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



PHOENIX

Building more reliable and performant batteries by embedding sensors and self-healing functionalities to detect degradation and repair damage via advanced Battery Management System

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ABSTRACT

This document outlines the strategy for the exploitation of PHOENIX's outcomes. It presents a clear roadmap aiming to maximize the project's impact and commercial potential. The strategy encompasses key aspects, including a series of strategic activities and a structured methodology that will help to identify a detailed exploitation plan encompassing the project and the partners' needs. The document outlines the main aspects that will be taken into consideration for the exploitation strategy, but the information is preliminary. It will be updated in accordance with the evolution and the needs of the project.



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LIST OF PARTNERS

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1		VRIJE UNIVERSITEIT BRUSSEL	VUB	Belgium
2		FRAUNHOFER GESELLSCHAFT ZUR FORDERUNG DER ANGEWANDTEN FORSCHUNG EV	FhG	Germany
3		DEUTSCHES ZENTRUM FÜR LUFT- UND RAUMFAHRT	DLR	Germany
4		ENWAIR ENERJI TEKNOLOJILERI ANONIMSIRKETI	ENW	Turkey
5		DEEP BLUE SRL	DBL	Italy
6		FUNDACION CIDETEC	CID	Spain
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8		ACCUREC-RECYCLING GMBH	ACC	Germany
9		CSEM CENTRE SUISSE D'ÉLECTRONIQUE ET DE MICROTECHNIQUE SA - RECHERCHE ET DEVELOPPEMENT	CSEM	Switzerland



ABBREVIATIONS

Acronym	Description
BMS	Battery Management System
EC	European Commission
IPR	Intellectual Property Rights
KER	Key Exploitable Results
MOF	Metal-Organic Framework
NMC	Nickel-Manganese-Cobalt
SEI	Solid Electrolyte Interface
SH	Self - Healing
WP	Work Package



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EXECUTIVE SUMMARY

D8.2 Exploitation strategy plan (a) defines and details the exploitable assets of the project and proposes an exploitation strategy to be carried out as part of the T8.5 activities. In particular, the KERs of the PHOENIX project are described in more detail here. The information collected is from the respective KER owners. At this early stage of the project, this deliverable shows only a rough structure of a possible future use. The stakeholder groups are described here, and a relevance analysis is provided in the next deliverable, D8.4. We will also explore the possibility of using the Horizon Result Booster service for the second version of the deliverable.



PROJECT OVERVIEW

The high demand for batteries in electric mobility, grid energy storage, and consumer electronics is projected to increase tenfold in the next decade. However, for sustainable and European batteries to be developed and utilised, certain improvements are necessary. That is the goal of the PHOENIX project: develop smart batteries that meet the evolving needs of the future generations. These advancements include:

- **longer cycle life.** Batteries can withstand prolonged usage and provide reliable performance over an extended period.
- **effective detection and prevention of degradation.** By implementing advanced monitoring and management systems, the project seeks to maximize the lifespan and performance of batteries, reducing the need for frequent replacements.
- **recyclability feasibility.** By incorporating sustainable materials and designing batteries with recycling in mind, the project aims to minimize the environmental impact associated with battery production and disposal.
- **reduced cost.** The project aims to make sustainable and European batteries more cost-effective, enabling their widespread adoption across various industries.

European batteries should prioritise safety, durability, and environmental friendliness by incorporating smart functionalities like sensor integration and self-healing capabilities. To achieve this, the next generation of batteries must integrate these functionalities into the Battery Management System (BMS), which will be responsible for triggering the required features. The PHOENIX project seeks to explore a range of possibilities in self-healing, sensing, and triggering. Sensors and self-healing properties will be prototyped and demonstrated in Generation 3b and 4a Li-Ion batteries as part of this initiative.



1. RESULTS AND POSITIONING

1.1 Project results

Table 1. Key Exploitable Results portfolio

Id	KER type	KER name	KER description
KER1	Prototype; Scientific publication; Copyright	Integration of multiple sensors in multilayer cells	Multi-sensor integrated proof of concept multi-layer 1Ah pouch cells.
KER2	Demonstrator; Prototype; Scientific publication; Copyright	Reference electrode	Reference electrode developed for multi-layer cells.
KER3	Demonstrator; Prototype; Scientific publication; Copyright	SH functionalized electrodes	Implementation of one or several SH functionalities in electrodes.
KER4	Prototype	SH polymer electrolytes	Two Self-healing polymer electrolytes will be developed to be applied either as a coating or to replace the liquid electrolyte all together. The prototype will be a material and/or a formulation together with its process, whose performance will be demonstrated in relevant pouch cell devices. The material will enable Si-anodes by promoting the formation of a stable SEI with vitrimer like proprieties.
KER5	Hardware	BMS	The BMS will allow interfacing with the sensors and SH developed withing the project (this may require the usage of some external electronics if a full integration into the BMS is not meaningful, for instance after the tests of WP4).



			The BMS will also allow running the needed algorithms. As for the electronics, some algorithms may not be embedded in the BMS directly.
KER6	Prototype; Commercial solution	Production of fully developed SH cells	Selection of the most suitable sensors and self-healing materials. First solutions to manufacture batteries with sensors on a pilot plant.
KER7	Methodology; Scientific publication (Refereed/ Non-Refereed)	Ni-rich NMC based core/shell cathode microparticles	Synthesis protocols to obtain Ni-rich cathode powders with core/shell morphology.
KER8	Feasibility study; Hardware for prototype; Scientific publication (Refereed/ Non-Refereed)	MOF-integrated separators	Gas absorbing MOF integration on separators and characterisation
KER9	Research; Hardware for prototype; Scientific publication (Refereed/ Non-Refereed)	Memristor and MOx type gas sensors	Sensor fabrication. Measurement and testing protocols.
KER10	Hardware	Sensor & Trigger technologies as toolbox for manufacturer of smart/self-healing batteries	Sensor and trigger hardware and methodology to detect battery ageing and battery failure and initiate self-healing functionality by using trigger mechanism.
KER11	Know-how; Training	Sustainability consulting and training	Expanding our consultancy and training portfolio in the sustainability domain and establishing connections within the relevant network.
KER12	Methodology	Communication and dissemination strategies for sustainability and circular economy sectors	Refine our approach to Communication and Dissemination strategies, specifically tailored to the energy and circular economy sectors.



KER13	Know-how; Academic publication; Copyright	Sensor-equipped self-healing single-layer pouch cells	Combining self-healing with the sensing, and triggering capabilities at the level of single-layer pouch cell prototypes
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1.2 Main actors in the field

Table 2. Differentiation with key actors in the field

Id	Closest competing/ related actors	Differentiator
KER1	Universities, R&D centres, battery manufacturers, sensor/actuator companies.	Multiple sensors in multilayer cells. Increase battery lifetime and monitoring.
KER2	Universities, R&D centres, battery manufacturers, sensor/actuator companies.	Improvement of cell diagnostic.
KER3	RTO/ Cell manufacturers.	Elimination/Avoiding of failure mechanisms.
KER4	Currently, there are no commercial solutions for pure silicone anodes. Many research entities and ventures propose anodes based on nanostructured Silicon, but none of them uses SH polymer electrolytes as a way to mitigate continuous SEI formation.	The SH polymer electrolytes developed by CSEM have the unique approach of designing the SEI on Silicon by the design of the polymer. The backbone will have a passivating component and a reversible cross-linking group to give elastomeric properties to the SEI layer, which will better resist the volumetric expansion of Silicon.
KER5	Actors: foxBMS, IREC BMS (not named yet).	<ul style="list-style-type: none"> - Advanced sensing features - SH integration - Improved management and control
KER6	Battery manufacturing companies.	Know-how from the PHOENIX project which sensors/materials/software are needed to build self-healing batteries.
KER7	NMC 90 development is a new area in the battery field, therefore no publicly shared and accessible research results are available on this topic.	For core/shell manufacturing, the previous studies are made with NMC 811. These are from USA Argonne National Lab (Dr. Khalil Amine), Korea, Japan, Republic of China etc.



KER8	No publicly accessible research data is available on gas absorbing MOF-integrated separators.	Metal–Organic Frameworks (MOFs) functionalized separators are investigated in some studies that are related to rechargeable Zn-ion batteries, for improvement of Li-ion battery capacity fading, Li-S batteries etc. These are from National Science and Technology Development Agency (NSTDA), Thailand, University of Minho, Portugal, Basque Center for Materials, Spain, Hunan University, Republic of China etc.
KER9	Gas sensors in batteries are applied so far externally. Memristor sensors have been a recent research topic for H2 sensing and its applicability in batteries has not been tested yet.	Battery cell integrated gas sensors might be under development in some research institutes, but they are not publicly available.
KER10	In general: other research and academia or even startups US sensors: Liminal Insights Inc., CA, U.S. Dielectric sensors: Mateligent (GER), Innovationlab (GER) Temperature sensors: Innovationlab (GER)	PHOENIX links self-healing and triggering with advanced sensor data.
KER11	All target stakeholders	The Human Factors expertise allows DBL to understand the needs of end-users effectively. Additionally, the strong background on environmental aspects and human-centred sustainability approaches positions DBL as a consultancy and training company specialised in socio-economic, environmental and sustainability aspects of innovations. Smart batteries are seen as technologies supporting the energy transition where our holistic and user-centred approach can be essential to deliver market-proof solutions and gain relevant know-how in the domain.
KER12	All target stakeholders	More than 20 years of experience in the field of communication and dissemination across



		various technology and innovation-oriented domains and the relevant expertise in past research and consultancy help DBL deliver effective communication strategies within and beyond the energy sector.
KER13	Universities; R&D centres; battery manufacturers	The PHOENIX know-hows on the combining SH materials with sensors and SH-triggering devices within the format of single-layer pouch cell.



2. STAKEHOLDER ANALYSIS

2.1 Target stakeholders

Table 3 - Stakeholders identification

Target stakeholder 1	
Institutions, decision makers, and policy makers at European and national level	The project establishes dedicated communication channels and products to communicate information and ideas early and often. This ensures that policymakers are aware and informed about the adopted methodologies and results, gaining their full endorsement regarding innovative regulations.
How can the stakeholder benefit from the project results	Target stakeholder 1 stand to benefit from the project results by gaining access to cutting-edge technologies, supporting energy policy development, promoting sustainable practices, and contributing to the achievement of climate and energy goals. The project's outcomes offer a pathway towards a greener and more resilient energy future.
Target stakeholder 2	
Research and innovation communities	Universities, EU RTD projects, BATTERY 2030+ large scale initiative, associations, academia and research organisations, educational institutions. The project establishes an Advisory Board to ensure the scientific soundness of the proposed solutions methodologies.
How can the stakeholder benefit from the project results	Target stakeholder 2 stand to benefit from the project results, as it offers new knowledge, collaboration opportunities, technology transfer prospects, and validation of concepts. The project's impact can strengthen the research community's position, foster innovation, and contribute to the advancement of sustainable battery technologies and their widespread adoption.
Target stakeholder 3	
Industry representatives	Member of the main industry representatives engaged in the development, marketability and sale of environmentally friendly and digital battery manufacturing for better, cheaper, cleaner and safer battery cells.



How can the stakeholder benefit from the project results	Target stakeholder 3 stand to benefit from the project results through technological advancements, a competitive edge, new business opportunities, and reduced environmental impact. Embracing these innovations can foster growth, strengthen brand value, and position them as leaders in the rapidly evolving market of sustainable energy storage solutions.
Target stakeholder 4	
Citizens and general public	Potential consumers of final products using more sustainable batteries.
How can the stakeholder benefit from the project results	Target stakeholder 4 can benefit from the project results through access to eco-friendly energy solutions, increased energy efficiency, and a reduced environmental impact. The project's efforts contribute to a cleaner, more sustainable future and empower citizens to make conscious choices that positively impact both their lives and the environment.

2.2 Barriers to dissemination and exploitation

Table 4. Barriers to dissemination and exploitation of stakeholders

Id	Stakeholder group	Description	Barriers and mitigations
B1	Institutions, decision makers, and policy makers at European and national level	This cluster can shape regulatory frameworks, enact impactful policies, and allocate resources towards innovative energy solutions. Their engagement ensures that the advancements in smart battery technology align with broader energy goals.	<p>Barrier: Policy makers and decision makers might not be aware of the significance and potential of smart battery technology.</p> <p>Mitigation: Launch awareness campaigns targeting relevant stakeholders through webinars, workshops, and conferences. Work closely with the BATTERY 2030+ initiative.</p> <p>Barrier: Institutions often receive an overwhelming amount of information from various sources, making it difficult to stand out.</p>



			<p>Mitigation: Develop engaging and visually appealing communication materials, such as infographics, videos, and interactive presentations.</p>
B2	Research and innovation communities	<p>This group is not only composed by consumers of new insights and discoveries but also potential collaborators, contributors, and evaluators of research outcomes. Develop effective communication, dissemination and exploitation strategies is crucial to ensure the project's research findings are accessible, impactful, and aligned with the demands of this diverse stakeholder group.</p>	<p>Barrier: Competition for attention in an information-rich environment could dilute the visibility of the project's outcomes.</p> <p>Mitigation: Adopt multiple communication channels and partnerships that resonate with the target audience. Involve market experts in the energy field that could support the consortium to develop an exploitation strategy that will better highlight the project's potential and support it in publishing high-level papers.</p>
B3	Industry representatives	<p>The stakeholder group embodies a wide spectrum of businesses and organizations within the energy sector. They possess valuable insights into market trends, manufacturing capabilities, and commercialization strategies, making their engagement</p>	<p>Barrier: Industry representatives operate in competitive markets with multiple technology options. Convincing them to adopt new solutions can be challenging, especially if they perceive existing technologies as sufficient.</p> <p>Mitigation: Highlight the unique selling points and advantages of smart battery technologies. Showcase how these technologies can offer a competitive edge and</p>



		<p>critical to bridging the gap between research outcomes and real-world applications. Effective communication and dissemination strategies tailored to their industry-specific needs and language are essential for conveying the project's value proposition.</p>	<p>enable innovation in their products and services.</p> <p>Barrier: Established industries may be resistant to adopting new technologies, fearing disruptions to their existing processes or scepticism about the readiness of innovative solutions. Industry representatives also receive numerous communications and information sources daily, making it challenging for project messages to stand out.</p> <p>Mitigation: Develop targeted and engaging communication materials, using multiple communication channels, including industry events, workshops, webinars, and industry-specific publications, to maximize visibility and demonstrate the effectiveness of the results and their applicability in the market.</p>
B4	Citizens and general public	<p>This stakeholder group represents individuals from diverse backgrounds who have a general interest in the project. Engaging with this group means providing information to a wide audience that can help promote awareness, understanding and support for the project.</p>	<p>Barrier: The technical nature of the project may lead to the use of complex jargon and terminology that could be difficult for the general public to comprehend.</p> <p>Mitigation: Use a tailored language can help make project information accessible and easily understood by a wide audience.</p> <p>Barrier: The general public may have limited prior knowledge about smart batteries, making it</p>



			<p>challenging to convey the relevance and significance of the project's outcomes.</p> <p>Mitigation: Use engaging visual aids, infographics, and real-world examples can make the information more relatable and capture the public's interest.</p>
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2.3 Stakeholder relevance analysis

Once the influence and interest of each stakeholder group is considered in the previous sections, this section aims at defining their strengths in terms of supporting the uptake of the group's results. This will help the consortium understand where to invest effort to maximise dissemination activities. This version of the deliverable shows the template in Figure 1 that will be used during the exploitation workshops to identify the influence and interest of stakeholders.

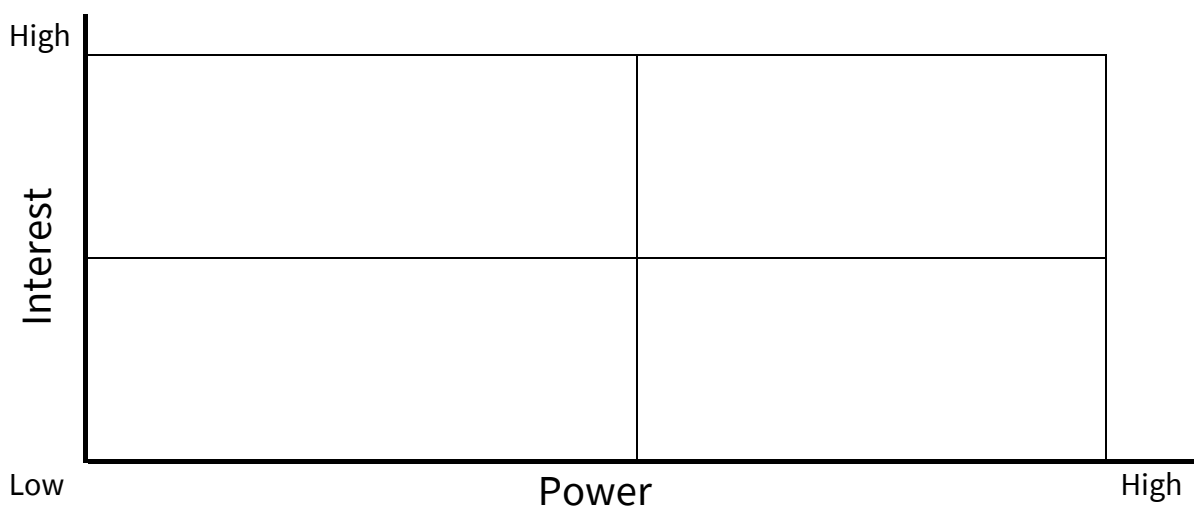


Figure 1. Influence vs interest grid



3. EXPLOITATION STRATEGY

3.1 Strategy for knowledge management and protection

Any details concerning the access rights to Background and Foreground IP is defined in the Consortium Agreement signed by all the partners in the Consortium. Partners will only use the products, information, source code or other protected items owned by another partner in the PHOENIX project, when the licensing conditions have been clearly communicated by the holder.

- **IP Ownership:** Foreground IP shall be owned by the project partner carrying out the work leading to such Foreground IP. The General Assembly will coordinate patent issues: if any Foreground IP is created jointly by at least two project partners and it is not possible to distinguish between the contributions of each of the project partners, such work will be jointly owned by the contributing project partners. The same shall apply to inventions. Any of such joint inventions and all related patent applications and patents shall be jointly owned by the contributing parties.
- **Confidentiality:** Information from other partners will be treated as confidential unless public.
- **Ownership of Knowledge:** Knowledge is owned by the partners who carried out the work generating the knowledge, or on whose behalf such work was carried out. If a partner wishes to assign any knowledge to a third party it should inform the other partners and request their consent, which should not unreasonably be withheld.
- **Patents:** Partners who own patentable knowledge may (and are encouraged to) at their own expense make applications for patent form of protection and will supply details of each such application to the other partners.
- **Access Rights:** The joint Exploitation Agreement will pay specific attention to IPR of the exploitation of the project results. The partners will reach a full agreement, complementing the EC contract, on pre-existing intellectual property rights excluded from PHOENIX and user licences in this agreement. The agreement will detail rights to exploit project results for commercial purposes; each partner will, however, maintain the right to use the project outcome for internal use. During the lifetime of PHOENIX, the implementation of these IPR principles will comprise the following main tasks: a) Updating of foreground knowledge, b) Management of the PHOENIX knowledge portfolio, c) Knowledge projection, d) Joint Exploitation Agreement maintenance and evolution.



3.2 Individual exploitation strategies

Table 5. KER's exploitation strategy

KER1	INTEGRATION OF MULTIPLE SENSORS IN MULTILAYER CELLS
Target stakeholder	Research & academia, RTO, cells manufacturers
Stakeholder benefit	Scientific/industrial knowledge
Barrier/ risks	Low uptake of result Mitigation: present or demonstrate the result at domain specific fairs and events
IPR protection	Licensing/Open access/Known-how
Expected TRL level	3 - 4
Owner and beneficiary(s) involved	CID
Strategy or route to exploitation	Bilateral partnership with companies, new public funded project; Patent (with licensing); publication (open access); conference
Time to market	Project implementation/End of project
Link to the result	D5.1 Sensorized SH multilayer cells D5.2 Validation of Sensorized SH multilayer cells

KER2	REFERENCE ELECTRODE
Target stakeholder	Research & academia, RTO, cells manufacturers
Stakeholder benefit	Scientific/industrial knowledge
Barrier/ risks	Low uptake of result Mitigation: present or demonstrate the result at domain specific fairs and events
IPR protection	Patenting/Industrial secret/Known-how
Expected TRL level	3-4
Owner and beneficiary(s) involved	CID



Strategy or route to exploitation	Exhibition shows; Scientific conferences; Licensing of know-how to sensor/actuator/cell manufacturer; new public funded project.
Time to market	Project implementation/End of project
Link to the result	D3.3 RE optimisation and validation

KER3 SH FUNCIONALIZED ELECTRODES	
Target stakeholder	RTO/ Cell manufacturers
Stakeholder benefit	Scientific/industrial knowledge
Barrier/ risks	Low uptake of result Mitigation: present or demonstrate the result at domain specific fairs and events.
IPR protection	Open access/ Internal Know how/ Patenting
Expected TRL level	4
Owner and beneficiary(s) involved	CID
Strategy or route to exploitation	Bilateral partnership with companies; new public funded project; spin-off; Patent (with licensing); publication (open access); conference
Time to market	Project implementation/End of project
Link to the result	N/A

KER4 SH POLYMER ELECTROLYTE	
Target stakeholder	Start-ups offering Si-anodes, battery manufacturers who are willing to integrate the production and/or modification of the anode in their assembly line
Stakeholder benefit	The SH polymer electrolyte will unlock a new battery generation with improved energy density while being cost competitive
Barrier/ risks	Willingness to adapt their process to integrate the proposed solution Mitigation: Feasibility study to demonstrate applicability and improve desirability



IPR protection	Confidentiality
Expected TRL level	4 - 5
Owner and beneficiary(s) involved	CSEM
Strategy or route to exploitation	Potential stakeholders will be contacted after the end of the project. A feasibility study of one year will be proposed to verify compatibility with their materials and processes. During this step, the solution will also be optimized to fit cost requirements. Potentially an LCA study can be performed to improve desirability. The target of the second year is to demonstrate the scaling up of the production of the polymer electrolyte and also the feasibility of the integration of the solution in a relevant pilot line to assembly large format cells. For subsequent commercialisation, 3-5 years.
Time to market	3 - 5 years after the project end
Link to the result	N/A

KER5	BMS
Target stakeholder	Battery pack manufacturers, integrators, ...
Stakeholder benefit	Increased battery lifetime, better control, improved monitoring
Barrier/ risks	Main barrier is cost related. The benefits of the solution must be clearly demonstrated (i.e., what sensor(s) to keep, what SH to keep). This will be demonstrated by testing and validation.
IPR protection	BM and SoX in particular based on EIS are part of CSEM's background
Expected TRL level	5 - 6 in case of full integration (lower to 4 if not all electronics is fully integrated)
Owner and beneficiary(s) involved	CSEM: most BMS components (excluding some electronics that might come from partners, in particular from FhG)



Strategy or route to exploitation	The BMS is part of CSEM’s core business. It is proposed in follow up projects and IP.
Time to market	End of the project
Link to the result	N/A

KER6 PRODUCTION OF FULLY DEVELOPED SH CELLS	
Target stakeholder	Costumers of battery packs who are interested in an extremely long battery life.
Stakeholder benefit	Existing or new customers could open up new fields of application for which a very long battery life is needed.
Barrier/ risks	Barriers: Costumers of battery cells have to adapt their module and pack assembly because of the additional sensors and new BMS has to be implemented. Mitigation: During the project the effort to implement sensors and self-healing initiators has to be monitored and reduced.
IPR protection	TBD
Expected TRL level	2 - 4
Owner and beneficiary(s) involved	Consortium partners
Strategy or route to exploitation	TBD
Time to market	TBD
Link to the result	N/A

KER7 NI-RICH NMC BASED CORE/SHELL CATHODE MICROPARTICLES	
Target stakeholder	Battery, e-vehicles, drones, smartphones manufacturers; different aerospace applications; mobile applications; R&D Centres; Start-ups; SMEs; innovation platform and clusters.
Stakeholder benefit	For the manufacturing and research purposes.



Barrier/ risks	Insufficient price/performance relation. Mitigation: optimization of raw material usage, increase of recyclability. Benefits of second life. Low uptake of results. Mitigation: intensive demonstration of the results to stakeholders at specific events
IPR protection	Access rights
Expected TRL level	3
Owner and beneficiary(s) involved	DLR (Methodology, synthesis protocols) CSEM (SH polymer development for coating of NMC cathode powders)
Strategy or route to exploitation	Exhibition shows; Scientific conferences
Time to market	3 – 5 years
Link to the result	D2.1 Synthesis of NMC90 core/shell

KER8	MOF-INTEGRATED SEPARATORS
Target stakeholder	Battery components manufacturers; R&D Centres; Start-ups; SMEs; innovation platform and clusters.
Stakeholder benefit	For the cell component and durable battery manufacturing; research purposes.
Barrier/ risks	Retarded charge transfer performance. Mitigation: increasing porosity. Insufficient price/performance relation. Mitigation: low-cost materials search. Low uptake of results. Mitigation: intensive demonstration of the results to stakeholders at specific events
IPR protection	Confidential, Patent.
Expected TRL level	2
Owner and beneficiary(s) involved	DLR (Gas absorbing MOF integration on separators and characterisation). ENW (Final battery cell testing).



Strategy or route to exploitation	Licence or industrial rights transfer.
Time to market	Project duration and 1 year after project ends.
Link to the result	D2.4 Thermally triggered MOF integrated separator.



KER9 MEMRISTOR AND MOX TYPE OF GAS SENSORS	
Target stakeholder	Battery and gas sensors manufacturers; R&D Centres; Start-ups; SMEs; innovation platform and clusters.
Stakeholder benefit	For manufacturing and research purposes.
Barrier/ risks	Detection limit remains below present species; Mitigation: altering of sensing material composition and sensor layer configuration. Low selectivity; Mitigation: sensor array application. Low uptake of results; Mitigation: intensive demonstration of the results to stakeholders at specific events.
IPR protection	Ownership of Knowledge
Expected TRL level	3
Owner and beneficiary(s) involved	DLR (Hardware for prototype; Measurement and testing protocols).
Strategy or route to exploitation	Scientific conferences and publications; where required licence or industrial rights transfer.
Time to market	3 – 5 years
Link to the result	D3.6 Gas sensing trials

KER10 SENSOR & TRIGGER TECHNOLOGIES AS TOOLBOX FOR MANUFACTURER OF SMART/SELF-HEALING BATTERIES ADVANCED	
Target stakeholder	Start-Ups, SMEs, research & academia, large enterprises, society
Stakeholder benefit	Research and Academia can use the sensors and trigger to understand battery ageing and self-healing even better and to model battery behaviour. Industry can benefit by a new field of application. Battery manufacturer can improve their battery management system by advanced sensing. Battery manufacturer can improve their products and internal quality management system QMS by using sensors (end of line quality).



	End-Users and society will have a more reliable and safe battery.
Barrier/ risks	<p>Sensor and trigger benefit might be too low to account for additional costs in mass market. Mitigation: look for niche market with high need of battery safety or use for increasing internal quality control of cell manufacturer</p> <p>Self-healing benefits might be too low to account for additional costs in mass market. Mitigation: exploit sensor system without self-healing.</p>
IPR protection	Parts of sensor technologies (DES) and Ultrasonic sensors are covered by patents.
Expected TRL level	Trigger: 3-4 Sensors: 4
Owner and beneficiary(s) involved	FhG ISC
Strategy or route to exploitation	<p>Exploit sensor and trigger methodology in future research activity (RA) by looking for public funded calls on national and EU level during second half of the project.</p> <p>Create and provide service (SER) to industry for identification of ageing mechanisms of battery electrodes.</p> <p>Develop sensor product (PRO) with sensor industry by setting-up of bilateral industry cooperations (dissemination of results to find industry partners).</p>
Time to market	RA: 1-5 years after project end SER: 1-5 years after project end PRO: 1-3 years after project end
Link to the result	N/A

KER11 SUSTAINABILITY CONSULTING AND TRAINING

Target stakeholder	SMEs; Industry representatives; Research and innovation communities; customers interested in training and consultancy.
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Stakeholder benefit	High-level training, manufacturing, and energy consulting
Barrier/ risks	N/A
IPR protection	To be investigated
Expected TRL level	N/A ¹
Owner and beneficiary(s) involved	DBL
Strategy or route to exploitation	Expanding our consultancy and training portfolio in the sustainability domain and establishing connections within the relevant network will be facilitated by Key Exploitable Result 5 (KER5) on Battery Management System (BMS) and Key Exploitable Result 10 (KER10) on triggering and self-healing. These results will enable us to enhance our expertise in processes related to the energy sector, paving the way for new research opportunities and collaborations involving systems and technologies where these competencies and processes can be applied or adapted for more complex scenarios, particularly those involving human-machine interactions operators, in which DBL’s expertise in Human Factors provides an added value and such expertise can be enhanced by the competence and understanding of the strengths and weaknesses of the functioning of the next generation batteries and BMS thus enriching human-factors aspects.
Time to market	4 years
Link to the result	N/A

¹ SRL: 7. The SRL is an approach to assess the level of societal acceptance of a certain technology, product, process, or intervention. The SRL is analysed through the readiness of the society to adopt the solution. Again, the approach is technology neutral and very importantly, there is no overlap with the TRL, making the two maturity models both valid and rigorous interpretative lenses. See: https://ec.europa.eu/isa2/sites/default/files/technology_readiness_revisited_-_icegov2020.pdf



KER12 COMMUNICATION AND DISSEMINATION STRATEGIES FOR SUSTAINABILITY AND CIRCULAR ECONOMY SECTORS	
Target stakeholder	SMEs; Industry representatives; Research and innovation communities; Institutions
Stakeholder benefit	DBL has a communication and dissemination background focused mainly on scientific and technical dissemination. Our expertise in communication allows us to create engaging and relevant content to meet the needs of end-users, thus enhancing the effectiveness of project interactions.
Barrier/ risks	N/A
IPR protection	N/A
Expected TRL level	N/A ²
Owner and beneficiary(s) involved	DBL
Strategy or route to exploitation	Evaluate how to adapt the dissemination and communication expertise developed in other domains into the energy sector, develop where necessary innovative methods for the effectiveness of the communication and dissemination strategies, identify possible synergies with other sectors dealing with sustainability to reinforce the message and impact of PHOENIX results, with the aim of achieving an effective package of strategies and content in this area and enriching our portfolio
Time to market	End of the project
Link to the result	N/A

² SRL: 8



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KER13		SENSOR-EQUIPPED SELF-HEALING SINGLE-LAYER POUCH CELLS
Target stakeholder	Universities; R&D centres; battery manufacturers	
Stakeholder benefit	Research and manufacturing/manufacturability purposes	
Barrier/ risks	Insufficient price/performance relation. Mitigation: optimization of raw material usage and manufacturing optimization by reduction of the amounts of scraps. Low uptake/visibility of the results. Mitigation: intensive demonstration of the results to stakeholders at specific events.	
IPR protection	Know-how; Academic publication; Copyright	
Expected TRL level	TRL 4	
Owner and beneficiary(s) involved	VUB	
Strategy or route to exploitation	Scientific conferences and publications; where required licence or industrial rights transfer.	
Time to market	End of the project	
Link to the result	D4.1: SH Battery Assembly D4.2: Sensorized SH single-layer pouch cells D4.3: Sensorized SH cells for larger manufacturing	



4. EXPLOITATION PLAN TIMELINE

4.1 At the start of the project

At the start of the project a strategic approach to define and analyse the existing background IP, the initial patent landscape, opportunities, and risks of sharing knowledge is carried out through this deliverable.

4.2 During the project implementation

During the project implementation a set of specific actions will be undertaken to analyse the existing and potential knowledge creation, to discuss possible IP protection methods and their advantages/ disadvantages. This analysis will be done through:

- a) The **D8.5 Exploitation Strategy Plan** will be updated at M24;
- b) A detailed **Exploitation Agreement** (that will integrate the Consortium Agreement) will be defined among partners to establish clear commercial routes with which project results and know-how will be exploited in the defined market providing commercial opportunities for all involved parties;
- c) Three **Exploitation Workshops** will be organised to allow partners to share their exploitation vision, to identify the exploitable results and agree on a common exploitation strategy and definition of IPR. These workshops will likely take place during General Assemblies starting from M24 onwards;
- d) **Involvement of relevant external stakeholders** in the exploitation through tailored activities such as expert interviews and focus groups.

4.3 After the project

After the project a strategic definition of joint/individual exploitation strategies and pathways will be undertaken. This includes identifying the possible IP ownership arrangements and related responsibilities, including possible joint ownership.



5. EXPLOITATION RESPONSIBILITIES

LEC has the leadership of task 8.5 on Exploitation, IPR management and business models by focusing on the content of the exploitation plan.

DBL supports this task, by organising the exploitation workshops, collecting the necessary input from partners for the deliverables and workshops.

VUB supports in establishing the structure of D8.2 and overall coordination if needed.

All partners are responsible for preparing their individual and joint exploitation plans and providing input to the task, deliverables and workshops.



6. REFERENCES

PHOENIX Consortium Agreement



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