"Research and Innovation Opportunities for a fossil-free Europe"

A SUNERGY & CO_2 VALUE EUROPE joint brokerage event on EU funding

29 April 2021, 13:00 – 16:15 (CET)

With the Green Deal and the Climate Law, the European Union (EU) has strongly engaged to take the global lead in mitigating climate change. To serve this effort, numerous initiatives and funding opportunities are arising to support R&I towards a more sustainable and fossil-free industry.

SUNERGY and CO_2 Value Europe are co-organising a brokerage virtual event to present and discuss EU funding opportunities related to Carbon Capture and Utilisation (CCU) and fossil free fuels, chemicals and materials.

The event will take place on **Thursday, the 29th of April 2021 from 1pm to 4:15pm (CET)** and will include presentations of the new Horizon Europe program as well as the Innovation Fund. Moreover, participants will be given the opportunity to pitch their ideas and to participate in match-making bilateral conversations and round-table discussions during the last hour of the event.

For more information, see agenda below.

The booklet:

The booklet, prepared by CO_2 Value Europe and SUNERGY, gathers the Funding Opportunities that Horizon Europe and the European Innovation Council offer in the areas of ***Carbon Capture and Utilisation (CCU) and fossil-free fuels & chemicals.***

The aim of the booklet is to help the event's participants navigating the many opportunities offered, identifying the ones that apply to the topics of the workshop. More information, such as eligibility criteria, can be found consulting the entire Work Programme of Horizon Europe.

Agenda:

Session content	Speaker	Time	Approx. duration
Welcome & introduction	Anastasios Perimenis, Secretary General, CVE	5 min	1 - 2 pm
About CO_2 Value Europe	Célia Sapart, Director Communications & Climate Science, CVE	8 min	
About SUNERGY	Bert Weckhuysen, Utrecht University, SUNERGY Coordinator	8 min	
Horizon Europe: overall approach & vision	Søren Bowadt, Deputy Head of Unit, European Health & Digital Executive Agency	15 min	
EIC Challenge based calls on Green Technologies	Francesco Matteucci and Marco Antonio Pantaleo, EIC Greentech Programme Managers	10 min	
Presentation of Innovation Fund	Maria Velkova, Policy Officer, Finance for Low Carbon Innovation, DG CLIMA	10 min	
Q&As		5 min	
Break		10 min	2 - 2.10 pm
Presentation of most relevant calls in Horizon Europe cluster 4 & 5	Frédéric Chandezon, CEA, SUNERGY Deputy Coordinator	20 min	2.10 - 3 pm
Pitches	~ 8 pitches foreseen	30 min	
Networking meetings + breakout sessions (Conversation Starter platform)	All speakers and participants		3 - 4 pm
Conclusions & next steps	SUNERGY & CVE		4 - 4.10 pm
Moderator: Anastasios Perimenis, Secretary General, CVE			

About the organisers:

SUNERGY is a pan-European research and innovation platform that gathers science, industry and other key players to work towards the conversion and storage of renewable energy into fossil-free fuels and chemicals to reach a climate neutral Europe.

CO_2 Value Europe is a non-profit organization representing the Carbon Capture and Utilisation (CCU) community in Europe. Its mission is to promote the development of sustainable industrial solutions that convert CO_2 into valuable products (materials, fuels or chemicals) to mitigate climate change and move away from fossil resources.

Horizon Europe Funding Opportunities

Carbon Capture and Utilisation (CCU) and fossil-free fuels & chemicals

Disclaimer: The topics appearing below have not yet been officially adopted by the European Commission and are subject to changes.

Topics marked with SUNERGY are particularly relevant for the ramp-up phase of the SUNERGY Initiative.

For further information, don't hesitate to reach out to CO_2 Value Europe (contact@co2value.eu) and SUNERGY (contact@sunergy-initiative.eu) colleagues.

Topics 2021	Opening	Deadline	Type	TRL (start)	TRL (end)	Budget (proposal)	Budget (topic)
HORIZON-CL4-2021-RESILIENCE-01-11 Safe- and sustainable-by-design polymeric materials	15/04/21	23/09/21	RIA	3	5	4-5 M€	19 M€
HORIZON-CL4-2021-RESILIENCE-01-14 Development of more energy efficient electrically heated catalytic reactors	15/04/21	23/09/21	IA	4/5	6	7-10 M€	33 M€
HORIZON-CL4-2021-RESILIENCE-01-16 Creation of an innovation community for solar fuels and chemicals	15/04/21	23/09/21	CSA	-	-	3-4 M€	4 M€
HORIZON-CL4-2021-RESILIENCE-01-17 Advanced materials for hydrogen storage	15/04/21	23/09/21	RIA	3	5	4-6 M€	21 M€
HORIZON-CL4-2021-TWIN-TRANSITION-01-11 Automated tools for the valorisation of construction waste	15/04/21	23/09/21	RIA	4	6	6-10 M€	21 M€
HORIZON-CL4-2021-TWIN-TRANSITION-01-14 Deploying industrial-urban symbiosis solutions for the utilization of energy, water, industrial waste and by-products at regional scale	15/04/21	23/09/21	RIA	4	6	8-12 M€	27.5 M€
HORIZON-CL4-2021-TWIN-TRANSITION-01-22 Adjustment of Steel process production to prepare for the transition towards climate neutrality	15/04/21	23/09/21	IA	6	8	4-5 M€	14 M€
HORIZON-CL5-2021-D2-01-08 Emerging technologies for a climate neutral Europe	15/04/21	19/10/21	RIA	-	4	2.5 M€	20 M€
HORIZON-CL5-2021-D2-01-10 Technologies for non-CO2 greenhouse gases removal	15/04/21	19/10/21	RIA			2-3 M€	15 M€ [1]
HORIZON-CL5-2021-D2-01-11 Direct atmospheric carbon capture and conversion	15/04/21	19/10/21	RIA	-	4/5	2-3 M€	15 M€ [1]
HORIZON-CL5-2021-D3-01-02 Sustainability and educational aspects for renewable energy and renewable fuel technologies	15/04/21	26/08/21	CSA	-	-	2.5 M€	10 M€
HORIZON-CL5-2021-D3-01-15 Integration of CCUS in hubs and clusters, including knowledge sharing activities	15/04/21	26/08/21	CSA	-	-	2 M€	2 M€
HORIZON-CL5-2021-D3-01-16 Cost reduction of CO_2 capture (new or improved technologies)	15/04/21	26/08/21	RIA	-	6	10-15 M€	30 M€
HORIZON-CL5-2021-D3-01-18 Support to the activities of the ETIPs and technology areas of the SET Plan	15/04/21	26/08/21	CSA	-	-	1 M€	9.8 M€
HORIZON-CL5-2021-D3-02-02 Next generation of renewable energy technologies	02/09/21	05/01/22	CSA	-	3/4	3 M€	33 M€
HORIZON-CL5-2021-D3-02-03 Hybrid catalytic conversion of renewable energy to carbon-neutral fuels	02/09/21	05/01/22	RIA	-	3/4	3.3 M€	10 M€
HORIZON-CL5-2021-D3-02-09 Carbon-negative sustainable biofuel production	02/09/21	05/01/22	RIA	-	4/5	5 M€	15 M€

HORIZON-CL5-2021-D3-02-16 Innovative biomethane production as an energy carrier and a fuel	02/09/21	05/01/22	IA	-	6/7	10 M€	20 M€
HORIZON-CL6-2021-CIRCBIO-01-09 Unlocking the potential of algae for a thriving European blue bioeconomy	15/04/21	01/09/21	IA	-	7	9 M€	18 M€
HORIZON-EIC-2021-PATHFINDERCHALLENGES-01 Novel routes to green hydrogen production	08/04/21	27/10/21	RIA	-	1-4	3-4 M€	133.6 M€ [2]
HORIZON-EIC-2021-TRANSITIONCHALLENGES-01 Energy harvesting and storage technologies	19/05/21	22/09/21	RIA	4	5/6	2.5 M€	40.85 M€ [3]
HORIZON-EIC-2021-ACCELERATORCHALLENGES-01 Green Deal innovations for the economic recovery	08/04/21	09/06/21, 06/10/21	IA	5/6	8	Blended [4]	507.2 M€ [5]

[1] Shared with 3 topics; [2] Shared with 5 topics; [3] Shared with 2 topics; [4] up to 2.5 M€ grant for technology development and validation, 0.5 -15 M€ investment for scaling up and other activities; [5] Shared with 2 topics

Topics 2022	Opening	Deadline	Type	TRL (start)	TRL (end)	Budget (proposal)	Budget (topic)
HORIZON-CL4-2022-RESILIENCE-01-14 Membranes for gas separations - membrane distillation	15/10/21	30/03/22	IA	4	7	6-8 M€	21 M€
HORIZON-CL4-2022-TWIN-TRANSITION-01-11 Valorisation of CO/CO_2 streams into added-value products of market interest	12/10/21	30/03/22	IA	5	7	12-18 M€	40 M€
HORIZON-CL4-2022-TWIN-TRANSITION-01-15 New electrochemical conversion routes for the production of chemicals and materials in process industries (RIA)	12/10/21	30/03/22	RIA	3/4	5/6	8-12 M€	28 M€
HORIZON-CL5-2022-D1-01-01-two-stage Carbon Dioxide Removal (CDR) approaches	12/10/21	10/02/22 (1) 27/09/22 (2)	RIA	-	-	7 M€	21 M€
HORIZON-CL5-2022-D3-01-15 Decarbonising industry with CCUS	14/10/21	23/02/22	IA	-	7/8	29 M€	58 M€
HORIZON-CL5-2022-D3-02-03 Innovative renewable energy carrier production for heating from renewable energies	26/05/22	27/10/22	IA	-	7	10 M€	10 M€
HORIZON-CL5-2022-D3-02-04 Technological interfaces between solar fuel technologies and other renewables	26/05/22	27/10/22	RIA	-	4	3-5 M€	10 M€
HORIZON-CL5-2022-D3-02-05 Renewable energy carriers from variable renewable electricity surplus and carbon emissions from energy consuming sectors	26/05/22	27/10/22	IA	-	7	10 M€	20 M€
HORIZON-CL5-2022-D3-02-06 Direct renewable energy integration into process energy demands of the chemical industry	26/05/22	27/10/22	RIA	-	4/5	3-5 M€	10 M€
HORIZON-CL5-2022-D3-02-08 Demonstration of complete value chains for advanced biofuel and non-biological renewable fuel production	26/05/22	27/10/22	IA	-	6/7	10 M€	20 M€
HORIZON-CL5-2022-D3-03-03 Efficient and circular artificial photosynthesis	06/09/22	10/01/23	RIA	-	5	3-5 M€	10 M€
HORIZON-CL5-2022-D3-03-07 Development of algal and renewable fuels of non-biological origin	06/09/22	10/01/23	RIA	-	4/5	5 M€	15 M€
HORIZON-CL6-2022-CIRCBIO-02-04-two-stage Photosynthesis revisited: climate emergency, "no pollution and zero-emission" challenge and industrial application	28/10/21	15/02/22 (1) 01/09/22 (2)	RIA	-	4/5	6 M€	6 M€

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Topics 2021-2022

This booklet has been prepared by CO2 Value Europe and SUNERGY to provide information on the Funding Opportunities that Horizon Europe offers in the areas of ***Carbon Capture and Utilisation (CCU) and fossil-free fuels & chemicals***.

The topics appearing in this booklet are publicly available, but have not yet been officially endorsed by the European Commission, therefore changes may appear in the final official publication.

The booklet is not exhaustive and presents the topics that are of closest relevance to these areas from Horizon Europe Clusters 4 (Digital, Industry and Space), 5 (Climate Energy and Mobility), 6 (Food, Bioeconomy, Natural Resources, Agriculture and Environment) and the European Innovation Council (EIC). Further topics, not appearing in this booklet, may also contain elements of interest in these areas.

Stakeholders are invited to consult in detail the entire Work Programmes of Horizon Europe, when they are officially published. The official Work Programmes will also describe any specific conditions of eligibility that may apply per topic.

For further information, don't hesitate to reach out to CO_2 Value Europe (contact@co2value.eu) and SUNERGY (contact@sunergy-initiative.eu) colleagues.

HORIZON-CL4-2021-RESILIENCE-01-11: Safe- and sustainable-by-design polymeric materials

Opening - Deadline	Type	TRL	Budget (proposal)	Budget (topic)
15/04/2021 – 23/09/2021	RIA	From 3 to 5	4-5 M€	19 M€

Expected outcome

The way plastics are currently made, used and discarded, fails to capture the economic, environmental and societal benefits of a more sustainable approach. Europe produces 25 million tons of plastic waste annually, less than 30% is recycled. Moreover, plastic production, use and disposal may result in the release of chemicals, which may give rise to health and environmental problems. The development of a common understanding and the transition to safe- and sustainable-by-design materials, including plastics, is a societal urgency.

Projects are expected to contribute to the following outcomes:

- Recyclable-by-design polymers with inherent recyclability properties for polymers where nowadays recyclability challenge is high;
- Safer (lower toxicity) plastics, with less reliance on potentially harmful additives;
- Reduced environmental footprint associated with the end-of-life phase of the polymers due to increased recyclability and /or reduced reliance on potentially harmful additives, compared with existing products for similar applications;
- Contribute to the development of safe- and sustainable-by-design criteria and guiding principles and apply them to polymers;
- Identification of priorities for substitution of plastic additives;
- New technologies and business opportunities for recycling industry across EU.

Scope

Thanks to their versatility, polymeric materials are used in a wide range of applications from consumer goods and construction to aerospace. The proposals should focus on:

- The design and development of new recyclable polymer systems substituting/improving nowadays difficult to recycle polymers e.g. PVC, thermosets or multicomponent (multilayer or blend) polymers;
- The design and development of safer plastics with less reliance on potentially harmful additives, e.g. plasticizers. The approach should allow to decrease their health and environmental impact and improve the purity of the secondary raw material and thus the quality of recycled plastic without compromising the material optimal properties and functionality;
- Carrying out an inventory of additives detected in plastics and their function and toxicity;
- Integration of safe- and sustainable-by-design aspects, including safety (toxicity), circularity and functionality of advanced polymeric materials, products and processes throughout their lifecycle.

The proposals, activities and approaches should cover both - specific considerations for the plastics under study, as well as developing overarching best practices that spans broader sectors of safe- and sustainable-by-design plastics. Proposals should involve all the actors in the value chain from the chemical and material industry, to formulators, recyclers and regulators. Areas for research include the intersection between chemicals and waste legislation.

Proposals submitted under this topic should include a business case and exploitation strategy, as outlined in the introduction to this Destination.

Leveraging the extensive experience from relevant initiatives and aligning with other EU-funded projects targeting safe- and sustainable- by-design materials, in particular under CSA topic HORIZON-CL4-RESILIENCE-2021-01-08, is essential.

In line with the European Union's strategy for international cooperation in research and innovation, international cooperation is encouraged.

The project partners shall make provisions to actively participate in the common activities of the large-scale research initiative on Fossil-free fuels and chemicals for a climate-neutral Europe.

The topic is open for international cooperation where the EU has reciprocal benefit.

HORIZON-CL4-2021-RESILIENCE-01-14: Development of more energy efficient electrically heated catalytic reactors

Opening - Deadline	Type	TRL	Budget (proposal)	Budget (topic)
15/04/2021 – 23/09/2021	IA	From 4/5 to 6	7-10 M€	33 M€

Expected outcome

A shift from fired- to electrically-heated catalytic reactors, powered by renewables will lead to a large decrease in CO2 emissions, coupled with a significant process intensification. As currently reactors are kept at high target temperatures in industrial-scale catalytic processes with energy supplied by the combustion of fossil fuels, substitution of fossil-fuel-derived heating with an emissions-free alternatives will substantially contribute to the greening of large industries. This requires the re-design of the reactor and in parallel with the development of novel catalysts as well as integration of up and downstream processes to operate with optimal energy efficiency and product yield.

Projects are expected to contribute to the following outcomes:

- A breakthrough reduction in carbon footprint for a given reaction (CO2 emission reduction > 40%, demonstrated by LCA or similar studies);
- Demonstrate a significant process intensification (a reactor size reduction of > 50% with respect to the state-of-the-art conventional approach) and industrial scalability;
- Environmental and techno-economic feasibility of novel catalytic reactor technologies and catalyst materials demonstrated and validated at suitable scale against current industrial processes to produce the same products;
- Integrated development methodology of catalysts and reactors for an optimized design up to pilot unit of novel catalytic reactors with significant carbon footprint reduction and allowing relevant process intensification, while maintaining cost competitiveness;
- Advanced catalytic reactor concepts to operate in synergy with alternative energy resources like e.g. non-thermal plasma.

Relevant indicators and metrics, with baseline values, should be clearly stated in the proposal.

Scope

Proposals should address an integrated development of:

- The next generation of industrially scalable and robust reactor technologies and associated catalytic materials for an electrified chemical production with an optimized design, up to pilot unit;
- Environmental and techno-economic impact studies should be part of the objectives to demonstrate the industrial feasibility and integration within the value chain of production and use of renewable energy sources.
- Solutions allowing the combined use of renewable energy resources with process intensification should be investigated in order to optimise energy efficiency, product yield and purity as an integrated part of the total process.

Proposals submitted under this topic should include a business case and exploitation strategy, as outlined in the introduction to this Destination.

Synergies are possible with any relevant projects from topics HORIZON-CL4-2021-RESILIENCE-01-16, HORIZON-CL4-2022-TWIN-TRANSITION-01-15, HORIZON-CL5-2021-D3-02-03, and HORIZON-CL5-2022-D3-03-03, and respective cooperation activities are encouraged

The topic is open for international cooperation where the EU has reciprocal benefit, while excluding industrial competitors from countries where the safeguarding of IPRs cannot be guaranteed.

HORIZON-CL4-2021-RESILIENCE-01-16: Creation of an innovation community for solar fuels and chemicals

Opening - Deadline	Type	TRL	Budget (proposal)	Budget (topic)
15/04/2021 – 23/09/2021	CSA	-	3-4 M€	4 M€

Expected outcome

Creation of an innovation eco-system gathering the various elements necessary to accelerate the development in the area of introduction of solar fuels and chemicals. This will require a strict synergy of actions between all stakeholder components, from R&D to industry and society, in order to foster their introduction. In addition, the development of solar fuels and chemicals requires a full redesign of the current technologies and processes based on fossil fuels, and the technological gap is a main factor limiting their introduction.

Projects are expected to contribute to the following outcomes:

- Solar fuels and chemicals constitute those products that are equivalent in terms of functionality to the ones currently in use based on fossil fuels, and thus well integrating within the existing infrastructure, but produced with the aid of renewable energy sources and with a disruptive decrease in terms of reduction of greenhouse gas emissions on LCA bases, larger than that based on biomass sources. They will play a crucial role to meet targets for decarbonizing Europe;
- Structuring/developing in the short term the European ecosystem in order to speed up technologies to move from the laboratory to industry;
- Tackle long-term research challenges in the field. This would be done mainly through the RIA & IA topics of the large-scale R&I initiative, as well as with actions at national and regional levels, with overall coordination by the CSA.

Scope

- Coordinating a large scale R&I initiative on storage of renewable (solar) energies in chemical form involving all relevant stakeholders (from academia, RTOs, industry and society) and linked with relevant international, national and local programmes and initiatives;
- Building and updating, a long-term roadmap;
- Building/structuring a gender balanced, inclusive community with all relevant stakeholders across EU;
- Participation of societal stakeholders to the activities of the community and initiative;
- Facilitating cooperation and communication between the stakeholders of the initiative on cross-cutting topics;
- Strengthening the engagement of the European industrial stakeholders in the long term beyond the CSA;
- Creating an innovation eco-system to foster and accelerate the technological, economic and societal impact of the initiative and pave the way to industrial exploitation of the technologies in the field of energy, transport and climate;
- Speeding-up and increasing the positive impacts of technologies on climate change and protection of environment;
- Spreading of S&T excellence across Europe and increase awareness of European activities;
- Addressing international cooperation in particular with other relevant actions (e.g. Mission Innovation);
- Preparing a large-scale research and innovation initiative beyond the CSA, as a partnership or another instrument to be discussed and agreed upon with the Commission and the Member States and Associated countries.

Synergies are possible with any relevant projects from topics HORIZON-CL4-2021-RESILIENCE-01-14, HORIZON-CL4-2022-TWIN-TRANSITION-01-15, HORIZON-CL5-2021-D3-02-03, and HORIZON-CL5-2022-D3-03-03, and respective cooperation activities are encouraged.

The project partners shall make provisions to actively participate in the common activities of the large-scale research initiative on Fossil-free fuels and chemicals for a climate-neutral Europe.

The topic is open for international cooperation where the EU has reciprocal benefit.

HORIZON-CL4-2021-RESILIENCE-01-17: Advanced materials for hydrogen storage

Opening - Deadline	Type	TRL	Budget (proposal)	Budget (topic)
15/04/2021 – 23/09/2021	RIA	From 3 to 5	4-6 M€	21 M€

Expected outcome

The benefits of a hydrogen based economy are well documented, since hydrogen is an abundant zero emission fuel, and possesses a higher energy density than conventional fossil fuels (e.g. petrol). However, safe hydrogen storage, either long or short term, faces several challenges. Chemical storage, fuel cells and liquefaction are all current means of hydrogen storage. Chemical storage is the prevailing method for long term storage due to the high storage density but the synthesis process needs further development to make it commercially attractive. Pressurised gaseous storage is the most attractive in practical terms but compression up to 700bar is needed to achieve practical volumetric storage capacities for transport applications, which requires expensive pressure vessels and is inherently dangerous. However, new approaches using ultra porous materials have demonstrated the feasibility of high storage densities of gaseous hydrogen at pressure of 100bar.

Projects are expected to contribute to the following outcomes:

- Provide commercially attractive and safe new technologies for long-term storage and transport of hydrogen;
- Enable efficient and safe hydrogen short term storage for example for fuel tanks for automobiles, rail vehicles, ships, airplanes, or stationary storage, etc., eliminating pollution caused by fossil fuels and facilitating the greening of transport;
- Elimination of economic dependence for EU's energy needs;
- Ability for distributed production, providing opportunities for new business ventures and the development of new centres for economic growth in both rural and urban areas that currently find it difficult to attract investment in the current centralised energy system.

Scope:

Research proposals should address at least one of the following:

- Development of new environmentally friendly catalysts for ammonia synthesis at low pressures for long term hydrogen storage and distribution;
- Development of new ultra-porous materials for hydrogen storage with a gravimetric storage capacity in excess of 6 wt% and a volumetric storage capacity in excess of 40g/lt. The use of machine learning techniques to assess combinations and substitutions in various porous materials to help optimise the development process should also be considered;
- Development of suitable pressure vessel materials for the containment of the adsorbent ultra-porous materials;
- Conduct full LCA of the new developed materials, (catalysts, ultra-porous materials) and processes (synthesis process, ultra-porous material production), including end-of-life;);
- Produce a demonstrator plant for low pressure ammonia synthesis;
- Produce a demonstrator pressure vessel containing ultra-porous hydrogen adsorbents.

Proposals submitted under this topic should include a business case and exploitation strategy, as outlined in the introduction to this Destination.

The topic is open for international cooperation where the EU has reciprocal benefit, while excluding industrial competitors from countries where the safeguarding of IPRs cannot be guaranteed.

HORIZON-CL4-2021-TWIN-TRANSITION-01-14: Deploying industrial-urban symbiosis solutions for the utilization of energy, water, industrial waste and by-products at regional scale

Opening - Deadline	Type	TRL	Budget (proposal)	Budget (topic)
15/04/2021 – 23/09/2021	RIA	From 4 to 6	8-12 M€	27.5 M€

Expected Outcome

Projects are expected to contribute to the following outcomes:

- Deploy real scale exemplary pilot solutions of the Industrial-Urban Symbiosis (I-US) concept, making the flows of energy, waste and water circular, achieving near-zero GHG emissions and near-zero water discharge;
- Reduce by 50 % (in weight or volume) industrial waste generation and reduce significantly the associated GHG emissions, by re-using and transforming waste, by-products and side-streams into new resources or raw materials;
- Plan a list of actions to overcome non-technological barriers for exploitation of cross-company symbiosis (i.e. waste regulations, standardisation, confidentiality and compliance, ownership, fair sharing of benefits, acceptance of the concept);
- Set up facilitation services for helping implementation of symbiotic processes directed to local authorities, and relevant businesses, private/industry actors, especially SMEs;
- Develop best practices for knowledge-sharing on technological and non-technological aspects (i.e. job profile optimisation) in close collaboration with the European Community of Practice (ECoP) CSA and other relevant bodies, dissemination the major innovation outcomes to support the implementation of I-US;
- Explore and demonstrate replication potential in other regions (i.e. by setting up a network amongst waste associations to optimise flow of secondary raw materials);
- Implement actions to facilitate relations and to involve the local community actors (authorities, associations, civil society, relevant businesses, especially SMEs, educational organisations, etc.), e.g. exchanging knowledge and human capital with the educational establishments and developing flexible learning resources.
- Implement a social innovation spin-off action1 involving one of the local community actors.

Relevant indicators and metrics, with baseline values, should be stated clearly in the proposal.

Scope

In March 2020, the European Commission launched the Circular Economy Action Plan for a cleaner and more competitive Europe. In order to accelerate the transition to a circular economy, exemplary pilot solutions integrating industrial urban symbiosis need to be exploited. The solutions could cover the reduction of waste, virgin raw materials and energy and water consumption, mainly by transforming underused waste materials (both industrial waste, industrial side streams, by-products and end of life urban waste) into feedstock for the process industries (urban mining). To support a wide implementation of industrial urban symbiosis for waste utilization, the regional dimension is important since local energy and utility networks, adjacent industrial infrastructures and available by-products and would have to be considered in a holistic approach. In the same way, logistics should be optimised wherever possible and should be an advantage from the sustainable and competitiveness perspective.

Technology and social based innovations should prove the potential for novel symbiotic value chains in demonstrators involving multiple industrial sectors (combining non-exhaustively energy, process and manufacturing industries) in pilot industrial settings. Projects are expected to address several but not necessarily all following aspects:

- A broad cross-sectorial symbiosis and circularity implementation from a regional perspective to potentially achieve climate neutrality by 2050 including cooperation with other suitable regions in terms of availability of resources, technologies, available infrastructures and knowledge transfer;

[1] *A social innovation spin-off action may not necessarily encompass a commercial activity.*

- Cross-cutting solutions (processes and equipment) for the processing of side/waste streams specifically for the use as feedstock for plants and companies across sectors and/or across value chains, while increasing the resource efficiency/circularity in industrial value chains and product-life cycles;
- Process (re-)design and adaptation to integrate new processes (energy and material flow coupling, infrastructure and logistics) and create new synergies between sectors;
- Integration of novel sensing technology, IoT and digital tools to support design, flow optimization and controls;
- Concepts, tools and business models for the flexible and robust management of exchange streams in dynamic production environments to maximise the impact on sustainability while respecting the technical limitations, economic interests of the producers and the interests of citizens;
- IT infrastructures and tools that provide a secure basis for the integrated management and the preservation of confidentiality of sensitive data;
- Assessment methodologies and KPIs to measure the performance of symbiosis, including environmental, economic and social impacts (including SRL). Life cycle assessment and life cycle cost analysis should take into account existing sustainability standards (e.g. ISO 14000) and existing best practices;
- Development/use (preferred) of common reporting methodologies for the assessment of industrial symbiosis activities and exchanges in close collaboration with the European Community of Practice (ECoP);
- Tools to support companies in redefining their products process and systems from the point of view of design, production, logistic and business models, preferably based on the outcomes of previous projects (see for example SPIRE project portfolio on Industrial Symbiosis);
- Study social aspects of the community and its improvement through the I-US where demonstration pilot is located (social innovation, underdevelopment, job quality gender and inclusiveness perspective);
- Create societal awareness through a participative approach locally and more broadly, highlighting and communicating political and regulatory obstacle between regions/countries.

Proposals submitted under this topic should include a business case and exploitation strategy, as outlined in the introduction to this Destination. Interoperability for data sharing should be addressed.

Clustering and cooperation with other selected projects under this cross-cutting call and others in HE, with activities as Circular Cities and Regions Initiative (CCRI) and European Circular Economy Stakeholder Panel (ECESP), as well as building on existing projects[2] is strongly encouraged, see also Industrial Symbiosis Report from March 2020[3].

In order to achieve the expected outcomes, international cooperation is advised on IS/I-US/circularity technologies and their implementation in processes, with INCO countries advanced in the field that could bring mutual benefit from different perspective.

This topic implements the co-programmed European partnership Processes4Planet.

[2] *e.g. Sharebox, Scaler, CIRCLEAN network or JRC Industry mapping EIGL, etc.*

[3] *Study and Portfolio Review of Cluster of Projects on Industrial Symbiosis https://op.europa.eu/en/publication-detail/-/publication/f26dfd11-6288-11ea-b735-01aa75ed71a1*

HORIZON-CL4-2021-TWIN-TRANSITION-01-22: Adjustment of Steel process production to prepare for the transition towards climate neutrality

Opening - Deadline	Type	TRL	Budget (proposal)	Budget (topic)
15/04/2021 – 23/09/2021	IA	From 6 to 8	4-5 M€	14 M€

Expected Outcome

Projects are expected to contribute to the following outcomes:

- Adaptation of the energy and materials flow in the existing steel installations to allow for a technically and economically feasible transition to reduce the use of fossil carbon as reducing agent;
- Reduction of carbon footprint by incrementally adapting to alternative feedstock gases and biomass as reducing agents;
- Showcase new technologies to reduce steelworks energy consumption by implementing improvements in the materials and energy flows whilst reducing fossil carbon related emissions;
- Develop technological pathways to increase the reutilization of internal process metallurgical gases by deploying advanced gas treatment solutions.

Scope:

The proposals submitted under this topic are expected to provide concepts addressing the modifications of the existing installations of both primary and secondary steel production (BF/BOF, EAF, DRI) concerning the internal and external flows of energy and materials in order to re-use metallurgical gases (internal re-cycling) and to upgrade them with new sources (H_2), e.g. by replacement of fossil carbon as reducing agent with hydrogen containing gases and biomass.

This also includes the integrated preparation (reforming, separation, heating, compression) of external carbon-lean reducing gases or internally-recycled CO/CO_2 streams for efficient injection in the BF or use in conventional plants.

The concepts to be addressed under this topic are expected to address one or more of the following areas:

- Injection of hydrogen or hydrogen-rich gases (including coke oven gas or BOF gas) or biomass to directly avoid the usage of fossil carbon as reducing agent in BF or as heat source in EAF operation;
- New process technologies for co-injection and new injection ports for BF and DRI plants and for EAF technology;
- Advanced gas treatment solutions (purification, reforming, preheating) for steel plants process gases for the purpose of internal re-use;
- Integration of gas injection with CO2 capture and storage technologies for the transition to CO2 neutral steelmaking;
- Adaption of the energy and materials flow in the energy system of the steel production process with adjustments of gas distribution/combustion to new gas properties and amounts including new developments regarding the related process technology and control technology.

Proposals submitted under this topic should include a business case and exploitation strategy, as outlined in the introduction to this Destination.

This topic implements the co-programmed European Partnership on Clean Steel.

HORIZON-CL4-2021-TWIN-TRANSITION-01-11: Automated tools for the valorisation of construction waste

Opening - Deadline	Type	TRL	Budget (proposal)	Budget (topic)
15/04/2021 – 23/09/2021	RIA	From 4 to 6	6-10 M€	21 M€

Expected outcome

- Increase significantly the construction and demolition waste (CDW) utilisation (at least 80% weight) by cascade approach including re-use, recycle and transformation of waste into secondary products in full cooperation between construction and waste management companies;
- Provide new value chain and sustainable business models for construction waste reduction mobilising cross sectorial actors;
- Implement appropriate tracing of material and /or component along the new value chain.
- Increase by 50% the reusability of construction products post demolition and reduce the down cycling of construction waste by facilitating modular dismantling of complex construction products;
- Plan a list of actions for overcoming relevant barriers (e.g. end of waste criteria, lack of trust in secondary products, awareness of circular potential);
- Develop holistic and replicable solutions for more circular and climate neutral construction materials and activities involving upstream and down-stream actors.

Relevant indicators and metrics, with baseline values, should be clearly stated in the proposal.

Scope

Based on volume, construction and demolition waste (CDW) is the largest waste stream in the EU. Considering that most of the waste share is glass, concrete, steel and aluminium (or other metals), the embodied energy and embodied eq. CO_2 emission in the CDW is significant (8.5 MT eq. CO2 for construction in Sweden in 2015). By reusing and recycling CDW in new constructions, the sector would come closer to the targets of becoming fully circular and climate neutral. Precise quantitative and qualitative waste estimation is crucial for waste management. This could be achieved by utilising digital technologies for instance Building Information Modelling (BIM), material and component tracing, dedicated apps for construction/de-construction and optimize site management. Such tools could provide data about material type and composition (e.g. whether there are hazardous materials that require special care) and quantities, and thus an estimation of the logistics needs, cost, etc. and make waste separation easier and faster, e.g. by combining with automated equipment and robots. Proposals should:

- Develop, test and promote the necessary digital tools for material and/or component tracing and CDW management in different types of construction or demolition sites;
- Develop automated solutions for de-construction and waste separation process;
- Implement cross-sectorial holistic solutions involving glass, concrete, steel, ceramics, non-ferrous, etc. from the construction product and material side but also waste management, transportation and construction equipment and machinery side;
- Produce all required training material for the proper use of the developed technologies The content should be sufficiently inclusive and encompass the diversity of different users;
- Demonstrate all developed solutions (reutilisation, recycling, transformation, etc.) in at least four implementation sites across different European countries, considering the material recovery, transformation and utilisation;
- Assess the value of the solutions in terms of the additional monetary value/reduction of eq. CO2 emissions produced;
- Besides the new solutions benefits, safety should be considered (on construction issues, hazardous materials, etc.)
- Proposals should consider the development of learning resources for the current and future generations of employees, with the possibility to integrate them in existing curricula and modules for undergraduate level and lifelong learning programmes. The projects should provide contributions to relevant standards or best practices.

In order to achieve the expected outcomes, international cooperation is advised, in particular with Asian countries.

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

Opening - Deadline	Type	TRL	Budget (proposal)	Budget (topic)
15/04/2021 - 19/10/2021	RIA	4 by the end	2.5 M€	20 M€

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;
- 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-D2-01-10: Technologies for non-CO_2 greenhouse gases removal

Opening - Deadline	Type	TRL	Budget (proposal)	Budget (topic)
15/04/2021 - 19/10/2021	RIA	3 or lower	2-3 M€	15 M€ (shared with 3 topics)

Expected Outcome

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.

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

Opening - Deadline	Type	TRL	Budget (proposal)	Budget (topic)
15/04/2021 - 19/10/2021	RIA	4-5 by the end	2-3 M€	15 M€ (shared with 3 topics)

Expected Outcome

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

- 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 CO2 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.

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

Opening - Deadline	Type	TRL	Budget (proposal)	Budget (topic)
15/04/2021 – 26/08/2021	CSA	-	2.5 M€	10 M€

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 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.

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-D3-01-15: Integration of CCUS in hubs and clusters, including knowledge sharing activities

Opening - Deadline	Type	TRL	Budget (proposal)	Budget (topic)
15/04/2021 – 26/08/2021	CSA	-	2 M€	2 M€

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[4]. Early planning will enable and accelerate the roll-out of a CCUS infrastructure consisting of capture points and clusters, 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[5].

[4] *REGULATION (EU) No 347/2013 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL on guidelines for trans-European energy infrastructure.*
[5] https://www.ccusnetwork.eu/

HORIZON-CL5-2021-D3-01-16: Cost reduction of CO2 capture (new or improved technologies)

Opening - Deadline	Type	TRL	Budget (proposal)	Budget (topic)
15/04/2021 – 26/08/2021	RIA	6 by the end	10-15 M€	30 M€

Expected Outcome

Significant step-change advances in CO2 capture rates, reductions in energy penalty and cost of CO2 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

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 CO2 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 CO2 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.

HORIZON-CL5-2021-D3-01-18: Support to the activities of the ETIPs and technology areas of the SET Plan

Opening - Deadline	Type	TRL	Budget (proposal)	Budget (topic)
15/04/2021 – 26/08/2021	CSA	-	1 M€	9.8 M€

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-D3-02-02: Next generation of renewable energy technologies

Opening - Deadline	Type	TRL	Budget (proposal)	Budget (topic)
02/09/2021 - 05/01/2022	CSA	3/4 by the end	3 M€	33 M€

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.

HORIZON-CL5-2021-D3-02-03: Hybrid catalytic conversion of renewable energy to carbon-neutral fuels

Opening - Deadline	Type	TRL	Budget (proposal)	Budget (topic)
02/09/2021 - 05/01/2022	RIA	3/4 by the end	3.3 M€	10 M€

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-D3-02-09: Carbon-negative sustainable biofuel production

Opening - Deadline	Type	TRL	Budget (proposal)	Budget (topic)
02/09/2021 - 05/01/2022	RIA	4/5 by the end	5 M€	15 M€

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-D3-02-16: Innovative biomethane production as an energy carrier and a fuel

Opening - Deadline	Type	TRL	Budget (proposal)	Budget (topic)
02/09/2021 - 05/01/2022	IA	6/7 by the end	10 M€	20 M€

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.

HORIZON-CL6-2021-CIRCBIO-01-09: Unlocking the potential of algae for a thriving European blue bioeconomy

Opening - Deadline	Type	TRL	Budget (proposal)	Budget (topic)
15/04/2021 – 01/09/2021	IA	7 by the end	9 M€	18 M€

Expected Outcome

In line with the European Green Deal objectives, EU Bioeconomy Strategy and Blue Growth Strategy, the successful proposal will support the development of algae-based greener aquatic industrial products/processes and/or environmental services sustaining the health of aquatic ecosystems for a healthy planet and people.

- Leveraging of the potential of algae as an industrial feedstock by upscaling and demonstration of the techno-economic viability of algae cultivation and biotransformation concepts with positive environmental, social and economic impacts. Implementation of the European Green Deal's sustainable blue economy and the EU Bioeconomy Strategy.
- Provision of market knowledge to align the development of new algae products to the uses and needs of various sectors.
- Strengthen the competitiveness of the European blue bioeconomy and marine biotechnology industry by reducing technical bottlenecks and developing promising business models making the whole algae sector more attractive to investment.

Provision of scientific evidence on environmental benefits - including possibly ecosystem services - and risks of algae-based cultivation including when applicable a comparison of the environmental footprint of algae-based products with their land based counterparts.

Scope

The farm production of micro- and macro-algae is one of the most promising emerging ocean sectors. Algae can be developed and processed into an almost endless number of products, thus enabling a shift to aquatic biomass production reducing the pressure on plant biomass derived from agriculture and forestry. Total algae production in the EU experienced an increase of 76% between 2006 and 2016.

EU policy is set to unlock the versatility and potential of algae. The European Green Deal and the Farm to Fork Strategy foster the role of algae in the protein transition and its contribution to a sustainable food system. Moreover, the 2018 EU Bioeconomy Strategy stresses the potential of algae as a source of innovative aquatic bio-based products such as pharmaceuticals, cosmetics and fine and speciality chemicals. The integrated processing of algae offers an interesting way to exploit, profitably and sustainably, most or all of the potential inherent in algae through recovering and separating the biomass components and by minimizing waste production.

Applicants should carry out activities along the following lines of research:

- Demonstrate viable concepts for the cost-effective cultivation and processing of algae into circular bio-based products and/or environmental services (e.g. medical, cosmetics, fine and speciality chemicals, remediation). The potential integration with food/feed production or with other processes (such as water treatment, crop and livestock farms and carbon sequestration) could be considered if they can add to the economic, environmental and social viability of the whole concept.
- Scale-up the production of algae products and bring them nearer to the market by addressing key challenges such as (i) optimising strains' biology (including if relevant associated microbiomes) and the mechanisms regulating cell performance for rapid growth and high yields of novel valuable compounds; (ii) pest and disease control; (iii) engage on the standardisation of the product and production lines; (iv) post-harvest treatment and storage; (v) assessment of risks of escape of propagules with the potential to affect local genetic biodiversity; (vi) secured the safety of the selected applications. Improve production systems both in terms of efficiency and capacity. Demonstrate downstream processing and fractionation of components enabling the practical implementation of multiproduct algal biorefineries.
- Establish European strategic development plans for the proposed algae farming that address biodiversity and ecosystems considerations. Key factors such as the carrying capacity of the European seas and the

availability and use of land/light/energy should be considered; Provide estimates of the market demand for algae products and of the market structure.

- Quantified assessment of environmental benefits and risks of algae farming and products, including vs. land-based products. Assessment of possible ecosystem services of algae farming.

Strong weight is placed on industrial leadership in the projects. Emphasis should be placed on the delivery of tangible social and environmental benefits. Proposals should carry out an LCA of the proposed concept. The improvement of professional skills and competences of those working and being trained to work within algae farming is expected;

Where relevant, proposals should seek synergies and capitalise on the results of past and ongoing research projects funded under Horizon 2020, European Maritime and Fisheries Fund and other funding streams.

Cooperation with other selected proposals under this topic and complementary topics included in this work programme is encouraged notably with other algae-relevant topics “HORIZON-CL6-CIRCBIO-02-04-two-stage: Photosynthesis revisited: climate emergency, “no pollution and zero-emission” challenge and industrial application” and “HORIZON-CL6-2022-FARM2FORK-02-05-two-stage: Innovative food from marine and freshwater ecosystems”.

HORIZON-CL4-2022-RESILIENCE-01-14: Membranes for gas separations - membrane distillation

Opening - Deadline	Type	TRL	Budget (proposal)	Budget (topic)
15/10/2021 – 30/03/2022	IA	From 4 to 7	6-8 M€	21 M€

Specific Challenge

Advanced membrane materials are essential to achieve the goals of the European Green Deal with significant reductions of industrial emissions in waste streams like wastewater and waste gas like removal of gas / volatile pollutants from liquid emissions or purification of wastewater.

Projects are expected to contribute to the following outcomes:

- The next generation membrane materials, delivering smart solutions for greening of industrial plants;
- Advanced membrane materials for recycling of waste streams from industrial plants to support the Zero Pollution strategy;
- Better materials with outstanding separation performance and/or superior properties either in chemical, mechanical or thermal stability compared to commercial materials;
- Reduction of the water footprint of 10% in industrial plants for the preservation of freshwater resources;
- Up-scaling the desalination process by solar powered membrane distillation systems and coupling membrane distillation with solar / photovoltaic collectors;
- Energy saving by 10% through the application of a new generation of membranes.
- End-of-life issues

Scope

Membranes separation is one of the key process elements needed for the next level of resource efficiency and for greener industrial plants. Proposals will address the development of the new generation membrane materials from gas separation to membrane contactors in comparison to the current state-of-the-art. Guidance by modelling and simulation techniques should be provided to save on extensive experimentation and support up-scaling.

Proposals should address at least two of the following activities:

- Advanced membrane materials for the recovery of valuable components (ammonia, phosphate, alcohols, reactants, products, catalysts) from aqueous, organic and mixed aqueous/organic process and waste streams to enhance the resource efficiency in industrial plants;
- Separating gas streams (e.g. CO_2 utilisation processes) in the process emissions by using membrane technologies, where in addition to the produced product, other gases are in the stream (e.g. unreacted CO_2 and hydrogen);
- Demonstrate the next generation of porous membranes for membrane contactors (membrane distillation, gas/liquid contactors, liquid/liquid contactors) with use of renewable energy sources (solar energy or waste heat) to achieve significant reduction in CAPEX and process costs of gas separations and distillation;
- Up-scaling the desalination process by solar powered membrane distillation systems by coupling membrane distillation with solar / photovoltaic collectors;
- New membrane materials to reduce the water footprint in industrial plants for the preservation of freshwater resources (e.g solvent tolerant reverse osmosis membranes, forward osmosis).

Proposals submitted under this topic should include a business case and exploitation strategy, as outlined in the introduction to this Destination.

In line with the European Union's strategy for international cooperation in research and innovation, international cooperation is encouraged.

HORIZON-CL4-2022-TWIN-TRANSITION-01-11: Valorisation of CO/CO_2 streams into added-value products of market interest

Opening - Deadline	Type	TRL	Budget (proposal)	Budget (topic)
12/10/2021 – 30/03/2022	IA	From 5 to 7	12-18 M€	40 M€

Expected outcome

Projects are expected to contribute to the following outcomes:

- Utilise CO/CO_2 streams to produce added value products and/or intermediates of wide industrial interest (e.g. polymers, resins, chemicals, food/feed ingredients, minerals, etc.). Excluding fuels and/or energy carriers;
- Enhance the market for CO/CO_2 based products providing economically viable and sustainable alternatives to existing products with strong market interest in one or more applications (e.g. consumer products, feed/food ingredients, automotive, construction, etc.);
- Develop concepts enabling 100% utilisation of RES (e.g. electrified processes, concentrated solar, etc.), coping with potential fluctuations in the energy supply;
- Achieve at least 60% GHG emissions mitigation in the overall lifecycle compared to existing processes for the same products (or relevant benchmark);
- Develop mature technologies for separation/purification of CO/CO_2 containing waste streams to allow the integration in the targeted industry sector/sectors.

Relevant indicators and metrics, with baseline values, should be clearly stated in the proposal.

Scope

The proposals submitted under this topic are expected to provide concepts for utilisation of CO/CO2 streams from point sources (e.g. large industrial installation such as steel, cement and chemical plants) converting them into added value products and/or intermediates and chemicals of wide interest (plastics, resins, composites, chemicals). The topic excludes explicitly fuels and renewable energy storage concepts. The technologies proposed should support cross-sectorial concepts and sector integration paradigms. They should also be able to work efficiently in a renewable based energy system, coping with potential fluctuations in the energy supply or be fully self-sustained from an energy standpoint. The concepts proposed are expected to:

- Process significant amounts CO/CO2 containing waste streams from energy intensive industries, including efficient approaches for the pre-treatment of the gaseous stream (e.g. cleaning, compression, drying, concentration, etc.) if needed;
- Target a range of products and/or intermediates with a wide variety of applications in different sectors (e.g. construction, automotive, food/feed, etc.) to replace existing ones (e.g. fossil based or from virgin raw materials);
- Consider clearly industrial specifications and relevant market requirements;
- Demonstrate that targeted products and/or intermediates can fully replace existing counterparts. The prevention of upcycling of hazardous substances, including their separation and disposal should be considered;
- Demonstrate the improved environmental footprint of the proposed products and processes, as well as other positive impacts using relevant methodologies (e.g. LCA, LCSA, etc.);
- Provide elements related to the replicability and scalability of the technology, along with the potential for applicability in other Energy intensive industry sectors;
- Demonstrate the proposed concepts in an industrially relevant environment and at an appropriate scale. The integration of the proposed technology in existing value chains and the relevance to several European contexts would be an added value;
- Proposals should consider the co-design of learning resources together with local and regional educational organisations for current and future generations of employees, with the possibility of integrating them in existing curricula and modules for undergraduate level and lifelong learning programmes. Learning resources should integrate the identification of new skills and should propose innovative learning-teaching methods that meet regional social needs and have a high potential for replication.

Proposals submitted under this topic should include a business case and exploitation strategy, as outlined in the introduction to this Destination.

This topic implements the co-programmed European partnership Processes4Planet.

HORIZON-CL4-2022-TWIN-TRANSITION-01-15: New electrochemical conversion routes for the production of chemicals and materials in process industries

Opening - Deadline	Type	TRL	Budget (proposal)	Budget (topic)
12/10/2021 – 30/03/2022	RIA	From 3/4 to 5/6	8-12 M€	28 M€

Expected outcome

Projects are expected to contribute to the following outcomes:

- Electrification of the industrial production process by shifting from the chemical conversion process to an electrochemical conversion process;
- Efficient integration of renewable electricity to drive the conversion process;
- Significant reduction of CO2 emissions of the overall industrial process, including the emissions related to the generation of the electricity;
- Energy savings compared to the classical production routes;
- Overall material savings (waste reduction) compared to the classical production routes;
- Competitive costs of the new process technology and its integration in the processing line, including upstream and downstream.

Relevant indicators and metrics, with baseline values, should be clearly stated in the proposal.

Scope

Renewable electricity will play a major role in the transition towards a low carbon energy supply. The production of chemicals, bulk materials and metals through the direct use of renewable electricity and energy sources can be realised by electrochemical conversion in photo- and/or electro-catalytic processes. Besides the reduction of CO_2 emissions, other advantages of electrochemical conversion with renewable electricity can be the higher selectivity, process flexibility, or the possibility of accessing chemical pathways unattainable in a conventional reactor. Furthermore, photoelectrocatalysis (PEC) directly uses the solar radiation to drive the electrochemical reaction, enabling potential higher efficiencies and lower costs.

At present, there are promising electrochemical routes towards a wide range of products in process industries. These include processes such as hydrogenation of biomass into valuable chemicals, recovery of metals from waste streams (including strategic or scarce materials), electrosynthesis of ammonia and organic molecules, production of lime by electrochemical splitting, electrolytic production of metals, (in-situ) production of hydrogen peroxide or ozone, etc.

Advanced electrochemical systems, configurations and novel technologies can enable higher efficiencies and/or lower investments or operational costs. High temperature electrochemical processes, using ionic liquids or molten salts as electrolytes, offer interesting alternatives to the classical production processes as well opportunities for the development of sustainable technology. Paired synthesis, where two valuable products are generated through the cathodic and anodic reactions, can help to reduce energy consumption and costs (per unit product). The integration of PEC technologies removes the intermediate electricity production step, which can make the conversion process more energy efficient. Processes that involve multistep transformations can be improved with a cell design that allows for the selective realisation of complex reactions in a single unit and low-cost downstream processing.

All these novel electrochemical paths need to integrate process design and optimisation with the development of advanced materials and reactor/cell components as well as low-energy separation processes.

Proposals should address the following aspects:

- Development of the new electrochemical conversion route towards a product or intermediate of interest for process industries and demonstration at an appropriate scale;
- Optimisation of the reactor design and operation and the electrochemical parameters (mass and charge transfer) towards an improved electrochemical performance (increased Faradaic efficiency, lower overpotential, etc.);
- Optimisation of the reactor design and operation and the electrochemical parameters towards the increased lifetime or reduced cost of the electrochemical reactor components (electrode, electrolyte, catalyst, membrane);

- Development of suitable electrodes and electrocatalyst for the new conversion route towards a high selectivity and performance;
- Efficient integration of renewable energy sources, considering also their intermittency and the possibility to offer demand-response flexibility;
- Integrated process design, including materials, reactor/cell and separation methods, from the process intensification and cost perspectives;
- Demonstration and validation of the proposed concepts at an appropriate scale under environmental relevant conditions. Industrial feasibility should be proven by techno-economic assessments.

The integration of oxidation and reduction reactions to produce valuable products in one system is a valuable aspect. The use of critical raw materials or toxic materials should be preferably avoided. The circular utilisation of a waste or emission stream as raw material and the use of inert or low carbon impact materials, in general, are positive aspects.

The proposed technology must not target the electrochemical conversion of CO_2 or the production of hydrogen by water splitting, as these subjects are covered in other topics of the Work Programme.

Proposals submitted under this topic should include a business case and exploitation strategy, as outlined in the introduction to this Destination.

Proposals submitted under this topic should include a safety assessment and a life cycle assessment for the implementation of the developed technologies.

In order to achieve the expected outcomes, International Cooperation is advised, in particular with Japan.

This topic implements the co-programmed European partnership Processes4Planet.

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

Opening - Deadline	Type	TRL	Budget (proposal)	Budget (topic)
12/10/2021 - 10/02/22 (1st) 27/09/22 (2nd)	RIA	-	7 M€	21 M€

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-D3-01-15: Decarbonising industry with CCUS

Opening - Deadline	Type	TRL	Budget (proposal)	Budget (topic)
14/10/2021 - 23/02/2022	IA	7/8 by the end	29 M€	58 M€

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 CO2 will be utilised and/or stored in a sustainable way. Projects carried out in areas with a sufficient concentration of CO2 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, 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.

HORIZON-CL5-2022-D3-02-03: Innovative renewable energy carrier production for heating from renewable energies

Opening - Deadline	Type	TRL	Budget (proposal)	Budget (topic)
26/05/2022 - 27/10/2022	IA	7 by the end	10 M€	10 M€

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

Opening - Deadline	Type	TRL	Budget (proposal)	Budget (topic)
26/05/2022 - 27/10/2022	RIA	4 by the end	3-5 M€	10 M€

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

Opening - Deadline	Type	TRL	Budget (proposal)	Budget (topic)
26/05/2022 - 27/10/2022	IA	7 by the end	10 M€	20 M€

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 CO2/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

Opening - Deadline	Type	TRL	Budget (proposal)	Budget (topic)
26/05/2022 - 27/10/2022	RIA	4/5 by the end	3-5 M€	10 M€

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 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-D3-02-08: Demonstration of complete value chains for advanced biofuel and non-biological renewable fuel production

Opening - Deadline	Type	TRL	Budget (proposal)	Budget (topic)
26/05/2022 - 27/10/2022	IA	6/7 by the end	10 M€	20 M€

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.

HORIZON-CL5-2022-D3-03-03: Efficient and circular artificial photosynthesis

Opening - Deadline	Type	TRL	Budget (proposal)	Budget (topic)
06/09/2022 – 10/01/2023	RIA	5 by the end	3-5 M€	10 M€

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 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-D3-03-07: Development of algal and renewable fuels of non-biological origin

Opening - Deadline	Type	TRL	Budget (proposal)	Budget (topic)
06/09/2022 – 10/01/2023	RIA	4/5 by the end	5 M€	15 M€

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.

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-CL6-2022-CIRCBIO-02-04-two-stage: Photosynthesis revisited: climate emergency, "no pollution and zero-emission" challenge and industrial application

Opening - Deadline	Type	TRL	Budget (proposal)	Budget (topic)
28/10/2021 – 15/02/2022 (1st) 01/09/2022 2nd)	RIA	4/5 by the end	6 M€	6 M€

Expected Outcome

The successful proposal will contribute to the Destination 3 impacts, and the European policies it supports, in particular the European Green Deal, the Circular Economy Action Plan and the Bioeconomy Strategy, and as related to improving European industrial[6] sustainability, competitiveness and resource independence, developing innovative bio-based products, with inclusive engagement of all stakeholders, enhancing knowledge and understanding of science, in particular biotechnology-based value chains, for all actors, as well as improving consumer and citizen benefits.

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

- Wider application of recent advances in molecular biology and biotechnology to increase photosynthetic efficiency of plants and/or algae and other autotrophic organisms, increasing their assimilation of carbon dioxide, boosting biomass yields, their processing and recovery of substance and materials of economic interest, and resulting in potential contribution to climate change mitigation and adaptation.
- Increased industrial uptake of plants and photoautotrophic organisms via biotechnology approaches, for production of high-value complex molecules, for cost- and resource-efficiency. Wider uptake of life sciences and biotechnology innovations, supporting high engagement of industry and SMEs in Europe.
- Greater understanding and application of biotechnology to address air pollution (especially ozone) by crops and plants related with heat waves and environmental stress.
- Greater and more inclusive understanding and awareness of innovations, via transparent communication and societal dialogue with all stakeholders (academia, industry, including SMEs, NGOs, regulatory institutions, international partners etc.).

Scope

The photosynthetic capacity of plants, algae and other photosynthetic organisms to assimilate atmospheric carbon dioxide positions them at the centre of the global climate change adaptation and mitigation challenge[7] [8]. Their autotrophic lifestyle also makes them ideal platform organisms for sustainable production of biomolecules[9], including molecules of high socio-economic value, of interest to diverse industrial sectors, by increasingly sophisticated synthetic and molecular biology approaches[10].

This nexus creates new opportunities for the industrial production, beyond improved yields, while contributing to the increased and more efficient CO_2 assimilation capacity, with important contributions to the reduction of pollution in Europe. In particular, recent research confirm a strong correlation between plant physiological reactions during drought and heat waves, which are increasing in frequency and intensity in Europe, notably by contributing to ozone pollution[11], the so-called 'climate penalty of plants" [12] [13].

The topic covers innovative technologies with potential to boost the efficiency of photosynthesis, reduce the 'climate penalty of plants', and increase their sustainable industrial application. All photoautotrophic organisms such as plants, micro- and macro algae, cyanobacteria and purple sulphur bacteria are in the scope. The

[6] *In synergy with European Partnerships under Cluster 6, in particular Circular Bio-based Europe (CBE).*
[7] *For instance, see Ort et al. Redesigning photosynthesis to sustainably meet global food and bioenergy demand. Proc. Natl Acad. Sci. USA112, 8529–8536 (2015).*
[8] *Notwithstanding the recognized need for even stronger emission reductions.*
[9] *O'Neill E. and Kelly, S. 2016 Engineering biosynthesis of high-value compounds in photosynthetic organisms,*
[10] *Schander et al., A synthetic pathway for the fixation of carbon dioxide in vitro, Science 18 (Nov 2016): 900-904*
[11] *Lin et al.Vegetation feedbacks during drought exacerbate ozone air pollution extremes in Europe. Nat. Clim. Chang.* ***10,*** *444–451 (2020). https://doi.org/10.1038/s41558-020-0743-y*
[12] *Sadiq, M. The climate penalty of plants. Nat. Clim. Chang.* ***10,*** *387–388 (2020). https://doi.org/10.1038/s41558-020-0765-5*
[13] *Air quality in Europe – 2019 report Report no. 10/2019 (European Environment Agency, 2019); https://www.eea.europa.eu//publications/air-quality-in-europe-2019*

international cooperation is encouraged, as a win-win scenario, while contributing to the European competitiveness.

Proposals should:

- Develop and apply a toolbox of technologies to optimize the photosynthesis pathways and structures of plants and algae to enable industrial manufacturing of large quantities of high-value bio-based compounds, substances or materials (excluding biofuels), while addressing the CO2 assimilation and the zero-pollution goals (especially ozone pollution) at sufficiently large scale.
- Identify and characterise the key aspects of the environmental and safety aspects, as well as the future scenarios of increasing environmental pressures under climate change conditions (water, gaseous inputs, land use etc.), for the selected crops, beyond the model species.
- Outline the necessary scale-up production processes for novel bio-based innovations in order to reach a critical mass for a given application (including the crop/species selection), to achieve economies of scale, address different market segments and applications.
- Address process and product safety, including occupational and consumer safety aspects, as elements for consideration in any value chain, as stipulated in the national or European regulation.
- Ensure transparent and inclusive engagement of all actors, including industry and SMEs, the scientific community, regulatory institutions, and broader civil society, including NGOs, to ensure the necessary impact and awareness.
- As relevant, proposals shouldseek synergies and capitalise on the results of past 14 and ongoing 15 research projects, taking care to avoid overlaps.

In this topic the integration of the gender dimension (sex and gender analysis) in research and innovation content is not a mandatory requirement.

[14] *E.g. FP7 project "3to4": Converting C3 to C4 photosynthesis for sustainable agriculture*

[15] *E.g. Horizon 2020 call BIOTEC-02-2019: Boosting the efficiency of photosynthesis (RIA), with projects CAPITALISE, GAIN4CROPS and PhotoBoost.*

HORIZON-EIC-2021-PATHFINDERCHALLENGES-01 – Novel routes to green hydrogen production

Opening - Deadline	Type	TRL	Budget (proposal)	Budget (topic)
15/04/2021 – 27/10/2021	RIA	Range 1-4	3-4 M€	133.6 M€ (shared with 5 topics)

The development of efficient, sustainable and flexible energy systems is a key challenge for Europe's energy decarbonisation and a corner stone of Europe's 2050 climate-neutrality goal, set out in the European Green Deal.[16] To achieve such viable energy system, a particular support should be given to solutions aimed at increasing [lifetime and decrease the cost of the overall system. In this context, Hydrogen (H_2) has the potential to contribute to the above mentioned objectives.[17] Currently $H_2$is largely produced from fossil fuels, commonly referred to as grey H_2, or promising but still expensive blue H_2 options, combining methane-to- H_2 with carbon capture and storage, or renewable H_2 pathways (green H_2), entirely based on renewable electricity. Referring to green H_2 production, the state of art technology is based on water-electrolysis, with costs still higher than grey H2 and production processes affected by the use of critical raw materials.[18]

This Pathfinder Challenge aims at developing novel processes and technologies to produce green H_2, at different scales (from small to large) and capturing cross sectorial coupling and system integration opportunities, entirely based on (i) renewable sources and (ii) non-toxic, non-critical raw materials. It focuses on the potentials of new biological, chemical, and physical routes for green H_2 production which could also facilitate the implementation of i the circular economy principles , possibly including the co-production of decarbonised chemicals. The specific target is to support the development of innovative technologies and platforms for green H_2 production, including both centralised and or on-demand generation (i.e. at the premises of the end users and for onsite consumption). Reaching these objectives requires multidisciplinary competencies and cross sectorial approaches addressing also environmental, industrial and logistic issues.

Specific conditions for this challenge

In order to apply, your proposal should develop a proof of concept or lab-scale validated innovative green H_2 production technology by biological, chemical or physical routes without the deployment of fossil fuels, potentially including the use of salt or waste water, air moisture, biomass or recycled by-products, or the co-production of decarbonised chemicals.

Projects with multidisciplinary and cross sectorial approaches, looking for inspiration, ideas and knowledge in disciplines that are typically not in this kind of research, are particularly welcome. Projects are strongly encouraged to consider the recovery and recycling of by-products and wastes (circular approach), as well as the use of abundant natural resources. The safe and sustainable use of non-critical raw materials is mandatory and the projects should include a full life cycle analysis of the proposed solutions and their impact on Europe's decarbonisation goals.[19]

[16] *https://ec.europa.eu/info/strategy/priorities-2019-2024/european-green-deal_en*
[17] *A hydrogen strategy for a climate-neutral Europe, COM(2020) 301 final (08/07/2020).* *https://ec.europa.eu/energy/sites/ener/files/hydrogen_strategy.pdf*
[18] *https://ec.europa.eu/growth/sectors/raw-materials/specific-interest/critical_en*
[19] *https://ec.europa.eu/clima/policies/strategies/2030_en*

HORIZON-EIC-2021-TRANSITIONCHALLENGES-01 – Energy harvesting and storage technologies

Opening - Deadline	Type	TRL	Budget (proposal)	Budget (topic)
19/05/2021 – 22/09/2021	RIA	From 3/4 to 5/6	Up to 2.5 M€	40.85 M€ (shared with 2 topics)

Innovative technologies for efficient, low cost, sustainable, compact and flexible energy harvesting, conversion and storage are crucial to reach the Green Deal targets of decarbonised energy systems while achieving the transition to secure and affordable energy. EU-funded early-stage research on innovative energy technologies is uncovering unique opportunities for systems integration of advanced and sustainable energy harvesting and storage technologies.

Efficient, sustainable, high density and low cost energy storage technologies are a key to enable increasingly high penetration of intermittent renewable energies. Energy storage facilitates cross sectoral coupling, integration of multiple energy vectors, and is a key asset for active demand response strategies and development of smart energy communities with end-user engagement. The most important barriers to storage technologies are high investment costs, efficiency, dynamic performance/fast response capabilities and sustainability (raw materials and overall life cycle). In addition, in several cases there are also regulatory framework bottlenecks and a lack of a viable business case.

Energy storage includes a broad range of technologies, with different characteristic features in terms of energy density, response capability, duration of charging/discharging, etc. Similarly, energy harvesting covers many different sources and scales (from portable to utility scale). In order to maximally benefit from these harvesting and storage technologies, a systems approach is needed that combines harvesting and storage or that integrates a specific storage technology into a comprehensive application-specific solution. To reach the EU clean energy goals, it is necessary to deploy harvesting and storage technologies in different applications, eventually optimizing infrastructural investments, as well as supporting the transition from passive customers to prosumers.

In order to capitalise on and deploy the EU deep tech know-how in energy harvesting and storage technologies, strategic choices beyond Li-based batteries are needed. In particular, *electrochemical technologies* not using critical raw or toxic materials or alternative solutions based on *power to heat to power* concepts, or *on solar energy conversion to decarbonized fuels* and combined/hybrid storage are particularly promising. These technologies could be developed for utility scale, distributed or portable micro-scale applications, and stationary or mobile uses.

The proposals are expected to develop energy storage technologies or combined energy harvesting/storage technologies ready for investment and business development, with the perspective to capture specific systems integration opportunities.

Some non-exhaustive and illustrative examples of energy storage technologies integration for stationary applications are the retrofit of fossil power plants, waste heat recovery, demand response and strategies for enhanced flexibility and stability of energy systems, buildings or industrial processes integration.

Proposals are expected to address at least one of the following:

- Innovative technologies and systems combining energy harvesting and storage, which are efficient, clean, high energy density and low-cost, integrated for stationary or mobile applications.
- Innovative concepts and techniques for the combined harvesting and storage of solar energy (in the form of heat or solar fuels), geothermal or waste heat, including topics such as long-term thermal storage, cooling and cryogenic storage, building integrated solutions, thermo-electricity, advanced heat transfer, power to heat to power, and thermo-mechanical energy storage and conversion
- Advanced materials and devices for electro-chemical storage (other than Li-Ion batteries), at utility scale, mobile or distributed/micro scale level, also integrated to PV/wind energy systems or for other intermittent sources. Concepts that offer the potentials for high flexibility, high energy density, efficiency, low-cost, made of toxic-free and non-critical raw materials, should be harnessed to make them usable for specific applications.

Specific conditions for this challenge

Transition activities foreseen in this Transition Challenge will aim to have impact on sustainability, using non critical and non-toxic raw materials and ensuring circular approaches and/or a high degree of recyclability in the whole lifetime, and on financial and business level, preparing a detailed plan to exploitation supported by a sound business model and identifying any regulatory hurdles that need to be addressed.

Proposals can address applications ranging from stationary (utility vs small scale vs stand-alone) to transport (for example electric mobility or solar fuels) to portable and micro scale applications.

Expected results are prototypes or demonstrators operating in relevant environment conditions combined with a sound business plan and business model. Given that the costs of such activities in this challenge tend to be high, budgets of above €2.5 million may be accepted if duly justified.

HORIZON-EIC-2021-ACCELERATORCHALLENGES-01 – Green Deal innovations for the economic recovery

Opening - Deadline	Type	TRL	Budget (proposal)	Budget (topic)
08/04/2021 – 09/06/2021, 06/10/2021	IA	From 5/6 to 8	Blended[20]	507.2 M€ (shared with 2 topics)

This EIC Accelerator challenge will fund transformative green innovations, which contribute to the goals enshrined in the European Green Deal strategy and the Recovery Plan for Europe. This call will complement and be coordinated with activities supported by other relevant pan-European public-private and public-public partnerships for circular bio-based solutions, green hydrogen, batteries or low-carbon industries. In particular it will focus on disruptive and breakthrough innovations by SMEs (including midcaps) and start-ups. This will also contribute to the implementation of various EU-wide initiatives, including the New Industrial Strategy for Europe regarding the decarbonisation and modernisation of energy-intensive industries, the Renovation Wave for more energy-efficient buildings, the Biodiversity Strategy, the Farm to Fork Strategy or the new Circular Economy Action Plan.

This EIC Accelerator challenge will contribute to the European Green Deal goals by nurturing and supporting the scale up of next generation low-carbon technologies and supporting European companies willing to become global technology leaders able to transform the world. Game-changing, breakthrough technologies combined with innovative business models, will be a key feature.

Why should you apply?

Your project must support the Green Deal implementation by significantly contributing to at least one of the following sustainability goals:

- Increasing the EU's climate mitigation and/or adaptation ambition;
- Supplying clean, affordable and secure energy;
- Transitioning of industry to a clean and/or circular economy (including waste prevention and/or recycling);
- Building and renovating in an energy and resource efficient way;
- Accelerating the shift to sustainable and smart mobility;
- Transition to a fair, healthy and environmentally-friendly food system;
- Preserving and restoring ecosystems and biodiversity (including nature based solutions that provide co-benefits for climate adaptation and mitigation);
- Realising a zero pollution ambition and a toxic-free environment.

Within the Green Deal goals, specific priority is given to projects relating to key innovations for the green economic transition as identified in the Recovery Plan for Europe[21] [22]. In that particular regard, at least 50% of the companies selected for the interview phase must have submitted proposals relating to one the following areas:

- Renewable energy, including renewable Hydrogen and energy storage: breakthrough innovations to further develop renewable energy sources, green hydrogen or decarbonized fuels production and/or storage at different scales, from centralized to on demand, as well as for different applications ranging from stationary to transport, including solutions that address the whole supply chain to limit the use of critical raw materials, to contribute to the goal of a carbon-neutral economy.
- Deep Renovation of buildings: breakthrough innovations that accelerate the growth of the deep renovation market to increase the energetic and environmental performance of residential, commercial and public buildings, also bundling energy supply and/or demand through innovative technologies and operating strategies, proposing building embedded energy generation and storage solutions, and financial schemes or business models.

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[20] up to 2.5 M€ grant for technology development and validation, 0.5 -15 M€ investment for scaling up and other activities
[21] Commission Staff Working Document on Identifying Europe's recovery needs, SWD (2020) 98 final, page 17
[22] Guidance to Member States on their national Recovery and Resilience Plans, SWD (2020) 205 final, page. 18-19.

- Low carbon industries: breakthrough innovations contributing to the de-carbonisation of energy-intensive industries, including solutions on electrification, circularity and industrial symbiosis industrial processes, the use of carbon capture storage and utilisation technologies or the digitisation of industrial processes.
- Batteries and other energy storage systems: breakthrough innovations related to the various segments of the strategic battery value chain, from critical raw materials to recycling, and comprising other energy storage systems such as chemical as well as physical storage technologies (including ultracapacitors), for use on stationary as well as transport applications.

You must base your proposal on a strategic business plan and specify the project's success criteria and expected outcomes. You must pay particular attention to IPR strategy, and you must present convincing evidence or measures to ensure the possibility of commercial uptake (often known as 'freedom to operate'). Moreover, you must address regulatory and standardisation issues.

Proposals must describe the project's contribution to the implementation of at least one of these Green Deal goals, using where possible quantitative impact assessments. Furthermore, apart from substantially contributing to one or more of the above-listed objectives, proposals must not cause significant harm to any of the EU taxonomy environmental goals.