is EUR 12.00 million.
Type of Action	Innovation Actions
Technology Readiness Level	Activities are expected to achieve TRL 6-7 by the end of the project – see General Annex B.

Expected Outcome: Project results are expected to contribute to all of the following expected outcomes:

- Faster transition to the next generation of new constructions and renovation of cost-effective energy positive, climate neutral residential buildings.
- Streamlined integration of advanced smart technologies, renewable energy and storage solutions in residential construction and renovation projects.
- Faster transition to buildings and technical elements that are capable to adapt to different user profiles and lifestyles, improving air quality, human health and well-being parameters.
- Improved skills and competences among the workforce.to support a rapid uptake of energy positive buildings in the residential sector.

Scope: The aim is to move beyond NZEB (nearly zero-energy buildings) for new constructions and to the extent possible, for renovations, and to streamline energy positive buildings, ensuring buildings can marry high energy performance with maximum flexibility and adaptability to a changing society in a cost-effective manner. This is a key challenge for the residential sector, where energy positive houses should become the norm.

Proposals should:

- Investigate and demonstrate approaches for the construction of new energy positive residential buildings (and /or the renovation of existing residential buildings), with a focus on multi-family, multi-storey buildings, encompassing all relevant areas:
    - Design phase (aesthetic and technical solutions and their potential, passive and active strategies, sustainable design);
    - Integrated design and construction concepts;

- Reconfigurable designs and technical elements capable of adapting to different user profiles and lifestyles;
- Selection of affordable and efficient construction materials, building on previous projects which have developed efficient insulation materials with improved properties and smart materials;
- Innovative processes from manufacturing to construction site;
- Integration of renewable energy production for heating and cooling, electricity production (e.g. BIPV and BAPV), and where relevant, thermal and electrical storage, including shared at neighbourhood and district levels; for existing buildings, cost-effective, innovative solutions that allow to (at least) fully cover the energy consumption of the building (electricity, heat and cooling) with renewable energy;
- Advanced use of smart management technologies (for control and operational issues, Building Management Systems (BMS) or Building Automation Systems (BAS)) to improve air quality, human health and well-being parameters, to facilitate engagement and inclusiveness of occupants and support measurement of (as-built) building performance;
- Reuse and recycling of elements, components and materials, in particular in relation to buildings end of life, also minimizing embodied carbon emissions over the whole life cycle, in particular for smart technologies;
- Where applicable, the use of grey- and black-waters.

- Ensure that the cost of such buildings/apartments does not increase substantially compared to current local / regional practises.

Clustering and cooperation with other relevant projects is strongly encouraged; in particular, liaison and synergies with the Horizon Europe Partnership on 'People-centric sustainable built environment'.

Each project is expected to include at least three demonstration sites located in different climatic regions.

The demonstrations are expected to span a continuous interval of at least twelve months and to ensure measurement of (as-built) building performances. The relevant building professionals (e.g. architects, installers, workers, craftsmen, building managers) should be involved.

Projects are expected to assess the sustainability of the proposed solutions in environmental, social and economic terms, considering among others the embodied carbon emissions from materials. The reuse and recycling of elements, components and materials of the proposed solutions at the end of life should be ensured.

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HORIZON-CL5-2022-D4-01-03: Smarter buildings for better energy performance

Specific conditions	
Expected EU contribution per project	The EU estimates that an EU contribution of between EUR 4.00 and 6.00 million would allow these outcomes to be addressed appropriately. Nonetheless, this does not preclude submission and selection of a proposal requesting different amounts.
Indicative budget	The total indicative budget for the topic is EUR 12.00 million.
Type of Action	Innovation Actions
Technology Readiness Level	Activities are expected to achieve TRL 8 by the end of the project – see General Annex B.

Expected Outcome: Project results are expected to contribute to all of the following expected outcomes:

- More innovative, affordable, user-friendly and accessible products and systems to continuously monitor and improve the energy performance of buildings.
- Increased building energy performance through the optimisation and integration of different technologies, including renewable energy and storage, and services.
- Easier and more systematic use smart products and services to achieve savings where energy renovation is not an option.
- Higher replicability to increase number of buildings with smart building devices and digital infrastructure resulting in a higher smart readiness rating.

Scope: Improvement and cost-reduction of technologies to predict, assess, monitor and control in real time the energy performance of buildings, including energy efficiency, renewables, storage and their optimisation.

The proposal should:

- Develop new or enhance existing solutions for interoperability of systems, including between building automation and control systems (BACS) and other technical building systems and devices (including IoT ones), as well as between buildings and the grid.
- Investigate innovative approaches to ensure high level of security and privacy by design in buildings.
- Investigate approaches to reduce costs of systems allowing the integration of energy efficiency, renewables, storage and their optimisation.

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- On the basis of the above, demonstrate the potential for energy savings from energy management solutions based on smart technical building systems (predictive controllers, smart thermostats, active sensors, smart lighting, etc.).
- Assess the contribution of proposed solutions to the enhancement of smart readiness of buildings as rated by the smart readiness indicator under Directive 2010/31/EU.
- Demonstrate that the developed solutions are user-friendly and ensure the desired indoor environment quality and user satisfaction.
- Where possible, demonstrate that such solutions can build flexibly on services/products not originally intended for energy management (e.g. a smart home system).
- Seek to ensure from the design phase that the project is developed with a view to integrate its results/deliverables under a digital building logbook.

Each project is expected to include at least three demonstration sites located in different climatic regions.

Clustering and cooperation with other relevant projects is strongly encouraged; in particular, liaison and synergies with the European Partnership on 'People-centric sustainable built environment'.

Industrial facilities in the energy transition

Proposals are invited against the following topic(s):

HORIZON-CL5-2022-D4-01-04: Development and pilot demonstration of heat upgrade technologies with supply temperature in the range 150-250°C

Specific conditions	
Expected EU contribution per project	The EU estimates that an EU contribution of between EUR 3.00 and 5.00 million would allow these outcomes to be addressed appropriately. Nonetheless, this does not preclude submission and selection of a proposal requesting different amounts.
Indicative budget	The total indicative budget for the topic is EUR 10.00 million.
Type of Action	Research and Innovation Actions
Technology Readiness Level	Activities are expected to achieve TRL 5 by the end of the project – see General Annex B.

Expected Outcome: Project results are expected to contribute to all the following expected outcomes:

- Validate the technical feasibility of industrial heat upgrade systems capable of supplying various industrial processes with useful heat in the (sink) temperature range of 150 – 250 °C from renewable heat sources (e.g. solar thermal), ambient heat or industrial waste heat.

- Development and demonstration at pilot scale (5 – 200 kWth).

- Better awareness of the challenges and benefits of heat upgrade in the relevant industrial sectors.

Scope: This topic aims to satisfy the need for low-medium temperature heat in the relevant industrial sectors, by upgrading lower temperature heat flows, including from renewable heat sources, ambient heat or industrial excess (waste) heat, as a cost-efficient way to improve energy efficiency and reduce the GHG emissions.

Available heat upgrade technologies, such as for example heat pumps, are limited to supply (sink) temperatures of 150°C. Innovative heat upgrade technologies have the potential to extend the temperature range up to 250°C, which would allow to cover more industrial applications.

In order to reach this goal all the following development areas need to be covered:

- Identify the target industrial processes which would benefit from this higher temperature heat upgrade technology, as excess (waste) heat sources and as users (heat sinks); make a preliminary assessment of the potential impacts of these industrial applications in terms of energy savings and GHG and air pollutant emissions reductions in the EU (and Associated States, if data are available), so as to maximise the impact and coverage of the most promising applications in the subsequent development step; estimate by extrapolation the benefits at global level. A preliminary analysis of the feasibility and GHG emissions reduction impact, of the proposed heat upgrade process is expected already in the proposal.

- Develop one or more heat upgrade technologies to raise the sink output temperature to the range 150 to 250°C. If needed investigate in new working fluids. Optimise the technical performances in terms of: temperature increase between sink inlet and sink outlet temperatures; temperature spread between source and sink temperatures; flexibility to source input temperature variations; higher sink thermal power potential; higher coefficient of performance.

- Integration and demonstration of at least one system at pilot scale, in conditions, as far as practical, similar to real industrial environment. The optional integration of renewable heat sources (e.g. solar thermal) as the input heat flow to be further upgraded, is in scope.

- Make a preliminary estimation of the future equipment cost for at least two industrial applications, to evaluate its economic potential; define an exploitation strategy.

- Dissemination of the technical and economic benefits, notably (but not only) to the communities of the relevant Horizon Europe private-public partnerships.

HORIZON-CL5-2022-D4-01-05: Development of high temperature thermal storage for industrial applications

Specific conditions	
Expected EU contribution per project	The EU estimates that an EU contribution of between EUR 3.00 and 4.00 million would allow these outcomes to be addressed appropriately. Nonetheless, this does not preclude submission and selection of a proposal requesting different amounts.
Indicative budget	The total indicative budget for the topic is EUR 8.00 million.
Type of Action	Research and Innovation Actions
Technology Readiness Level	Activities are expected to achieve TRL 4-5 by the end of the project – see General Annex B.

Expected Outcome: Project results are expected to contribute to all the following expected outcomes:

- Short term (intraday or a couple of days) thermal storage systems for decoupling the heat generation from the heat use in industrial processes.
- Development of economically affordable new materials (including better basic understanding) for heat storage dedicated to medium to high temperature industrial processes.
- Better awareness of the challenges and benefits of heat storage in the relevant industrial sectors.

Scope: This topic aims to satisfy the need for decoupling the heat generation from the heat use in continuous or non-continuous industrial processes, in order to allow for heat exchanges between different industrial processes and so enable industrial symbiosis, or to generate heat during off-peak times and so provide energy demand flexibility.

In order to reach this goal all the following development areas need to be covered:

- Cost effective and new designs for high temperature storage of industrial heat, with minimal footprint. The large capacity storages in combination with long design lifetime, require the development of novel materials and designs.
- Development of materials and components: thermal storage materials, container construction, insulation technology, heat exchangers with aid of computational fluid dynamics.
- Integration and demonstration of the system at lab scale.

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- Make a preliminary estimation of the future equipment cost for at least two industrial applications, to evaluate its economic potential.
- Make an analysis of the potential industrial applications and related benefits of the proposed storage system in EU27 and (if data are available) in the Associated States and, by extrapolation, at global level; a preliminary version of this analysis is expected already in the proposal. Define an exploitation strategy.
- Dissemination of the technical and economic benefits, notably (but not only) to the communities of the relevant Horizon Europe private-public partnerships.

Call - Efficient, sustainable and inclusive energy use

HORIZON-CL5-2022-D4-02

Conditions for the Call

Indicative budget(s)[129]

Topics	Type of Action	Budgets (EUR million)	Expected EU contribution per project (EUR million)[130]	Number of projects expected to be funded
		2022		
Opening: 06 Sep 2022 Deadline(s): 24 Jan 2023				
HORIZON-CL5-2022-D4-02-01	IA	15.00	5.00 to 7.50	2
HORIZON-CL5-2022-D4-02-02	IA	15.00	5.00 to 7.50	2
HORIZON-CL5-2022-D4-02-03	RIA	20.00	4.00 to 5.00	4
HORIZON-CL5-2022-D4-02-04	IA	18.00	6.00 to 9.00	2
HORIZON-CL5-2022-D4-02-05	IA	18.00	6.00 to 9.50	2
Overall indicative budget		86.00		

129 The Director-General responsible for the call may decide to open the call up to one month prior to or after the envisaged date(s) of opening.
The Director-General responsible may delay the deadline(s) by up to two months.
All deadlines are at 17.00.00 Brussels local time.
The budget amounts are subject to the availability of the appropriations provided for in the general budget of the Union for years 2021 and 2022.

130 Nonetheless, this does not preclude submission and selection of a proposal requesting different amounts.

General conditions relating to this call	
Admissibility conditions	The conditions are described in General Annex A.
Eligibility conditions	The conditions are described in General Annex B.
Financial and operational capacity and exclusion	The criteria are described in General Annex C.
Award criteria	The criteria are described in General Annex D.
Documents	The documents are described in General Annex E.
Procedure	The procedure is described in General Annex F.
Legal and financial set-up of the Grant Agreements	The rules are described in General Annex G.

Highly energy-efficient and climate neutral EU building stock

Proposals are invited against the following topic(s):

HORIZON-CL5-2022-D4-02-01: Designs, materials and solutions to improve resilience, preparedness & responsiveness of the built environment for climate adaptation (Built4People)

Specific conditions	
Expected EU contribution per project	The EU estimates that an EU contribution of between EUR 5.00 and 7.50 million would allow these outcomes to be addressed appropriately. Nonetheless, this does not preclude submission and selection of a proposal requesting different amounts.
Indicative budget	The total indicative budget for the topic is EUR 15.00 million.
Type of Action	Innovation Actions
Legal and financial set-up of the Grant Agreements	The rules are described in General Annex G. The following exceptions apply: The funding rate is up to 60% of the eligible costs. This funding rate applies both to members and non-members of the partnership, except

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	for non-profit legal entities, where the funding rate is up to 100% of the total eligible costs.
Technology Readiness Level	Activities are expected to achieve TRL 6-7 by the end of the project – see General Annex B.

Expected Outcome: Project results are expected to contribute to all of the following expected outcomes:

- Increased awareness of the built environment's protective role for people and climate adaptation in case of disruptive events.
- Mainstreamed resilience as a key feature of the built environment across its life cycle.
- Improved ability of the built environment to support the preparedness and responsiveness to disruptive events at larger scales.
- Improved ability of the built environment to contribute to the overall quality of living and working.
- Strengthened supply chains for materials and solutions for a resilient and climate proof built environment, adapted to local risks.

Scope: The proposal should:

- Deliver innovative designs, materials and solutions to improve resilience and climate proofing of the built environment (in particular new and existing buildings) in a cost-effective and reliable manner.
- Ensure the proposed solutions cover a broad spectrum of natural risks and disasters, for instance natural disruptive events such as earthquakes, floods, heat waves, with a particular focus on extreme climatic events.
- Ensure the proposed solutions make use of natural, easy to manage, as well as advanced, evolutive materials and technologies that help combat the effects of global warming (increased cooling demand, heat island effects, etc.) and result in increased durability, resilience and adaptability of buildings and infrastructures, including their foundations.
- Consider social innovation where relevant, notably as new tools, ideas and methods leading to active citizen engagement and resilience, and as drivers of social change, social ownership, and new social practices.
- Develop and deploy digital and interoperable tools for monitoring, detection of, and response to critical situations (e.g. evacuation of people and first responders).
- Rely, where relevant, on self-sensing and adaptable materials, and materials with embedded sensors and actuators.

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- Include, as part of the proposed solutions, built environment concepts that are self-sustained for a certain period of time – including off-grid electricity supply, green infrastructure and water purification and / or rain water provision in buildings.

- Where relevant, investigate whether and how the proposed approaches could apply to cultural heritage buildings across different typologies and geographic conditions, also including innovations in business models and ensuring holistic integration of disciplines across the value chain.

- Validate the proposed solutions for a set of locations that is coherent with the risks and disasters considered in the proposal, ensuring a high degree of awareness and involvement of supply chains.

- Demonstrate that the proposed solutions improve the protection of people when experiencing disruptive events and contribute to enhance resilience and climate proofing at a larger scale (e.g. district, city, energy system).

- Demonstrate that the proposed solutions contribute to improving the overall quality of living and working in the buildings (e.g. in terms of accessibility, comfort and well-being).

- Demonstrate cost-effective improvement of the energy performance, reducing the cost of the interventions compared to traditional methods, as well as the energy related operational costs after the renovation.

- Demonstrate that the proposed solutions improve the use of relevant data such as weather forecasts or catastrophe warnings by monitoring and management systems in the built environment (e.g. to launch automatic emergency protocols to warn and protect buildings users).

- Lead at least 3 large-scale demonstration of the solutions in diverse geographical areas, with various local environmental, social, and economic conditions.

Clustering and cooperation with other relevant projects is strongly encouraged; e.g. with the Horizon Europe Partnership on 'Driving urban transitions'.

This topic requires the effective contribution of SSH disciplines and the involvement of SSH experts, institutions as well as the inclusion of relevant SSH expertise, in order to produce meaningful and significant effects enhancing the societal impact of the related research activities.

For this topic, projects are encouraged to define and implement ambitious international outreach and cooperation strategies.

This topic implements the co-programmed European Partnership on 'People-centric, Sustainable Built Environment' (Built4People).

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HORIZON-CL5-2022-D4-02-02: Solutions for the sustainable, resilient, inclusive and accessible regeneration of neighbourhoods enabling low carbon footprint lifestyles and businesses (Built4People)

Specific conditions	
Expected EU contribution per project	The EU estimates that an EU contribution of between EUR 5.00 and 7.50 million would allow these outcomes to be addressed appropriately. Nonetheless, this does not preclude submission and selection of a proposal requesting different amounts.
Indicative budget	The total indicative budget for the topic is EUR 15.00 million.
Type of Action	Innovation Actions
Legal and financial set-up of the Grant Agreements	The rules are described in General Annex G. The following exceptions apply: The funding rate is up to 60% of the eligible costs. This funding rate applies both to members and non-members of the partnership, except for non-profit legal entities, where the funding rate is up to 100% of the total eligible costs.
Technology Readiness Level	Activities are expected to achieve TRL 6-7 by the end of the project – see General Annex B.

Expected Outcome: Project results are expected to contribute to all of the following expected outcomes:

- Lasting behavioural change of people and economic actors towards lower carbon footprint lifestyles and businesses.
- Mainstreamed participatory planning processes and interaction with all relevant stakeholder groups in city planning.
- More sustainable, low emission, inclusive and affordable neighbourhoods and built environment.
- Improved accessibility of neighbourhoods through building-integrated, sustainable mobility solutions.
- Extended application of digital applications and tools to ease decision-making processes in complex stakeholder structures.
- Raised awareness and increased capacity of citizens on participatory processes for enhanced sustainability and environmental performance.

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- Increased well-being and economic prosperity of citizens in a low carbon, sustainable built environment by ensuring high indoor and outdoor quality, and affordability of renovation solutions.

- Increased attractiveness of deep renovation through new regeneration and smart growth models for sustainable living.

Scope: The proposal should:

- Deliver innovative methods and solutions for the regeneration of neighbourhoods, with due consideration of, inter alia, energy efficiency, sustainability, resilience, health, inclusiveness and accessibility, based on participatory planning processes and innovative decision-making procedures and digital applications.

- Ensure the proposed solutions allow to identify and integrate local sources of raw materials for building renovation in built environment planning scenarios.

- Ensure the proposed solutions include new evidence-based approaches (e.g. strategies and digital tools) to help quantify the benefits of integrated built environment transformation aimed at climate neutrality.

- Ensure the proposed solutions allow for involving all stakeholder groups, including inter alia elderly people, those with reduced mobility and persons with disabilities, and households affected by energy poverty, also seeking to address gentrification issues in neighbourhoods affected by energy poverty.

- Ensure the proposed solutions include concepts for local renewable energy generation and consumption integrated at building and district level in combination with multi-modal mobility concepts targeted to both urban and rural neighbourhoods.

- Ensure the proposed solutions contribute to optimising energy balancing at local level (e.g. thanks to energy sharing platforms and services connected to local micro-grids and / or virtual energy markets, including demand response and decision-support systems and block chain applications).

- Ensure the proposed solutions comply with the principles of circular economy, favouring urban mining, efficient use of resources, durability, reuse and recyclability.

- Ensure the proposed solutions are developed taking into account local environmental, social, and economic conditions and are relevant for the different geographical locations targeted.

- Where relevant, include concepts for energy circularity such as waste heat recovery from local industries (or other sources) and use in nearby buildings or in low-temperature district networks and, valorisation of by-products and residues (e.g. from local agro-food industry) for energy or other uses.

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- Where relevant, investigate whether and how the proposed approaches could apply to cultural heritage buildings.
- Lead at least 3 large-scale demonstrations of the solutions in diverse geographical areas, with various local environmental, social, and economic conditions.
- Consider social innovation where relevant and in the case where the proposed solutions are at the socio-technical interface and require social change, new social practices, social ownership or market uptake.
- Facilitate awareness raising and capacity building of citizens and relevant stakeholders (e.g. citizen associations, local authorities, businesses from the relevant sectors) on the principles and multi-benefits of sustainable, inclusive and accessible built environment.

Clustering and cooperation with other relevant projects is strongly encouraged; e.g. with the European Partnership on 'Driving urban transitions'.

This topic requires the effective contribution of SSH disciplines and the involvement of SSH experts, institutions as well as the inclusion of relevant SSH expertise, in order to produce meaningful and significant effects enhancing the societal impact of the related research activities.

This topic implements the co-programmed European Partnership on 'People-centric, Sustainable Built Environment' (Built4People).

HORIZON-CL5-2022-D4-02-03: Sustainable and resource-efficient solutions for an open, accessible, inclusive, resilient and low-emission cultural heritage: prevention, monitoring, management, maintenance, and renovation (Built4People)

Specific conditions	
Expected EU contribution per project	The EU estimates that an EU contribution of between EUR 4.00 and 5.00 million would allow these outcomes to be addressed appropriately. Nonetheless, this does not preclude submission and selection of a proposal requesting different amounts.
Indicative budget	The total indicative budget for the topic is EUR 20.00 million.
Type of Action	Research and Innovation Actions
Technology Readiness Level	Activities are expected to achieve TRL 5 by the end of the project – see General Annex B.

Expected Outcome: Project results are expected to contribute to all of the following expected outcomes:

- Increased availability and enhanced overall performance, including with regard to cost-effectiveness, of solutions applicable to the reliable and respectful historical renovation of heritage buildings, preserving their architectural and cultural identity.
- Demonstrated potential of sustainable, energy and resource-efficient historical renovation of heritage buildings.
- Better protection of the value and long-term inclusiveness, accessibility and usability of cultural heritage sites.
- More cost-effective and less disruptive modernisation and preservation of the heritage built environment.
- Enhanced prevention and monitoring of the heritage built environment.
- More important role of the cultural heritage in deployment, showcasing and replication of solutions for a sustainable built environment.

Scope: The proposal should:

- Deliver technically and socially innovative, sustainable, energy and resource-efficient solutions for the cost-effective improvement and preservation of cultural heritage built environment along all relevant aspects: inclusiveness, accessibility, resilience, environmental and energy performance.
- Ensure the proposed solutions cover all relevant aspects of the heritage built environment's life cycle: design, renovation works, operation, monitoring and management, and maintenance.
- Ensure the proposed solutions allow to maintain the heritage value (e.g. artistic, historic, social and scientific) of targeted sites, while improving access and comfort of users and visitors, and reducing maintenance and operational costs.
- Ensure, where relevant, that the proposed solutions rely on (adapted) historic or traditional construction techniques and materials for sustainable restoration.
- Ensure the proposed solutions include natural low maintenance as well as advanced renovation techniques for high quality design and construction, including new digital technologies, while preserving the cultural value of the targeted sites.
- Ensure the proposed solutions contribute to facilitate the integration renewable energy sources while respecting the aesthetic and cultural identity of the targeted buildings.
- Ensure the proposed solutions contribute to the cost-effective improvement of the energy performance, also reducing the cost of the interventions compared to traditional methods.

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- Ensure the involvement of relevant stakeholder groups (e.g. civil society organisations, associations, cultural heritage stakeholders such as cultural heritage protection bodies) and citizens' acceptance thanks to co-creation processes and socially innovative ideas.
- Deliver and demonstrate decision-support tools for low-disruptive, optimal renovation of heritage built environment to enhance sustainability.
- Clustering and cooperation with other relevant projects is strongly encouraged; e.g. with the Horizon Europe Partnership on 'Driving urban transitions'.
- This topic requires the effective contribution of SSH disciplines and the involvement of SSH experts, institutions as well as the inclusion of relevant SSH expertise, in order to produce meaningful and significant effects enhancing the societal impact of the related research activities.
- This topic should consider social innovation as driver of social change, new social practices, social ownership and/or market uptake.

This topic implements the co-programmed European Partnership on 'People-centric, Sustainable Built Environment' (Built4People).

HORIZON-CL5-2022-D4-02-04: Smart-grid ready and smart-network ready buildings, acting as active utility nodes (Built4People)

Specific conditions	
Expected EU contribution per project	The EU estimates that an EU contribution of between EUR 6.00 and 9.00 million would allow these outcomes to be addressed appropriately. Nonetheless, this does not preclude submission and selection of a proposal requesting different amounts.
Indicative budget	The total indicative budget for the topic is EUR 18.00 million.
Type of Action	Innovation Actions
Legal and financial set-up of the Grant Agreements	The rules are described in General Annex G. The following exceptions apply: The funding rate is up to 60% of the eligible costs. This funding rate applies both to members and non-members of the partnership, except for non-profit legal entities, where the funding rate is up to 100% of the total eligible costs.
Technology Readiness Level	Activities are expected to achieve TRL 7 by the end of the project – see General Annex B.

Expected Outcome: Project results are expected to contribute to all of the following expected outcomes from the grid and to adapt their behaviour accordingly;

- Improved interoperability and synergies between electricity and other energy carriers, and with other relevant non-energy sectors (e.g. mobility), supported by buildings, contribution to energy system integration at building's level.

- Improved competitiveness of buildings as flexibility assets for grid and network management.

Scope: The proposals should:

- Deliver building-to-grid integration solutions that are cost-effective, simple to use and easy to install and maintain, and are applicable to both new and existing buildings.

- Enhance interoperability and synergies between buildings and grids, electricity and other energy carriers (e.g. district heating networks, hydrogen, etc.) and where relevant, other relevant sectors (e.g. e-mobility).

- Enhance synergies between on-site energy storage and on-site renewable energy sources.

- Contribute to enhance interoperability in the modelling of energy grids and buildings.

- Ensure the proposed solutions include 'big data' applications for real-time management and predictive maintenance of technical building systems.

- Ensure the proposed solutions minimise potential negative impacts neither on the satisfaction of building users (e.g. in relation to comfort or accessibility) nor on the potential of circular material flows during the building's life cycle, and maximise potential benefits (e.g. energy costs savings and health).

- Ensure the proposed solutions give access to accessible, inclusive, reliable and user-friendly tools with limited maintenance needs and, to relevant building (and grid / network) data for interested stakeholders (e.g. facility managers).

- Assess the contribution of proposed solutions to the enhancement of smart readiness of buildings as rated by the smart readiness indicator under Directive 2010/31/EU.

- Where relevant, rely on advanced monitoring and management solutions such as those that integrate digital models / BIM with energy modelling and simulation at building level and district level.

- Implement and demonstrate innovative and competitive balancing, storage and generation services in buildings, while maximising building users' and occupants' health, comfort and satisfaction.

- Demonstrate cost-effectiveness and economic viability of the proposed solutions and underlying business models for both consumers / end-users and the economic actors involved.

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- Demonstrate the use of large-scale interoperable platforms that bring together different actors and sectors (ESCOs, aggregators, DSOs, etc.) to exchange data and develop services.

- Seek to involve major European innovators, including social innovators, in relevant fields (demand response, communications, smart appliances, building services, facility management, energy services, etc.) with limited experience of Horizon 2020.

Clustering and cooperation with relevant projects is strongly encouraged; e.g. with the European Partnership on 'Driving urban transitions'.

This topic implements the co-programmed European Partnership on 'People-centric, Sustainable Built Environment' (Built4People).

HORIZON-CL5-2022-D4-02-05: More sustainable buildings with reduced embodied energy / carbon, high life-cycle performance and reduced life-cycle costs (Built4People)

Specific conditions	
Expected EU contribution per project	The EU estimates that an EU contribution of between EUR 6.00 and 9.50 million would allow these outcomes to be addressed appropriately. Nonetheless, this does not preclude submission and selection of a proposal requesting different amounts.
Indicative budget	The total indicative budget for the topic is EUR 18.00 million.
Type of Action	Innovation Actions
Legal and financial set-up of the Grant Agreements	The rules are described in General Annex G. The following exceptions apply: The funding rate is up to 60% of the eligible costs. This funding rate applies both to members and non-members of the partnership, except for non-profit legal entities, where the funding rate is up to 100% of the total eligible costs.
Technology Readiness Level	Activities are expected to achieve TRL 6-7 by the end of the project – see General Annex B.

Expected Outcome: Project results are expected to contribute to all of the following expected outcomes:

- Increased and more traceable reduction of the GHG emissions of buildings in design, construction, renovation, operation and end of life.

- Faster market uptake of design solutions, materials, products, techniques and business models that are demonstrated to reduce significantly building related life-cycle costs and impacts, including whole life emissions, compared to current building completions.

- Mainstreamed affordable high life-cycle performance, and improved circularity of buildings in construction and renovation.

Scope: The proposal should:

- Demonstrate innovative design, construction and renovation methods, design and technology solutions that minimise the overall life-cycle environmental impact, reducing energy consumption and carbon footprint of the built environment across the life cycle, from construction to end of life thanks to, inter alia, applying circularity principles throughout the design and construction process, flexible use and lifecycle extension by design, design for deconstruction, disassembly and reassembly, integration of waste, reused, recycled, upcycled and bio-based materials and components, optimisation of design, construction and operation by means of digital tools.

- Deliver scalable full building demonstrations (both new and renovation) with validated performance measurements based on appropriate Level(s) indicators, demonstrating that the proposed methods and technology solutions optimise the use of energy and resources, and minimise the emissions of CO_2 and other air pollutants across all phases of the life cycle, including construction and renovation works, and operation.

- Integrate the use of low embodied carbon products and solutions, including those that are locally sourced and bio-based with low carbon impact and capturing / storing CO_2, selected based on modelling of their performance in terms of (inter alia) insulating, cooling, acoustic and hygrometric performance, ageing patterns, potential for deconstruction and/or reuse at end of life, and potential for automated / mechanised deployment.

- Identify and integrate local sources of reused or recycled construction products and secondary raw materials for building renovation in urban and rural planning scenarios.

- Where relevant, investigate whether and how the proposed approaches could apply to cultural heritage buildings.

- Seek to ensure from the design phase that the project is developed with a view to integrate its results/deliverables under a digital building logbook.

- Deploy advanced, market-ready prefabs and multifunctional materials and components with optimal recycling and re-using potential (e.g. through new designs enabling the re-use) and optimal performance across relevant areas (energy, durability, safety and protection against fire).

- Demonstrate innovative solutions for optimal design, construction, operation and maintenance of sustainable buildings, including efficient technical building systems, automation and control, digital building logbooks, digital twins and other tools.

- Demonstrate the solutions in diverse geographical areas, with various local environmental, social, and economic conditions.

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- Clustering and cooperation with other relevant projects is strongly encouraged; e.g. with the Horizon Europe Partnership on ‘Driving urban transitions’.

This topic implements the co-programmed European Partnership on ‘People-centric, Sustainable Built Environment’ (Built4People).

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Destination – Clean and competitive solutions for all transport modes

This Destination addresses activities that improve the climate and environmental footprint, as well as competitiveness, of different transport modes.

The transport sector is responsible for 23% of CO_2 emissions and remains dependent on oil for 92% of its energy demand. While there has been significant technological progress over past decades, projected GHG emissions are not in line with the objectives of the Paris Agreement due to the expected increase in transport demand. Intensified research and innovation activities are therefore needed, across all transport modes and in line with societal needs and preferences, in order for the EU to reach its policy goals towards a net-zero greenhouse gas emissions by 2050 and to reduce significantly air pollutants.

The areas of rail and air traffic management will be addressed through dedicated Institutional European Partnerships and are therefore not included in this document.

This Destination contributes to the following Strategic Plan's **Key Strategic Orientations (KSO)**:

- *C: Making Europe the first digitally led circular, climate-neutral and sustainable economy through the transformation of its mobility, energy, construction and production systems.*
- *A: Promoting an open strategic autonomy by leading the development of key digital and enabling technologies, sectors and value chains to accelerate and steer the digital and green transitions through human-centred technologies and innovations.*

It covers the following **impact areas**:

- Industrial leadership in key and emerging technologies that work for people;
- Smart and sustainable transport.

The **expected impact**, in line with the Strategic Plan, is to contribute *"Towards climate-neutral and environmental friendly mobility through clean solutions across all transport modes while increasing global competitiveness of the EU transport sector*", notably through:

a. Transforming **road transport to zero-emission mobility** through a world-class European research and innovation and industrial system, ensuring that Europe remains world leader in innovation, production and services in relation to road transport (more detailed information below).

b. Accelerating the reduction of all **aviation** impacts and emissions (CO_2 and non-CO_2, including manufacturing and end-of-life, noise), developing aircraft technologies for deep reduction of greenhouse gas emissions, and maintaining European aero-industry's global leadership position (more detailed information below).

c. Accelerate the development and prepare the deployment of climate neutral and clean solutions in the shipping sector, reduce its environmental impact (on biodiversity, noise,

pollution and waste management), improve its system efficiency, leverage digital and EU satellite-navigation solutions and contribute to the competitiveness of the European **waterborne sector** (more detailed information below).

d. Devising more effective ways for **reducing emissions and their impacts** through improved scientific knowledge (more detailed information below).

When considering their impact, proposals also need to assess their compliance with the "Do No Significant Harm" principle[131] according to which the research and innovation activities of the project should not be supporting or carrying out activities that make a significant harm to any of the six environmental objectives of the EU Taxonomy Regulation.

Zero-emission road transport

With the aim of accelerating the development and deployment of zero tailpipe emission road transport with a system approach in Europe, the European Partnership "Towards zero emission road transport" (2Zero) will work towards a common vision and delivering a multi-stakeholders roadmap for a climate neutral and clean road transport system that improves mobility and safety of people and goods and ensures future European leadership in innovation, production and services.

The transformation towards zero tailpipe emission road mobility will deliver tangible benefits including, at the local scale, pollutant emission reductions, cleaner air (including unregulated pollutants, nanoparticles and secondary pollutants), reduced noise, increased accessibility and more liveable urban plus peri-urban spaces. Major benefits for citizens' health and quality of life will be generated, and European economic growth will be supported, hence a solid base for new business opportunities will be created. Within 2Zero, priority will be given to the development of drivetrains for zero emission heavy-duty long-haul vehicles, where progress is lagging behind other sectors of road transport.

Several levels of interactions are foreseen with other European initiatives, in particular with the Industrial Battery Value Chain (Batteries) and the Cooperative Connected and Automated Mobility (CCAM) co-programmed partnerships, as well as Clean Hydrogen Europe (CHE) and the Mission on Climate Neutral and Smart Cities.

The main impacts to be generated by topics targeting zero emission road transport under this Destination are:

a. Accelerated uptake of zero tailpipe emission, affordable, user-centric solutions (technologies and services) for road-based mobility all across Europe.

b. Increased user acceptance, improved air quality, a more circular economy and reduction of environmental impacts.

[131] as per Article 17 of Regulation (EU) No 2020/852 on the establishment of a framework to facilitate sustainable investment (EU Taxonomy Regulation)

c. Affordable, user-friendly charging infrastructure concepts and technologies that include vehicle-grid-interactions.

d. Innovative use cases for the integration of zero tailpipe emission vehicles, and infrastructure concepts for the road mobility of people and goods.

e. Effective design, assessment and deployment of innovative concepts in road vehicles and mobility services thanks to life-cycle analysis tools and skills, in a circular economy context.

Aviation

Aviation, the climate and the economy are all inherently global and interlinked. Aviation's global economic impact, before COVID-19, was more than €2.4 trillion per year, while the European one was more than EUR 700 billion per year. However, the environmental impact, although in absolute terms small, it is projected to increase towards 2050 to a level that is not compatible with the Paris Agreement, if action is not taken now.

The proposed European aviation R&I in Horizon Europe will follow a policy-driven approach along the two main priorities (i.e. climate neutrality by 2050 and digital transformation) and implemented in three streams of activities:

1. Collaborative aviation R&I under this Destination of the cluster 5 work programme focuses on transformative low-TRL (1-4) technologies, notably precompetitive fundamental aviation research and technologies for future development, validation and integration activities, in line with climate neutrality by 2050 and the new Industrial Strategy for Europe.

2. The European Partnership Clean Aviation (EPCA) focuses on three clearly identified paths, as described in Strategic Research and Innovation Agenda (SRIA). It aims at accelerating the development, integration and validation of climate-neutral aviation technologies (TRL 4-6), for earliest possible deployment.

3. The European Partnership for Integrated Air Traffic Management (IATM) focuses on solutions that will support evolving demand for using the European sky, increased expectations on the quality of ATM and U-space service provision, transforming and optimising how ATM and U-space services are provided as well as accelerating market uptake. The focus of the IATM (IATM) is on digitisation, automation and Artificial Intelligence.

While these three work streams will work in complementarity, all propulsion technologies for integration at engine level will be developed exclusively in EPCA.

The main impacts to be generated by topics targeting aviation under this Destination are:

- Disruptive gains by 2035, with up to 30% reduction in fuel burn and CO_2 between the existing aircraft in service and the next generation, compared to 12-15% in previous

replacement cycles (when not explicitly defined, baselines refer to the best available aircraft of the same category with entry into service prior to year 2020).

- Disruptive technologies entering into service by 2035 as well as 2050, based on new energy carriers, hybrid-electric architectures, next generation of ultra-high efficient engines and new aircraft configurations.
- New technologies for significantly lower local air-pollution and noise.
- Increased understanding of aviation's non-CO_2 climate impacts, enabling R&I activities to more effectively contribute to the EU's climate targets.
- Maintain global competitiveness and leadership of the European aeronautics industry and the whole aviation ecosystem, including modernization of Air-Traffic Management by leveraging space-based services.
- Protect the passenger and increase the resilience of the aviation ecosystem to external shocks (e.g. health issues, manufacturing, operations, cybersecurity).
- Deliver an EU policy-driven planning and assessment framework/toolbox towards a coherent R&I prioritization and timely development of technologies in all three pillars of Horizon Europe.

Enabling climate neutral, clean, smart, and competitive waterborne transport

The European Green Deal refers to the need to achieve clean, climate neutral shipping and waterborne operations and to the importance of research and innovation in this respect. Waterborne transport, in particular where large sea-going vessels are used, remains an important emitter of GHG and the sector needs to step up its efforts on a significant scale and through a wide range of measures. Within the International Maritime Organisation (IMO) global agreement was reached in 2018 to cut total shipping GHG emissions by at least 50% by 2050 compared to 2008 (baseline). The EU considers this too timid and is committed to a much higher level of ambition. By the same date the Union aims to cut all transport emissions by at least 90%.

Even though the share of Inland Waterway Transport with regard to global GHG emissions is of minor importance the Central Commission for the Navigation of the Rhine (CCNR) and its Member States take various steps to reduce the GHG emissions of the fleet. In 2018 the Mannheim Declaration was adopted which incorporates the EU GHG reducing targets for inland navigation and these efforts are supported through this work programme.

To provide the innovations needed to achieve the targets and show global leadership (also in pushing far more ambitious global regulatory standards) a new co-programmed European Partnership "Zero Emission Waterborne Transport" (ZEWT) will mobilise resources and leverage private and public investments towards the central objective of demonstrating by 2030 the deployable solutions needed for all main types of waterborne transport to become "net zero emission" by 2050 at the latest. Most topics on waterborne transport will contribute to the

implementation of this partnership. Projects under ZEWT partnership topics are expected to provide up to two presentations on progress made to the ZEWT partnership members, also with the aim to support the monitoring of the ZEWT partnership performance as well the necessary underlying development to make these achievements possible within the time frame of the partnership.

Furthermore, in the context of the EU's digital strategy "A Europe Fit for the Digital Age" the waterborne transport sector will have to embrace a wide-ranging digitalisation, resulting in new business patterns, smart ports, automation of shipping and cargo handling (which will provide higher efficiency and significantly safer operations), autonomous vessels, and new design and decision tools.

Topics on waterborne transport under this Destination of the cluster 5 work programme address climate neutrality and protection of the marine environment, digitalisation, and industrial competitiveness with the aim to support all pertinent EU policy objectives, also with regard to synergies with related programmes like the Connecting Europe Facility and the EU Innovation Fund.

The main impacts to be generated by topics targeting waterborne transport under this Destination are:

a. Increased and early deployment of climate neutral fuels and significant electrification of shipping, in particular and foremost in intra-European transport connections.

b. Increased overall energy efficiency and drastically lower fuel consumption of vessels (important in light of more expensive alternative fuels for which the sector will have to compete with other transport modes).

c. Enable the innovative port infrastructure (bunkering of alternative fuels and provision of electrical power) needed to achieve zero-emission waterborne transport (inland and maritime).

d. Enable clean, climate-neutral, and climate-resilient inland waterway vessels before 2030 helping a significant market take-up and a comprehensive green fleet renewal which will also help modal shift.

e. Strong technological and operational momentum towards achieving climate neutrality and the elimination of all harmful pollution to air and water.

f. Achieve the smart, efficient, secure and safe integration of maritime and inland shipping into logistic chains, facilitated by full digitalisation and automation.

g. Enable fully automated shipping (maritime and inland) and efficient connectivity.

h. Competitive waterborne industries, including the globally active European maritime technology sector, providing the advanced green and digital technologies which will support jobs and growth in Europe.

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Impact of transport on environment and human health

Transport emissions are one of the main contributors to air quality problems, particularly in urban areas. At the same time, noise also negatively affects health. The World Health Organization (WHO) has classified traffic noise, including road, rail and air traffic, as the second most important cause of ill health in Western Europe, behind only air pollution caused by very fine particulate matter. Transport noise, particularly from road traffic, but also from rail and aviation, is a major contributor to noise pollution in urban areas. While type-approval noise limits for road vehicles, including their tyres, have been tightened over the years, the overall exposure to noise generated by road vehicles has not improved mainly due to increasing traffic volumes. L category vehicles are often perceived as a significant contributors to noise pollution and this might be due to the fact that noise emissions seem to be strictly optimised for specific conditions (but also due to tampering by their users, which in some cases is made too easy by the way the vehicles are built).

Electrification promises to address most of these issues, but as some transport modes are more difficult to electrify in the near future, there is need for research and innovation activities to develop appropriate and environmentally sustainable solutions. Furthermore, possible new pollutants and related health- challenges need to be monitored and investigated, and ways to deal with emissions by the existing fleet need to be studied and demonstrated.

The main impacts to be generated by topics targeting transport-related health and environmental issues under this Destination are:

a. The reduction of road vehicle polluting emissions (looking at both regulated, unregulated and emerging ones) from both existing and future automotive fleets; prevention of smog episodes in Europe and a better understanding of the impact of air and noise pollution on human health (including potential sex and gender differences) .

b. The better monitoring of the environmental performance and enforcement of regulation (detection of defeat devices, tampered anti-pollution systems, etc.) of fleets of transport vehicles, be it on road, airports and ports.

c. The reduction of noise emitted by L category road vehicles.

d. Substantially reduce the overall environmental impact of transport (e.g.: as regards biodiversity, noise, pollution and waste)

The following call(s) in this work programme contribute to this destination:

Call	Budgets (EUR million)		Deadline(s)
	2021	2022	
HORIZON-CL5-2021-D5-01	258.00		07 Sep 2021
HORIZON-CL5-2022-D5-01		253.00	26 Apr 2022

Overall indicative budget	258.00	253.00	

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Call - Clean and competitive solutions for all transport modes

HORIZON-CL5-2021-D5-01

Conditions for the Call

Indicative budget(s)[132]

Topics	Type of Action	Budgets (EUR million)	Expected EU contribution per project (EUR million)[133]	Number of projects expected to be funded
		2021		
Opening: 15 Apr 2021 Deadline(s): 07 Sep 2021				
HORIZON-CL5-2021-D5-01-01	IA	45.00	10.00 to 15.00	3
HORIZON-CL5-2021-D5-01-02	RIA	20.00	4.00 to 6.00	4
HORIZON-CL5-2021-D5-01-03	RIA	25.00	7.00 to 10.00	3
HORIZON-CL5-2021-D5-01-04	CSA	4.00	Around 4.00	1
HORIZON-CL5-2021-D5-01-05	RIA	25.00	2.00 to 6.00	6
HORIZON-CL5-2021-D5-01-06	RIA	29.00	3.00 to 6.00	5
HORIZON-CL5-2021-D5-01-07	IA	20.00	Around 10.00	2
HORIZON-CL5-2021-D5-01-08	RIA	15.00	Around 15.00	1
HORIZON-CL5-2021-D5-01-09	CSA	0.50	Around 0.50	1
HORIZON-CL5-2021-D5-01-10	RIA	20.00	Around 5.00	4
HORIZON-CL5-2021-D5-01-11	IA	14.00	Around 7.00	2
HORIZON-CL5-2021-D5-01-12	IA	7.00	Around 7.00	1

132 The Director-General responsible for the call may decide to open the call up to one month prior to or after the envisaged date(s) of opening.
The Director-General responsible may delay the deadline(s) by up to two months.
All deadlines are at 17.00.00 Brussels local time.
The budget amounts are subject to the availability of the appropriations provided for in the general budget of the Union for years 2021 and 2022.

133 Nonetheless, this does not preclude submission and selection of a proposal requesting different amounts.

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HORIZON-CL5-2021-D5-01-13	RIA	7.00	Around 7.00	1
HORIZON-CL5-2021-D5-01-14	IA	10.00	Around 10.00	1
HORIZON-CL5-2021-D5-01-15	IA	10.00	4.00 to 5.00	2
HORIZON-CL5-2021-D5-01-16	RIA	5.00	4.00 to 5.00	1
HORIZON-CL5-2021-D5-01-17	CSA	1.50	Around 1.50	1
Overall indicative budget		258.00		

General conditions relating to this call	
Admissibility conditions	The conditions are described in General Annex A.
Eligibility conditions	The conditions are described in General Annex B.
Financial and operational capacity and exclusion	The criteria are described in General Annex C.
Award criteria	The criteria are described in General Annex D.
Documents	The documents are described in General Annex E.
Procedure	The procedure is described in General Annex F.
Legal and financial set-up of the Grant Agreements	The rules are described in General Annex G.

Zero-emission road transport

Proposals are invited against the following topic(s):

HORIZON-CL5-2021-D5-01-01: Nextgen vehicles: Innovative zero emission BEV architectures for regional medium freight haulage (2ZERO)

Specific conditions	
Expected EU contribution per project	The EU estimates that an EU contribution of between EUR 10.00 and 15.00 million would allow these outcomes to be addressed

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	appropriately. Nonetheless, this does not preclude submission and selection of a proposal requesting different amounts.
Indicative budget	The total indicative budget for the topic is EUR 45.00 million.
Type of Action	Innovation Actions
Legal and financial set-up of the Grant Agreements	The rules are described in General Annex G. The following exceptions apply: The funding rate is up to 60% of the eligible costs. This funding rate applies both to members and non-members of the partnership, except for non-profit legal entities, where the funding rate is up to 100% of the total eligible costs.
Technology Readiness Level	Activities are expected to achieve TRL 7-8 by the end of the project – see General Annex B.

Expected Outcome: Projects' results are expected to contribute to all the following expected outcomes:

- Provide innovative, competitive and affordable zero tailpipe emissions vehicles architectures for regional medium freight transport and distribution full electric N2 and/or N3 category vehicles (VECTO vehicle group 1, 2 or 3), with prototype(s) fully validated for a zero-emission driving range of at least 200 km under driving conditions comparable to VECTO regional and urban delivery mission profiles, with strong synergies of urban and suburban operations.

- Demonstrate the vehicle's functionality and performance in real world conditions, with innovative freight transport and logistics use cases, at least matching the vehicle dynamic performance of non-zero tailpipe emission vehicles and maximising productivity in terms of usage (t/km transported per year).

- Provide fleet managers with ZEV-specific, flexible, managerial tools (e.g. adapted to the characteristics of vehicles and infrastructure) supporting the seamless integration of zero tailpipe emissions vehicles into fleets and facilitating the assignment of tasks and routes (infrastructure, range, charging time, payload etc.).

- Demonstration of fast charging concepts capable of fitting established regulations and business practices, particularly at load/unload points enabling efficient operations.

- Optimizing the specific charging infrastructures for logistics hubs and/or TEN-T urban nodes.

- Contribute to significant price reduction steps by demonstrating a net total cost of operation (TCO) parity with 2020 engine-based solutions and assuming a production volume of >= 10.000 pieces/year and net TCO reductions beyond that volume.

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- Contribution to increasing economies of scale, following demonstration of powertrain integration in different applications and the realisation of the necessary value chains.

Scope: The action will focus on validation of full electric N2 and/or N3-category vehicle(s), specific regional, suburban and urban freight transport applications seamlessly integrated into fleets.

Proposals are expected to address all the following:

- Validation of zero emissions vehicle(s) in the above mentioned categories demonstrating the capabilities of the proposed architecture in terms of range, payload, charging requirements, access to connected data etc.

- Demonstration of high efficiency powertrains capable of at least 300 km range between recharging events, whilst operating with at their maximum allowed GVW.

- Demonstrate at least 200 km average daily operation in real conditions over a period of at least 6 months, according to different mission profiles and requirements (distribution and delivery of refrigerated payloads optionally included) including end users from across Europe.

- Achievement of total 10% improvement in overall efficiency over current generation electric vehicles of the same categories.

- Demonstration of a delivery load capacity not less than 90% of a current ICE vehicle.

- Define and develop charging infrastructure solution(s) and associated strategies (private, public or public-private) for the different use cases associated to logistics hubs and TEN-T urban nodes, also proposing an analysis of the minimum viable European recharging stations network, possibly also in coordination with projects issuing from 2Zero topic HORIZON-CL5-2021-D5-CCT-01-03.

- Development of specific powertrain components might be included where needed, considering synergies with HORIZON-CL5-2021-D5-CCT-01-02 where appropriate.

- Assess the capabilities under real operational conditions/use cases and propose strategies to overcome payload and range limitations (e.g. charging strategies while loading/unloading), exploiting all potential operational benefits (e.g. low maintenance and operational cost) as well as innovation enabled by big data acquisition, analysis, and usage to broaden the missions in terms of payload and daily running within the regional scope, and maximizing vehicle productivity (ton km per year) thus demonstrating value for fleet operators and end users.

- Assess the potential impact in terms of emissions reduction considering the potential scale-up opportunities of the addressed use cases, prioritizing higher impact use cases.

- Synergies with shorter range/lower payloads urban and suburban applications in the municipal waste collection or construction activities, can be included.

- Projects should deliver digital twin models of the demonstrator vehicles, such that the impact of the innovations towards the overall objectives of the 2Zero partnership might be determined prior to the completion of the project. Data that is produced as output from a 'digital twin' should be FAIR, and deposition in relevant repositories should be encouraged[134].

- Develop and validate tools for zero tailpipe emission vehicles integration in fleets (and mixed fleets) for efficient assignment of tasks (routes, charging strategies, assignments etc.).

This topic implements the co-programmed European Partnership on 'Towards zero emission road transport' (2ZERO).

HORIZON-CL5-2021-D5-01-02: Nextgen EV components: Integration of advanced power electronics and associated controls (2ZERO)

Specific conditions	
Expected EU contribution per project	The EU estimates that an EU contribution of between EUR 4.00 and 6.00 million would allow these outcomes to be addressed appropriately. Nonetheless, this does not preclude submission and selection of a proposal requesting different amounts.
Indicative budget	The total indicative budget for the topic is EUR 20.00 million.
Type of Action	Research and Innovation Actions
Technology Readiness Level	Activities are expected to achieve TRL 5-6 by the end of the project – see General Annex B.

Expected Outcome: Project results are expected to contribute to all of the following expected outcomes:

- Demonstrate a minimum of 20% cost reduction of power electronic modules and inverters for a given power, to increase the overall affordability of EVs in mass production (in comparison to the cost of the best current-generation or close to market components at proposal submission time).

- Significant advancements in efficiency (reduction of losses by 25%) and thermal performance (increased maximum operational temperature), both parameters versus the state of the art of the targeted application. This allows further range increases, faster charging and easier thermal management of the whole powertrain, as well as possible improvement in cabin-heating and defrosting in winter.

134 Final Report and Action Plan from the European Commission Expert Group on FAIR Data, "TURNING FAIR INTO REALITY" - https://ec.europa.eu/info/sites/info/files/turning_fair_into_reality_0

- Development of power electronics enabling drastic size and weight reductions for the electric drive, with significant advances beyond 5 kW/kg or 20kW/litre for a BEV.

- Facilitating the integration of power electronics in batteries and electric motors/axles (including modular approaches).

- Increased reliability and availability of powertrain by intelligent control and diagnostics techniques, predictive maintenance of machine and inverter.

- Achieve automotive quality levels in the whole system with new, robust and reliable functionalities and materials.

Scope: In the constant drive to improve efficiency and performance while increasing affordability, the recent introduction of wide bandgap (WBG) technologies (such as SiC, GaN and beyond, whose development is excluded in this topic since it is covered in the KDT partnership) need further effort for their integration in new, on-board architectures, taking into account new powertrain generations with different voltage levels, e.g. 400V, 800V and higher.

Achieving innovative compact integrated solutions will be both a strong lever for future economies of scale and a strong advantage for flexibility that will satisfy user's needs and increase acceptance, as well as an enabler for new powertrain architectures with distributed multiple wheel drive.

Proposals are expected to address all the following:

- System-partitioning/-integration: Intelligent, redundant and fail-safe topology/system architecture; highly integrated power electronics with component integration and building-block approaches for minimal level of parasitics; integration and functional modularity of power converters (integrated on-board charger and traction inverter, integrated inverter and electric motor, integrated DC/DC and inverter, high-frequency DC/DC power conversion with WBG components).

- Circuit concepts and control: Topologies adapted to advanced WBG semiconductors and new materials, "including & beyond GaN"; control approaches for improved reliability as well as reduction of losses, noise and interference at a system level; novel control strategies with self-learning and intelligent monitoring capabilities, suitable for very high-frequency operation.

- Interconnected technologies: robust assembly and materials, better suited for integration and new power semiconductors, alongside the capability for higher temperatures and currents, as well as extension to 3D design.

- Joining and connecting technologies: Power output stages with low impedance connection and increased robustness against temperature cycling, as well as advanced interfaces for modular building blocks.

- Thermal management: Module and component concepts with improved thermal performance; concepts for integrating cooling in housings, assemblies and component groups, and with environmental control if appropriate; direct liquid-cooling for high power can be considered through different solutions such as direct cooling with an immersed power module, jet impingement and spray, microchannel heatsinks or heat pipes; extension of air-cooling up to medium power levels.

- Simulation/Prediction: Holistic simulation chain (e.g. along the value chain: Vehicle/ Motor/Electronics/IC); advanced physics-based simulation tools/models to increase development capabilities in order to close the gap to physical limits and reduce over-engineering; prediction of functional availability dynamically during operation predictive maintenance.

- Gate Drivers: integration of the driver component with the power module to limit the stray inductance between the gate driver and the semiconductor; the gate driver should allow maximum switching speed by dealing with electromagnetic interferences (EMI) to drive wide bandgap devices.

This topic implements the co-programmed European Partnership on 'Towards zero emission road transport' (2ZERO).

HORIZON-CL5-2021-D5-01-03: System approach to achieve optimised Smart EV Charging and V2G flexibility in mass-deployment conditions (2ZERO)

Specific conditions	
Expected EU contribution per project	The EU estimates that an EU contribution of between EUR 7.00 and 10.00 million would allow these outcomes to be addressed appropriately. Nonetheless, this does not preclude submission and selection of a proposal requesting different amounts.
Indicative budget	The total indicative budget for the topic is EUR 25.00 million.
Type of Action	Research and Innovation Actions
Technology Readiness Level	Activities are expected to achieve TRL 5-7 by the end of the project – see General Annex B.

Expected Outcome: Projects' results are expected to contribute to all of the following expected outcomes:

- Definition of the optimal smart charging concepts able to cope with several million of Electric Vehicles (EV) deployed in different environments.

- Development of smart charging strategies and control mechanisms that maximise the EV drivers' satisfaction and the efficiency of the whole energy system, increasing the use of

renewable electricity harnessing unused EV storage capacity, whilst minimising grid reinforcements and energy generation needs.

- Innovative concepts and technologies performances to create affordable, user-friendly smart and bidirectional (V2X, where X can be G for Grid, H for Home and B for Business) charging solutions, co-optimising the needs of EV users, of the house/building and of the supplying grid.

- A better understanding of the operational and economic trade-offs for the user and the vehicle (e.g; cost of battery damage, additional cost for electronics to enable V2G), and on the charging (e.g. installation cost, battery damage/degradation) infrastructure of the different smart and bidirectional (V2G) charging approaches and technologies (for instance AC vs DC), as well as the costs for the different actors involved.

- Contribution to the integrated planning process of systems aimed at exploiting cross-sector mutual benefits (G2X and V2X).

- Contribution to the standardisation process of interfaces for V2X.

- Assess customer expectations and implement an open architecture (i.e. not proprietary) concerning smart and bidirectional charging solutions, as key success factors to build a mutually beneficial charging experience for the user and for the grid.

- Demonstrate V2X potential in encouraging renewable energy growth through the integration with low power renewable energy sources (e.g. photovoltaics on the roof or in parking lots), by reducing energy exchange with the grid (in both directions) by 50%.

Scope: Digitally controlled charging solutions represent a fundamental building block of a full and effective shift to electromobility. When scaled to a mass-market-level, current uncontrolled charging (i.e. maximum available power from the moment the vehicle is plugged in) could contribute to create an extra burden on the power system. Mass availability of battery storage, provided by parked EVs (both light and heavy-duty vehicles) can however be turned into a clear upside if an integrated approach is adopted considering the different charging scenarios (public charging, home charging, depot charging, etc.). Moreover, the effective exploitation of EV charging flexibility can minimise investments in the electric grids, resulting in reduced system charges for the network users.

Proposals are expected to address all the following:

- Improve the whole user experience (localization, booking, payment and billing process) when charging EVs under different scenarios (on street and in personal parking, in company and public buildings, etc.) and considering different electric vehicle fleets (passenger cars, light and medium commercial duty vehicles). The quantity and quality of drivers' needs (e.g. range anxiety, duration and preferred time slot for charging, acceptance of incomplete charge levels), the conditions for allowing a shared control of battery State-of-Charge, and the availability to commit to vehicle utilisation limitations (rewards & penalties) have to be considered as a starting point for designing smart and

bidirectional charging solutions; integration and control solutions should also be considered, in view of achieving the best customer acceptance.

- Consider current slow/medium power charging, analyse and develop and demonstrate lower cost alternatives, appropriate for the mass deployment of slow charging, considering both AC and DC V2X solutions, related costs and issues (for instance power quality of AC systems), in view of optimising the cost of on-vehicle and infrastructure-side electronics.

- Complementing previous bullet innovative scalable solutions for large parking areas and urban, on-road parking in smart cities, e.g. from a suitable central power system with multiple outputs vs individual distributed low power chargers, are expected to be considered, developed and validated.

- In order to define optimal charging concept/strategies, trade-offs are expected to be performed in different EV penetration scenarios with a view to defining the optimal balance between the vehicle and infrastructure costs, the location and typology of charging infrastructures, and its interoperability whilst demonstrating the efficiency of V2X centralized and decentralized scenarios and catering for different EV categories, in different environments. The following alternatives are expected to be considered: public (including on-road and covered parking), private (residential and office buildings), in cities with high or low private parking availability, for light and heavy duty vehicles, in cities or countries with monophase and triphase systems, integration with personal (V2H) or business power generation (V2B), participation to grid service markets (V2G), aggregation with other consumer/prosumer facilities, behind-the-meter energy optimisation for prosumers.

- The impact of the different bidirectional charging profiles on the life of the EV battery and power electronics are expected to be quantified, used to define the damage cost and, therefore, the right level of incentives for the users in allowing their battery to be used.

- Performing fast charging can be an alternative to a pervasive low power charging network. These concepts are expected to be analysed and the respective pros and cons defined, including the impact on the grid of a large number of fast chargers adequately spread in the urban environment (considering the potential of local storage), with a view to providing authorities with a complete perspective of the optimal infrastructure depending on local conditions.

- Defining optimal charging concept/strategies through the development of smart charging processes and data models, considering current international and European standardisation activities, minimising EV driver's costs by rewarding their charging/discharging flexibility via effectively exploiting the storing capabilities of EVs both in a planned way (charging in low cost/generation surplus time slots) and considering contingencies (fast response in balancing grids flows fluctuations). AI-driven energy management schemes are expected to be developed, including their market and regulatory frameworks (dynamic tariffs criteria and focused incentives), to be tested preferably through regulatory

sandboxes. In this respect, the communication requirements among the energy actors are expected to be evaluated, promoting the interoperability (preferably at European level) between the proposed solutions.

- A final assessment of the conditions in which full V2X functionalities are needed and beneficial, and where simple V1G charge control is sufficient, are expected to be performed.

- Quantitative parametric and probabilistic models for assessing the impact of progressive, massive EV penetration on the electricity system are expected to also be established: these should consider modifications of hourly/weekly load profiles, conditions for energy adequacy (primary energy supply) and power adequacy (grid congestions/reinforcements).

- Clear framework for use of the necessary personal data and data portability generated by the natural persons making use of vehicle infrastructure pair should be investigated thoroughly in line with the General Data Protection Regulation.

- In order to achieve a seamless smart charging experience for the EV driver, the connectivity and interoperability between the vehicle and the different players in the EV charging ecosystem, including charging point operators (CPOs), electromobility service providers (EMSPs), roaming platforms and distribution system operators (DSOs), together with access to all the necessary data to facilitate this objective, should be considered. This should help in creating an integrated mobility system, assisting drivers and passengers to take optimal decisions in selecting the charging points and overall trip planning, in terms of cost, waiting time, and the extra services provided to drivers and to vehicles.

- The relevant data collection, exchange and management for smart and bidirectional charging are expected to be assessed, with a focus on the required in-vehicle data types (especially in relation to the battery management system) which are indispensable to operationalise these new charging technologies. Additionally, communication protocols and user interfaces (including the need for new/updated standards) are expected to be assessed and developed as needed in line with the work carried out by international and European standardisation organisation.

This topic implements the co-programmed European Partnership on 'Towards zero emission road transport' (2ZERO).

HORIZON-CL5-2021-D5-01-04: LCA and design for sustainable circularity - holistic approach for zero-emission mobility solutions and related battery value chain (2ZERO & Batteries Partnership)

Specific conditions

Expected EU contribution per project	The EU estimates that an EU contribution of around EUR 4.00 million would allow these outcomes to be addressed appropriately. Nonetheless, this does not preclude submission and selection of a proposal requesting different amounts.
Indicative budget	The total indicative budget for the topic is EUR 4.00 million.
Type of Action	Coordination and Support Actions

Expected Outcome: The project addressing this "Batteries-2Zero" Joint Call approaches a commonly accepted Life Cycle Assessment (LCA) of zero-emission road transport solutions, focussing on zero-emission vehicles and their batteries, as one of their central components, as well as other applications of the same types of battery cells (e.g. industrial, stationary applications etc.).

Proposals are expected to provide for coordinated activities on LCA and Life Cycle Inventory (LCI) at vehicle and cell levels, to define and develop a unique and shared approach with common methodologies for both zero-emission vehicles and the battery value chain. The project's main governance (e.g. Steering Group, Advisory Board) is expected to provide for direct involvement of relevant stakeholders from the automotive and battery sectors, as well as relevant EC services (in particular DGs JRC, RTD, CLIMA, ENV, ENER and GROW).). Close cooperation with running EU-funded projects performing LCA in these sectors will also be expected to maximise synergies and reduce duplication of efforts.

The project's results are expected to contribute to all of the following expected outcomes:

- A consensus concept for a harmonised, robust, transparent and real-data based LCA approach and tools (also with consideration for extension to social Life Cycle Assessments, S-LCA), with an emphasis on light-duty and heavy-duty zero-emission vehicles (ZEV) and batteries; enabling the assessment of the sustainability performance and evaluation of optimal designs along the value chain and over the full life-cycle (cradle-to-cradle), also taking into account the need of comparing with conventional solutions.

- New, holistic and applicable quantitative tools to drive an approach to the design of ZEV, their components and batteries.

- Take into account in particular uptake of the Renewable Energy both for manufacturing processes and for information to the end users.

- A harmonised strategy for sustainability by design, describing requirements and specifications of tools for all life-cycle phases required to improve the environmental performance of ZEV and batteries, including their components and sub-systems.

- A commonly accepted ontology for a European-wide LCI database for zero emission vehicles and batteries, including all sub-systems and components, and using real data for the present and short-term future, whilst using provisional data, based on trajectories for

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the reduction of GHG emissions in the Power, Industry and Transport sectors, and use cases, including pre-defined data quality indicators.

- Greater environmental sustainability and lower TCO (total cost of ownership) through consistent and frontloaded real-data based assessment of technologies and solutions, with extension to other sectors using the same cells and technologies.

- Alignment of on-going harmonisation and standardisation activities relevant for a road transport-specific LCA approach, with emphasis on ZEV and the related battery value chain.

- In line with existing or upcoming legislation, and based on guidance from the EC, agree on the common access to the database, including, where this could be necessary for the Member States/Associated Countries to inform their policies.

- Increased awareness and acceptance of a European-wide, battery and road transport-specific LCA approach and LCI database.

Scope: In order to make the best, most informed choices in terms of sustainability, it is of utmost importance for zero emission road transport to have the right tools to assess technologies, non-technical measures and product life cycle processes in a holistic way. In selecting the right technologies for clean and sustainable mobility at a system, vehicle and component level, the ecological footprint and the impact of technologies upon society have to be assessed, based on highly reliable data at an early stage of development and planning in a harmonised and comparable way.

Proposals are expected to address all the following:

- Screening, collecting and evaluating existing LCA and S-LCA needs, methodologies, tools datasets and metrics, to identify and overcome knowledge gaps, to identify development needs in current methodologies and tools, as well as to identify the impact reduction potential for ZEV and batteries.

- Elaborate a consensus LCA (and S-LCA) approach specific for zero-emission solutions, with an emphasis on light-duty and heavy-duty ZEV and the related battery value chain, suitable for the full life-cycle (cradle-to-cradle) whilst expanding the existing complexity of an environmental LCA to assess and compare the impact of solutions in a holistic way, and reflecting the needs of a resource-efficient circular economy.

- Elaborate the baseline for a Europe-wide, commonly accepted, road transport sector LCA approach and LCI database for ZEV and the related battery value chain, based on real data or on provisional data based on trajectories for the reduction of GHG emissions in the Power, Industry and Transport sectors, ensuring openness, accessibility and transparency,

implementing the FAIR data principles[135], whilst ensuring applicability to existing technologies.

- Taking into account existing and upcoming legislation, under policy guidance of the EC, define access to the database, for purposes of policy makers, including to the authorities of the Member States, where appropriate.

- Promote the uptake of Renewables in manufacturing processes and information on renewables to the end users. Harmonise across all stakeholders for methodologies, tools, datasets and metrics as well as for target criteria, to help improve consistency, robustness and transparency, and to address important gaps in transport-specific LCA and LCI, with focus on ZEV and the battery value chain. It is of utmost importance to involve all stakeholders, including the European Commission services, Member States/Associated Countries and standardisation bodies, to ensure the acceptance and succeeding implementation of the LCA approach and LCI database.

- Conceptualise the frontloading of a LCA and S-LCA for ZEV and the related battery value chain, at an early stage of development and planning, in a harmonised and comparable way, ensuring the compatibility and comparability with (conventional) alternatives.

- Definition of use cases for ZEV and batteries, representative of real-world conditions (e.g. for activity, lifetime, impacts linked to the specific duty-cycle and accounting for user behaviour) and the exemplary characterisation and calculation of impacts from zero-emission vehicle components, through applying the consensus LCA approach, and assessing the variability inherent to key real-world parameters.

- Elaborate the potential and outline the transfer of the consensus LCA and S-LCA for other applications, such as fuel cells or stationary battery systems, or markets such as aerospace or maritime.

- This work should build upon both recent existing EC- and stakeholder-funded research (such as the eLCAr project and the reports "Circular Economy Perspectives for the Management of Batteries used in Electric Vehicles" and "Determining the environmental impacts of conventional and alternatively fuelled vehicles through LCA"[136], aiming at aligning ongoing activities within this context towards a single LCA approach. Cooperation and exchange of experience and data with running projects performing LCA of batteries and cells is also expected to enrich the results.

135 Final Report and Action Plan from the European Commission Expert Group on FAIR Data, "TURNING FAIR INTO REALITY" - https://ec.europa.eu/info/sites/info/files/turning_fair_into_reality_0.pdf

136 "Circular Economy Perspectives for the Management of Batteries used in Electric Vehicles" (Hill, N., Clarke, D., Blair, L. and Menadue, H., Publications Office of the European Union, Luxembourg, 2019, ISBN 978-92-76-10937-2 (online), doi:10.2760/537140 (online), JRC117790); "Determining the environmental impacts of conventional and alternatively fuelled vehicles through LCA" (Hill N. et a., 2020, DG CLIMA),

This topic implements the co-programmed European Partnerships on 'Towards zero emission road transport' (2ZERO) and 'Towards a competitive European industrial battery value chain for stationary applications and e-mobility'.

Aviation

Proposals are invited against the following topic(s):

HORIZON-CL5-2021-D5-01-05: Greenhouse gas aviation emissions reduction technologies towards climate neutrality by 2050

Specific conditions	
Expected EU contribution per project	The EU estimates that an EU contribution of between EUR 2.00 and 6.00 million would allow these outcomes to be addressed appropriately. Nonetheless, this does not preclude submission and selection of a proposal requesting different amounts.
Indicative budget	The total indicative budget for the topic is EUR 25.00 million.
Type of Action	Research and Innovation Actions
Technology Readiness Level	Activities are expected to achieve TRL 2-4 by the end of the project – see General Annex B.

Expected Outcome: Project results are expected to contribute to at least one of the following expected outcomes:

- Deliver transformative technologies that will substantially reduce non-CO_2 emissions. The selection of technologies should be compatible with operational procedures and aligned with a potential inclusion of non-CO_2 emissions in EU and International aviation market-based measures (e.g. EU Emissions Trading System and ICAO CORSIA) and other potential relevant policy tools (e.g. European Green Deal).

- Deliver transformative technologies for aircraft engines, systems and structures that will maximise the life cycle environmental impact reduction.

- Explore new modular aircraft and/or component configurations, optimised for the lowest possible environmental impact and noise footprint at take-off and landing operations, allowing 24/7 operations.

- Deliver improved aircraft performance technologies (including engine, hybrid-electric systems, electric & electromechanical systems, integrated H2 storage, management systems, light-weight multi-functional materials and structures and/or morphing capabilities), compatible with aviation climate reduction operational-mitigation strategies, in areas with high climate cost. The selection of technologies should deliver intermediate benefits and bridge the aviation climate neutrality gap towards 2050.

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Scope: The impact of aviation to environment and climate is driven by long-term effects from CO_2 emissions and shorter-term ones from non- CO_2 emissions (water vapour, nitrogen oxides, sulphur oxides, aerosols, contrails and contrail cirrus). The CO_2 effects are well understood and are proportional to the fuel used, while the non-CO_2 effects are still poorly understood and carry large uncertainties. The total climate impact of aviation is estimated to two to four times higher than the effect of CO_2 emissions alone (ref. International Panel of Climate Change - IPCC). R&I activities in Horizon Europe will pay adequate attention to CO_2 and non-CO_2 emissions, as well as their interdependencies.

Regarding the reduction of full-flight fuel burn and CO_2 emissions, the selection of technologies should have a holistic approach to aviation ecosystem, considering aircraft (including engines) technologies, improved air-traffic management solutions (input and synergies with ATM partnership), new fuel options (input and synergies with hydrogen partnership) and operational improvements. Timely alignment with European medium-term industrial roadmaps (beyond 2030) should be established.

Regarding the reduction of aviation non- CO_2 emissions, the selection of technologies and operational measures should consider climate optimised flight trajectory planning avoiding sensitive areas, should be compatible with operational procedures and aligned with a potential inclusion of non-CO_2 emissions in EU and International aviation market-based measures (e.g. EU Emissions Trading System and ICAO CORSIA).

A potentially high risk in pursuing transformative and disruptive climate neutral aviation technologies is the recent evidence (last decade) from not as flawless as expected entry into service of innovative propulsion and aircraft technologies at large. To mitigate this risk, the R&I actions proposed in this topic should profit and linked with more integrated design and manufacturing advancements that are covered in topic HORIZON-CL5-2021-D5-01-06 (digital transformation).

Overall, this topic aims for new low TRL technologies for reduced life-cycle GHG emissions that will reach TRL4 by 2030, at the latest. The topic has synergies with the EPCA and Integrated ATM partnerships. All activities higher than TRL 3 that address the reduction of GHG aviation emissions, with emphasis on propulsion technologies and their integration, will be dealt in the European Partnership on Clean Aviation (EPCA) and the IATM partnership. The low-TRL technologies in this topic may enable expanding the design envelope with new configurations, more electrified aircraft and engine architectures, more electric systems, more integrated metallic, composite and multifunctional aerostructures, advanced flow control and high-lift aerodynamics as well as advancements in flight control systems. To enable effectively addressing the non-CO_2 climate impacts, the topic will also support research to fill gaps in their understanding, and thereby enable addressing these impacts.

HORIZON-CL5-2021-D5-01-06: Next generation digital aircraft transformation in design, manufacturing, integration and maintenance

Specific conditions

Expected EU contribution per project	The EU estimates that an EU contribution of between EUR 3.00 and 6.00 million would allow these outcomes to be addressed appropriately. Nonetheless, this does not preclude submission and selection of a proposal requesting different amounts.
Indicative budget	The total indicative budget for the topic is EUR 29.00 million.
Type of Action	Research and Innovation Actions
Technology Readiness Level	Activities are expected to achieve TRL 2-4 by the end of the project. However, exceptionally for this topic, activities may arrive up to TRL 6 in well-justified cases, in coordination with the forthcoming European Partnership on Clean Aviation and Integrated Air-Traffic Management Work Programmes.

Expected Outcome: Project results are expected to contribute to [all/some] of the following expected outcomes:

- Deliver transformative digital technologies that will allow flawless entry into service of future European aircrafts (including engines, structures and systems) of all platforms. The outcomes should be in-line with technologies for future climate-neutral aircraft configurations and their integration. Multi-disciplinary model-based digital twins that cover the complete aircraft lifecycle, scaled-prototypes, representative rigs and unique research infrastructures fall within the expected outcomes.

- Advance further technologies that will enable flexible integration of simulation ecosystems in an extended enterprise context and allow multi-disciplinary design, optimisation and uncertainty quantification at realistic time-scales for commercial aviation.

- Deliver new technologies and methodologies for model-based validation and certification, measurement and prediction of hardware and software reliability and impact on flight safety for commercial aviation, new standards and alternative methods of compliance. Ensure compatibility between EASA-FAA working groups on standards (e.g. APR 4754/ED-79, ARP 4761, DO 178/ED-12 and DO-254/ED-80).

- Reduce the lifecycle greenhouse gas impact of aircraft materials (including rare earth elements) and explore the fastest path towards their economical substitution. Advance further recovery and recycling methods in order to extend the useful life of materials, reduce the carbon footprint and produce new high-quality parts for new applications. Enable a clear path towards a fully circular aircraft.

- Deliver transformative digital and eco-efficient manufacturing technologies, advance further composite manufacturing, maintenance-repair-overhaul (MRO) and health assessment processes and procedures (including Health & Usage Monitoring Units) that will allow flawless entry into service and continuous airworthiness of European aircrafts

of all platforms. Optimised manufacturing and MRO processes and tools, as well as on-board and on-site sensors and communication platforms are within the expected outcomes.

Scope: This topic is about a real digital transformation with a holistic and circular approach for the aviation ecosystem.

This topic aims to accelerate the design and manufacturing processes (including additive manufacturing) as well as allow flawless entry into service of new aircrafts and systems. The topic is in-line with the European new industrial policy and will bring even closer together the European supply chain (including innovative SMEs and start-ups). This topic may cover all aspects of digital aircraft, from design and manufacturing to operations and recycling. Digital-physical scaled demonstrator aircrafts for education, research and development are within the scope of this topic. Digital factory for all tiers and integrators and for all aircraft platform, from components to final assembly line (FAL) are also within the scope of this topic. As software becomes a vital part of the aircraft, new digital methods, tools and certification processes are of outmost importance. Synergies with the European High Performance Computing platform and European Digital Twin initiatives should be exploited.

Enabling climate neutral, clean, smart, and competitive waterborne transport

Proposals are invited against the following topic(s):

HORIZON-CL5-2021-D5-01-07: Enabling the safe and efficient on-board storage and integration within ships of large quantities of ammonia and hydrogen fuels (ZEWT Partnership)

Specific conditions	
Expected EU contribution per project	The EU estimates that an EU contribution of around EUR 10.00 million would allow these outcomes to be addressed appropriately. Nonetheless, this does not preclude submission and selection of a proposal requesting different amounts.
Indicative budget	The total indicative budget for the topic is EUR 20.00 million.
Type of Action	Innovation Actions
Legal and financial set-up of the Grant Agreements	The rules are described in General Annex G. The following exceptions apply: The funding rate is up to 60% of the eligible costs. This funding rate applies both to members and non-members of the partnership, except for non-profit legal entities, where the funding rate is up to 100% of the total eligible costs.
Technology Readiness Level	Activities are expected to achieve TRL 6-7 by the end of the project – see General Annex B.

Expected Outcome: Project outputs and results are expected to contribute concretely to the following expected outcomes as marked ("*") whilst supporting the overall medium and longer term objectives:

- Contribution to the establishment by 2027 of at least two full scale demonstration projects using or potentially using 100% climate neutral fuels in a realistic shipping environment.
- Enabling the timely transition to climate-neutral ship operations by facilitating the wider adoption of carbon-neutral alternative fuels at a large scale and for shipping distances of 3000 nm or more.
- Supporting the conditions for a timely and efficient uptake of sustainable alternative fuels along the specific supply and usage chain for maritime transport and inland navigation.
- *Demonstration of the feasibility to store and use hydrogen based fuels (generally in liquid form) on a medium and large scale (capacities equivalent to +300 tons of conventional marine fuel [HFO, MGO or MDO]) in a realistic environment on-board.
- *Demonstration of the use of these fuels in high power applications with long autonomy.
- *Demonstration of the applicability, in particular with respect to short sea shipping, IWT vessels, and the stricter environmental expectations for passenger ships.
- *Development of pertinent technical rules.

Scope: Commercial shipping, including deep sea shipping (intercontinental maritime transport), short sea shipping (services between European destinations), and other ship operations with high power demand (which may include also certain aspects in IWT), requires the storage of large amounts of energy with conventional fuel capacities from hundreds to thousands of tons allowing operational autonomy up to several months. The use of sustainable alternative fuels at scale embracing a number fuel options needs to be studied and solutions developed for a wide range of applications.

Sustainable hydrogen, ammonia and other hydrogen derived fuels are potentially promising alternative fuels to make shipping fully climate neutral and independent of fossil fuels. Only very limited experience with the use of ammonia and hydrogen as fuel in a maritime environment exists today.

Hydrogen and ammonia are particularly challenging in terms of on-board storage capacities, storage methods, safe handling, space constraints and the structural integration of tanks, and their subsequent use in high power propulsion systems.

The aim is to develop large and very large storage solutions for hydrogen and ammonia (e.g. compressed H2, liquid H2, LOHC, hydrides, ammonia derived compounds) and their integration on-board. Whilst a certain fuel neutrality is sought a rigorous preselection of the most suitable type and form of fuels is required in order to come to a realistic demonstration environment as early as possible.

Research and innovation is needed with respect to the efficient and safe on-board storage and use under real shipping conditions, taking into account aspects such as pressure, temperature, explosion risk and toxicity. These aspects have to be investigated considering all the relevant issues related to the maritime environment such as structural response of the ship, ship motions and related effects (e.g. sloshing, resonance), corrosion, etc.. In order to facilitate the wide-spread use of these clean fuels, solutions should be modular with the possibility of upscaling, and pertinent technical rules should be developed.

Solutions are not necessarily limited to maritime freight transport if it can be shown that these fuels can be used economically and efficiently at the specific scale of passenger services (ferries) and IWT. This may imply different regulatory constraints and infrastructure (bunkering) situations which have to be taken into account.

Projects will address both the storage of hydrogen and ammonia at capacities exceeding the equivalent of 300 tons of conventional marine fuels in order to show the use in a realistic environment with practical range and autonomy, although the fuel capacity may be adapted to the requirements of different ship types in a first stage of development. The scope extends to the design, testing and overall assessment of on-board systems for these fuels, developing concepts and testing them at lab scale with a robust perspective of scaling up to achieve the levels needed for operational commercial vessels. The structural integration of fuel and energy systems on-board, related safety issues, supporting standards development, and the minimisation of storage volumes and distributions systems towards the energy converters will be addressed. This also needs to take into account bunkering situations as part of the fuel handling on-board.

Transport of such fuels in dedicated carriers does not fall within the scope of this topic.

This topic implements the co-programmed European Partnership on 'Zero Emission Waterborne Transport' (ZEWT).

HORIZON-CL5-2021-D5-01-08: Enabling the full integration of very high power fuel cells in ship design using co-generation and combined cycle solutions for increased efficiency with multiple fuels (ZEWT Partnership)

Specific conditions	
Expected EU contribution per project	The EU estimates that an EU contribution of around EUR 15.00 million would allow these outcomes to be addressed appropriately. Nonetheless, this does not preclude submission and selection of a proposal requesting different amounts.
Indicative budget	The total indicative budget for the topic is EUR 15.00 million.
Type of Action	Research and Innovation Actions
Technology Readiness Level	Activities are expected to achieve TRL 5 by the end of the project – see General Annex B.

Expected Outcome: Project outputs and results are expected to contribute concretely to the following expected outcomes as marked ("*") whilst supporting the overall medium and longer term objectives:

- Establishing the basis for achieving TRL 8 in on-board use of high power fuel cells by 2030.
- *Feasibility and technical demonstration of the use of high-power fuel cells in co-generation and/or combined cycle mode in waterborne transport.
- *Proof of scaling up, to a target of significantly above 3 MW power output, of fuel cell installations for all shipping applications, including main propulsion of a short sea shipping or inland navigation vessel.
- *In case of a fuel cell using fossil fuel as input proof of significant efficiency gains (at least 20%) in a realistic environment compared to the conventional use of the fuels (e.g. within an ICE) with consequent reduction in GHG emissions.
- *Demonstration of the exploitation on-board of waste thermal energy produced by high temperature fuel cells in ship-specific applications (e.g. hot water, steam production, HVAC, etc.) for potential mass-market application.
- *Showing a realistic pathway to the wider use of fuel cell technology in waterborne transport including the assessment of the maturity and resulting mid-term potential of various fuel cell systems. This may include an initial focus on lower power propulsion applications in inland navigation where power reserves for adverse sailing conditions are less relevant.

Scope: The use of fuel cells (FC) for waterborne applications is becoming increasingly relevant as stack power increases and the problem of the storage of un-regulated alternative fuels is solved. Demonstrating and upscaling this technology will lead to initial and earlier applications in IWT and short sea shipping vessels, as well as to complementary power generation on-board ships with high power demand, whilst also setting foundations towards deployment within even larger scale long distance applications.

Whilst previous projects have addressed applicability of mainly smaller fuel cell systems on-board, the full integration of very high power fuel cells on-board large ships represents a major challenge.

The total efficiency of high temperature FCs, using a variety of fuels, can be substantially increased through their use within a combined cycle, recovering secondary heat or using them in combination with secondary combustion systems. Whilst such installations are operating on land with substantial improvements in energy efficiency compared to an internal combustion engine, a fully integrated dual cycle multi-MW FC system has yet to be achieved on-board a ship. Regardless of the fuel used efficiency improvements would be expected to substantially

contribute to climate neutrality as well as moving towards high power 100% hydrogen operations.

The aim is to prove the use of high-temperature FCs in a co-generation and combined cycle mode, either on a ship powered uniquely by FCs, or on-board a large ship with high power demand together with other power and thermal energy generation and management systems. Solutions need to address comprehensively the complexity of ship integration, e.g. the balance of plant components, batteries for dynamic loads and waste heat recovery systems.

A demonstrator of a high-temperature system as a large efficient unit will be developed and installed on-board a suitable vessel, and the budget foreseen reflects this ambition. The power of the FC will aim to exceed significantly 3 MW. The system may be run with conventional fossil fuels, with the use of an internal reformer. In this case the system needs to show a significant efficiency gain in terms of reduced GHG emissions compared to the conventional use of the fuel. Overall, the superiority of a FC solution over conventional ICEs should be demonstrated in a comparable arrangement. This may include an IWT application with less power to show the early marketability of the concept and its applicability on a large scale.

Initial target applications are those where the existing regulatory framework facilitates the introduction of a prototype which may depend on the sector of application, the ship type or the fuel used. The project should address the propulsion architecture and/or the electric system, but it shall not address the development of new FCs per se.

This topic implements the co-programmed European Partnership on 'Zero Emission Waterborne Transport' (ZEWT).

HORIZON-CL5-2021-D5-01-09: CSA identifying waterborne sustainable fuel deployment scenarios (ZEWT Partnership)

Specific conditions	
Expected EU contribution per project	The EU estimates that an EU contribution of around EUR 0.50 million would allow these outcomes to be addressed appropriately. Nonetheless, this does not preclude submission and selection of a proposal requesting different amounts.
Indicative budget	The total indicative budget for the topic is EUR 0.50 million.
Type of Action	Coordination and Support Actions

Expected Outcome: Project outputs and results are expected to contribute to all of the following expected outcomes:

- A full understanding of clean fuel scenarios for different regions including sensitivity analysis of the different variables, consideration of evolving technologies and their applicability to maritime transport, inland navigation and waterborne operations.

- Development of quantified and dynamic techno-economic models for the uptake of sustainable fuels in a variety of waterborne application cases and for a range of regional conditions, clearly identifying uncertainties and parameters to enable technical and economic viability.
- Support for the transposition of RDI results into commercial and regulatory reality.
- Support to identify the impacts on ports (e.g. bunkering supply and other services, also for IWT, emissions measuring and verification), derived for the defined scenarios for different regions.

Scope: Other than for short distances, waterborne transport is expected to become climate neutral mainly by the introduction of alternative, sustainable, and carbon-neutral fuels, by massive efficiency improvements and through related technologies for the fuel's use in propulsion and power generation on-board.

However, the uptake of specific alternative fuels in different European waterborne segments and geographical areas will vary and depend on fuel costs, fuel availability (generation and distribution), national or regional incentives, international co-operation, and many other fixed and dynamic factors. Whilst some studies addressing fuels for maritime transport and/or inland navigation exist, a proper characterisation per segment and per area including sensitivity and variability analysis has not yet been addressed.

Supporting decision making within the ZEWT partnership the CSA will identify and monitor the evolution of different sustainable alternative fuel deployment scenarios, taking into account different types of services, the evolution of sustainable fuel supplies, operational costs and capital expenditure, environmental factors (in particular those affecting coastal and port communities), as well as distribution and infrastructure implications relevant to the sector. Evolving and potential market mechanisms, regulations (e.g. the integration of the maritime transport sector in the ETS, the FuelEU Maritime Directive etc.) and incentives are to be considered. Discussions with sustainable fuel suppliers and facilitating the timely commercial deployment of partnership outcomes to accelerate climate neutrality and emission reduction of shipping are tasks of the CSA.

A model is to be developed considering the wider aspects of waterborne transport (incl. IWT, short and deep sea shipping, high-tech vessels) involving energy and waterborne stakeholders, with an approach that is neutral with regard to specific energy carriers or technologies. Focus will be on the cost-efficient and timely deployment of solutions on a large scale and the potential evolution of these factors over time. A life cycle assessment should be included and linkages or synergies with alternative fuel use in other transport modes should be explored.

Activities will be undertaken in close and formal cooperation with the H2020 STEERER project which is identifying strategic technological paths and priorities towards climate neutrality as well identifying business model evolutions. Therefore, the budget of this CSA is reduced. The project will support the waterborne community in the identification of market trends with a systematic approach to future scenarios, understanding of uncertainties and critical factors.

The project will liaise with EU and international bodies and their initiatives with respect to future fuel scenarios and emission control governance (e.g. FuelEU Maritime, ESSF, IMO) and will establish contacts with the main associations of fuel suppliers.

This topic implements the co-programmed European Partnership on 'Zero Emission Waterborne Transport' (ZEWT).

HORIZON-CL5-2021-D5-01-10: Innovative on-board energy saving solutions (ZEWT Partnership)

Specific conditions	
Expected EU contribution per project	The EU estimates that an EU contribution of around EUR 5.00 million would allow these outcomes to be addressed appropriately. Nonetheless, this does not preclude submission and selection of a proposal requesting different amounts.
Indicative budget	The total indicative budget for the topic is EUR 20.00 million.
Type of Action	Research and Innovation Actions
Technology Readiness Level	Activities are expected to achieve TRL 5 by the end of the project – see General Annex B.

Expected Outcome: Project outputs and results are expected to contribute concretely to the following expected outcomes as marked ("*") whilst supporting the overall medium and longer term objectives:

- Proof of gains in vessel energy performance and operational efficiency through demonstrators that are applicable to maritime transport and/or inland navigation.
- Significant reduction in GHG emissions from waterborne transport.
- Enabling the timely on-board application of innovative and green solutions for energy transformation that require significantly higher volumes for storage and equipment.
- *Deliver at the end of the project deployable energy efficiency solutions (stand alone or in combination, for new builds and for retrofitting) with at least 10% energy savings compared to best available technologies for stand-alone solutions and at least 20% for combined solutions, each on the level of the vessel.

Scope: The transformation of maritime transport and inland navigation towards climate neutrality can be accelerated through the development and deployment of innovative technologies to improve energy efficiency. The wide-spread adoption of these technologies, in particular for high-power vessels, is crucial. RDI efforts will develop technological solutions for higher efficiency, reducing fuel consumption as well as increasing performance. The overall aim is reducing the vessel's energy demand, facilitating the transition to sustainable energy sources with lower energy density and potentially higher cost.

Energy efficiency measures may have specific applications linked to new technologies (e.g. alternative fuels, fuel cells, electrification, assisted wind power propulsion) which require significant changes in the on-board energy balance and management.

Projects are expected to address technological solutions for energy efficiency yielding at least 10% reduction in energy consumption compared to best available technologies for similar applications in case of a single measure and at least 20% in case of combined measures.

A wide range of potential solutions may be proposed, including for example: reducing thermal, electrical and propulsive loads, optimisation of on-board energy management systems, design based systemic/holistic approaches and/or the use of active/adaptive technologies.

Digital solutions supporting operational strategies and remote monitoring and control can also be addressed if they are contributing to higher energy efficiency. More and advanced sensors integrated with advanced energy management can form the basis for an increased full life-cycle ship energy efficiency and can feed into digital twin models for the ship and for its sub-systems. Cyber security aspects are expected to be taken into account.

Other potential solutions may include waste heat recovery systems, HVAC improvements, new hull forms, advanced propeller and appendages for enhanced hydrodynamics, reduced hull resistance through air lubrication, new automation and control strategies, new coatings, employing new high performance materials (in particular lightweight materials such as composites) or enhanced production processes.

To maximise the potential for GHG reduction, solutions will be prioritised that are applicable to a wide variety of waterborne operations (and not just selective cases), regarding both maritime and inland navigation.

The technical and operational transferability will be ensured through standardisation and the development of multi-media documentations and training programmes enabling also the long term development of skills.

Activities addressing efficiency gains through the design of internal combustion engines or power generation systems are excluded.

Solutions are expected to be demonstrated in line with the expected TRL but testing within an operational environment would be a benefit.

This topic implements the co-programmed European Partnership on ‘Zero Emission Waterborne Transport’ (ZEWT).

HORIZON-CL5-2021-D5-01-11: Hyper powered vessel battery charging system (ZEWT Partnership)

Specific conditions

Expected EU contribution per project	The EU estimates that an EU contribution of around EUR 7.00 million would allow these outcomes to be addressed appropriately. Nonetheless, this does not preclude submission and selection of a proposal requesting different amounts.
Indicative budget	The total indicative budget for the topic is EUR 14.00 million.
Type of Action	Innovation Actions
Legal and financial set-up of the Grant Agreements	The rules are described in General Annex G. The following exceptions apply: The funding rate is up to 60% of the eligible costs. This funding rate applies both to members and non-members of the partnership, except for non-profit legal entities, where the funding rate is up to 100% of the total eligible costs.
Technology Readiness Level	Activities are expected to achieve TRL 6-7 by the end of the project – see General Annex B.

Expected Outcome: Project outputs and results are expected to contribute concretely to the following expected outcomes as marked ("*") whilst supporting the overall medium and longer term objectives:

- Faster turnaround times of battery electric ships and facilitating the charging of larger on-board batteries.
- New business models are developed for electrical ships and their port operations in close cooperation with land side stakeholders.
- Increase Europe's technological lead in fast charging systems for batteries that can be applied to a wide range of vessel types in the medium term.
- Increase Europe's competitive advantage within the electric shipping market supporting jobs and growth.
- *At least two full scale demonstrators in two European ports showing the practical use for an end-to-end service between these ports (without a proprietary solution, the system needs to be compatible with charging in other ports as well).
- *Demonstration and performance assessment in a realistic environment of fast multi-MW recharging systems, leading to an increase in the technical and economic viability of battery electric shipping.
- *Market analysis and feasibility assessment of the more wide-spread deployment of fast high power electrical charging of vessels in European ports (or at certain offshore facilities), including short sea vessels and ferries.

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- *Demonstrated flexibility regarding different waterborne applications to be served by the same connecting facility.

Scope: Electrification is an important means to make waterborne transport climate neutral and is already successfully deployed within diesel hybrid ships and fully electric ferries serving shorter distances. The capacity and range of electric vessels are increasing and the cost of batteries are coming down. Due to comparatively high capital costs, business models of electric ships are often founded on high availability, reduced maintenance and fast turnaround.

The provision of high charging powers is often impeded by the lack of availability of high power fast charging and of an adequate electrical supply infrastructure in ports or ferry terminals. The provision of such infrastructure to enable (parallel) multi-MW charging can substantially increase the costs to deploy electric shipping services. Furthermore, charging infrastructures are usually bespoke to a particular electric vessel design. This lack of standardisation further hinders the deployment of electric ships of all types.

Focusing on the ship and shore side interface, R&I will deliver solutions and technology to minimise high power recharging times at port, explore the applicability of charging solutions to a variety of batteries and their usefulness for different ship types. R&I will develop standard interfaces which ensure a seamless integration of different electric ships into conventional port and ferry terminal operations, including their integration with future port and energy infrastructures as they evolve.

Projects will address technologies and solutions for minimising time-to-recharge, by ensuring a recharging system of at least 5 MW capacity. No specific type of connection (either physical or inductive) is preferred.

A high level of charging performance is expected being suitable for new vessels, but solutions should also be adaptable towards existing or refitted vessels.

The following aspects need to be addressed: Ease and required connection time, flexibility regarding power levels and energy transfer whilst minimising impacts on electrical grid infrastructure (cables, switchboards, etc.), addressing potential battery degradation during fast charging, impacts on materials through e.g. corrosion and thermal stress.

Substantial progress beyond the state of the art should be achieved, such as with respect to the Horizon 2020 E-Ferry project. Applicability should be towards a range of vessel types, with larger battery systems and longer autonomy.

It should be explored whether the results can be adapted to a range of particular charging situations where power demand may be lower but the resilience of the system has to be higher and the connection may be more difficult to make. For example, vessels serving wind parks or offshore installations may be able to benefit from direct and distributed charging at the park or installation to enable longer periods of fully electric operation increasing operational efficiency and eliminating excessive transit times.

The energy supply at the port side is not within the scope of this topic. However, projects are expected to consider overall feasibility and constraints on the land side and assess the European market demand for recharging stations.

This topic implements the co-programmed European Partnership on 'Zero Emission Waterborne Transport' (ZEWT).

HORIZON-CL5-2021-D5-01-12: Assessing and preventing methane slip from LNG engines in all conditions within both existing and new vessels (ZEWT Partnership)

Specific conditions	
Expected EU contribution per project	The EU estimates that an EU contribution of around EUR 7.00 million would allow these outcomes to be addressed appropriately. Nonetheless, this does not preclude submission and selection of a proposal requesting different amounts.
Indicative budget	The total indicative budget for the topic is EUR 7.00 million.
Type of Action	Innovation Actions
Legal and financial set-up of the Grant Agreements	The rules are described in General Annex G. The following exceptions apply: The funding rate is up to 60% of the eligible costs. This funding rate applies both to members and non-members of the partnership, except for non-profit legal entities, where the funding rate is up to 100% of the total eligible costs.
Technology Readiness Level	Activities are expected to achieve TRL 7 by the end of the project – see General Annex B.

<u>Expected Outcome</u>: Project outputs and results are expected to contribute concretely to the following expected outcomes as marked ("*") whilst supporting the overall medium and longer term objectives:

- Ensure that the transitional deployment of LNG fuel does not increase GHG emissions but maximises its potential to contribute to climate neutrality.
- Strengthening the European leadership in LNG technologies, allowing for a transitional sustainable use of LNG where it is beneficial.
- *At least one full scale demonstrator for full methane slip abatement for a vessel in operation.
- *Development and practical demonstration of technical abatement solutions both for retrofitted vessels and new builds, covering a range of operational scenarios.

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- *Where still necessary and duly justified quantification of methane slip founded upon both in-situ measurements and consolidated pre-existing validated test results in the public domain addressing a range of LNG engine types and load factors, including dynamic loads as, for example, encountered in manoeuvring.

Scope: Nearly all commercial vessels in operation today have a power generation based on one or more Internal Combustion Engines (ICE). Directive 2014/94/EU on the Deployment of Alternative Fuels Infrastructure defined minimum requirements for the building-up of alternative fuels infrastructure e.g. for natural gas. Currently Liquefied Natural Gas (LNG - methane) is an alternate viable marine fuel deployed to substantially reduce ship-borne pollutant emissions.

However, the impact of LNG on greenhouse gas emissions is strongly influenced by "methane slip", including the release of unburnt LNG from LNG-fuelled ICEs. This is a problem that is being tackled but not fully solved.

Since methane is a greenhouse gas 84 times more potent than CO2 on a 20 year basis, the potential release of unburnt methane substantially increases the fuel's impact on climate change. Whilst it is known that operations under some engine loading conditions and with some engine types can significantly increase methane slip, there is a lack robust data on the scale of the challenge for the existing LNG fleet and for new vessels.

Projects will address the current state of the art and the scatter of emissions between different types of LNG-powered engines. Operational data on methane slip from existing engine installations will be assessed, compared and made available. Activities may include additional measurement campaigns of methane slip where necessary and duly justified, addressing the complexity of different engine types at different load factors (including highly dynamic loads) and operational profiles. Activities will lead to a better understanding of the parameters involved in order to develop the most efficient abatement strategies through ICE improvement and/or post-treatment technologies. Such activities are expected to go significantly beyond existing measuring campaigns and provide distinctively new knowledge. A repetition of measurements already made by producers of large marine engines will not be funded.

Project(s) will develop and demonstrate such strategies and the corresponding technologies for better performing ICEs and/or after treatment systems which virtually eliminate methane slip in all conditions in refitted or newly built vessels. By developing technologies also suitable for retrofitting this action will also have an impact on the existing LNG-powered fleet whilst ensuring that negative impacts on energy efficiency (potentially resulting in higher CO2 emissions) and on the suppression of pollutant emissions (in particular NOx) are avoided.

This topic implements the co-programmed European Partnership on 'Zero Emission Waterborne Transport' (ZEWT).

HORIZON-CL5-2021-D5-01-13: Digital Twin models to enable green ship operations (ZEWT Partnership)

Specific conditions	
Expected EU contribution per project	The EU estimates that an EU contribution of around EUR 7.00 million would allow these outcomes to be addressed appropriately. Nonetheless, this does not preclude submission and selection of a proposal requesting different amounts.
Indicative budget	The total indicative budget for the topic is EUR 7.00 million.
Type of Action	Research and Innovation Actions
Technology Readiness Level	Activities are expected to achieve TRL 5 by the end of the project – see General Annex B.

Expected Outcome: Project outputs and results are expected to contribute to all of the following expected outcomes:

- Reduced emissions and improved efficiency enabled through development of digital models and tools for a wide range of vessel types, ship systems and operational environments.
- Prove and quantify the impact regarding emissions reductions and improved efficiency through productivity and performance increases based on a proven and efficient environmental impact assessment methodology.
- Ensuring the wider applicability of digital models for different ship types, both for new constructions and for retrofitting, through a comprehensive methodology and a transferable system architecture.
- Proving the interoperability of data models between different ship types and regarding the link with port digital twin models.
- Benchmarking efficiency improvements against other industry sectors.
- Increase the confidence of investors concerning the expected improvements in energy efficiency and reduced emissions resulting from upgrades and modifications for both new designs and retrofitting.
- In the medium term, enable the development of the "zero emission decision support system" as a contribution to the 55% reduction goals of fuel consumption in 2030.

Scope: The digital revolution is affecting most industrial sectors, enabling the digital modelling of designs, manufacturing processes and operations. A wider and better development of Digital Twin (DT) models enables new functionalities for the design and operation of vessels to improve operational efficiency to be developed and validated with increased confidence

without resorting to more costly physical testing. DT modelling can be founded and validated using sensor data, data mining and merging, big data, AI and self-learning to improve efficiency on all levels. Such developments increase owner confidence in the expected performance when procuring innovative green systems as well as providing operational feedback to the manufacturer which can be used to further improve energy efficiency. In this respect DT models are understood as wide-ranging tools with known application areas and those still to be explored.

The waterborne (transport) sector is characterised by very diverse requirements and market realities. Ships, their systems and related technical and commercial processes are already widely using digital technologies including virtual models but those are generally developed individually and with significant overlaps. Capital expenditure is often very high. The wider implementation and integration of digital technologies into more coherent Digital Twins on-board and onshore supporting user oriented decisions is still in its infancy.

Whilst simulation environments are relatively mature maritime system tools, development to enable full exploitation of the potential functionalities is still lacking.

Activities will address the DT concept in order to improve energy efficiency and environmental performance from the early design phase of vessels to the end of the life cycle, thus providing assurance to the owner or operator concerning the expected improvements resulting from upgrades and modifications. This will be a key factor to achieve the zero-emission targets for waterborne transport, while increasing the understanding of vessel performance in a wide range of operations, in particular in the view of the parallel uptake of a multitude of innovative technologies for on-board energy storage, distribution and conversion as well as those for voyage optimisation and manoeuvring. A methodology to assess environmental impacts and performance improvements through the DT model should be developed and validated, with the definition of KPIs orienting the design choices and manufacturing processes.

Project(s) will develop DT models, preferably based on existing specifications and simulation environments, addressing different ship systems (e.g. engine and machinery operations, hull/propeller performance and interaction models, electric network management including in particular HVAC, cargo handling) in order to have a significant impact on energy efficiency as well as on operational performance, both in maritime transport and IWT and with regard to newbuildings and existing vessels. To this end the dynamic use of real life data (feedback loop) is expected to be addressed as well.

This topic implements the co-programmed European Partnership on ‘Zero Emission Waterborne Transport’ (ZEWT).

HORIZON-CL5-2021-D5-01-14: Proving the feasibility of a large clean ammonia marine engine (ZEWT Partnership)

Specific conditions

Expected EU contribution per project	The EU estimates that an EU contribution of around EUR 10.00 million would allow these outcomes to be addressed appropriately. Nonetheless, this does not preclude submission and selection of a proposal requesting different amounts.
Indicative budget	The total indicative budget for the topic is EUR 10.00 million.
Type of Action	Innovation Actions
Legal and financial set-up of the Grant Agreements	The rules are described in General Annex G. The following exceptions apply: The funding rate is up to 60% of the eligible costs. This funding rate applies both to members and non-members of the partnership, except for non-profit legal entities, where the funding rate is up to 100% of the total eligible costs.
Technology Readiness Level	Activities are expected to achieve TRL 6-7 by the end of the project – see General Annex B.

Expected Outcome: Project outputs and results are expected to contribute concretely to the following expected outcomes as marked ("*") whilst supporting the overall medium and longer term objectives:

- Contribution to at least one full scale demonstrator with the ammonia-fuelled marine engine used in a commercial vessel for main propulsion and/or (large scale) main power generation by 2027.
- In the medium term, enabling operations for maritime intercontinental transport (tankers, bulk carriers, container ships, passenger ships) and realisation of bunkering infrastructures, depending on fuel availability scenarios.
- Enable the timely transformation of the existing maritime fleet towards climate neutrality through retrofitting of existing vessels with ammonia-fuelled engines.
- *Demonstration and validation of an ammonia-fuelled marine engine with power output in the +10 MW range. The validation shows safe and reliable operation in realistic scenarios and for a range of load cases.
- *In case of proven feasibility pathways to the uptake of ammonia as a marine fuel for deep sea shipping and high power vessels are set out.
- *Analysis of pathways to ammonia as a marine fuel through the establishment of regulations and solutions for health and safety issues.

Scope: Deep sea shipping (maritime intercontinental transport) and ship operations with very high power demand require the storage of large amounts of energy carriers aboard in order to ensure the required autonomy and the ability to navigate safely in adverse and extreme

conditions. The use of low energy density green fuels will in these operational environments lead to a significant loss of cargo volumes or useable space (e.g. passenger cabins) which directly impacts the economic parameters of the vessels and consequently leads to reluctance by ship owners to invest in clean ships.

Ammonia is a zero carbon fuel, with a (slightly) higher volumetric energy density than liquid hydrogen and with comparatively high liquefaction temperatures and pressures. Due to this, and its combustion characteristics, green ammonia has been widely advocated as a potential sustainable alternative marine fuel. Yet its possible use within a large low-speed marine engine has yet to be proven. A practical and easy use of ammonia may be a game changer in making shipping climate neutral, in particular if it can be used in the existing fleet through retrofitting.

The aim is to develop, demonstrate and validate a multi-cylinder internal combustion engine of at least 10 MW power output running on ammonia as its main fuel, with IMO-Tier III or lower NOx emissions and negligible emissions of SOx, particulates and other harmful substances or odours. As an indication total tank-to-wake GHG emission reduction versus an MGO baseline should be at least 80% (taking into account that the climate-neutral upstream supply of ammonia is not part of this topic). Risks should be assessed and the engine should also comply with all relevant safety rules and regulations as stipulated by classification societies and flag states.

Projects should demonstrate the engine operating at its rated power in a laboratory or on board of an actual vessel, thus going beyond the state of the art which is currently demonstrating ammonia combustion in smaller (road vehicle-based) test engines, or rapid compression machines.

Assuming feasibility, pathways toward deployment will be proposed.

This topic implements the co-programmed European Partnership on 'Zero Emission Waterborne Transport' (ZEWT).

Impact of transport on environment and human health

Proposals are invited against the following topic(s):

HORIZON-CL5-2021-D5-01-15: Development and demonstration of cost affordable and adaptable retrofit solutions for tailpipe and brake polluting emissions

Specific conditions	
Expected EU contribution per project	The EU estimates that an EU contribution of between EUR 4.00 and 5.00 million would allow these outcomes to be addressed appropriately. Nonetheless, this does not preclude submission and selection of a proposal requesting different amounts.
Indicative budget	The total indicative budget for the topic is EUR 10.00 million.
Type of Action	Innovation Actions

Technology Readiness Level	Activities are expected to achieve TRL 8 by the end of the project – see General Annex B.

Expected Outcome: Project results are expected to contribute to the following expected outcomes:

- Cleaner urban air and water quality and reduced health impacts and damage to historic buildings due to lower emissions from road transport by 2025.
- Affordable and adaptable retrofit solutions that with a fraction of the vehicle market value (e.g. 10% or less), could reduce the emissions of the existing Internal Combustion Engine (ICE) based fleet by over 50-60% for NOx and 90% for particles (exhaust emissions).
- Avoidance of transfer of pollution from high to low-income EU countries (exhaust emissions).
- Reduced health impact for highly exposed groups like public transport workers and users (emissions from brakes).
- Affordable and adaptable retrofit solutions to reduce particle emissions by over 90% for particles both in terms of numbers and mass (emissions from brakes).
- Reduced impact by heavy metals on soil and surface and ground waters (emissions from brakes).
- Reduced noise impact for retrofitted vehicles (exhaust emissions) and rolling stock (emissions from brakes).

Scope: The impact of transport on air and water quality has been repeatedly found to be due to tailpipe emissions from older vehicles, vehicles exceeding emissions limits in real driving conditions, or by vehicles, which, by not being subjected to specific limits, have high emissions of certain pollutants (e.g. ammonia-fuelled vehicles which emit a high number of particulates).Considering that the current automobile fleet in Europe is unlikely to be significantly renewed within the next 10 years, the proposed research actions should address emissions of nanoparticles from indirect injection (i.e. conventional) gasoline and natural gas engines or Pre-Euro 6 c direct injection gasoline cars that will continue to occur for the next couple of years. In all these cases, when the vehicles are sufficiently recent and therefore not candidates for scrapping, the proposed actions on retrofit technologies should aim at reducing real emissions at a relatively low cost, thus providing an early improvement of air quality without waiting for the vehicles to be replaced (or exported to other markets, thus just shifting the pollution to poorer countries).

The Horizon Prize for the Cleanest Engine retrofit has already demonstrated very high NOx reduction performance on a high emitting Euro 5 diesel, and one of the participants has brought a product on the market, while at the moment no solution is present on the market for ammonia and particulates by vehicle categories not fitted with particle filters (natural gas cars, trucks and buses, gasoline cars). Therefore, the proposed actions should demonstrate in the field the results

of deploying available retrofits, in particular to public and private fleets running high numbers of kilometres within the city (buses, delivery vans, taxis), as well as developing and demonstrating new, low cost retrofit technologies for natural gas buses and natural gas and gasoline cars in the above mentioned applications, with a clear validation in real driving of the reduction of emissions. The proposed actions should also consider awareness raising of little known emissions issues (for instance, ammonia and nanoparticles below the regulated threshold) and specific incentive schemes to facilitate the adoption of these technologies should also be considered, taking into account the results of the currently running EU-funded projects on retrofits.

In addition to tailpipe particles, there is a growing awareness of the contribution by tires and brakes from road and rail vehicles. Brakes, different from tires, have the potential to emit large amounts of very fine particles and these can include harmful materials like heavy metals and resins. Moreover, they contribute to poor local air and water quality in specific and sometimes closed environments like bus stops, tunnels and train and metro stations. Therefore, the proposed activities should assess the specific contribution of brake particles on local air and water quality, possibly including citizen science contributions, for instance to assess the situation of complete network of metro and rail stations in cities or workers exposure, and to develop low cost retrofit solutions for these transport vehicles and demonstrate existing solution in the field to assess their benefit and usability/operating costs, while at the same time reducing the acquisition and installation costs, both for first installation and retrofitting (specifically on long-lived public transport assets).

In some specific cases, like urban heavy duty vehicles and rail rolling stock, noise is also an issue, therefore the retrofit solutions for these applications should also look at reducing exhaust noise, particularly during transients, while low particle emissions brake solutions should also look at integrating ways to reduce brake noise.

In line with the Union's strategy for international cooperation in research and innovation, international cooperation is encouraged.

Typically, projects should have a duration of 36 to 48 months. Nonetheless, this does not preclude submission and selection of proposals requesting other amounts or durations.

HORIZON-CL5-2021-D5-01-16: Assessment of noise and particle emissions of L category vehicles from real driving conditions

Specific conditions	
Expected EU contribution per project	The EU estimates that an EU contribution of between EUR 4.00 and 5.00 million would allow these outcomes to be addressed appropriately. Nonetheless, this does not preclude submission and selection of a proposal requesting different amounts.
Indicative budget	The total indicative budget for the topic is EUR 5.00 million.

Type of Action	Research and Innovation Actions
Technology Readiness Level	Activities are expected to achieve TRL 5-6 by the end of the project – see General Annex B.

Expected Outcome: Project results are expected to contribute to the following expected outcomes:

- In-depth assessment of the noise and pollutant emissions of at least 150 L category vehicles, starting from the 10 top sellers of the different subcategories having significant sales (at least mopeds, 125cc, 250cc, 500 cc and above 500cc motorbikes, l6 and l7 microcars, light freight transport 3 and 4 wheelers), including different brands and geographical coverage. This will allow to take into account a large share of their environmental impact.
- Measures for mitigating the noise from L category vehicles.
- Development of reliable detection techniques for tampered L category vehicles.
- Best practices for integrating a growing number of L category vehicles in the urban traffic without increasing the noise and emission pollution.

Scope: Noise pollution is a growing environmental concern and has been affecting quality of life and well-being. It is caused by a varied number of sources and is widely present not only in the busiest urban environments, it is also pervading once natural environments. The adverse effects affect the well-being of exposed human populations, in the health and distribution of wildlife, in the abilities of our children to learn properly at school and in the high economic price society must pay because of noise pollution. Health effects, for instance, can be as bad as increasing the risk of hypertension and cardiovascular disease.

Whilst the increase in traffic volume results in higher noise levels, the increase in urbanisation results in a higher number of people affected by noise. As a result, the adverse health impacts, both direct and indirect, of traffic noise are expected to increase in the future despite potential noise-reducing improvements in vehicles, tyres and roads.

One of the ways of reducing noise from road (or rail) traffic is by tackling the problem at source. Setting lower emission limits via regulation is doubtless effective if it is based upon an appropriate test methodology, and good results have been achieved on large vehicles. However L category vehicles are often perceived as a significant contributors to noise pollution and this might be due to the fact that noise emissions seem to be strictly optimised for specific conditions (but also due to tampering by their users, which in some cases is made too easy by the way the vehicles are built). Moreover, recent measurement campaigns in EU funded projects found some motorbikes having extremely high nanoparticles emissions. Real driving portable emissions measurement system (PEMS) tests will also allow to verify if there are issues in emissions testing, while lab tests should assess the risks posed by particle emissions down to

2.5nm. Tampering is also often performed in order to increase performance, leading to higher emissions.

There proposals should address the following:

- Assess the behaviour of a large sample of these L vehicles in real driving conditions for both noise and emissions in comparison with certification tests (complemented where necessary by lab tests, since mini-PEMS cannot measure certain pollutants like particles, ammonia and hydrocarbons).
- In particular, assess the real world driving behaviour that can produce particularly high annoyance and effect on health (noise emissions).
- Propose specific technical improvements in the standard test procedure (performed in homologated test tracks) so that the tests could better approach real world driving conditions and improve measurement technology for detecting nanoparticles.
- Assess how significant the impact of these emissions is on urban environments and health and examine whether the current regulatory limits are sufficient.
- Assess how widespread tampering is, its impact on global urban noise and emissions lev, its impact on global urban noise and emissions levels, and propose solutions to prevent it.
- Develop reliable technological solutions and effective experimental techniques for better enforcement of the regulatory measures for detecting noise under real driving conditions

This action will be focussed in particular in cities and regions with high powered two wheelers use and the derived knowledge will provide significant support to designing future measures aimed at reducing the noise and pollution emission levels from these vehicles.

Projects should make use of available results and technologies from projects funded in projects on remote monitoring issuing from topics LC-MG-1-1-2018 and LC-MG-1-9-2019, from projects on tampering LC-MG-1-4-2018, and from projects on nanoparticles measurement issuing from topic GV-02-2016.

Selected projects under this topic are strongly encouraged to participate in joint activities as appropriate.[137]

[137] These joint activities could, for example, take the form of clustering of projects and involve joint coordination and dissemination activities such as the participation in joint workshops, the exchange of knowledge, or the development and adoption of best practices. Successful proposals will also be encouraged to exchange with other relevant proposals funded under other topics and other clusters to ensure synergies on cross-cutting challenges of common interest [such as topics *HORIZON-HLTH-ENVHLTH-2022-05-two-stage-01 under cluster 1*]. Therefore, proposals are expected to include a budget to cover those joint coordination and dissemination activities without the prerequisite to define concrete joint activities at this stage. The details of these joint activities will be defined during the grant preparation phase with the Commission.

In line with the Union's strategy for international cooperation in research and innovation, international cooperation is encouraged.

Cross-cutting actions

Proposals are invited against the following topic(s):

HORIZON-CL5-2021-D5-01-17: Support for dissemination events in the field of Transport Research

Specific conditions	
Expected EU contribution per project	The EU estimates that an EU contribution of around EUR 1.50 million would allow these outcomes to be addressed appropriately. Nonetheless, this does not preclude submission and selection of a proposal requesting different amounts.
Indicative budget	The total indicative budget for the topic is EUR 1.50 million.
Type of Action	Coordination and Support Actions
Procedure	The procedure is described in General Annex F. The following exceptions apply: The granting authority can fund a maximum of one project.

Expected Outcome: Project's results are expected to contribute to all of the following expected outcomes:

- Higher visibility, political and strategic relevance of the transport sector and of the EU policy in the field;
- Enhanced dissemination, communication and valorisation of transport R&I objectives, perspectives, strategies and results;
- More effective links and exchanges between research and innovation stakeholders and policy makers, to support the development and deployment of innovative solutions in Europe;
- Increased attractiveness of transport related studies and reinforce the pursuit of excellence in European transport research and innovation, by giving recognition and visibility to the best achievements.

Scope: The action will prepare and provide support to the Transport Research Arena conference (TRA) to be organised in 2024 gathering road transport stakeholders for discussing political, industrial and research issues on a European and global level.

Proposals are expected to demonstrate the financial and organisational support of the national authorities' and a preliminary economic plan covering the additional funding needs. In order to

ensure high political and strategic relevance, preference will be given to proposals involving Member States holding the Presidency of the European Union in year 2024.

In line with previous TRA biannual conferences, the event should address the technological and industrial developments of the transport sector (road, rail, waterborne, aviation sectors and cross-modal aspects) providing a high level, future oriented perspective coming from politics, the industry and the research community, in response to Europe's social needs and expectations.

In collaboration with the relevant actors, such as the European Commission services, the different European Technology Platforms (ERTRAC for road, ERRAC for rail, WATERBORNE TP for waterborne, ALICE for logistics and ACARE for aeronautics and ECTP for construction), the Conference of European Directors of Roads (CEDR), the European Transport Research Alliance (ETRA) and the previous TRA conference organisers in order to maintain continuity, the action will define the overall planning of the conference, structure the technical and political sessions of the event, contribute to select the appropriate location for the venue and offer operational IT tools for the registration of participants, the handling of speakers' contributions, contribute to the organisation of logistics, etc. Support to the organisation of demonstration activities should also be foreseen.

Specific attention should be put on a broad and balanced participation i.e. students, young researchers, women, a large number of countries' representatives, etc.

The proposal is expected to also organise two competitions for transport research and innovation awards covering all transport modes and cross-cutting issues (technological, socio-economic and behavioural aspects) in line with the EU policy objectives for climate-neutral and environmentally friendly mobility:

- A competition for students and young researchers with the goal of stimulating the interest among young researchers/students in the field of transport;
- A competition for senior researchers in the field of innovative transport concepts based on results from EU-funded projects only.

The organisation of these awards should ensure high-quality competition and very good media coverage before, during and after the TRA conference, in line with previous editions (TRA Visions). The competition is expected to give particular attention to gender issues.

Call - Clean and competitive solutions for all transport modes

HORIZON-CL5-2022-D5-01

Conditions for the Call

Indicative budget(s)[138]

[138] The Director-General responsible for the call may decide to open the call up to one month prior to or after the envisaged date(s) of opening.
The Director-General responsible may delay the deadline(s) by up to two months.

Topics	Type of Action	Budgets (EUR million)	Expected EU contribution per project (EUR million)[139]	Number of projects expected to be funded
		2022		
Opening: 02 Dec 2021 Deadline(s): 26 Apr 2022				
HORIZON-CL5-2022-D5-01-01	IA	16.00	Around 8.00	2
HORIZON-CL5-2022-D5-01-02	RIA	15.00	Around 5.00	3
HORIZON-CL5-2022-D5-01-03	RIA	18.00	Around 9.00	2
HORIZON-CL5-2022-D5-01-04	IA	25.00	Around 5.00	5
HORIZON-CL5-2022-D5-01-05	RIA	15.00	Around 15.00	1
HORIZON-CL5-2022-D5-01-06	IA	7.00	Around 7.00	1
HORIZON-CL5-2022-D5-01-07	RIA	7.00	2.50 to 3.00	3
HORIZON-CL5-2022-D5-01-08	IA	58.00	15.00 to 20.00	3
HORIZON-CL5-2022-D5-01-09	RIA	20.00	3.00 to 6.00	4
HORIZON-CL5-2022-D5-01-10	IA	25.00	20.00 to 25.00	1
HORIZON-CL5-2022-D5-01-11	CSA	2.00	Around 2.00	1
HORIZON-CL5-2022-D5-01-12	RIA	20.00	2.00 to 5.00	5
HORIZON-CL5-2022-D5-01-13	RIA	20.00	2.00 to 5.00	5
HORIZON-CL5-2022-D5-01-14	RIA	5.00	0.50 to 2.50	3
Overall indicative budget		253.00		

General conditions relating to this call	
Admissibility conditions	The conditions are described in General Annex A.

All deadlines are at 17.00.00 Brussels local time.
The budget amounts are subject to the availability of the appropriations provided for in the general budget of the Union for years 2021 and 2022.
139 Nonetheless, this does not preclude submission and selection of a proposal requesting different amounts.

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Eligibility conditions	The conditions are described in General Annex B.
Financial and operational capacity and exclusion	The criteria are described in General Annex C.
Award criteria	The criteria are described in General Annex D.
Documents	The documents are described in General Annex E.
Procedure	The procedure is described in General Annex F.
Legal and financial set-up of the Grant Agreements	The rules are described in General Annex G.

Enabling climate neutral, clean, smart, and competitive waterborne transport

Proposals are invited against the following topic(s):

HORIZON-CL5-2022-D5-01-01: Exploiting electrical energy storage systems and better optimising large battery electric power within fully battery electric and hybrid ships (ZEWT Partnership)

Specific conditions	
Expected EU contribution per project	The EU estimates that an EU contribution of around EUR 8.00 million would allow these outcomes to be addressed appropriately. Nonetheless, this does not preclude submission and selection of a proposal requesting different amounts.
Indicative budget	The total indicative budget for the topic is EUR 16.00 million.
Type of Action	Innovation Actions
Legal and financial set-up of the Grant Agreements	The rules are described in General Annex G. The following exceptions apply: The funding rate is up to 60% of the eligible costs. This funding rate applies both to members and non-members of the partnership, except for non-profit legal entities, where the funding rate is up to 100% of the total eligible costs.
Technology Readiness Level	Activities are expected to achieve TRL 7 by the end of the project – see General Annex B.

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Expected Outcome: Project outputs and results are expected to contribute concretely to the following expected outcomes as marked ("*") whilst supporting the overall medium and longer term objectives:

- Contributions to two full scale vessel demonstrators, hybrid and fully electric, by 2027 covering a sailing distance of at least 300 nm in the case of a fully electric vessel.
- *Development and validation of electrical architectures for large battery systems on-board.
- *Proof of the safe integration of battery systems into the ship's electrical grid for a relevant number of ship types (e.g. IWT, short sea vessels, cruise ships, ferries) and operational scenarios.
- *Verification of the architecture and the power management system for two cases: hybrid and fully electric.
- *Documentation of skills requirements for the crew.
- *In the short term, facilitate full battery electric transit for reduced noise and zero emissions on shorter routes (up to 100 nm) and during approach and harbour stay.

Scope: Electrification and electrical energy storage is one of the major drivers for climate neutrality in the waterborne sector. 100% electrical power can potentially be used on any kind of vessel, with an initial focus on ferries and short sea shipping where re-charging can be frequent, but also extending within hybrid applications to larger vessels on longer routes as well as to high power vessels and high-end complex ships with a high number and a wide variety of electrical consumers.

Large battery based electrical energy storage systems offer the highest energy conversion efficiencies. Within fully electric ships, notably ferries, batteries are the most energy efficient method to achieve climate neutrality. Within ICE hybrid vessels batteries increase total efficiency, cutting engine peak power demands, providing a "spinning reserve" and enabling the possibility of zero emission port entries and coastal passages utilising only battery power.

The latest industrial outcomes in large marine batteries are already addressing safe, long-life and cost-effective solutions. On the other hand, at ship level, the development of systems which ensure the full integration of batteries in the ship's highly complex electrical network is crucial to ensure the optimal use of the electrical energy stored, alone or in combination with other zero-emission ship power sources like, for instance, fuel cells.

Projects will develop solutions for the on-board integration (including the optimisation of the electrical distribution grid) and control of batteries which will maximise the operational flexibility of different ships under electric-driven zero-emission operations, focussing on an optimal operation and the longest lifetime and lowest weight of the electrical systems and its key components. While ensuring the ship's energy balance and efficiency, solutions need to address one of these two cases:

- The hybrid arrangement for zero local pollution (long and complete discharge cycles), or
- The full electric arrangement, plug-in charging (charging strategy and battery size adapted to route).

Strategies for safe energy management systems with sufficient safety margins need to be addressed.

Projects will also investigate (e.g. through performance modelling) different optimisation strategies for the large capacity batteries on board and will need to prove the applicability to several ship types and operational profiles. It will need to establish connections with the project(s) awarded under the Horizon 2020 call LC-BAT-11-2020 which is focused on the development of cost-efficient batteries, including the certification methodology.

Consideration should be given to technology transfer from potentially related sectors, such as the energy management from solar panel systems.

Long term skills' development needs and strategies with the aim to provide operational transferability of the developed solutions are integral to the topic and should also be investigated.

This topic implements the co-programmed European Partnership on 'Zero Emission Waterborne Transport' (ZEWT).

HORIZON-CL5-2022-D5-01-02: Innovative energy storage systems on-board vessels (ZEWT Partnership)

Specific conditions	
Expected EU contribution per project	The EU estimates that an EU contribution of around EUR 5.00 million would allow these outcomes to be addressed appropriately. Nonetheless, this does not preclude submission and selection of a proposal requesting different amounts.
Indicative budget	The total indicative budget for the topic is EUR 15.00 million.
Type of Action	Research and Innovation Actions
Technology Readiness Level	Activities are expected to achieve TRL 5 by the end of the project – see General Annex B.

Expected Outcome: Project outputs and results are expected to contribute concretely to the following expected outcomes as marked ("*") whilst supporting the overall medium and longer term objectives:

- Contributions to at least two full scale on-board demonstrators for two different electrical energy storage solutions by 2027.

- Improve efficiency and make waterborne transport climate neutral through the exploitation of new innovative electrical storage systems.
- In the medium term, upscaling of proven solutions for a broad range of ship types (e.g. IWT, ferries, short sea shipping) and operational scenarios, as an alternative to batteries.
- Ensuring European leadership for energy storage solutions based on different technologies that will be fit-for-purpose for diverse waterborne applications.
- *Achieve a comprehensive understanding of potential innovative energy storage systems other than batteries and their applicability to waterborne transport.
- *Solutions to improve energy efficiency and make waterborne transport climate neutral founded upon innovative energy storage.
- *Comprehensive assessment of the technical feasibility and adequacy of innovative energy storage for a range of waterborne operations including efficiency, safety, cost competitiveness compared to batteries, skills requirements, and regulatory aspects.

Scope: Battery based electric energy storage systems are increasingly deployed within the waterborne sector, particularly for sea short shipping, complex high-end ships and inland navigation.

Nonetheless, specific operational requirements (e.g. autonomy, power peaks, etc.), in particular in adverse conditions outside sheltered waters or going upstream on rivers, remain a concern. Fully battery electric shipping is demanding, requiring very high energy levels to achieve a realistic operational range and the necessary speed and thrust performance, whilst hybrid applications can also be excessively large. Both hybrid and full battery operations are subject to many more charging cycles and longer lifetimes than other transport applications.

Batteries within most waterborne applications deployments are founded upon established battery technologies. However, other energy storage systems exist which maybe valuable for waterborne application in the future which have not been fully investigated. For example, super-/ultra-capacitors, superconductivity magnetic energy storage, flywheels, flow batteries, etc.

Projects will focus on low TRL solutions for waterborne transport, preliminary integration, safety studies and the potential combination with other disruptive technologies such as super conductors and the wider use of DC grids. It will address the integration on-board of innovative energy storage systems (excluding storage of fuels and conventional batteries), including control systems and optimised operational deployment, and the connection to the on-board electrical grid.

Projects will address the cost competitiveness of the innovative solutions when compared with batteries, specify the applicability in specific waterborne segments (in particular in IWT where electrification may be pioneered through a dedicated project), determine risk levels, identify safety measures and propose possible regulatory aspects. The pertinent skills development will be outlined.

Activities will address innovative energy storage for waterborne applications, it will not address the internal design of the energy storage technology itself. For example, the design of super capacitors would be excluded.

This topic implements the co-programmed European Partnership on 'Zero Emission Waterborne Transport' (ZEWT).

HORIZON-CL5-2022-D5-01-03: Exploiting renewable energy for shipping, in particular focusing on the potential of wind energy (ZEWT Partnership)

Specific conditions	
Expected EU contribution per project	The EU estimates that an EU contribution of around EUR 9.00 million would allow these outcomes to be addressed appropriately. Nonetheless, this does not preclude submission and selection of a proposal requesting different amounts.
Indicative budget	The total indicative budget for the topic is EUR 18.00 million.
Type of Action	Research and Innovation Actions
Technology Readiness Level	Activities are expected to achieve TRL 5 by the end of the project – see General Annex B.

Expected Outcome: Project outputs and results are expected to contribute concretely to the following expected outcomes as marked ("*") whilst supporting the overall medium and longer term objectives:

- Renewable energy assistance is commercially viable and deployed at scale in commercial shipping and maritime operations, significantly contributing to making waterborne transport climate neutral.
- In the medium term, enabling the wide adoption of automated wind technologies for long distance maritime transport.
- *Through full scale demonstration prove the viability at large scale of power generation and propulsion assistance systems on-board harvesting renewable energies such as wind and solar.
- *System designs (including modular/drop-in) to reduce the costs of and increase confidence in refitting of the most appropriate existing vessels addressing several types of ships and different forms of renewable energy.
- *System designs including power management architectures and energy efficiency solutions (including wind-assisted and wind-based propulsion) for purpose built new ships including designs that are "wind-ready". Demonstration of efficiency gains of at least 15% for power generation or at least 25% for propulsion purposes.

- *Provision of a summary and an analysis of pertinent regulatory issues and how to address them.
- *Documentation of skills requirements and incentives for the crew, for different types of ships and renewables adopted.

Scope: The use of on-board renewable energies, in particular automated wind assistance, has potential to substantially reduce the ship's energy demands and hence reduce fuel consumption. Wind energy, harvested through e.g. rotors, hard and soft sails, kites, suction wings, turbines or specific hull forms, can serve multiple purposes on-board, including in particular primary propulsion with the additional beneficial effect of noise reduction. Potentially more expensive climate neutral fuels and carbon taxes will further enhance the economic benefits from efficiency gains and the exploitation of freely available renewable energies. With wind being a genuinely maritime feature shipping would also avoid costly competition with other transport sectors for sustainable fuels.

Whilst some renewable energy systems have been trialled at comparatively small scale, for particular routes and ship types, their scale has often been too small to provide conclusive data, and robust systems applicable for long distance trans-oceanic shipping are not yet available. R&I is needed to harvest the wind energy potential, significantly enlarging the current scale and expanding the typology for a much wider range of applications, demonstrating cost-effective, safe, reliable and easy-to-handle technologies in a variety of conditions. These conditions should be considered variable and dynamic if combined with beneficial changes in operational profiles such as advanced (satellite enabled) weather routing. The optimisation of aerodynamic efficiency of devices and the reduction of superstructure drags will be considered.

Overall energy efficiency strategies and architectures for the power management in large ships will be developed, with an optimised and self-adaptive operation of wind power systems as part of a hybrid architecture. For certain ship types and routes wind energy could become the main propulsion. This may in particular apply to smaller craft and fishing vessels (in transit) or to ships where wind propulsion can free bunker spaces for more paying cargo or passengers. In these cases attention needs to be given to the most practical and efficient system installation (e.g. retractable, auto-furling, hinged, multi-positional).

Projects are expected to address both retrofitting existing ships and new purpose built designs, taking into account regulatory issues and making use of the existing guidelines by classification societies on wind-assisted shipping. Large scale testing and preferably demonstration is expected. Attention should be given to the conditions under which renewable power sources on-board compete with specific fuel solutions in terms of life cycle and opportunity costs, proven sustainability and reliable sourcing, and operational risks in order to make the most convincing business case.

In addition to wind, other renewables such as solar electric systems should be considered for different ship types, to the extent they can significantly contribute to the ship's overall power systems.

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This topic implements the co-programmed European Partnership on 'Zero Emission Waterborne Transport' (ZEWT).

HORIZON-CL5-2022-D5-01-04: Transformation of the existing fleet towards greener operations through retrofitting (ZEWT Partnership)

Specific conditions	
Expected EU contribution per project	The EU estimates that an EU contribution of around EUR 5.00 million would allow these outcomes to be addressed appropriately. Nonetheless, this does not preclude submission and selection of a proposal requesting different amounts.
Indicative budget	The total indicative budget for the topic is EUR 25.00 million.
Type of Action	Innovation Actions
Legal and financial set-up of the Grant Agreements	The rules are described in General Annex G. The following exceptions apply: The funding rate is up to 60% of the eligible costs. This funding rate applies both to members and non-members of the partnership, except for non-profit legal entities, where the funding rate is up to 100% of the total eligible costs.
Technology Readiness Level	Activities are expected to achieve TRL 7-8 by the end of the project – see General Annex B.

Expected Outcome: Project outputs and results are expected to contribute concretely to the following expected outcomes as marked ("*") whilst supporting the overall medium and longer term objectives:

- Accelerated achievement of climate neutrality of waterborne transport through retrofit modifications to the existing fleet.
- Ensuring cost effective solutions for retrofitting existing ships, thus supporting ship owners in the process of making the European fleet more environmentally friendly.
- Business models, industry standards, regulatory approvals, best practice guidance, and easy-to-customise strategies for retrofitting removing the commercial risk of deployment.
- Increased competitiveness of European shipyards, repair yards, and European marine equipment providers within the domain of green shipping technology.
- *Demonstrated retrofitting solutions for sea-going and inland navigation vessels in operation.

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- *Retrofit solutions to reduce GHG emissions that are developed and ready to deploy. The target is to achieve a GHG emissions reduction of at least 35% compared to the original design.

- *Retrofit solutions involving climate neutral fuels making vessels GHG emission free. These solutions are expected to have a significant R&I content going beyond a simple exchange of fuels through minor technical adaptations.

- *Establishment of an up-to-date catalogue of suitable solutions for a wide variety of ship types and operation scenarios.

Scope: Progress towards climate neutrality of waterborne transport can be achieved more quickly by means of retrofit solutions that improve the performance of the existing fleet (sea-going and IWT) whilst solutions which are exclusive to new ships can only be implemented at the pace of the commercially driven fleet renewal.

In the trajectory towards the transition to new technologies that will make waterborne transport and operation greener and climate neutral picking the low hanging fruits is important. With the comparatively long life cycles of maritime assets and their high initial capital costs addressing the existing fleet is paramount in order to achieve fast and tangible results. Therefore, interventions that are easily implemented by shipyards, ship owners and operators need to be developed in the shortest possible time to reduce emissions from vessels already in service, both seagoing and those operating in inland navigation. The latter are particularly relevant as they tend to be in use in excess of 30 years and are largely owned by SMEs with limited investment potential.

In this context the owner-operator dilemma poses additional problem in the waterborne sector: A large number of ships are bareboat chartered by an operator who does not take investment decisions although he could benefit from them through lower running costs. The owner who would have to make those investment decisions, however, does not gain financial advantages as charter rates are generally fixed and depend on ship size and speed only. A performance related charter rate system has often been discussed but rarely implemented. Easy and relatively cheap retrofitting solutions may help in overcoming this dilemma.

For inland navigation and/or maritime shipping projects are expected to address one or more of the following:

- Retrofit solutions to significantly reduce air or water pollution without increasing fuel consumption and hence GHG emissions, for example main engine abatement systems or engine and propulsion system modifications.

- Retrofit solutions which significant reduce GHG emissions through partial or full electrification, clearly progressing beyond the state of the art. Indicative examples are battery ICE hybridisation for the main propulsion system and auxiliary power, electric network reconfiguration, electrical power management.

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- Retrofit innovative hydrodynamic improvements (hull, hull management, appendages) to significantly improve energy efficiency and reduce GHG emissions by reducing fuel consumption.

Projects will focus on the design for technically and economically efficient retrofitting of the ship along these main lines. Cost efficiency of the proposed solutions will come from standardised and modular solutions applicable to different ships or by significantly reducing operational costs over the expected remaining life time of the asset. This may require new business models and implementation strategies based on a catalogue of solutions including smart maintenance. Attention will be paid to solutions which are not causing secondary emissions to air or water and which will not significantly increase fuel consumption.

This topic implements the co-programmed European Partnership on 'Zero Emission Waterborne Transport' (ZEWT).

HORIZON-CL5-2022-D5-01-05: Seamless safe logistics through an autonomous waterborne freight feeder loop service

Specific conditions	
Expected EU contribution per project	The EU estimates that an EU contribution of around EUR 15.00 million would allow these outcomes to be addressed appropriately. Nonetheless, this does not preclude submission and selection of a proposal requesting different amounts.
Indicative budget	The total indicative budget for the topic is EUR 15.00 million.
Type of Action	Research and Innovation Actions
Technology Readiness Level	Activities are expected to achieve TRL 5 by the end of the project – see General Annex B.

Expected Outcome: Project outputs and results are expected to contribute concretely to the following expected outcomes as marked ("*") whilst supporting the overall medium and longer term objectives:

- Enable seamless safe logistics through an autonomous (or highly automated) waterborne freight feeder loop service for inland waterway and/or maritime transport applications. The autonomous system will provide an integrated, reliable, resilient, predicable fully automated service, also taking into account the interconnection of inland navigation and maritime transport in terms of serving the hinterland.

- Provide increased legal and regulatory certainty concerning autonomous waterborne services within national maritime and/or inland waters, e.g. concerning COLREGs, national and inter-governmental legislation etc. Expansion to the international dimension where feasible.

- Moving more freight by water with high levels of safety (taking in account all aspects related to fully autonomous navigation, e.g. manoeuvring, situational awareness, collision avoidance, failsafe operations), reduced environmental impact and contributions to climate neutrality, increased operational resilience and decongested land transport infrastructures.

- Autonomous waterborne freight feeder services can be taken up by the market on basis of a sound business case. Development of new business models based on autonomous waterborne feeder services within national maritime and/or inland waters.

- Reduced risk for first movers concerning autonomous waterborne technologies.

- Improved European competitive advantage within global markets with respected to connected and autonomous shipping as well as broadening expertise across several member states and associated countries.

- Exploitation of EU satellite navigation and other space based services.

- Better understanding of the societal issues and consequences of automated shipping services, in particular regarding skills challenges.

- *Preferably demonstrate the solution at full scale with all technology building blocks in a real world scenario. If full scale demonstration is unfeasible, solutions and key technology building blocks may be validated by means of testing within relevant environments, noting the lower project budget foreseen in this case.

Scope: Digitisation and automation are increasingly disrupting business models and the operation of the waterborne transport sector.

Whilst digital and connected solutions are widely deployed, autonomous waterborne transport remains at an early stage of development, particularly outside of military applications. A small number of early stage demonstrators are foreseen in the coming years with modest ambition and focus. The main challenges are both technical and regulatory. Automated maritime or inland waterways feeder services are seen as the most promising applications where the feasibility and commercialisation of automated shipping can be proven. In particular, an autonomous waterborne feeder loop or shuttle service providing regular reliable, resilient and integrated supplies of freight with an ambition of zero emissions is likely to have many applications.

Developing the necessary expertise for such services provides Europe with a competitive advantage in the face of strong global competition which is investing to develop similar technologies. Autonomous waterborne feeder services are expected to disrupt logistics, remove freight from congested land infrastructures, increase safety by reducing the human factor in accidents and incidents, and make transport climate neutral. They will change business models, increasing logistic chain integration and exploiting telemetry and shore-based support, whilst modifying the role of crews and legal responsibilities which will raise further societal issues that need to be addressed. These anticipated changes to waterborne transport also require clarity

concerning the local rules and regulations in order to ensure legal certainty. Project(s) is/are expected to co-operate closely with the Horizon 2020 project MOSES which is already addressing aspects of robotic cargo handling and autonomous vessel manoeuvring and docking.

Building on the current state of the art and on-going activities, proposals should address all of the following points in line with the expected outcomes above:

- Develop an autonomous waterborne freight feeder loop service for inland or maritime transport suitable for specific commercial applications and which can provide an integrated, reliable, resilient, predicable fully automated service with a preference for zero GHG and pollutant emissions as well as supporting safer navigation (e.g. manoeuvring, situational awareness, collision avoidance, failsafe operations). Feeder service is to be understood to include Ro-Ro services.

- Given that an IWT application will significantly differ from a short sea application common technology building blocks need to be defined and developed. Project(s) should analyse differences and communalities in sufficient detail.

- Key aspects to be addressed are real time data acquisition, management, storage and exchange, and the supporting digital infrastructure(s), standards and connectivity, also addressing the potential use of Galileo GNSS services.

- Develop business cases which demonstrate the viability of the proposed solutions and their impact on logistic chains. The latter will require addressing port handling and intermodality.

- In addition to the vessel projects should address the port and any other necessary shore side infrastructure as well as any adaptions to existing infrastructure such as locks and bridges in the case of inland waterways transport.

- Address requirements for telemetry, its architecture, infrastructure monitoring and security needed for controlling the system's water-side and shore-side assets.

- Address the necessary safety, regulatory and legal rules (including liability, COLREGs etc.) needed to deploy such services. A clear distinction needs to be made between inland navigation and short sea shipping as different legal, fiscal and commercial conditions as well as emission baselines apply. The possibility for modifications of COLREGS and similar regulations as well as a more active role of shore traffic management services should be explored.

- Whilst ensuring European added value, and visibility of the European activities, engage with wider activities addressing automated shipping, including internationally within IMO, as well as supporting EU policy making in the domain of autonomous and connected shipping.

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- Address reliability, liability and the consequences of system failure or breakdown. Special attention needs to be given to cyber security and resilience against malicious acts in all aspects.

- Address the socio-economic implications of such automated feeder services, including employment, training and skills requirements as well as the social acceptance of such vessels. The latter may have higher pertinence where vessel operations are taking place in proximity to population areas.

- Broaden European autonomous waterborne transport expertise amongst EU Member States and associated countries.

HORIZON-CL5-2022-D5-01-06: Computational tools for shipbuilding

Specific conditions	
Expected EU contribution per project	The EU estimates that an EU contribution of around EUR 7.00 million would allow these outcomes to be addressed appropriately. Nonetheless, this does not preclude submission and selection of a proposal requesting different amounts.
Indicative budget	The total indicative budget for the topic is EUR 7.00 million.
Type of Action	Innovation Actions
Technology Readiness Level	Activities are expected to achieve TRL 7-8 by the end of the project – see General Annex B.

Expected Outcome: Project outputs and results are expected to contribute to all of the following expected outcomes:

- Achieve a competitive advantage for European shipbuilders within global markets, particularly for complex high added value vessels.

- Rapid early ship design (including an AI-based analysis of technical and legal requirements derived from historic data or from a structured feedback loop between builder and operator), underpinning the functional design concept and production cost estimations.

- Virtual prototyping to increase the reliability of early stage capital cost estimations, particularly taking into account the full range of greening options and innovative (and potentially difficult to cost) technologies such as green power systems (batteries, fuels etc.), the impacts on weight and revenue generating spaces as well as benefits towards operational cost.

- Provide benefits towards the competitiveness of the wider European shipbuilding sector, beyond single shipyards, through the creation of a fast, flexible and reliable design

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environment and platform that also includes repair yards. The platform is expected to be based on Industry 4.0 digital technologies and is expected to be fully tested through a dedicated design case as a demonstrator. This should include all relevant design disciplines and focus specifically on the full range of technologies supporting the reduction of emissions, with linkage to highly automated and robotised processes in parts manufacturing, assembly and outfitting with full supply chain integration.

- Integration of the ship design stages (conceptual, functional, production), considering also supply chain management issues. Demonstration of a future proof ship design concept based on modular architectures that allow for (cost) efficient retrofitting during the ship's life cycle.

- Computational shipbuilding tools and data management systems which are resilient to cyber threats.

- A European workforce that is highly skilled in the deployment and use of advanced computational tools in shipbuilding, particularly with respect to the integration of new technologies.

Scope: Advanced computational systems are essential to Europe's competitive advantage in the construction, maintenance, conversion and repair of the world's most complex, high added value ships. Present computational systems are often proprietary, increasingly outdated and difficult to maintain whilst Europe's competitors are continuing to develop their advanced computational capacity. It is essential that Europe is able to maintain and extend its competitive lead within the high technology shipbuilding segment and that advanced computational tools are developed which in particular are able to integrate a wide range of emerging innovative technologies within designs, such as alternative power systems based on e.g. e-fuels, renewables, electrification, and hybridisation. Systems need to feed into competitive production processes as well as support potential changes to a ship design during its entire life-cycle.

The complexity of such tools and systems calls for novel solutions regarding design and production platforms, infrastructures, and services which may not be within reach of smaller European shipyards and design consultancies. Therefore, new concepts for a reliable and cost efficient roll-out of advanced platforms and tools are expected to be developed and demonstrated.

Furthermore developments should benefit the wider European shipbuilding sector and address the necessary skills development to enable full exploitation of the advanced computation tools.

Proposals should develop advanced innovative computational tools for shipbuilding that increase the European sectors competitiveness by addressing all of the following points:

- Facilitate rapid early stage design to support lower risk bid development particularly when integrating innovative new technologies.

- Provide better capital cost estimations and performance predictions, particularly showing the improvements expected from the inclusion of new technologies.

- Tools to be integrated with ship construction and production, as well as considering supply chain management and future maintenance and repair of vessels.
- Address and quantify the competitiveness gains provided by the tool(s) in the context of the wider European shipbuilding sector.
- Ensure that the tool is robust and resilient against cyber threats.
- Identify and address the necessary skills development needed to achieve the maximum benefit from innovative advanced computational shipbuilding tools.
- Develop a business case to quantify the added value from the developed tool to the shipbuilder concerned and within the context of the wider European shipbuilding sector.

Impact of transport on environment and human health

Proposals are invited against the following topic(s):

HORIZON-CL5-2022-D5-01-07: Prevent smog episodes in Europe: Air quality impact of engine-emitted volatile, semi volatile and secondary particles

Specific conditions	
Expected EU contribution per project	The EU estimates that an EU contribution of between EUR 2.50 and 3.00 million would allow these outcomes to be addressed appropriately. Nonetheless, this does not preclude submission and selection of a proposal requesting different amounts.
Indicative budget	The total indicative budget for the topic is EUR 7.00 million.
Type of Action	Research and Innovation Actions
Technology Readiness Level	Activities are expected to achieve TRL 5 by the end of the project – see General Annex B.

Expected Outcome: Project results are expected to contribute to [all/some] of the following expected outcomes

- Achieve better understanding of (semi)volatiles particles and secondary aerosol formation as well as their effects on health, air quality (in particular during winter season) and climate.
- Assess the contribution to PM2.5 of precursors present in exhaust from transport (i.e. volatile organic compounds, NOx, unburned hydrocarbons, nano-particles below 23nm, ammonia, etc.) through the formation of secondary aerosol (organic –SOA- and inorganic).

- Find ways in which scientific evidences of the role of emissions in atmospheric processes could be an input to develop policies and mitigate SOA formation in urban areas of EU.
- Improved quantification of transport externalities.
- Support of future emissions legislation and of "polluter pays" legislation.

Scope: The impact of transport emissions on air quality and health is relatively well known as far as direct pollutants emission are concerned, i.e. particulate, NOx, hydrocarbons etc. However, some of the emissions from engines and combustion processes in general are also leading to further formation of health impacting compounds due to atmospheric aerosol chemistry, and the specific impact of these compounds is less understood (except for ozone, whose chemistry has been widely studied for other reasons). Also, in fields where regulation limits particles emissions (cars, trucks, aircraft, non-road mobile machinery) current engine particles emissions count only assesses the number of solid particles, disregarding the so-called volatile and semi-volatile particles, thus underestimating the impact on air quality and health.

Proposals should assess in detail engines emissions in Real Driving Emissions (RDE)-compliant testing conditions (based on currently used fuels) leading to volatile and semi-volatile and secondary particulate, taking into account the wide available literature and results from projects issuing from topics LC-MG-1-1-2018 and GV-02-2016, prioritise them according to available information and assess their health impact with relevant modelling and in vitro and in vivo testing.

After assessing the risks associated to each emission, proposals should define a robust and transparent measurement and modelling system in order to determine an equivalent total particles emissions index for each engine encompassing all these emissions, to complement the direct solid particles emissions count currently in use to better quantify the total externalities of combustion engines in all transport fields and related fuels.

In line with the Union's strategy for international cooperation in research and innovation, international cooperation is encouraged.

Zero-emission road transport

Proposals are invited against the following topic(s):

HORIZON-CL5-2022-D5-01-08: Modular multi-powertrain zero-emission systems for HDV (BEV and FCEV) for efficient and economic operation (2ZERO)

Specific conditions	
Expected EU contribution per project	The EU estimates that an EU contribution of between EUR 15.00 and 20.00 million would allow these outcomes to be addressed appropriately. Nonetheless, this does not preclude submission and selection of a proposal requesting different amounts.

Indicative budget	The total indicative budget for the topic is EUR 58.00 million.
Type of Action	Innovation Actions
Legal and financial set-up of the Grant Agreements	The rules are described in General Annex G. The following exceptions apply: The funding rate is up to 60% of the eligible costs. This funding rate applies both to members and non-members of the partnership, except for non-profit legal entities, where the funding rate is up to 100% of the total eligible costs.
Technology Readiness Level	Activities are expected to achieve TRL 7-8 by the end of the project – see General Annex B.

Expected Outcome: Projects' results are expected to contribute to all of the following expected outcomes:

- Demonstration of high efficiency long haul Heavy Duty Vehicle (HDV) powertrain for truck-trailer combinations, Vehicle Group 4, 5, 9, 10, 11 or 12 of VECTO capable of 750 km unrefuelled/unrecharged range whilst operating at maximum gross vehicle weight (GVW) of minimum 40 tons under operational conditions comparable to the VECTO long haul mission profile.

- Demonstration of the developed concepts over a period of at least 6 months in real world conditions involving manufacturer(s), energy provider(s), electric and hydrogen infrastructure and end users (e.g. carriers, logistics service providers and cargo owners) from across Europe, covering at least 500 km (for long haul) average daily operation in real conditions – in line with drive and resting time regulation.

- Provide fleet managers with ZEV-specific, flexible, managerial tools (e.g. adapted to the characteristics of vehicles and infrastructure) supporting the seamless integration of zero tailpipe emissions vehicles into fleets and facilitating the assignment of tasks and routes (infrastructure, range, charging time, payload etc.).

- Contribute to significant price reduction steps by targeting and showing a pathway towards total cost of operation equality with 2020 engine-based solutions assuming a production volume of >= 10.000 pieces/year, and net TCO reductions beyond that.

Scope: The call is asking for a modular and flexible powertrain approach for large heavy-duty trucks which can serve varying mission demands (range, power and re-charging/-fuelling requirements) by varying battery/tank sizes to serve different missions and driving profiles within one vehicle platform.

Flexible vehicle platforms can allow the installation of modular powertrain solutions including either pure BEV/FCEV versions or hydrogen FC range extended battery vehicles, exploiting the scalability and modularity of the installed power units to allow cost efficient solutions for dedicated missions.

At least two different prototypes need to be demonstrated covering two different missions under operational conditions: one of which is mandatorily for long haul freight transport, as defined in expected outcomes, while the additional prototype(s) is/are open to Vehicle Group 4, 5, 9, 10, 11 or 12 of VECTO capable of operating at maximum gross vehicle weight (GVW) of minimum 40 tons under operational conditions comparable to the VECTO regional mission profile, and/or long distance coach(es).

Applicants should go beyond activities carried out by actions funded under topic HORIZON-CL5-2021-DEST5-CCT-01-01, avoiding duplication of activities already performed under this topic, as well as of activities developed by ongoing Fuel Cell and Hydrogen Joint Undertaking projects[140].

Proposals are expected to address the following:

- Efficient energy/thermal management including the HVAC system and during ultra-fast charging both while driving and during breaks (including auxiliaries like overnight hotel and, optionally, refrigeration loads) achieving a minimum 44% energy efficiency in FC "charge sustaining mode" or 82% for BEV configurations (both at "tank-to-wheel" on the VECTO Regional Distribution and Long Haul cycles as appropriate).

- For FC applications, the scalable power level of a hydrogen-based power unit for full power operation or range extension to vary power and range demands of different mission profiles is expected to demonstrate at least 90% availability and 30.000 hr FC operational life for safe and efficient operations, including scale-up options; (FC and tank development are excluded from this topic; suitable engagement with FCH projects needs to be foreseen).

- For BEV long haul applications, demonstration of fast charging concepts, capable of fitting established regulations and business practices, with a range recovery of at least 400 km in 45 min, with an overall charge efficiency of at least 80%. The proposed solutions are expected to not reduce transport productivity (i.e. km per day, including driver resting time) and should be deployable at load/unload points and staging areas, while ensuring grid compatibility.

- Demonstration of a delivery load capacity not less than 90% of a current such vehicle.

- Improvement of inverter and DC/DC technologies integration in regard to optimized and novel cooling concepts and cost reduction, considering where appropriate synergies with HORIZON-CL5-2021-DEST5-CCT-01-02.

- Improvement of specific central, high power electric motors or modular in-wheel motor concepts, considering where appropriate synergies with HORIZON-CL5-2022-DEST5-CCT-01-02.

140 https://www.fch.europa.eu/page/fch-ju-projects

- Achievement of cost benefits by optimization of the control architecture.
- Predictive maintenance strategies considering AI technologies, including deployment of prognostic and diagnostic techniques and control units in order to improve the lifetime of the fuel cells systems.
- Show the minimum achievable impact on environment (GHG, polluting emissions, biodiversity, resources etc.) using a comparative life-cycle assessment.
- Projects should deliver digital twin models of the demonstrator vehicles, such that the impact of the innovations towards the overall objectives of the 2Zero partnership might be determined prior to the completion of the project. Data that is produced as output from a 'digital twin' should be FAIR, deposition in relevant repositories should be encouraged[141].
- Price reduction resulting from economies of scale due to modularity and standardization of components in other truck, bus/coach (and where possible railway) applications (also creating links with on-going projects in the FCH partnership) with a clear roadmap for how to increase production numbers after the end of the project and for developing the necessary value chains. System level cost-effectiveness of solutions (including needed infrastructure) need to be analysed.
- Develop and validate tools for zero tailpipe emission vehicles integration in fleets (and mixed fleets) for efficient assignment of tasks (routes, charging strategies, assignments etc.).
- Identify European cross-border corridors with lower barriers or higher benefits to start market operations, along with possible future initiatives within the Connecting Europe Facility context.

This topic implements the co-programmed European Partnerships on 'Towards zero emission road transport' (2ZERO).

HORIZON-CL5-2022-D5-01-09: Nextgen EV components: High efficiency and low cost electric motors for circularity and low use of rare resources (2ZERO)

Specific conditions	
Expected EU contribution per project	The EU estimates that an EU contribution of between EUR 3.00 and 6.00 million would allow these outcomes to be addressed appropriately. Nonetheless, this does not preclude submission and selection of a proposal requesting different amounts.
Indicative budget	The total indicative budget for the topic is EUR 20.00 million.
Type of Action	Research and Innovation Actions

[141] Final Report and Action Plan from the European Commission Expert Group on FAIR Data, "TURNING FAIR INTO REALITY" - https://ec.europa.eu/info/sites/info/files/turning_fair_into_reality_0.pdf

Technology Readiness Level	Activities are expected to achieve TRL 5-7 by the end of the project – see General Annex B.

Expected Outcome: Projects' results are expected to contribute to all of the following expected outcomes:

- Lower cost, higher efficiency and power density electric motors for mass produced cars and vans, with a design-to-X approach enabling easy dismantling and recyclability and a reduced use of (rare) resources through the development or application of alternative materials or advanced configurations.
- Lower electric vehicles (EV) cost and improved range and, therefore, a wider market penetration.
- Improved motor design and development processes, considering a full product life-cycle assessment in a circular economy environment, for lower total energy and resources consumption.
- European job creation/retention by developing a world-leading design and production base, including supplying SMEs.

Scope: Electrical machines are a fundamental part of zero emission powertrains for all classes of road vehicles, but the target of this topic is the core market (with powertrains of 50-120kW continuous power).

Proposals are expected to address all the following:

- Increasing primary efficiency, in particular by widening the high efficiency area and compactness, for example through topology or operational improvements, inclusion of increased features in integrated solutions, analysis of performance aspects over the machine-in-system life-cycle.
- Demonstrate the following specific targets (percentages with respect to automotive state of the art in 2020):
    - Continuous power densities >23kW/litre and >7 kW/kg or continuous torque densities > 50Nm/litre and >20Nm/kg, for the complete motor including its cooling, allowing global performance optimisation specific for the category and type of vehicle;
    - A 20% reduction in losses during typical vehicle operation;
    - A reduction in the use of rare resources by 60%;
    - Unit cost for the complete motor at mass production levels (100.000 units/year) < 6€/kW;

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- A recyclability rate >60%, or demonstrating the possibility of "functional" recycling of critical raw materials by repurposing magnets without extracting the single rare elements, thus keeping a higher share of the value.

- Increase high system voltages offering new opportunities for readdressing the current versus voltage trade-offs, throughout the vehicle systems and in aspects of the recharging infrastructure, duly considering potential impacts.

- Guarantee the heat rejection of high energy density motors through multiphysics models in order an optimal design (use of rare resources, reduction in losses, high efficiency).

- Novel manufacturing process supporting increased integration, enabling, amongst other things, improved thermal control.

- The use of alternative architectures and materials to the currently used rare earths-based magnets and configurations. Recyclability plus life-cycle environmental impact aspects need to be considered, aiming at the best compromise with other performance parameters to reach the stated outcomes. If composite reinforced materials (CRM) are included in the design, the development of processes for the economic recycling of at least 60% of any rare materials needs to be included: only this additional work will justify the use of up to EUR 2 million of the expected EU contribution.

- The proposed motor concepts are expected to comply with automotive standards, given the normal dynamic and duty-cycle requirements, reliability, EMC etc. The proposed concepts should consider the motor (integration of electronics, excluding their development at component level), and integration of any related transmission. The concept has to be validated through representative duty-cycle evaluation, as a minimum on the test bed or, optionally with minimum-change integration, on an existing vehicle.

- The provision of a digital-twin of the concept, in-line with current best practice modelling and simulation standards, is required.

This topic implements the co-programmed European Partnerships on 'Towards zero emission road transport' (2ZERO).

HORIZON-CL5-2022-D5-01-10: New generation of full electric urban and peri-urban Bus Rapid Transit systems to strengthen climate-friendly mass transport (2ZERO)

Specific conditions	
Expected EU contribution per project	The EU estimates that an EU contribution of between EUR 20.00 and 25.00 million would allow these outcomes to be addressed appropriately. Nonetheless, this does not preclude submission and selection of a proposal requesting different amounts.
Indicative budget	The total indicative budget for the topic is EUR 25.00 million.

Type of Action	Innovation Actions
Legal and financial set-up of the Grant Agreements	The rules are described in General Annex G. The following exceptions apply: The funding rate is up to 60% of the eligible costs. This funding rate applies both to members and non-members of the partnership, except for non-profit legal entities, where the funding rate is up to 100% of the total eligible costs.
Technology Readiness Level	Activities are expected to achieve TRL 7-8 by the end of the project – see General Annex B.

Expected Outcome: Projects' results are expected to contribute to all of the following expected outcomes:

- Development of next generation innovative effective public transport systems concepts using full electric buses (M3[142]) through e-BRT.
- Present efficient, economically viable and flexible, integrated solutions of e-BRT within existing mass transport networks (all modes) and with personal mobility solutions (walk, bike, powered two-wheelers, cars etc.).
- Develop innovative, integrated, infrastructure solutions combining charging, bus-stops and dedicated bus lines, for both urban and peri-urban road networks.
- Development of flexible bus transport, end-user solutions, for both urban use in dense city centres and for less populated peri-urban environments, meeting future user demands of convenience, efficiency, safety and security.
- Development of an international market for European e-BRT systems, in particular, in countries with low offer of public transport with challenging conditions (climate, environment, poverty, etc.).
- Reduction of greenhouse gas and pollutant emissions as well as traffic congestion, by demonstrating the developed technologies and advanced electrified Bus Rapid Transit (e-BRT) concepts in European and in developing countries' partner countries cities.

Scope: The scale-up phase of clean and intelligent city buses should cover the most demanding routes, by switching the longest, fastest and busiest routes to electricity. Therefore, the investment in innovations in city buses (e.g. clean propulsion) can be optimized through BRT systems, as the operations can be planned, mileage is known and energy requirements can be predicted on-board since the roads and distances are familiar. As such, revisiting the concept of

[142] Category M3: motor vehicles designed and constructed primarily for the carriage of passengers and their luggage with more than eight seating positions in addition to the driver's seating position and having a maximum mass exceeding 5 tonnes.

BRT with new, enabling technologies and solutions offers a key opportunity to reduce the carbon footprint of the transport sector, particularly in cities.

Demonstration and testing in real operation are expected to be developed in four or five different European cities and at least one city in a partner country in a developing context either in Africa or in CELAC area (Community of Latin American and Caribbean States). The demonstration activities should include mega-cities, larger/smaller cities and the link to peri-urban, inter-urban and sub-urban dwellings in order to afford complementary solutions in test and demonstrations. Zero tailpipe emission buses and their related infrastructure are expected to be applied in BRT lines, in different city contexts, together with the needed integration of e-BRT with other mass-public transport systems, and with personal mobility solutions. Solutions include both the physical vehicles, recharging infrastructure and the overall services offering.

Proposals are expected to address all the following:

- Electrification combined with automation and connectivity enablers[143], to optimize and validate the whole advanced BRT system.
- Operational concepts: increasing the capacity use rate; the average commercial speed; punctuality / regularity.
- Synchronization with other city transport modes[144]; service quality whilst reducing CO_2 emissions, and cost per km/passenger.
- Replicability: use of the e-BRT technology under environmental, infrastructure and social conditions different from the European ones.

The focus of projects is expected to be on mass transport, full electric Bus Rapid Transit (e-BRT) systems using full size buses (M3). Vehicle, infrastructure and operational aspects have to be addressed, considering charging systems for stationary, opportunity[145] and Electric Road Systems (ERS) for buses (wireless, contact, SRS etc.) and strategies (IMC, Opportunity at stops or terminal, offline charging etc.).

Proposals are expected to take into consideration the transport operators' and transport authorities' needs for financial viability, effectiveness, flexibility, environment conformance, safety and security. The impact of e-BRT technologies on bus performance and on the frequency of necessary repair and maintenance work, the life duration of the bus, and the costs that have to be covered at the end of the life (recycling; upgrading etc.) might have a huge influence on the financial side and should, therefore, also be covered. The impact of the solutions implemented in the different cities in terms of GHG emissions and traffic should also be quantified. Guidelines for regional and international replication conditions to reach out a larger number of cities and countries are expected to be developed.

143 e.g. big data, cloud computing, artificial intelligence
144 e.g. metro, bike-sharing, ferry
145 e.g www.oppcharge.org

This topic requires the effective contribution of Social Sciences and Humanities (SSH) disciplines and the involvement of SSH experts, institutions as well as the inclusion of relevant SSH expertise, in order to produce meaningful and significant effects enhancing the societal impact of the related research activities. Indeed, crosscutting issues related to socio-economic, gender, socio-cultural, and user aspects need to be addressed with the development of e-BRT systems in cities, taking into account location-specific characteristics of the implementation area, such as local policy targets, population density, and cultural matters. This will help at a better understanding and greater acceptability of such systems as well as socioeconomic benefits.

In line with the strategy for EU international cooperation in research and innovation, international cooperation is encouraged.

This topic implements the co-programmed European Partnerships on 'Towards zero emission road transport' (2ZERO).

HORIZON-CL5-2022-D5-01-11: Stimulating Road Transport research and innovation dissemination and implementation in Europe and around the World

Specific conditions	
Expected EU contribution per project	The EU estimates that an EU contribution of around EUR 2.00 million would allow these outcomes to be addressed appropriately. Nonetheless, this does not preclude submission and selection of a proposal requesting different amounts.
Indicative budget	The total indicative budget for the topic is EUR 2.00 million.
Type of Action	Coordination and Support Actions
Procedure	The procedure is described in General Annex F. The following exceptions apply: The granting authority can fund a maximum of one project.

Expected Outcome: Project's results are expected to contribute to all of the following expected outcomes:

- Strengthen and widely promote research and innovation activities, including among the public/civil society, via road transport dedicated events;
- Identify, highlight and disseminate the contribution from road transport, in particular from projects focused on zero tailpipe emission solutions, to the realization of the European Green Deal and the Paris Agreement;
- Provide a comprehensive overview of international developments in the field of road transport research to keep Europe competitive and successful;

- Increase of cooperation with road transport related national and international organizations and support of international EU activities in line with the UN Sustainable Development Goals;

- Contribute to identifying and analyse research and innovation areas for the future of road transport in the EU.

Scope: The objective of this topic is to promote sustainable road transport in Europe and at international level. This action will contribute to a further harmonisation of research and innovation activities, and therefore contribute to the European Research Area, as well as to the European strategies for future transport systems. The action should also help accelerating time to market of new mobility solutions, by stimulating a wider participation to EU activities and supporting European and worldwide dissemination of results. In addition, this initiative will support climate action and air quality improvement in line with the Green Deals targets and objectives, and contribute to the United Nations (UN) Sustainable Development Goals.

In line with these objectives, all the following aspects should be addressed:

- Organisation of events, conferences, workshops and dissemination activities to present and discuss future technology and trends, results, exchange experience and foster innovation aspects of road transport research and innovation;

- Identification of actions to support road transport area, in particular in the fields of education, training and skills at European level and standardisation and business models – mainly at EU level;

- Fostering of the links between European, national and (where feasible) regional programmes for road transport research, supporting coordination of activities with Member States;

- In the field of international cooperation, facilitating exchange between Europe and emerging economies in particular within Africa, Asia and Latin America;

- Identification of barriers for the deployment of research results and improvement of framework conditions at European and international level, including development of pre-feasibility studies at least in the specific areas of “Urban zero-emission mobility”, “Air quality and climate change” and “Road safety”;

- Track global progress on urban electric mobility, air quality and road safety and support UN activities (e.g. with UN Habitat and UNEP), and ITF/OECD;

- Updating and coordinating research agendas and roadmaps in the field of road transport, in particular for urban mobility, road infrastructure, considering also road safety and logistics, taking into account relevant Horizon Europe partnerships and international activities in the field.

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Aviation

Proposals are invited against the following topic(s):

HORIZON-CL5-2022-D5-01-12: Towards a silent and ultra-low local air pollution aircraft

Specific conditions	
Expected EU contribution per project	The EU estimates that an EU contribution of between EUR 2.00 and 5.00 million would allow these outcomes to be addressed appropriately. Nonetheless, this does not preclude submission and selection of a proposal requesting different amounts.
Indicative budget	The total indicative budget for the topic is EUR 20.00 million.
Type of Action	Research and Innovation Actions
Technology Readiness Level	Activities are expected to achieve TRL 2-4 by the end of the project – see General Annex B.

Expected Outcome: Project results are expected to contribute to at least one of the following expected outcomes:

- Deliver transformative technologies that will allow a step change in the reduction of local air quality (LAQ) from NOx, SOx, volatile organic compounds (VOCs) and particulate matter (PM) that occur below 900m above ground level around airports. Explore synergies with land-based energy systems in Destination 3 and 4 of this Work Programme for the capture of these emissions and/or purification of air.

- Deliver transformative technologies towards a silent aircraft operations around airports, including a study on airport noise map towards assessing the airports that would most benefit from noise reduction policies.

- Advance further integrated and reference European models and methods for estimating aircraft emissions (LAQ and noise) inventories for operations in the airport vicinity, highly accurate estimations on the number of people affected. The models, methods and advancements in measurement technologies should advance further, contribute to and collaborate with existing ICAO CAEP and EUROCONTROL initiatives. They should also be aligned with H2020-ARTEM outcomes towards meeting the ACARE Flighpath2050 goals.

Scope: LAQ and noise aviation emissions effect the quality of life and health. Air pollution is the number one environmental cause of premature death in the European Union. Despite progress in recent decades, it still causes more than 400,000 premature deaths every year, and it brings respiratory and cardiovascular diseases to millions.

While the aviation contribution is estimated to 0.4% of the total deaths attributed annually to global air quality degradation, aviation has a substantial impact on local air pollution around airport areas and efforts are ongoing to reduce it further. Aircraft noise remains a matter of concerns for airports and local authorities despite significant improvements, due to anticipated increase of total number of flights in Europe (could reach 12.8 million by 2035 – despite the present COVID-19 disruption).

Regarding the reduction of local air quality (LAQ) from NOx and particulate matter (PM), the selected technologies may consider sustainable drop-in and non-drop-in fuel options, aligned with EU industrial roadmaps and R&I activities in topic 5-03-02-2021.

Regarding the reductions of aviation noise around airports, the selected technologies should consider propulsion and aircraft-propulsion integration interdependencies as well as operational air-traffic management procedures.

This topic aims to support the EU and ICAO LAQ and noise policies. This topic aims for new aircraft and engine technologies that satisfy the design and operational interdependencies between CO_2, non-CO_2 and noise emissions, are compatible with approved operational procedures and are aligned with the European industrial roadmaps for further development, validation and integration beyond 2030.

HORIZON-CL5-2022-D5-01-13: Digital aviation technologies for new aviation business models, services, emerging global threats and industrial competitiveness

Specific conditions	
Expected EU contribution per project	The EU estimates that an EU contribution of between EUR 2.00 and 5.00 million would allow these outcomes to be addressed appropriately. Nonetheless, this does not preclude submission and selection of a proposal requesting different amounts.
Indicative budget	The total indicative budget for the topic is EUR 20.00 million.
Type of Action	Research and Innovation Actions
Technology Readiness Level	Activities are expected to achieve TRL 2-4 by the end of the project – see General Annex B.

Expected Outcome: Project results are expected to contribute to at least one of the following expected outcomes:

- Transformative digital aviation technologies that will enable new European business models and products (e.g. Urban Air-Mobility (UAM), seaplanes) with minimal environmental impact and opportunities for European competitiveness.
- Transformative digital aviation and space technologies as well as Unmanned Aircraft Systems (UAS), that will enable new services with pronounced societal impact for

intermodal and multimodal transport, search and rescue operations, fast response to natural disasters, freight, firefighting, high altitude earth data-services, agriculture and forestry.

- New aviation products and services that exploit Artificial Intelligence and have pronounced impact to productivity, efficiency, automation and cost reduction.

- Breakthrough technologies that will minimise the risks from emerging global threats (cybersecurity, COVID-19) as well as increase the resilience of aircraft systems from increasing frequency of extreme weather conditions (e.g. temperature change, wind patterns). Technologies that address applications in difficult to access areas, including the open sea emergency response, avalanches, landslides and floods are within the scope of the topic.

- Transformative and breakthrough technologies that exploit synergies with aviation, space and defence. The development of materials and components for high-power density electrical architectures at high altitude environment (e.g. cabling, insulation, power electronics) are within the scope of this topic.

Scope: On 10 March 2020 the Commission presented a new Strategy to help Europe's industry lead the twin transitions towards climate neutrality and digital leadership. Europe needs industry to become greener, more circular and more digital while remaining competitive on the global stage.

The topic aims to enable new digital aviation technologies for new aircraft business models and services, (e.g. EGNSS-based search and rescue, urban air-mobility, firefighting, AI-based technologies, digital data platforms) as well as minimise the risk from emerging threats (extreme weather phenomena, cybersecurity, COVID-19 communicable diseases) to aviation. Synergies with other EU initiatives should be exploited towards European digital platforms that deliver insights and analytics for citizens, businesses and decision makers.

HORIZON-CL5-2022-D5-01-14: European Aviation Research Policy in support to EU policies and initiatives

Specific conditions	
Expected EU contribution per project	The EU estimates that an EU contribution of between EUR 0.50 and 2.50 million would allow these outcomes to be addressed appropriately. Nonetheless, this does not preclude submission and selection of a proposal requesting different amounts.
Indicative budget	The total indicative budget for the topic is EUR 5.00 million.
Type of Action	Research and Innovation Actions
Technology Readiness Level	Activities are expected to achieve TRL 2-4 by the end of the project, where applicable – see General Annex B.

Expected Outcome: Project results are expected to contribute to one of the following expected outcomes:

- Deliver at mid-term of Horizon Europe an update of European aviation R&I roadmap, while ensuring the alignment with the EU regulatory framework.
- Deliver a coherent framework and toolbox for technology and policy assessment of the impact of European aviation research – with emphasis to GHG emissions, local air-quality and noise. Ensure coordination with EPCA, IATM, HFC, ACARE and ASD, taking into consideration the work performed in the CS2 Technology Evaluator and the envisioned Clean Aviation Impact Monitor in its environmental, scientific, societal and economic dimensions.
- Support EU Member States/Associated Countries towards a coherent update of ICAO standards that will prevent backsliding.
- Connect better European aviation R&I with education and skills and communicate the European aviation R&I to citizens and stakeholders.
- Strengthen ERA in Aviation R&I, assess the R&I needs of European SMEs and promote aeronautics/aerospace spin-offs in all aspects of life.
- Strengthen the synergies between all aviation-relevant R&I activities in Horizon Europe.

Scope: In 2021, the European R&I will operate in a new European and global political context, with a new EU budget, new policy priorities, and a new R&I programme. As the Commission moves away from program implementation, while works much closer with Member States, a new European aviation research policy framework is necessary. This aviation WP is a representative example that aims towards EU policies and priorities (European Green Deal and new European industrial policy).

The European aviation research policy aims to contribute with science-based informed decisions that will bridge the gap between R&I, regulatory framework and economic investments (with emphasis on climate neutrality by 2050 and European competitiveness). The European aviation research policy also aims to connect better European aviation R&I with education and skills as well as communicate the European aviation R&I to citizens and stakeholders.

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Destination – Safe, Resilient Transport and Smart Mobility services for passengers and goods

This Destination includes activities addressing safe and smart mobility services for passengers and goods.

Europe needs to manage the transformation of supply-based transport into safe, resilient and sustainable transport and demand-driven, smart mobility services for passengers and goods. Suitable research and innovation will enable significant safety, environmental, economic and social benefits by reducing accidents caused by human error, decreasing traffic congestion, reducing energy consumption and emissions of vehicles, increasing efficiency and productivity of freight transport operations. To succeed in this transformation, Europe's ageing (and not always sustainable) transport infrastructure needs to be prepared for enabling cleaner and smarter operations.

Europe needs also to maintain a high-level of transport safety for its citizens. Resilience should be built in the transport systems to prevent, mitigate and recover from disruptions. Research and innovation will underpin the three safety pillars: technologies, regulations and human factors.

This Destination contributes to the following Strategic Plan's **Key Strategic Orientations (KSO)**:

- *C: Making Europe the first digitally led circular, climate-neutral and sustainable economy through the transformation of its mobility, energy, construction and production systems.*
- *A: Promoting an open strategic autonomy by leading the development of key digital and enabling technologies, sectors and value chains to accelerate and steer the digital and green transitions through human-centred technologies and innovations.*

It covers the following **impact areas**:

- Industrial leadership in key and emerging technologies that work for people;
- Smart and sustainable transport.

The **expected impact**, in line with the Strategic Plan, is to contribute to *"Safe, seamless, smart, inclusive, resilient and sustainable mobility systems for people and goods thanks to user-centric technologies and services including digital technologies and advanced satellite navigation services"*, notably through:

a. Accelerating the implementation of innovative **connected, cooperative and automated mobility (CCAM)** technologies and systems for passengers and goods (more detailed information below).

b. Further developing a **multimodal transport system** through sustainable and smart long-haul and urban freight transport and **logistics**, upgraded and resilient physical and digital

infrastructures for smarter vehicles and operations, for optimised system-wide network efficiency (more detailed information below).

c. Drastically decreasing the number of **transport accidents, incidents and fatalities** towards the EU's long-term goal of moving close to zero fatalities and serious injuries by 2050 even in road transportation (Vision Zero) and increase the **resilience** of transport systems (more detailed information below).

When considering their impact, proposals also need to assess their compliance with the "Do No Significant Harm" principle[146] according to which the research and innovation activities of the project should not be supporting or carrying out activities that make a significant harm to any of the six environmental objectives of the EU Taxonomy Regulation.

Connected, Cooperative and Automated Mobility (CCAM)

The aim of relevant topics under this Destination is to accelerate the implementation of innovative connected, cooperative and automated mobility (CCAM) technologies and systems. Actions will help to develop new mobility concepts for passengers and goods – enabled by CCAM - leading to healthier, safer, more accessible, sustainable, cost-effective and demand-responsive transport everywhere. CCAM solutions will shift design and development from a driver-centred to mobility-user oriented approach, providing viable alternatives for private vehicle ownership while increasing inclusiveness of mobility. CCAM must be integrated in the whole transport system to fully exploit the potential benefits of CCAM and minimise potential adverse effects, such as increasingly congested traffic or new risks in mixed traffic environments.

The focus is on road transport, but relevant interfaces with other modes (for instance transfers and integration with public transport or rail freight transport) will be considered.

All technologies, solutions, testing and demonstration activities resulting from these actions should be documented fully and transparently, to ensure replicability, increase adoption, up-scaling, assist future planning decisions and EU and national policy-making and increase citizen buy-in.

Actions are in line with the recommendations of the new European Partnership on CCAM. The Vision of the Partnership is: "European leadership in safe and sustainable road transport through automation". It aims to harmonise European R&I efforts to accelerate the implementation of innovative CCAM technologies and services. It aims to exploit the full systemic benefits of new mobility solutions enabled by CCAM. The European Partnership on CCAM plans to closely cooperate with other European Partnerships, in particular with "Towards zero emission road transport" (2ZERO), "Driving Urban Transitions" (DUT), "Key digital technologies" (KDT), "Smart networks and services" (SNS) and "AI, data and robotics" (AI). The European

146 as per Article 17 of Regulation (EU) No 2020/852 on the establishment of a framework to facilitate sustainable investment (EU Taxonomy Regulation)

Partnership will establish cooperation mechanisms to ensure close interaction when defining R&I actions to maximise synergies and avoid overlaps.

R&I actions taking place at a socio-technical level aiming to better understand the science-society relationship (particularly when social practices, market uptake or ownership are concerned) should favour solutions that are grounded in social innovation in order to achieve its desired outcomes, i.e. by matching innovative ideas with social needs and by forming new collaborations between public and private actors, including civil society and researchers from the Social Sciences and Humanities (SSH).

To test CCAM solutions, applicants can seek possibilities of involving the European Commission's Joint Research Centre (JRC) in order to valorise the relevant expertise and physical facilities of JRC in demonstrating and testing energy and mobility applications of the JRC Living Lab for Future Urban Ecosystems https://ec.europa.eu/jrc/en/research-facility/living-labs-at-the-jrc

The main impacts to be generated by topics targeting connected, cooperative and automated mobility under this Destination are:

- Validated safety and security, improved robustness and resilience of CCAM technologies and systems.
- Secure and trustworthy interaction between road users, CCAM and "conventional" vehicles, infrastructure and services to achieve safer and more efficient transport flows (people and goods) and better use of infrastructure capacity.
- Seamless, affordable and user oriented CCAM based mobility and goods deliveries for all and high public acceptance of these services with clear understanding of its benefits and limits as well as rebound effects; based on the changing mobility needs and desires of a society in transition (digitally and environmentally).
- Better coordination of R&I and large-scale testing activities in Europe and expanded knowledge base on CCAM solutions.
- European leadership in the development and deployment of connected and automated mobility and logistics services and systems, ensuring long-term growth and jobs.

Multimodal and sustainable transport systems for passengers and goods

Multimodal and sustainable transport systems are the backbone for efficient mobility of passengers and freight. In particular, the areas of infrastructure, logistics and network/traffic management play a major role in making mobility and transport climate neutral, also through the digitalisation of the sectors. At the same time, being vulnerable to climate change and other disruptions, resilience in these three areas need to be increased. New and advanced infrastructures across all transport modes are required to enable the introduction of new vehicles, operations and mobility services. Furthermore, efficient and smart multimodal logistics are key for seamless and sustainable long-haul, regional and urban freight transport

movements. Finally, dynamic multimodal network and traffic management systems are the "glue" of the entire transport network, for optimised door-to-door mobility of both passengers and freight.

The main impacts to be generated by topics targeting Multimodal and sustainable transport systems for passengers and goods under this Destination are:

- Upgraded and resilient physical and digital infrastructure for clean, connected and automated multimodal mobility.
- Sustainable and smart long-haul, regional and urban freight transport and logistics, through increased efficiency, improved interconnectivity and smart enforcement.
- Reduced external costs (e.g. congestion, traffic jams, emissions, air and noise pollution, road collisions) of urban, peri-urban (regional) and long distance freight transport as well as optimised system-wide network efficiency and resilience.
- Enhanced local and/or regional capacity for governance and innovation in urban mobility and logistics.

Safety and resilience - per mode and across all transport modes

Safety and resilience are of primary concern for any transport system. The EU set ambitious targets in its 2011 Transport White Paper, the third Mobility Package and, more recently, the Sustainable and Smart Mobility Sttrategy[147]. COVID-19 has been a stark reminder of the importance of resilience to external disruptions, particularly for transport. Research and innovation will underpin the three pillars affecting safety and resilience: technologies; regulations (alongside acceptable level of risks); and human factors (individual and organisational aspects, including interaction with automation). The approach is risk-based and systemic, including transport means/vehicles, infrastructure, the physical environment (e.g. weather) and the various actors (e.g. manufacturers, regulators, operators, users) as well as all their interfaces, including certification and standardisation bodies.

Synergies should be exploited across research at national, EU and international level together with national authorities, EU agencies and international organisations to improve rulemaking, safety promotion and oversight.

The main impacts to be generated by topics targeting transport safety and resilience under this Destination are:

Safety in Urban Areas/ Road Transport Safety

- 50% reduction in serious injuries and fatalities in road crashes by 2030.

[147] COM(2020) 789 final.

- Improved reliability and performance of systems that aim to anticipate and minimize safety risks, avoiding risks and collisions, and reducing the consequences of unavoidable crashes.
- Drastic reduction of road fatalities and serious crash injuries in low and medium income countries in Africa.
- Better design principles of future road transport systems enabling also better traffic flow in big cities.

Waterborne Safety and Resilience

- Ensure healthy passenger shipping by preventing and mitigating the spread of contagious diseases and infections.

Aviation Safety and Resilience

- Decrease number of accidents and incidents due to organisational/human/automation factors and external hazards in all phases of flight, also beyond CAT category (80% goal in FlightPath2050), while enabling all weather operations.
- Saving lives following a crash (post-crash survivability).
- Anticipate emergence of new threats that could generate potential accidents and incidents (short, medium, and long term).
- Ensure safety through aviation transformation (from green/digital technologies uptake up to independent certification).
- Maintain safety and resilience despite the scale, pace and diversity of new entrants.

The following call(s) in this work programme contribute to this destination:

Call	Budgets (EUR million)		Deadline(s)
	2021	2022	
HORIZON-CL5-2021-D6-01	167.00		19 Oct 2021
HORIZON-CL5-2022-D6-01		122.00	12 Jan 2022
HORIZON-CL5-2022-D6-02		91.00	06 Sep 2022
Overall indicative budget	167.00	213.00	

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Call - Safe, Resilient Transport and Smart Mobility services for passengers and goods

HORIZON-CL5-2021-D6-01

Conditions for the Call

Indicative budget(s)[148]

Topics	Type of Action	Budgets (EUR million)	Expected EU contribution per project (EUR million)[149]	Number of projects expected to be funded
		2021		
Opening: 15 Apr 2021 Deadline(s): 19 Oct 2021				
HORIZON-CL5-2021-D6-01-01	IA	15.00	6.00 to 8.00	2
HORIZON-CL5-2021-D6-01-02	RIA	15.00	12.00 to 15.00	1
HORIZON-CL5-2021-D6-01-03	IA	18.00	7.00 to 9.00	2
HORIZON-CL5-2021-D6-01-04	RIA	12.00	5.00 to 6.00	2
HORIZON-CL5-2021-D6-01-05	RIA	8.00	3.00 to 4.00	2
HORIZON-CL5-2021-D6-01-06	RIA	6.00	5.00 to 6.00	1
HORIZON-CL5-2021-D6-01-07	IA	15.00	7.00 to 8.00	2
HORIZON-CL5-2021-D6-01-08	IA	15.00	7.00 to 8.00	2
HORIZON-CL5-2021-D6-01-09	IA	23.00	Around 7.50	3
HORIZON-CL5-2021-D6-01-10	RIA	12.00	4.00 to 5.00	3
HORIZON-CL5-2021-D6-01-11	RIA	8.00	4.00 to 5.00	2
HORIZON-CL5-2021-D6-01-12	RIA	8.00	3.00 to 5.00	2

148 The Director-General responsible for the call may decide to open the call up to one month prior to or after the envisaged date(s) of opening.
The Director-General responsible may delay the deadline(s) by up to two months.
All deadlines are at 17.00.00 Brussels local time.
The budget amounts are subject to the availability of the appropriations provided for in the general budget of the Union for years 2021 and 2022.

149 Nonetheless, this does not preclude submission and selection of a proposal requesting different amounts.

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HORIZON-CL5-2021-D6-01-13	IA	12.00	4.00 to 8.00	2
Overall indicative budget		167.00		

General conditions relating to this call	
Admissibility conditions	The conditions are described in General Annex A.
Eligibility conditions	The conditions are described in General Annex B.
Financial and operational capacity and exclusion	The criteria are described in General Annex C.
Award criteria	The criteria are described in General Annex D.
Documents	The documents are described in General Annex E.
Procedure	The procedure is described in General Annex F.
Legal and financial set-up of the Grant Agreements	The rules are described in General Annex G.

Connected, Cooperative and Automated Mobility (CCAM)

Proposals are invited against the following topic(s):

HORIZON-CL5-2021-D6-01-01: More powerful and reliable on-board perception and decision-making technologies addressing complex environmental conditions (CCAM Partnership)

Specific conditions	
Expected EU contribution per project	The EU estimates that an EU contribution of between EUR 6.00 and 8.00 million would allow these outcomes to be addressed appropriately. Nonetheless, this does not preclude submission and selection of a proposal requesting different amounts.
Indicative budget	The total indicative budget for the topic is EUR 15.00 million.
Type of Action	Innovation Actions

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Eligibility conditions	The conditions are described in General Annex B. The following exceptions apply: If projects use satellite-based earth observation, positioning, navigation and/or related timing data and services, beneficiaries must make use of Copernicus and/or Galileo/EGNOS (other data and services may additionally be used).
Legal and financial set-up of the Grant Agreements	The rules are described in General Annex G. The following exceptions apply: The funding rate is up to 60% of the eligible costs. This funding rate applies both to members and non-members of the partnership, except for non-profit legal entities, where the funding rate is up to 100% of the total eligible costs.
Technology Readiness Level	Activities are expected to achieve TRL 6-7 by the end of the project – see General Annex B.

Expected Outcome: Project results are expected to contribute to all of the following expected outcomes:

- Determination of the appropriate compositions of cost-efficient sensor suites that most effectively and reliably deliver the lateral, spatial and temporal resolution needed for real-time driving decision-making of Connected and Automated Vehicles (CAVs).
- Ability to perform advanced environment and traffic recognition and prediction, limiting false detections and non-detections of obstacles, with particular attention to Vulnerable Road Users (VRU), in order to reduce existing disparities in the harm-to-exposure ratios of these vulnerable groups.
- Ability to determine the appropriate course of action of a CAV in a real world environment with a wide range of traffic scenarios and identify use cases in which the vehicle's decision-making might be contradictory to existing traffic rules (e.g. to make way for a priority vehicle, to obey police officers directing traffic).
- Availability of robust, transparent and accurate systems to enable the safe and reliable operation of automated vehicles in expanding Operational Design Domains (ODDs) including all weather conditions, complex urban environments, challenges in rural environments, etc.
- Standardization mandate for performance requirements for environment perception systems with respect to different automation levels and ODDs.

Scope: To achieve secure and trustworthy interaction between vehicles, infrastructure and road users, robust (e.g. weather resilient) and accurate on-board environment positioning and perception systems are essential for the extraction of reliable information required for real-time driving decision-making. Furthermore, advanced on-board decision-making functionalities

need to handle the diversity of use cases in their respective operational domains. Such functionalities have to guarantee the safety and reliability of future automated vehicles, which will integrate complex in-vehicle systems-of-systems with advanced sensors, control and actuators, relying on extensive computational power and an increased dependency on software for decision-making.

The proposed actions are expected to address the development and demonstration of each of the following aspects:

- More powerful and reliable embedded in-vehicle perception systems with increased performance, (weather) resilience and accuracy based on enhanced sensing, localization (with reliable, dynamic, high-definition digital maps, reliable and precise location from EU satellite navigation services) and improved object/person classification and cognition (with greater integration with infrastructure-based perception systems and other vehicles to complete data fusion and real time updates).

- System self-assessment methods for environment perception technologies and improved hardware integration into the vehicle need also to avoid reliability issues due to environmental stresses, temperature shifts, vibrations, potential malicious attacks, low speed crashes, etc.

- On-board, real-time, fail-safe, unambiguous and traceable decision-making systems for safe Connected and Automated Vehicles (CAVs) based on complex in-vehicle systems-of-systems requiring extensive computational power and highly advanced algorithms in order to address complex traffic scenarios (with VRU). These systems should be cost effective and respecting the protection of personal data with improved minimum risk manoeuvres in the event that the limit of the ODD is reached or in the case of a malfunction.

In order to achieve the expected outcomes, international cooperation is advised, in particular with projects or partners from the US, Japan, Canada, South Korea, Singapore, Australia.

This topic implements the co-programmed European Partnership on 'Connected, Cooperative and Automated Mobility' (CCAM).

HORIZON-CL5-2021-D6-01-02: Common approaches for the safety validation of CCAM systems (CCAM Partnership)

Specific conditions	
Expected EU contribution per project	The EU estimates that an EU contribution of between EUR 12.00 and 15.00 million would allow these outcomes to be addressed appropriately. Nonetheless, this does not preclude submission and selection of a proposal requesting different amounts.
Indicative budget	The total indicative budget for the topic is EUR 15.00 million.

Type of Action	Research and Innovation Actions
Technology Readiness Level	Activities are expected to achieve TRL 5 by the end of the project – see General Annex B.

Expected Outcome: Project results are expected to contribute to all of the following expected outcomes:

- Common methodologies and tools for the safety validation of CCAM systems defined, accepted and validated
  - by the CCAM value chain and its R&I partners for the efficient verification of CCAM systems in their R&I and product development processes;
  - by authorities and certification bodies for the validation of CCAM systems within type approval schemes and in future exemption procedures;
  - and by consumer testing campaigns for the safety rating of automated vehicles assisting users in identifying the safest choices for their needs.
- Verification, validation and rating procedures based on realistic and relevant test cases generated from an openly accessible European database, compliant with the FAIR data principles[150], providing the widest possible range of relevant scenarios, which CCAM systems will potentially encounter on European roads as a basis for robust system design.

Scope: A decisive factor for the successful implementation of innovative CCAM technologies and for their acceptance and adoption in society will be assuring the effective safety of CCAM systems.

While different assessment methods for automated driving functions have been developed, common standard methodologies meeting all the requirements for testing, validation and certification of all levels and use cases of automated driving do not yet exist. Therefore, consensus building between all stakeholders is urgently needed to establish common, validated methodologies and tools. Existing approaches are currently analysed in Horizon 2020, an experts' network has been set up and validation concepts are demonstrated for selected use cases e.g. in the HEADSTART project[151].

Proposed actions should move the development of common verification and validation methodologies to a new level by widening substantially the scope of use cases addressed and by preparing the required tools to enable the comprehensive safety verification and validation of CCAM systems. This should take into account mixed traffic situations and include functional safety issues and cybersecurity. Such methodologies and tools should allow for their further

150 FAIR (Findable, Accessible, Interoperable, Reusable). Further information: https://www.go-fair.org/fair-principles/; and Final Report and Action Plan from the European Commission Expert Group on FAIR Data, "TURNING FAIR INTO REALITY" (https://ec.europa.eu/info/sites/info/files/turning_fair_into_reality_0.pdf)

151 https://www.headstart-project.eu/

development and adaptation with future technological evolution. Scenario-based approaches combining virtual and physical testing are needed, as conventional verification and validation approaches would require hundreds of millions of test kilometres for higher levels of CCAM.

Proposed actions are expected to develop a commonly accepted and harmonised simulation environment with standardised, open interfaces and quality controlled data exchange to enable the virtual testing of CCAM functions and systems in a multitude of relevant test cases and to enable the efficient and seamless use of validated models from different sources.

The validation of CCAM systems depends on the definition of relevant safety-critical scenarios and test cases. Several national and European projects have started to collect such scenarios and store them in databases. There is, however, no European database of relevant scenarios nor an agreed database structure. Scenario descriptions also need to be harmonised and not all relevant scenarios are known. Therefore, proposals need to define and develop processes and tools to continuously identify relevant events and convert them into detailed scenarios from various sources (including accidents), complemented by an ontology-based tool to define relevant future/theoretical scenarios. Diverse weather, lighting and road conditions, a broad spectrum of behaviour of other road users as well as edge cases should be considered. Following the collection of such scenarios, which can partly be derived from other projects and collaborations, scenarios need to be shared and centrally stored in a European database. This database should be established by the proposed actions based on an agreed structure and a harmonised scenario description (ontology layer) and metadata framework, in line with the FAIR data principles.

Proposed actions are expected to develop recommendations for harmonisation, standardisation and homologation including the conceptual description of an approval scheme for CCAM systems considering all types of vehicles and fed into on-going discussions regarding EU type vehicle approval rules as well as in the framework of the UNECE.

This topic requires the effective contribution of SSH disciplines and the involvement of SSH experts, institutions, as well as the inclusion of relevant SSH expertise, in order to produce meaningful and significant effects enhancing the societal impact of the related research activities.

In order to achieve the expected outcomes, international cooperation is advised, in particular with projects or partners from the US, Japan, Canada, South Korea, Singapore, Australia.

This topic implements the co-programmed European Partnership on ‘Connected, Cooperative and Automated Mobility’ (CCAM).

HORIZON-CL5-2021-D6-01-03: Physical and Digital Infrastructure (PDI), connectivity and cooperation enabling and supporting CCAM (CCAM Partnership)

Specific conditions

Expected EU contribution per project	The EU estimates that an EU contribution of between EUR 7.00 and 9.00 million would allow these outcomes to be addressed appropriately. Nonetheless, this does not preclude submission and selection of a proposal requesting different amounts.
Indicative budget	The total indicative budget for the topic is EUR 18.00 million.
Type of Action	Innovation Actions
Eligibility conditions	The conditions are described in General Annex B. The following exceptions apply: If projects use satellite-based earth observation, positioning, navigation and/or related timing data and services, beneficiaries must make use of Copernicus and/or Galileo/EGNOS (other data and services may additionally be used).
Legal and financial set-up of the Grant Agreements	The rules are described in General Annex G. The following exceptions apply: The funding rate is up to 60% of the eligible costs. This funding rate applies both to members and non-members of the partnership, except for non-profit legal entities, where the funding rate is up to 100% of the total eligible costs.
Technology Readiness Level	Activities are expected to achieve TRL 6-7 by the end of the project – see General Annex B.

Expected Outcome: Project results are expected to contribute to all of the following expected outcomes:

For Area A:

- Common understanding of requirements and minimum set of infrastructure adaptations for the physical and digital infrastructure for CCAM systems and services, in mixed traffic with conventional vehicles and other road users and modes of transport.
- Description and development of service architectures of PDI for CCAM systems and services and agreed classification of infrastructure support levels stimulating EU-wide/global harmonisation for classification of infrastructure support.
- PDI support concepts of proven maturity (technically, functionally, etc.), developed in cooperation with road users and vehicle manufacturers to extend their Operational Design Domains (ODD), and ready for large-scale demonstration actions.

For Area B:

- Connectivity and cooperation enablers and needs for higher levels of automation identified and assessed, based on a detailed use-case-approach for the CCAM mobility system.

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- Requirements for availability (e.g. coverage, security) and performance of connectivity and cooperation enablers (e.g. data rates, latency, robustness and redundancy, quality of service, resilience against cyberattacks) specified per use case, meeting requirements of functional safety and safety-critical applications.

- Ensured quality of and trust in external data by common definitions (incl. quality indicators definition) meeting requirements of cross-border interoperability and continuity.

- Feasible and sustainable concepts for and provision of road infrastructure coverage (short- and long-range connectivity along the road network) developed to enable CCAM services, included in testing at living labs and ready for large scale demonstration.

Scope: Physical and Digital Infrastructure (PDI), connectivity as well as cooperative information and action represent important resources which enable and support the integration of vehicles in the entire transport system. Road authorities and operators can provide essential PDI information to vehicles, road users and other modes of transport. As a complement, connectivity and cooperation are important capabilities of the full range of V2X actors (vehicles, infrastructures, vulnerable road users etc.). This is a necessary condition to proceed towards CCAM services in a developing CCAM ecosystem (involving benefits for e.g. road and mobility users, manufacturers across sectors, traffic management actors).

Actions are expected to address the activities either under area A) Physical and Digital Infrastructure (PDI) supporting CCAM or under area B) Connectivity and cooperation as enablers for CCAM and advanced traffic management while taking into account the complementing nature of both areas.

Area A: Physical and Digital Infrastructure (PDI) supporting CCAM

The Physical and Digital Infrastructure (PDI) is pivotal to improve CCAM services. The physical elements of infrastructure include markings, road signs, layout, etc., while the digital components encompass digitised spatial network including relevant traffic rules and regulations, input from road-side sensors, HD maps integrating static and dynamic data, etc. PDI support will particularly help in more challenging geographical or weather conditions, and can mitigate failure situations or gaps in the Operational Design Domain (ODD).

Research results so far have shown that the definition of ODD and infrastructure support level requirements serve as common basis of physical and digital infrastructure attributes in different Operational Environments (e.g. highly complex urban, interurban and motorway, peri-urban, dense traffic). Proposals are expected to develop a service architecture built upon this basis, which improves the functionality of highly automated vehicles by supporting their “sense, plan and act” ability. This service architecture will provide PDI support, which offers a finer gradation of dynamic traffic management regulations and can further increase the functional safety and the traffic efficiency – or more general, the performance – of CCAM services. Secure and trustworthy interaction between vehicles, infrastructure, and third-party services needs to

be ensured, as well as addressing the aspect of maintenance/evolution for both types of infrastructure.

Proposed actions should build upon recent work of the CCAM Platform on classifying PDI elements[152] and develop a comprehensive classification scheme that also allows for describing the PDI support (and the regular update) on road network sections (what, where, when).

R&I actions should advance the technological readiness of PDI support (e.g. Proof-of-Concept) to level 6/7 on the way towards (pre-) deployment as an important contribution to large-scale demonstration actions.

Recurring technology and process innovation however bears the risk that investment, especially in sectors with long cycles, are devalued well before their (end of) lifetime. It is crucial to balance premature action versus deferral of decision making and proposed actions should therefore analyse the risks, benefits and required investments in PDI support and provide guidance towards minimum adaptations of PDI that provide a substantial and sustainable added value to CCAM.

Proposals should take into account that EU-wide/global harmonisation is key in this R&I action, enabling broad uptake of services in the common single market and paving the way towards coordinated deployment of necessary infrastructure support for CCAM. Potential needs for standardisation or input for future regulatory action should be developed.

Area B: Connectivity and cooperation as enablers for CCAM and advanced traffic management

CCAM systems and services as well as advanced traffic management use connectivity and cooperation for e.g. exchanging information on status and intentions, realising collective perception, planning cooperative manoeuvres on roads, negotiating slots (time, space) for executing manoeuvres. The first generation of C-ITS services (Day 1 services), limited to provide status information, represents a prominent example of grown technological readiness that have recently made their way into deployment in vehicles and the road infrastructure. The next wave of services, also taking advantage of emerging technologies, should enable connected cooperative automated mobility. Proposals have to build upon or further progress already deployed services, first concepts and message designs for next generation C-ITS services, as developed in C-ROADS, as well as insight from ongoing 5G Corridors for Connected and Automated Mobility. Proposed actions should address and sufficiently test all the following aspects in real traffic conditions:

- Data provision through communication channels from external sources (e.g. road status, traffic and weather conditions from vehicle external sources) increasing the functionality

[152] To gain a deeper understanding how infrastructure can support CCAM, CCAM Platform WG 3 (Physical and Digital Road Infrastructure) is working on a matrix linking physical and digital infrastructure attributes to basic driving tasks of sense – plan – act. Moreover, the WG 3 scoping paper provides recommendations for follow-up actions addressed to the CCAM partnership, a.o. to identify pre-deployment opportunities. More information on Working Group 3 of the CCAM Platform: https://ec.europa.eu/transparency/regexpert/index.cfm?do=groupDetail.groupDetail&groupID=3657

of CCAM services and traffic management as well as road safety, traffic efficiency and environmental protection.

- Ensuring interoperability and continuity of services, backwards compatibility of proposed solutions, supporting a mixed use or range of technologies (hybrid communication) while ensuring privacy and security for all, in all communication channels.

Because of the enabling nature of connectivity and cooperation as well as cross-sector links, proposed research has to contribute to an integrated collaborative perspective of CCAM. Proposals should include in research and testing all relevant actors across sectors to co-design CCAM services. Proposals should also embrace the necessity to come up with concepts for a sustainable organisation of the necessary co-investment, co-management and joint implementation of CCAM.

In order to achieve the expected outcomes, international cooperation is advised for all projects of this topic, in particular with projects or partners from the US, Japan, Canada, South Korea, Singapore, Australia.

This topic implements the co-programmed European Partnership on 'Connected, Cooperative and Automated Mobility' (CCAM).

HORIZON-CL5-2021-D6-01-04: Cyber secure and resilient CCAM (CCAM Partnership)

Specific conditions	
Expected EU contribution per project	The EU estimates that an EU contribution of between EUR 5.00 and 6.00 million would allow these outcomes to be addressed appropriately. Nonetheless, this does not preclude submission and selection of a proposal requesting different amounts.
Indicative budget	The total indicative budget for the topic is EUR 12.00 million.
Type of Action	Research and Innovation Actions
Eligibility conditions	The conditions are described in General Annex B. The following exceptions apply: If projects use satellite-based earth observation, positioning, navigation and/or related timing data and services, beneficiaries must make use of Copernicus and/or Galileo/EGNOS (other data and services may additionally be used).
Technology Readiness Level	Activities are expected to achieve TRL 5 by the end of the project – see General Annex B.

Expected Outcome: Project results are expected to contribute to all of the following expected outcomes:

- Safe and secure operation of CCAM vehicles and mobility systems and services, enhancing trust and end user adoption of CCAM solutions.
- Cybersecurity requirements including data security and access control enabling harmonised approaches and tools for data sharing.
- Improved understanding of the new, emerging and specific CCAM related cyber security and resilience challenges, by using the contextual definition, including sector specific security features.
- Inclusion of cybersecurity and resilience as an integral part into the development process of CCAM solutions by OEMs, Tiers, telecom providers and service providers, with common aims and objectives, frameworks/architectures and designs.
- Cybersecure data sharing approaches from pilot applications towards CCAM on a harmonised larger scale.

Scope: Safe and secure operation of vehicles and mobility systems is key to the further deployment of CCAM enabled mobility solutions, also to establish trust and acceptance amongst end users. Extending the system domains beyond the vehicle through connectivity (short range or networked) makes cybersecurity a fundamental building block for trusted (digital) interaction of road users with each other, the infrastructure and cloud-based solutions/services. Systems for CCAM need to be fail-operational and cyber-secure in their entire Operational Design Domains (ODD) guaranteeing a safe and secure operation of vehicles -independent of the respective security level the element or system has within its ODD.

Cybersecurity needs to be an integral part of the development process, with common aims and objectives, frameworks/architectures, and designs (including normal operation, decision making and actuation as well as anomaly detection).

Proposed R&I actions are expected to develop and validate methods and tools strengthening the security of CCAM solutions (vehicles, infrastructure, etc.). They involve specific security building blocks, which are ready-to-use in CCAM applications in vehicles, infrastructure with feasible communication protocols. As a system's approach integrating vehicles, infrastructure, back-offices and mobility service centres is required, proposed actions are expected to develop harmonised interfaces and protocols.

Further R&I actions have to address continuous assessment of the robustness and resilience of CCAM enabled mobility solutions versus cyber-attacks, malfunction, misuse or system failure of the systems in use.

Actions should consider the security value chain at each level – from vehicle parts up to the transport infrastructure including the related services (e.g. maintenance, mobility) and protecting the user's privacy and guaranteeing data integrity and authenticity. Actions should propose easy to use and re-use of best practices in cybersecurity for CCAM (i.e. architecture, design and implementation patterns).

This topic requires the effective contribution of SSH disciplines and the involvement of SSH experts, institutions, as well as the inclusion of relevant SSH expertise, in order to produce meaningful and significant effects enhancing the societal impact of the related research activities.

In order to achieve the expected outcomes, international cooperation is advised, in particular with projects or partners from the US, Japan, Canada, South Korea, Singapore, Australia.

This topic implements the co-programmed European Partnership on 'Connected, Cooperative and Automated Mobility' (CCAM).

HORIZON-CL5-2021-D6-01-05: Analysis of socio-economic and environmental impacts and assessment of societal, citizen and user aspects for needs based CCAM solutions (CCAM Partnership)

Specific conditions	
Expected EU contribution per project	The EU estimates that an EU contribution of between EUR 3.00 and 4.00 million would allow these outcomes to be addressed appropriately. Nonetheless, this does not preclude submission and selection of a proposal requesting different amounts.
Indicative budget	The total indicative budget for the topic is EUR 8.00 million.
Type of Action	Research and Innovation Actions

Expected Outcome: Project results are expected to contribute to all of the following expected outcomes:

For Area A:

- A well-founded understanding of effects and impacts (positive as well as negative), benefits and costs of CCAM systems and services (short, medium, long-term).
- Methods and indicators to assess the impacts of CCAM solutions on mobility and wider socio-economic and environmental aspects (public health, land use/infrastructure need, accessibility, economy, employment, working conditions and required skills, energy use, air quality, carbon emissions, etc.).
- Definition of KPIs incorporating societal targets with individual mobility needs.
- Methods and tools for CCAM developers and manufacturers, authorities, municipalities and citizens enabling design and decision-making based on an integrated understanding of all its possible short, medium and long-term impacts, thereby avoiding negative rebound effects, such as discrimination or bias towards certain user groups, like women, the elderly, and disabled persons, but also ethnic minorities, persons from low income backgrounds, persons with varying digital literacy and skills, and those living in rural or peri-urban areas.

- Input for the design and evaluation of CCAM partnership activities, in particular for the large-scale demonstrators (ex-ante and ex-post) and for public engagement activities aimed at realistically informing users of CCAM capabilities and expectations.

For Area B:

- Methods and measures that capture the mobility needs of European citizens in the context of economic, social and environmental objectives at national, regional and local levels and that provide guidance on how to engage with citizens on CCAM solutions aiming to address these needs.

- Robust and documented knowledge (e.g. knowledge maps) of users' and implementers' expectations, concerns and desires with regards to CCAM solutions for the mobility of persons and goods, with special attention to the needs of vulnerable users and under-researched groups, including women, disabled persons, and the elderly, but also ethnic minorities, persons from low income backgrounds, persons with varying digital literacy and skills, and those living in rural or peri-urban areas. This knowledge is to be integrated into the design and development of CCAM solutions to support these specific needs.

- Tools that allow CCAM developers, deployers and public authorities to implement user-centred CCAM solutions that effectively contribute to societal targets, including equity, and the uptake of CCAM systems at regional level.

- Recommendations for large-scale demonstration projects to include user and societal aspects taking into account location-specific characteristics of the implementation area, such as local policy targets, population density, and cultural matters.

All the above expected outcomes should support the uptake of CCAM solutions (including acceptance and adoption).

Scope: With the increasing digitalisation of road transport, CCAM solutions have the potential to deliver an improved quality of life, by increasing safety and providing more sustainable and inclusive mobility solutions. However, for these solutions to be successful, a comprehensive understanding of all effects of CCAM on individuals, society and the environment over time is needed. Moreover, the successful deployment of CCAM solutions will depend on their availability and accessibility to future users, including the deploying organisations, as well as on the willingness of the general public to use and accept future CCAM solutions.

This topic requires the effective contribution of SSH disciplines and the involvement of SSH experts, institutions, as well as the inclusion of relevant SSH expertise, in order to produce meaningful and significant effects enhancing the societal impact of the related research activities.To make sure that the proposed actions reflect the realities of a society with changing mobility, digital and environmental needs, participatory processes with a wide and diverse range of future user groups, civil society organisations, citizens, experts, deployers and decision makers at various levels are strongly encouraged. The resulting methods and tools should therefore be designed and developed in a co-creation manner between authorities,

municipalities and citizens, as well as CCAM developers and manufacturers. To this end, it is recommended to develop solutions that are grounded in social innovation.

Actions must address the activities either under area A) Analysis of socio-economic and environmental impacts of CCAM systems and services OR under area B) Assessment of societal, citizen and user aspects for needs-based CCAM solution development and deployment.*Area A: Analysis of socio-economic and environmental impacts of CCAM systems and services*

The analysis of CCAM benefits and risks are, or have been, addressed in R&I projects, which resulted in the creation of several impact assessment frameworks and decision support tools. However, these are not sufficiently comprehensive and lack a higher-level systems approach to fully understand and assess the short, medium and long-term risks of CCAM solutions on societal and environmental aspects. The impact level of existing assessment tools varies: the analysis of accident risk of automated vehicles has been considered extensively, while the understanding of wider health and equity effects on users' mobility experience is much less mature.

Actions will enhance existing methods/frameworks or develop new, broader, more comprehensive and inclusive methods for the assessment of how CCAM solutions, systems and services impact mobility and wider socio-economic and environmental aspects to ensure that the design of CCAM solutions are tailored to evolving mobility and environmental needs.

The proposed actions should include all the following aspects:

- Develop comprehensive impact assessment methods that cover the full range of effects of CCAM systems and services by taking a systems perspective that includes e.g. effects on jobs, health, inclusiveness, environment.

- For these methods, existing KPIs should be reviewed and updated if needed. In addition, new KPIs need to be developed, to capture aspects like equity in terms of access to mobility, or sustainability. User expectations towards e.g. comfort, perceived safety, necessary digital skills and access to information should also be addressed with qualitative assessments (e.g. observations, surveys, interviews).

- Ensure practical usefulness of these methods by addressing regional specifics within Europe, as well as the evolving needs and dynamics of a society in transition towards more sustainable and shared mobility for both people and goods.

- Cover under-researched fields in terms of impact assessment of CCAM solutions, such as the inclusion of underserviced or socio-economically challenged geographical areas and specific population groups.

Area B: Assessment of societal, citizen and user aspects for needs-based CCAM solution development and deployment

The assessment of societal, citizen and user aspects of CCAM has been addressed in a number of Horizon 2020 projects[153], typically focusing on the acceptance of automated vehicles by drivers and the public, driver needs and trust, and ways to increase driver performance. Yet the assessment of CCAM solutions in terms of inclusiveness, equity and accessibility is lacking in most R&I projects, and rarely goes beyond considering gender, disability and age. While these categories need sustained attention, persons with different income levels, different digital experiences, literacy and access, as well as people living in rural or peri-urban areas, are examples of user groups that also need to be included in these assessment criteria so that extensive analyses of user needs and expectations can be carried out.

The aim is to proactively consider all user groups and societal objectives in the design and development phases of CCAM solutions.

The proposed actions should include all the following aspects:

- Develop and apply a systems approach for better understanding and considering user and societal needs, desires and expectations related to CCAM solutions, systems and services. A broad understanding of "users" is to be applied, including persons, public institutions such as hospitals and schools, organisations and businesses.
- Analyse equity aspects related to the deployment of CCAM solutions in terms of e.g. income level and solutions for deprived or underserviced areas, digital access, covering personal mobility as well as provision of supplies and necessities to end users.
- Map the broad range of concerns and expectations concerning CCAM involving a variety of stakeholders (including citizens, communities, transport service providers, professional drivers, road transport operators, road authorities, vehicle and other industry) and disciplines, including SSH (social sciences and humanities) to invest in social innovation that can complement the deployment of needs-based CCAM solutions.
- Define methodologies and mechanisms to communicate with future users/ citizens about CCAM aspects related to trust, ethics and acceptance.
- Develop tools that foster capacity building on CCAM among planners and decision makers to enhance their ability to influence solution design and development.
- Provide guidance on how to align overarching long-term policy goals and societal ambitions with user needs.

In order to achieve the expected outcomes, international cooperation is advised for all projects of topic (addressing either area A or area B), in particular with projects or partners from the US, Japan, Canada, South Korea, Singapore, Australia.

153 SUaaVE (http://www.suaave.eu/), PAsCAL (https://www.pascal-project.eu), Trustonomy (https://h2020-trustonomy.eu/), Levitate (https://levitate-project.eu)

HORIZON-CL5-2021-D6-01-06: Framework for better coordination of large-scale demonstration pilots in Europe and EU-wide knowledge base (CCAM Partnership)

Specific conditions	
Expected EU contribution per project	The EU estimates that an EU contribution of between EUR 5.00 and 6.00 million would allow these outcomes to be addressed appropriately. Nonetheless, this does not preclude submission and selection of a proposal requesting different amounts.
Indicative budget	The total indicative budget for the topic is EUR 6.00 million.
Type of Action	Research and Innovation Actions

Expected Outcome: Project results are expected to contribute to all of the following expected outcomes:

- Comprehensive analysis of all demonstrated CCAM use cases and harmonised approaches for implementing future large-scale demonstrations in Europe.
- Common framework for large-scale demonstration pilots in Europe including the identification of common use cases and Operational Design Domains (ODDs) as well as the definition of a common taxonomy and tools for scenario assessment.
- EU CCAM common evaluation methodology building on the outcome and recommendations from Working Group 2 of the CCAM Platform.
- Test data exchange framework with a collection of best practices and guidelines, including specifications for data labelling (e.g. ODD definition) and common data formats (aligned with ongoing standardisation activities) as well as tools and documentation to use them, a common openly accessible platform safeguarding ethical usage of test data in a transparent manner to improve cooperation across projects and stakeholders.
- Harmonised conditions and processes for tests of CCAM systems on public roads, including criteria for a mutual recognition of procedures (building on the outcome and recommendations from Working Group 4 of the CCAM Platform).
- Common basis for CCAM Knowledge in Europe through an up-to-date and continuously maintained Knowledge Base on CCAM adapted to the needs of the potential members of the European Partnership on CCAM and all relevant stakeholders.
- Efficient and sustainable governance structure for the collection of CCAM Knowledge in Europe and globally, thus facilitating the engagement and contribution of stakeholders from all sectors and in particular exchanges and cooperation with and amongst EU Member States/Associated Countries.
- Network and forum of experts in the different thematic fields of R&I on CCAM with adequate tools and processes to enable the exchange of experiences and practices,

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stimulate collaboration and cooperation between all CCAM stakeholders and reach consensus on challenges and future R&I needs.

Scope: Many diverse CCAM related R&I activities, tests and large-scale demonstration projects are ongoing across Europe and coordination, knowledge and data exchange as well as harmonised approaches for implementing future large-scale demonstrations in Europe are needed to better exploit synergies between all these activities.

There is a need for a common and searchable baseline of CCAM, thus ensuring transferability of knowledge for future research, development and testing of CCAM.

The aim of this action is twofold:

- to improve the coordination of CCAM demonstrations in Europe by developing a European framework for testing on public roads including common approaches for evaluation and test data exchange for large-scale demonstration pilots in Europe.
- to expand, maintain and update the existing EU-wide Knowledge which should centralise information about stakeholders, CCAM related R&I programmes and projects in Europe and beyond.

Proposed actions must address Area A and Area B.

Area A: Framework for coordination of CCAM demonstrations in Europe

The numerous CCAM demonstration projects in Europe lack a common vocabulary and the impact assessments of these projects are often difficult to compare. If different methodologies lead to incompatible evaluations, it will be hard to get an overall picture on the socio-economic and environmental impacts across several activities.

Proposed actions should establish a well-structured overview of European evaluation methodologies and its testing instances (test sites, living labs, simulations, open road) and develop a common evaluation framework and methodology with common indicators for large-scale demonstration pilots. This will allow comparability of results, complementing evaluations and meta-analysis over multiple evaluation studies. It will thus allow maximizing the profits and ease spreading of the lessons learned across Europe. It will enable to assess the wider impacts of future CCAM systems and services, providing necessary input for decision and policy making by governments and industry. Links should be established with other initiatives developing methodologies and indicators for CCAM solutions in specific areas, in particular on societal aspects[154].

Actions should build on the outcome of the CCAM Platform WG2[155] and on the methodologies and practices developed by past and ongoing R&I activities and gathered in the CCAM

[154] In particular HORIZON-CL5-2021-DEST6SMS-01-05: Analysis of socio-economic and environmental impacts and assessment of societal, citizen and user aspects for needs based CCAM solutions

[155] Working Group 2 of the CCAM Platform focussing on the "Coordination & Cooperation of R&I and testing activities" has analysed key challenges and identified actions regarding the development of a common evaluation methodology (CEM) and has provided a first outline of a European CEM. During

Knowledge Base[156] to establish common criteria for the preparation, execution and evaluation of all types of impacts of large-scale CCAM demonstrations in Europe, in particular common assessment indicators and methodologies.

Different parties involved in CCAM testing generate large amounts of test data (from in-vehicle or infrastructure). Actions should develop a test data exchange framework, which addresses legal and administrative aspects as well as technical aspects like data provision, access, protection of user data, and labelling of data and proper description of the data format. This latter includes describing objects, features and other road users around the vehicle, but also the driver and passenger whereabouts inside the cabin, efficient (semi)-automatic annotation processes and complex-label description in a large-scale data environment. As part of the labelling, a standardised and structured annotation model should be included.

Different national policy and legal frameworks make the organisation of cross-border testing difficult. To facilitate the development of both cross border testing and support authorities and in particular cities in organising piloting projects, a European framework for testing on public roads based on criteria for mutual recognition of procedures should be established. Proposed actions should establish links with UNECE and have very close cooperation with the EU Member States and Associated Countries through the CCAM Member States Advisory Board, in particular regarding testing conditions and regulations and associated harmonisation aspects.

Area B: EU-wide Knowledge Base

Proposed actions should continue and extend the existing EU-wide Knowledge Base[157] on CCAM as the "one-stop shop" for the exchange of knowledge and experiences on CCAM in Europe and beyond and to promote existing and valuable datasets. The Knowledge Base should collect structured, up-to-date and targeted information on European and national large and small scale demonstration projects and testing activities, test sites, corridors and living labs with their features and capabilities, standards, testing and assessment methodologies as well as regulations, policies and programmes in the field of CCAM in Europe and worldwide.

It should provide a common and searchable basis of CCAM, thus ensuring transferability of knowledge for future research, development and testing of CCAM. A wider engagement of the stakeholder community in providing content and actively contributing to its future development needs to be ensured.

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this process, it has been deemed valuable to develop a set of guidelines and establish a support team that can offer advice to projects on methodological aspects and for setting up an evaluation plan. More information on Working Group 2 of the CCAM Platform: https://ec.europa.eu/transparency/regexpert/index.cfm?do=groupDetail.groupDetail&groupID=3657

156 See https://knowledge-base.connectedautomateddriving.eu/methodology/

157 The existing Knowledge Base (https://knowledge-base.connectedautomateddriving.eu) has been established as the one-stop shop for CCAM knowledge in Europe, which is used by an increasing number of stakeholders from Europe and other regions of the world. It features a number of essential elements for the identification of future R&I needs, supporting the harmonisation of procedures and the transferability of best practices. These elements include past and present R&I projects (both on a European and national level), information on related regulation and national policies, strategies and action plans, guidelines and evaluation methodologies, data sharing, relevant terms, related events (including materials from past events)

The Knowledge Base should also function as the key information tool of the future European Partnership on CCAM to support the development and updates of the Strategic Research and Innovation Agenda (SRIA).

Particular emphasis should be placed on:

- Extending the content about CCAM activities in Europe and globally and ensuring it is up-to-date and mapped.
- Developing knowledge summaries and collecting background information about purposes and drivers behind testing and piloting activities, lessons learned, best practices, implementation guidelines enabling the translation towards actions and agendas by authorities, decision makers and the CCAM Partnership.
- Structuring information and adding specific information, in particular according to stakeholder's needs and priorities and developing targeted toolkits to support new stakeholders in setting up, running and assessing testing and piloting initiatives.
- Collecting common terminologies, methodologies, standards and procedures related to CCAM and promoting the implementation of common metadata frameworks and the FAIR data principles[158] to support interoperability.
- Maximize the outreach of the Knowledge Base through newsletters, dedicated social media channels.

In close cooperation with the future European Partnership on CCAM, proposed actions should establish a network of experts in different thematic fields of R&I on CCAM. Actions should provide a forum to facilitate the interaction of experts, the exchange of experiences, implemented technologies and solutions and practices, stimulate collaboration and cooperation between all parties involved in the CCAM European partnership and beyond. Actions should organise conferences and workshops on CCAM, in cooperation with the future European Partnership on CCAM.

Particular attention should also be given to international cooperation activities to stimulate the exchange and collaboration with partners from other regions of the world on common R&I challenges in the area of CCAM. It is important to establish close contacts with the CCAM Member States Advisory Board to ensure good support for feeding the Knowledge Base with up-to-date information.

This topic implements the co-programmed European Partnership on 'Connected, Cooperative and Automated Mobility' (CCAM).

[158] FAIR (Findable, Accessible, Interoperable, Reusable). Further information: https://www.go-fair.org/fair-principles/; and Final Report and Action Plan from the European Commission Expert Group on FAIR Data, "TURNING FAIR INTO REALITY" (https://ec.europa.eu/info/sites/info/files/turning_fair_into_reality_0.pdf)

Multimodal and sustainable transport systems for passengers and goods

Proposals are invited against the following topic(s):

HORIZON-CL5-2021-D6-01-07: More efficient and effective multimodal freight transport nodes to increase flexibility, service visibility and reduce the average cost of freight transport

Specific conditions	
Expected EU contribution per project	The EU estimates that an EU contribution of between EUR 7.00 and 8.00 million would allow these outcomes to be addressed appropriately. Nonetheless, this does not preclude submission and selection of a proposal requesting different amounts.
Indicative budget	The total indicative budget for the topic is EUR 15.00 million.
Type of Action	Innovation Actions
Eligibility conditions	The conditions are described in General Annex B. The following exceptions apply: If projects use satellite-based earth observation, positioning, navigation and/or related timing data and services, beneficiaries must make use of Copernicus and/or Galileo/EGNOS (other data and services may additionally be used).
Technology Readiness Level	Activities are expected to achieve TRL 7-8 by the end of the project – see General Annex B.

Expected Outcome: Project results are expected to contribute to all of the following expected outcomes:

- More efficient, effective and sustainable management of goods and freight flows in (air)ports and inland terminals, taking into account all costs (economic, social and environmental) of the proposed solutions/innovations, including externalities and possible rebound effects.
- Expanded throughput of the nodes thanks to increased operational efficiency and optimised use of assets and infrastructures, without expanding the physical facilities.
- Improved access to transhipment services at reduced costs.
- More visible and standardised services provided within the multimodal freight transport nodes, seamlessly accessible by end users to maintain continuous door-to-door tracking of freight locations and boost shifting cargo to more efficient and sustainable transport modes.

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- Increased automation, digitalisation, standardisation and interoperability of processes, technologies and equipment, particularly intermodal transport units (ITUs) and cargo transport/transhipment procedures in multimodal freight transport nodes.

- Better integration of the various freight transport nodes into overall logistic chains.

Scope: To achieve competitive sustainability and higher levels of efficiency taking account of all costs and externalities and to maximise the utilisation of the multimodal freight transport nodes' capacity, the proposals should research and demonstrate all of the following points:

- Building on previous EU and other funded projects[159], and enabling compatibility with legacy systems, demonstrate and quantify the benefits of using different intermodal transport units (ITUs) and innovative automated loading systems to support multimodal logistics operations. Further develop standardisation strategies on intermodal transport units also focusing on different modes and logistics operators, cargo transport/transhipment procedures, technologies and interfaces to enable flexibility, efficiency and sustainability of the transport system.

- In line with the strategy for EU international cooperation in research and innovation, international cooperation on standardisation of ITUs is encouraged.

- Building on previous and on-going Horizon 2020 and CEF funded projects[160] and the Digital Transport and Logistics Forum's findings[161], deploy and demonstrate advanced cooperative logistics IT solutions in actual operational environment (minimum at TRL 7) focusing on better integration of the nodes in overall supply chains and the accessibility and usability of node services in an automated/digital manner, with a user perspective approach. The deployed IT solutions should:

    - Provide full visibility of the standard services offered by the multimodal freight transport nodes, and by the companies operating in them, e.g. open and shared warehouses, terminal services, transhipment facilities, transport services from and to the terminals;

    - Providing better estimated and actual times of arrival and of departure through real time track and trace of the transport and goods, benefitting from standardised identification (e.g. RFID, new sensors) and improved positioning accuracy based on European GNSS;

159 Horizon 2020 funded projects such as MODULUSHCA (https://cordis.europa.eu/project/id/314468), Clusters2.0 (http://www.clusters20.eu/), AEROFLEX (https://aeroflex-project.eu/), and Less than Wagon Load (http://lessthanwagonload.eu/).

160 Horizon 2020 funded projects such as AEOLIX (https://aeolix.eu/), SELIS (http://www.selisproject.eu/), COREALIS (https://www.corealis.eu/), 5G-LOGINNOV (https://5g-ppp.eu/5g-loginnov/), and Connecting Europe Facility (CEF) funded projects such as iTerminals 4.0 (https://iterminalsproject.eu/)

161 Enabling organisations to reap the benefits of data sharing in logistics and supply chain, https://www.dtlf.eu/sites/default/files/public/uploads/fields/page/field_file/executive_summary2_reading__0.pdf

- Provide automated decision support system functionalities to optimise the supply chain overall performance and its resilience against disruptive events (including pandemics);
- Ensure compatibility of deployed solutions with existing legacy systems;
- Ensure the resilience of data and management systems to mitigate the consequence of accidental or malicious interventions;
- Address data ownership, confidentiality, governance and access rights;
- Facilitate greenhouse gas emissions reduction through, for example, smart scheduling and information on expected port arrivals times with support slow steaming operations.

- Capitalising on previous Horizon 2020 projects[162], demonstrate the effectiveness of new business models and collaborative approaches - preferably supported by the IT infrastructure and solutions outlined above - able to support cooperative logistics operations with focus on the provision of open logistics nodal services. The business models should consider the legal constraints and include appropriate frameworks for contractual relations in collaborative environments. Based on the deployment of these new business models, identify concrete legal barriers and regulations at both European and national levels preventing their adoption and market uptake, and propose solutions and specific policy recommendations.
- Ensure compatibility with existing and emerging EU logistics standards such as the European Maritime Single Window environment[163] for maritime transport and the platforms for Electronic Freight Transport information[164] and with the outcomes of initiatives such as the Digital Transport and Logistics Forum (DTLF).

Social innovation is recommended when the solution is at the socio-technical interface and requires social change, new social practices, social ownership or market uptake.

HORIZON-CL5-2021-D6-01-08: New delivery methods and business/operating models to green the last mile and optimise road transport

Specific conditions	
Expected EU contribution per project	The EU estimates that an EU contribution of between EUR 7.00 and 8.00 million would allow these outcomes to be addressed appropriately.

162 Horizon 2020 funded projects such as ICONET https://www.iconetproject.eu/, and LOGISTAR https://logistar-project.eu/.

163 Regulation (EU) 2019/1239 of the European Parliament and of the Council of 20 June 2019 establishing a European Maritime Single Window environment and repealing Directive 2010/65/EU.

164 Regulation (EU) 2020/1056 of the European Parliament and of the Council of 15 July 2020 on electronic freight transport information (Text with EEA relevance)

	Nonetheless, this does not preclude submission and selection of a proposal requesting different amounts.
Indicative budget	The total indicative budget for the topic is EUR 15.00 million.
Type of Action	Innovation Actions

Expected Outcome: Project results are expected to contribute to all of the following expected outcomes:

- Take up and upscaling of innovative, best practice and replicable safe and sustainable last mile solutions in the living labs[165] involved in the proposals, while facilitating the common lesson drawing and learning at European level, in order to contribute to the priorities of the European Green Deal, which stresses that ''transport should become drastically less polluting, especially in cities."[166]

- Develop solutions for logistic hubs and micro consolidation centres and space management in cities. During the assessment process of possible locations for micro consolidation centres and micro hubs cooperation with local authorities is required. Locations should be checked against the sustainable mobility plans of the concerning city.

- Test and deploy urban-consolidation centres as well as new delivery methods (including but not limited to e-cargo bikes) in at least 3 cities/project. The establishment of energy savings objectives (e.g. electricity) regarding urban-consolidation centres in relation other traditional strategies could also be included.

- Optimise loads and reduce empty miles through dynamic routing, load policies, multi/single-brand parcel lockers and boxes.

- Demonstration of cost-efficient, zero-emission modes of last mile transport for urban and peri-urban deliveries in the living labs involved in the projects (as listed in the scope part below).

- Increased quality and liveability of urban and metropolitan areas by reducing road risk, congestion, air and noise pollution.

- Improve knowledge of user needs, habits and preferences in terms of deliveries by collecting and sharing information amongst public authorities and private companies aiming at clustering users while respecting GPDR.

Scope: The large scale introduction and application of cargo bikes, in urban and peri-urban areas has shown to be a game changer for cities: the image of cycling improves; general levels of cycling increase (both for freight and passengers); urban space is used more efficiently; air quality, noise and safety levels as well as quality of life improve. However, this innovative

165 At least three cities/living labs.

166 https://eur-lex.europa.eu/resource.html?uri=cellar:b828d165-1c22-11ea-8c1f-01aa75ed71a1.0002.02/DOC_1&format=PDF

solution is present in only a few cities and at best in the starting phase in other European cities. Its full potential has not been achieved in any European city.

Projects should address both methodological and vehicles aspects to help optimising last mile deliveries, where the benefits and how it can be replicated across several cities.

Demonstration of cleaner modes for last mile transport vehicles such as, electric cycles (2/3/4 wheels), bikes and cargo bikes in combination with the testing of innovative tools such as dynamic e-routing, load policies, multi/single-brand parcel lockers and boxes, micro consolidation centres and zero emission freight in the urban context to measure their effects on optimisation (reducing empty miles), efficiency, and congestion reduction should be considered. Results could also contribute to better delivery technologies transforming the last mile such as camera-based object tracking, precise location brought by enhanced EU satellite navigation (GNSS) services, application of AI technologies and CCAM solutions to delivery services and advanced analysis based on driver apps. It is recommended the establishment of energy savings objectives (e.g. electricity) regarding micro-consolidation centres in relation to other traditional strategies.

Actions should focus on piloting cooperation with private logistics operators, local businesses and establish new models for addressing governance and management of logistics operations in urban and peri-urban areas. Projects should achieve cost-efficient and scale up potential and deployment of innovative and sustainable urban people and goods mobility solutions enabled by better governance and regulations, including procurement or white-label schemes as an efficient tool for achieving these goals.

A thorough evaluation, using if appropriate the common 'CIVITAS Process and Impact Evaluation Framework' or the Sustainable Urban Mobility Indicators[167] with a clear baseline in each city, should provide qualitative and quantitative information on the results of the local solutions implemented. The effectiveness of the proposed measures in achieving local policy objectives should be evaluated and the possible barriers to their broad take up and deployment identified, together with recommendations on how to overcome them. This should be accompanied by mechanisms for common lesson drawing and learning, within the project, between the projects funded under this topic and through the CIVITAS Initiative.

Proposals may include preparatory, take up and replication actions, research activities, as well as tools to support local planning and policy making.

A demonstrated contribution to the implementation of the cities' Sustainable Urban Mobility Plans and Sustainable Urban Logistics Plans, without forgetting higher scales planning scope, is expected.

Funding for major infrastructure works is not covered by this action. Proposals should plan for an active collaboration within the CIVITAS initiative. They should demonstrate that the

[167] https://ec.europa.eu/transport/themes/urban/urban_mobility/sumi_en

proposed approaches are truly innovative and build on the results from previous research and demonstration actions in this area.

Social innovations should be considered, notably as new tools, ideas and methods leading to active citizen engagement and as drivers of social change, social ownership, and new social practices.

This topic requires the effective contribution of SSH disciplines and the involvement of SSH experts, institutions as well as the inclusion of relevant SSH expertise, in order to produce meaningful and significant effects enhancing the societal impact of the related research activities

HORIZON-CL5-2021-D6-01-09: Climate resilient and environmentally sustainable transport infrastructure, with a focus on inland waterways

Specific conditions	
Expected EU contribution per project	The EU estimates that an EU contribution of around EUR 7.50 million would allow these outcomes to be addressed appropriately. Nonetheless, this does not preclude submission and selection of a proposal requesting different amounts.
Indicative budget	The total indicative budget for the topic is EUR 23.00 million.
Type of Action	Innovation Actions
Eligibility conditions	The conditions are described in General Annex B. The following exceptions apply: If projects use satellite-based earth observation, positioning, navigation and/or related timing data and services, beneficiaries must make use of Copernicus and/or Galileo/EGNOS (other data and services may additionally be used).
Technology Readiness Level	Activities are expected to achieve at least TRL 7 by the end of the project – see General Annex B.

Expected Outcome: Project results are expected to contribute to all of the following expected outcomes:

- Ensure navigability for inland waterways by assuring at least 50% capacity during extreme weather events.
- Enhance land/sea/infrastructure resilience to extreme weather and human caused events by assuring at least 80% capacity at network level during the disruptions.
- Contribute with at least a 20% increase in modal shift to the sustainability of transport systems.

- Ensure resilience and smooth functioning of passenger mobility as well as freight transport and logistics networks operating on these infrastructures.

- Increase the use of recycled materials within or across transport modes by at least 30%.

- Reduce environmental impact (emissions, soil/water pollution, degradation of ecosystems and fragmentation of habitats) during construction, maintenance, operation and decommissioning of the infrastructure in line with the EU environmental legislation.

Scope: Transport infrastructure is vulnerable to climate change and other natural or human caused disruptions. Maintaining an elevated infrastructure reliability and performance is crucial for increasing the resilience of the transport system. For example, low or excessive precipitations and extreme temperatures put a strain on transport infrastructure, lowering its performance and capacity, exacerbating its vulnerabilities and raising safety concerns. At the same time when focusing at a resilient and performing transport infrastructure its environmental footprint, resource and material consumption and habitat fragmentation and biodiversity degradation should be reduced to a minimum. The goal is smart, green, sustainable, climate-resilient and biodiversity friendly infrastructure.

Research is needed in order to limit transport infrastructure vulnerability to climate change and other natural or human caused disruptions. Making infrastructures more resilient to climate change should focus on improving the ability of the transport infrastructure network to withstand disruption, adapt to changing conditions under extreme circumstances while maintaining its performance. The goal is to strengthen infrastructure reliability, improve its performance and increase the resilience of the whole transport system, creating a climate resilient infrastructure system. The proposals will develop and validate new solutions to increase efficiency, inter-modality, resilience, safety and security of the transport system, for passengers and freight. Proposals should address all of the following aspects with particular attention to inland waterways:

- Solutions for ensuring the performance of inland waterways during periods of low or high water levels (as they are primary reasons blocking smooth functioning of this type of transport infrastructures).

- Solutions for ensuring the performance and safety of land transport infrastructure and ports during extreme weather and man-made events. Development of strategies for increasing the capacity of resilient infrastructures during disruptive events. Interconnection of infrastructure health monitoring, traffic management and emergency management systems to support informed decision making during and after these events, also supporting possible redistribution of passenger and freight flows to complementary infrastructures.

- Building on state-of-the-art solutions for surveillance and prediction of climate change effects, and identification of infrastructure points vulnerable to climate change, proposals should develop cross-modal strategies to upgrade (including physical upgrade) existing infrastructures and reduce their vulnerability, while using sustainable materials and construction techniques.

- Design of standard, modular infrastructure elements for rapid deployment after disruptive events in order to increase the capacity of the transport network or create new provisional links as a temporary measure until the transport network recovers its normal capacity. Both mode-specific and multi-modal solutions can be considered.

- Development of new governance models that enable cooperation across institutional, modal and national boundaries. Together with stakeholders and end users at various levels, develop and demonstrate innovative concepts and solutions to make operations for passenger mobility, freight transport and logistics supply chains more resilient to large-scale shocks and disruptions by enhanced planning, management and flow redistribution (considering also shifting to less carbon-intensive transport modes). Development of standard models and procedures to foster the implementation of resilient methodologies from design and construction and throughout the life-cycle of the infrastructure.

Innovative infrastructure solutions should contribute to lowering the environmental footprint, resources and material consumption. Exploring Nature-based solutions (NBS) is an opportunity for creating sustainable, climate-resilient EU transport infrastructure in a cost-effective manner, while producing substantial social, economic, and environmental co-benefits. The goal is smart, green, sustainable and climate-resilient infrastructure, planned in a way that maximises positive impact on economic growth and minimises the negative impact on the environment and, significant and lasting degradation of ecosystems and fragmentation of habitats, promoting environmentally friendly modes of transport and leading to the reduction of transport emissions.

Proposals need to include at least two pilot demonstrations in operational environment (minimum at TRL7) in CEF corridors, one specific for inland waterways and a second one for integrated with waterways hinterland infrastructure. Proposals should also consider results from previous calls on infrastructure resilience[168] and sustainable construction and should uptake relevant EU guidance on development and management of EU transport infrastructures and be compatible with EU environmental legislation[169].

Safety and resilience - per mode and across all transport modes

Proposals are invited against the following topic(s):

HORIZON-CL5-2021-D6-01-10: Testing safe lightweight vehicles and improved safe human-technology interaction in the future traffic system

Specific conditions

168 EU funded projects such as RESIST, FORESEE, SAFEWAY, PANOPTIS

169 Guidance on Inland waterway transport and Natura 2000 Sustainable inland waterway development and management
Water Framework Directive : Directive 2000/60/EC
Habitats Directives : Directive 92/43/EEC
Birds Directive : Directive 2009/147/EC
Environmental Impact Assessment Directive : Directive 2011/92/EU amended by Directive 2014/52/EU
Strategic Environmental Assessment : Directive 2001/42/EC
Floods Directive : Directive 2007/60/EC

Expected EU contribution per project	The EU estimates that an EU contribution of between EUR 4.00 and 5.00 million would allow these outcomes to be addressed appropriately. Nonetheless, this does not preclude submission and selection of a proposal requesting different amounts.
Indicative budget	The total indicative budget for the topic is EUR 12.00 million.
Type of Action	Research and Innovation Actions
Technology Readiness Level	Activities are expected to achieve TRL 5-6 by the end of the project – see General Annex B.

Expected Outcome: Project results are expected to contribute to the following expected outcomes:

For Area A:

- Safer but also lighter and circular vehicle structures.
- Advanced vehicle concepts with higher compatibility between vehicles of different sizes and masses in dissimilar crashes.
- Advanced structural designs tolerant to a wider set of crash angles.
- Demonstration of a minimum number of crash tests designed to validate virtual testing for a large number of different scenarios
- Improved safety in future mixed traffic scenarios including an increasing number of automated vehicles

For Area B

- Reduced driver distraction as an important factor in road crashes.
- Intuitive and unobtrusive information of drivers and other road users about expected actions at any time.
- Safer mobility for all road users including the ones with impaired mental and/or physical capacity.
- Availability of human-centric adaptive interfaces and positive stimulation and utilisation of human abilities by new human-technology interfaces.
- Improved validation methods for HMI.

Scope: Actions should address the activities EITHER under area A) Testing safe lightweight vehicles OR under area B) Safe human-technology interaction in the future traffic system. Proposals should clearly indicate which area they are covering.

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Area A –Testing safe lightweight vehicles

Automotive safety has significantly progressed in the last decades thanks to advanced modelling and testing capabilities and new structural concepts, as well as the introduction of active safety.

Future vehicles and their structures, however, will have to be lighter and lighter, and this means already an intrinsic reduction of safety when crashing with a heavier crash counterpart. Moreover, new structural concepts will need to be more and more designed with a circular use of materials in mind, and structures with mixed light materials and related manufacturing concepts (including casting and 3D printing of complex shapes, for instance in energy absorbers or highly integrated structural components) will be widely different from today's mostly sheet steel based concepts. Advanced testing on crash, toughness, fracture and fatigue of new materials and concepts should be performed where relevant. A smart integration of these concepts are expected to lead the demonstration of a more sustainable and safe body-in-white with at least a 10% weight reduction on already achieved results for multimaterial research structures.

In this context, the proposed actions should analyse the crash scenarios of the future, considering active safety devices but also their potential failure and the fact that for a long time there will be a mixed traffic situation where automated and semi-automated vehicles will share the road with normal "manually driven" vehicles and all types of unprotected road users.

This requires a new way of conceiving structures and their components, to ensure that all requirements are met at the same time and to further increase safety by including vehicle compatibility concept, like harmonised rigidity between light and heavy vehicles, so that the heavy vehicle helps the more vulnerable one in absorbing the impact energy. Standardised positions for crash absorbing elements should be addressed to ensure the best engagement scenarios, as well as multi-angle optimisation, to avoid that structures are optimised only for the exact test cases in regulation or in EuroNCAP tests. A significant number of crash tests is expected to be performed for validating the different scenarios.

Area B –Safe human-technology interaction in the future traffic system

Another challenge for the safety in future transport systems and services is the ever growing and intensified human interaction with ubiquitous digital content. The overload of various kinds of information from multiple sources can lead to increased driver or unprotected road user distraction and have negative impacts on road safety.

Human machine interfaces (HMI) with adaptive characteristics continue to be developed and new functionalities are continuously added, yet the impacts of those systems on the behaviour of drivers and other road users are not sufficiently known. Further research on the effects of such technologies in road transport safety is required.

These adaptive HMI systems can support a wide range of traffic users and could be included in scenarios based on the mixed traffic and accidentology where needed. As such the applications are not limited to higher levels of vehicle automation. Therefore, they need to consider a wide

variation of human capabilities and reactions as well as long-term mental and physical capacities (including disabilities and disorders) and instantaneous limitations in capabilities (collapse, illness, drowsiness, etc.).

In particular, the following aspects should be considered by future research:

- Design and development of intuitive, understandable, non-distracting and reliable adaptive interfaces for human-technology interaction in road vehicles minimising training needs for safe usage.
- Develop concepts of external interfaces, also considering the characteristics (for instance speed, direction) that are possible to interpret and understand by all road users.
- Understand long-term effects (physical and mental), potential risks and possible benefits for road users exposed to and actively using adaptive HMI technologies, and propose means to improve or maintain road user performance in terms of safety.
- Development of safety validation methods for new adaptive HMI technologies.

While this topic is open to research on all human-technology interaction in the road transport system, specific issues of the interaction of highly automated vehicles with their occupants and other road users are covered in topic HORIZON-CL5-2022-D6-01-02.

Typically, projects should have a duration of 36 to 48 months. Nonetheless, this does not preclude submission and selection of proposals requesting other amounts or durations.

Social innovation is recommended when the solution is at the socio-technical interface and requires social change, new social practices, social ownership or market uptake.

HORIZON-CL5-2021-D6-01-11: Radical improvement of road safety in low and medium income countries in Africa

Specific conditions	
Expected EU contribution per project	The EU estimates that an EU contribution of between EUR 4.00 and 5.00 million would allow these outcomes to be addressed appropriately. Nonetheless, this does not preclude submission and selection of a proposal requesting different amounts.
Indicative budget	The total indicative budget for the topic is EUR 8.00 million.
Type of Action	Research and Innovation Actions
Technology Readiness Level	Activities are expected to achieve TRL 5-6 by the end of the project – see General Annex B.

Expected Outcome: Project results are expected to contribute to the following expected outcomes:

- Contribute to the global target of 50% fewer road fatalities and serious injuries by 2030 in low to medium income countries in Africa.
- Contribute to implementing the recommendations of the Road Safety Cluster of the African-EU Transport Task Force adopted in 2020.
- More effective design of road safety practices, measures and policies in the targeted countries ; establishment of the safe system approach in national road safety strategies.
- In line with the Sustainable Development Goals and with the principles of the Joint EU-Africa Strategy (JAES), the activities to be implemented should contribute to the improvement of road safety and traffic fluidity conditions in Africa, ultimately saving thousands of lives and lessening the human, social and economic burden of road accidents.
- The reinforcement of endogenous African capabilities with a view to long term sustainable progress in the fight against road casualties and for a more efficient and sustainable transport system.
- The dissemination of European know-how and the deployment of sound technical and governance solutions. In particular, the outcomes of the SaferAfrica action should be included (in particular the African Road Safety Observatory).

Scope: Over 650 road deaths per day occur on African roads and unless measures are taken, road crashes in Africa are projected to increase by 68% over the next decade. African road traffic death rates are the highest globally and more than four times higher than the European average.

Building upon the work and activities already undertaken at EU level in this area, including the Safer Africa project and in line with the recommendations of the Road Safety Cluster of the African-EU Transport Task Force adopted in 2020, R&I is needed to create a strong analytical base and to develop and assess, with local partners, the implementation of small scale system pilots and its various components, at city, regional, national and continent level. Actions should contain the sharing of knowledge and best practice, data analysis, infrastructure for effectively reducing road deaths in Africa.

To address this challenge, proposals should address all of the following:

- In-depth road accident investigations should be carried out at least in selected areas/countries to be able to find evidence of the underlying contributing factors behind accidents, whether related to the road user, vehicle, traffic environment or the traffic system.
- develop an innovative approach to promote the Safe System approach in selected African countries, enabling the exchange of data, methodologies, training, knowledge and best practice with particular focus on leading road safety agencies, traffic system “owners” such as road authorities, the police, regulating and certifying agencies to support the preparation of their road safety strategies and targets.

- Analyse the most appropriate road safety assessment methodologies and traffic management systems, as well as protection principles for the vulnerable road users and vehicle occupants, and define criteria for measuring future progress. Moreover, identify requirements for skills development and training of staff, and research and innovation needs, with a view to quick deployment of suitable solutions.

- design, develop and implement a series of small scale pilot demonstration projects to test the implementation of a safe system approach at different levels (national, regional, city), involving different local stakeholders (e.g. civil society organisations such as citizens' associations, and non-governmental organisations), local government bodies and institutions as well as private companies.

- carry out an evaluation and assessment of the pilot demonstration projects that includes feedback from local actors, national and international stakeholders gathered through specific participatory workshops.

- Define guidelines detailing requirements and propose recommendations from the small scale pilot demonstrations useful for the implementation of a safe system approach to be up-scaled for the African continent (capacity building).

A balanced participation of European and African partners in these activities is expected, also with the aim of reinforcing endogenous African capabilities, and will be taken into account in the evaluation of proposals. Multinational international cooperation with relevant third countries is encouraged in order to leverage resources and impact.

Typically, projects should have a duration of 36 to 48 months. Nonetheless, this does not preclude submission and selection of proposals requesting other amounts or durations.

Social innovation is recommended when the solution is at the socio-technical interface and requires social change, new social practices, social ownership or market uptake.

HORIZON-CL5-2021-D6-01-12: Controlling infection on large passenger ships

Specific conditions	
Expected EU contribution per project	The EU estimates that an EU contribution of between EUR 3.00 and 5.00 million would allow these outcomes to be addressed appropriately. Nonetheless, this does not preclude submission and selection of a proposal requesting different amounts.
Indicative budget	The total indicative budget for the topic is EUR 8.00 million.
Type of Action	Research and Innovation Actions
Technology Readiness Level	Activities are expected to achieve TRL 5 by the end of the project – see General Annex B.

Expected Outcome: Project outputs and results are expected to contribute to all of the following expected outcomes as applicable for the two sub-activities:

- Communicable infections (Covid-19, influenza, norovirus) do not spread rapidly amongst passengers and crew on large passenger ships, in particular on cruise ships. The spread is controllable also beyond the vessel in ports and port communities.
- Communicable infections on board large passenger ships can be detected systematically at an early stage and effective measures are put in place to prevent the spread of infection. Crews and other personnel are duly trained.
- Large passenger ships are intrinsically designed to prevent the spread of infection and to facilitate measures in case of detection to eliminate further spread.
- An evidence base is established concerning the specific mechanisms facilitating the on-board spread of infection and the effectiveness of different mitigation methods.
- A knowledge base is publicly available concerning mechanisms facilitating the spread of on-board infection, mitigation measures and underlying evidence.
- Evidence based guidance for healthy passenger ship design is available to improve the design of ships which can help avoiding infections and facilitate the detection on board infections at an early stage, inherently mitigate the spread of infection and facilitate actions to prevent its further spread.

Scope: Passenger ships and in particular cruise ships (with their high occupancy rates and elevated passenger and crew numbers of up to 8000 persons, close proximity of passengers and crews, high crew turnover with crews coming from many different countries, frequent port calls naturally implying common shore side excursions, and on-board activities with intense social interaction) have been implicated in the spread and multiplication of disease. Large and medium-sized cruise ships have seen a highly dynamic and sometimes dramatic multiplication of Covid-19 infections on-board and the disembarkation of several hundred infected (and often asymptomatic) passengers who subsequently became vectors for infection within the regions concerned and their home regions. In this context it needs to be kept in mind that cruise passengers often travel to and from the ship by air, adding to the potential spread. Passenger ships have also been hosts for the rapid spread of Norovirus illness, influenza and legionella infections. This can be particularly problematic for (generally smaller) passenger ships that undertake longer expedition-type cruises away from population centres, thus entirely or predominantly relying on on-board medical services and facilities. Europe as the world's largest and almost exclusive producer of large and medium-sized passenger and cruise ships and as home to a large number of important cruise destinations must ensure a healthy on-board environment which is also crucial for the viability and the sustainable growth of the business. Whilst guidelines to control the spread of on-board infections have been published, it is clear that these are not fully effective and there is a lack of an evidence base to underpin the effectiveness of the suggested measures for different infections. Important knowledge gaps

continue to exist and so far the real effectiveness of different mitigation measures now deployed remains largely anecdotal.

To address these challenges, proposals will address one of the following two aspects and cover all of the tasks mentioned.

1. "Infection control on-board large passenger ships - prevention, mitigation and management".
    - Establishing a comprehensive scientific basis concerning the effectiveness of different prevention, mitigation and management measures.
    - Developing and demonstrating solutions for improving the prevention, mitigation and management of on-board disease and illness.
    - Cooperate and coordinate with other projects selected from this topic as well as other relevant actions such as the EU's "healthy gateways" action.
    - Outcomes and data to be made publicly available to facilitate the take up of best practices, also in function of vessel type and size, type of cruise and cruise destination. A distinction should be made between large ferries as typically deployed in Europe and cruise ships.
2. "Healthy ship design":
    - Applying a bottom-up evidence based approach address the functional and concept design of large passenger ships so as to reduce the on-board spread of infection.
    - Research should in particular address ventilation systems and their airflows, germicidal surfaces and disinfection practices, contamination control in all relevant ship areas, facilitating enhanced quarantine, process separation, the design of social areas including those for the crew, the design of crew work areas, especially pantries, laundries etc.. In this respect a better interaction of people with the vessel and its equipment on the basis of social innovations (e.g. hands-free accessibility solutions) should also be considered.
    - Innovative systems should be addressed to enable early stage detection of the spread of on-board infections such as for example employing AI, big data, smart sensors etc.
    - Cooperate and coordinate with other projects selected from this topic as well as other relevant actions such as the EU's "healthy gateways" action.
    - Outcomes and guidance concerning healthy ship design should be made available to facilitate the take up of best practices by ship interior designers, shipyards, and equipment manufacturers.

This topic requires the effective contribution of SSH disciplines and the involvement of SSH experts, institutions as well as the inclusion of relevant SSH expertise, in order to produce

meaningful and significant effects enhancing the societal impact of the related research activities.

HORIZON-CL5-2021-D6-01-13: Safe automation and human factors in aviation – intelligent integration and assistance

Specific conditions	
Expected EU contribution per project	The EU estimates that an EU contribution of between EUR 4.00 and 8.00 million would allow these outcomes to be addressed appropriately. Nonetheless, this does not preclude submission and selection of a proposal requesting different amounts.
Indicative budget	The total indicative budget for the topic is EUR 12.00 million.
Type of Action	Innovation Actions
Technology Readiness Level	Activities are expected to achieve TRL 6 by the end of the project – see General Annex B.

Expected Outcome: Project results are expected to contribute to all of the following expected outcomes:

- Improved monitoring of human performance, system performance and external hazards, in order to pave the way to more automation in aviation while meeting Flightpath2050 safety goals.
- Avoiding startle response or "automation surprise", enabling intelligent assistance to all operators on the air and on the ground in all safety-critical situations and allowing fall-back response in case of severe system perturbations - including pilot incapacitation, cyber-attacks and/or broader operational system-wide failures.
- New crew and team configurations, including human-machine teaming, automation supervisory roles and distributed human crew (both airborne and on the ground) to ensure safety and optimise performance without leading to complacency or to loss of critical skills.
- Better prepared workforce and training, with smarter selection, qualification and training tools and methods to maintain high standards of safety and resilience, including advanced simulation for complex safety-critical events.
- Increased organisational and regulatory preparedness, safety culture and societal acceptance in the advent of more automation in aviation, from earlier integration of human factors and automation into design processes and safety case methods up to ensuring an appropriate level of human factors and automation competence in key organisations, including regulators.

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Scope: Activities should address a renewed safety focus on the teaming between the human and automation, given the steady increase in automation in aviation operations at large (e.g. in cockpit, ATC, maintenance, etc.), including for new airborne services and vehicles such as drones. When automation is unable to cope, control should be handed back safely to the human.

Prepare the next step-change in automation, artificial intelligence (AI), in two steps. Firstly, in the medium term with the role of AI as 'Digital Assistant', part of the team, earning the trust of the human operators and the flying public. Secondly, in the long term, with the potential of AI to take over operations. For the transition to digital assistant and ultimately to AI-run operations, develop a novel approach to Human Factors and to safety (and security) assurance methods and processes.

System transition issues should be addressed, to avoid an initial spate of 'automation-assisted accidents', as it happened at the last step change in the level of automation in aviation ('glass cockpits'), which nevertheless resulted in significantly improved safety.

Activities should consider the increasing complexity in aviation e.g. traffic growth expected back in the mid/long-term, more 'new entrants' as drones, more extreme weather events, more environmental constraints leading to more complex systems and operations. In such an evolving aviation environment it is needed to better understand and anticipate why incidents happen – the triggering events/hazards, the cognitive failures and the challenges at the human-machine interface – in order to learn the right lessons and then share them both internally and externally. This includes the impact of physical and mental wellbeing on human performance and safety, both in a positive sense (e.g. motivation, positive safety culture) and in a negative sense (e.g. fatigue, fitness for duty, skill loss, and complacency).

More focus is needed then on Human Digital Interface design and on integrating AI into human crews and teams, as a smart assistant to explain, accompany and support operators, in particular at safety-critical situations and to recover from emergencies. More adaptive and trustworthy human-machine systems and more intuitive interfaces should be developed.

Developments should be applied to realistic operational and regulatory contexts while devising how to maintain safety culture and societal acceptance along with organisational and regulatory preparedness. Particular attention should be paid to possible differences such as age, gender and ethnography. Social innovation is recommended when the solution is at the socio-technical interface and requires social change, new social practices, social ownership or market uptake.

This topic requires the effective contribution of Social Sciences and Humanities (SSH) disciplines and the involvement of SSH experts, institutions, as well as the inclusion of relevant SSH expertise, in order to produce meaningful and significant effects enhancing the societal impact of the related research activities.

Activities should go beyond the state of the art and previous R&I activities, at least at EU level[170]. Activities should ensure no overlap but complementarity for integration with any other

[170] Examples of aviation safety research projects available on:

aviation activities, such as SESAR / Transforming the European ATM System partnership. The proposals may include the explicit commitment from the European Aviation Safety Agency (EASA) to assist or to participate in the actions[171].

In order to achieve the expected outcomes with increased resources and impact, international cooperation can be foreseen with third countries with relevant capacities in this domain, while ensuring that the respect of European IPR, interests and values is strictly guaranteed.

Synergies with other transport modes and safety/security critical sectors adopting more automation is welcomed, in particular on risk assessment and pre-normative research to ensure fit-for-purpose rulemaking and management systems and a high level of cyber-attack protection.

Synergies with other topics in Horizon Europe can be exploited such as in Cluster 4 e.g. HORIZON-CL4-2021-DIGITAL-EMERGING-01-02 (Software for low-power operation at the edge), HORIZON-CL4-2021-DIGITAL-EMERGING-01-11 (Pushing the limit of robotics cognition), in Cluster 3 e.g. HORIZON-CL3-2021-INFRA-01-01 (European infrastructures and their autonomy safeguarded against systemic risks), as well as with other EU programmes such as Connecting Europe Facility (CEF), NextGenerationEU and Digital Europe.

Call - Safe, Resilient Transport and Smart Mobility services for passengers and goods

HORIZON-CL5-2022-D6-01

Conditions for the Call

Indicative budget(s)[172]

Topics	Type of Action	Budgets (EUR million)	Expected EU contribution per project (EUR million)[173]	Number of projects expected to be funded
		2022		
Opening: 14 Oct 2021 Deadline(s): 12 Jan 2022				

- Projects For Policy (P4P) on Aviation Safety https://publications.europa.eu/en/publication-detail/-/publication/b4690ade-3169-11e8-b5fe-01aa75ed71a1/language-en/format-PDF/source-75248795
- Coordination-support action OPTICS2 https://www.optics-project.eu/narratives/

171 https://www.easa.europa.eu/domains/safety-management/research

172 The Director-General responsible for the call may decide to open the call up to one month prior to or after the envisaged date(s) of opening.
The Director-General responsible may delay the deadline(s) by up to two months.
All deadlines are at 17.00.00 Brussels local time.
The budget amounts are subject to the availability of the appropriations provided for in the general budget of the Union for years 2021 and 2022.

173 Nonetheless, this does not preclude submission and selection of a proposal requesting different amounts.

HORIZON-CL5-2022-D6-01-01	IA	50.00	20.00 to 25.00	2
HORIZON-CL5-2022-D6-01-02	RIA	8.00	6.00 to 8.00	1
HORIZON-CL5-2022-D6-01-03	RIA	8.00	7.00 to 8.00	1
HORIZON-CL5-2022-D6-01-04	IA	10.00	4.00 to 5.00	2
HORIZON-CL5-2022-D6-01-05	RIA	12.00	5.00 to 6.00	2
HORIZON-CL5-2022-D6-01-06	RIA	13.00	4.00 to 4.33	3
HORIZON-CL5-2022-D6-01-07	IA	9.00	4.00 to 8.00	1
HORIZON-CL5-2022-D6-01-08	IA	12.00	3.50 to 6.00	2
Overall indicative budget		122.00		

General conditions relating to this call	
Admissibility conditions	The conditions are described in General Annex A.
Eligibility conditions	The conditions are described in General Annex B.
Financial and operational capacity and exclusion	The criteria are described in General Annex C.
Award criteria	The criteria are described in General Annex D.
Documents	The documents are described in General Annex E.
Procedure	The procedure is described in General Annex F.
Legal and financial set-up of the Grant Agreements	The rules are described in General Annex G.

Connected, Cooperative and Automated Mobility (CCAM)

Proposals are invited against the following topic(s):

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HORIZON-CL5-2022-D6-01-01: European demonstrators for integrated shared automated mobility solutions for people and goods (CCAM Partnership)

Specific conditions	
Expected EU contribution per project	The EU estimates that an EU contribution of between EUR 20.00 and 25.00 million would allow these outcomes to be addressed appropriately. Nonetheless, this does not preclude submission and selection of a proposal requesting different amounts.
Indicative budget	The total indicative budget for the topic is EUR 50.00 million.
Type of Action	Innovation Actions
Eligibility conditions	The conditions are described in General Annex B. The following exceptions apply: If projects use satellite-based earth observation, positioning, navigation and/or related timing data and services, beneficiaries must make use of Copernicus and/or Galileo/EGNOS (other data and services may additionally be used).
Legal and financial set-up of the Grant Agreements	The rules are described in General Annex G. The following exceptions apply: The funding rate is up to 60% of the eligible costs. This funding rate applies both to members and non-members of the partnership, except for non-profit legal entities, where the funding rate is up to 100% of the total eligible costs.
Technology Readiness Level	Activities are expected to achieve TRL 7 by the end of the project – see General Annex B.

Expected Outcome: Project results are expected to contribute to all of the following expected outcomes:

- Demonstration of inclusive, user-oriented and well-integrated shared CCAM systems and services for people and goods in real traffic conditions, which contribute to
    - reduced carbon footprint and harmful emissions;
    - reduced congestion, more reliable, predictive travel times and more efficient transport operations;
    - Increased safety and security;
    - End-users' adoption for specific use cases of innovative shared mobility solutions.
- Demonstration of innovative cross-sector business models and partnerships for CCAM.

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- Assessment of all impacts of shared CCAM solutions in real world conditions, specifically on sustainability, inclusiveness and safety based on viable economic use cases for passengers and goods.

Scope: CCAM solutions have to provide a more user-centred, all-inclusive road mobility, while increasing safety, reducing congestion, emissions and contributing to climate neutrality. These novel mobility services enable seamless integration with existing services (e.g. public transport, logistics), and higher levels of automation support, transport productivity and efficiency (e.g. transportation of goods at lower speeds to save energy, operational efficiency at logistics hubs and in hub to hub corridors or last mile operations). Yet all these benefits need to be proven. Previous and currently ongoing demonstration projects for CCAM systems and services show, that further testing of highly automated systems and services with high scaling potential is necessary, involving more mature technologies or additional use cases in extended Operational Design Domains (ODDs). Proposed actions for this topic are expected to address all the following aspects:

- implement a set of European demonstrators of smart, shared mobility and/or logistics use cases in real traffic conditions with ambitious and realistic operational domains (balancing environmental complexity, risk, speed, economic viability, etc.) enabled by CCAM solutions (SAE Level 4) with market potential (i.e. with scalable business and operating models).

- Test robustness, reliability and safety of highly automated CCAM systems and services, while focussing on user interaction and interaction with other road users (specifically vulnerable road users such as pedestrians and cyclists). This includes testing of key enabling technologies (e.g. sensors, connectivity, cybersecurity, AI, big data, space-based services), physical/digital infrastructure support and optimised traffic and fleet management.

- address user and customer needs for mobility and logistics, paying special attention to differences in mobility patterns by gender, age, disability and other social groups[174]. Further, deploy high quality services that are well integrated with other modes and existing mobility services.

- apply, test and demonstrate the common evaluation framework for large-scale demonstration pilots in Europe and the test data exchange framework, provide input to the European knowledge base on CCAM (see topic HORIZON-CL5-2021-D6-01-06) and contribute to the European database of relevant scenarios (see topic HORIZON-CL5-2021-D6-01-02).

Proposed actions should contribute to effective assessment and demonstration of benefits on energy efficiency, traffic flow, safety, user appreciation, etc. based on holistic modelling solutions. If possible, already existing investments at national and European level on

[174] See for example the Gendered Innovations case study on smart mobility (2020, p.114): https://ec.europa.eu/info/sites/info/files/research_and_innovation/strategy_on_research_and_innovation/documents/ki0320108enn_final.pdf

demonstration activities should be leveraged, optimising return on investments and create a strong basis for even larger scale demonstrations and system integration.

Proposed actions should foster the collaboration between public and private stakeholders (e.g. cities, regions and infrastructure operators, authorities, civil society organisations, public transport operators, OEMs and suppliers, logistics hubs, freight transport and logistics service providers and freight transport and logistics users, research providers, ITS and telecom sector) to achieve common objectives and assess societal impacts. Co-creation with users should be considered to demonstrate benefits and raise public acceptance/adoption of CCAM under real-world conditions. To this end, it is recommended to develop solutions that are grounded in social innovation.

This topic requires the effective contribution of SSH disciplines and the involvement of SSH experts, institutions, as well as the inclusion of relevant SSH expertise, in order to produce meaningful and significant effects enhancing the societal impact of the related research activities.

Proposed actions are expected to focus on demonstrators for integrated shared automated mobility solutions for people, for goods or for both, and should address resulting synergies and complementarities in the CCAM ecosystem when possible. All vehicles used for testing the innovative CCAM concepts should use zero emission technologies.

In order to achieve the expected outcomes, international cooperation is advised, in particular with projects or partners from the US, Japan, Canada, South Korea, Singapore, Australia.

This topic implements the co-programmed European Partnership on 'Connected, Cooperative and Automated Mobility' (CCAM).

HORIZON-CL5-2022-D6-01-02: Reliable occupant protection technologies and HMI solutions to ensure the safety of highly automated vehicles (CCAM Partnership)

Specific conditions	
Expected EU contribution per project	The EU estimates that an EU contribution of between EUR 6.00 and 8.00 million would allow these outcomes to be addressed appropriately. Nonetheless, this does not preclude submission and selection of a proposal requesting different amounts.
Indicative budget	The total indicative budget for the topic is EUR 8.00 million.
Type of Action	Research and Innovation Actions
Technology Readiness Level	Activities are expected to achieve TRL 5 by the end of the project – see General Annex B.

Expected Outcome: Project results are expected to contribute to all of the following expected outcomes:

- Protection systems in Connected and Automated Vehicles (CAVs) designed for a greater variation of unconventional seating positions and body postures, including sex, age and ability differences, to be sufficiently inclusive to encompass the diversity of the occupant population, considering all situations and conditions for the application of such systems and taking into account different accident configurations with a higher market penetration of CAVs.

- New, advanced Human-Machine-Interface (HMI) solutions as enablers for the safe and efficient co-existence and interaction of CAVs with other road users (including Vulnerable Road Users and non-automated vehicles). Interfaces should be reliable and seamless, based on comprehensive knowledge and models of individual human behaviour and capabilities.

- Advanced driver/passenger condition monitoring and improved HMI functionalities to prepare the driver to take control as may be necessary when the vehicle reaches the limits of its Operational Design Domains (ODD).

- Consistent design methodologies and tools for performance assessment of the new protection systems.

- Delivering evidence-based support to the regulatory bodies for the potential adaptation of traffic rules.

Scope: In order to ensure the safety of highly automated vehicles, on-board systems need to anticipate risks reliably, prevent crashes and minimise the consequence of unavoidable collisions while enhancing user acceptance, and generating trust and reliance on automated systems through well-designed, informative Human-Machine-Interfaces.

The proposed actions should address all the following aspects:

- Development of vehicle crashworthiness and advanced safety solutions in order to protect passengers and mitigate injury risk in unavoidable collisions also with new, unconventional seating positions and body postures, considering new protection principles and taking into account all situations and conditions for the application of such systems (for example in shared automated road vehicles). This also includes the identification of new accident configurations and adaptations to the structural layout of vehicles.

- Development of empathic HMI solutions, which includes a framework for modelling human emotions, in order to enable natural and intuitive interaction of CAVs with the driver, passengers and with other road users (including unprotected ones) also in mixed traffic situations.

- Monitoring approaches and simulation models to detect and assess occupant status (including health) and level and point of attention of the driver, enabling appropriate HMI, linked also to the new intelligent protection systems in order to fully leverage their potential in terms of adapting to different seating positions, body postures, occupant sizes etc., including gender, age, and ability differences.

- Improved solutions to address situations in which human drivers are expected to seamlessly resume control, for example when the limit of the ODD is approaching.
- Recommendations for user-centric HMI design guidelines and for an extension of the European Statement of Principles for human-machine interaction (ESoP)[175] towards automated vehicles should be derived, taking into account also the interaction with unprotected road users and other non-automated, non-connected vehicles.
- Development of assessment tools for the developed protection technologies and advanced safety solutions in order to support the definition of safety requirements, standards (e.g. UNECE) and the analysis of potential needs for the adaptation of traffic rules.

This topic requires the effective contribution of SSH disciplines and the involvement of SSH experts, institutions, as well as the inclusion of relevant SSH expertise, in order to produce meaningful and significant effects enhancing the societal impact of the related research activities.

In order to achieve the expected outcomes, international cooperation is advised, in particular with projects or partners from the US, Japan, Canada, South Korea, Singapore, Australia.

This topic implements the co-programmed European Partnership on 'Connected, Cooperative and Automated Mobility' (CCAM).

HORIZON-CL5-2022-D6-01-03: Human behavioural model to assess the performance of CCAM solutions compared to human driven vehicles (CCAM Partnership)

Specific conditions	
Expected EU contribution per project	The EU estimates that an EU contribution of between EUR 7.00 and 8.00 million would allow these outcomes to be addressed appropriately. Nonetheless, this does not preclude submission and selection of a proposal requesting different amounts.
Indicative budget	The total indicative budget for the topic is EUR 8.00 million.
Type of Action	Research and Innovation Actions
Technology Readiness Level	Activities are expected to achieve TRL 4 by the end of the project – see General Annex B.

Expected Outcome: Project results are expected to contribute to all of the following expected outcomes:

A robust and scalable reference model of human driving behaviour:

175 European Commission Recommendation on safe and efficient in-vehicle information and communication systems: update of the European Statement of Principles on human-machine interface, 2008/653/EC

- Replicating the full performance spectrum of human drivers, which allows comparing the performance of an automated driving system in a specific situation to the human driver population. This serves as a basis to define the required safety level of CCAM systems and to take decisions on validation requirements in type approval schemes. The model will also help to define fair assessment criteria in consumer testing campaigns relative to human-driven vehicles and for the safety verification of CCAM systems in industrial development processes.

- Serving as a reference for the automotive industry and its R&I partners to design human-like and therefore easily predictable and acceptable behaviour of automated driving functions in mixed traffic.

- Helping the automotive industry, its R&I partners, certification bodies and consumer testing organisations to realistically represent the behaviour of other human-driven vehicles in the (virtual) simulation of mixed traffic. Virtual testing shortens development cycles and accelerates the implementation of CCAM technologies.

Scope: Statistical data available today gives a good idea of overall human driving, vehicle and infrastructure performance in terms of safety. However, evidence is missing on the precise performance of humans in the variety of specific situations that might be critical for automated driving systems. The variability of human behaviour and performance with factors like gender, cultural and ethnic background, ageing, diseases, driving experience, mental workload or fatigue makes the acquisition of such evidence a very challenging task. External factors such as diverse weather and lighting conditions play a role in this context, as well. Data on the dependence of human driving behaviour from such factors is partly available from previous research, but not sufficiently broken down to the level of specific driving situations.

Available software modules to simulate human driving behaviour only cover specific aspects of human driving performance so far and do not cover the full spectrum of drivers with statistical data on the probability of certain behavioural patterns.

Therefore, proposed actions have to develop a probabilistic human behavioural model with the potential to cover all relevant aspects of human driving performance as well as the broad spectrum of drivers and influencing factors. A methodology will be needed to extract consistent data on human driving performance from different data sources (e.g. real traffic, simulator tests) and collect such data with the long-term objective of fully depicting the large variance of human driving behaviour in different situations, while respecting gender, age and other factors like disabilities and diversity criteria. Proposals should calibrate the parameters of the model with the help of this data, and develop a corresponding validation concept based on real-world experiments. Potential ethical issues will have to be considered, as tests with humans need to be carried out and their personal data will have to be captured. The model should be transparent, independent from proprietary software tools and easy to use. It should be validated at least for selected fields of application with the perspective of extending these fields of application gradually and also simulating human behaviour in future scenarios of mixed traffic.

In order to achieve the expected outcomes, international cooperation is advised, in particular with projects or partners from the US, Japan, Canada, South Korea, Singapore, Australia.

This topic implements the co-programmed European Partnership on 'Connected, Cooperative and Automated Mobility' (CCAM).

HORIZON-CL5-2022-D6-01-04: Integrate CCAM services in fleet and traffic management systems (CCAM Partnership)

Specific conditions	
Expected EU contribution per project	The EU estimates that an EU contribution of between EUR 4.00 and 5.00 million would allow these outcomes to be addressed appropriately. Nonetheless, this does not preclude submission and selection of a proposal requesting different amounts.
Indicative budget	The total indicative budget for the topic is EUR 10.00 million.
Type of Action	Innovation Actions
Eligibility conditions	The conditions are described in General Annex B. The following exceptions apply: If projects use satellite-based earth observation, positioning, navigation and/or related timing data and services, beneficiaries must make use of Copernicus and/or Galileo/EGNOS (other data and services may additionally be used).
Legal and financial set-up of the Grant Agreements	The rules are described in General Annex G. The following exceptions apply: The funding rate is up to 60% of the eligible costs. This funding rate applies both to members and non-members of the partnership, except for non-profit legal entities, where the funding rate is up to 100% of the total eligible costs.
Technology Readiness Level	Activities are expected to achieve TRL 6-7 by the end of the project – see General Annex B.

<u>Expected Outcome</u>: Project results are expected to contribute to all of the following expected outcomes:

- Concepts of fleet and traffic management in the CCAM eco-system enabling optimised systems for the mobility of people and goods that take into account the balance between societal and individual user needs.

- Intermodal interfaces and interoperability between traffic management systems (of different geographical locations and/or of CCAM vehicles and other modes of transport)

considering integration beyond road transport in the overall multimodal transport system providing seamless mobility services.

- Advanced simulation models and tools that enable and help assessing new traffic management strategies (including dedicated lanes, priorities at intersections etc.) for CCAM.
- Optimised mobility network load balancing approaches through advanced traffic management guidance and information loops that can reach individual users as well as operational traffic management actors.
- Effective cooperation and governance models for operating CCAM services as part of real-life fleet and traffic management systems developed and tested.

Scope: Proposed actions should develop and demonstrate concepts of traffic and fleet management to achieve a desirable integration of CCAM vehicles in the entire mobility system. CCAM vehicles should be considered in their different sizes and usages as well as their mobility service provision (private, public, shared, pooled etc.). Proposed actions should address both the transport of people and goods with automated fleets (commercial/logistics fleets, fleets operated by public or private transport operators) and individual vehicles (CCAM- or conventional vehicles) well integrated in the entire traffic management system. They have to address technology gaps to foster vehicle integration, communication and better manoeuvre coordination and orchestration concepts in managing fleets and traffic as well as integrating public transport and other shared mobility concepts. This involves planning, forecasting and managing fleet and individual vehicles' movements according to their specific needs. Proposed actions should demonstrate traffic efficiency improvements by mobility network load balancing of routes, optimizing reliability of arrival times of goods delivery or shared mobility services, organize measures in case of events, or bilateral communication and acknowledgement of traffic management guidance if advised from an appropriate control centre.

Proposed R&I actions are expected to address intermodal interfaces and interoperability between traffic management systems from one geographical location to another and from one user group to another to attain seamless mobility for all.

Proposed actions should develop and demonstrate mixed traffic orchestration concepts, enabling or involving new mobility business cases for fleet operation (logistics, public or private transport operator, etc.). These new fleet and traffic management approaches should closely link to societal and individual user needs (including VRUs and other connected or non-connected users).

Advanced simulation models and tools should be able to test and demonstrate in real life traffic their ability to support the optimisation and balancing of the mobility network load. Testing and demos in real life traffic conditions should be undertaken through engagement with stakeholders from the industry, public authorities, public and private operators, service providers, the research sector and road and vehicle users and by satisfactorily addressing the priorities of all (win-win-win).

Governance of the traffic management system has to take into account the different needs and requirements of the users, depending on their gender, socio-economic background, age, ethnicity or ability, and the availability of services enabled by CCAM and the accordingly relevant supporting infrastructure. Both citizen-led needs and CCAM developments will guide the governance of traffic management systems which will eventually see the CCAM fleets of private and public transport (including on demand PT) integrated fully into the transport network. It is recommended to develop solutions that are grounded in social innovation.

This topic requires the effective contribution of SSH disciplines and the involvement of SSH experts, institutions, as well as the inclusion of relevant SSH expertise, in order to produce meaningful and significant effects enhancing the societal impact of the related research activities.

In order to achieve the expected outcomes, international cooperation is advised, in particular with projects or partners from the US, Japan, Canada, South Korea, Singapore, Australia.

HORIZON-CL5-2022-D6-01-05: Artificial Intelligence (AI): Explainable and trustworthy concepts, techniques and models for CCAM (CCAM Partnership)

Specific conditions	
Expected EU contribution per project	The EU estimates that an EU contribution of between EUR 5.00 and 6.00 million would allow these outcomes to be addressed appropriately. Nonetheless, this does not preclude submission and selection of a proposal requesting different amounts.
Indicative budget	The total indicative budget for the topic is EUR 12.00 million.
Type of Action	Research and Innovation Actions
Technology Readiness Level	Activities are expected to achieve TRL 5 by the end of the project – see General Annex B.

Expected Outcome: Project results are expected to contribute to all of the following expected outcomes:

- Concepts, techniques and models based on Artificial Intelligence (AI) used for situational awareness, prediction, decision making and triggering of actions for time critical and safety relevant CCAM applications as well as for cyber threat detection and mitigation.
- A clear understanding of the capabilities, limitations and potential conflicts of AI based systems for CCAM.
- Increased user acceptance from an early stage, based on explainable, trustworthy and human-centric AI. Interactions with vehicles using AI should be understandable, human-like and reflect human psychological capabilities, and free of gender, ethnic or other biases.

- Accelerated AI development and training for CCAM enabled by a relevant set of real and synthetic traffic events and scenarios.

- AI based CCAM solutions will evolve from reactive and/or adaptive system support into predictive system state awareness (including driver state and user diversity), decision-making and actuation, enhancing road safety especially in near-critical situations.

Scope: The deterministic understanding and consequential design of assistance systems are mostly reactive or to some extent adaptive. In the transition from driver assistance systems towards fully automated systems, a critical aspect is the decision making (i.e. planning and acting), based on robust and reliable detection and perception. AI has a huge potential to advance this process.

Specifically, in more complex and dense traffic environments, highly automated driving functions will benefit from the system state prediction enabled by AI. Yet, the current state of technology using AI for CCAM has limitations regarding human-like actions, more specifically the intuitive, split-second (predictive) assessments and 'reflex decision making'. As such, any AI requires good integration into the overall system with close interaction and compatibility with the active safety systems (e.g. automated emergency braking).

For the development process, training is essential for the performance of unbiased AI. It requires sufficient traffic and event data under varying conditions from all over Europe, avoiding limited data sets. The current, mainly deterministic approaches for validation in automotive development will not be sufficient for future training and validation of AI-based or AI-supported functions, which will also need to be able to deal with complex issues as (un)intended miscommunication.

Proposed R&I actions therefore are expected to address all the following aspects

- Support the development and integration of AI in CCAM with explainable, trustworthy and human-centric and unbiased concepts, techniques and models; this can be on vehicle level and on transport system level, where tactical and strategic links to traffic management and traffic conditions need to be established.

- Address the knowledge gap on AI training and validation approaches as well as efficient and ethical approaches for data handling of increasing amounts of data.

- Build upon existing and generated data for training and verification of AI supporting situational awareness in CCAM in more complex traffic scenarios (e.g. digital twins).

Specific automotive requirements on functional safety and security need to be considered in the development process of an automotive-grade AI ensuring consistency with existing validation procedures.

In order to achieve the expected outcomes, international cooperation is advised, in particular with projects or partners from the US, Japan, Canada, South Korea, Singapore, Australia.

This topic implements the co-programmed European Partnership on 'Connected, Cooperative and Automated Mobility' (CCAM).

Safety and resilience - per mode and across all transport modes

Proposals are invited against the following topic(s):

HORIZON-CL5-2022-D6-01-06: Predictive safety assessment framework and safer urban environment for vulnerable road users

Specific conditions	
Expected EU contribution per project	The EU estimates that an EU contribution of between EUR 4.00 and 4.33 million would allow these outcomes to be addressed appropriately. Nonetheless, this does not preclude submission and selection of a proposal requesting different amounts.
Indicative budget	The total indicative budget for the topic is EUR 13.00 million.
Type of Action	Research and Innovation Actions
Technology Readiness Level	Activities are expected to achieve TRL 5-6 by the end of the project – see General Annex B.

Expected Outcome: Project results are expected to contribute to the following expected outcomes:

For Area A:

- Harmonised, prospective assessment framework for road safety, both active and passive, solutions (for policy, regulatory and consumer assessment).
- Comprehensive virtual representation of challenging scenarios in future road traffic.
- Well-founded prognoses on the effects of new solutions on road safety and protection of vulnerable road users and vehicle occupants.

For Area B:

- 50% reduction in serious injuries and fatalities in road crashes by 2030, with a focus on measures addressing unprotected vulnerable road users
- Better prediction of all road users behaviour and the use of new transport modes
- Concepts and guidelines for safe inclusion of new types of vulnerable road users, e.g. those using new means of transport into the traffic system

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- Development of solutions that facilitate inclusion of all vulnerable users in the transport system, including people with disabilities, the elderly, and children by providing a safe environment for walking and cycling.

- Facilitation of modal shift to active and clean modes of transport, improving the health of road users and the quality of urban environments.

Scope: A Safe System approach recognises that since accidents will continue to occur despite preventive efforts, it is a shared responsibility between stakeholders (road users, road managers, vehicle manufacturers, etc.) to take appropriate actions to ensure that road collisions do not lead to serious or fatal injuries. The safe system approach requires a systematic, multi-disciplinary, multi-sectoral, and multi-stakeholder approach which addresses the safety needs of all users; fatal and serious injury prevention, collision prevention and mitigation and post-collision care and aligns with other policies for co-benefits such as health, occupational health and safety, sustainable development and poverty reduction. In a Safe System approach, mobility is a function of safety rather than vice versa. It involves the implementation of system-wide measures that ensure, in the event of a collision, that the impact forces remain below the thresholds likely to produce either death or serious injury.

Area A – Predictive safety assessment framework

The road traffic system is changing with new technology, new means of transport as well as with regulatory and behavioural changes, and so will scenarios which are relevant for safety. Such future scenarios are not yet captured in accident databases. Traditional analysis methods and road studies can no longer predict the impact of new developments and new measures on road safety with an increased speed of technological development, but relatively slow penetration rates in the road traffic system. Also for already developed safety measures, scenarios need to be provided which cover more complex transport system levels where safety can be described in terms of risk and probability due to interplay between societal and technological driving forces as well as different stakeholder and user needs. A predictive safety assessment framework on higher system levels will support considerably the proactive management of road safety as an important principle of the safe system approach.

Virtual simulation allows for fast and extensive evaluation of safety measures even in scenarios which do not exist in real traffic yet. With growing computer power, safety assessment methods should therefore be extended to potential future scenarios and to the transport system level also allowing for the evaluation of socio-economic benefits. Such predictive assessment requires appropriate simulation environments and realistic models of all elements of the transport system (incl. human behaviour and traffic flow), which need to be harmonised to make them available for policy, regulatory and consumer assessment.

Within this context, actions should address the following aspects:

- Develop new methods to efficiently predict the effects of the implementation of a new technology, new means of transport and regulatory or behavioural changes on road safety up to the level of socio-economic benefits.

- Further develop virtual models of the relevant elements of the transport system for which such further development is most urgently needed, and validate them through testing activities and corresponding correlation.

- Analyse, based on selected examples, how the application of new technology and/or the introduction of new regulation will affect the remaining road safety burden, and how traffic and crash scenarios will change with their market penetration and/or enforcement respectively.

Area B – Safer urban environment for vulnerable road users

A safe system strategy and targets to reduce accidents in urban areas inevitably should have at its core the safety of vulnerable road users. Vulnerable road users (pedestrians, cyclists and powered two wheelers) constitute almost 70% of the fatalities from road crashes in urban areas. Our society is characterized by an ageing generation, which is still mobile and more active in road traffic than in the decades before, therefore it is of high importance to improve safety in road traffic for elderly people by seeking solutions that would concomitantly address infrastructure and road user behaviour. A safe system strategy needs also to take into account the interactions between different modes of transport, especially the road intersection with trams, light-rail, commuter rail, including infrastructure and human factors of vulnerable users in relation to level-crossings and trespassing.

In this context, building on best practices (technological, non-technological and social), as well as ongoing projects and planned initiatives in the area of safe urban environment for vulnerable road users, actions should address the following aspects:

- Protection principles and solutions to provide a safe environment for vulnerable road users through infrastructure measures and lifelong learning initiatives for vulnerable road users as well as for vehicle occupants (behavioural change, training courses, road safety education from an early age)

- Identify specific mobility needs and public space design needs to promote a safe journey for the vulnerable road users, and enhance their perception of safety (considering among others women's perception of safety and people with disabilities, like blind people in shared spaces).

- Safe inclusion of new means of transport into the traffic system (including personal light electric vehicles, PLEVs, such as electric scooters and self-balancing vehicles and the safe transition to higher levels of automation e.g. automated public transport vehicles). Safety measures on the vulnerable road users' vehicles, improving stability, robustness and helping to prevent crashes overall.

- Protective equipment (helmets, clothes, reflectors) that is innovative, effective, user friendly and likely to lead to higher usage rates. Possibilities of active equipment able to detect oncoming collisions and warn the VRU in order to prevent crashes should be explored and demonstrated

- Improved detection mechanisms of vulnerable road users by other users and accurate prediction of their behaviour including at road intersections.
- Analysis of the most common causes of accidents concerning vulnerable road users and demonstration of applied solutions.
- Provide clear guidance to cities and Member States/Associated Countries on how to incorporate the vulnerable road users dimension into infrastructure planning and sustainable urban mobility plans especially for the aspects of safety, security and accessibility.

Actions should address the activities EITHER under area A) Predictive safety assessment framework OR under area B) Safer urban environment for vulnerable road users. Proposals should clearly indicate which area they are covering. At the same time, links will ideally be established between projects under both areas, so that solutions, concepts and measures developed under Area B) could be assessed using the framework from Area A).

Typically, projects should have a duration of 36 to 48 months. Nonetheless, this does not preclude submission and selection of proposals requesting other durations.

Social innovation is recommended when the solution is at the socio-technical interface and requires social change, new social practices, social ownership or market uptake.

HORIZON-CL5-2022-D6-01-07: More resilient aircraft and increased survivability

Specific conditions	
Expected EU contribution per project	The EU estimates that an EU contribution of between EUR 4.00 and 8.00 million would allow these outcomes to be addressed appropriately. Nonetheless, this does not preclude submission and selection of a proposal requesting different amounts.
Indicative budget	The total indicative budget for the topic is EUR 9.00 million.
Type of Action	Innovation Actions
Eligibility conditions	The conditions are described in General Annex B. The following exceptions apply: If projects use satellite-based earth observation, positioning, navigation and/or related timing data and services, beneficiaries must make use of Copernicus and/or Galileo/EGNOS (other data and services may additionally be used).
Technology Readiness Level	Activities are expected to achieve TRL 6 by the end of the project – see General Annex B.

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Expected Outcome: Project results are expected to contribute to two or more of the following expected outcomes in order to contribute to Flightpath2050 safety goals:

- Near real-time proactive prediction, detection, communication and avoidance/mitigation of anomalies and hazards at the airport (e.g. on the runway, at ground-handling, etc.), in the atmosphere (e.g. extreme weather phenomena) and on-board (e.g. fire, electromagnetic interference, structural issues, etc.), including self-protection.

- Improved safety modelling and design of aircraft and airports to increase survivability e.g. in case of fire, crash, ditching, including impact of new fuels or energy systems.

- Improved means and methods for reliable tracking of aircraft and timely evacuation, search and rescue of passengers and crew.

Scope: Activities should contribute to maintain a high-level of safety in aviation by encompassing the evolution of external hazards with the evolution of aviation systems. Aircraft should be more resilient to external hazards and internal failures in all phases - from ground-handling, runway operations, up to flight and emergency operations. Should such rare events occur, the aircraft should be able to fly safely back to an airport, or, in the worst case, ensure the survivability of passengers and crew and their safe evacuation and rescue.

Increase the ability to predict and avoid or mitigate weather hazards, which remain one of the major challenges on the ground and in flight, such as thunderstorms, lightning strikes, turbulence and wind shear to icing, snow and fog, as well as emerging events such as drones incursion, and major events such as volcanic ash clouds that can affect large swathes of airspace. Prevent and handle electromagnetic interferences (including cosmic radiation) and fire events, triggered by internal failures or external hazards. Improve modelling and protections systems accordingly together with tools to assist the design and the certification process, considering also climate risks.

Advance systems and methods for reliable aircraft tracking and for safe evacuation, search and rescue of passengers and crew, including with new aerial means as drones. Advanced features of Galileo Search & Rescue operating service should be fully explored and exploited, if applicable.

Activities should go beyond the state of the art and previous R&I activities, at least at EU level[176]. The proposals may include the explicit commitment from the European Aviation Safety Agency (EASA) to assist or to participate in the actions[177].

[176] Examples of aviation safety research projects available on:
- Projects For Policy (P4P) on Aviation Safety https://publications.europa.eu/en/publication-detail/-/publication/b4690ade-3169-11e8-b5fe-01aa75ed71a1/language-en/format-PDF/source-75248795
- Coordination-support action OPTICS2 https://www.optics-project.eu/narratives/

[177] https://www.easa.europa.eu/domains/safety-management/research

In order to achieve the expected outcomes with increased resources and impact, international cooperation can be foreseen with third countries with relevant capacities in this domain, while ensuring that the respect of European IPR, interests and values is strictly guaranteed.

Synergies with other transport modes and safety/security critical sectors is welcomed, in particular on risk assessment and pre-normative research to ensure fit-for-purpose rulemaking and management systems.

Synergies with the relevant topics in Horizon Europe Cluster 4 can be exploited e.g. HORIZON-CL4-2021-SPACE-02-52 (EGNSS applications for Safety and Crisis management), HORIZON-CL4-2022-SPACE-02-51(EGNSS applications for Smart mobility) as well as with other EU programmes such as Connecting Europe Facility (CEF), NextGenerationEU and Digital Europe.

HORIZON-CL5-2022-D6-01-08: Safer navigation and tackling containership fires

Specific conditions	
Expected EU contribution per project	The EU estimates that an EU contribution of between EUR 3.50 and 6.00 million would allow these outcomes to be addressed appropriately. Nonetheless, this does not preclude submission and selection of a proposal requesting different amounts.
Indicative budget	The total indicative budget for the topic is EUR 12.00 million.
Type of Action	Innovation Actions
Technology Readiness Level	Activities are expected to achieve TRL 7 by the end of the project – see General Annex B.

Expected Outcome: Projects are expected to contribute to the following outcomes:

- Navigational accidents including vessel collisions and groundings, damage to vessels and boats from debris (in particular lost containers), and harm to marine mammals are significantly reduced.
- There is systematic understanding of the causes of navigational accidents and high standards are established for their prevention.
- Automated systems reducing the human factor as a cause of navigational accidents are introduced on a relevant scale and deployed in particular on vessels operating in sensitive areas where navigational accidents and incidents would have a particular negative impact (coastal zones, marine protected areas).
- Digital solutions ("smart ships") that help in the prevention of accidents are developed and integrated in the overall vessel architecture and in traffic control systems. A link to automated and autonomous shipping solutions under development is established.

- Containership fires can be systematically prevented, and when occurring they will be detected swiftly and tackled safely without recourse to external intervention.
- The serious risk to crews, coastal and port communities from the toxic combustion products of containership fires is mitigated.
- The frequency of containership fires is reduced in a statistically proven way.

Scope: Whilst the safety of shipping has significantly improved since the major disasters in the past decades navigational accidents remain a frequent and almost daily occurrence. In addition, the growing size of containerships has been linked to an increasing frequency of major containership fires which are difficult to tackle and have often resulted in the loss of lives and the total loss of ship and cargo as well as dangers from toxic combustion products. Lost containers remain a serious navigational hazard with consequences for the safety of smaller vessels and boats as well as for imminent and longer term coastal pollution.

Human factors are often the most important causal factor within navigational accidents including collisions with waterborne traffic and structures, and groundings. Furthermore hazards such as collisions with large marine mammals and debris can be difficult to detect by means of human observation.

Despite improvements fires on-board containerships continue to be a regular occurrence which often require external intervention for crew evacuation (where at all possible) and on certain occasions have remained uncontrolled for days before burning out or being extinguished. Such interventions cannot be assured easily on most major shipping routes and are not always effective with consequent risks to crews, the marine environment and potentially coastal communities.

To address these challenges applicants will address one of the following two aspects:

Navigational accidents

a. Systematically assess the causes, consequences and probability of navigational accidents, including collisions involving vessels and offshore structures, groundings, container losses, as well as collisions with marine mammals and floating objects.

b. Develop solutions and standards to address the most important causal factors, including the removal/reduction of human factors through smart sensors and automatic prevention and evasion measures.

c. To reduce and potentially eliminate the human factor develop and test innovative solutions beyond the state of the art to locate and stay clear of objects in order to avoid navigational accidents including collisions with marine mammals, floating debris and small surface vessels, in particular recreational crafts and fishing boats. Based on open source principles and common data protocols (e.g. AIS) the developed systems should also support digital networking to alert other waterborne traffic in real time of the location of hazards as well

as supporting a European navigational hazards data base. The exploitation of Galileo GNSS services and eventually other space based services is to be foreseen.

d. Propose solutions to the tracking and recovery of lost containers in cases where those containers pose a risk to navigation and the marine environment.

Containership fires

a. Undertake a systematic analysis of containership fires' causal factors (including malicious and erroneous cargo declarations), the currently established responses based on on-board means, and the consequences, including the potential consequence of a fire in coastal regions with an onshore wind.

b. Research should address the range of risks, ship and cargo system design issues, fire detection and firefighting methods, accident management methodologies, and pertinent regulatory issues in order to greatly reduce the risk of fires at sea.

c. Special attention should be given to fires within cargo areas (in holds and on deck) for which relevant risk control options should be presented, analysed and the effects of their application validated though computer simulation and model tests, including those for specific firefighting equipment.

d. In cooperation with relevant authorities (EMSA, European flag states, coast guards, rescue services) accident management strategies and plans to minimise the consequences from containership fires in European coastal and port areas should be developed. This should include an analysis of and proposition for stand-by equipment and assets.

e. Outcomes and strategies should be widely communicated to facilitate best practice and develop specific training plans, including practical exercises on a realistic scale, for crews in cooperation with operators and seafarer organisations.

Call - Safe, Resilient Transport and Smart Mobility services for passengers and goods

HORIZON-CL5-2022-D6-02

Conditions for the Call

Indicative budget(s)[178]

Topics	Type of Action	Budgets (EUR million)	Expected EU contribution per	Number of projects

[178] The Director-General responsible for the call may decide to open the call up to one month prior to or after the envisaged date(s) of opening.
The Director-General responsible may delay the deadline(s) by up to two months.
All deadlines are at 17.00.00 Brussels local time.
The budget amounts are subject to the availability of the appropriations provided for in the general budget of the Union for years 2021 and 2022.

		2022	project (EUR million)[179]	expected to be funded
Opening: 28 Apr 2022 Deadline(s): 06 Sep 2022				
HORIZON-CL5-2022-D6-02-01	IA	15.00	7.00 to 8.00	2
HORIZON-CL5-2022-D6-02-02	IA	15.00	7.00 to 8.00	2
HORIZON-CL5-2022-D6-02-03	RIA	8.00	Around 4.00	2
HORIZON-CL5-2022-D6-02-04	IA	20.00	8.00 to 10.00	2
HORIZON-CL5-2022-D6-02-05	RIA	15.00	4.00 to 5.00	3
HORIZON-CL5-2022-D6-02-06	IA	10.00	Around 5.00	2
HORIZON-CL5-2022-D6-02-07	RIA	8.00	Around 4.00	2
Overall indicative budget		91.00		

General conditions relating to this call	
Admissibility conditions	The conditions are described in General Annex A.
Eligibility conditions	The conditions are described in General Annex B.
Financial and operational capacity and exclusion	The criteria are described in General Annex C.
Award criteria	The criteria are described in General Annex D.
Documents	The documents are described in General Annex E.
Procedure	The procedure is described in General Annex F.
Legal and financial set-up of the Grant Agreements	The rules are described in General Annex G.

[179] Nonetheless, this does not preclude submission and selection of a proposal requesting different amounts.

Multimodal and sustainable transport systems for passengers and goods

Proposals are invited against the following topic(s):

HORIZON-CL5-2022-D6-02-01: Logistics networks integration and harmonisation through operational connectivity to optimise freight flows and drive logistics to climate neutrality

Specific conditions	
Expected EU contribution per project	The EU estimates that an EU contribution of between EUR 7.00 and 8.00 million would allow these outcomes to be addressed appropriately. Nonetheless, this does not preclude submission and selection of a proposal requesting different amounts.
Indicative budget	The total indicative budget for the topic is EUR 15.00 million.
Type of Action	Innovation Actions
Technology Readiness Level	Activities are expected to achieve TRL 6-7 by the end of the project – see General Annex B.

Expected Outcome: Project results are expected to contribute to all of the following expected outcomes:

- Freight transport and logistics companies, including small and medium-sized enterprises, evolve to operate seamlessly engaging with nodes, partners and customers in an effective way, thus achieving a better utilisation of the assets and other resources in the freight transport and logistics chain within Europe.
- Energy and emissions reduction potentials higher than 20%, based on the operative gains without needing to renew the assets, are demonstrated by the shared logistics networks (collaborative logistics).

Scope: Integration and harmonisation of closed independent logistics networks and of clusters of networks (e.g. from different logistics service providers or different cargo owners) providing open and shared services to manufacturers and retailers focussing on intra-European flows, would enable to optimise freight flows at system level, thus overcoming operational inefficiencies (e.g. peak overloads, partially loaded or empty transportation, sub-optimal transit routing, waiting times, higher overall costs, inefficient asset utilisation, increased emissions) and driving climate neutrality in logistics.

Projects will have to advance the adoption of technological solutions and organisational and behavioural models in use cases and applications under the leadership of logistics operators taking into account stakeholders' preferences.

In pilot actions, two or more logistics providers or shippers' logistics networks should develop and demonstrate a systemic framework for connecting effectively their independent logistics

networks (at least partially) pooling the demand of various cargo owners and develop a system of logistics networks in which assets and services, including synchro-modal services, are shared and flows are managed in a consolidated way demonstrating potential benefits. Proposals should address all the following points and subpoints:

- Develop and demonstrate a robust and transparent collaborative framework with guiding principles to ensure operational connectivity of logistics networks (e.g. services, shared resources and assets, information and financial flows, etc.) under the lead of logistics providers and addressing governance and potential anti-competition law issues. Current independent closed networks gradually are expected to become connected networks with shared and open capabilities, including intermodal transport solutions in specific demonstrators.

- Through the pilot cases and demonstrators:

    - Identify and demonstrate potential gains of these logistics networks / systems of logistics networks compared to independent logistics networks in terms of emissions and energy consumption reduction and potential business models for uptake beyond the project duration.

    - Identify main barriers and opportunities to achieve a system of logistics networks, propose solutions and pilot them to deliver guidelines for expansion and implementation.

    - Address governance aspects (e.g. how to organise and expand the logistic network with other logistics networks willing to join or how to legally engage with users of these shared logistics networks services and capabilities) and propose actions to accelerate organic and jointly acceptable growth of these logistics networks.

    - Identify innovative business models addressing also revenue sharing.

    - Identify and assess existing regulation (e.g. anti-competition) preventing or the need for new regulation to enable this shared and holistic approach, by building on the results and outcomes of previous and ongoing projects and activities[180]. Develop guidelines to address specific concerns and propose specific recommendations that should be considered.

- Identify and assess the main drivers and barriers towards horizontal collaboration in terms of organisational cultures and frameworks of the logistics service providers and the transport operators. Propose solutions to overcome the barriers and recommendations on how to create the best conditions (success factors) to boost new logistics collaborations, maintain them and reap their benefits.

[180] E.g. Digital Transport and Logistics Forum www.dtlf.eu,, Collaboration Concepts for Co-modality (CO3) http://www.co3-project.eu/., NexTrust

Social innovation is recommended when the solution is at the socio-technical interface and requires social change, new social practices, social ownership or market uptake.

HORIZON-CL5-2022-D6-02-02: Urban logistics and planning: anticipating urban freight generation and demand including digitalisation of urban freight

Specific conditions	
Expected EU contribution per project	The EU estimates that an EU contribution of between EUR 7.00 and 8.00 million would allow these outcomes to be addressed appropriately. Nonetheless, this does not preclude submission and selection of a proposal requesting different amounts.
Indicative budget	The total indicative budget for the topic is EUR 15.00 million.
Type of Action	Innovation Actions
Eligibility conditions	The conditions are described in General Annex B. The following exceptions apply: If projects use satellite-based earth observation, positioning, navigation and/or related timing data and services, beneficiaries must make use of Copernicus and/or Galileo/EGNOS (other data and services may additionally be used).

Expected Outcome: Project results are expected to contribute to all of the following expected outcomes:

- Take up and upscaling of innovative, best practice and replicable data driven logistics solutions and planning in the living labs[181] involved in the proposals, while facilitating the common lesson drawing and learning at European level, in order to contribute to the priorities of the European Green Deal, which stresses that ‘’transport should become drastically less polluting, especially in cities.[182] This action supports city sustainability targets such as climate neutrality, road safety, improved air quality, reduced congestion and better use of public space.

- Optimal mix distribution of land uses both in city centres and peripheries looking at the preferred rationales for achieving the best combination of residential, commercial, leisure and industrial space to reach the most sustainable mobility patterns according to the available and future transport supply and demand.[183]

- Valorisation of data and information gathered for urban freight to better understand the impact of e-commerce on non-sustainable delivery patterns as “just in time” deliveries are

181 At least 3 living lab cities should be in included as demonstrators of the innovative solutions.

182 https://eur-lex.europa.eu/resource.html?uri=cellar:b828d165-1c22-11ea-8c1f-01aa75ed71a1.0002.02/DOC_1&format=PDF

183 These patterns are data supported, by collecting and analysing freight data.

producing longer and more trips with more and emptier Light Duty Vehicles (LDV), potentially leading to more congestion, pollution, Greenhouse gas (GHG) emissions and road risk in urban areas.

- Improved local authority capacity in the managing and collection of data, estimation and measurements of the impacts achieved by new measures and if a regulation is needed to ensure this happening.

- Optimise the potential mix of strategically positioned land, owned by public authorities (unused railway tracks and marshalling yards, real estate, parking) or by logistics service providers in urban areas, for developing a comprehensive policy strategy integrating transport, logistics and land use. The scope of this exercise includes the roll-out of new modes (such as drones) and increasing use of sustainable modes (waterways and rail).Better understand the impact of increasing transport and logistics patterns on the climate and environment, resilience and robustness of the transport network and the urban infrastructure. This exercise addresses as well the increasing impact of new modes, such as drones, cargo bicycles and vehicles on alternative fuels.

- Optimize shared transport facilities for both passengers and goods through smart solutions.

- Improved space management and urban planning focusing on the “new normal” after the Covid-19 pandemic considering how cities are optimising their planning and allocation of space.

- Demonstrate economically viable and sustainable solutions driven by relevant technologies (e.g. real-time traffic information, space management, floating car data) and utilising models that can influence the convenience of consolidation, consistent with the full planning of loading and unloading spaces, to deliver the services and the goods.

- Defined and shared principles by main stakeholders (cities, logistics operators, couriers, real state and retail industries) for the development of safe and sustainable logistics and delivery models in cities addressing low emission zones/data collection and usage/consolidation and space management/clean and alternative vehicles/stakeholders dialogue & sustainable urban logistics plans/ environmentally friendly e-commerce solutions.

Scope: Assessing how urban space is being used and allocated enables to reduce the impacts on congestion, noise, road risk, air quality, GHG emissions as well as liveability. At the same time the development and demonstration of purpose-oriented data collection on freight transport in cities to support cities' decision making towards sustainability targets such as climate neutrality, air quality, road safety reducing congestion and better use of public space need to be addressed.

Proposals should address dynamic space re-allocation for the integration of urban freight at local level and the impacts of how urban space is being used as well as the optimal mix of space distribution and of land uses. Proposals should analyse the potential of strategically positioned

urban (or peri-urban) spaces to develop and implement a pilot demonstration, (but without interfering with parks, trees or other recreational green areas). The aim is to reduce the impact of freight transport and logistics on the urban fabric.

Projects could consider involving real estate companies, logistics service providers, together with cities, to develop sustainable business models for open and clean hubs/consolidation spaces in cities (for example using/sharing existing private locations such as underground private parkings in banks, office buildings and other potential available spaces in cities – while respecting security constraints), for dynamic space reallocation and inspired by the Physical Internet concept[184].

A more efficient policymaking on urban freight logistics requires cities to enhance their data collection capabilities, while private logistics or e-commerce (like food delivery) companies and services should be encouraged to share data, considering what are the useful data, how can companies be encouraged to share and systematisation of data. Potential applications are Urban Vehicle Access Regulations (UVARs), including Low Emission Zones (LEZ), smart parking and dynamic space management. A vast amount of transport data from different parts of the transport system currently remains unexploited. If these data were collected, contextualised, and combined more optimally, this would enhance machine learning models' ability to infer useful patterns from both historical and real-time data**.** Understanding barriers and opportunities as well as developing local capacity related to data sharing within the urban and peri-urban transport system could be a first step to encourage private and public organisations to share their transport data. Potential benefits of the data applications need to be checked on how they could support the optimization of sustainable mobility plans (SUMPs) and sustainable logistics plans (SULPs).

Also the role SME and their digital capabilities should be addressed throughout the projects.

A thorough evaluation, using if appropriate the common 'CIVITAS Process and Impact Evaluation Framework' with a clear baseline in each city or the Sustainable Urban Mobility Indicators[185], should provide qualitative and quantitative information on the results of the local solutions implemented. The effectiveness of the proposed measures in achieving local policy objectives should be evaluated and the possible barriers to their broad take up and deployment identified, together with recommendations on how to overcome them. This should be accompanied by mechanisms for common lesson drawing and learning, within the project, between the projects funded under this topic and through the CIVITAS Initiative.

Proposals may include preparatory, take up and replication actions, research activities, as well as tools to support local planning and policy making. A demonstrated contribution to the implementation of the cities' Sustainable Urban Mobility Plans is expected. Funding for major infrastructure works is not eligible. Proposals should plan for an active collaboration within the

184 For reference, see Roadmap to the Physical Internet (at http://www.etp-logistics.eu/wp-content/uploads/2020/11/Roadmap-to-Physical-Intenet-Executive-Version_Final.pdf).

185 https://ec.europa.eu/transport/themes/urban/urban_mobility/sumi_en

CIVITAS initiative. They should demonstrate that the proposed approaches are truly innovative and build on the results from previous research and demonstration actions in this area.

This topic requires the effective contribution of SSH disciplines and the involvement of SSH experts, institutions as well as the inclusion of relevant SSH expertise, in order to produce meaningful and significant effects enhancing the societal impact of the related research activities.

HORIZON-CL5-2022-D6-02-03: Smart enforcement for resilient, sustainable and more efficient transport operations

Specific conditions	
Expected EU contribution per project	The EU estimates that an EU contribution of around EUR 4.00 million would allow these outcomes to be addressed appropriately. Nonetheless, this does not preclude submission and selection of a proposal requesting different amounts.
Indicative budget	The total indicative budget for the topic is EUR 8.00 million.
Type of Action	Research and Innovation Actions
Eligibility conditions	The conditions are described in General Annex B. The following exceptions apply: If projects use satellite-based earth observation, positioning, navigation and/or related timing data and services, beneficiaries must make use of Copernicus and/or Galileo/EGNOS (other data and services may additionally be used).

<u>Expected Outcome</u>: Projects are expected to contribute to the following outcomes:

- An innovative, efficient, consistent and resilient enforcement system thanks to the direct contactless access to real-time digitized information on vehicle, driver and cargo by competent authorities.
- A more competitive and fairer transport internal market thanks to the realisation of “compliance by design” and “compliance by default” principles.
- Optimisation of the use of human and economic resources and increased productivity for both, public control authorities and transport operators, due to reduced administrative burden and time, while achieving a very significant increased control efficiency and consistency.
- Improved transport workers social conditions and increased attractiveness of the sector, by reducing the pressure put on them as the main subjects responsible for law compliance.

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- Accelerated deployment of e-government services by authorities and uptake of digital solutions by transport operators for information exchange.
- Decreased number of transport accidents, incidents and fatalities linked to the higher levels of compliance with road transport legislation.
- Accelerated deployment of innovative connected, cooperative and automated mobility (CCAM) technologies and systems for passengers and goods to increase safety and reduce environmental impacts.

Scope: The research and innovation activities should provide innovative solutions for allowing the authorities to access directly and in real time all relevant information required under the different pieces of legislation in "one click". In particular, that should include social rules (such as Regulation No 561/2006 on Driving times and resting periods, Regulation (EU) 165/2014 on the Tachograph and Directive 2006/22/EC as regards enforcement requirements for posting drivers in the road transport sector), market rules (such as Regulation 1071/2009 on access to the occupation of road transport operator, Regulations 1072/2009 and 1073/2009 on access to the market for freight and passenger road transport, Directive 96/53/EC on weights and dimensions of certain road vehicles, Directive (EU) 2016/797 on the interoperability of the rail system, Directive (EU) 2016/1629 on technical requirements for inland waterway vessels, and Directive 2005/44/EC on harmonised river information services (RIS) on inland waterways in the Community), as well as safety legislation (such as Directive 2006/126/EC on driving licences, Directive 2003/59/EC on the certificate of professional competence of drivers, Directive 2007/59/EC on the certification of train drivers and Directive (EU) 2017/2397 on the recognition of professional qualifications in inland navigation).

Research and innovation actions are expected to bring together stakeholders at various level, from supply chain (e.g. manufacturers, retailers, freight forwarders and logistics service providers), transport services (e.g. transport operators, enforcing authorities) and infrastructure networks (e.g. road / rail / inland waterways operators and transport node public authorities) to ensure a truly integrated approach.

The technical solutions should take into account the work done in the Digital Transport and Logistics Forum[186] and in its subgroup on electronic documents in particular, and build on the existing electronic databases and exchange of information platforms (RESPER, ERRU, TACHONET, RIS, IMI, eFTI, etc.), as well as privately developed tools already in place, allowing for their interconnection or integration in order to provide seamless access and exchange of information under the "only once principle". They should also develop existing and/or new concepts and systems to incorporate the areas that are not yet covered by such electronic databases and platforms. The aim is to achieve a comprehensive ecosystem for smart transport enforcement that is tested and proved to be viable, economically and technically, and allows for future integration with relevant information exchange systems in use or considered

[186] https://www.dtlf.eu/

for deployment in all modes of transport, as part of a wider multimodal transport information exchange environment.

The research should also provide assessment and recommendations on ensuring that there is a business case for the operators to make the information available electronically to the authorities, and for the authorities to accept it and implement the means to use this information in line with the "once only principle". Recommendations could eventually include the need for legislative measures to support the uptake of the digital and communication technologies for smart enforcement.

Furthermore, the research should consider the business case and conditions for reusing administrative information, where relevant, for the purposes beyond proving legal compliance. This includes, for instance, for compiling statistics, informing research, assessing the use of infrastructure, optimising logistics operations and maximising utilisation of assets.

Social innovation is recommended when the solution is at the socio-technical interface and requires social change, new social practices, social ownership or market uptake.

HORIZON-CL5-2022-D6-02-04: Accelerating the deployment of new and shared mobility services for the next decade

Specific conditions	
Expected EU contribution per project	The EU estimates that an EU contribution of between EUR 8.00 and 10.00 million would allow these outcomes to be addressed appropriately. Nonetheless, this does not preclude submission and selection of a proposal requesting different amounts.
Indicative budget	The total indicative budget for the topic is EUR 20.00 million.
Type of Action	Innovation Actions
Eligibility conditions	The conditions are described in General Annex B. The following exceptions apply: If projects use satellite-based earth observation, positioning, navigation and/or related timing data and services, beneficiaries must make use of Copernicus and/or Galileo/EGNOS (other data and services may additionally be used).
Technology Readiness Level	Activities are expected to achieve TRL 7-8 by the end of the project – see General Annex B.

Expected Outcome: Project results are expected to contribute to all of the following expected outcomes:

Developing and pilot testing at least three different business models scenarios based on collaboration platforms or public-private partnerships/project, each of them contributing to:

- Congestion and air pollution reduction, reduced road risk, social inclusion, accessibility in each city (living lab)[187].

- Increased share of new and shared mobility services (NMS) in the modal distribution, e.g. by 25% compared to a realistic baseline and financial viability of services.

- Integration of new and shared mobility services with public transport (e.g. filling service gaps and off-peak periods), in at least following three collaborative use cases/living lab that will facilitate data sharing and connectivity with remote/peri-urban areas.

- (Re-)Designing transport infrastructure[188] or upgrading/reusing existing infrastructure elements (e.g. street profile/layout, intersection/junction design, priority corridors/lanes, dedicated parking, charging/docking stations, street surfaces/pavements, etc.) to accommodate new mobility modes, patterns and behaviours with highest safety levels while being resilient to various climate conditions.

- Developing results based policies as well as recommendations/each project in line with the Sustainable Urban Mobility Planning guidelines, to increase the understanding and take-up of new mobility services by local/regional authorities and public and private mobility service providers.

- Actively engage in communicating the common learning, lesson drawing, evaluation, dissemination and the exchange of knowledge and best practices, both within the project and with the wider urban mobility and transport community.

Scope: New and shared mobility services have shown that they have the potential to meet urban dweller's needs while at the same time bring about a more rational use of cars. However, in order to succeed at delivering ''Mobility As a Service'' and address the challenges that cities face, high-quality, user centric, and reliable new mobility solutions need to be offered as a credible alternative to the private car, coupled with safe and integrated infrastructure.

New solutions should be explored and deployed for newly designed or existing transport infrastructure to accommodate new and shared mobility services. Mobility services that could be considered are, for example: micro mobility, including bike/scoter sharing, demand responsive transport, car-pooling or car sharing.

New and shared mobility services should be proposed in at least 3 living labs/project in integrated, complementary and reinforcing packages of urban mobility and planning measures and new technological solutions, combining "push'' and "pull" measures.

The services deployed should enable the idea of a social optimum in mobility from several perspectives (including socio-economic, environmental, health, accessibility; gender and inclusion; and safety and security aspects) while considering the implications for transport infrastructure and urban design.

187 At least 3 living lab cities should be in included as demonstrators.
188 Solutions need to demonstrate that traffic congestion is not increased.

The new services should also be tested beyond the commercially interesting urban cores, providing low and zero emission solutions for car-dependent suburban, peri-urban and rural areas linked to specific needs of diverse target groups such as populations with no access to public transport or affluent communities dependent on the private car.

Projects should test new and shared mobility services in mobility management (such as for companies, schools, attractions). Innovative approaches that respond to the needs of a large variety of users (such as families with children, people living in remote locations, commuters, housing developers) are expected. The role of marketing and communication, and approaches based on the co-creation of solutions should be considered.

Equally eligible would be cooperative approaches with employers willing to enter in a pilot to test a 'Mobility as a Service' (MaaS) type of service for their employees or with housing developers that are offering reduced parking spaces to residents and seek to offer smart and shared mobility solutions in return.

The proposals should also explore how the adaptation of transport infrastructure (e.g. bike-lanes or new street designs, profiles and layouts, etc…), promotes the use of shared, micro- and active- mobility, limiting risks and increasing safety while reducing transport congestion.

The results and impacts should be assessed using a wide range of quantitative indicators and compared with the situation before the implementation of the proposed solutions.

Public space redesign actions targeted by the awarded projects should not come at the cost of removing or deterioration of parks, trees or green recreational areas in the selected partner cities.

The potential adverse impacts some NMS may generate for example on high-density urban areas, on safety and security, travel demand, public transport use and traffic volumes, should be considered.

A demonstrated contribution to the implementation of the cities' Sustainable Urban Mobility Plans is expected. Proposals should collaborate with the CIVITAS initiative. They should demonstrate that the proposed approaches are truly innovative for the local context. Proposals should ensure that an appropriate geographical balance across Europe is achieved through twinning activities and other means to maximise impact without leaving anyone behind, and by demonstrating commitment of cooperation though their planned activities.

HORIZON-CL5-2022-D6-02-05: Advanced multimodal network and traffic management for seamless door-to-door mobility of passengers and freight transport

Specific conditions	
Expected EU contribution per project	The EU estimates that an EU contribution of between EUR 4.00 and 5.00 million would allow these outcomes to be addressed appropriately. Nonetheless, this does not preclude submission and selection of a proposal requesting different amounts.

Indicative budget	The total indicative budget for the topic is EUR 15.00 million.
Type of Action	Research and Innovation Actions
Technology Readiness Level	Activities are expected to achieve TRL 5-6 by the end of the project – see General Annex B.

Expected Outcome: Project results are expected to contribute to at least four of the following expected outcomes:

- Improved multimodal transport network and traffic management capabilities, facilitating seamless door-to-door mobility for passengers and freight.
- Effective and resilient network-wide data exchange and new integrated data management systems for dynamic and responsive multimodal network and traffic management.
- Tested and validated systems for enhanced prediction and resolution of network bottlenecks, substantially increasing safety, security, resilience and overall performance of the entire transport network.
- Innovative tools and services for optimising mobility flows of passengers and freight in cities and other operating environments, cutting congestion, journey times and traffic jams across transport modes, and thereby significantly reducing emissions (CO_2, SOx, NOx, particles, noise).
- New governance arrangements for multimodal transport network and traffic management, in view of further regulatory and policy actions.
- High market adoption and transferability of innovations to different ecosystems.

Scope: Advanced multimodal network and traffic management capabilities are essential for the efficient operation of the entire transport network and for seamless door-to-door mobility of both passengers and freight. This is even more pertinent in view of new mobility trends and technologies, connected and automated vehicles, new physical and digital infrastructures and innovative services. At the same time however, a number of challenges remain to develop validated concepts and leverage multi-actor data exchange, ensure interoperability of new technologies and develop interfaces across transport modes, as well as to design appropriate governance arrangements for relevant public and private stakeholders.

In this context, building on best practices (technological, non-technological and socio-economic), ongoing projects on multimodal network and traffic management, as well as other initiatives (e.g. the Digital Transport and Logistics Forum), actions should address at least six of the following aspects:

- Developing and carrying out validation for multimodal, dynamic, (cyber and physically) secure and resilient transport network and traffic management systems, leveraging state of

the art technologies (e.g. artificial intelligence, high-performance computing, edge computing).

- Demonstrating effective collection, analysis and use of network-wide fixed and variable data (e.g. using ICT and EU satellite-based information from vehicles, physical infrastructures and users) and developing integrated data management and monitoring systems, for effective and intelligent multimodal network and traffic management.

- Developing new methods and tools for harmonised and comparable international monitoring of mobility demand, for passenger mobility and freight transport, including through survey data collection and big data processing, leveraging the opening of service providers' databases to research and public authorities.

- Conducting simulations for system-wide optimisation of demand/capacity balancing for multimodal passenger and freight flows, against foreseen (e.g. traffic disruption due to an important city-wide event) and unforeseen scenarios (e.g. major network/traffic disruption as a result of a hazard manifestation or compromise in transport safety due to a health emergency), to enable real-time prediction and balancing of mobility behaviour, as well as early problem detection and resolution.

- Developing and testing network and traffic management visualisation and decision-making tools (e.g. using big data, artificial intelligence, machine learning), while taking into account regular mobility patterns (including soft modes) and user needs of citizens (including vulnerable road users and different gender groups) and businesses, as well as ad-hoc and flexible mobility-on-demand services, in the context of mobility/logistics as a service.

- Demonstrating interoperability and enhanced interfaces of network and traffic management systems across stakeholders, transport modes and country borders.

- Performing early pilot activities on multimodal network/traffic management, of limited scale and in defined environments, such as in the context of urban mobility of passengers and freight.

- Conceiving, developing and preparing the introduction of next-generation multimodal network and traffic management services, provided by public and/or private stakeholders and operationalised at a centralised and/or decentralised level.

- Develop and test implementable multi-level governance models, with roles and responsibilities for public and private stakeholders to share data and engage in transport network and traffic management functions, providing recommendations for further regulatory and policy actions.

In line with the Union's strategy for international cooperation in research and innovation, international cooperation is encouraged.

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HORIZON-CL5-2022-D6-02-06: Smart and efficient ways to construct, maintain and decommission with zero emissions from transport infrastructure

Specific conditions	
Expected EU contribution per project	The EU estimates that an EU contribution of around EUR 5.00 million would allow these outcomes to be addressed appropriately. Nonetheless, this does not preclude submission and selection of a proposal requesting different amounts.
Indicative budget	The total indicative budget for the topic is EUR 10.00 million.
Type of Action	Innovation Actions
Technology Readiness Level	Activities are expected to achieve at least TRL 7 by the end of the project – see General Annex B.

Expected Outcome: Project results are expected to contribute to the following expected outcomes:

- A holistic approach to lowering transport infrastructure environmental impact, which takes into account the whole life cycle of transport infrastructure; carbon-neutral construction, maintenance, operation and decommissioning of the infrastructure
- Implementation of circular economy principles (for example, by fostering new solutions and systems that are easy to maintain, repair, update, adapt and replace and by maximising the re-use/recycle of infrastructure components) to reduce emissions and the environmental impact; 100% reutilisation of construction materials within or across transport modes.
- Performance-based design models and manufacturing techniques (e.g. additive and subtractive manufacturing) with the objective to substantially reduce materials consumption in construction and maintenance activities.
- Enhanced modular construction, maintenance and decommissioning interventions able to reduce life cycle cost (LCC) by at least 30%.
- Optimisation of energy use and increased share of renewable energy for infrastructure management operations as a way leading to achieving energy neutrality
- Novel governance, public procurement and data utilization models to decrease the emissions and carbon footprint of the whole life cycle of transport infrastructure by 20%

Scope: The overall objective of the topic is to support the development of sustainable transport infrastructure, addressing its environmental and economic efficiency dimensions.

Research should provide knowledge and technical solutions to limit transport emissions, both caused by transport infrastructure and to which transport infrastructure contributes, as the

infrastructure related emissions are often unaccounted for. This in due to the long time between construction and decommissioning. Projects should cover the whole life cycle of transport infrastructure to which extent transport infrastructure design can influence and limit the overall emissions from construction, maintenance, operation and decommissioning of the infrastructure.

Proposals should address all of the following aspects:

- Development of new methods and technologies to construct, manage and maintain transport infrastructure in order to further contribute to lowering emissions while allowing for cost saving.
- Fostering of green, sustainable and innovative public procurement (particularly focused on the reduction of emissions, recycling and climate adaptation and mitigation).
- Development of smart techniques for effective construction, maintenance and decommissioning tasks leading to zero emissions from transport infrastructure. Modular, standard and prefabricated solutions need to be considered. Additive manufacturing techniques (e.g. 3D-printing) can be also taken into account. Recycling and reuse of materials should be also incorporated into the automated processes.
- Design and development of solutions for reduction of emissions through more efficient energy management on transport infrastructure operations by, for example energy harvesting on infrastructure and its verges, adaptive lighting systems, self-powered signalling systems and innovative tunnel ventilation. The proposed solutions should take into consideration existing regulations.
- Validation of all the proposed solutions in at least three demonstration pilots at minimum TRL7, considering different environments and phases of the infrastructure life cycle, , namely design, construction, maintenance and decommissioning.

Proposals should build on previous results from projects on sensoring, digitalisation, asset management, decision support and automation in the construction and maintenance of infrastructures.

HORIZON-CL5-2022-D6-02-07: New concepts and approaches for resilient freight transport and logistics networks against disruptive events (including pandemics)

Specific conditions	
Expected EU contribution per project	The EU estimates that an EU contribution of around EUR 4.00 million would allow these outcomes to be addressed appropriately. Nonetheless, this does not preclude submission and selection of a proposal requesting different amounts.
Indicative budget	The total indicative budget for the topic is EUR 8.00 million.

Type of Action	Research and Innovation Actions
Eligibility conditions	The conditions are described in General Annex B. The following exceptions apply: If projects use satellite-based earth observation, positioning, navigation and/or related timing data and services, beneficiaries must make use of Copernicus and/or Galileo/EGNOS (other data and services may additionally be used).

Expected Outcome: Projects are expected to contribute to the following outcomes:

- An adaptive multimodal European freight transport and logistics network, including its international connections, that reacts quickly and seamlessly upon disruptions (including pandemics), hence minimising the damage and shortening the recovery time.
- European freight transport and logistics networks which are resilient by design, thanks to better operational interconnectivity of the stakeholders, services provided based on real-time infrastructure, pre-defined alternative routes and synchro-modal approaches, robust data management, secure and resilient digital logistic and network management tools.
- New business models and services are adopted by the sector in the short-medium term, also supported by appropriate regulatory frameworks and participatory planning processes.

Scope: New production and distribution trends (e.g. globalisation, lean manufacturing, just-in-time inventory) as well as emerging digital technologies have introduced new kinds of challenges to the supply chain. Together with resilient and smart infrastructures, new concepts, innovative solutions and better cooperation of operators are needed for freight transport to minimise the negative impacts of disruptions, shorten the recovery and ease the transition time.

Research and innovation actions will have to bring together stakeholders at various level, from supply chain (e.g. manufacturers, retailers, freight forwarders and logistics service providers), transport services (e.g. transport operators, enforcing authorities) and infrastructure networks (e.g. road / rail / inland waterways operators and transport node public authorities) to ensure a truly integrated and jointly acceptable approach.

Proposals will have to:

- Evaluate the resilience of strategic logistics networks and their related data and IT systems and propose management systems and operations, including alternative networks and transport services, to increase their resilience against natural, accidental and human triggered disruptive events. Proposed concepts and solutions should be suitable to increase the resilience and sustainability of the entire transport network. Lessons learnt from the COVID-19 crisis on how to make supply chains concurrently more resilient to large-scale shocks and environmentally friendly should be considered.

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- Develop and demonstrate how synchro-modal approaches (shipment split and merge, dynamic synchronisation of multimodal schedules, realignment in case of disruptions etc.) provide resilience and sustainability by design to the freight transport and logistics networks in which these services are operated.

- Develop business intelligence capabilities, such as intermodal freight corridor performance and resilient measurement and assessment (e.g. evaluate what could be the alternative logistics networks and services to manage a failure in a main infrastructure in a transport corridor).

- Define new business models able to be adopted by the sector in the short-medium term and propose business/regulatory roadmaps and recommendations to support the adoption of the new proposed approaches and other solutions enhancing the capability to manage disruptions.

Social innovation is recommended when the solution is at the socio-technical interface and requires social change, new social practices, social ownership or market uptake.

Establishing synergies with projects funded under the Cluster 3 Civil Security for Society topic 'Ensured infrastructure resilience in case of Pandemics' could be envisaged.

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Other actions not subject to calls for proposals

Grants to identified beneficiaries

1. Support for the SET Plan Conference

Slovenia will organise the annual Strategic Energy Technology Plan conference in 2021. The conference will take place in Slovenia during the Slovenian Presidency of the Council of the European Union. The European Commission will support the organisation of the annual SET Plan conference in cooperation with the entity designated by the Slovenian Presidency

This grant will be awarded without a call for proposals according to Article 195(e) of the Financial Regulation and Article 20(4) of the Horizon Europe Framework Programme and Rules for Participation to the legal entity identified below as it is responsible for energy policy and will lead all activities on energy policies during the time of Slovenian Presidency of the Council of the European Union. As such, the co-organisation of SET Plan Conference falls under its competence.

Legal entities:

Republic of Slovenia, Ministry of Infrastructure , Langusova 4, SI- 1000 Ljubljana

Form of Funding: Grants not subject to calls for proposals

Type of Action: Grant to identified beneficiary according to Financial Regulation Article 195(e) - Coordination and support action

Indicative timetable: 4th quarter of 2021

Indicative budget: EUR 0.25 million from the 2021 budget

2. Support to the IEA's Clean Energy Transition Programme (CETP) for emerging economies

The IEA's Clean Energy Transitions Programme (CETP) aims to accelerate global clean energy transitions, particularly in major emerging economies, such as Brazil, China, India, Indonesia, Mexico and South Africa and others. Drawing on the IEA's recognised expertise across all fuels and technologies, this programme assists the target countries in overcoming the energy technology and policy challenges of moving towards the implementation of the Paris Climate Agreement. The CETP hence also contributes to the objectives of the European Green Deal's international dimension, and it has therefore received EU funding since 2020.

The CETP includes collaborative analytical work, technical cooperation and strategic dialogues with key energy stakeholders in emerging economies. In particular, the EU is keen to continue supporting, through a 3-year project, activities related to (among others) the development of innovative and timely indicators of the clean energy transition, the integration of renewable energy through adequate policies and market design, and accelerated energy technology innovation and deployment through policy and international cooperation.

This grant will be awarded without a call for proposals according to Article 195 (e) of the Financial Regulation and Article 20(4) of the Horizon Europe Framework Programme and Rules for Participation to the legal entity identified below as it contributes directly and significantly to the external dimension of the EU Green Deal and the Paris Climate Agreement and can leverage IEA's unique clean energy expertise and recognition in major emerging economies.

Legal entities:

Organisation of Economic Cooperation and Development (International Energy Agency), OECD, rue André-Pascal 2, PARIS CEDEX 16 75775

Form of Funding: Grants not subject to calls for proposals

Type of Action: Grant to identified beneficiary according to Financial Regulation Article 195(e) - Coordination and support action

Indicative timetable: 3rd/4th quarter 2022

Indicative budget: EUR 3.00 million from the 2022 budget

3. IRENA - Clean Energy Innovation Analysis & RE-MAP grants[189]

Description: Provision of enhanced technical analysis and the fostering of broader information exchange on renewable energy innovation potential and deployment opportunities to support the implementation of the EU Green-Deal and its supporting strategies for reaching net-zero emissions in the EU energy system by 2050.

The International Renewable Energy Agency (IRENA) has developed detailed knowledge and expertise on the status and prospects of innovative solutions for renewable energy amongst the major global players in clean energy innovation including in the EU and many EU member states. In addition, IRENA's near-global membership of 162 countries enables the agency to convene experts and decision-makers from around the world to facilitate the exchange of knowledge and to increase collaboration.

The planned activities will leverage and allow IRENA to expand upon that expertise and its established collaborative frameworks. The activities will draw on IRENA Regional Remap analysis, including the upcoming REMap-EU, and will deepen IRENA's work on the development, discussion and dissemination of an evidence base on innovation opportunities that can inform policy development and long-term planning including enhanced roadmaps for the pathway to the 2050 net-zero emissions goal. The expanded scope will ensure that EU specific opportunities to both learn from and share insights with countries within and outside

[189] This activity directly aimed at supporting the development and implementation of evidence base for R&I policies and supporting various groups of stakeholders is excluded from the delegation to Executive Agencies and will be implemented by the Commission services.

the EU are identified as well as opportunities for EU innovations to be utilized further afield. Topics to be covered will include the following:

- Analysis of emerging systemic innovative solutions and their deployment potential for the deep decarbonization of challenging end-use sectors including long-distance and freight transportation and energy-intensive industries.
- Analysis of emerging systemic innovative solutions and their deployment potential for the deep decarbonization of buildings and urban environments.
- Fostering of closer collaboration and enhanced information exchange between countries and companies, within and beyond the EU, on the topic of innovative solutions for the production and use of renewable fuels including hydrogen.
- Fostering of closer collaboration and enhanced information exchange between countries and companies, within and beyond the EU, on the topic of making fuller use of underutilized renewable resources – including off-shore renewables and hydropower.

This grant will be awarded without a call for proposals according to Article 195(e) of the Financial Regulation and Article 20(4) of the Horizon Europe Framework Programme and Rules for Participation to the legal entity identified below as the International Renewable Energy Agency (IRENA) is an intergovernmental organisation that include all EU Member States and the European Union as members. IRENA has been requested by its members to develop a global renewable energy roadmap (REmap), which is published yearly.

From 2016-2018, the EC supported the development of a REmap analysis for the European Union which analysis supported EU policy development as well as IRENA's global renewables roadmap. The Remap analysis consists of a technology-rich, bottom-up analysis of renewable energy potential, cost and benefits based on country by country analysis, with a methodology that is developed within IRENA and that needs to be consistent with other IRENA analyses to contribute to the global roadmap.

This study will provide an update and extension of the 2018 EU REmap analysis. As explained above, the services can only be provided by IRENA which is therefore placed in a de facto monopoly situation under Article 134 (1) (b) of the Implementing Rules of the Financial Regulation.

Legal entities:

International Renewable Energy Agency (IRENA), Masdar City P.O. Box 236, Abu Dhabi, United Arab Emirates

Form of Funding: Grants not subject to calls for proposals

Type of Action: Grant to identified beneficiary according to Financial Regulation Article 195(e) - Coordination and support action

Indicative timetable: 2nd quarter 2021 – 4th quarter 2022

Indicative budget: EUR 1.00 million from the 2021 budget

4. Improved offshore energy development in areas reserved for defence activities

The "EU Strategy to harness the potential of offshore renewable energy for a climate neutral future" COM(2020) 741 final, specify the need to identify barriers for offshore renewable energy developments in areas reserved for defence activities and improve co-existence. This action shall present a mapping of the areas in question, their potential for offshore energy generation including an analysis of the defence related barriers. On this basis solutions shall be developed for improved co-existence involving stakeholders and experts from both defence and energy sectors.

This grant will be awarded without a call for proposals according to Article 195(e) of the Financial Regulation and Article 20(4) of the Horizon Europe Framework Programme and Rules for Participation to the legal entity identified below as the EDA is justified as an identified beneficiary through the dedicated action point in the offshore strategy (COM(2020) 741 final) that commits "The Commission and the European Defence Agency" to "set up a joint action". Furthermore the particular confidentiality aspects related to the use of military installations and the EDA collaboration with the Ministries of Defence in the Member States positions them as the only organisation that can implement this action. "

Legal entities:

European Defence Agency, Rue des Drapiers 17-23; 1050 Bruxelles; Belgium

Form of Funding: Grants not subject to calls for proposals

Type of Action: Grant to identified beneficiary according to Financial Regulation Article 195(e) - Coordination and support action

Indicative timetable: launch before end 2021 with a duration of 15 months

Indicative budget: EUR 2.00 million from the 2022 budget

5. Support to European Standardisation Organisations for biomethane injection in the grid in support of the implementation of the RED II as well as gas quality regulatory work

CEN/TC 408 worked on the Commission's Standardization Request M/475 on standards for biomethane use in transport and injection in natural gas pipelines under contract SA/CEN/ENTR/EFTA/475/2012-15 and the standardisation work has progressed well. However, the work identified important topics for which research has to be continued in order to provide certainty for the specification and in particular:

a. Impact of siloxanes on industrial boilers;

b. Impact of Sulphur on engines;

c. Impact of oxygen on underground storages;

d. Impact of components on health;

e. corrosion tests in gas networks;

f. impacts of Hydrogen content in biomethane on gas grid;

g. statistical analysis on biogas composition;

h. purification process.

This grant will be awarded without a call for proposals according to Article 195(e) of the Financial Regulation and Article 20(4) of the Horizon Europe Framework Programme and Rules for Participation to the legal entity identified below as previous work under H2020 specific grant agreements with CEN have identified that there are knowledge gaps on impacts of biomethane related siloxanes on heavy duty vehicles engines and industrial boilers as well as the sulphur and oxygen content impact on gas facilities. In order to be able to update the bio-methane standards EN16723-1:2016 and EN16723-2:2017 it is necessary to perform experiments on these 2 topics. These are particularly relevant for advancing regulatory work for greening the gas grid under the Green Deal. It is also relevant for implementing RED II.

There is urgency to begin in 2021 to complement existing specific grant agreement ENER/C2/452-2019 as some work will need to run in parallel and to avoid significant gaps. Revision of EN16723 would follow on the basis of this work in 2023. Without this follow up agreement, it will not be possible to complete the work needed to revise CEN standard EN/16723.

Legal entities:

CEN – European Committee for Standardisation, Avenue Marnix 17, 1000 Brussels Belgium

Form of Funding: Grants not subject to calls for proposals

Type of Action: Grant to identified beneficiary according to Financial Regulation Article 195(e) - Coordination and support action

Indicative timetable: 4th quarter 2021 with a duration of 12 months

Indicative budget: EUR 3.00 million from the 2021 budget

Public procurements

1. Study on development of outlook for the necessary means to build industrial capacity for drop-in advanced biofuels

The study will analyse the means which are needed to achieve the necessary industrial growth for advanced biofuels contribution to meeting the new targets for 2030 and 2050 under the European Green Deal by collecting industrial input directly from industrial associations operating in the alternative and renewable transport fuels sector, analysing and putting forward recommendations and a roadmap. The study will make an analysis on the actual status in

capacity and supply of alternative to fossil fuels for transport, and on the demand, which will be created if different policy scenarios are applied to meet the new targets for 2030 and climate neutrality for 2050. The analysis will take into account all available alternative fuel options including those based on technologies still in development and demonstration stage today. Based on the results for the demand in drop-in advanced biofuels, the input of the relevant fuel producers will be collected in order to determine the necessary developments of the relevant industry in terms of actions and investments for meeting this demand in 2030 and 2050 with full compliance at highest standards with regards to socioeconomic and environmental sustainability. The study will provide factual evidence and rigorous analysis of industries outlooks and will define strategic research and innovation directions and a roadmap for the industrial developments. The overall output will be presented in a strategic report, which will be validated in a workshop with relevant industrial stakeholders and experts.

Form of Funding: Procurement

Type of Action: Public procurement

Indicative timetable: 2nd quarter 2021

Indicative budget: EUR 0.70 million from the 2021 budget

2. Study on Prize development for renewable energy systems (recognition and inducement prizes)

The study will investigate the potential candidates for prizes to be launched WP2023-2024 with the objectives to stimulate and accelerate the development and the market introduction of renewable energy systems. The scope of the work will cover the analysis of past prizes launched under Horizon 2020 and draw lessons to be learned, will establish criteria for prize selection in the field of renewable energy for both types, recognition and inducement prizes, and will draft aims and rules of contest for five prizes with the relevant stakeholders.

Form of Funding: Procurement

Type of Action: Public procurement

Indicative timetable: Q2 in 2021

Indicative budget: EUR 0.70 million from the 2021 budget

3. Study on using pre-commercial procurements for drop-in advanced biofuel for commercial cargo-shipping and aviation

The study will address how to use pre-commercial procurements in the context of production capacities, target fleets and distribution infrastructure to create substantial uptake of drop-in advanced biofuel for commercial cargo-shipping and aviation which is essential for decarbonisation of the maritime and aviation sectors, yet those fuels are less competitive to fossil alternatives.

Form of Funding: Procurement

Type of Action: Public procurement

Indicative timetable: 3rd quarter in 2021

Indicative budget: EUR 0.30 million from the 2021 budget

4. Dissemination and information activities[190]

Communication activities such as meetings, conferences, out-reach communication events/papers/materials and publications should support dissemination of knowledge and information to relevant stakeholders.

Form of Funding: Procurement

Type of Action: Public procurement

Indicative timetable: as of 2nd quarter in 2021 and as of 1st quarter in 2022

Indicative budget: EUR 0.17 million from the 2021 budget and EUR 0.17 million from the 2022 budget

5. Dissemination and information activities related to the EIC Prize Fuel From the Sun[191]

Communication activities such as meetings, Grand Final, conferences, award ceremony out-reach communication events/papers/materials and publications should support dissemination of knowledge and information to relevant stakeholders.

Form of Funding: Procurement

Type of Action: Public procurement

Indicative timetable: 3rd quarter 2021

Indicative budget: EUR 0.05 million from the 2021 budget

6. Information, dissemination and logistic support for EU in Mission Innovation[192]

The European Commission, on behalf of the European Union, joined the Mission Innovation (MI) in June 2016. MI is a global initiative that aims to reinvigorate and accelerate public and private global clean energy innovation to make clean energy widely affordable and it is one of

190 This activity directly aimed at supporting the development and implementation of evidence base for R&I policies and supporting various groups of stakeholders is excluded from the delegation to Executive Agencies and will be implemented by the Commission services.

191 This activity directly aimed at supporting the development and implementation of evidence base for R&I policies and supporting various groups of stakeholders is excluded from the delegation to Executive Agencies and will be implemented by the Commission services.

192 This activity directly aimed at supporting the development and implementation of evidence base for R&I policies and supporting various groups of stakeholders is excluded from the delegation to Executive Agencies and will be implemented by the Commission services.

the key strategic forum for the EU's international cooperation in clean energy RD&D. MI members committed to share information on their clean energy RD&D activities, double their governmental clean energy investments within 5 years, and encourage greater levels of private sector investments.

To guarantee continuation of MI initiative, and maintain the ownership of the activities the EC, on behalf of the EU, is actively engaged in and another set of activities it leads, a series of supporting services need to be covered, mainly the websites, information and dissemination activities and logistic support, etc.

Form of Funding: Procurement

Type of Action: Public procurement

Indicative timetable: 3rd quarter 2021 and 3rd quarter 2022

Indicative budget: EUR 0.10 million from the 2021 budget and EUR 0.10 million from the 2022 budget

7. Information services for energy research and innovation policy development[193]

An information platform is planned to be used to gain a better understanding of the energy research sector. Intelligence gained through the platform will help to establish priority areas, base policy decisions on hard evidence, and allocate resources optimally.

Form of Funding: Procurement

Type of Action: Public procurement

Indicative timetable: 3dr quarter 2021 and 3rd quarter 2022

Indicative budget: EUR 0.10 million from the 2021 budget and EUR 0.10 million from the 2022 budget

8. Smart Cities Marketplace[194]

This action aims to continue the current well-established service portfolio of the Smart Cities Marketplace (knowledge-exchange, capacity building, matchmaking process) and expanding/supplementing it with a pan-European programme with certified experts and practitioners, which will provide hands-on help and know-how for making the much needed city-needs-led change a reality.

193 This activity directly aimed at supporting the development and implementation of evidence base for R&I policies and supporting various groups of stakeholders is excluded from the delegation to Executive Agencies and will be implemented by the Commission services.

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The Smart Cities Marketplace has established a large community of more than 6.000 smart city stakeholders across all relevant sectors (city administrations, industry, finance, research, EU and international initiatives, etc.) over the past few years.

Supported by and actively engaging these stakeholders the project fostered purposeful and tangible collaborations for the replication and upscaling of Smart City solutions.

Form of Funding: Procurement

Type of Action: Public procurement

Indicative timetable: tender launch in 4th quarter 2021; contract duration: 4 years

Indicative budget: EUR 7.00 million from the 2022 budget

9. Energy system modelling, optimisation and planning tools

Provide local, regional, national and European public authorities and network operators, with an open source tool to allow them to better plan and optimise the development of renewable energy sources and the enhancement of infrastructure to meet the future energy needs in a geographical area.

- Advanced modelling tools to perform cross-border and cross- energy vector reliability-of-supply assessments on a long time horizon, where cross-sectoral disruptive innovations in industry, mobility and building sector can be included

- Building on existing open source models, the project shall further develop and validate an open source model of the components of the energy system and provide tools to integrate these component models into a system model to satisfy the (future) needs in a geographical area, thereby providing a planning tool for cost and emissions optimisation of the enhanced energy system at pan-European level. The aim is to better plan and optimise the energy generation and transmission and storage system to meet the (future) energy needs aggregated at the NUTS2 level; the distribution layer to individual energy users is not to be considered.

Form of Funding: Procurement

Type of Action: Public procurement

Indicative timetable: call for tender launch in 3rd quarter Q3-2021; project duration of contract: 2 - 3 years

Indicative budget: EUR 3.00 million from the 2021 budget

10. Assessment of the competitiveness of clean energy technologies

This work will support the preparation of the annual Competitiveness Progress Reports required under the Regulation on the Governance of the Energy Union. It will build on the clean energy competitiveness framework and bring improvements, including on its social, economic, and

environmental indicators, as well as its international dimension. It will also fill data gaps for specific technologies.

Form of Funding: Procurement

Type of Action: Public procurement

Indicative timetable: Calls for tender launch in 2nd quarter 2021 – duration of contracts: 1.5 years

Indicative budget: EUR 0.50 million from the 2021 budget

11. Response to lessons-learnt from recent accidents / incidents in air transport [195]

Specific challenges:

The investigations of recent incidents and accidents in commercial aviation have raised the need to enhance further the end-to-end verification of complex systems, evolve airworthiness and flight standards, detect potential faults and improve the survivability of occupants in case of accidents.

Scope:

The targeted actions focus on specific safety issues, for which no new technological development will be undertaken but, building on previous research and innovation actions, the relevant changes to the aviation safety standards will be prepared and coordinated with stakeholders:

- Further develop the understanding of complex errors in critical or automated aircraft systems (e.g. air sensors, flight controls and the applicability of new techniques for design verification and real-time fault detection);
- Understand the risks for fire and smoke from lithium batteries in aircraft cabin, refinement of operational standards and procedures to mitigate these;
- Develop comprehensive analysis and gather representative data for the assessment of aircraft evacuation issues, particularly for helicopter and VTOL ditching on water.

Contribution to EASA activities:

- Evolution of airworthiness standards (risk mitigations and regulatory compliance demonstration);
- Address EU MS safety investigation authority safety recommendations.

[195] This activity directly aimed at supporting the development and implementation of evidence base for R&I policies and supporting various groups of stakeholders is excluded from the delegation to Executive Agencies and will be implemented by the Commission services.

Impact:

- Introduction of innovative methods and solutions for safety management;
- Improvement of the European aviation safety system;
- Reinforcement of EU industry's leading position due to safety technologies.

Results needed by: 2023

Form of Funding: Procurement

Type of Action: Public procurement

Indicative timetable: 1st quarter 2022

Indicative budget: EUR 3.40 million from the 2022 budget

12. Safety standards for the introduction of key concepts and technologies[196]

Specific challenges:

Technological innovation for air transport requires the comprehensive evaluation of benefits, constraints, standardisation and deployment issues. Often, before new product approval, Aviation Authorities need to re-assess existing safety standards and certification processes to ensure their applicability to new technologies. Here the absence of up-front dedicated safety assessment and relevant data raises the risk of delaying deployment, or worse creating safety gaps with new products and processes. This research action concerns preparation for the safe introduction of several new concepts (reduced crew or single crew operations) and technologies (big data technologies, artificial intelligence, drones and U-Space) culminating with new or evolved aviation standards and regulations, encompassing aircraft system certification methods and tools, operational procedures and flight training processes and systems.

Scope:

The targeted actions focus on specific safety issues, for which no new technological development will be undertaken but, building on previous research and innovation actions, the relevant changes to the aviation safety standards will be prepared and coordinated with stakeholders:

- Risk assessment framework for reduced crew and single crew operational concepts;
- Development of certification standards supporting the introduction of artificial intelligence techniques for safety-critical aviation applications;

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- Introduction of new technologies for flight training devices (rules adaptation);
- New safety standards for drone autonomous operations and U-Space services.

Contribution to EASA activities: Evolution of airworthiness and flight standards

Impact: Support of EU citizens and industry stakeholders through the safe and streamlined deployment of innovative products and operations

Results needed by: 2023-2024

Form of Funding: Procurement

Type of Action: Public procurement

Indicative timetable: 1st quarter 2022

Indicative budget: EUR 3.40 million from the 2022 budget

13. Solutions for runway safety [197]

Specific challenges:

With the forecasted increase of traffic the importance of maintaining the highest levels of safety standards for runway operations remains paramount, in particular to address the risks of aircraft runway collisions and excursions. These risks are part of the key risk areas for commercial air transport as reported from the EASA Annual Safety Review. The underlying issues include technical and operational issues, for instance the incomplete situational awareness for dense traffic runway operations, the gaps in solutions for the monitoring of runway surface conditions and the entry of erroneous flight parameters by crews.

This research action will build upon previous developments for the prevention and mitigation of runway accidents, such as those undertaken by the SESAR Programme and the EREA Future Sky Safety initiative, and will align with joint action plans prepared by aviation stakeholders for the prevention of runway incursions or excursions.

Scope:

The targeted actions focus on specific safety issues, for which no new technological development will be undertaken but, building on previous research and innovation actions, the relevant changes to the aviation safety standards will be prepared and coordinated with stakeholders:

- Consolidation of best-practice and issues for the implementation of the ICAO 'triple one' concept (one runway, one frequency, one language);

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- Introduction of new technologies for runway state assessment (assessing runway micro-texture);
- Enable mitigating means for frequent causes of incidents such as the entry of erroneous take-off parameters.

Contribution to EASA activities:

- Contribution to Best Intervention Strategies;
- Evolution of safety standards.

Impact:

- Improved technology and operations for the EU aviation industry;
- Reduction of runway incidents / accidents.

Results needed by: 2023

Form of Funding: Procurement

Type of Action: Public procurement

Indicative timetable: 1st quarter 2022

Indicative budget: EUR 2.10 million from the 2022 budget

14. Standards supporting the digital transformation of aviation[198]

Specific challenges:

The fast-paced digital transformation observed in several industrial sectors is extending to aviation and air transport. The need to anticipate the changes and evolutions of aviation standards requires timely and upstream investigation, through several case studies, of the application of radically new concepts and processes for aviation products, processes and operations (such as machine-learning techniques, 'internet of things'). This includes developing capabilities such as tools and methods for design, simulation (digital twins), verification and validation and their application to aircraft certification, regulatory approval and safety monitoring processes.

Scope:

The targeted actions focus on specific safety issues, for which no new technological development will be undertaken but, building on previous research and innovation actions, the

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relevant changes to the aviation safety standards will be prepared and coordinated with stakeholders:

- Develop a robust safety risk assessment methodology to support the identification and consolidation of safety hazards and their mitigation using numerical tools (the 'digital twin' concept);
- Prepare the roadmap for the next evolution(s) of airworthiness and maintenance standards for new digital applications and validate the new capabilities for the associated performance and risk assessment.

Contribution to EASA activities: Roadmap for the changes to aviation standards

Impact: EU preparedness for the deployment of digital innovation in aviation and air transport

Results needed by: 2024

Form of Funding: Procurement

Type of Action: Public procurement

Indicative timetable: 1st quarter 2022

Indicative budget: EUR 2.10 million from the 2022 budget

15. Development of new aviation health safety standards (for flight crews) [199]

Specific challenges:

Current aviation standards have been built with duly consideration to occupational safety and health conditions affecting flight crew members. Nevertheless the lack of a comprehensive investigation centred on actual air transport operations of the potential hazards, incidents, causes and the appropriate mitigations, including new health monitoring solutions, represent a major obstacle for the evolution of those standards.

In particular the monitoring of the impact of diseases or health issues during the career of aviation professionals requires the investigation of the state-of-the-art of medical research developments, the development of extensive health data sets and the validation of solutions for use in an aviation environment.

As an example, a review of the current examination process of pilots living with HIV and HIV treatment revealed a lack of specific research on this subject.

- Scope: Comprehensive assessment of health risks for aviation professionals in the fields of cardiovascular diseases and mental health, incl. risks following COVID-19 infection;

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- Investigation of aviation health safety issues (causes, incidence, mitigations) in the context of aircraft cabin environment, including air contamination events;
- Evaluation of innovative solutions for health monitoring and protection in the context of aircraft operations;
- Evolution of aeromedical standards for aviation professionals, including solutions for health monitoring of aviation professionals during their career, for pilots living with HIV.

Contribution to EASA activities:

- Evolution of aeromedical standards;
- Comprehensive assessment of health safety risk and mitigations for air transport.

Impact:

- Development of international health safety standards for air transport;
- Clarity and improvement of conditions for the EU aviation sector.

Results needed by: 2023-2024

Form of Funding: Procurement

Type of Action: Public procurement

Indicative timetable: 1st quarter 2022

Indicative budget: EUR 1.70 million from the 2022 budget

16. Impact of security measures on safety

Specific challenges:

The implementation of aviation security measures can have a direct impact on safety aspects of aerodrome or aircraft operations. Airport security, aircraft security, cargo and mail or inflight security are the areas where interdependencies are highly visible and where any security requirements should also consider possible impacts on and potential contribution to aviation safety.

The research action aims to provide new methods, tools and data for the effective performance of safety analysis while considering security measures, involving the different stakeholders concerned and to support the preparation of the evolutions needed in safety standards and in the aviation regulatory framework.

Scope:

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- Assessment of the impact of security requirements on operational safety and performance, including development of new solutions and tools to ensure efficient assessment in the early phases of development.

Contribution to EASA activities: Impact analysis of security requirements on safety standards

Impact:

- Enhanced standards for EU aviation industry;
- Contribution to international aviation standards.

Results needed by: 2023-2024

Form of Funding: Procurement

Type of Action: Public procurement

Indicative timetable: 1st quarter 2022

Indicative budget: EUR 1.50 million from the 2022 budget

17. Study on gender balance in the R&I field in Europe and how to improve the role of women in the energy transition

The study will investigate the gender balance in the R&I field in Europe and assess how to improve the role of women in the energy transition decision making process and in access to new employment opportunities: barriers, good practices and recommendations.

Form of Funding: Procurement

Type of Action: Public procurement

Indicative timetable: 3rd quarter 2021

Indicative budget: EUR 0.90 million from the 2021 budget

18. Study on circular approaches for a sustainable and affordable clean energy transition

The study will investigate the horizontal nature of circularity, proposing a holistic view (circularity + sustainability + clean energy transition + increasing EU resilience and autonomy in technologies).

Form of Funding: Procurement

Type of Action: Public procurement

Indicative timetable: 2nd quarter 2022

Indicative budget: EUR 0.90 million from the 2022 budget

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19. Organisation and operation the Grand Final event for the EIC Prize Fuel From the Sun[200]

To contribute to the organisation and operation of the Grand Final event for the EIC Prize Fuel From the Sun, that is part of the final assessment of the applications.

Form of Funding: Procurement

Type of Action: Public procurement

Indicative timetable: 3rd quarter 2021

Indicative budget: EUR 0.05 million from the 2021 budget

20. Support to the development, implementation, monitoring and evaluation of climate, energy and mobility research and innovation policy activities[201]

The action will focus on three types of activities:

- Technical assistance, and economic and policy analysis to support various aspects of the research and innovation policy relevant in climate, energy and mobility and related sectors.
- Communication activities, such as events and publications, that could support dissemination of knowledge and information to interested organisations and individuals, as well as development of new forms of cooperation and information exchange between interested organisations and individuals.
- Supporting new forms of innovation in the climate, energy and mobility sectors, as well as new forms of supporting innovation, e.g. start-up support, new business models, new financing instruments, cooperation with organisations outside the climate, energy and mobility sectors., supporting innovation investment communities and intermediaries.

Form of Funding: Procurement

Type of Action: Public procurement

Indicative timetable: as of 2nd quarter 2021 and as of 1st quarter 2022

Indicative budget: EUR 1.00 million from the 2021 budget and EUR 1.00 million from the 2022 budget

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Subscription actions

1. Contribution to Technology Collaboration Programmes (TCPs) of the International Energy Agency (IEA)[202]

The Commission represents the European Union in the Technology Collaboration Programmes (TCPs) concluded under the framework of the International Energy Agency where it participates in activities in certain areas of energy research. The annual financial contributions will be paid to the entities responsible for managing the following TCPs:

- Geothermal;
- Bioenergy;
- Ocean Energy Systems;
- International Smart Grids Action Network (ISGAN);
- Greenhouse Gas R&D;
- Concentrated Solar Power;
- Photovoltaic Power Systems;
- Solar Heating and Cooling;
- Clean Coal Centre;
- Wind Energy Systems;
- Renewable Energy Technology Deployment;
- Hydropower;
- Gas and Oil Technologies;
- Energy Efficient End-Use Equipment (4E);
- Clean Energy Education and Empowerment (C3E).

Type of Action: Subscription action

Indicative timetable: as of 1st quarter 2021, as of 1st quarter 2022

Indicative budget: EUR 0.45 million from the 2021 budget and EUR 0.45 million from the 2022 budget

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2. International Partnership for Hydrogen and Fuel Cells in the Economy [203]

The Commission represents the European Union in the International Partnership for Hydrogen and Fuel Cells in the Economy. The annual financial contribution will be paid to the entity responsible for managing it.

Type of Action: Subscription action

Indicative timetable: as of 1st quarter 2021, as of 1st quarter 2022

Indicative budget: EUR 0.05 million from the 2021 budget and EUR 0.05 million from the 2022 budget

3. Voluntary contribution to the CEM Secretariat for Phase III (July 2022 – June 2025) and to participation in its initiatives and campaigns[204]

While the Commission has been active in the Clean Energy Ministerial (CEM) since its inception in 2010, the European Union formally became a member on 6 June 2016 when the EU Energy Ministers formally endorsed the CEM Framework Document. This Framework Document is a combination of political commitment and more detailed procedural arrangements of the co-operation, but does not create any legal or financial obligations under domestic or international law.

The CEM Framework Document establishes a multilateral CEM Secretariat to facilitate the long-term engagement of all CEM Members in the work of the CEM. This is hosted at the International Energy Agency (IEA) under an "Administrative Arrangement" between the IEA and CEM Members. In order to provide "adequate and predictable financial resources" for the CEM Secretariat, CEM Members are encouraged to provide voluntary contributions on an annual or multi-annual basis.

The CEM consists of major economies that, together with the European Commission on behalf of the EU, are aiming to accelerate the global clean energy transition. Together they have the potential for making a major impact as they represent about 90% of global clean energy investment and 75% of global greenhouse gas emissions.

The Commission has already expressed political support to extending the mandate of CEM from Phase II (July 2019-June 2022) to Phase III (July 2022-June 2025). Preparations of this new mandate (also referred to as CEM3.0) are underway with the Commission's active participation in the CEM Steering Committee.

Under CEM, groups of member countries may create, engage in and provide voluntary financial contributions for initiatives and campaigns to advance specific CEM objectives. The

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Commission currently co-leads and supports financially the operating agents of the following initiatives: the Super-efficient Equipment and Appliance Deployment (SEAD) initiative (50.000 EUR/year) and the Hydrogen initiative (20.000 EUR/year); and it is in the process of joining the Equal by 2030 campaign (10.000 EUR/year).

Type of Action: Subscription action

Indicative timetable: Q2/Q3 2022 for the CEM Secretariat, and Q2/Q3 2021 and 2022 for the CEM initiatives and campaign

Indicative budget: EUR 0.08 million from the 2021 budget and EUR 0.68 million from the 2022 budget

4. IEA (EE HUB)[205]

The purpose of the International Partnership for Energy Efficiency Cooperation (IPEEC) is to strengthen international cooperation on energy efficiency. The action carried out under the auspices of the Partnership should result in more effective energy policy and programme output, in best practices being more widely known, disseminated and applied and in economies of scale. The aim of the Partnership is to offer a topic-driven, structured dialogue and an operational network for enhanced cooperation and exchanges on energy efficiency between countries and international organisations by:

- exchanging information and experience on development of regulatory measures, policies and programmes;
- developing benchmarks and sharing information on goods and services, along with measurement methods regarding energy performance and energy savings;
- strengthening information, education and training for energy consumers;
- building stakeholder capacity by improving contacts between national, regional and local authorities and other relevant partners and stakeholders, exchanging views and sharing knowledge and experience.

Type of Action: Subscription action

Indicative budget: EUR 0.08 million from the 2021 budget

[205] This activity directly aimed at supporting the development and implementation of evidence base for R&I policies and supporting various groups of stakeholders is excluded from the delegation to Executive Agencies and will be implemented by the Commission services.

5. Contribution to the International Renewable Energy Agency[206]

The European Union is a member of IRENA. According to the organisation's Statute and Financial Regulation this implies the obligation to pay an annual contribution to its budget covering the participation of the EU in IRENA's activities. IRENA's main objective is to disseminate best practices in the field of renewables as the principal platform for international cooperation in the field, a centre of excellence on renewable energy and a repository of policy, technology, resource and financial knowledge. This includes:

- The promotion of the widespread and increased adoption and the sustainable use of all forms of renewable energy globally, including in the EU, in particular to bring down costs and also to increase market experience, in order to contribute to economic growth and social cohesion as well as access to and security of energy supply;
- Support activities for countries in their transition to a renewable energy future;
- Reducing of barriers for renewable energy, stimulating best practice and raising awareness.

Type of Action: Subscription action

Indicative budget: EUR 0.56 million from the 2021 budget and EUR 0.56 million from the 2022 budget

Scientific and technical services by the Joint Research Centre

1. Clean Energy Technology Observatory[207]

Development of a Clean Energy Technology Observatory that will monitor the EU research and innovation activities on clean energy technologies needed for the delivery of the European Green Deal; and will assess the competitiveness of the EU clean energy sector – and its positioning in the global energy market. It will build on the previous Low Carbon Energy Observatory and other related Commission activities.

Form of Funding: Direct action grants

Type of Action: Provision of technical/scientific services by the Joint Research Centre

Indicative timetable: 3rd quarter 2021

Indicative budget: EUR 5.00 million from the 2021 budget

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2. Energy markets analysis[208]

To use and further enhance the METIS model for better understanding energy economy-environment interactions at national, EU and regional levels, with a particular emphasis on the detailed assessment of EU energy policy impacts on the power and gas systems and markets.

Form of Funding: Direct action grants

Type of Action: Provision of technical/scientific services by the Joint Research Centre

Indicative budget: EUR 0.50 million from the 2022 budget

3. Energy scenarios[209]

To use, further develop and maintain JRC's modelling capabilities for better understanding energy-economy-environment interactions at both the EU and global levels, with a particular emphasis on the detailed assessment of EU energy policy impacts. The tools to be developed, maintained and applied include POTEnCIA, GEME3 and POLES.

Form of Funding: Direct action grants

Type of Action: Provision of technical/scientific services by the Joint Research Centre

Indicative budget: EUR 0.50 million from the 2022 budget

4. Technical assistance for reviewing Annex V and VI in RED II[210]

There is a legal obligation to keep Annex V and Annex VI of the directive (EU) 2018/2001 (RED II) updated. JRC technical assistance is required to adding or revising values for biofuel, bioliquid and biomass fuel production pathways.

Form of Funding: Direct action grants

Type of Action: Provision of technical/scientific services by the Joint Research Centre

Indicative budget: EUR 0.10 million from the 2021 budget

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5. Smart specialisation for climate adaptation[211]

Provide guidance and support to EU regions and Member States in the development of smart specialisation strategies to unlock / identify links to EU Regional Funds to implement their climate adaptation plans and strategies contributing to a sustainable and inclusive growth. Development of specific synergetic actions in the area of climate adaptation among Horizon Europe, national research and innovation programmes, the EU Regional and cohesion programmes and the Next generationEU recovery instrument.

Form of Funding: Direct action grants

Type of Action: Provision of technical/scientific services by the Joint Research Centre

Indicative timetable: as of 2nd quarter 2021

Indicative budget: EUR 1.00 million from the 2021 budget

Expert contract actions

1. Experts for the monitoring of actions

This action will support the use of appointed independent experts for the monitoring of actions (grant agreement, grant decision, public procurement actions, financial instruments) and where appropriate include ethics checks.

Form of Funding: Other budget implementation instruments

Type of Action: Expert contract action

Indicative timetable: As of 1st quarter 2021 and 1st quarter 2022

Indicative budget: EUR 0.80 million from the 2021 budget and EUR 0.80 million from the 2022 budget

2. External expertise to advise on EU research and innovation policy[212]

This action will support the provision of independent expertise in support of the design, implementation and valorisation of EU research policy. Individual experts will work in the following domains:

- Analysis, design, assessment and implementation of strategic climate, energy and mobility research and technology options and actions

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- Future climate, energy and mobility -related research actions and programmes, contribution to their impact assessment.
- International cooperation in the field of climate, energy and mobility research and innovation.
- Analysis and valorisation of EU climate, energy and mobility research results in view of contributing to the elaboration of policy reports (such as projects for policy, project cluster reports, etc).

The tasks of individual experts would include:

- Analysis of the contribution of the funded research to the EU policy objectives spanning across all climate, energy and mobility modes and systems;
- Analysis of the state-of-the-art at international level; investigation of deployment options for the developed knowledge;
- Participation in international symposia, including the drafting of White Papers and reports on the symposia's conclusions;
- Advise the Commission on promising technologies covered by European and nationally funded projects and on ways to stimulate synergies.

In addition to individual experts, this action could provide for Commission expert groups.

Form of Funding: Other budget implementation instruments

Type of Action: Expert contract action

Indicative timetable: As of 2nd quarter 2021 and as of 1st quarter 2022

Indicative budget: EUR 0.80 million from the 2021 budget and EUR 1.00 million from the 2022 budget

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Budget[213]

	Budget line(s)	2021 Budget (EUR million)	2022 Budget (EUR million)
Calls			
HORIZON-CL5-2021-D1-01		136.00	
	from 01.020250	*136.00*	
HORIZON-CL5-2022-D1-01-two-stage			51.00
	from 01.020250		*51.00*
HORIZON-CL5-2022-D1-02			87.00
	from 01.020250		*87.00*
HORIZON-CL5-2021-D2-01		231.00	18.50
	from 01.020250	*231.00*	*18.50*
HORIZON-CL5-2022-D2-01			138.00
	from 01.020250		*138.00*
HORIZON-CL5-2021-D3-01		303.80	35.00
	from 01.020250	*303.80*	*35.00*
HORIZON-CL5-2021-D3-02		280.00	
	from 01.020250	*280.00*	
HORIZON-CL5-2022-D3-01			381.00
	from 01.020250		*381.00*

213 The budget figures given in this table are rounded to two decimal places.
The budget amounts are subject to the availability of the appropriations provided for in the general budget of the Union for years 2021 and 2022.

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HORIZON-CL5-2022-D3-02			99.00
	from 01.020250		*99.00*
HORIZON-CL5-2022-D3-03			127.50
	from 01.020250		*127.50*
HORIZON-CL5-2021-D4-01		66.00	
	from 01.020250	*66.00*	
HORIZON-CL5-2021-D4-02		38.00	
	from 01.020250	*38.00*	
HORIZON-CL5-2022-D4-01			54.00
	from 01.020250		*54.00*
HORIZON-CL5-2022-D4-02			86.00
	from 01.020250		*86.00*
HORIZON-CL5-2021-D5-01		258.00	
	from 01.020250	*258.00*	
HORIZON-CL5-2022-D5-01			253.00
	from 01.020250		*253.00*
HORIZON-CL5-2021-D6-01		167.00	
	from 01.020250	*167.00*	
HORIZON-CL5-2022-D6-01			122.00
	from 01.020250		*122.00*
HORIZON-CL5-2022-D6-02			91.00

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	from 01.020250		*91.00*
Contribution from this part to call HORIZON-MISS-2021-CLIMA-01 under Part 12 of the work programme		2.50	
	from 01.020250	*2.50*	
Contribution from this part to call HORIZON-MISS-2021-OCEAN-01 under Part 12 of the work programme		2.50	
	from 01.020250	*2.50*	
Contribution from this part to call HORIZON-MISS-2021-CIT-01 under Part 12 of the work programme		4.00	
	from 01.020250	*4.00*	
Contribution from this part to call HORIZON-MISS-2021-DEPL-01 under Part 12 of the work programme		0.58	
	from 01.020250	*0.58*	
Other actions			
Grant to identified beneficiary according to Financial Regulation Article 195(e)		4.25	5.00
	from 01.020250	*4.25*	*5.00*
Public procurement		7.57	23.47
	from 01.020250	*7.57*	*23.47*
Subscription action		1.22	1.74
	from 01.020250	*1.22*	*1.74*
Provision of technical/scientific services by the Joint Research Centre		6.10	1.00
	from 01.020250	*6.10*	*1.00*
Expert contract action		1.60	1.80
	from 01.020250	*1.60*	*1.80*
		1.00	

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Contribution from this part to Provision of technical/scientific services by the Joint Research Centre under Part 12 of the work programme	*from 01.020250*	*1.00*	
Contribution from this part to Indirectly managed action under Part 12 of the work programme		0.63	
	from 01.020250	*0.63*	
Contribution from this part to Public procurement under Part 12 of the work programme		0.58	
	from 01.020250	*0.58*	
Contribution from this part to Expert contract action under Part 12 of the work programme		0.44	
	from 01.020250	*0.44*	
Estimated total budget		1512.77	1576.01

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