

HEALING BAT



Advanced sensing, monitoring and self-healing mechanisms to self-repair batteries

General overview of the project



Funded by
the European Union

Funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or the European Climate, Infrastructure and Environment Executive Agency (CINEA). Neither the European Union nor the granting authority can be held responsible for them.



This project is part of BATTERY2030+, a large-scale European initiative to invent the sustainable batteries of the future, which has received funding from the European Union's Horizon 2020 programme under Grant Agreement No. 957213.

1

INTRODUCTION TO HEALING BAT



Funded by
the European Union

BATTERY
2030+

WHAT IS HEALING BAT?

HEALING BAT is a Horizon Europe project meant to develop and implement self-healing materials and healing strategies in key battery components, used in conventional lithium-sulfur (Li-S) batteries, and extrapolate the designs and concepts to build a new class of self-restoring Li-S batteries.

48

months

(from June 2023
to May 2027)

10

partners

(from 6 countries)

+€5M

Public funds

(from the EU and the Swiss
and UK governments)



EU funding under Horizon Europe through the European Climate, Infrastructure and Environment Executive Agency (CINEA), with Grant Agreement No.101104006. UK funding under UK Research and Innovation (UKRI). Swiss funding under the State Secretariat for Education, Research and Innovation (SERI).

THE HEALING BAT SOLUTION

Innovative ideas are needed to allow the development of **future sustainable batteries in Europe**, fostering its positioning as a world leader. In this context, the HEALING BAT project will:



1

Develop a **new class of self-healing structural batteries based on Lithium-Sulfur (Li-S)**



2

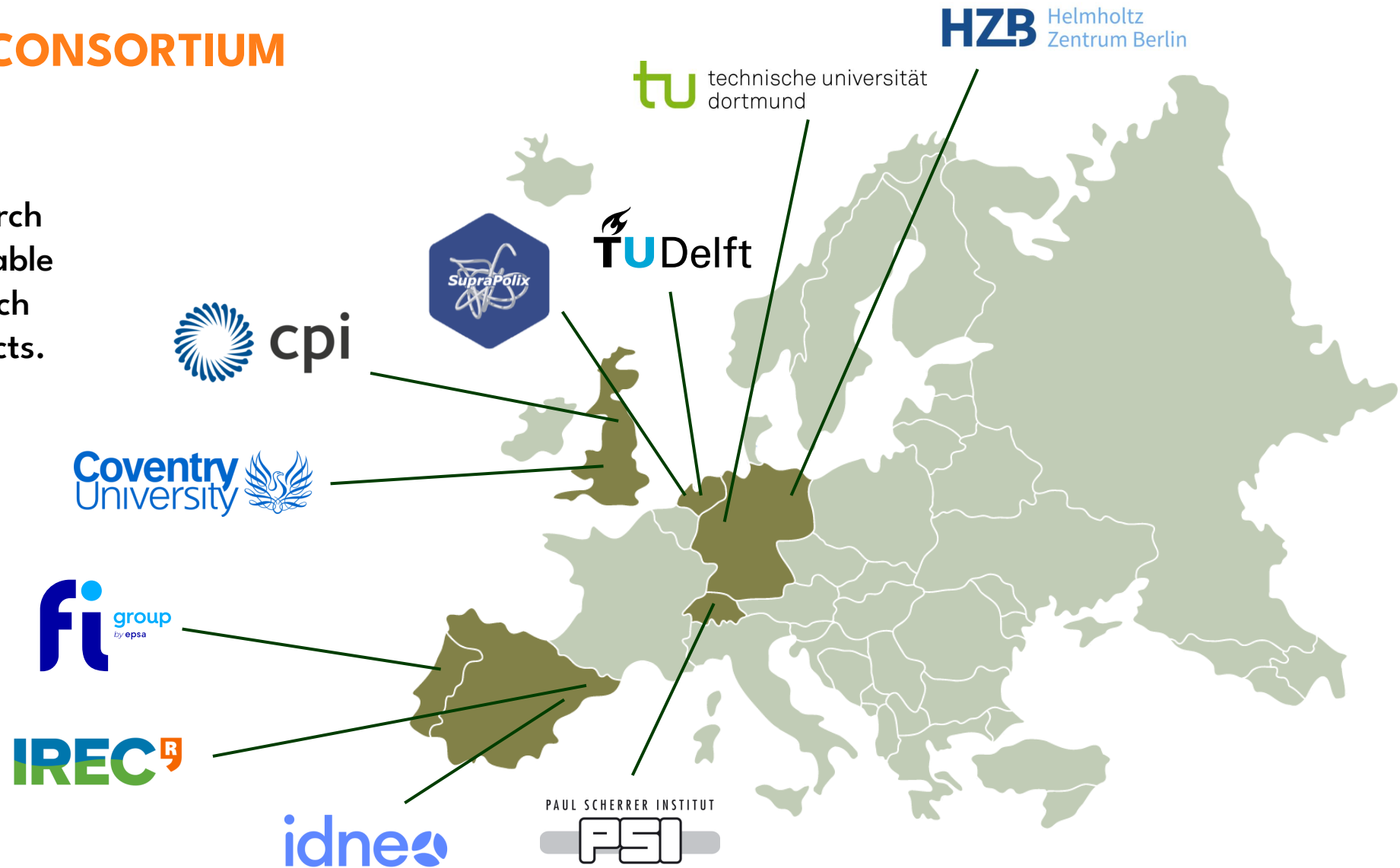
Create a **toolbox** consisting of **self-healing materials**, relevant **sensors** and a **Battery Management System (BMS)**

THE HEALING BAT CONSORTIUM

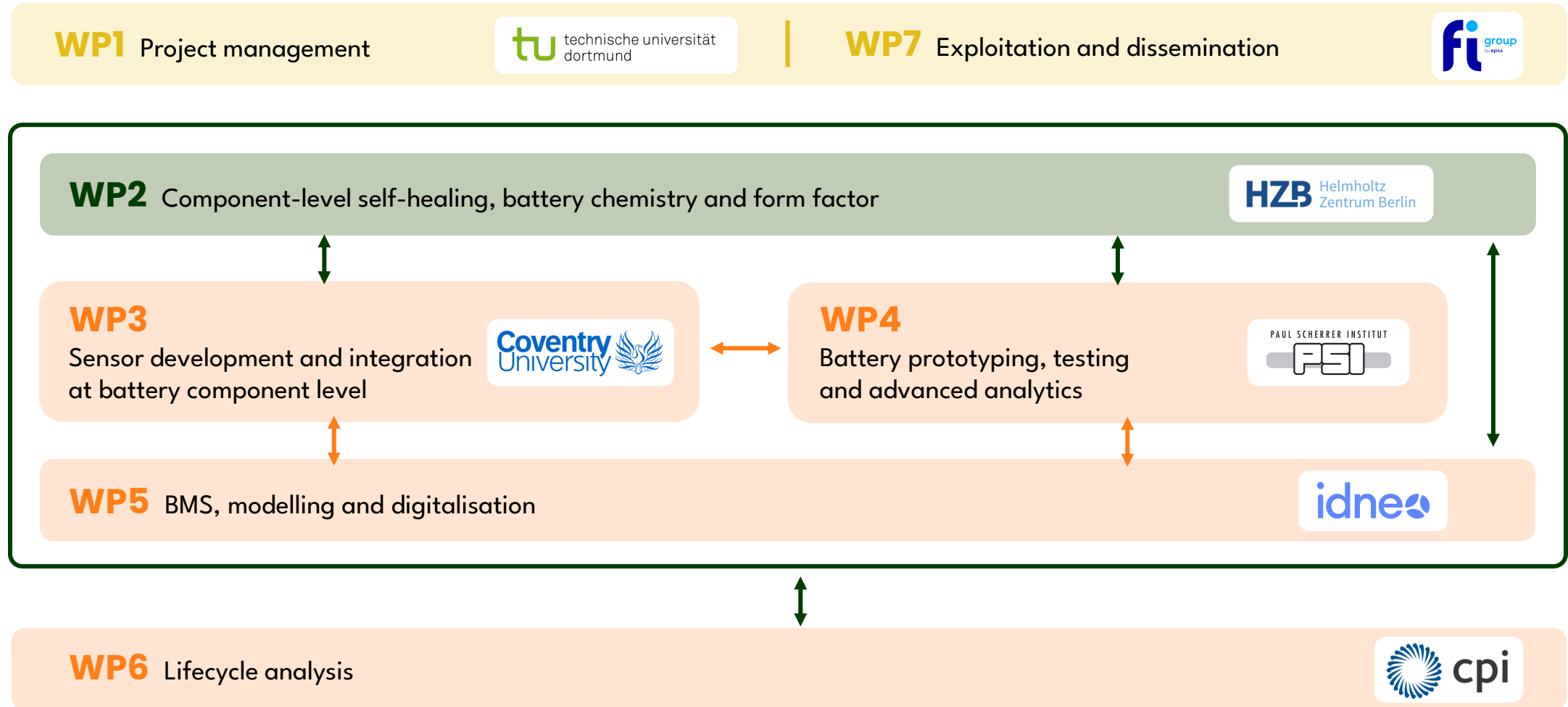
We strike a good balance between universities, research centres, and industry to enable the transfer of basic research results to innovative products.

10 partners

6 countries



OVERVIEW OF THE WORK PACKAGES



HEALING BAT, PART OF BATTERY 2030+

Battery 2030+ is a large-scale, long-term European research initiative in the field of batteries that works on concrete actions to support the implementation of the **European Green Deal**, the **UN Sustainable Development Goals**, as well as the **European Action Plan on Batteries** and the **European SET Plan**.

BATTERY
2030+

battery2030.eu

7

new
projects

7

running
projects

5

past
projects

2

OUR ROADMAP TO SELF-HEALING



Funded by
the European Union

BATTERY
2030+

THE NEED FOR FUTURE SUSTAINABLE BATTERIES IN THE EU

The EU seeks to re-emerge as a world leader in the field of batteries by speeding up the development of underlying critical technologies, enabling a **European battery cell manufacturing industry** making use of **sustainable energy** and implementing concepts of the **Circular Economy**.

Lithium-ion batteries (Li-ion)

They currently **dominate the market** for rechargeable batteries but are nearing the **end of their improvement limits**.

Performance and manufacturing are unlikely to keep up improvements for a climate-neutral society without substantial breakthroughs.

Lithium-Sulfur batteries (Li-S)

They appear to be the **most promising technologies** for future electrochemical energy storage, but currently **suffer from**:

- Fast loss of capacity
- Low power density
- Poor cycling stability
- Low energy efficiency
- Short service of life



Innovative ideas are needed to allow the development of **future sustainable batteries** which demand less resources and create the groundwork for EU competitiveness.

THE HEALING BAT SOLUTION



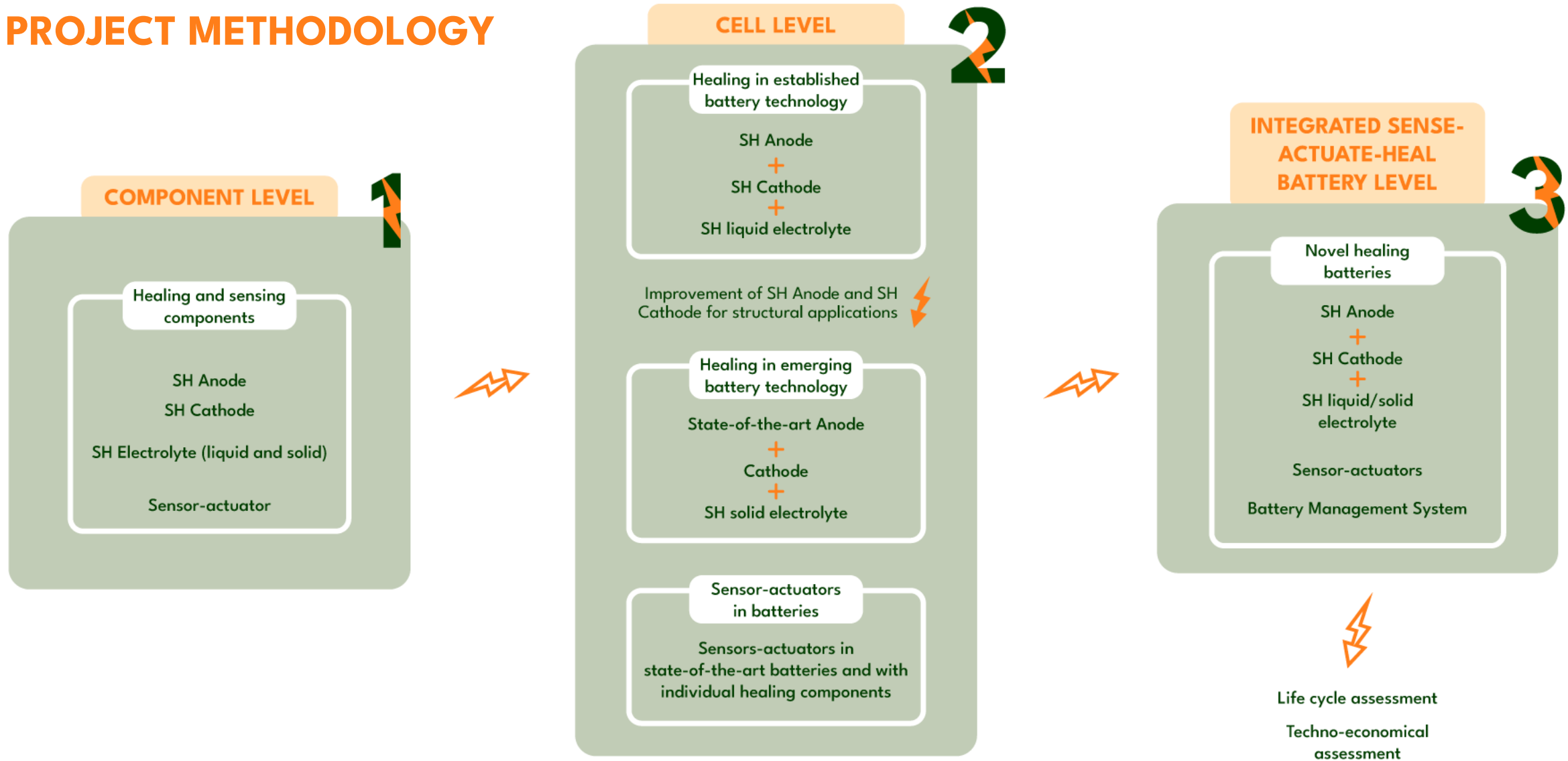
1

Develop and implement **self-healing concepts and materials** in the **key battery components**, used in conventional Li-S batteries and extrapolate the designs and concepts to develop a **new class of self-healing structural battery based on Li-S**

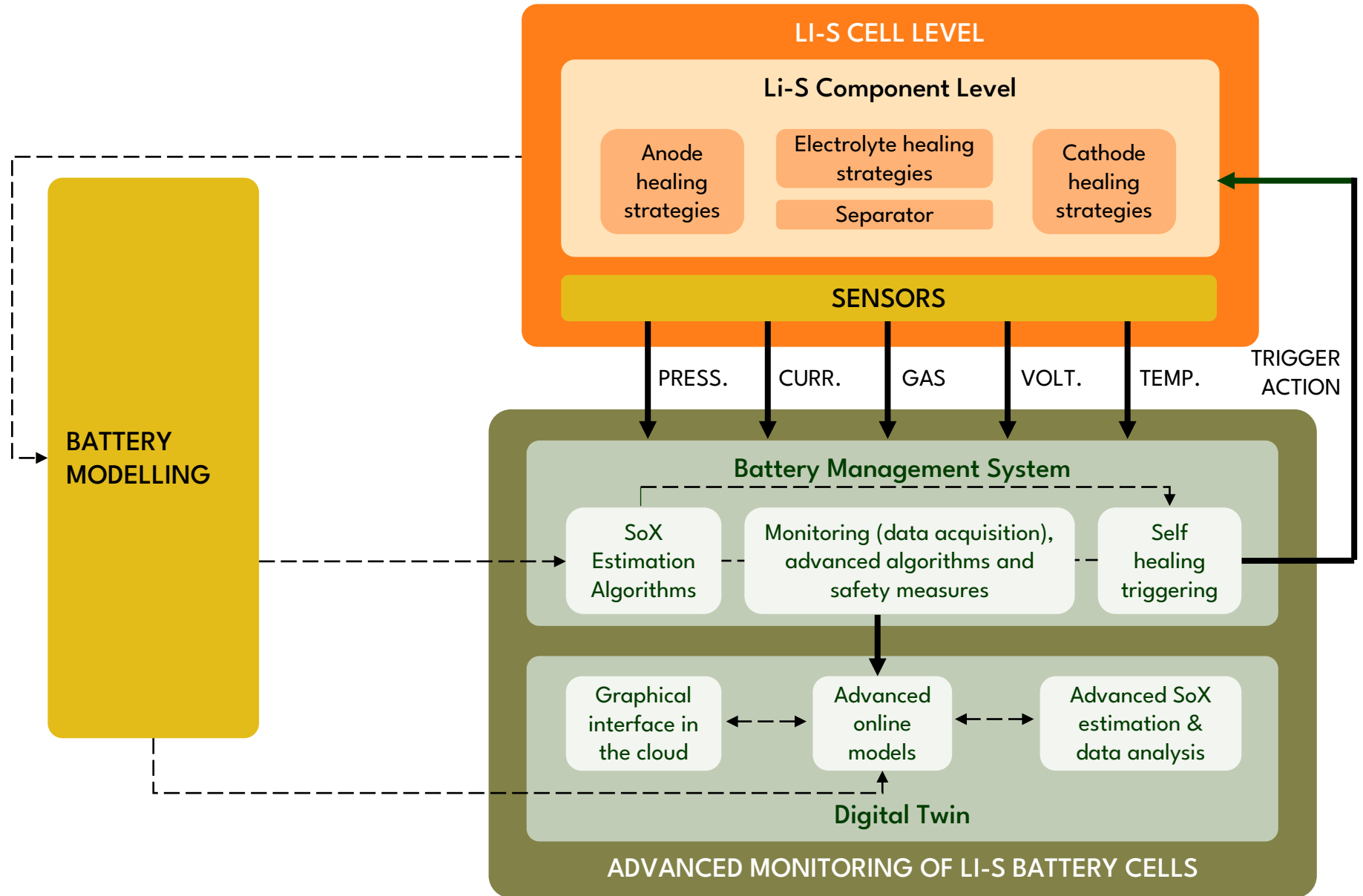
2

Create a **toolbox** consisting of **self-healing materials**, relevant **sensors** and bespoke **Battery Management System (BMS)** to maximize performance of the developed Li-S battery in terms of **quality, reliability and lifetime (QRL)** and avoid or timely heal occurring damages

PROJECT METHODOLOGY



LI-S BATTERY LEVEL



BATTERY MANAGEMENT SYSTEM (BMS)

Purpose of the Battery Management System

1. Control the **flow of energy** to and from the battery system
2. Monitor for **errors**
3. Apply **corrective actions** if necessary

BMS parameters to characterise a battery system

- **State of Charge (SoC):** quantifies the present capacity of a cell
- **State of Health (SoH):** a particular measure of the performance characteristics, such as peak-current delivery, cycle-time and capacity degradation



How will the BMS predict them?

The **integrated sensors** with actuator capabilities can be a very promising solution to predict a battery's SoC and SoH.

The BMS monitors data from sensors, alongside **computational algorithms** to observe the events, indicating that degradation start to occur, as well as trigger self-healing measures.

OUR SIGNIFICANT CONTRIBUTIONS

- 1** Increase the **quality, reliability, and lifetime (QRL)** of Li-S batteries by rationally designing and engineering their components with healing remedies
- 2** Provide new self-healing battery components for state-of-the-art and emerging battery systems to ensure **long-lasting safety characteristics** at the cell level
- 3** Enhance the **industrial opportunities** for exploiting new concepts and technologies for integrating sensing and self-healing capabilities in the battery cell, in association with the **Battery 2030+** large scale initiative, amongst others

3

OUR WORK PACKAGES



Funded by
the European Union

BATTERY
2030+

WP1. PROJECT MANAGEMENT

WP1 aims to allow the **management** of the whole EU project under development, by providing the necessary **resources** for each work package and verifying that each **milestone** has been reached at appropriate times and with acceptable **results**.

Furthermore, it involves managing foreseen and unforeseen **changes to the project** itself or its schedule and the relations between the HEALING BAT and **external bodies** in the European research and Horizon Europe ecosystem.



Starts: M1 (June 2023)

Ends: M48 (May 2027)

Led by:

tu technische universität
dortmund

WP2. COMPONENT-LEVEL SELF-HEALING, BATTERY CHEMISTRY AND FORM FACTOR

WP2 focuses on the study of the **battery degradation mechanisms** and the development of **self-healing strategies** for the battery cell and battery components, namely cathodes, anodes, separators, and electrolytes, both solid and liquid.

It involves the development of **healing strategies** that will be undertaken through Solid Electrolyte Interface (SEI), polymers for polymer electrolyte membranes and separators, and surface layer treatments of anode and cathode.

The different healing components will be tested and integrated with the **sensors** developed in WP3 and with the **battery prototypes** developed in WP4.



Starts: M1 (June 2023)

Ends: M36 (May 2026)

Led by:

HZB Helmholtz
Zentrum Berlin

WP3. SENSOR DEVELOPMENT AND INTEGRATION AT BATTERY COMPONENT LEVEL

WP3 aims to develop **sensor instrumentation, communication electronics** and **monitoring technology** to create smart, self-healing batteries. The sensors will be embedded directly into the battery cell during manufacture.

Moreover, a **two-way smart communication technology** will be developed and deployed using hybrid Radio-frequency powerline communication. This will allow the Battery Management System (BMS) to monitor and predict sulfur oxide (SO_x) activity and deploy self-healing strategies.



Starts: M1 (June 2023)

Ends: M48 (May 2027)

Led by:



WP4. BATTERY PROTOTYPING, TESTING & ADVANCED ANALYTICS

WP4 aims to determine the **cycling stability and lifetime** of the battery cell, with self-healing functionality and to understand self-healing mechanisms.

It also seeks to establish the **electrochemical markers** needed for self-healing, the **triggers** that can be used to initiate self-healing and the ways it can be triggered by the Battery Management System (**BMS**).

Its final purpose is to determine the safety improvements with self-healing implementation and sensor-activated self-healing, **preventing battery degradation**.



Starts: M1 (June 2023)

Ends: M48 (May 2027)

Led by:

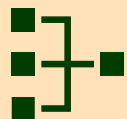


WP5. BMS, MODELING & DIGITALISATION

WP5 has two main objectives. Firstly, it aims to develop a **Battery Management System (BMS)** for battery protection, monitoring of the battery cell and activation of its healing trigger, preventing battery degradation.

Secondly, it seeks to develop a **Digital Twin platform**, a cloud system to store all the data collected by the BMS and the complete characterization of the Li-S battery, allowing the computation of its essential parameters.

All this will result in the complete **characterisation and monitoring** of smart, self-healing Li-S batteries, acquiring the actual health (SoH) and state of charge (SoC), thanks to the battery cells and sensors developed in earlier work packages.



Starts: M12 (May 2024)

Ends: M48 (May 2027)

Led by:

idneo 

WP6. LIFE CYCLE ANALYSIS

WP6 will create an understanding of the benefits of the developed battery technology in terms of **life cycle and economics**.

It will identify and assess **value chain concepts** for user cases and perform an **environmental life cycle assessment** of battery production value chains, to identify key issues to reaching circularity and climate neutrality.

Key variables will be identified alongside the dynamics affecting the developed solutions and their impact on technology, cost and environment through **techno-economic analysis**, to reach the **sustainable EU batteries** of the future.



Starts: M1 (June 2023)

Ends: M48 (May 2027)

Led by:



WP7. EXPLOITATION AND DISSEMINATION

WP7 involves all actions that contribute to **increasing the impact** of the HEALING BAT project, transcending its own consortium and timeframe. This includes the **dissemination** of its results in scientific and professional publications and events; the **communication** of its scope, activities, and results to a broader audience, with a focus on its stakeholders; and the **exploitation** of its results after its ending.

It is also responsible for developing **policy briefs**, coordinating **data management** in the consortium, and ensuring compliance with **GDPR** and intellectual property rights (**IPR**).

Moreover, it represents HEALING BAT in **Battery2030+**, a large-scale European research initiative that brings together different Horizon Europe projects to invent the sustainable EU batteries of the future.



Starts: M1 (June 2023)

Ends: M48 (May 2027)

Led by:



4

THE HEALING BAT CONSORTIUM



Funded by
the European Union

BATTERY
2030+

TECHNISCHE UNIVERSITÄT DORTMUND (TU DORTMUND)



Project coordinator and WP1 leader

Since its founding **more than 50 years** ago, TU Dortmund University has developed a special profile encompassing 17 departments ranging from **science and engineering** to **social sciences and culture studies**.

TU Dortmund University has a **strong focus on research**. The university's disciplines, e.g. mechanical engineering with its emphasis on production and logistics, physics, biochemical- and chemical engineering, statistics and computer science, as well as education research, are well known for their **outstanding research achievements** both nationally and internationally.

As part of TU Dortmund, the **Professorship for Sensors** focuses its investigations on new technologies suitable for the quantitative detection and analysis of fluids. The ultimate aim of the research efforts is to miniaturise novel sensing approaches using microsystem technology to allow for **embedding sensors** and enable **large-scale deployments**.

CONVENTRY UNIVERSITY

WP3 leader



Coventry University is a global, modern university with a mission of **Creating Better Futures**.

It has greatly increased its research capacity and capability with a focus on **impactful research**, delivered for and with partners to address **real-world challenges** and support **businesses and communities** to grow.

The depth and breadth of its rapidly growing research portfolio has been validated by the **UK research assessments**. Its commitment is to delivering **transformational change** for its students, partners and communities around the world as it continues to evolve.

CENTRE FOR PROCESS INNOVATION (CPI)

WP6 leader



CPI catalyses the adoption of advanced technologies and manufacturing solutions to benefit people, places, and our planet. As a trusted partner of industry, academia, government, entrepreneurs, and the investment community, we connect the dots within the innovation ecosystem to make great ideas and inventions a reality.

- Digitalisation and process optimisation: Leveraging needs-driven plant data and using soft sensors to solve problems and increase efficiencies through data review, modelling and visualisation and automation.
- Materials discovery: Screening sustainable materials, materials characterisation, failure analysis and predictive manufacturing process modelling,
- Product development: Adaptive design of experiments for rapid product development.

TECHNISCHE UNIVERSITEIT DELFT (TU DELFT)

Project partner



TU Delft is the **oldest and largest** technical university in the Netherlands.

Its department of **Aerospace Structures and Materials** contributes to making aviation and spaceflight more sustainable by developing the structures and materials of tomorrow.

It works on the creation of **new materials** with smaller environmental footprint and finding ways of **reusing old materials**. It researches how to make **structures smarter and lighter**, to support the transition to new sources of energy.

It develops **new manufacturing techniques**, which use less energy and enable easier recycling. It devises new experimental, analytical, and numerical analysis techniques, to ensure the **structural integrity and safety** of future air and spacecraft. Using **innovative sensing and monitoring technology**, supported by AI, it closes the gap between the physical and digital world, easing manufacturing and gaining new insight into the health of a vehicle's structures.

SUPRAPOLIX BV

Project partner



SupraPolix BV is a **young materials company** from Eindhoven that has developed a broad portfolio of proprietary **self-healing polymeric materials** based on specific **hydrogen-bonding systems**.

These flexible materials are used in a variety of applications where **self-healing and reversible interactions** are delivering new and unique properties.

HELMHOLTZ-ZENTRUM BERLIN (HZB)

WP2 leader



The Helmholtz-Zentrum Berlin (HZB) is one of the largest **non-university research centres** in Berlin.

It is working on **highly efficient solar cells** of the next generations, such as thin-film technologies and new classes of materials such as perovskites. In doing so, it seeks contact with the industry at an early stage.

It is developing **novel catalysts and materials** that convert sunlight into chemical energy and thus **produce renewable fuels**, such as hydrogen.

Battery materials with better properties are also being explored at HZB.

Another important field of research is **quantum materials** for tomorrow's energy-efficient **information technologies**.

CATALONIA INSTITUTE FOR ENERGY RESEARCH (IREC)

Project partner



The Catalonia Institute for Energy Research (IREC) is a **public research centre** ascribed to the Department of Climate Action, Food and Rural Agenda of the Government of Catalonia, in which the Department of Research and Universities, and the Catalan Energy Institute (ICAEN) also participate. IREC is a **CERCA centre** and is accredited as a **TECNIO centre**.

Created in 2008, it aims to contribute to the **sustainable development** of society and to increase the **competitiveness of industry** in the **energy sector**.

The centre develops **research of excellence** in the medium and long term, **innovation and development** of new technological products, and **dissemination** of relevant knowledge to the public.

IDNEO

WP5 leader



Idneo supports its worldwide clients in transforming their businesses by integrating **innovative and customised technology solutions**.

Idneo is a comprehensive technology services company, specialising in the design, development, certification and manufacturing of **value-added technology products or services**.

Its highly qualified and client-focused team has extensive experience in its target markets, consolidating its position as an **engineering and manufacturing partner**.

Idneo is committed to facing **complex challenges** and ensuring **robustness and quality** in every project developed.

PAUL SCHERRER INSTITUTE (PSI)

WP4 leader



The Paul Scherrer Institute (PSI) is the largest **research institute for natural and engineering sciences** in Switzerland, conducting cutting-edge research in four main fields: future technologies, energy and climate, health innovation and fundamentals of nature.

PSI develops, builds and operates **complex large research facilities**, such as the Swiss Light Source (SLS), the free-electron X-ray laser SwissFEL, the SINQ neutron source, the S μ S muon source and the Swiss research infrastructure for particle physics CHRISP, and is part of the ETH Domain.

FI GROUP

WP7 leader



FI Group advises companies on the management of their **R&D&I financing**, through the design and implementation of actions aimed at boosting their **technological and economic development**.

These actions focus on the integral treatment of **R&D&I tax incentives** and the management of **calls for public grants and subsidies** at the national and European levels, resulting in an improvement of the companies' profit and loss accounts.

Its commitment to **achieving excellence** in all its services has led FI Group to assume the **leadership of the sector**, both at the national and European levels, thus promoting an ambitious **internationalisation plan** with a clear objective: to help its clients in the **generation of value**.



**KEEP INFORMED THROUGH OUR
COMMUNICATION CHANNELS!**



healingbat.eu



HEALING BAT



@HealingBatEU



@HEALINGBAT



**Funded by
the European Union**

Funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or the European Climate, Infrastructure and Environment Executive Agency (CINEA). Neither the European Union nor the granting authority can be held responsible for them.



This project is part of BATTERY2030+, a large-scale European initiative to invent the sustainable batteries of the future, which has received funding from the European Union's Horizon 2020 programme under Grant Agreement No. 957213.