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 2019 (topics, dates, budget) have, with this revised version, been updated. The changes relating to this revised part are explained on the Participant Portal. The parts that relate to 2020 are provided at this stage on an indicative basis. Such Work Programme parts will be decided during 2019.

(European Commission Decision C(2018)4708 of 24 July 2018)

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Introduction

This work programme part contains the cross-cutting call "Building a Low-Carbon, Climate Resilient Future: Next-Generation Batteries".

Business cases and exploitation strategies for industrialisation

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)

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.

<u>Synergies with other funds:</u> Where possible, proposers could actively seek synergies with, and possibilities for further funding from other relevant EU, national or regional research and innovation programmes (including ESIF), private funds or financial instruments (including EFSI). In all these cases, business cases and exploitation strategies will outline such synergies and/or additional funding, in particular where they make the project more ambitious or increase its impact.

One possibility is that of cumulative funding with European Structural and Investment Funds (ESIF) in connection with smart specialisation strategies. Consortia could therefore identify, amongst other possibilities, the Smart Specialisation fields of their EU Member States or regions. For this purpose the 'Guide on Enabling synergies between ESIF, H2020 and other research and innovation related Union programmes' may be useful. Some projects may, moreover, contribute to regional smart specialisation strategies by capitalising on concentrated and complementary competences for the development of new industrial value chains and emerging industries with a clear EU added-value.

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

Contribution to focus area(s)

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

In addition to COP 21 and decarbonisation, the whole proposed activities are in line with the Energy Union policies as well as the SET-plan and STRIA.

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 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[1] 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

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

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
- 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.[2] 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,[3] ideally beyond 50%, and a demonstrated economic viability.

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

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

[2] 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

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

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[4].

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 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)[5].

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

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

5 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.

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)[6]

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..

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;

6 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).

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 [7] 8-1-1 at the same energy density.

7 Nickel Manganese Cobalt

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.

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.

<u>Expected Impact</u>: 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.

Indicative topics for 2020

- LC-BAT-8-2020: Next-generation batteries for stationary energy storage
- LC-BAT-9-2020: Hybridisation of battery systems for stationary energy storage
- LC-BAT-10-2020: Next generation and realisation of battery packs for BEV and HEV

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

Opening date(s), deadline(s), indicative budget(s):[8]

Topics (Type of Action)	Budgets (EUR million)		Deadlines
	2019	2020	
	Opening: 24 Jan 2019		
LC-BAT-1-2019 (RIA)	25.00 [9]		25 Apr 2019
LC-BAT-2-2019 (RIA)	24.00 [10]		
LC-BAT-3-2019 (RIA)	5.00 [11]		
LC-BAT-4-2019 (RIA)	15.00 [12]		
LC-BAT-5-2019 (RIA)	30.00 [13]		

8 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.
The deadline(s) in 2020 are indicative and subject to a separate financing decision for 2020.
The budget amounts for the 2020 budget are indicative and will be subject to separate financing decisions to cover the amounts to be allocated for 2020.

9 of which EUR 25.00 million from the 'Smart, green and integrated transport' WP part.

10 of which EUR 24.00 million from the 'Secure, clean and efficient energy' WP part.

11 of which EUR 5.00 million from the 'Secure, clean and efficient energy' WP part.

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

LC-BAT-6-2019 (RIA)	13.00 [14]		
LC-BAT-7-2019 (CSA)	2.00 [15]		
	Opening: To be defined		
Focus area topic(s) for 2020		70.00 [16]	To be defined
Overall indicative budget	114.00	70.00	

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.

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 Participant 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.

[13] of which EUR 30.00 million from the 'Smart, green and integrated transport' WP part.
[14] of which EUR 13.00 million from the 'Smart, green and integrated transport' WP part.
[15] of which EUR 2.00 million from the 'Smart, green and integrated transport' WP part.
[16] of which EUR 40.00 million from the 'Smart, green and integrated transport' WP part, EUR 30.00 million from the 'Secure, clean and efficient energy' WP part

Budget[17]

	Budget line(s)	0 Budget (EUR million)	2018 Budget (EUR million)	2019 Budget (EUR million)	2020 Budget (EUR million)
Calls					
H2020-LC-BAT-2019-2020				114.00	70.00
	from 08.020303			*44.00*[18]	*30.00*
	from 08.020304			*70.00*[19]	*40.00*
Estimated total budget				114.00	70.00

[17] The budget figures given in this table are rounded to two decimal places.

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.

The budget amounts for the 2020 budget are indicative and will be subject to separate financing decisions to cover the amounts to be allocated for 2020.

[18] which includes a budget transfer of EUR 24.00 million from the 'Nanotechnologies, Advanced Materials, Biotechnology and Advanced Manufacturing and Processing' WP part.

[19] which includes a budget transfer of EUR 25.00 million from the 'Nanotechnologies, Advanced Materials, Biotechnology and Advanced Manufacturing and Processing' WP part.