Destination – Cross-sectoral solutions for the climate transition

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

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

- *C: Making Europe the first digitally enabled circular, climate-neutral and sustainable economy through the transformation of its mobility, energy, construction and production systems;*
- *A: Promoting an open strategic autonomy*[1] *by leading the development of key digital, enabling and emerging technologies, sectors and value chains to accelerate and steer the digital and green transitions through human-centred technologies and innovations;*
- *D: Creating a more resilient, inclusive and democratic European society, prepared and responsive to threats and disasters, addressing inequalities and providing high-quality health care, and empowering all citizens to act in the green and digital transitions.*

It covers the following **impact areas**:

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

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

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

[1] *'Open strategic autonomy' refers to the term 'strategic autonomy while preserving an open economy', as reflected in the conclusions of the European Council 1 – 2 October 2020.*

b. Increased efficiency of Europe's **cities' and communities'** energy, resource use and mobility patterns and cities' and communities' overall sustainability, thereby improving their climate-resilience and attractiveness to businesses and citizens in a holistic fashion. This also includes improved air and water quality, resilience of energy supply, intelligent mobility services and logistics, liveability and accessibility of cities, public health, comfortable, affordable zero emissions housing as well as the exploitation of relevant European technologies and knowledge (more detailed information below).

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

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

A competitive and sustainable European battery value chain

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

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

The Partnership "Towards a competitive European industrial battery value chain for stationary applications and e-mobility", with as short name Batt4EU, to which all battery-related topics under this Destination will contribute, aims to establish world-leading sustainable and circular European battery value chain to drive transformation towards a carbon-neutral society.

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

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

- Significant contribution to the policy needs of the European Green Deal through new solutions for circularity and recycling of batteries.

- Accelerated growth of innovative, competitive and sustainable battery manufacturing industry in Europe.
- Development of sustainable and safe technologies and systems for decarbonisation of transport and stationary applications.
- Contributing to the strategic independence of Europe through investigation of alternative battery chemistries using non-critical raw materials and efficient recycling technologies.
- Increasing synergies with other partnerships and initiatives.

A competitive and sustainable European battery value chain

D2-1-1. Technologies for sustainable, cost-efficient and low carbon footprint downstream processing & production of battery-grade materials

Opening	2023
Expected EU contribution per project	The EU estimates that an EU contribution of EUR 7 million would allow these outcomes to be addressed appropriately. Nonetheless, this does not preclude submission and selection of a proposal requesting different amounts.
Indicative budget	The total indicative budget for the topic is EUR 21 million.
Type of action	Research and Innovation Action
Technology readiness level	Activities are expected to achieve TRL5 by the end of the project

Expected outcomes:

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

- A European economic base which is stronger, more resilient, competitive and fit for the green and digital transitions, by reducing strategic dependencies for critical raw materials by promoting resource efficiency.
- Increased European competitiveness by offering sustainable, safe, energy efficient and low carbon, water and biodiversity footprint battery materials production technologies and scalable solutions and create new business opportunities and models for EU industry.
- Battery-grade intermediates which are developed, produced and refined/purified in a sustainable and socially acceptable way, improving the competitiveness and value of European battery and mobility industries.
- Proven technical feasibility of downstream processing for battery-grade materials at larger scale, considering economic feasibility, safety, health and regulatory targets.
- A stronger EU battery manufacturing industry, through the implementation of continuous processes related conditions at larger scale with reduced carbon emissions, increased energy efficiency and more efficient resources use; (e.g. combining secondary materials into existing primary processing).

- Use of European low-grade deposits and secondary material sources such as tailings (e.g., as a source of nickel, cobalt and lithium) or underutilised battery raw materials deposits and extend the local refining capacity of battery-grade materials, to reduce the dependency on imported materials and to limit supply risks.

Scope:

The proposals are expected to cover research and innovation activities with focus on improved battery metal and material production, refining and recovery while minimizing environmental impact of downstream processing by addressing all of the following points:

- Developing sustainable and cost-efficient processing methods for battery-grade materials and components, coming from either primary or secondary streams and novel technologies for battery metals processing enabling the reduction of CO2 footprint and other emissions while increasing energy and resource efficiency; enabling thereby vertical integration into the battery production.

- Developing and demonstrating technologies to improve battery grade metals and materials production, refining and/or recycling with efficient and stable reagent circulation, targeting low use chemical and reducing environmental impacts from production processes while improving recovery rate/grade and yield considering the SRIA objectives and KPIs, the Green Deal objectives and the EU Battery regulation.

- Addressing zero waste and zero discharge strategies for the valorisation of the generated waste materials during the refining processes by: improving the reuse of waste where CRM are present; Increasing the sustainability of batteries materials by reducing the use of chemicals and energy use in the downstream processing considering the objectives of the battery regulations and the LCA or similar approaches.

- Pre-assessing recycling concepts by their life cycle sustainability and safety impacts and studying overall techno-economical solutions for recovery systems in order to minimize cost, environmental impact and system losses.

- Addressing understanding of physico-chemical mechanisms for more sustainable hydrometallurgical steps in order to propose significant processes' improvements to reduce significantly water effluents quantities and chemical reagents.

- Implementing of continuous process for cathode active materials and precursors synthesis related conditions at larger scale.

Plans for the exploitation and dissemination of results for proposals submitted under this topic should include a strong business case and sound exploitation strategy, as outlined in the introduction to this Destination. The exploitation plans should include preliminary plans for scalability, commercialisation, and deployment (feasibility study, business plan).

Projects may collaborate and/or contribute to the activities of the Coordination and Support Action defined under the topic HORIZON-CL5-2022-D2-01-08.

In order to achieve the expected outcomes, international cooperation is encouraged, in particular with Africa (Morocco in particular), Australia and Canada.

D2-1-2. New processes for upcoming recycling feeds

Opening	2023
Expected EU contribution per project	The EU estimates that an EU contribution of EUR 5 million would allow these outcomes to be addressed appropriately. Nonetheless, this does not preclude submission and selection of a proposal requesting different amounts.
Indicative budget	The total indicative budget for the topic is EUR 15 million.
Type of action	Research and Innovation Action
Technology readiness level	Activities are expected to achieve TRL 4 by the end of the project

Expected outcomes:

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

- A European economic base which is stronger, more resilient, competitive and fit for the green and digital transitions, by reducing strategic dependencies for critical raw materials by promoting a circular economy.
- The development of recycling technologies targeting upcoming recycling feeds and producing high quality precursors, semi-products and battery materials enabling their use in the battery production and other production processes.
- Achievement of the recycling targets as described in the battery regulation by industries, especially for low metal and low material value components.
- Recycling chains with a cost-effective process in comparison with primary materials.
- Safeguarding of the sustainability, low CO2 footprint, low chemicals usage and minimal emissions of newly developed recycling processes.

Scope:

Focus will be on improved and verified circularity of collected, dismantled and pre-treated battery waste feeds (Strong interaction with call "Advanced sustainable and safe pre-processing technologies for End-of-Life batteries recycling (2024)" is encouraged). All recycling concepts

should address waste stream(s) in question in a comprehensive manner, aiming at the maximal recovery of input elements and components, rather than selected fractions. Focus in all concepts should be kept on recycling process development; a maximised material recovery efficiency, operational energy efficiency, mass- and energy balance, purity of the products and verified holistically decreased carbon footprint supported by life cycle assessment. Battery development is out of the scope, interaction with other projects is, however, encouraged.

The following issues should be addressed:

1. New recycling concepts targeting the recycling of economically low value materials, (e.g. from Lithium-iron phosphate or sodium-ion technologies…) **are expected to** be covered. To enable recycling of low value battery compositions, new recycling concepts should be developed, including direct recycling routes that may include selective material recovery technologies and the reconditioning of the active materials. The additional recovery and recycling of non-cathode component materials are encouraged.

2. Highly efficient recycling of battery production scrap **are expected to** be covered, for example including direct recycling concepts to re-introduce the materials in the battery production chain, including the handling and processing of relevant semi-material.

3. Highly robust or flexible processes for the recycling of material streams of varying composition and quality **may** be covered.

4. Material feeds from other industries (e.g. Ni/Co rich materials) **may** be introduced into the recycling concepts.

5. Material feeds from future battery technologies with an expected market introduction no later than 2025 **may** be included.

6. The processing of side streams (e.g. waste waters) **may** be targeted.

All proposed recycling concepts must be pre-assessed for their economical, ecological and safety impact.

This topic is building upon the BATTERY 2030+ Roadmap (https://battery2030.eu/research/roadmap/) Projects must collaborate and contribute to the activities of the Coordination and Support Action defined under the topic HORIZON-CL5-2022-D2-01-08. The proposal must cover the contribution and collaboration to the Coordination and Support Action.

Plans for the exploitation and dissemination of results for proposals submitted under this topic should include a strong business case and sound exploitation strategy, as outlined in the introduction to this Destination. The exploitation plans should include preliminary plans for scalability, commercialisation, and deployment (feasibility study, business plan).

This topic is considered for contribution by the EU Joint Research Centre, modalities TBC.

D2-1-3. Advanced materials and cells development enabling large-scale production of Gen4 solid-state batteries for mobility applications

Opening	2023
Expected EU contribution per project	The EU estimates that an EU contribution of EUR 8 million would allow these outcomes to be addressed appropriately. Nonetheless, this does not preclude submission and selection of a proposal requesting different amounts.
Indicative budget	The total indicative budget for the topic is EUR 24 million.
Type of action	Innovation Action
Technology readiness level	Activities are expected to achieve TRL 6 by the end of the project

Expected outcomes: Building on the results of earlier research projects on solid-state advanced materials, the objective of this topic is to demonstrate, at cell level, the scale-up of solid-state advanced materials for anodes, cathodes, electrolytes and separator with performances and costs compatible for mobility markets.

Projects are expected to contribute to all the following outcomes:

- The selection of solid-state cell components and architecture (anode; electrolyte, cathode, collector, and interfaces) meeting, by the end of the project, the performances at ambient temperature necessary for mobility, in terms of:
    - Safety: with a technology compatible with the level 4 EUCAR at module/pack level.
    - Gravimetric and volumetric energy density: > 400Wh/kg and 1000Wh/l.
    - Cycling: > 3000 cycles at 50% DoD (depth of discharge).
    - C Rate: at charge up to 3 to 5 C at 80% SoC (state of charge).
    - Materials and cells design with mechanical properties and constraints that enable large scale production processes at a competitive cost, especially in terms of pressure conditions at cell and module level.
    - Atmospheric conditions in factories.
- A competitive cost level towards 75€/kWh at pack level by 2030.
- An optimised environmental footprint of cell materials in terms of carbon footprint and quantity of metals.

- Cell manufacturing processes which allow the fabrication of performant, reliable, sustainable, and affordable solid-state cells, demonstrated at pilot level.

- Cell materials and designs which are compatible with a recycling process that respects the requirements as put forward in the European Batteries regulation.

Scope:

Proposals are expected to cover all the following points:

- Develop or leverage the materials-specific models and digital tools for material and cell design to identify the best combinations of materials and speed up the cell optimisation process.

- Ensure ionic conductivity and stability of the electrolyte.

- Integrate high voltage cathode (> 4V) to reach the KPIs for mobility as listed in the Expected Outcomes section.

- Propose and evaluate interfaces and coating solutions especially to suppress dendrite growth and enable a stable solid-electrolyte interphase (SEI) and cathode-electrolyte interphase (CEI).

- Optimise the cell design with respect to all the cell components to meet high energy density objectives.

- Anode current collectors and/or electrolyte capable of accommodating volume changes upon charge/discharge.

- Demonstrate the potential for scale up of materials, cells and sustainable industrial processing methods with cells reaching a capacity of several Ah, produced in a statistical meaningful number to demonstrate the process repeatability.

- Project publications should adhere to the guidelines for publication of research results, as laid out by the "Batteries Europe - Reporting Methodologies" report, subject to the need to maintain confidentiality for future commercial exploitation.

Plans for the exploitation and dissemination of results for proposals submitted under this topic should include a strong business case and sound exploitation strategy, as outlined in the introduction to this Destination. The exploitation plans should include preliminary plans for scalability, commercialisation, and deployment (feasibility study, business plan) indicating the possible funding sources to be potentially used (in particular the Innovation Fund).

Projects should link to ongoing Horizon Europe calls, especially **HORIZON-CL5-2021-D2-01-03: Advanced high-performance Generation 4a, 4b (solid-state) Li-ion batteries supporting electro mobility and other applications** and HORIZON_CL5-2021-D1-01-05 (Manufacturing technology development for solid-state batteries (SSB, Generations 4a - 4b batteries). Projects should also take stock of the outcomes of the projects under call LC-BAT-

1-2019 (Strongly improved, highly performant ad safe all-solid-state batteries for electric vehicles).

D2-1-4. Sustainable high-throughput production processes for stable lithium metal anodes for next generation batteries

Opening	2024
Expected EU contribution per project	The EU estimates that an EU contribution of EUR 8 million would allow these outcomes to be addressed appropriately. Nonetheless, this does not preclude submission and selection of a proposal requesting different amounts.
Indicative budget	The total indicative budget for the topic is EUR 8 million.
Type of action	Innovation Action (IA)
Technology readiness level	Activities are expected to achieve TRL 6-7 by the end of the project

Expected outcomes:

As Li metal anodes will be needed for the Gen 4b, Gen 4c and Gen 5 batteries, it is important to create a European production chain for their manufacturing, in order to guarantee secure supply chains for the next generation battery producers with a focus on high performance and recyclability for Gen 4b, Gen4c or Gen5 cells.

The proposed project are expected to contribute to the following outcomes:

1. A European economic base which is stronger, more resilient, competitive and fit for the green and digital transitions, by reducing strategic dependencies for critical raw materials by promoting resource efficiency.
2. Energy consumption/carbon footprint of processing lower than [TBC on basis of ongoing projects].
3. Throughput of Li foil and/or electrode production to support cell manufacturing, including a technical pathway towards production at MWh/(sub-)GWh scale.
4. Ensure stability of Li during handling, processing and operation using coatings or other protective technologies (e.g. barriers/protective layers).
5. Processing of Li (Metal) and Li electrodes within cell assembly at industrial scale, including, but not limited to, high-quality cutting of the Li foil and/or electrode.

6. Homogeneous Li films with thickness below 20µm, contributing towards energy density levels of 400-500 Wh/kg.
7. The developed process should be compatible with recycling targets (with respect to purification of scrap with protective coating) and assure recyclability to more than 70% of Li metal in battery waste, (90% Li metal for production scrap).
8. Collaboration with other projects from calls [TBC – calls on Gen 4 and or Gen 5] is expected.
9. The proposed projects are encouraged to contribute to a competitive price of 75€/kWh at pack level.

Scope:

Proposals under this topic are expected to cover all of the following points:

- Sustainable, cost-efficient and large-scale production of Li-metal foils and/ or electrodes, demonstrated up to pilot level during the project. Activities can include, but are not limited to, extrusion, comparison extrusion / electrostatic spray, rolling and co-rolling.
- Control of the passivation of Li metal films, and to understand how the passivation is linked with the dry room conditions and requirements. The goal is to find the optimal way: high passivation and lower quality dry room, or low passivation and higher quality dry room, and how these selections are linked with cost, energy consumption and performance of the cells.
- A demonstration of the performance of Li at cell level in SoA benchmark cell (at least TRL5 with at least 5 Ah capacity). However, extensive cell design and development are out of the scope as this topic focuses on the Li anode production. It is expected that the Li metal anode (with protective layers) allows more than 1000 cycles (C/2 or C? TBC) with min. 400 Wh/kg.

The projects must also guarantee safety of the Li film production and handling, which must be demonstrated in a process that is compatible for large scale production.

Plans for the exploitation and dissemination of results for proposals submitted under this topic should include a strong business case and sound exploitation strategy, as outlined in the introduction to this Destination. The exploitation plans should include preliminary plans for scalability, commercialisation, and deployment (feasibility study, business plan).

Projects are encouraged to cooperate with projects stemming from call topic D2-1-1. Technologies for sustainable, low carbon and cost-efficient downstream processing and production of battery-grade materials.

D2-1-5. Advanced digital twins for battery cell production lines

Opening	2023
Expected EU contribution per project	The EU estimates that an EU contribution of EUR 7 million would allow these outcomes to be addressed appropriately. Nonetheless, this does not preclude submission and selection of a proposal requesting different amounts.
Indicative budget	The total indicative budget for the topic is EUR 14 million.
Type of action	Research and Innovation Action (RIA)
Technology readiness level	Activities are expected to achieve TRL 4-5 by the end of the project

Expected outcomes:

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

- The understanding of digital twins as systems with automated data acquisition, connected digital models and value-adding applications
- The capacity to go beyond single process consideration with potential perspective on the process chain
- The implementation and the transfer of digital twins into existing and future battery cell production plants
- Safety and security, scalability, explainability, computational speed as well as contributions to sustainability of battery cell production
- Optimise product quality, improving the resource efficiency and, consequently, the production time and cost of battery cells in the manufacturing process at the targeted scale

Scope:

The battery production chain consists of diverse multi-disciplinary, rather novel processes with numerous influencing factors and interdependencies. Digital twins, as a core element of the accelerating digitisation in manufacturing, bear the potential to improve planning and operation of current and future battery production system. With their connection of advanced digital models and most up-to-date data, decision support or even autonomous control of battery production processes and process chains is enabled. First applications can be found in research

and partly also in industrial practice – however, those still tend to be rather specific, covering just selected aspects of digital twins (e.g. just specific models) and are often hardly transferable in terms of the underlying IT architectures and models.

Proposals are expected to address all following points:

1. Developing digital twins of battery cell manufacturing routes at pilot line level that incorporate appropriate models but also their connection to real manufacturing plants, e.g. to support process development and operation, accelerate the set-up of effective manufacturing processes for the next generation battery cells or to demonstrate the capability for predictive maintenance.
2. Design robust digital tools integrating multi-physics, data-driven models and hybrid modelling.
3. Flexible Digital Twins capable to evolve to different battery chemistries, new disruptive materials as well as new manufacturing processes (the model would be chemistry neutral so easily adaptable to new disruptive materials and chemistries).
4. Verify the transferability from pilot to production plant level.
5. Propose applications that will enable to overcome single process considerations towards process chain perspectives.
6. Implementation of the sensorizsation of the manufacturing plant and automatization of the data acquisition.
7. Ensuring greater interoperability, by implementing available data standards, e. g., Modelling-Data (MODA) and Characterization Data (CHADA), as well as, a common semantic framework, like The European Materials Modelling Ontology (EMMO) and the battery interface ontology (BattINFO).
8. Promote the control and decision making of the manufacturing chain.
9. Aspects like safety and security, explainability of models as well as contributions to sustainability of battery production must be addressed.

This call topic addresses the need of increasing the level of autonomy to the whole battery cell value chain (with special emphasis in the manufacturing).

Plans for the exploitation and dissemination of results for proposals submitted under this topic should include a strong business case and sound exploitation strategy, as outlined in the introduction to this Destination. The exploitation plans should include preliminary plans for scalability, commercialisation, and deployment (feasibility study, business plan).

This topics building upon the BATTERY 2030+ Roadmap[2] and will build upon the shared data infrastructure, standards and protocols developed within this initiative, and in particular

[2] https://battery2030.eu/research/roadmap/

the BIG-MAP[3] project. Projects must collaborate and contribute to the activities of the Coordination and Support Action defined under the topic HORIZON-CL5-2022-D2-01-08. The proposal must cover the contribution and collaboration to the Coordination and Support Action."

D2-1-6. Battery management system (BMS) and battery system design for stationary energy storage systems (ESS) to improve interoperability and facilitate the integration of 2nd life batteries

Opening	2023
Expected EU contribution per project	The EU estimates that an EU contribution of EUR 7.5 million would allow these outcomes to be addressed appropriately. Nonetheless, this does not preclude submission and selection of a proposal requesting different amounts.
Indicative budget	The total indicative budget for the topic is EUR 15 million.
Type of action	Innovation Action
Technology readiness level	Activities are expected to achieve TRL 6-7 by the end of the project

Expected outcomes:

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

- A European economic base which is stronger, more resilient, competitive and fit for the green and digital transitions, by reducing strategic dependencies for critical raw materials by promoting a circular economy.
- Battery pack and Battery Management System (BMS) design for single module operation or recombination (reconfiguration) of modules or battery packs for consolidated and new battery technologies.
- Safe, accessible and reliable operation of batteries and compatible with the battery passport concept.
- Battery system design to enable disassembly and reconfiguration for 2nd life.

[3] https://www.big-map.eu/

- Development of fast and efficient qualification strategies and assessment of Electric Vehicle (EV) batteries for 2nd life applications and quantify it with respect to SoA in terms of time and efficiency.

- Reduction of 30% of repurposing/refurbishment cost for adapting EV batteries to stationary applications in 2nd life.

- Environmental impact assessment, from both positive and negative aspects, for adapting EV batteries to 2nd life applications.

- Impact in the European economy by a growth of the market and employment, by facilitating the uptake of stationary ESS Feasibility of operation in the batteries extended life domain (2nd life).

Scope:

This topic aims at developing an open and interoperable BMS and suitable battery system design for stationary ESS, enabling a better integration of 2nd life applications for used batteries.

In order to fulfil these objectives, activity in all of the following fields is expected:

- The BMS could be used for 1st and 2nd life batteries in stationary applications, e.g., microgrids, uninterrupted power supply, hybrid (different types of chemistries and batteries, multibattery management systems) and circular power system, ensuring safety during operation.

- The BMS and system design should be technology agnostic and not exclusive to 2nd life EV batteries and can cover consolidated technologies as well as new battery technologies.

- Development and validation of open-source algorithms and BMS, allowing for the integration of 2nd life batteries including approaches as semi-empirical, data-driven and multiphysics supported battery state estimators. Recommendations for the development of standards related to the battery state defining parameters, e.g., SoH and safety assessment at the end of first life applications.

- Development of BMS software that can be adapted via firmware update to other communication protocols, estimation algorithms and models.

- Development of functionalities focused on increasing the reliability during the second life application, e.g., prediction of RUL, self-diagnostic algorithm for assessment of second life use suitability and BMS connectivity to track batteries during 2nd life application.

- Recommendation to standardization of a BMS public structure and access to public SOX in order to ease the second use of a battery. The goal must be to agree a minimum set of data requirements, duly justified, to be provided by the batteries and let the

industry define the best procedure to provide this set of data and link up with battery passport concept.

- Development and demonstration of strategies to recombine optimally and safely used batteries to be operated in second life, with special focus on advanced critical event control and mitigation systems. Recommendations for standardization of 2nd life battery system design for stationary applications based on packs, type of chemistry and cell.

- Design of accessible and adaptable BMS in order to customize the BMS to the requirements of the 2nd life use case, including improved battery models for improved BMS design.

- Demonstration of battery operation in second life use according to TRL6.

- Projects are expected to share information with projects emanating from [Battery Passport topic] where relevant and conform to all relevant EU standardisation requirements.

- The proposal should take into account pending amendments to the Renewable Energy Directive, including Article 20A dealing with access to battery SOX information.

Proposals are expected to establish links with the results of HORIZON-CL5-2022-D2-01-09: Physics and data-based battery management for optimised battery utilisation (Batteries Partnership), HORIZON-CL5-2022-D2-01-10: Streamlined collection and reversed logistics, fully automated, safe and cost-efficient sorting, dismantling and second use before recycling (Batteries Partnership) and HORIZON-CL5-2022-D2-01-05: Next generation technologies for High-performance and safe-by-design battery systems for transport and mobile applications (Batteries Partnership). They should specifically address BMS and system design issues that affect stationary Energy Storage Systems (ESS) and in particular, the integration of used batteries as a 2nd life application.

Plans for the exploitation and dissemination of results for proposals submitted under this topic should include a strong business case and sound exploitation strategy, as outlined in the introduction to this Destination. The exploitation plans should include preliminary plans for scalability, commercialisation, and deployment (feasibility study, business plan) indicating the possible funding sources to be potentially used (in particular the Innovation Fund).

In order to achieve the expected outcomes, international cooperation is encouraged, in particular with the USA, India, Africa and Australia.

This topic is considered for contribution by the EU Joint Research Centre, modalities TBC.

D2-1-7. Hybrid electric energy storage solutions for grid support and charging infrastructure

Opening	
Expected EU contribution per project	The EU estimates that an EU contribution of EUR 6 million would allow these outcomes to be addressed appropriately. Nonetheless, this does not preclude submission and selection of a proposal requesting different amounts.
Indicative budget	The total indicative budget for the topic is EUR 12 million.
Type of action	Innovation Action
Technology readiness level	Activities are expected to achieve TRL 7 by the end of the project

Expected outcomes:

Projects are expected to contribute to all the following outcomes:

- Demonstration of hybrid energy storage technologies for long duration storage (from hours to days) and provision of multiple grid services with improved technical performances (increased power and energy density with respect to single EESS +20%, reduced storage system losses -10%, improved HESS cycle life +15%, improved reliability and availability +15%), sustainability, as well as increased safety during operation, transport and storage.

- Enable improved levelized cost of storage supported by design optimisation and optimal service stacking, putting the cost of storage on the path to fall below 0.05 €/kWh/cycle by 2030 (for storage durations > 12 hours - **TBC**) while reducing the use of CRMs.

- Creating synergies between producers and strengthening the European Battery Ecosystem, improving the European battery value chain and thus contributing to the EU climate neutrality objectives.

- Increasing digitalisation of energy storage systems from design to operation phase enabling a faster development and optimal use in grid applications.

- The establishment of multi-service approaches to energy storage reducing costs and increasing benefits for the European electricity system.

- Promoting an increased reliability and resilience of the electricity system by demonstrating new multi-purpose energy storage solutions.

Scope:

The objective is to design and demonstrate in at least three different use cases a Hybrid Energy Storage System (HESS) capable of long duration storage and provision of multiple services for supporting the electrical grid and EV charging infrastructure.

In particular, proposals are expected to:

- Design and demonstrate a sustainable and safe Hybrid Energy Storage System (HESS) either combining different battery technologies, including next-gen technologies, or combining batteries and other electrostatic/electrochemical storage technologies (e.g., supercapacitors) aiming at providing long duration storage while ensuring the possibility of service-stacking and enabling ultra-fast services. The proposed storage solution should be scalable and modular and show clear innovation with respect to the state of the art (new materials/new designs), always bearing in mind the objectives of sustainability and performance. Proper power conversion devices should be selected or customized for enabling an efficient operation of the hybrid storage in grid-connected, grid-following and grid-forming modes.

- Perform a life cycle assessment of the HESS starting from the design phases to ensure its sustainability along the entire value chain, also avoiding, whenever possible, or limiting the use of CRMs.

- Develop physics-based and data-driven digital models of HESS supporting optimal design, and real-time management and diagnosis as well as facilitating the inclusion of storage in grid-planning processes considering forecasted weather conditions, production and consumption. Models should allow the combination of different battery technologies based on specific use cases.

- Develop and validate management policies and control systems (BMS, EMS) for HESS that maximise the benefits of a hybrid storage, facilitate asset management and participation in electricity and service markets.

- Demonstrate HESS integration in standard grid architectures (Smart Grids Architecture Model – SGAM) ensuring interoperability for most use cases of ESS (e.g., provision of services to the European grid, supporting islanded and weak distribution grids, load levelling for charging stations).

- Analyse business cases of the proposed hybrid solution considering electricity and balancing markets of three representative EU countries, also assessing the applications where HESS provides improved techno-economic performances compared to non-hybridized storage systems.

Plans for the exploitation and dissemination of results for proposals submitted under this topic should include a strong business case and sound exploitation strategy, as outlined in the introduction to this Destination. The exploitation plans should include preliminary plans for

scalability, commercialisation, and deployment (feasibility study, business plan) indicating the possible funding sources to be potentially used (in particular the Innovation Fund).

In order to achieve the expected outcomes, international cooperation is encouraged, in particular with the USA, India, Africa and Australia.

D2-1-8. New Approaches to Develop Enhanced Safety Materials for Gen 3 Li-Ion Batteries for Mobility Applications

Opening	2023
Expected EU contribution per project	The EU estimates that an EU contribution of EUR 5 million would allow these outcomes to be addressed appropriately. Nonetheless, this does not preclude submission and selection of a proposal requesting different amounts.
Indicative budget	The total indicative budget for the topic is EUR 10 million.
Type of action	Research and Innovation Action
Technology readiness level	Activities are expected to achieve TRL **5** by the end of the project

Expected outcomes:

Projects are expected to contribute to all of the following outcomes: **(To be elaborated)**

- Advanced Li-ion batteries with enhanced safety behaviour
- Improved cyclability and operational lifetime, whilst maintaining competitive performance for cost, energy and power density
- Improved sustainability and recyclability
- Preparation for industrial scale-up of manufacturing

Scope:

NB TEXT TO BE SHORTENED – WORK ONGOING

This topic aims at developing safer materials for high-performing cells by targeted modification in main cell components, namely the cathode, anode, separator and electrolyte. The most severe danger arises from exothermic reactions, interaction of materials used in the cell with organic or contaminants, and/or unwanted side reactions under peculiar operating conditions (Li-dendrite formation, temperature induced oxygen loss of cathode materials, uncontrolled interactions on SEI and CEI, etc.).

Effective countermeasures should be undertaken by material modification on electrolyte, electrode and separator manufacturing level to mitigate and minimise aforementioned risks, and enhance the intrinsic safety of the cell.

The multiple aspects of safety enhancement must be covered through a comprehensive design of new materials for some of following components:

- New cathode materials with no exothermal decomposition/reactions, reduced probability for oxygen and other gasses release, and preventing corrosion at current collector. Development can include the following approaches/strategies at different levels:
    - Doping strategies or surface coating materials leading to more robust and effective cathode electrolyte interphase (CEI).
    - Design of high-capacity cathode materials based on safer chemistries (e.g. stabilized Li-rich layered oxides, disordered rock salts, polyanionic materials…).
    - Design high-voltage cathodes and high voltage anodes in order to combine them in a large voltage and energy cell, avoiding stripping/plating of lithium.
    - Innovative approaches of cathode structuring to mitigate heat generation in abuse conditions.
- New stable anode materials and electrode designs with non-swelling, or low degree of expansion over the whole cell lifetime, with no decomposition/exfoliation, high resistance against Li-dendrite formation – specially at high anode rate capabilities, and favouring the formation of a thermally stable, and low-resistivity SEI. Development can include the following approaches/strategies at different levels.
    - Design and development of new systems with higher standard potential compared to lithium stripping/plating. (High SiOx, Si/C, etc. content);
    - Surface coating materials for more robust and effective SEI;
    - New approaches to minimize material/anode swelling and expansion during cycling, including anode manufacturing (polymeric and ceramic coating-based approaches, etc.) and structuring the anode-current collector interface.
- New electrolyte formulations, including solvents, supporting salts and additives, with shear thickening, flame retardant and over-charge/discharge properties, maintained high ionic conductivity, broad electrochemical stability i.e., voltage-operating window, and high onset point for Li-dendrite formation, SEI decomposition and CEI effectiveness. Development can include the following approaches/strategies at different levels:

- (Multi-)functional additives for SEI and CEI stabilization and protection on anode and cathode such as flame-retardant additives or solvents, ionic conductivity boosters, stability window promoters, etc.;
- Addition of selective particles (i.e. oxides, etc.) to hinder mechanical abuse and improve shear thickening behaviour.

- New separator materials with flame retardant and improved ion transport capabilities, high melting point, and mechanical stability, for example multilayer approaches for disruption of ionic conductivity (shutdown effect) and maximize electrode voltage compatibility.
- New binder materials with thermal, mechanical and electrochemical stability (self-healing systems), low ionic and electrical resistance, improved adhesion and cohesion, and preventing swelling and porosity reduction in electrodes.

Projects need to justify the relevance of the selected components which will be addressed and how the new materials, and the combination of them, will lead to better safety outcomes.

The improvement in safety must be demonstrated at representative cell level for mobility applications by direct comparison with SOA Gen. 3 cells tested at the beginning of the project.

A EUCAR Hazard Level of 3 or other equivalent mobility standard should be validated.

Plans for the exploitation and dissemination of results for proposals submitted under this topic should include a strong business case and sound exploitation strategy, as outlined in the introduction to this Destination. The exploitation plans should include preliminary plans for scalability, commercialisation, and deployment (feasibility study, business plan).

In order to achieve the expected outcomes, international cooperation is encouraged, in particular with the USA.

Projects may collaborate and/or contribute to the activities of the Coordination and Support Action defined under the topic HORIZON-CL5-2022-D2-01-08.

D2-1-9. Creating a digital passport to track battery materials, optimize battery performance and life, validate recycling, and promote a new business model based on data sharing

Opening	2023
Expected EU contribution per project	The EU estimates that an EU contribution of EUR 8 million would allow these outcomes to be addressed appropriately. Nonetheless, this does not preclude submission and selection of a proposal requesting different amounts.

Indicative budget	The total indicative budget for the topic is EUR 8 million.
Type of action	Innovation Action
Technology readiness level	Activities are expected to achieve TRL 7 by the end of the project

Expected outcomes:

Stakeholders engaged with the battery value chain need to be provided with accurate, reliable and immutable battery information e.g. related to ESGE (Environmental, Social, Governance & Economic) indicators and monitor thermal runaway at any stage of the value chain. The increase in sales of EVs and other ESSs in Europe increases the need to promote new business opportunities around the whole battery value chain, which will improve battery life span and second life application opportunities. Furthermore, the Battery Regulation and future regulations will extend the due diligence to all domains in the next few years. The EU Data Strategy is setting a clear architectural approach to federated data and is enabling a great opportunity to boost the EU dataspace on batteries.

The availability of shared, interoperable, and trusted data for improving recycling and second life application might promote new business, assuring workforce and transportation safety. Indicators such as SoH (State of Health), SoS (State of Safety), SoP (State of Power) should be calculated in accurate, reliable, immutable, and standardized way, based on historical data (usage profile, working temperatures, etc.) of the battery or cells.

Projects are expected to contribute to the following outcomes:

- A European economic base which is stronger, more resilient, competitive and fit for the green and digital transitions, by reducing strategic dependencies for critical raw materials by promoting resource efficiency.
- Must provide a proper tracking and blockchain or DLT (Distributed Ledger Technology) based solution, along the value chain, with no data duplication, avoiding data manipulation assuring privacy by design and low power consumption and promoting data interoperability.
- Need to be able to demonstrate new business models in the different value chains and circular data extraction, based on data sharing.
- Are expected to demonstrate the improvement of the battery transportation and workforce safety and contribute to the related regulation standards.
- Must be tested throughout the battery value chain or part of it, demonstrating at least 2 real life pilots capable to exploit data generated by Digital Product Passport (DPP) and test innovative solutions proposed.

Projects are also encouraged to address some of the following outcomes:

- Improvement of the recycling efficiency (more than one material).
- Promotion of sustainability and circularity through the adoption of 4R methodological approach Reduce, Repair, Reuse, Recycle.
- Boost of the use of recycled and reusable material to reduce energy usage/CO2 footprint.
- Increase of competitiveness of the European battery industry across the value chain (from mines and refiners to cell manufacturers to cell integrators).
- Streamlined compliance with the European Battery Regulation and EU federated dataspace.

Scope:

The project:

- Must promote the adoption of a downstream development and implementation of a battery pack Digital Product Passport (DPP) at minimum subset design system level addressing raw materials (at least anode and cathode critical raw materials), cells and modules.
- Must also be able to facilitate real-time data recognition for different indicators and at local device - even when the battery ceases to be part of the ESS.
- Must engage a variety of stakeholders along the whole battery value chain to assure the continuous traceability and assure that accountability will not be lost from raw or recycled raw material to first and second life and recycling. Blockchain solutions are requested to demonstrate trustworthy tracking.
- Is requested to validate its interoperable data sharing strategy by adopting a unique battery data space and testing of interoperability between different subsystems (mobility, energy,..) is encouraged.
- Need to develop a safety second life-battery certification protocol, and hazard alerts system to assure liability and protection during transport, and second use.
- Should validate new business models, capable to demonstrate improvement in remanufacturing, repurposing and recycling. International collaborations are welcome and alignment and interoperability with the Global Battery Alliance and other worldwide networks is encouraged.
- Is requested to have an ambition for cross-sectorial applications and must focus on the lithium-ion battery chemistries currently on the market - or reaching the market in the

short term, with the potential to quickly adapt to next-generation battery chemistries and assess its safety tracking.

Project outcomes:

- Should be applicable to 3 or more use cases among the main transport or mobile applications (such as road, waterborne, airborne and rail transport, as well as non-road mobile machinery and industrial applications), with the aim to maximize the impact on the European industry.
- Should consider the key performance indicators proposed by Batteries Europe or by the dedicated Partnerships, reflected in the Partnership Strategic Research Agenda (SRA), to guide the technology developments on the application segments and use cases that will be selected.

Projects need to be compliant with the following EU strategy and regulations framework:

1. Green Deal and in particular Circular Economy Action Plan's Sustainable Product Initiative,
2. the EU Digital strategy's Circular Electronics Initiative and
3. the EU Data strategy,
4. New Regulation on Batteries / Due diligence

The project results shall also be applicable to stationary energy storage applications.

Plans for the exploitation and dissemination of results for proposals submitted under this topic should include a strong business case and sound exploitation strategy, as outlined in the introduction to this Destination. The exploitation plans should include preliminary plans for scalability, commercialisation, and deployment (feasibility study, business plan).

In order to achieve the expected outcomes, international cooperation is encouraged, in particular with the USA, Japan and South Korea.

Proposals should interface with the project(s) funded under the topic DIGITAL-2021-TRUST-01-DIGIPASS and notably its activities regarding batteries. They should also establish cooperation and complementarity with the selected proposal under the topic HORIZON-CL4-2022-RESILIENCE-01-05- Technological solutions for tracking raw material flows in complex supply chains (RIA), which is tracking raw material flows for a.o. batteries value chains. They should furthermore establish collaboration with the partnership "Battery Passport" under the Global Battery Alliance[4].

[4] https://www.globalbattery.org/battery-passport/

This topic is considered for contribution by the EU Joint Research Centre, modalities TBC

D2-1-10. Advanced sustainable and safe pre-processing technologies for End-of-Life (EoL) battery recycling

Opening	2024
Expected EU contribution per project	The EU estimates that an EU contribution of EUR 7 million would allow these outcomes to be addressed appropriately. Nonetheless, this does not preclude submission and selection of a proposal requesting different amounts.
Indicative budget	The total indicative budget for the topic is EUR 21 million.
Type of action	Research and Innovation Action
Technology readiness level	Activities are expected to achieve TRL 5 by the end of the project

Expected outcomes:

The pretreatment process is the first and indispensable step in recycling Lithium-ion batteries (LIBs), which significantly affects the recycling rate of the spent devices and the extraction rate of the high-value metals in the subsequent metallurgical processes. The batteries also contain toxic chemicals, which should be preventatively separated to promote environmental protection and sustainability. Moreover, the pretreatment processes also help to reduce the scrap volume and allow the separation of the battery components.

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

1. A European economic base which is stronger, more resilient, competitive and fit for the green and digital transitions, by reducing strategic dependencies for critical raw materials by promoting a circular economy.

2. The direction of the EU battery industry towards the zero-waste concept by developing holistic batteries and components repurposing, materials and energy efficient recycling processes that can increase the content of recovered mass and by improving the cooperation between recyclers and battery manufacturing through a vertical integration strategy.

3. The circularity of battery materials, where also non-metallic elements (electrolyte, solvent, salts and polymers) are recycled back to use (as raw materials or valuable chemicals). The “cradle to cradle approach” will be addressed though waste pre-treatment by safe and sustainable separation and recovery.

4. Environmentally beneficial processes for battery pre-treatment (pre-processing and separation) of the main elements to decrease the CO_2 footprint and other emissions of the recycled materials.

5. Safe technologies aimed at improved recovery yield, increased quality and purity level of the recycled/recovered materials, improved impurity removal.

Scope:

The current EOL LIB recycling technologies are focused on improving the recovering efficiency of Cobalt that is the most valuable material. However, other no-Co battery contents need to be extracted in one go to develop recycling processes with economic, societal and environmental perspectives. They, for instance, include low-density plastics, metal shells and foils, binders, separators, organic solvents, Li salt, anode active materials. Successful separation methods have the potential to enrich the constituent of targeted materials and improve the profit for recycling.

In recent years, several pretreatment processes were tested at least at lab-scale (usually mechanical, thermal and chemical options). The goal is to develop and integrate new advanced pre-processing concepts that enable more efficient and safe technologies for recycling EoL LIBs. Substantial improvements should be achieved in the processes environmental and economic viability and in the circular economy, narrowing the sustainability gaps in the whole battery recyclates pre-treatment.

The following pre-treatment concepts are expected to be addressed:

1. Battery repurposing (e.g. from mobile to stationary usesuse);

2. Battery sorting at component level that should be more efficient, accurate, including standardisation of labelling, due to the huge variation of physical configurations, cell types and chemistries, with the aim of re-using the suitable components;

3. Advanced pre-processing methods including (but not limited to) physical, mechanical, dry, thermal and aqueous pre-treatment methods that allow improved pre-concentration while minimising as much as possible waste side products;

4. Process design enabling the recovery and valorisation of anode materials;

5. Electrolyte valorisation through the development of sustainable and safe processes for the recovery of Li-salts;

6. Separation of all the strategic battery materials that should be integrated into existing/innovative recycling processes to mitigate potential effect of impurities;

7. Recovery of electrode current collectors (Al and Cu) that should be improved by developing more efficient separation methods of the metal foils from the electrode materials and easier removal of the organic binder;

8. Other recoverable not-active materials from the EoL battery (solvent as EC, DEC, DMC, binders, separator);

9. Pre-assessing concepts by their life cycle sustainability and safety impacts and studying overall techno-economical solutions for recovery systems in order to minimize cost, environmental impact and system losses.

Plans for the exploitation and dissemination of results for proposals submitted under this topic should include a strong business case and sound exploitation strategy, as outlined in the introduction to this Destination. The exploitation plans should include preliminary plans for scalability, commercialisation, and deployment (feasibility study, business plan).

The topic will generate insights that may be of use for on-going Research and Innovation on new recycling processes and concepts [D2-1-2].

This topic is considered for contribution by the EU Joint Research Centre, modalities TBC.

Projects may collaborate and/or contribute to the activities of the Coordination and Support Action defined under the topic HORIZON-CL5-2022-D2-01-08.

D2-1-12. Post-Li-ion technologies and relevant manufacturing techniques for mobility applications (Generation 5)

Opening	2024
Expected EU contribution per project	The EU estimates that an EU contribution of EUR 5 million would allow these outcomes to be addressed appropriately. Nonetheless, this does not preclude submission and selection of a proposal requesting different amounts.
Indicative budget	The total indicative budget for the topic is EUR 15 million.
Type of action	Research and Innovation Action
Technology readiness level	Activities are expected to achieve TRL 4 by the end of the project

Expected outcomes:

The request for higher gravimetric and volumetric energy densities, lower costs, higher sustainability, ubiquitous raw materials with high and improved safety has triggered research into Generation 5 battery concepts as defined in the Strategic Research Agenda as published

by Batteries Europe[5], including secondary batteries related to conversion systems based on metal anodes.

This call aims at developing Gen. 5 technologies for mobility applications and relevant manufacturing techniques which is affecting performance, safety, costs and also their design to be fully and easily recyclable at the end of their life. It also aims at evaluating their possible manufacturing compatibility with existing lithium-ion production infrastructure.

Projects must contribute to at least one of the following outcomes:

- Conversion systems based on metallic anodes with enhanced safety, delivering on cost, performance, sustainability and recyclability, with clear prospects for the feasibility of the scale-up of the manufacturing processes.
- Metallic anode protection and/or activation for conversion systems (polymer, ceramic and hybrid electrolytes) with increased safety, cycle life and low cost.
- Post lithium-ion cells based on cations other than lithium with long cycle-life (Na-ion is excluded and covered by call HORIZON-CL5-2024-D2-1-13.)

In addition, projects are expected to contribute to creating batteries that will work in realistic environments, are recyclable and with low environmental impact, and have safe manufacturing processes.

Translating these outcomes into indicative KPIs to guide the R&I efforts, projects are expected to show a credible technical pathway to achieve all of the following targets by 2030 and beyond:

- A safe behaviour at cell level: expected EUCAR Hazard level below 4;
- Specific energy at cell level targeting 500 Wh/kg, and volumetric energy density at cell level targeting 600 Wh/l;
- Charge and discharge at 2<C-rate<10;
- 800+ cycles at 50%DoD OR **400 cycles at >80%DoD;**
- Cost at cell level < 75 euro/kWh.

Scope:

Proposals should address improvements in sustainable material designs to reach the manufacturability and high safety of the selected technology.

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5 https://ec.europa.eu/energy/sites/ener/files/documents/batteries_europe_strategic_research_agenda_december_2020__1.pdf

Successful projects are expected to cover at least three of the following:

- Improvement of materials:
    - Scalable and manufacturable surface coating materials for metallic anode protection and/or activation (e.g. CVD, PLD, ALD…) to increase safety and cycle life;
    - Binders with high chemical and thermal stability to reduce toxicity and enable the use of water-based manufacturing processes;
    - Design and development of new cell technologies with higher capacities compared to Li-ion cells;
    - Improve and increase the electrodes-electrolyte compatibility with additives to increase over cell time;
    - Improve the understanding of the chemical and/or electrochemical reaction mechanisms using advanced techniques in the cells for Gen5 technologies developed;
    - Improve the insertion cathode with high charge-storage capacity;
    - Use of safe and non-toxic materials;
    - New efficient and sustainable catalysts that can promote polysulfide conversion in Metal-S batteries or the oxygen evolution/reduction reactions in Metal-air batteries.
- Design and manufacturing:
    - Innovative cell design ensuring high performances, low cost and ready for recycling;
    - Develop relevant manufacturing processes and assess the possible manufacturing compatibility with the existing lithium-ion production infrastructure and production lines;
    - Proof of concept possibly at small pilot line scale;
    - Design production with low environmental impact, safe and healthy environment for workers, low energy consumption.

Projects are encouraged to demonstrate also techno-economic suitability of the solution for other emerging markets, such as motive power for off-road applications, or energy storage applications.

Plans for the exploitation and dissemination of results for proposals submitted under this topic should include a strong business case and sound exploitation strategy, as outlined in the

introduction to this Destination. The exploitation plans should include preliminary plans for scalability, commercialisation, and deployment (feasibility study, business plan).

Projects must collaborate and contribute to the activities of the Coordination and Support Action defined under the topic HORIZON-CL5-2022-D2-01-08. The proposal must cover the contribution and collaboration to the Coordination and Support Action."

D2-1-13. Non-Li Sustainable Batteries with European Supply Chains for Stationary Storage

Expected EU contribution per project	The EU estimates that an EU contribution of EUR 7.5 Million would allow these outcomes to be addressed appropriately. Nonetheless, this does not preclude submission and selection of a proposal requesting different amounts.
Indicative budget	The total indicative budget for the topic is EUR 15 Million
Type of action	Innovation Action
Technology readiness level	TRL 6-7 by project-end

Expected outcomes:

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

1. A European economic base which is stronger, more resilient, competitive and fit for the green and digital transitions, by reducing strategic dependencies for critical raw materials.
2. Development of post-lithium cell chemistries with target cell- and system-level cost, safety, energy density and power metrics suitable for the selected stationary energy storage markets;
3. Credible projected storage costs of less than 0.05 €/kWh/cycle by 2030, for (minimum) storage durations of up to 8 hours **(TBC)**;
4. Set out a clear route to a feasible, European-based European supply chain that reduces reliance on critical raw materials, substituting with abundant, non-toxic, inherently safe raw materials and minimises the impact of possible international trade disruptions and customs tariffs, taking account of the requirements for a range of stationary storage use cases;
5. Demonstration of system operated in end-user conditions for at least 3,000 hours;

6. Projected product cycling life of at least 5,000 cycles in conditions typical for the selected application;
7. A battery storage solution, that works safely and efficiently across a wide range of ambient conditions;
8. A defined concept for demonstrable, highly sustainable, circular manufacturing for the selected battery type, with sustainability measured in terms of recognised economic, environmental, social and ethical metrics.

Scope:

Proposals are invited for projects which advance the development of non-Li battery systems, show their potential to be manufactured at scale at a cost the market will bear and which meet regulatory requirements (including regulations for the recycling/re-use of batteries).

Projects may target any stationary storage applications, from a few kWh in small-scale domestic behind-the-meter units, to many MWh in large utility-scale front-of-meter installations.

Whilst stationary storage packaging constraints may not be as stringent as mobile applications in terms of volume and mass, total cost (€/kWh/cycle) and safety are critical to proving technological and commercial viability. Safety concerns become especially prominent as installation sizes increase due to the huge amount of stored chemical energy.

This topic is open to all non-lithium battery chemistries.

Projects are expected to:

- develop and demonstrate an innovative post-lithium battery technology with energy density and power metrics suited to stationary energy storage applications; and
- prove the battery system’s sustainability and compatibility with a European supply chain.
- are expected to adhere to the guidelines for publication of research results, as laid out by the "Batteries Europe - Reporting Methodologies" report, subject to the need to maintain confidentiality for future commercial exploitation.

Projects are encouraged to:

- Develop and demonstrate sustainable and safe post-lithium battery solutions from abundant, non-toxic raw materials that can be deployed in a large share of the energy storage markets;
- Develop new materials that improve techno-economic performances and/or the ability to meet sustainability targets;

- Show how cell and system design and material improvements optimise techno-economic performance by defining (i) technical and commercial targets, and (ii) quantified success criteria/KPIs by which progress toward achieving the targets may be evaluated during both development and validation phases of the project;

- Demonstrate a credible commercial and technical path, from end-of-project outcomes to a stationary-energy-storage product, and which takes account of future manufacturing and recycling requirements.

- Provide evidence of current and future sustainability, viable European supply chains and rigorous analyses of the complex sustainability and recyclability issues including compatibility with regulation, including recycling regulations.

BMS development is within scope where relevant, but should not be the main focus of the project.

Projects which, in addition, demonstrate the suitability of the solution under development for other emerging energy storage markets, such as motive power for off-road and transport applications with similar system requirements are encouraged.

Projects focussed on materials discovery for novel chemistries are out of scope. However, material refinements of known chemistries undertaken to achieve performance, sustainability, safety and cost targets are in scope.

Plans for the exploitation and dissemination of results for proposals submitted under this topic should include a strong business case and sound exploitation strategy, as outlined in the introduction to this Destination. The exploitation plans should include preliminary plans for scalability, commercialisation, and deployment (feasibility study, business plan) indicating the possible funding sources to be potentially used (in particular the Innovation Fund).

In order to achieve the expected outcomes, international cooperation is encouraged, in particular with India, Africa and Australia.

D2-1-15. Size & weight reduction of cell and packaging of batteries system, integrating lightweight and functional materials, innovative thermal management and safe by design approach

Expected EU contribution per project	The EU estimates that an EU contribution of EUR 8 million would allow these outcomes to be addressed appropriately. Nonetheless, this does not preclude submission and selection of a proposal requesting different amounts
Indicative budget	The total indicative budget for the topic is EUR 16 million

Type of action	Innovation Action
Technology readiness level	Activities are expected to achieve TRL 6-7 by the end of the project

Expected outcomes:

Widespread electrification of mobile applications is necessary to achieve the goals of the European Green Deal. A competitive European battery value chain will have to deliver highly performant and safe battery systems in order to enable the necessary uptake of electrified mobility applications.

This topic focuses on delivering a safe by design approach for batteries reduced in size and weight which will deliver the performance necessary for mobile applications. The objective is to ruggedise energy storage packs by enlarging the environmental and operational conditions in which they can operate, while maintaining a high level of performance and achieving a reduction in the size and weight of the battery pack.

Successful projects are expected to deliver on both following points:

- An increase of the net useful mass and volumetric energy density of the battery system by 30% compared to the state-of-the-art battery systems.
- The improvement of the safety by design measures throughout the battery lifetime and during operation.

Projects are furthermore expected to deliver innovative thermal management to

- Increase performance over the complete operational conditions
- Enable fast charging requirements 10%-80% in 10 minutes maximum.

The solutions shall be demonstrated and validated at application level and should comply with all relevant standards (performance and safety).

Scope:

Projects should achieve size and weight reduction by integrating different technologies such as:

- Integration of advanced cell technologies/generations, sensing technologies,
- The use of lightweight and multi-functional materials (including, but not limited to, the use of nanomaterials) and lightweight structures for battery casing.

- Improvement of the cell to system ration by adopting innovative packaging approaches to enable smart battery cell concepts. Approaches to reduce the complexity of HV and BMS architecture and substitution by alternatives.

To reach those targets, improvements in both components in the cell and in the pack must be considered.

The proposals must also address innovations in the manufacturing processes that result in size and weight reduction of the packs.

In addition, projects are expected to improve battery performance and safety by demonstrating innovative thermal management systems, which enhance fast charging capability or high power application during operational lifetime (heating and cooling).

are expected to Finally, projects should enhance the safety throughout the full battery lifetime and for failure conditions by developing and demonstrating safe by design measures, for example such as:

- Thermal propagation measures;
- Fire retardant properties;
- Mechanical properties ameliorations.

The effectiveness of safety measures should be demonstrated by simulation at pack level.

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

The integration of battery systems into larger systems of application (e.g., into vehicles structure) can be part of scope (e.g. cell to casing integration) as long as it can be demonstrated as a possibility to reduce overall packaging space, battery weight and battery performance improvement.

All solutions shall consider optimal design for manufacturing, end of life management and LCA analysis and disassembly.

Plans for the exploitation and dissemination of results for proposals submitted under this topic should include a strong business case and sound exploitation strategy, as outlined in the introduction to this Destination. The exploitation plans should include preliminary plans for scalability, commercialisation, and deployment (feasibility study, business plan) indicating the possible funding sources to be potentially used (in particular the Innovation Fund).

In order to achieve the expected outcomes, international cooperation is encouraged, in particular with the USA.

D2-1-16. Accelerated multi-physical and virtual testing for battery aging, reliability and safety evaluation

Expected EU contribution per project	The EU estimates that an EU contribution of EUR 7.5 million would allow these outcomes to be addressed appropriately. Nonetheless, this does not preclude submission and selection of a proposal requesting different amounts.
Indicative budget	The total indicative budget for the topic is EUR 15 million.
Type of action	IA
Technology readiness level	Activities are expected to achieve TRL 6 by the end of the project.

Expected outcomes:

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

- Shortening the development time of battery cells and battery systems by minimising the experimental testing effort and thus reducing the overall costs and time in battery system development and reducing the time to market.
- Increasing the battery reliability and safety through better understanding of the ageing, reliability and safety-relevant mechanisms and phenomena.
- Supporting the uptake of zero emission vehicles and the deployment of stationary energy storage systems (ESS) through safer and cost-effective battery systems.
- Fostering innovations in the eco-system battery through accelerated and more reliable verification and validation of advanced technological solutions contributing to increased use acceptance (safety & costs) and competitiveness of the European battery value chain.
- Standardisation of battery system testing & validation approaches focussing on the fusion of physical and virtual test methodologies.

Scope:

This call aims to reduce the development cost and time to market of battery systems by accelerated multi-physical and virtual testing. Current test strategies are still very time consuming and costly due to the need to understand the impact of multi-physical operational loads (electric, thermal, mechanical, …), potential failure modes, ageing and mis-use on the safety and reliability of battery cells, modules and systems level. For overcoming these barriers,

new multi-physical test strategies supplemented by virtual testing are required deepening the understanding of factors impacting ageing, reliability and safety and their dependencies.

This call complements the previous call HORIZON-CL5-D2-2022-01-07 focusing on the digitisation of battery testing. To differentiate, research activities should focus on the orchestration of accelerated testing and should result in a coherent test strategy from cell to system as much as possible independent from chemistries and technologies applicable also to next-generation batteries. Proposals can address mobile as well as stationary applications and should address and demonstrate at least following activities:

- Understanding and describing the impact of multi-physical operational loads, failure modes, ageing and mis-use on battery reliability and safety highlighting the dependencies between them in order to design the most adequate testing methods and parameters. This includes deeper understanding of aging and degradation mechanisms induced by accelerated tests both on batteries safety performance and cycle-life to optimise the testing strategy. Assessment from the multi-physical modelling domain on the nature of the cell components microscopic evolution to understand the achieved results at laboratory.

- Deriving advanced drive files for testing and development of novel X-in-the-Loop (XiL) test environments for multi-physical and accelerated testing addressing electrical, thermal and mechanical loads at the same time. This includes the design of specimen mountings representing real-life conditions.

- Combining physics-based with data-driven test strategies enabling reliable virtual and distributed battery testing from cell to system also including the integration of the battery in specific applications (mobile and stationary) and its operation. This includes developing methodologies for accelerated model convergence mixing digital and XiL test results as well as of decision-making algorithms for automatized test definition and execution.

- Development of test strategies to exploit synergies between different battery chemistries, including next generation battery, sizes and designs allowing to re-use or scale test results from cell level to system level.

- Development of simplified test strategies reducing the number of test and their complexity while improving battery safety and reliability. This includes on the fly testing protocols to facilitate/accelerate the parametrization and reduce the experimental load as well as the testing of aged or damaged batteries. The prevention of fire propagation between cells and modules is an important element.

- Research activities should also lead to advance response strategies for damaged and aged batteries as well as should contribute to an EU wide safety classification system for safety. For the latter, the development of concepts for such a safety classification system are being expected.

Activities could be complemented by following aspects:

- Development of virtual methods to reduce the complexity of testing sample to sub-system DUTs (device under test) while full system is validated by virtual methods using the results from physical sub-system test.
- Development, exploitation, and harmonisation of advanced battery cell/pack measurement & diagnostic methods for enhancing the data depth and breadth over what is currently available from standard instrumentation. Development of performance indicators relating to battery degradation and safety and methods / requirements for correlating / validating digital models.
- Application of AI to the collected data at laboratory to redefine designed test matrix in order to improve the potential conclusions, reduce the testing time and effort and in general, to enhance the applied testing methodology.

Plans for the exploitation and dissemination of results for proposals submitted under this topic should include a strong business case and sound exploitation strategy, as outlined in the introduction to this Destination. The exploitation plans should include preliminary plans for scalability, commercialisation, and deployment (feasibility study, business plan).

This topic is considered for contribution by the EU Joint Research Centre, modalities TBC.

D2-1-18. Development of technical and business solutions to optimise the circularity, resilience, and sustainability of the European battery value chain

Expected EU contribution per project	The EU estimates that an EU contribution of EUR 5 million would allow these outcomes to be addressed appropriately. Nonetheless, this does not preclude submission and selection of a proposal requesting different amounts.
Indicative budget	The total indicative budget for the topic is EUR 5 million.
Type of action	Research and Innovation Action
Technology readiness level	Activities are expected to achieve TRL 5 by the end of the project

Expected outcomes:

Project results are expected contribute to all the following outcomes:

- A European economic base which is stronger, more resilient, competitive and fit for the green and digital transitions, by reducing strategic dependencies for critical raw materials by promoting a circular approach to manufacturing and resource efficiency.

- Advancing circular and sustainable design and business practices relating to advanced batteries and associated value chains.
- Improving the life cycle sustainability performance of batteries produced in the EU, both in terms of reducing environmental impacts and maximising socio-economic benefits, including increased closed-loop practices.
- Enhancing EU strategic independence in terms of battery raw materials, the competitiveness of EU industry, and maximising socio-economic benefits at the EU level and beyond.
- Supporting the achievement of established EU recycling efficiency targets for 2030 and beyond.

Contribution to the following outcomes is optional, depending on the scope of the project:

- Enabling tools and best practice for multiple industry sectors in order to improve the EU industrial ambitions and global leadership beyond batteries
- Improving batteries and their materials/components circularity through the promotion of more material efficient designs by enabling longer material/component lifetimes, improving added-value remanufacturing, refurbishing, repairing and recycling and ultimately decreasing the cost of using secondary materials/components in batteries.

Scope:

Proposals should cover at least two of three scope categories (business models, cross-industry tools, sustainable design) and at least three bullet points in total:

- Business models
    - Definition of assessment approaches for sustainable business models, including value proposition, value creation and delivery and value capture including environmental, social and economic dimensions. This activity will include analysis of best practice examples for sustainable business models.
    - Development of sustainable business methods for technical, economic, and environmental evaluation of cycle life options: retrofit, second life, and recycling.
    - Development of new business models and social innovations that promote the sustainable mobilisation of resources.
    - Development of business methods to address outstanding issues, such as on-liability, across applications.
- Cross-industry tools

- Quantitative methodologies and tools that enable understanding whether recycling or second life is the preferred sustainable option, and at which level (pack, cell, electrode, material) recycling should be deployed.

- Optimisation of design and operation using LCA. Using high-quality data, exploring trade-offs between i) impacts at fabrication stage, ii) design for durability, iii) energy usage, iv) other functional aspects such as optimal sizing, hybridization, electronic management, thermal management.

- Development of a central data information system and database (users of resources can see who offers which type and amount of battery system) and prototype Europe-wide information system for accident vehicles and their available battery systems for re-use.

- Sustainable design

  - Innovations in battery design and architecture at all levels (system, pack, cell) supporting dismantling and recycling at the end of life. These could include the choice of materials and assembly methods and should not compromise the performance.

  - Design of innovative sourced materials for improving sustainability in batteries by sustainable processes that avoid toxic/dangerous solvents and require controlled environments.

  - Research and design of batteries from recycled materials and fully recyclable.

Cooperation with complementary projects launched specifically in the Cluster 5[1] work program and specifically, in the Destination *"A competitive and sustainable European battery value chain"* is required. Examples of collaborative activities includes information sharing, promotion of results at thematic transnational events, conferences and open webinars.

Plans for the exploitation and dissemination of results for proposals submitted under this topic should include a strong business case and sound exploitation strategy, as outlined in the introduction to this Destination. The exploitation plans should include preliminary plans for scalability, commercialisation, and deployment (feasibility study, business plan).

This topic is considered for contribution by the EU Joint Research Centre, modalities TBC