EN

Horizon 2020

Work Programme 2018-2020

20. Cross-cutting activities

IMPORTANT NOTICE ON THIS WORK PROGRAMME

This Work Programme covers 2018, 2019 and 2020. The parts of the Work Programme that relate to 2020 (topics, dates, budget) have, with this revised version, been updated. The changes relating to this revised part are explained on the Funding & Tenders Portal.

(European Commission Decision C(2019)4575 of 2 July 2019)

Table of contents

Introduction

This work programme part contains the following cross-cutting calls:

- BUILDING A LOW-CARBON, CLIMATE RESILIENT FUTURE: NEXT-GENERATION BATTERIES
- COMPETITIVE, LOW CARBON AND CIRCULAR INDUSTRIES

SYNERGIES WITH OTHER FUNDS

Project proposers should consider and actively seek synergies with, and where appropriate possibilities for further funding from, other relevant EU, national or regional research and innovation programmes (including the EU-ETS Innovation Fund, ERDF/ESF+ or the Instrument for Pre-accession Assistance [IPA II]), private funds or financial instruments (including EFSI).

Examples of synergies are actions that build the research and innovation capacities of actors; mutually supportive funding from different Union instruments to achieve greater impact and efficiency; national/regional authorities actions that capitalise on on-going or completed Horizon 2020 actions aimed at market up-take/commercialisation.

In order to explore options for synergies, project proposers could seek contact with national/regional managing authorities and the authorities who developed the Research and Innovation Smart Specialisation Strategies (RIS3)[1]. For this purpose the 'Guide on Enabling synergies between ESIF, H2020 and other research and innovation related Union programmes'[2] may be useful. Horizon 2020 project proposals should outline the scope for synergies and/or additional funding, in particular where this makes the projects more ambitious or increases their impact and expected results. Please note, however, that while the increase in the impact may lead to a higher score in the evaluation of the proposal, the reference to such additional or follow-up funding will not influence it automatically.

OPEN RESEARCH DATA

Grant beneficiaries under this work programme part will engage in research data sharing by default, as stipulated under Article 29.3 of the Horizon 2020 Model Grant Agreement (including the creation of a Data Management Plan). Participants may however opt out of these arrangements, both before and after the signature of the grant agreement. More information can be found under General Annex L of the work programme.

BUSINESS CASES AND EXPLOITATION STRATEGIES FOR INDUSTRIALISATION

1 1.http://s3platform.jrc.ec.europa.eu/map
2 http://ec.europa.eu/regional_policy/sources/docgener/guides/synergy/synergies_en.pdf

This section applies only to the following topics, for which proposals should demonstrate the expected impact by including a business case and exploitation strategy for industrialisation.

- LC-BAT-1-2019: Strongly improved, highly performant and safe all solid state batteries for electric vehicles (RIA)
- LC-BAT-2-2019: Strengthening EU materials technologies for non-automotive battery storage (RIA)
- CE-NMBP-42-2020: Materials life cycle sustainability analysis (RIA)
- CE-SPIRE-01-2020: Tapping into the potential of Industrial Symbiosis (IA)
- CE-SPIRE-07-2020: Preserving fresh water: recycling industrial waters industry (IA)
- CE-SPIRE-09-2020: Alternative mineral resources for high volume production (IA)
- CE-SC5-07-2020: Raw materials innovation for the circular economy: sustainable processing, reuse, recycling and recovery schemes (IA)
- CE-SC5-08-2020: Raw materials policy support actions for the circular economy - Expert network on Critical Raw Materials (CSA)
- CE-SC5-31-2020: Develop, implement and assess a circular economy oriented product information management system for complex products from cradle to cradle (IA)
- LC-SC3-CC-9-2020: Industrial (Waste) Heat-to-Power conversion
- LC-SC3-NZE-5-2020: Low carbon industrial production using CCUS

The business case and exploitation strategy will be evaluated under the 'Impact' criterion:

The business case should demonstrate the expected impact of the proposal in terms of enhanced market opportunities for European enterprises and innovators and enhanced manufacturing capacities in Europe, and thus growth and jobs in Europe, in the short to medium term. It should describe the targeted market(s); estimated market size in Europe and globally; user and customer needs; and demonstrate that the solutions will match the market and user needs in a cost-effective manner; and describe the expected market position and competitive advantage.

The exploitation strategy should be realistic and identify obstacles, requirements and necessary actions involved in reaching higher TRLs, such as

1. Improved material/product robustness and reliability;
2. Matching European value chains;
3. Securing an industrial integrator to adapt the new technologies to industrial scale;
4. Availability of large-scale testing, pilot and manufacturing facilities;

5. Standardisation;
6. IPR and technology transfer;
7. Product approval by regulatory and/or relevant international bodies;
8. User acceptance and the needs of industrial users, including SMEs;
9. Sustainability of financing (after the EU funding).

For TRLs 6-7, a credible strategy to achieve future full-scale manufacturing in Europe is expected, indicating the commitments of the industrial partners after the end of the project (including financial commitments). In the case of demonstrators and pilot lines, the planned use and expected impact from using the final installation should be considered.

Exploitation plans, outline financial arrangements and any follow-up will be developed further during the project.

The results of these activities as well as the further activities envisaged in this respect should be covered by the final report (and intermediate deliverables) of the project.

Contribution to focus area(s)

Focus Area 'Building a low-carbon, climate resilient future' (LC): EUR 275.00 million

Focus Area 'Connecting economic and environmental gains - the Circular Economy' (CE): EUR 176.50 million

Call - Building a Low-Carbon, Climate Resilient Future: Next-Generation Batteries

H2020-LC-BAT-2019-2020

In the wake of the Paris agreement (COP21), as well as the EU 2020 and EU 2050 targets, there is a need for significant reductions in CO2 and greenhouse gas emissions in a short time span. Electric batteries are currently seen as important technological enablers to drive the transition towards a de-carbonised society, by integration of renewable and clean energy sources (such as wind energy and photovoltaics) in the electricity grid, and, in particular, by electrification of transport. Energy storage is the common denominator: it includes both electro-mobility and stationary applications despite the different constraints applying to each of these applications in real life.

Electric batteries have recently achieved considerable improvements in terms of their technical performance (such as energy density, power density, thermal stability and durability) and economic affordability. Such improvements are major contributors to the successful introduction of electric vehicles (which are becoming cheaper and have longer range) and of stationary energy storage systems. But for a successful mass introduction of electrified mobility and renewable and clean energy systems with market competitive performances and - in the case of electric vehicles - fast charging capability, substantial improvements of the electric battery technologies are required.

The competitiveness of new advanced energy storage systems or sustainable battery powered vehicles is strongly dependent on the performance and cost of the battery and battery cells and the materials used for the production of the cells. This is especially valid for the fast growing market of electrified vehicles. However, the world production of automotive battery cells is dominated by Asian companies which represent more than 90% of the present world capacity.

It will be very challenging for European companies to catch-up. Europe has to search for better performance, and strongly force the development of more price competitive and sustainable battery storage solutions. Beyond research on improved electrochemistry and new battery materials (e.g. advanced Li-ion, solid-state and post-Li-ion technologies), it is the complete electric batteries value chain and life-cycle that has to be considered, from access to raw material, over innovative advanced materials and nanotechnologies to modelling, production, recycling, second life, life cycle and environmental assessment and skills.

To face the challenge, Vice-President Maroš Šefčovič has initiated in October 2017 the EU Battery Alliance as a joint industry-led initiative to prevent a major technological dependence in batteries cells supply and ensure that European companies capture a significant share of the emerging electric battery market.

The selected topics proposed in this Call cover a relevant spectrum of activities in the field of electric batteries technology: short term research for advanced Li-ion electrochemistry and production processes, short to medium term research for solid-state electrochemistry,

modelling tools, new materials for stationary electric batteries, hybridisation of battery systems, next generation batteries for stationary energy storage, next generation and validation of battery packs and battery management systems, networking of pilot lines and skills development and training.

Large scale research initiative on Future Battery Technologies:

The last four topics in this Call (from LC-BAT-12-2020 to LC-BAT-15-2020) kick-start a large-scale research initiative on Future Battery Technologies that will ensure the European knowledge base in long term battery research. This new large-scale, long-term research initiative was announced in May 2018 as part of the Third Mobility package, with its research activities starting to receive support in 2020 from Horizon 2020[3].Such a coordinated long-term effort is essential, given that at the dawn of a new, connected, green era - represented by autonomous vehicles, smart cities, smart grids based on renewable energy sources, drone aircraft, robotic devices, - reliable and safe batteries with ultra-high performance are becoming essential. Novel cross-disciplinary approaches empowered by digital technologies can accelerate research on the next generations of smart, safe and high-performing batteries.[4] They will provide Europe with a competitive advantage in the fast growing market of electro-chemical energy storage and will be key for the development of a world-class European industry capable of addressing the needs of many sectors, including e-mobility and renewable energy storage.

In addition to the COP 21 Paris Agreement and decarbonisation, all topics under this call are in line with the Energy Union policies as well as the SET-plan[5] and STRIA[6].

Proposals are invited against the following topic(s):

LC-BAT-1-2019: Strongly improved, highly performant and safe all solid state batteries for electric vehicles (RIA)

Specific Challenge: International developments towards less air pollution and CO2 production are pushing towards a rapid implementation of electrification of transport. In addition, according to market forecasts, a rapid growth of the sales and deployment of battery electric vehicles (BEV) is predicted. Considering the global competition, the rush for better technology implies also the need for a better traction battery technology as a key enabling technology. Europe has to regain its competitiveness in markets that nowadays are dominated by non-European countries. This could occur by developing a new European owned battery technology.

Furthermore, an international tendency of Original Equipment Manufacturers (OEM) is to consider more and more the solid state technology as a solution that could replace the current

[3] See https://ec.europa.eu/transport/sites/transport/files/3rd-mobility-pack/com20180293-annex2_en.pdf.
[4] See Manifesto for a long-term research initiative to create the batteries of our future: http://battery2030.eu/
[5] See https://setis.ec.europa.eu/
[6] See https://ec.europa.eu/transport/sites/transport/files/swd20170223-transportresearchandinnovationtomobilitypackage.pdf

Li-ion technology based on liquid electrolytes. The reason is the need of higher energy density, but also of inherently safe batteries.

New chemistries, materials and production technologies have to be developed to strengthen the European industrial base, in line with the EU initiatives as the Strategic Energy Technology Plan (SET Plan) Implementation Plan for Action 7 ('Batteries') and in support of the Šefčovič battery initiative "EU *Battery Alliance"*, to be ready for market deployment by 2026.

This challenge is based on the results of previous calls and stakeholder consultations[7] and is supplementary to the topic published in the Sustainable Transport Challenge of 2019 on "Next generation of high energy density, fast chargeable lithium ion batteries".

Scope:

Activities should develop further the current solid state battery technology and present solutions beyond the current state-of the art of solid state electrolytes that are suffering from various issues, e.g. a too high operating temperature, too low ion conductivity, too high impedance of the electrode electrolyte interface, short cycle life and lack of knowledge of suitable production technologies at a competitive cost. The ideal solid state battery and electrolyte would provide a solution for all these shortcomings.

Three dominant categories of electrolyte materials seem to emerge:

- Inorganic electrolyte materials :
    - Inorganic crystalline materials (e.g. perovskites, garnets, sulphides, Nasicon, e.g. suffering from high interfacial resistance and poor interface contacts, problems during cell assembly and/or cycling due to reactivity between solid electrolyte and electrodes);
    - Inorganic amorphous materials (e.g. LiPON, glass oxides).
- Solid polymers/polymeric materials (e.g. polyethylene oxide, PIL, single-ion, e.g. suffering from low ionic conductivity, electrochemical stability, not suitable working temperature, Li dendrites) ;
- All solid state hybrid systems (e.g. suffering from low polymer stability at high voltages, and/or knowledge on details and behaviour of the interface in the composite).

Solid state technology, according to a recent stakeholder proposal, has been classified in 2 sub-generations:

- So called generation 4a with conventional Li-ion materials (as NMC/Si to be developed by 2020-2022) and

[7] "Innovative batteries for eVehicles Workshop", 12 May 2017, and
"European Battery Cell R&I Workshop", 11 - 12 January 2018, European Commission DG RTD

- So called generation 4b with Li-metal as anode (to be developed by 2025-2030)

This call addresses all three main categories of electrolyte materials mentioned above, and includes also solid state batteries of the so-called "post Lithium-ion" batteries (generation 4a and 4b), as e.g. solid state forms of Li-S or Li-air.

The work should include:

- Cell design;
- Identification of problems and proposals of solutions to overcome issues hampering an optimal function of the specifically proposed electrolyte material(s) at bulk, surface, interface and grain boundary levels;
- In depth interface optimization, characterization and integration, including multiscale modelling which should target in particular problems of the ion transport processes at the interfaces of the solid state battery system;
- Demonstration of suitability to work with high voltage electrode materials, where applicable;
- IP protection and know how creation. A solid analysis and description of the state of the art of specific R&I and the patent situation has to be included.

The developed cells should meet the typical EV operating conditions in a broad temperature range, i.e. 10 to 50 ºC. Moreover, the cells should demonstrate negligible loss of charge during lengthy standby periods at sub-zero temperatures. Fast charging requirements of BEV should be met. Cyclability should be suitable for application in BEV.

The choice of the electrolyte to be developed should be duly justified in terms of chances of market success in the coming years. Validation of a pre-industrial prototype in relevant industrial environment should include an assessment of the scale-up potential in view of large scale manufacturability.

The TRL level of the project should start at TRL 3 and reach TRL 6 at the end of the project.

The Commission considers that proposals requesting a contribution from the EU between EUR 6 and 8 million would allow this specific challenge to be addressed appropriately. Nonetheless, this does not preclude submission and selection of proposals requesting other amounts.

Expected Impact:

- For generation 4a, an energy density >350 Wh/kg and >1000 Wh/l, for generation 4b a higher energy density >400 Wh/kg and >1200 Wh/l ;
- Fast charge rates above 10C with power density values >10000 W/kg as 2030 target;
- Proven safety;

- IPR protection guaranteed and demonstrated;
- Cost euro < 100euro/kWh;
- The European materials modelling capacity and ecosystem should be increased;
- The European battery value chain towards cell production in Europe should be strengthened.

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

The proposal has to do a thorough Life Cycle Analysis cradle to cradle and consider recycling as far as possible.

This work contributes to the work developed in the running EC-EGVIA agreement and to EGVI related activities of the "Transport Challenges".

Type of Action: Research and Innovation action

The conditions related to this topic are provided at the end of this call and in the General Annexes.

LC-BAT-2-2019: Strengthening EU materials technologies for non-automotive battery storage (RIA)

Specific Challenge: Driven by the needs for a cleaner environment and the transition towards a low-carbon competitive economy, deployment of solar and wind energy increases. The respective energy supply will be much more decentralised, resulting in enhanced needs for deployment of large to small scale industrial electricity grids, and in an increased share of electricity produced in private households. Also industry 4.0 with its new less centralised production methods will need a more delocalised energy supply. And more and more small robotised devices dedicated for industry or private households appear on the market that need energy. For all these new technologies and markets, the respective energy storage challenges have to be solved. This can be done by specific batteries, and Europe has to use its knowledge and competitive advantage in advanced materials and nanotechnologies to strengthen the related battery storage value chain and prepare European industry to be competitive in these new markets.

Scope: Proposals should cover the following:

- Develop more price competitive, better performant and highly safe battery storage solutions, with improved lifetime by lowering the cost and capital expenditure through development of less expensive and more performant materials (e.g. novel advanced electrode materials, including nanostructured and 2D materials and electrolytes), chemistries, packaging and cell design and battery component production processes. The progress should make use of the advantages of the existing EU value chain. Synergies with the electrified vehicle battery production sector could be explored;

- Duly consider safety aspects depending on the application, e.g. by consideration of polymer or solid electrolytes for solid-state batteries;

- Sustainable materials and environmental friendly production processes, possible second life applications, and materials that are easily available in Europe, in order to avoid market dependence. Recycling should be inherently possible on a large scale, permitting overall costs that will not hamper market acceptance;

- The new solution and respective output targets (such as cyclability, reliability, usage and lifetime) should be demonstrated and tested where possible in a relevant industrial environment; and developments in the European regulatory framework as well as the impact on industrial standards should be considered;

- To allow comparison with currently existing solutions, a full life cycle assessment covering environmental and economic aspects of the proposed alternatives should be included.

Activities should start at TRL 4 and achieve TRL 6 at the end of the project.

The Commission considers that proposals requesting a contribution from the EU between EUR 6 and 8 million would allow this specific challenge to be addressed appropriately. Nonetheless, this does not preclude submission and selection of proposals requesting other amounts.

Expected Impact: The performance levels of the proposed solution(s) should be in line with those specified in the relevant parts of the SET-Plan.[8] The new developments should respond to all of the following requirements:

- Enhanced market success of the new more competitive and sustainable technologies, obtained by strong reduction of the cost for stationary applications, below 0.05 €/kWh/cycle; the reduction of cost should be at least 20% in all other cases;

- More competitive products due to increased life time, with a cycle life for stationary energy storage applications that should be clearly beyond the current standards, and reach at least 5000 cycles at 80% Depth of Discharge; and it should be significantly improved with respect to the state-of-the-art in all other cases;

- More sustainable products, with a recycling efficiency beyond currently legal obligations, as established in the Batteries Directive,[9] ideally beyond 50%, and a demonstrated economic viability.

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

---

8 Action 7 of the SET Plan on "Batteries for e-mobility and stationary storage", see: https://setis.ec.europa.eu/system/files/integrated_set-plan/action7_issues_paper.pdf

9 Batteries Directive, EC/2006/66, http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:02006L0066-20131230&qid=1420631813560&from=EN

Type of Action: Research and Innovation action

The conditions related to this topic are provided at the end of this call and in the General Annexes.

LC-BAT-3-2019: Modelling and simulation for Redox Flow Battery development

Specific Challenge: Redox flow batteries (RFB) are considered prime candidates for grid-scale stationary energy storage due to their ability to store large amounts of electrical energy for extended periods and release it quickly when needed. Their extended lifetime and reasonable efficiency are additional benefits. The redox couples and the electrolytes are the most important component in redox flow batteries, as they largely determine system energy density and cost. Currently used RFB rely on metal-based redox pairs that are non-indigenous to Europe, and can be highly corrosive and sometimes toxic. In addition, these systems are mostly water-based, which can potentially result in water electrolysis at high voltage, and membrane cross-over. Mining and extraction of metals can have substantial social and environmental impact. These issues all affect the cell's efficiency, cost, safety and sustainability. The challenge is to identify suitable redox pairs and electrolyte chemistries for low-cost, high-efficiency and sustainable stationary RFB systems that are optimised in terms of redox potential, electrochemical reaction reversibility, chemical stability, solubility and material availability. Since extensive laboratory testing is both time consuming and costly, modelling and simulation is needed to prioritise promising redox species for further analysis and testing. This challenge is in line with the identified priorities in the context of the SET-Plan.

Scope: The objective is to develop mathematical models for numerical simulation and high-volume pre-selection of multi-species electrolyte flow and electrochemistry. Models should allow the characterisation of new chemicals and designs, the related charge, mass and heat transport mechanisms, identifying cell-limiting mechanisms, forecasting cell performance and optimising the design and scale-up. Of particular interest are performances in terms of cell voltage, energy and power density, reliability and cost.

The simulation models should be validated with experimental examples from known chemistries and representative prototypes, and show how new chemistries can be explored.

The Commission considers that proposals requesting a contribution from the EU of up to EUR 2 million would allow this specific challenge to be addressed appropriately. Nonetheless, this does not preclude submission and selection of proposals requesting other amounts.

Expected Impact: The proposed action should allow to significantly enhance research and engineering processes, and accelerating the search for new non-rare and non-toxic redox couples and electrolytes. These would allow reducing production costs in materials and component development, contributing to optimising the design and performance of full-scale low-cost and environmentally sustainable RFB systems for balancing intermittent renewables on a grid scale. Project results should in the medium to long-term term contribute to reach the

targets set in the SET Plan and stimulate investment in the low-carbon energy sector, with the long term aim to boost innovation-driven growth and industrial competitiveness in stationary electrical energy storage.

Type of Action: Research and Innovation action

The conditions related to this topic are provided at the end of this call and in the General Annexes.

LC-BAT-4-2019: Advanced Redox Flow Batteries for stationary energy storage

Specific Challenge: Redox flow batteries (RFB) are considered prime candidates for grid-scale stationary energy storage due to their ability to store large amounts of electrical energy for extended periods and release it quickly when needed. Key features include their scalability, independent sizing of energy and power rating, room temperature operation and potential long cycle life. However, currently used RFB rely on redox couples that are non-indigenous to Europe, not widely available and therefore relatively costly. In addition, the voltage and energy density that can be achieved in aqueous flow batteries are constrained by undesired water electrolysis and the low solubility of the active species. This challenge is in line with the identified priorities in the context of the SET-Plan[10].

Scope: The objective is to develop and validate RFB based on new redox couples and electrolytes (such as organic or earth-abundant substances) that are environmentally sustainable, have a high energy and power density, maximise lifetime and efficiency, while minimising their cost. Validation of new designs must include testing of full-size prototypes in pilot facilities.

Specific issues to be addressed include:

- Long-term stability of the redox couples under repetitive voltage swings, and their enhanced solubility and reversibility;
- Low membrane resistance (or even membrane-free systems);
- Improved electrode reaction kinetics;
- Upscaling (especially increasing the reaction surface);
- Improved battery control systems;
- Environmental sustainability; and
- Safety aspects (toxicity, flammability).

Since cost is the most important driver for grid scale electricity storage, targets for key performance indicators such as levelised cost of energy (€/MWh), cost per surface power

[10] https://setis.ec.europa.eu/implementing-integrated-set-plan/batteries-e-mobility-and-stationary-storage-ongoing-work

density (€/Wm^{-2}) and capital cost (€/kWh of capacity) should be set. "Balance of plant" components should be included in cost optimisation.

The activities are expected to bring the technology from TRL 3 to TRL 5 (please see part G of the General Annexes)[11].

The Commission considers that proposals requesting a contribution from the EU of between EUR 3 and 4 million would allow this specific challenge to be addressed appropriately. Nonetheless, this does not preclude submission and selection of proposals requesting other amounts.

Expected Impact: Project results should contribute to reach the targets set in the SET Plan, putting the energy storage cost on the path to fall below 0.05 €/kWh/cycle by 2030. Overall, the results should stimulate investment in the low-carbon energy sector, with the long term aim to boost innovation-driven growth and industrial competitiveness in stationary electrical energy storage. The proposed action should contribute to accelerating the integration of large shares of intermittent renewables (in particular solar and wind) into the energy system by pushing the boundaries of stationary electrical energy storage.

Type of Action: Research and Innovation action

The conditions related to this topic are provided at the end of this call and in the General Annexes.

LC-BAT-5-2019: Research and innovation for advanced Li-ion cells (generation 3b)[12]

Specific Challenge: The high growth rate of electrified vehicles (xEV) with substantial unit forecasts is driving the demand for electrochemical battery cells. To achieve a significant market share for European suppliers, global competitiveness for xEV batteries has to be achieved.

For the future it is important that European industry and research have the system knowledge in next generation lithium ion battery technology (generation 3b) covering the full value chain and the capability to provide the most essential parts of them both at cell and at the system levels: the cells and their constituent components (anode and cathode materials, separators, electrolytes), the control and sensor systems and the assembly know how. At the same time competitiveness in terms of performance, safety, cycle and calendar life has to be achieved.

With the intended research the development of a strong European industrial base in this field has to be supported. In addition to this topic, topic LC-BAT-1-2019 of this call addresses solid state battery electrochemistry issues, in a longer term perspective..

---

11 This topic is complementary to topic LC-NMBP-27-2019 (Strengthening EU materials technologies for non-automotive battery storage), which addresses TRL 4 to 6.

12 More information regarding definitions (i.e., generation 3b, generation 4, etc) can be found in SET-Plan Action 7, Implementation Plan "Become competitive in the global battery sector to drive e-mobility and stationary storage forward" (page 20).

Scope: The activities will be based on a multidisciplinary approach that includes the system knowledge for the most promising electrochemistries to achieve possible production-readiness by two to three years after the end of the project. The whole system performance for batteries has to be addressed and related monitoring systems / smart management have to be developed (TRL 5-6 achievement at the project end). The advanced performance parameters critical to customer acceptance (low cost per unit of energy and power capacity, safety, resistance to high-power charging, durability), environmental sustainability (energy-efficient manufacturing, recyclability and 2nd life usage) and aspects for large scale manufacturing solutions have to be considered.

At least one of the following bullet points has to be addressed (although a full integration of the three bullet points would provide the best impact):

- Research in cell chemistry, cell morphology & cell architecture to:

a) maximise energy and power density;

b) reduce critical raw materials (in particular cobalt) use per unit stored energy;

c) develop and apply green production processes for cathode, anode and electrolyte materials and coating processes;

d) maintain or improve overall system capability (cell, pack and system levels) in terms of critical parameters such as safety, durability (including deeper understanding of degradation in normal and fast charging and discharging and better balancing of low temperature performance and high temperature life time), high power capability (for regenerative braking and fast charging);

e) environmental sustainability (energy for manufacturing, recyclability, 2nd life opportunities & design for manufacturing) of chemistries and processes achieve all the above while further reducing cost, particularly by pursuing cost reduction of electrode active materials;

- Development of smart micro-sensors and micro-circuits in/at cells or modules for monitoring and diagnosis of cell status thus enabling a wider operational range according to the requirements (usage profile, life time requirements cycles, temperature conditions) in xEV applications by advanced battery management.

- Development of advanced manufacturing methods and equipments capable of managing thinner material layers, increasing quality and its control and enhancing throughput, thus increasing density and reducing cost.

Any needed modelling can be included, provided that it does not need extensive development and can immediately support the needed design aspects. Longer term modelling efforts are developed in the topic LC-BAT-6-2019.

The Commission considers that proposals requesting a contribution from the EU between EUR 5 to 12 million would allow this specific challenge to be addressed appropriately.

Nonetheless, this does not preclude submission and selection of proposals requesting other amounts.

Expected Impact: Research and innovation activities will bring European industry to a stronger position on the world market having the technological knowledge and be prepared for a fast implementation to launch competitive next generation Li-ion cell based (3b) mass production in Europe.

The proposed solutions should demonstrate technological readiness and safety through prototypes in accordance to the required TRL levels (TRL 5-6), improving cell-level energy densities of at least 750 Wh/l, and costs lower than 90€/kWh at pack level, with at least 2,5C (preferably 3 or more) fast charging capability while keeping a useful life of at least 2000 deep cycles (with 10% fast charging) to 80% residual capacity.

At least 20% reduction of critical materials with respect to NMC [13] 8-1-1 at the same energy density.

Type of Action: Research and Innovation action

The conditions related to this topic are provided at the end of this call and in the General Annexes.

LC-BAT-6-2019: Li-ion Cell Materials & Transport Modelling

Specific Challenge: Europe is strong in research capabilities, the ability to industrialize products and competences in terms of material research related to battery chemistry. However, the step towards large-scale mass production of competitive battery technology (mainly Li-ion / advanced Li-ion) has not been established so far and still requires fundamental research. Especially when moving to cell materials beyond conventional Li-Ion battery for mobility applications, it is no longer possible to rely on classic cell design methodology to achieve the ambitious goals set for cell technology after 2025 (both generation 3b and generation 4). As such, advanced modelling and simulation tools are required that specifically target the electrode and cell level and addressing the fundamental understanding of materials and cell behavior. These tools are vital to support future cell development, but require significant advancements in order to meet this challenge. Not only the material characterization must be considered, but in particular the validation of the models and simulation tools must be of utmost priority.

These efforts will require sufficient prototype manufacturing of cells to measure and validate, and is expected to result in a key cornerstone in the overall framework needed to improve European competitiveness in cell design and manufacture. Via a highly dynamical iterative exchange process between prototyping, simulation and newly developed analytical tools an accelerated development process can be established, leading to a significantly accelerated adoption of new battery technologies to the market.

[13] Nickel Manganese Cobalt

Scope: Proposals should address all of the following items:

- Advanced modelling approaches based on different physical domains correctly describing the behaviour of micro-structures in advanced Li-ion cell chemistries and 3D structure, but also considering packing conditions under arbitrary usage scenarios. The new model approaches should be able to take into account the behavior, performance and both homogeneous and inhomogeneous/heterogeneous ageing

- Systematic measurements of basic input parameters for modelling (like heat coefficients, diffusion coefficients, conductivity etc.) to establish a reliable data base for these parameters. This may require measurement techniques and methodologies that may not even currently exist, in order to sufficiently confirm that the simulation data, results and predictions to match the actual cell behavior observed (this could also include new measurement tools to monitor changes in electrode structure or cells, for example mechanical stresses, changes in porosity, microstructure) including complete cell behavior (with respect to formation and cycling) needed for the simulation models and future progress with new advanced modelling approaches.

- Manufacture of prototype cells or cell components with distinctive features to allow 1) generating input parameters to initialize the model, and 2) validating the usability of the simulation models and, at the same time, being clearly conform with future industrialization efforts. Cooperation with projects in LC-BAT-5-2019 can provide support to design, manufacturing and sensitization aspects.

- Demonstrate sufficient correlation between cell measurements and simulation, especially for all relevant cell design needs, as well as the validity and robustness of the models for multiple test variations which account for the relatively big state-space of electrochemical systems. (models should not be just optimized for one particular test case, but also show good correlation with valid test variations).

Additionally some specific aspects can be also considered, such as:

- Sensitivity analysis on model parameters to assess governing parameters and model robustness can also be performed to allow an efficient calibration method and experimentation.

- Investigation of tolerances for cell production by means of simulation, study and prediction failure propagation and consequences on ageing and safety.

- Assessment of EOL properties of newly high optimized (>300Wh/kg) developed cell chemistries based on combined simulation / experimental validation approach, referring to automotive standards & requirements.

- Investigation of new methodologies and procedures to shorten the endurance validation of cells, in terms of functionalities, ageing and safety.

For future battery industry collaborative round-table approaches would achieve a considerable gain, bringing together the whole value chain from academia to the OEM. Furthermore, this can bring together representatives from experimental & simulation fields of expertise, exchanging their knowledge via a structured approach.

The activities should thus focus on a multidisciplinary approach from fields of expertise in simulation and experimental field, investigating battery chemistries most relevant for the automotive field in the next 5-10 years and oriented on the specific ERTRAC energy density targets for advanced Li-ion technologies (generation 3b). By means of such a round table approach; at least TRL 5 level or above is aspired. The synergetic development approach by combining simulation and rapid prototyping on the experimental side is expected to speed up the development processes of battery technologies relevant for cell production in Europe, targeting the automotive market.

The Commission considers that proposals requesting a contribution from the EU between EUR 3 to 6 million would allow this specific challenge to be addressed appropriately. Nonetheless, this does not preclude submission and selection of proposals requesting other amounts.

Expected Impact: The final simulation solution should not increase significantly computing costs and should be compatible with available computing resources in modern engineering workplace, while providing the following benefits:

- Reduce the development time and cost for battery cell up to 30% each.
- Get a better optimum of the design thanks to the analysis based on different physical domains.
- Demonstrate the potential for reduction of number of experiments by factor 3, for the overall development process.
- Reduce battery R&I cost by 20%

It is expected that progress in the area of new and innovative measurement technologies would lead, at some point, to standardized measurement procedures.

Type of Action: Research and Innovation action

The conditions related to this topic are provided at the end of this call and in the General Annexes.

LC-BAT-7-2019: Network of Li-ion cell pilot lines

Specific Challenge: Awareness of the need for a competitive European knowledge base in Li-ion cell technology and manufacturing processes has led to the establishment of a multitude of non-industrial pilot lines all around the EU, recently. Many of these activities are focussed on highly specific systems or processes, and can each alone hardly keep up with the immense advancements of battery cell production, particularly in Asia. In order to maximize the

benefits of the related investments, mutual exchange of data, expertise, and access rights between these pilot lines would be desirable. Therefore, a network of Li-ion pilot lines shall be built, which should include industrial stakeholders, thus establishing the competencies, value chains, and unique selling propositions of the arising European innovation and production ecosystem for li-ion cell technologies. It will be of particular relevance to jointly develop strategies for scaling up the impact of the network and to support the market access of European cell production companies in view of international competition and standardization. Availability of industrial scale or pilot scale production lines can be challenging within Europe. Li-ion battery is an emerging technology established on know-how of the specific companies. There will be difficulties to having a common approach on pilot production facilities due to information security reasons.

Scope: Proposals should address all the following issues:

- Determine the competence profiles of EU Li-ion battery cell pilot lines regarding technologies, production scale, testing & validation, expertise and specialisation;
- Analyse skill and equipment gaps the pilot lines are suffering from in view of arising technology paradigms and worldwide competition;
- Outline a standardized data exchange platform to further the Li-ion cell production know-how in Europe;
- Develop models for the shared access to the pilot lines and for the collaboration of academia and industry including the access of observers as well as for solutions regarding IPR-management ensuring the ownership of IP within the collaboration;
- Develop a common type of contract for ensuring information security of the pilot lines beneficiaries;
- Identify opportunities for the network to exchange results and to work on energy- and resource efficient production processes;
- Following establishment of the above points, a round-robin of parameter measurements in European Li-ion cell pilot lines who allow external access to compare qualification method and match results and to analyse sensitivity of cell properties to production effects;
- Organize joint workshops and conferences within the network and create platforms for mutual learning and focussed training;
- Develop a roadmap of joint strategies for the network to scale up pilot processes from small batch testing towards processes of industrial dimension. This shall outline recommendations and harmonize actions regarding funding, accelerated technology transfer, IPR, roles and responsibilities as well as for business models;

- Carry out dissemination actions to build the network incorporating public and private stakeholders along the value chain and conceptualize formats to increase visibility of the network.

The Commission considers that proposals requesting a contribution from the EU between EUR 1 to 2 million would allow this specific challenge to be addressed appropriately. Nonetheless, this does not preclude submission and selection of proposals requesting other amounts.

Expected Impact: The established network of Li-ion cell pilot lines should lead to:

- Further the production of Li-ion cells towards industrial scale in Europe
- Better utilize synergies of mutual collaboration of pilot lines
- Increase the basis of trained Li-ion battery cell experts in Europe
- Ensure fair competition, open source and access within the network and stakeholders
- Establish a Unique selling proposition (USP) for efficiency in Li-ion cell production
- Create visibility of the network
- Accelerate the advancement of innovation in the field.

Type of Action: Coordination and support action

The conditions related to this topic are provided at the end of this call and in the General Annexes.

LC-BAT-8-2020: Next-generation batteries for stationary energy storage

Specific Challenge: Stationary applications such as utility grids and industrial sites require storage applications that have the ability to combine high power and heavy use, going through multiple deep cycles per day, with a long lifetime and maximum safety. In addition, future battery systems should have optimal sustainability throughout the entire supply chain, including the substitution of critical raw materials, second-life, and recycling. Current generation Li-ion batteries, despite their success in e-mobility, may not be the ultimate solution for stationary storage; in addition, the growth of Li-Ion battery market is not enough to meet the demand for stationary and e-mobility applications. Interest in next-generation Li-ion and non-Li-ion batteries (for example molten salt, metal-air, lithium-sulphur, sodium, flow batteries, solid state, new ion-based systems) for these applications is growing, but many fundamental and technological obstacles remain to be overcome. This challenge is in line with the identified priorities in the context of the SET-Plan.

Scope: The objective is to develop and validate or demonstrate innovative next-generation battery technologies for stationary energy storage that have a low cost, high safety, high depth

of discharge, and high cycle life and efficiency. Development must include the integration of sensors and/or battery management electronics in the cell, and the potential for upscaling the battery systems. The battery systems should have optimal sustainability throughout the entire supply chain, including the substitution of critical raw materials. A key issue is the design of an efficient production process with minimal environmental impacts across the whole life-cycle, including recycling. Solutions must be validated or demonstrated in a relevant environment. Since cost is the most important driver for grid scale electricity storage, targets for key performance indicators such as capital cost, storage cost and end-of-life cost should be set. "Balance of plant" components should be included in cost estimates.

The activities are expected to bring the technology from TRL 3 to TRL 5 (please see part G of the General Annexes).

The Commission considers that proposals requesting a contribution from the EU of between EUR 6 and 8 million would allow this specific challenge to be addressed appropriately. Nonetheless, this does not preclude submission and selection of proposals requesting other amounts.

Expected Impact: Project results are expected to contribute to:

- Assure best possible performance and lifecycle for the next-generation battery technologies for stationary energy storage at lowest cost, in particular by putting the energy storage cost on the path to fall below 0.05 €/kWh/cycle by 2030;
- Reduce the pressure on limited natural resources due to longer battery lifespan, improved recyclability and the use of more abundant and less harmful materials;
- Speeding up development and subsequent deployment of batteries for energy storage applications.

Type of Action: Research and Innovation action

The conditions related to this topic are provided at the end of this call and in the General Annexes.

LC-BAT-9-2020: Hybridisation of battery systems for stationary energy storage

Specific Challenge: Advanced batteries are expected to play a major role in electricity grid management in systems with a high share of renewable electricity. The need for simultaneously providing multiple services (e.g. artificial inertia, frequency regulation, renewables balancing, load levelling, backup power and longer-term energy storage) requires compromises between power needs and energy needs. Hybrid battery systems can provide the ability to optimise power/energy performances by the combination of different technologies. Such hybrid systems would reach better business cases by mixing the contribution to different

services and/or products. This challenge is in line with the identified priorities in the context of the SET-Plan [14].

Scope: The objective is to develop and demonstrate optimised innovative battery storage systems based on hybridisation. The resulting storage system can be engineered either by the twinning of distinct systems, or internal hybridisation of cells and control systems. Focus should be on cell and stack design, on advanced battery management systems and on high-level, hybrid storage control systems. The hybrid storage systems may for example be optimised for one or more of the following applications:

- Stand-alone provision of services to the interconnected pan-European grid
- Provision of services to island grids
- Provision of services in weak distribution grids
- Provision of services in private grids such as industrial parks
- Provision of load levelling for EV charging service stations.

The activities are expected to bring the technologies from TRL 4 to TRL 6 (please see part G of the General Annexes). The battery systems should have optimal sustainability throughout the entire supply chain, including the substitution of critical raw materials. The systems should be demonstrated in a relevant environment and at a scale that allows future business cases to be developed.

The Commission considers that proposals requesting a contribution from the EU of EUR 3 to 4 million would allow this specific challenge to be addressed appropriately. Nonetheless, this does not preclude submission and selection of proposals requesting other amounts.

Expected Impact: Increased competitiveness of electrical energy storage by balancing power needs with energy needs, providing a more efficient system with a longer and better performing lifespan, and by optimising balance-of-plant and installation costs. Project results should put the energy storage cost on the path to fall below 0.05 €/kWh/cycle by 2030.

Type of Action: Research and Innovation action

The conditions related to this topic are provided at the end of this call and in the General Annexes.

LC-BAT-10-2020: Next generation and realisation of battery packs for BEV and PHEV

Specific Challenge: To accelerate the mass market take-up of battery electric vehicles (BEV) and plug-in hybrids (PHEV), it will be necessary to increase the density of battery packs in terms of weight and package space in order to improve range and decrease weight. Moreover, shorter charging times for BEVs through high-power charging will enable travelling over

[14] https://setis.ec.europa.eu/sites/default/files/set_plan_batteries_implementation_plan.pdf

longer distances, imposing further challenges on cooling needs. Higher performance of battery pack raises safety issues which require more robust and flexible advanced Battery Management Systems (BMS).

Besides research on advanced electro-chemistries and cell manufacturing, which are not part of this topic, the integration of battery rechargeable cells into battery packs plays an important role. However, the manufacturing of battery primary cells and their electrochemistry influences their shape and thermal behaviour and hence also the way how they can be integrated into modules and battery packs.

Advanced concepts of BMS relating to hardware and software enabling cell/module/pack communication need to be developed in order to maximise the performance of the final battery system used in vehicles. When aiming at large-scale production of high-density battery packs, manufacturing processes of modules, and their easy and efficient integration into packs need to take into consideration the choice of materials and requirements related to safety, quality, and fast and cost efficient fabrication.

Scope: Proposals will have to address all of the following technical areas for passenger car applications (developed module concept scalability to delivery vans, heavy duty vehicles or busses would be beneficial, but not obligatory. Same applies to concept transfer between BEV and PHEVs):

- Design of advanced battery packs and systems satisfying lightweighting, crashworthiness, electrical and thermal requirements using advanced lightweight materials improved packaging, integration and modularity while considering aspects of ecodesign for manufacturing and dismantling (including their automation), reuse (second life) and recycling/sustainability, leading to a global LCA improvement.

- Development of specific solutions and processes for the sustainable dismantling and recycling of battery pack/modules and their materials, components and sub-systems taking into account safety and automation.

- Flexible advanced battery management systems capable of being used on different types of packs and mid-sized vehicles with different use patterns, and underlying provision to be used in second life applications.

- Advanced functionalities of battery management systems to enable control of modules and packs and their remote maintenance and troubleshooting, software updating and other functions. Safety and modularity aspects must be taken into account when increasing battery pack energy density. In addition, health and environmental aspects of advanced battery pack materials shall be considered over the lifecycle including cases of failure, and reuse/recycling.

- Development of high voltage systems compatible with high-power ultra-fast charging and related implications, including high and low temperature charging, insulation, advanced models (including for instance data mining and big data on existing databases)

for monitoring thermal state and estimation of application-dependant State of Health (i.e. in first and second use).

- Development and qualification of future performance-related test procedures of developed functionalities under real-world conditions, incl. extreme environmental conditions.

- Concept validation of battery performance functionalities at full scale should be demonstrated through pack integration into an existing vehicle (no vehicle development can be included in claimed costs) which should also serve as a benchmark of achieved performance.

- Development and qualification of future safety related test procedures e.g. venting/management of gases, battery failure warning signals, thermal propagation.

The combination of achieved improvements with new components and functionalities on the vehicle and infrastructure sides coming from topics LC-GV-01-2018, LC-GV-02-2018 and LC-GV-03-2019) should allow the development of new concepts for affordable FEVs which enable long duration trips (e.g. 700-1000km day trips across different Member States) with not more than respectively 60-90 minutes additional travel time in comparison with ICE vehicles and without additional degradation impact on the FEV powertrain including the battery when used for max 10% of the charging events.

The Commission considers that proposals requesting a contribution from the EU of between EUR 8 and 10 million would allow the specific challenge to be addressed appropriately. Nonetheless, this does not preclude submission and selection of proposals requesting other amounts.

Expected Impact:

- Considerably improved performance of the EV through reduced battery system weight by 20% at constant electric vehicle range for mid-size battery electric car.

- Overcome the uncertainty of range by achieving 25% shorter recharging time with a 150kW charger compared to best in class electric car available on the market in 2018. The demonstrator must have the same battery capacity as the reference car and meet the useful battery life mentioned below.

- Improved attractiveness of the EV through achieving extended useful battery life to 300 000 km in real driving[15] referring to a mid-size passenger car using improved battery management, balancing and thermal management during high-power charging/discharging.

[15] A realistic driving cycle like WLTC can be used, adding simulated heating, defrosting and cooling consumption along the year and slow-medium charging for normal use plus a group of two consecutive fast charges to 80% every 6.000 km and one fast charge to 80% every 2000km.

- Contribution to Circular Economy goals through a minimum 20% Life Cycle Analysis improvement compared to existing products.
- Considerably improved knowledge on module and pack sensorisation and thermal management.

Type of Action: Innovation action

The conditions related to this topic are provided at the end of this call and in the General Annexes.

LC-BAT-11-2020: Reducing the cost of large batteries for waterborne transport

Specific Challenge: Large battery packs are increasingly deployed to improve the efficiency and to eliminate emissions from waterborne transport. However waterborne transport batteries can be up to ten times more expensive than an automotive battery of equivalent capacity and their high cost is an important barrier to increasing the deployment of both hybrid and fully battery electric shipping. Unlike for other transport modes, the space, weight and consequently power density of waterborne transport batteries is usually of secondary importance within the systems total life cycle cost. Several factors contribute to the cost difference including production processes, safety certification, fire suppression, lower economies of scale and higher assembly costs. The challenge is to substantially reduce the cost of large waterborne transport battery systems and cells for both marine and inland waterway transport applications.

Scope: Proposals can address either the battery cell or the battery system (racks, battery management system, fault detection and any integrated fire suppression) or both the cell and battery system.

All of the following aspects should be addressed:

- With respect to waterborne transport, research and develop a large battery system and/or specific battery cells that are substantially cheaper on a total cost basis with respect to existing system.
- Work should be applicable to battery systems of at least 1 MWh capacity.
- Prove the technology and manufacturing processes through system trials and testing.
- Address production process efficiency.
- Address the requirements for type approval from relevant authorities including a comprehensive risk based safety assessment.
- Development of a marine battery certification methodology with the objective of: validating and verifying safety (with consideration of air, liquid or passive cooling), including the standardisation of test methods and tools for certification cost reduction.

- Considering of different vessel types, address the integration of battery systems into Energy/Power management system of vessel.
- Undertake a cost benefit analysis to convincingly demonstrate the cost savings in comparison to current state of the art waterborne battery technology.
- Assess end of life and disposal strategies.
- Develop a convincing business case and consider potential financing models.

The Commission considers that proposals requesting a contribution from the EU of between EUR 8 and 12 million would allow the specific challenge to be addressed appropriately.

Expected Impact: The principal impact should be to substantially reduce the lifetime cost of large waterborne battery systems and to enhance the competitiveness of European industry within the waterborne battery market. Cut greenhouse gas emissions from waterborne transport. Increase the European skills base in large battery technology and manufacturing processes. Support European jobs and growth. Increase confidence in waterborne battery technology investment. Speed up the transition of most short range freight and ferry services towards zero emission.

Type of Action: Research and Innovation action

The conditions related to this topic are provided at the end of this call and in the General Annexes.

A large-scale research initiative on Future Battery Technologies

The last four topics in this Call (from LC-BAT-12-2020 to LC-BAT-15-2020) implement a large-scale research initiative on Future Battery Technologies, as announced in May 2018 as part of the Third Mobility Package[16]. It aims to ensure the European knowledge base in long term battery research. The topics tackle long-term research challenges expected to result in 'game changing' impacts on future battery technologies paving the way for providing a technological competitive advantage to the European battery industry. Because of their ambition, their scale and their interdisciplinary nature, these challenges can only be realised through a long-term, coordinated and sustained effort at European level, by building on large scale research cooperation across academia and industry and with other research initiatives at regional, national and European level, and by mobilising Europe's best researchers around an ambitious research agenda[17]. Note that a further topic in this work programme part, CE-NMBP-41-2020, calls for an ERANET Cofund action, including for fostering synergy between European, national and regional initiatives and promoting broader partnerships between the European stakeholders in future battery technologies.

Proposals are invited against the following topic(s):

[16] See https://ec.europa.eu/transport/sites/transport/files/3rd-mobility-pack/com20180293-annex2_en.pdf

[17] See Manifesto for a long-term research initiative to create the batteries of our future: http://battery2030.eu/

LC-BAT-12-2020: Novel methodologies for autonomous discovery of advanced battery chemistries

Specific Challenge: The performance and durability of existing batteries are limited due to insufficient knowledge in managing the complex and dynamic processes taking place in the materials and in particular at the interfaces/interphases within the battery cell. The long-term challenge is to integrate advanced multi-scale computational modelling, materials synthesis, characterization and testing to perform closed-loop autonomous materials findings and interphase engineering that would accelerate by at least a factor of 5 the discovery of new battery chemistries with ultra-high performances.

Scope: The target is to develop a pilot materials platform for computational and experimental material characterization that would pave the way towards the development of a full-scale autonomous battery Material Acceleration Platform (MAP) enabling closed-loop materials discovery, automated characterization, device-level testing and addressing aspects related to manufacturability and recyclability. The pilot MAP should deliver a blueprint of the targeted autonomous material discovery platform that could demonstrate key features such as: the ability to use modeling, simulation and machine learning techniques to determine optimal materials composition, the ability to autonomously direct an automated material synthesis robot in optimizing selected battery materials and the ability to perform autonomous analysis and interpretation of experimental data and of deriving previously unknown structures and compositions. The pilot MAP should demonstrate the potential of this novel approach on a specific test case targeting the optimization of specific advanced or emerging battery chemistries. It should be sufficiently flexible to be adaptable for future disruptive battery chemistries, concepts and technologies and for integrating aspects like manufacturability, ageing, degradation and recycling of importance to the entire battery lifecycle. Proposals should be specifically targeting battery interfaces such as the Solid Electrolyte Interphase and the Cathode Electrolyte Interphase that are critical for the battery functionality, as well as controlling their formation, composition and morphology.

The Commission considers that proposals for Research and Innovation Actions of a 3-year duration and requesting a contribution from the EU up to EUR 20 million would allow this specific challenge to be addressed appropriately. Nonetheless, this does not preclude submission and selection of proposals of another duration and/or requesting other amounts.

The project partners shall make provisions to actively participate in the common activities of the large scale research initiative on Future Battery Technologies and in particular: coordinate technical work with the other selected projects under topics LC-BAT-13-2020 and LC-BAT-14-2020; and contribute to the activities of the Coordination and Support Action defined under the topic LC-BAT-15-2020. In particular, the project partners will need to conclude a written collaboration agreement with the other projects selected from these topics as indicated in the Grant Conditions.

Note that special Grant Conditions will apply for projects granted under this topic. Please see under Call Conditions.

Expected Impact:

- Demonstrate a fundamental paradigm shift in the materials discovery process for clean energy materials, yielding to a significant acceleration in the development cycle for future battery materials and technologies, which cannot be achieved using conventional Edisonian type trial-and-error approaches.
- Demonstrate the potential to achieve a 5-10 fold acceleration in the materials discovery process, e.g. through a reduction in the number of required experimental trials.
- Demonstrate the ability to improve the performance of the selected battery interfaces with the developed methodologies.

Type of Action: Research and Innovation action

The conditions related to this topic are provided at the end of this call and in the General Annexes.

LC-BAT-13-2020: Sensing functionalities for smart battery cell chemistries

Specific Challenge: Today, battery performance monitoring and control basically takes place only at the module or battery pack level via a battery management system (BMS). To gain a full supervision and thus control of the battery system and to increase their quality, reliability and life (QRL), it is necessary to monitor in operando the battery performance and control of their state of health (SoH), state of charge (SoC), state of energy (SoE), state of power (SoP) and state of safety (SoS). The challenge is to incorporate smart functionalities into the battery cell for following in time and space different relevant cell component parameters such as temperature variations, interface and interphase dynamics, structural changes by the integration and development of various sensing technologies so as to facilitate control of individual cells within the battery system.

Scope: The target is to develop a proof of concept for the establishment of successful sensing technologies capable of monitoring changes within a battery cell under various operation conditions, including their use under extreme weather conditions, as a first step towards the development of a wider range of sensing technologies capable of monitoring of cells from various emerging battery chemistries. The proof of concept should focus on the sensing technologies and the integration of sensors in liquid electrolyte cell technologies since it is deemed to be the technology of choice for short to medium term. Proposals should aim at smart functionalities incorporated into the battery cell and relying on the integration and development of various sensing technologies to transmit information out of the cell, in order to facilitate control of individual cells within the battery system. Sensors could be used to simultaneously measure with high sensitivity and resolution changes in multiple parameters, such as chemical composition, strain, temperature, pressure, and concentration of dissolved cations, and this at various locations and for diverse components within the cell, under different use cases, especially during high power charging. They must consider the adaptability of sensors to the targeted cell environment in terms of chemical and

electrochemical reactivity, thermal design and foresee boundary manufacturing constraints. Additional constraints such as cost and recyclability of the battery with embedded sensor technology should also be tackled. Data processing within an advanced battery management system (BMS) and the synchronization with sensor data coming from the module and the pack level, incl. provisions for conflicting data management, is another essential aspect. Advancements towards standardisation of the BMS could also be included. With this regard, collaboration shall be ensured with the topic LC-BAT-10-2020: Next generation and realisation of battery packs for BEV and HEV.

All results shall be validated and demonstrate significant improvements compared to the state-of-the art technologies, incl. benchmarking to initiatives or projects supported under national funding schemes.

The Commission considers that proposals for Research and Innovation Actions of a 3-year duration and requesting a contribution from the EU of between EUR 2 and 4 million would allow this specific challenge to be addressed appropriately. Nonetheless, this does not preclude submission and selection of proposals of another duration and/or requesting other amounts.

The project partners shall make provisions to actively participate in the common activities of the large scale research initiative on Future Battery Technologies and in particular: coordinate technical work with the other selected projects of the call under topics LC-BAT-12-2020 and LC-BAT-14-2020; and contribute to the activities of the Coordination and Support Action defined under the topic LC-BAT-15-2020. In particular, the project partners will need to conclude a written collaboration agreement with the other projects selected from these topics as indicated in the Grant Conditions.

Note that special Grant Conditions will apply for projects granted under this topic. Please see under Call Conditions.

Expected Impact:

- Increased quality, reliability and life (QRL) of the battery system by maximizing the performance and safety of the complete battery system over its lifetime, including forecasting the remaining lifetime under different use cases, especially the suitability for possible "second life" usage.
- Assured best possible performance and lifecycle for a range of applied cell types at lowest cost
- Industrial opportunities for exploiting new concepts and technologies for integrating multifunctional sensor capabilities in the battery cells and for optimizing the performance of the complete battery systems
- Better identification of defective cell components, allowing replacement of components or introduction of local targeted repair mechanisms, such as self-healing, in future cell design and chemistry generations.

- Improved knowledge on different factor (use patterns, ambient temperature etc.) impact on battery performance and characteristics.

- Provide the foundations for collecting large amounts of data that can be used for autonomous discovery of future battery chemistries and for development of advanced modelling approaches to improve current chemistries with a view of optimizing cell performance for mobility applications (linking with topic LC-BAT-6-2019)

Type of Action: Research and Innovation action

The conditions related to this topic are provided at the end of this call and in the General Annexes.

LC-BAT-14-2020: Self-healing functionalities for long lasting battery cell chemistries

Specific Challenge: Increasing our daily dependence on batteries calls for increased efforts in ensuring their quality, reliability and life (QRL). While sensing is the natural instrument to monitor and control QRL, it can also serve to identify defective components and local spots in the cell that need to be repaired by injection or addition of self-healing functions.

Scope: The target is to deliver a proof-of-concept for the realization of battery cells with the proper repairing additives and to elucidate the modus operandi of the specific self-healing functionality by advanced analytical tools. Proposals should aim at developing innovative auto-repairing approaches for cell components such as mechanisms for on-demand administration of molecules that can solubilize a resistive deposit or at injecting self-repairing polymers to restore a defective electrode within the battery. They should lay the foundation for a sound scientific platform on battery self-healing relying on chemical/physical tooling. Whatever the pursued approach, it will have to comply with the electrochemical environment of the targeted cell environment, be readily adaptable to battery cell mass production processes and not hinder subsequent recycling process. The competitive advantage over alternative approaches like replacement or recycling or second-use should be demonstrated.

The Commission considers that proposals for Research and Innovation Actions of a 3-year duration and requesting a contribution from the EU of between EUR 2 and 4 million would allow this specific challenge to be addressed appropriately. Nonetheless, this does not preclude submission and selection of proposals of another duration and/or requesting other amounts.

The project partners shall make provisions to actively participate in the common activities of the large scale research initiative on Future Battery Technologies and in particular: coordinate technical work with the other selected projects under topics LC-BAT-12-2020 and LC-BAT-13-2020; and contribute to the activities of the Coordination and Support Action defined under the topic LC-BAT-15-2020. In particular, the project partners will need to conclude a written collaboration agreement with the other projects selected from these topics as indicated in the Grant Conditions.

Note that special Grant Conditions will apply for projects granted under this topic. Please see under Call Conditions.

Expected Impact:

- Increased quality, reliability and life (QRL) of the battery system by extending the lifetime of the battery cells and maximizing their performance
- Industrial opportunities for exploiting new concepts and technologies for integrating self-healing capabilities in the battery cell.

Type of Action: Research and Innovation action

The conditions related to this topic are provided at the end of this call and in the General Annexes.

LC-BAT-15-2020: Coordinate and support the large scale research initiative on Future Battery Technologies

Specific Challenge: To network and coordinate the large scale research initiative on Future Battery Technologies and its contribution to the broader efforts of the European research and innovation stakeholders in battery technologies foreseen at European level and in the Strategic Energy Technology (SET) Plan[18]

Scope: Proposals are expected to coordinate the research activities and the stakeholders participating in the initiative; to facilitate communication, dialogue and cooperation on cross-cutting topics; to monitor the initiative's progress and maintain its roadmap; to provide support for its governance; to promote and communicate the objectives of the initiative[19] and its achievements, including by ensuring media presence and public visibility, by engaging with industry and society and by participating or organising outreach events; to identify training and education needs and promote European curricula in future battery technologies. In particular, proposals should identify and coordinate relevant efforts for modelling and data sharing, standardisation, IPR actions in cooperation with other relevant initiatives at European level. They should also help networking and collaboration with other relevant national and international activities in the field. They should cooperate with the ETIP on battery announced in the EU Strategic Action Plan on Batteries[20].

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

The Commission considers that proposals for Coordination and Support Actions of a 3-year duration and requesting a contribution from the EU of up to EUR 2 million would allow this

[18] See https://ec.europa.eu/en/topics/technology-and-innovation/strategic-energy-technology-plan

[19] encompassing the overall strategy and all activities funded under topics LC-BAT-12-2020, LC-BAT-13-2020 and LC-BAT-14-2020

[20] See https://ec.europa.eu/transport/sites/transport/files/3rd-mobility-pack/com20180293-annex2_en.pdf

specific challenge to be addressed appropriately. Nonetheless, this does not preclude submission and selection of proposals of another duration and/or requesting other amounts.

Note that special Grant Conditions will apply for projects granted under this topic. In particular, the project partners will need to conclude a collaboration agreement with the other projects selected from the topics LC-BAT-12-2020, LC-BAT-13-2020 and LC-BAT-14-2020 as indicated in the Grant Conditions.

Please see under Call Conditions.

Expected Impact:

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

Type of Action: Coordination and support action

The conditions related to this topic are provided at the end of this call and in the General Annexes.

Conditions for the Call - Building a Low-Carbon, Climate Resilient Future: Next-Generation Batteries

Opening date(s), deadline(s), indicative budget(s):[21]

Topics (Type of Action)	Budgets (EUR million)		Deadlines
	2019	2020	
Opening: 24 Jan 2019			

[21] The Director-General responsible for the call may decide to open the call up to one month prior to or after the envisaged date(s) of opening.
The Director-General responsible may delay the deadline(s) by up to two months.
All deadlines are at 17.00.00 Brussels local time.
The budget amounts for the 2019 budget are subject to the availability of the appropriations provided for in the draft budget for 2019 after the adoption of the budget 2019 by the budgetary authority or, if the budget is not adopted, as provided for in the system of provisional twelfths.

LC-BAT-1-2019 (RIA)	25.00 [22]		25 Apr 2019
LC-BAT-2-2019 (RIA)	24.00 [23]		
LC-BAT-3-2019 (RIA)	5.00 [24]		
LC-BAT-4-2019 (RIA)	15.00 [25]		
LC-BAT-5-2019 (RIA)	30.00 [26]		
LC-BAT-6-2019 (RIA)	13.00 [27]		
LC-BAT-7-2019 (CSA)	2.00 [28]		
Opening: 09 Jul 2019			
LC-BAT-12-2020 (RIA)		20.00 [29]	16 Jan 2020
LC-BAT-13-2020 (RIA)		10.00 [30]	
LC-BAT-14-2020 (RIA)		10.00 [31]	
LC-BAT-15-2020 (CSA)		2.00 [32]	
Opening: 03 Dec 2019			
LC-BAT-10-2020 (IA)		40.00 [33]	21 Apr 2020
LC-BAT-11-2020 (RIA)		20.00 [34]	
LC-BAT-8-2020 (RIA)		20.00 [35]	
LC-BAT-9-2020 (RIA)		10.00 [36]	
Overall indicative budget	114.00	132.00	

Indicative timetable for evaluation and grant agreement signature:

22 of which EUR 25.00 million from the 'Smart, green and integrated transport' WP part.
23 of which EUR 24.00 million from the 'Secure, clean and efficient energy' WP part.
24 of which EUR 5.00 million from the 'Secure, clean and efficient energy' WP part.
25 of which EUR 15.00 million from the 'Secure, clean and efficient energy' WP part.
26 of which EUR 30.00 million from the 'Smart, green and integrated transport' WP part.
27 of which EUR 13.00 million from the 'Smart, green and integrated transport' WP part.
28 of which EUR 2.00 million from the 'Smart, green and integrated transport' WP part.
29 of which EUR 20.00 million from the 'Future and Emerging Technologies' WP part.
30 of which EUR 10.00 million from the 'Future and Emerging Technologies' WP part.
31 of which EUR 10.00 million from the 'Future and Emerging Technologies' WP part.
32 of which EUR 2.00 million from the 'Future and Emerging Technologies' WP part.
33 of which EUR 40.00 million from the 'Smart, green and integrated transport' WP part.
34 of which EUR 20.00 million from the 'Smart, green and integrated transport' WP part.
35 of which EUR 20.00 million from the 'Secure, clean and efficient energy' WP part.
36 of which EUR 10.00 million from the 'Secure, clean and efficient energy' WP part.

For single stage procedure:

- Information on the outcome of the evaluation: Maximum 5 months from the final date for submission; and
- Indicative date for the signing of grant agreements: Maximum 8 months from the final date for submission.

Eligibility and admissibility conditions: The conditions are described in General Annexes B and C of the work programme.

Evaluation criteria, scoring and threshold: The criteria, scoring and threshold are described in General Annex H of the work programme.

Evaluation Procedure: The procedure for setting a priority order for proposals with the same score is given in General Annex H of the work programme.

The full evaluation procedure is described in the relevant guide published on the Funding & Tenders Portal.

Grant Conditions:

LC-BAT-12-2020, LC-BAT-13-2020, LC-BAT-14-2020, LC-BAT-15-2020	Grants awarded under this topic shall be implemented as a programme through the use of complementary grants to those awarded under topics LC-BAT-12-2020, LC-BAT-13-2020, LC-BAT-14-2020 and LC-BAT-15-2020, and the respective options of Article 2, Article 31.6 and Article 41.4 2 of the Model Grant Agreement will be applied. In particular the projects are required to conclude a collaboration agreement, in principle prior to the signature of the grant agreement.
LC-BAT-12-2020, LC-BAT-13-2020, LC-BAT-14-2020	For grants awarded under this topic for Research and Innovation Actions the Commission or Agency may object to a transfer of ownership or the licensing of results to a third party established in a third country not associated to Horizon 2020. The respective option of Article 30.3 of the Model Grant Agreement will be applied.

Consortium agreement:

All topics of this call	Members of consortium are required to conclude a consortium agreement, in principle prior to the signature of the grant agreement.

Call - COMPETITIVE, LOW CARBON AND CIRCULAR INDUSTRIES

H2020-LOW-CARBON-CIRCULAR-INDUSTRIES-2020

This call addresses research challenges related to the Circular Economy – a priority since the 2015 Circular Economy Action Plan – as well as to reaching carbon neutral industries as set out in the November 2018 Commission Communication "A Clean Planet for all– A European strategic long-term vision for a prosperous, modern, competitive and climate neutral economy".

Research and Innovation implementing these two priorities will significantly contribute to the modernisation of industrial processes and to new ways designing products and business models. Results coming out of the project portfolio under this call should demonstrate the economic, environmental, climate and social added-value of decarbonised and circular production systems.

The cross-cutting nature of this call should lead to an improved cooperation and integration between sectors and value chains, and to making circular economy practices more mainstreamed and widespread and contributing to a carbon neutral industry in the medium term.

This call supports the development of innovative productions systems and business models, in which resource efficiencies, waste management and system thinking should be incorporated in the initial design, across sectors that are traditionally resource and energy intensive and/or with significant environmental footprints. The objective is the design and demonstration of profitable and sustainable (circular) value chains of materials, products and services, and of transactions for novel sourcing of required inputs and value-added destinations for non-product outputs between industrial facilities (industrial symbiosis). The environmental, climate, economic and social gains should be assessed from a comprehensive full life cycle perspective, including production and recycling processes, materials, and products (cradle-to-cradle).

Portfolio approach as to the envisaged impact

In order to strengthen the impact of the activities under the call, clustering of projects around certain activities into portfolios will be facilitated. This portfolio approach will be pursued to establish regular exchange of information between all projects under this call and to clarify thematic links across topics. Where relevant, clusters will be created to ensure optimal coordination between relevant projects, to promote continuous dialogue and exchange of good practices between all actors involved, improve communication and transfer of knowledge and to identify technological and non-technological barriers. Proposals are therefore encouraged to contribute be open to such clustering activities, including coordinated deliverables and joint dissemination or exploitation activities, with other projects selected under this call and under

previous relevant ones. A workshop at the beginning of the projects will be organised to explain and put into practice this portfolio approach.[37].

Proposals are invited against the following topic(s):

CE-NMBP-41-2020: ERA-NET on materials, supporting the circular economy and Sustainable Development Goals

Specific Challenge: Maintaining Europe's position in research related to materials science and engineering requires concentrated action on common European research priorities in view of implementing joint initiatives.

The M-ERA.NET 2 network has successfully targeted the Low Carbon Energy Technologies addressed by the SET Plan. Now the scope should on one hand guarantee some continuation, and on the other hand become more ambitious and underline the commitment of the EU regarding the circular economy and Sustainable Development Goals.

The European Commission has adopted an ambitious new Circular Economy Package to help European businesses and consumers to make the transition to a stronger and more circular economy. Moreover, in 2016, the 17 Sustainable Development Goals (SDGs) of the 2030 Agenda for Sustainable Development came into force. They aim to end poverty, protect the planet, ensure prosperity and tackle climate change. The EU is fully committed to be a frontrunner in implementing the 2030 Agenda and SDGs. Finally, the Commission launched the Battery Alliance initiative in 2017.

Materials research is a relevant field for addressing these overall challenges and for making substantial contributions to achieving the specific objectives.

Global challenges call for co-operation on a global scale to build capacity in science, technology and innovation (STI) at both national and international levels. A strategic and industrially relevant approach is needed that cover the entire research and innovation chain by pooling national research and innovation capacities, thereby mobilising European infrastructure networks as well as promoting education and training in materials research and innovation.

Scope: The proposed ERA-NET aims at coordinating the research efforts of the participating Member States, Associated States and Regions in the field of materials, continuing the activities started by M-ERA.NET, for materials research and innovation, especially targeting the circular economy and Sustainable Development Goals (such as Goal 7 – "Affordable and clean energy", by enabling electromobility through sustainable energy storage technology or Goal 9 "Industrial innovation and infrastructure", by enhancing scientific research and upgrading the technological capabilities of industrial sectors). Proposals should pool the necessary financial resources from participating national or regional research programmes by implementing a joint transnational call for proposals (resulting mainly in grants to third parties) with EU co-funding to fund multinational innovative research initiatives in this

[37] SPIRE-13-2017, CIRC-01-2016-2017, SC5-04-2019

domain, including support to the large scale research initiative on future battery technologies launched under the H2020-LC-BAT-2019-2020 Call[38].

Proposers are also requested to implement other joint activities and, additional joint calls without EU co-funding. The proposal should demonstrate that these additional joint calls exclude any overlaps with related on-going actions co-funded by the EU under NMBP.

Proposals should demonstrate the expected impact on national and transnational programmes as well as the leverage effect on European research and competitiveness, and should plan the development of key indicators for supporting this.

Participation of legal entities from third countries, and/or regions including those not automatically eligible for funding in accordance with General Annex A is encouraged in the joint call as well as in other joint activities including additional joint calls without EU co-funding. Participants from countries not listed in General Annex A are eligible for EU funding under this topic and may request a Union contribution (on the basis of the ERA-NET unit cost) only for the coordination costs of additional activities.

The Commission considers that proposals requesting a contribution from the EU of EUR 15 million would allow this specific challenge to be addressed appropriately. Nonetheless, this does not preclude submission and selection of proposals requesting other amounts. EUR 5 million of the requested contribution from the EU should be used as support to transnational projects, co-funded by the Commission, on future battery technologies, fostering synergy between European, national and regional initiatives and promoting broader partnerships between the European stakeholders in future battery technologies.

Expected Impact:

- synergies with international, national and regional programmes that support research and innovation;
- synergies but no overlap with the topics of Horizon 2020 and with related European Partnership initiatives and be open to adapt to future coming initiatives of Horizon Europe;
- leverage of national, regional and European funding;
- contribution to meeting Global Challenges through Better Governance: International Co-operation in Science, Technology and Innovation;
- relevant contribution to the SDGs, including sustainable battery based energy storage technology;
- relevant contribution towards a circular economy.

Type of Action: ERA-NET Cofund

[38] http://ec.europa.eu/research/participants/data/ref/h2020/wp/2018-2020/main/h2020-wp1820-cc-activities_en.pdf

The conditions related to this topic are provided at the end of this call and in the General Annexes.

CE-NMBP-42-2020: Materials life cycle sustainability analysis

Specific Challenge: The main purpose of the Circular Economy (CE) is to develop material/product business models that are economically and environmental sustainable, with actions supporting each stage of the value chain (from production to consumption, from design to recycling and upcycling of waste-materials) while promoting industrial and social innovation. In line with this, the challenge is to evaluate product improvement, taking into consideration, all relevant subsystem interactions (environmental, economic and social) and all the life cycle stages of the product. However, although environmental indicators and methodologies for product level assessment are well advanced and harmonised (LCA-PEF[39]) this is not yet the case as regards the social and economic pillars of sustainability assessment. Life cycle sustainability analysis (LCSA) is needed, integrating social and economic benefits with environmental burdens, which fit these causal interrelations into an holistic approach understandable to different stakeholders.

Scope:

- Develop approaches/methodologies to incorporate social and economic indicators in sustainability evaluations;
- Develop approaches and select indicators that allow formalising connections between subsystems. Existing standard methods[40] should be used in this project for assessing environmental impacts. As regards, social life cycle assessment it is suggested to build on the work done by the Life Cycle Initiative[41];
- Develop a quantitative approach that allows assessment of the sustainability multi-criteria trade-offs of circularity (cradle to cradle) dynamically in real cases. The approach needs to facilitate the incorporation of existing product LCSA harmonised approaches;
- Develop a public demonstration of the LCSA approach, which can contribute towards effective uptake of LCSA within different sectors;
- Work with industrial associations and clusters to engage with industry and especially SMEs but also with consumer organisations, as well as governmental and standardisation bodies;
- Stimulate the use of existing ontologies developed under Horizon 2020.

Clustering and cooperation with other selected projects under this cross-cutting call and other relevant projects is strongly encouraged.

39 http://ec.europa.eu/environment/eussd/smgp/PEFCR_OEFSR_en.htm
40 https://www.lifecycleinitiative.org/resources/reports/,
41 https://product-social-impact-assessment.com/handbook/

Proposals submitted under this topic should include a business case and exploitation strategy, as outlined in the Introduction of this part of the Work Programme.

Activities should start at TRL 3 and achieve TRL 6 at the end of the project.

The Commission considers that proposals requesting a contribution from the EU around EUR 6 million would allow this specific challenge to be addressed appropriately. Nonetheless, this does not preclude submission and selection of proposals requesting other amounts.

Expected Impact:

- More robust early-stage evaluations and increase consistency across sectors and through value chains through improved sustainability evaluation tools;
- Better informed investment decision-making for future products and processes through improved visualisation and communication of potential sustainability trade-offs with stakeholders
- Support the implementation of EU policies, including the transition to a more circular economy at different scales of economic and social conditions.
- Creation of new business opportunities and increased competiveness of EU industries and supporting SMEs in the transition to the circular and sustainable economy;
- Improved product investment decisions for industry;
- Contribution to a future LCSA at European Union level linked to the certification of final products.

Type of Action: Research and Innovation action

The conditions related to this topic are provided at the end of this call and in the General Annexes.

CE-SPIRE-01-2020: Tapping into the potential of Industrial Symbiosis

Specific Challenge: Industrial Symbiosis holds significant potential to provide major improvements in resource and energy efficiency for all energy intensive industries. Exploiting this potential could accelerate the transition to a circular economy and to renewable energy systems, reduce waste heat energy and lead to significant reduction of GHG emissions. However, Industrial Symbiosis is currently not yet widely implemented. The challenge is to tackle all technological and non-technological barriers. The full potential of industrial symbiosis could only unfold if the consequences for energy grids and adjacent infrastructures (e.g. waste heat recovery through district heating or heat integration in chemical processes, waste to energy, or waste and gaseous effluents management), as well as the regional dimension are taken into account.

Scope: Technology based innovations should prove the potential for novel symbiotic value chains in demonstrators involving multiple industrial sectors in real industrial settings. Proposals are expected to address e.g.:

- Broader symbiosis, from local and regional perspectives, with infrastructures (e.g. waste and water management infrastructure, gas networks), communities and energy grids (e.g. smart operations scheduling, district heat integration), including distributed generation and the role that symbiosis can play in fluctuating energy grids (i.e. grid services, seasonal storage, biomass or heat pumps integration);

- Management of side/waste streams (through e.g. capturing, purification, concentrating, sorting, collecting, exchanging or preparation) specifically for the use as resource for other plants and companies across sectors and/or across value chains;

- Process (re-)design and implementation to integrate and adapt existing processes to enhance industrial symbiosis (energy and material flow coupling, infrastructure and logistics).

- Integration of information technology, including artificial intelligence, and operational technology; appropriate ICT tools (e.g. aggregation technologies) for multi-criteria decision making, for the design and the operation management of exchange streams in a dynamic production environment, advanced modelling to design and establish novel symbiotic interactions; data sharing and preservation of data confidentiality;

- Assessment methodologies and KPIs to measure the performance of symbiosis, including environmental, economic and social impacts. Life cycle assessment and life cycle cost analysis should take into account existing sustainability standards (e.g. ISO 10410) and existing best practices;

Creation of an inventory of successful symbiotic relations and solutions, as well as best practices. Non-technological aspects, which may include regulatory issues, the need for redefining standards, and new business models, covering ownership, management and fair sharing of benefits, should be considered. This may entail devising collaboration strategies via contracts and platforms for cross-sectorial sharing of resources and benefits in industrial parks, clusters or distributed plants.

Clustering and cooperation with other selected projects under this cross-cutting call and other relevant projects is strongly encouraged.

Proposals submitted under this topic should include a business case and exploitation strategy, as outlined in the Introduction of this part of the Work Programme.

Activities should start at TRL 6 and achieve TRL 7 at the end of the project.

The Commission considers that proposals requesting a contribution of EUR between EUR 12 and 20 million would allow this specific challenge to be addressed appropriately.

Nonetheless, this does not preclude submission and selection of proposals requesting other amounts.

Expected Impact: Several of the following impacts are expected:

- Step change towards closing circular loops;
- Improvement of at least 15% in energy efficiency of the targeted industrial processes, compared to the non-symbiotic scenario;
- Reduction of at least 30% in total energy intensity, on the basis of full life cycle considerations;
- Overall reductions in CO2 emissions of 40% compared to the non-symbiotic scenario;
- Reduction in primary raw material intensity of up to 20%;
- Reduction of waste generation by at least 25%;
- Better understanding of relevant barriers (e.g. end of waste criteria);
- Effective dissemination of major innovation outcomes to the current and next generation of employees, through the development of learning resources with flexible usability. These should be easy to integrate in existing curricula and modules for undergraduate level and lifelong learning programmes;
- The environmental gains in absolute figures, and weighted against EU and global environmental footprints, should be demonstrated;
- In addition, the replication potential should also be be assessed.

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

Type of Action: Innovation action

The conditions related to this topic are provided at the end of this call and in the General Annexes.

CE-SPIRE-07-2020: Preserving fresh water: recycling industrial waters industry

Specific Challenge: Energy-intensive industries are major users of fresh water, for e.g. processing, washing, diluting, heating, cooling, and transporting products. Since fresh water is a scare resource, breakthrough innovations are needed in energy-intensive industries to recycle water and create closed loops in industrial processes. Such closed loops would significantly reduce the use of fresh water and improve water availability in the relevant EU water catchment areas, as outlined in the Water Framework Directive, for other purposes (adjacent communities, farming and bio-based industries). Industrial symbiosis offers the potential for energy, water and other resource efficiency at a scale beyond energy intensive industries.

Scope: Proposals should aim at near-zero discharge using closed-loop systems in combination with recovery of energy and/or substances (resources) through the development of integrated water-smart strategies for industrial processes.

Strategies should take into account:

- Better characterising the water usage and production in the industrial processes;
- Defining recycling options with a combined water, waste and energy approach in an integrative system design method considering investment and optimal operations;
- Future production demand through design, control options, and technologies integration that reduce water consumption, recycle water, and reduce the use of fresh water resources in closed-loop industrial processes including cascading use of different kinds of water in industrial settlements or for compatible re-use in urban and rural areas.

Reprograming of water resources and optimisation of water management in industrial processes should apply the principles of waste - water - energy design in a circular context.

Proposals should develop new technologies and approaches at a large scale. It is anticipated to combine:

- Real time smart monitoring and management systems with innovative digital solutions for sensors and actuators (e.g. modelling and artificial intelligence) and;
- Recycling technologies such as highly selective separation or extraction processes and new solutions for water treatment to prevent fouling and corrosion.

Integrated Water Management should consider different qualities and sources of water, including desalination, re-use of treated wastewater, rainwater harvesting and gas humidity condensation (e.g., cooling tower blowdown). Development of `tailor-made' system solutions with demand orientation and scale-up testing to robust industrial processes will be required. Water re-use will subsequently lead to accumulation of pollutants. In-line monitoring should include these water quality control parameters linked to the process.

Clustering and cooperation with other selected projects under this cross-cutting call, and with other relevant projects, in particular those selected under SC5-04-2019 "Building a water-smart economy and society", is strongly encouraged.

Proposals submitted under this topic should include a business case and exploitation strategy, as outlined in the Introduction of this part of the Work Programme.

Activities should start at TRL 5 and achieve TRL 7 at the end of the project.

The Commission considers that proposals requesting a contribution from the EU between EUR 8 and 12 million would allow this specific challenge to be addressed appropriately. Nonetheless, this does not preclude submission and selection of proposals requesting other amounts.

Expected Impact: Several of the following impacts are expected:

- Significant reduction of the current use of fresh water resources;
- Significant steps towards near-zero discharge using closed-loop systems in industrial processes;
- Significant increase of the recovery of water, energy and/or substances and materials;
- Increase of resource and water efficiency by 30% compared to the state-of-the-art;
- Effective dissemination of major innovation outcomes to the current and next generation of employees, through the development of learning resources with flexible usability. These should be easy to integrate in existing curricula and modules for undergraduate level and lifelong learning programmes;
- The environmental gains in absolute figures, and weighted against EU and global environmental footprints, should be demonstrated;
- In addition, the replication potential should also be assessed.

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

Type of Action: Innovation action

The conditions related to this topic are provided at the end of this call and in the General Annexes.

CE-SPIRE-09-2020: Alternative mineral resources for high volume production (IA)

Specific Challenge: Energy intensive industries in Europe depend on the one hand on very large volumes of minerals and other raw materials (e.g. 70% of process manufacturing depends on minerals and metals). On the other hand, they heavily rely on imports from third countries (extraction in Europe covers only 29% of the demand). The environmental footprint of high-volume products is also too high. The challenge is to develop technologies for the uptake of secondary raw materials based on industrial symbiosis, waste collection, or water treatment systems, and leading to new value chains or even value loops (i.e. reusing waste, by-products and recycled materials repeatedly) instead of just further optimising existing processes. Such new technologies should enable overcoming barriers such as low costs of primary raw materials or differences in taxes across countries and regions (e.g. landfilling taxes for primary and secondary raw materials).

Scope: Proposals should address the development of new high volume value loops and integrated supply chains through industrial processes enabling the cross-sectorial, symbiotic, use of mineral waste, by-products and end-of-life materials from other industry sectors. The secondary materials can be used either as raw material for the production process or can be introduced in a subsequent process step to an intermediate product where they become a constituent of the final product. Composition variability of wastes or by-products can be

addressed either by purification processes prior to production, or within the production process.

The following aspects should also be considered:

- Product specifications according to customer expectations (e.g. durability, versatility, quality, traceability), clearly shown by involving relevant actors in the value chain;
- Economic viability of the proposed processes together with potential new business concepts and simplified methodologies;
- Regulatory aspects such as transport and use of secondary material in new products put on the market.

Information guides should be provided before the end of the project. These should address elements covering the quality of information from product manufacturers, for the efficient use of secondary materials (beneficiation, quality concepts, test procedures, applications and training) and facilitate decision making.

Proof of concept should be delivered at pilot or demo scale (excluding commercially usable prototypes) to demonstrate convincingly scalability towards industrial applications. Projects are encouraged to develop advanced modelling tools or to use them to build dedicated pilot installations.

Clustering and cooperation with other selected projects under this cross-cutting call and other relevant projects is strongly encouraged.

Proposals submitted under this topic should include a business case and exploitation strategy, as outlined in the Introduction of this part of the Work Programme.

Activities should start at TRL 5 and achieve TRL 7 at the end of the project.

The Commission considers that proposals requesting a contribution from the EU between EUR 8 and 12 million would allow this specific challenge to be addressed appropriately. Nonetheless, this does not preclude submission and selection of proposals requesting other amounts.

Expected Impact: Several of the following impacts are expected:

- Reduction potential of at least 30% of primary raw material use per ton of main high volume final product;
- Reduction of waste generation by at least 25%;
- Significant energy savings and reductions in CO2 emissions (including through a higher share of renewable energy) in the overall sustainable production lines in which the technology is fully integrated;

- Secure and sustainable provision of secondary resources at total cost lower than existing solutions;
- Contribution to new standards for the use of secondary materials for new products;
- Effective dissemination of major innovation outcomes to the current and next generation of employees, through the development of learning resources with flexible usability. These should be easily integrable in existing curricula and modules for undergraduate level and lifelong learning programmes;
- The environmental gains in absolute figures, and weighted against EU and global environmental footprints, should be demonstrated;
- In addition, the replication potential should also be assessed.

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

Type of Action: Innovation action

The conditions related to this topic are provided at the end of this call and in the General Annexes.

CE-SC5-07-2020: Raw materials innovation for the circular economy: sustainable processing, reuse, recycling and recovery schemes

Specific Challenge: Securing the sustainable access to raw materials, including metals, industrial minerals, wood- and rubber-based, construction and forest-based raw materials, and particularly Critical Raw Materials (CRM), is of high importance for the EU economy. Complex primary and secondary resources contain many different raw materials. Their processing, reuse, recycling and recovery schemes are complex and imply different steps, ranging from collection, logistics, sorting and separation to cleaning, refining and purification of materials.

The challenge for industry is to scale up promising raw materials production technologies and to demonstrate that raw materials can be produced in an innovative and sustainable way in order to make sure that research and innovation end up on the market, to strengthen the competitiveness of the European raw materials industries, meet ambitious energy and climate targets for 2030, minimise environmental impacts and risks, and gain the trust of EU citizens in the raw materials sector.

This specific challenge addresses the development of "innovative pilot actions"[42], which is one of the major targets of the European Innovation Partnership (EIP) on Raw Materials.

Scope: Actions should develop and demonstrate innovative pilots for the clean and sustainable production of non-energy, non-agricultural raw materials in the EU from primary and/or secondary sources finishing at Technology Readiness Levels (TRL) 6-7.

[42] https://ec.europa.eu/eip/raw-materials/en/content/strategic-implementation-plan-sip-0#Targets

All actions should contribute to achieving the targets of the EIP on Raw Materials, particularly in terms of innovative pilot actions on processing, refining and/or recycling for the innovative production of raw materials, and to building the EU knowledge base of primary and secondary raw materials by feeding into the EC Raw Materials Information System – RMIS[43]. Actions should also contribute to improving the awareness of relevant external stakeholders and the general public across the EU about the importance of raw materials for society, the challenges related to their supply within the EU and about proposed solutions which could help to improve society's acceptance of and trust in sustainable raw materials production in the EU, duly taking into account the applicable EU environmental legislation.

All actions should facilitate the market uptake of solutions developed through industrially- and user-driven multidisciplinary consortia covering the relevant value chain and should consider standardisation aspects when relevant.

All actions should justify the relevance of selected pilot demonstrations in different locations within the EU (and also outside if there is a clear added value for the EU economy, industry and society).

All actions should include an outline of the initial exploitation and business plans, as outlined in the Introduction of this part of the Work Programme (with indicated CAPEX, OPEX, IRR and NPV[44]), with clarified management of intellectual property rights, and commitment to the first exploitation.

Clustering and cooperation with other selected projects under this cross-cutting call and other relevant projects supporting the EIP on Raw Materials is strongly encouraged..

In line with the strategy for EU international cooperation in research and innovation (COM(2012)497), international cooperation is encouraged.

The Commission considers that proposals requesting a contribution from the EU of between EUR 8 million and EUR 13 million would allow this specific challenge to be addressed appropriately. Nonetheless, this does not preclude submission and selection of proposals requesting other amounts.

Applying a circular economy approach throughout the entire value chain, actions for this topic should address only one of the following sub-topics:

a) Sustainable processing and refining of primary and/or secondary raw materials: Actions should demonstrate new or improved systems integrating relevant processing and refining technologies for better recovery of minerals and metals at increased efficiency in terms of better yield and process selectivity as well as better utilisation of resources (hence reducing wastes). This would include processing of and recovery from low grade and/or complex ores and/or from industrial or mining wastes or landfills, and/or the reduction of the content of toxic elements or compounds in the resulting materials. The importance of the

[43] https://ec.europa.eu/jrc/en/scientific-tool/raw-materials-information-system

[44] Capital expenditures (CAPEX), operational expenditure (OPEX), internal rate of return (IRR), and net present value (NPV)

targeted raw materials and their sources for the EU should be demonstrated in the proposal. The solution proposed should be flexible enough to adapt to different or variable ore/secondary raw material grades and should be supported by efficient and robust process control. Where relevant, any solution proposed for the reduction of the content of toxic elements or compounds in the resulting materials should also include the appropriate management of the hazardous substances removed. Recycling of end-of-life products is excluded from this option.

b) Recycling of raw materials from end-of-life products: Actions should develop and demonstrate novel and environmentally sound solutions for a higher recycling and recovery of secondary raw materials from end-of-life products such as waste electrical and electronic equipment (WEEE), batteries, wood-based panels, multi-material paper packaging, end-of-life tyres, etc. These products can contain different minerals, metals, wood and wood-fibre, rubber, etc. (including critical raw materials and other technology metals).

c) Recycling of raw materials from buildings and infrastructures: Actions should develop and demonstrate novel solutions for a high-value recovery of raw materials from buildings and infrastructures. Actions should also benchmark against a series of comparative case studies of construction and demolition waste (C&DW) management in deconstruction of buildings and infrastructure of representative size categories in countries with different types of end-of-life building and infrastructure stocks, showcasing the appropriate use of the following: the EU C&DW Management Protocol[45], pre-demolition audit, smart demolition practices, using appropriate technical equipment, and sorting/processing and quality management of waste fractions such as metals, aggregates, concrete, bricks, plasterboard, glass, polymers and plastics and wood.

d) Advanced sorting systems for high-performance recycling of complex end-of-life products: Actions should develop and demonstrate innovative dismantling and sorting systems enabling functional recycling of critical raw materials, or other types of highly efficient recovery of metals, minerals or construction materials, from complex end-of-life products and scrap thereof. The advanced sorting systems should achieve very high throughput rates in order to allow their economically viable operation on the European market.

e) Sustainable metallurgical processes: Actions should develop and demonstrate innovative metallurgical systems integrating pyro-, hydro-, bio-, and/or electro-metallurgical and/or electrochemical technologies, in order to enhance the production efficiency in terms of increased yield and selectivity, higher grade and purity of the produced metals from primary and/or secondary raw materials as well as the environmental performance throughout the whole life cycle.

Expected Impact: The project results are expected to contribute to:

[45] http://ec.europa.eu/DocsRoom/documents/20509/attachments/1/translations/en/renditions/native

- pushing the EU to the forefront in the area of raw materials processing and/or recycling technologies and solutions through generated know-how (planned patents, publications in high impact journals and joint public-private publications etc.), and promoting socially innovative solutions;

- improving significantly the economic viability and market potential that will be gained through the pilot, leading to expanding the business across the EU after the project is finished, as well as creating added value and new jobs in raw materials producing, equipment manufacturing and/or downstream industries;

- unlocking a significant volume of various primary/secondary raw materials currently unexploited/underexploited within the EU, hence improving their 'circularity' in the economy and ultimately closing the material cycles for a circular economy;

- improving significantly the health, safety and environmental performance throughout the whole life cycle considered, including better energy and water efficiency, a reduction in emissions of greenhouse gases and pollutants, a reduction in waste generation and wastewater and a better recovery of resources from generated waste or a better recovery and recycling of resources from complex end-of-life products;

- additionally, only for sub-topic b) 'Recycling of raw materials from end-of-life products', in the shorter term, increasing measurably the efficiency and effectiveness (range, yield, quality and selectivity of recovered materials) of the exploitation of complex and heterogeneous secondary raw materials deposits ('urban mines') when compared to the state of the art;

- additionally, only for sub-topic c) 'Recycling of raw materials from buildings and infrastructure', lead to wider application of smart demolition techniques, C&DW processing, quality assurance practices, traceability and standardization for secondary raw materials in the construction sector, thus improving the material and value recovery rate.

Type of Action: Innovation action

The conditions related to this topic are provided at the end of this call and in the General Annexes.

CE-SC5-08-2020: Raw materials policy support actions for the circular economy - Expert network on Critical Raw Materials

Specific Challenge: In order to secure the sustainable access to primary and secondary raw materials, including metals, industrial minerals, construction raw materials, wood, and particularly Critical Raw Materials (CRMs) for the EU economy, there is a need to tackle a number of specific non-technological challenges at local, regional, national, EU and global levels.

The supply of CRMs to the EU is at risk as they are often mined as by-products and usually still have recycling rates below 1% after decades of use. There is a need for an expert advice in support of decision-making at the EU level covering all the raw materials and their value chains screened in the CRMs assessment[46].

Scope: All actions should contribute to improving EU official statistics and to building the EU knowledge base of primary and secondary raw materials (EC Raw Materials Information System – RMIS[47]).

Clustering and cooperation with other selected projects under this cross-cutting call and other relevant projects supporting the EIP on Raw Materials is strongly encouraged.

Actions should strengthen an EU expert network and community covering all raw materials screened in the CRM assessment of 2017[48], and once available also the raw materials of 2020 assessment. The consortium should organise the expert community across the EU covering expertise on primary and secondary resources; production, including exploration, mining, processing, recycling and refining; substitution of CRM; raw materials markets; future demand and supply; materials flows; socio-economic analysis, and strategic value chains and end-use sectors, including batteries, e-mobility, renewable energy, electronics, defence and aerospace.

The actions should improve data and knowledge on all screened raw materials; flexibly support the Commission in policy making related to CRM in general or linked to specific applications or sectors; as well in the relevant events organised by the Commission. The actions should also support the Commission in the analysis of the future supply and demand of raw materials, policy and technology gaps and innovation potential along the raw materials value chains.

The Commission considers that proposals requesting a contribution from the EU of up to EUR 3 million would allow this specific challenge to be addressed appropriately. Nonetheless, this does not preclude submission and selection of proposals requesting other amounts.

Expected Impact: The project results are expected to contribute to:

- achieving the objectives and the implementation of both the Raw Materials Initiative and the EIP on Raw Materials, in particular in terms of securing the supply of critical raw materials (CRMs);
- better informed and more effective decision-making by the EU and Member States policy makers and the producers and users of raw materials regarding the supply and demand of raw materials and the associated environmental and social aspects;

[46] https://ec.europa.eu/growth/sectors/raw-materials/specific-interest/critical_en
[47] https://ec.europa.eu/jrc/en/scientific-tool/raw-materials-information-system
[48] https://ec.europa.eu/growth/sectors/raw-materials/specific-interest/critical_en

- improved awareness of society across the EU about importance of the critical raw materials and other relevant materials for strategic value chains in support of the implementation of the Sustainable Development Goals (SDGs) in the EU;

- in the longer term improved diversification of CRMs supply to the EU.

Type of Action: Coordination and support action

The conditions related to this topic are provided at the end of this call and in the General Annexes.

CE-SC5-31-2020: Develop, implement and assess a circular economy oriented product information management system for complex products from cradle to cradle

Specific Challenge: The transition to a circular economy requires that the value in products is retained as long as possible. To achieve this, reliable information about the composition of components and materials is needed for health and safety in repair and recycling enterprises and for improved user integration in sustainable product design and in new business models.

Other aspects such as recyclability, dismantlability, recycled content, the sustainability of sourcing of raw materials, security of supply, and ultimately the overall environmental and social performance along the life cycle, are also related to the composition and design of products. If the downstream actors in the value chain, such as consumers, retailers or end-product manufacturers demand this information, it needs to be collected in the whole supply chain upstream. The implementation of resource efficiency benchmarks in products e.g. via Ecodesign or the EU Ecolabel also requires product composition and environmental performance data. The information needs of consumers are of course different from those of manufacturers and recyclers, and suppliers and manufacturers are traditionally worried about excessive transparency and possible violations of proprietary data rights. All this needs to be considered in the design of the information flow in the economic value chain.

Although some manufacturers and suppliers use specific software for internal communication, upstream aggregation and compliance documentation for sectoral product legislation, this does not cover the critical information needs with regard to circularity or the overall life cycle performance. Some SMEs, start-ups, and social and municipal enterprises outside the supply chain would benefit from access to such information management systems, but they have too limited resources to invest in complex and expensive software solutions.

There is thus a need for designing and piloting an information system for raw materials and components in products and their environmental performance that is linked to the material and value flows in an ideally circular system.

The design should be flexible and smart with regard to data volume and conversions and should include the whole flow for a specific business, from raw materials supply via components to the finished product, including customers, repair business, refurbishers, and recyclers.

In addition, the flexibility should allow actors to use the data for compliance reasons, such as REACH or the (future) ECHA database on the presence of hazardous chemicals in articles (ECHA, 2018). It should also allow aggregation and extrapolation with a view to the analysis and mapping of raw material flows and needs in Europe. The concept, the data flow and the specific needs of each actor should be studied in a pilot with operators that are interested in making their business sustainable and future-proof.

Scope: Proposals are expected to bring together all relevant actors along product related value chains – product designers, producers, consumers, businesses providing repair or refurbishment, data provider and manager, sorters and recyclers. The selected products should have a major environmental impact, offer a high potential for circularity, have a complex supply chain, and be linked at both ends of the lifecycle to critical resource issues, e.g. the manufacturing industry, which includes amongst others textiles and plastics, construction and sectors with products that may contain critical raw materials. Where applicable, official nomenclature, such as used in Prodcom[49], should be used for all products and materials. Ideally, a fully functional system should be set up in a value chain with high internal quality standards and an established refurbishment business. The knowledge gained in this set-up should be comprehensive and systemic enough to be easily transferable to less complex sectors and business models. All information flows should be designed with a view to increased circularity, traceability and minimisation of the overall environmental footprint. Proposals should explore, develop and test integrated information flows that take into account the diverse information needs throughout and beyond the original lifecycle of the product.

To facilitate open innovation and transferability, open solutions such as open source software, open hardware design, and open access to data are encouraged. Results from the supported projects might play a central role in the further development of the policies for the transition to a circular economy. The ambition to grant open access to the underlying architecture such as databases, encryption and access rights management should therefore be a central element of the proposals, while adequately addressing possible data protection, user privacy and liability issues. Beneficiaries are encouraged to build value-added services based on the established architecture.

In order to facilitate project management, the development of respective technologies should be decentralised. Proposals are expected to provide quantitative information on the potential for transferring the implemented solution to the wider sector and to other relevant sectors. Based on the pilot data, environmental benefits should be assessed from a lifecycle perspective and quantified using the Product Environmental Footprint (PEF) method[50], which has already been elaborated for certain product categories in cooperation with industrial partners[51]. The social assessment part shall build on the work done in the context of the life

[49] https://ec.europa.eu/eurostat/web/prodcom
[50] http://ec.europa.eu/environment/eussd/smgp/PEFCR_OEFSR_en.htm
[51] http://ec.europa.eu/environment/eussd/smgp/ef_pilots.htm#pef

cycle initiative and the Platform for Life Cycle Assessment[52]. Economic benefits should also be assessed and quantified under a life cycle perspective.

Participation of actors across the value chain, e.g. material and product producers, end-user organisations, civil society organisations, repair and recycling businesses, etc. is considered essential. Specific information needs at each point in the value chain should be addressed in a satisfactory way, systemised, and the respective data generated out of the integrated information flow. An additional aim of this testing is to obtain a better understanding of the mutual dependencies between the several operators in the system.

Clustering and cooperation with other selected projects under this cross-cutting call and other relevant projects is strongly encouraged.

Activities are expected to focus on Technology Readiness Levels (TRLs) 5-7.

Proposals submitted under this topic should include a business case and exploitation strategy, as outlined in the Introduction of this part of the Work Programme.

The Commission considers that proposals requesting a contribution from the EU in the range of EUR 7-8 million would allow this specific challenge to be addressed appropriately. Nonetheless, this does not preclude submission and selection of proposals requesting other amounts.

Expected Impact: The project results are expected to contribute to:

- the development of new businesses related to the transition to a circular economy, and related value-adding consulting services;
- effective use of both primary and secondary resources in Europe, strengthening geopolitical resource independency, facilitating the market for secondary raw materials, closing material cycles, and reducing waste generation, environmental pollution and greenhouse gas emissions;
- achieving the targets of the EIP on Raw Materials, particularly in terms of feeding secondary raw materials knowledge into the EC Raw Materials Information System (RMIS);
- better insights into the material composition of products and the amount of secondary raw materials in circulation, increasing circularity of relevant material streams, and strengthening the use of PEF as the standard means for the assessment of the material efficiency and overall environmental performance of products;
- streamlined social life cycle assessment ensuring comparability and validity, allowing to critically review green claim and enabling consumers to take environmentally informed

[52] https://www.lifecycleinitiative.org/resources/reports/;
https://product-social-impact-assessment.com/handbook/

purchasing decisions, as well as allowing product designers and developers to take environmentally informed design decisions at an early stage;

- better insights on how to transfer successful information management approaches to other businesses and sectors.

Type of Action: Innovation action

The conditions related to this topic are provided at the end of this call and in the General Annexes.

LC-SC3-CC-9-2020: Industrial (Waste) Heat-to-Power conversion

Specific Challenge: Better use of process excess/waste heat represents a significant source of energy savings for industries. In a context of reducing greenhouse gas emissions and introducing the concept of circular economy in heat management in view of industrial process electrification, European industries have a clear interest in finding new ways to capture the heat produced by their process and to reuse it or to produce electricity. The conversion of excess heat back to electricity would also improve energy efficiency, mitigate the increase of electricity consumption due to industrial electrification and thereby reduce the load on the power grids. This will also facilitate balancing the grid due to intermittent supply of electricity from renewables.

Innovative heat to (mechanical or electrical) power conversion cycles using either organic fluid or supercritical CO2 fluid, present several benefits compared to conventional steam cycles. Organic cycles have the potential to recover waste heat sources as low as 150 °C, whereas steam systems are limited to heat sources above 260 °C. The supercritical CO2 cycle covers medium and high temperatures with drastically reduced footprint, higher efficiency, reduced or eliminated water requirement, reduced operational costs, compared to steam cycles.

These technologies are also transferable to renewable and conventional power generation with higher efficiency and reduced footprint than established technologies.

Scope: Accounting for the results of previous research[53], proposals will integrate an industrial waste heat-to-power conversion system using one type of fluid (supercritical CO2 or organic) and demonstrate the system operation in industrial environment at an output power level of at least 2 MW, with improved cost efficiency compared to existing solutions. Proposals are expected to bring the technologies to TRL 6 or 7 (please see part G of the General Annexes)

In order to reach this goal all the following development areas need to be covered:

- Optimisation of thermal cycles for different temperature levels of recovered heat and constrained industrial environment, in terms of efficiency and economics (capex, opex);

[53] EU co-funded projects I-Therm (680599), sCO2-flex (764690), sCO2-HeRo (662116), TASIO (637189)

- Development/improvement of design tools at components and system levels;
- Development/improvement of materials and components: heat exchangers, turbomachinery, waste heat recovery unit, power generator and electronics, etc.
- Integration and demonstration of the system in industrial environment;
- Technical, and economical life cycle assessment of heat-to-power systems adapted for at least 4 energy intensive industrial sectors, to demonstrate economic viability, define business cases and exploitation strategy;
- Dissemination of the technical and economic benefits.

Given the transversal nature of the technology, the potential for transferring the technology to the generation of electrical power from conventional and renewable energy sources should be assessed and disseminated.

In the case of supercritical CO2 technology, the potential for international cooperation[54] to facilitate technology development and market uptake should also be explored, notably to: establish mechanisms for exchange of R&D results (e.g. on materials performance); establish forum on safety issues, on standardisation of performance models; establish standards for instrumentation performance and calibration.

This topic contributes to the roadmap of the Sustainable Process Industry through Resource and Energy Efficiency (SPIRE) cPPP. Clustering and cooperation with other selected projects under this cross-cutting call and other relevant projects is strongly encouraged.

The proposals should demonstrate cycles, components and systems designs that are particularly suitable for industrial use with proven contributions in terms of industrial excess/waste heat use and impact on power distribution networks.

Proposals submitted under this topic should include a business case and exploitation strategy, as outlined in the Introduction of this part of the Work Programme.

The Commission considers that optimizing cycles, components and systems and demonstrating the solution in an industrial setting would require an EU contribution of EUR 12 to 14 million. Nonetheless, this does not preclude submission and selection of proposals requesting other amounts.

Expected Impact: Actions are expected to make substantial contributions in terms of industrial excess/waste heat use and impact on power distribution networks:

- Improved cycles to achieve scalability to higher power levels, higher cost effectiveness, wider input temperature ranges, significantly reduced system size compared to steam turbines, allowing wider take up of heat recovery from more industrial processes;

[54] The US-DoE is supporting activities on supercritical CO2 turbine system, for example the STEP project

- Primary energy savings (GWh/year) in industry (heat recovery) and potential primary energy savings in the power generation sector, assuming full deployment in EU Member States and (as far as data are available for the calculation of the impact) in Associated Countries.

Type of Action: Innovation action

The conditions related to this topic are provided at the end of this call and in the General Annexes.

LC-SC3-NZE-5-2020: Low carbon industrial production using CCUS

Specific Challenge: CCUS in industrial applications faces significant challenges due to its high cost and the fierce international competition in the sectors concerned. However, these sectors currently account for 20% of global CO2 emissions, and in the 2 degree scenario, should represent half of the stored CO2 by 2050. Relevant sectors with high CO2 emissions are for example steel, iron and cement making, oil refining, gas processing, hydrogen production, biofuel production and waste incineration plants.

Scope: Projects will focus on integrating CO2 capture in industrial installations, whilst addressing the full CCUS chain. Projects will elaborate a detailed plan on how to use the results, i.e. the subsequent transport, utilisation and/or underground storage of the captured CO2. Important aspects to address are of technical (e.g. the optimised integration of capture plant with industrial processes; scalability; CO2 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).

Projects are expected to bring technologies to TRL 6-7 (please see part G of the General Annexes). Technology development has to be balanced by an assessment of the societal readiness towards the proposed innovations. Relevant end users and societal stakeholders will be identified in the proposal, and their concerns and needs 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.

In line with the strategy for EU international cooperation in research and innovation (COM(2012)497), international cooperation is encouraged, in particular with relevant Mission Innovation[55] countries such as China[56].

Proposals submitted under this topic should include a business case and exploitation strategy, as outlined in the Introduction of this part of the Work Programme.

[55] http://mission-innovation.net/our-work/innovation-challenges/

[56] A Co-funding mechanism is in place in China; seehttps://ec.europa.eu/programmes/horizon2020/en/news/eu-china-research-and-innovation-co-funding-mechanism-first-call-launched-china

The Commission considers that proposals requesting a contribution from the EU of up to EUR 15 million would allow this specific challenge to be addressed appropriately. Nonetheless, this does not preclude submission and selection of proposals requesting other amounts.

Expected Impact: Successful, safe and economic demonstration of integrated-chain CCUS from relevant industrial sources such as mentioned in the specific challenge will accelerate the learning, drive down the cost and thus help break the link between economic growth and the demand for industrial output on one hand, and increasing CO2 emissions on the other hand. The impact of projects under this call will to a large extent be determined by the extent to which the results will be exploited, i.e. the plan on how the captured CO2 will be actually utilised and/or stored, either in the project or planned as a future phase. This will be evaluated based on the maturity and quality of the proposed post-capture solutions. Projects under this call that are carried out in areas where there is both a high concentration of CO2 emitting industries and a nearby capacity for geological storage are considered prime sites for hub and cluster developments, and will generate the highest impact on full-scale deployment in the medium to longer term.

Type of Action: Innovation action

The conditions related to this topic are provided at the end of this call and in the General Annexes.

Conditions for the Call - COMPETITIVE, LOW CARBON AND CIRCULAR INDUSTRIES

Opening date(s), deadline(s), indicative budget(s):[57]

Topics (Type of Action)	Budgets (EUR million)	Deadlines
	2020	
Opening: 03 Jul 2019		
CE-NMBP-41-2020 (ERA-NET-Cofund)	15.00 [58]	05 Feb 2020
CE-NMBP-42-2020 (RIA)	6.00 [59]	
CE-SC5-08-2020 (CSA)	3.00 [60]	

[57] The Director-General responsible for the call may decide to open the call up to one month prior to or after the envisaged date(s) of opening.
The Director-General responsible may delay the deadline(s) by up to two months.
All deadlines are at 17.00.00 Brussels local time.

[58] of which EUR 10.00 million from the 'Nanotechnologies, Advanced Materials, Biotechnology and Advanced Manufacturing and Processing' WP part, EUR 5.00 million from the 'Future and Emerging Technologies' WP part.

[59] of which EUR 6.00 million from the 'Nanotechnologies, Advanced Materials, Biotechnology and Advanced Manufacturing and Processing' WP part.

CE-SPIRE-01-2020 (IA) CE-SPIRE-07-2020 (IA) CE-SPIRE-09-2020 (IA)	97.50 [61]	
CE-SC5-07-2020 (IA)	40.00 [62]	05 Feb 2020 (First Stage) 03 Sep 2020 (Second Stage)
CE-SC5-31-2020 (IA)	15.00 [63]	
Opening: 05 May 2020		
LC-SC3-CC-9-2020 (IA)	14.00 [64]	01 Sep 2020
LC-SC3-NZE-5-2020 (IA)	15.00 [65]	
Overall indicative budget	205.50	

Indicative timetable for evaluation and grant agreement signature:

For single stage procedure:

- Information on the outcome of the evaluation: Maximum 5 months from the final date for submission; and
- Indicative date for the signing of grant agreements: Maximum 8 months from the final date for submission.

For two stage procedure:

- Information on the outcome of the evaluation: Maximum 3 months from the final date for submission for the first stage and maximum 5 months from the final date for submission for the second stage; and
- Indicative date for the signing of grant agreements: Maximum 8 months from the final date for submission of the second stage.

Eligibility and admissibility conditions: The conditions are described in General Annexes B and C of the work programme.

Evaluation criteria, scoring and threshold: The criteria, scoring and threshold are described in General Annex H of the work programme. The following exceptions apply:

---

60 of which EUR 3.00 million from the 'Climate action, environment, resource efficiency and raw materials' WP part.

61 of which EUR 97.50 million from the 'Nanotechnologies, Advanced Materials, Biotechnology and Advanced Manufacturing and Processing' WP part.

62 of which EUR 40.00 million from the 'Climate action, environment, resource efficiency and raw materials' WP part.

63 of which EUR 15.00 million from the 'Climate action, environment, resource efficiency and raw materials' WP part.

64 of which EUR 14.00 million from the 'Secure, clean and efficient energy' WP part.

65 of which EUR 15.00 million from the 'Secure, clean and efficient energy' WP part.

CE-NMBP-42-2020, CE-SC5-07-2020, CE-SC5-31-2020, CE-SPIRE-01-2020, CE-SPIRE-07-2020, CE-SPIRE-09-2020, LC-SC3-CC-9-2020, LC-SC3-NZE-5-2020	The threshold for the criteria Excellence and Impact will be 4. The overall threshold, applying to the sum of the three individual scores, will be 12.
CE-NMBP-42-2020, CE-SC5-07-2020, CE-SC5-31-2020, CE-SPIRE-01-2020, CE-SPIRE-07-2020, CE-SPIRE-09-2020, LC-SC3-CC-9-2020, LC-SC3-NZE-5-2020	Proposals submitted under these topics should include a business case and exploitation strategy, as outlined in the Introduction of this part of the Work Programme.

Evaluation Procedure: The procedure for setting a priority order for proposals with the same score is given in General Annex H of the work programme. The following exceptions apply:

All topics of this call	**Under 3 (a)** Proposals are first ranked in separate lists according to the topics against which they were submitted (‘topic ranked lists’). When comparing ex aequo proposals from different topics, proposals having a higher position in their respective 'topic ranked list' will be considered to have a higher priority in the overall ranked list. **Under 3 (b)** For all topics and types of action, the prioritisation will be done first on the basis of the score for Impact, and then on that for Excellence.

The full evaluation procedure is described in the relevant guide published on the Funding & Tenders Portal.

Consortium agreement:

All topics of this call	Members of consortium are required to conclude a consortium agreement, in principle prior to the signature of the grant agreement.

Budget[66]

	Budget line(s)	2019 Budget (EUR million)	2020 Budget (EUR million)
Calls			
H2020-LC-BAT-2019-2020		114.00	132.00
	from 08.020303	*44.00*	*30.00*
	from 08.020304	*70.00*	*60.00*
	from 09.040101		*42.00*
H2020-LOW-CARBON-CIRCULAR-INDUSTRIES-2020			205.50
	from 02.040301		*43.00*
	from 08.020201		*113.50*
	from 08.020303		*15.00*
	from 08.020305		*15.00*
	from 09.040101		*5.00*
	from 32.040301		*14.00*
Other actions			
Estimated total budget		114.00	337.50

66 The budget figures given in this table are rounded to two decimal places.
The budget amounts for the 2020 budget are subject to the availability of the appropriations provided for in the draft budget for 2020 after the adoption of the budget 2020 by the budgetary authority or, if the budget is not adopted, as provided for in the system of provisional twelfths.