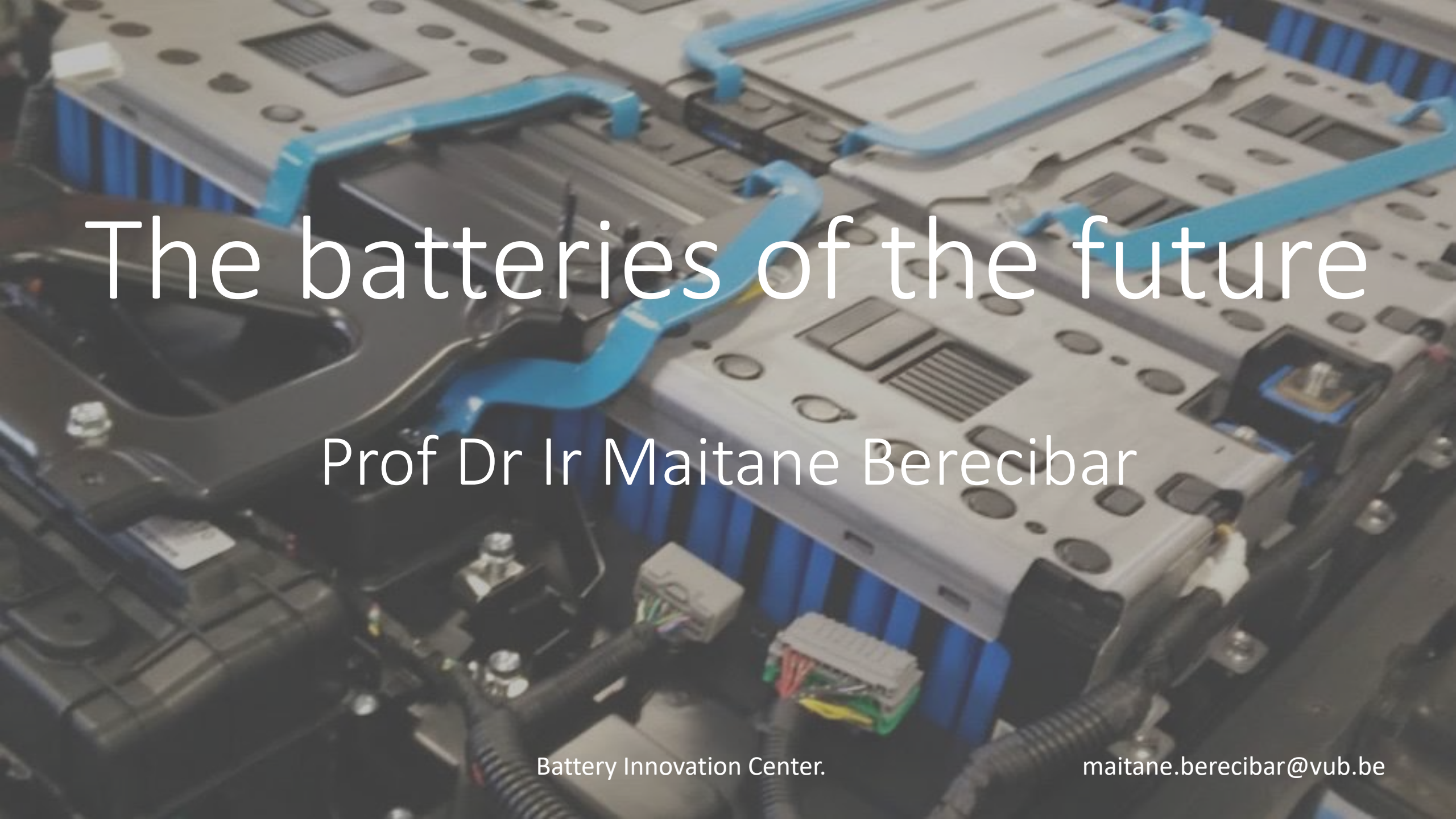

The batteries of the future

Prof Dr Ir Maitane Berecibar

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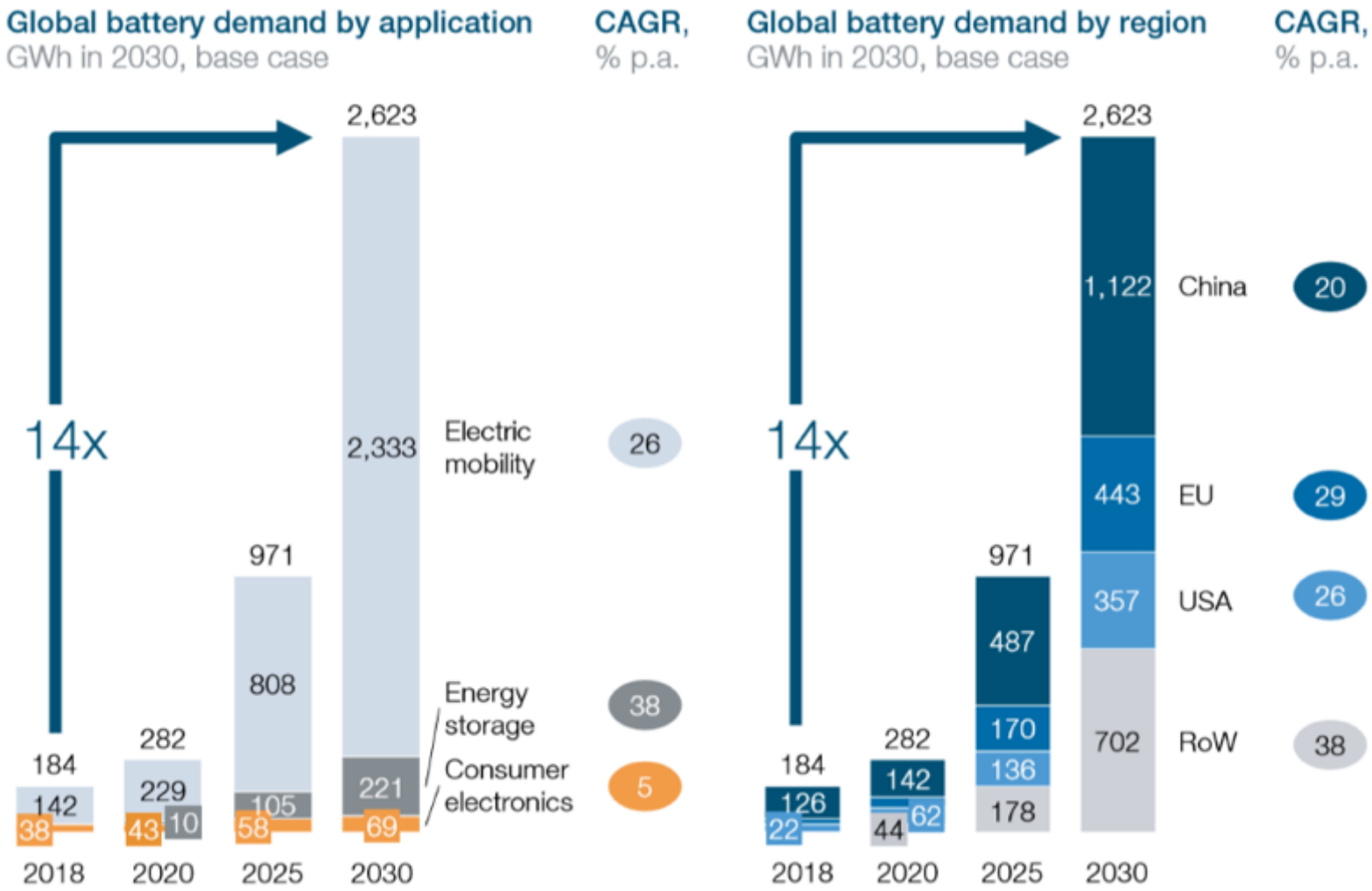
Expected growth in global battery demand by application (left) and region (right).



Battery2030+ Roadmap, March 2020

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WHAT ARE WE DOING?

NOVEL MATERIALS

- Solid State batteries for Mobility Applications
- Less Cobalt for Stationary Batteries

LONGER LIFETIME

- Sensor Integration
- Self Healing Properties

FAST CHARGING

- Novel Cooling Systems
- Real Time Cloud Computing
- Smart Charging

SECOND LIFE

- Second life battery used for industrial or commercial buildings and sites
- Integrate and use smartly 2nd life batteries in a grid application

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WHAT ELSE CAN WE DO?

BATTERY MANUFACTURING

- Machinery with intelligent control processes to minimize costs, scrap and energy consumption

SMART FUNCIONALITIES

- Embedding sensors and self-healing functionalities to detect degradation and repair

BATTERY MODELLING

- Next generation batteries through the use of battery digital twins

BATTERY TESTING

- Novel battery testing techniques to minimize the time to market

BATTERY

2030+

- Inventing the sustainable batteries of the future.

BATTERY 2030+

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BATMACHINE

- **Objectives:**

✓ Develop **new battery cell manufacturing machinery**, with priority on minimising energy;

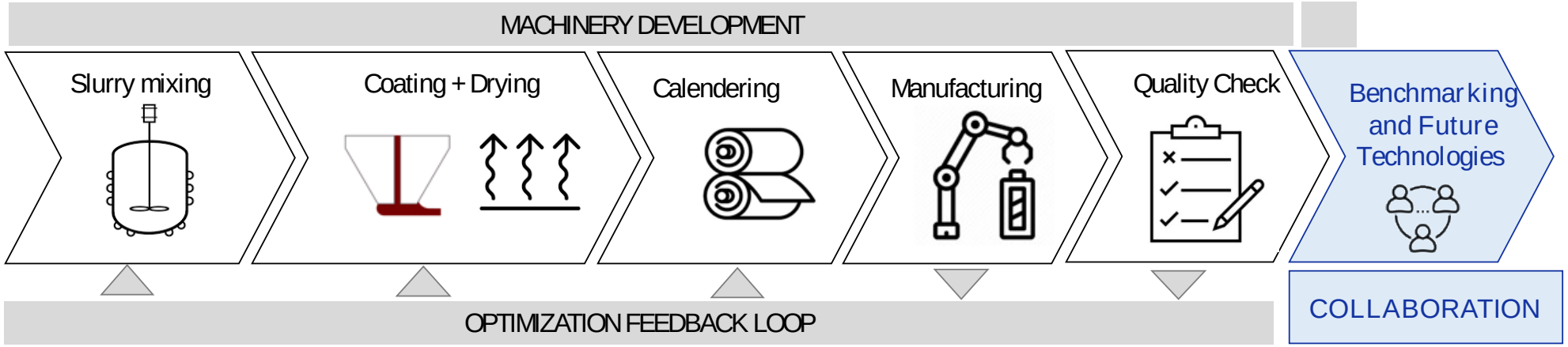
✓ Implement **intelligent control processes and Industry 4.0** to enable the site integration and optimisation;

✓ **Cost and energy optimisation** of the battery manufacturing process

✓ Implement **ecological standards** in the design phase;

✓ Develop a **horizontal integration** procedure of the European supply chain for battery process equipment;

✓ Intensify a **deeper collaboration** between equipment companies, industrial-scale manufacturing, and supply chain sectors



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PHOENIX

- Objectives:

✓ **Materials with self-healing functionalities** that are triggered by external stimuli

✓ **Sensors to detect healable degradation** mechanisms

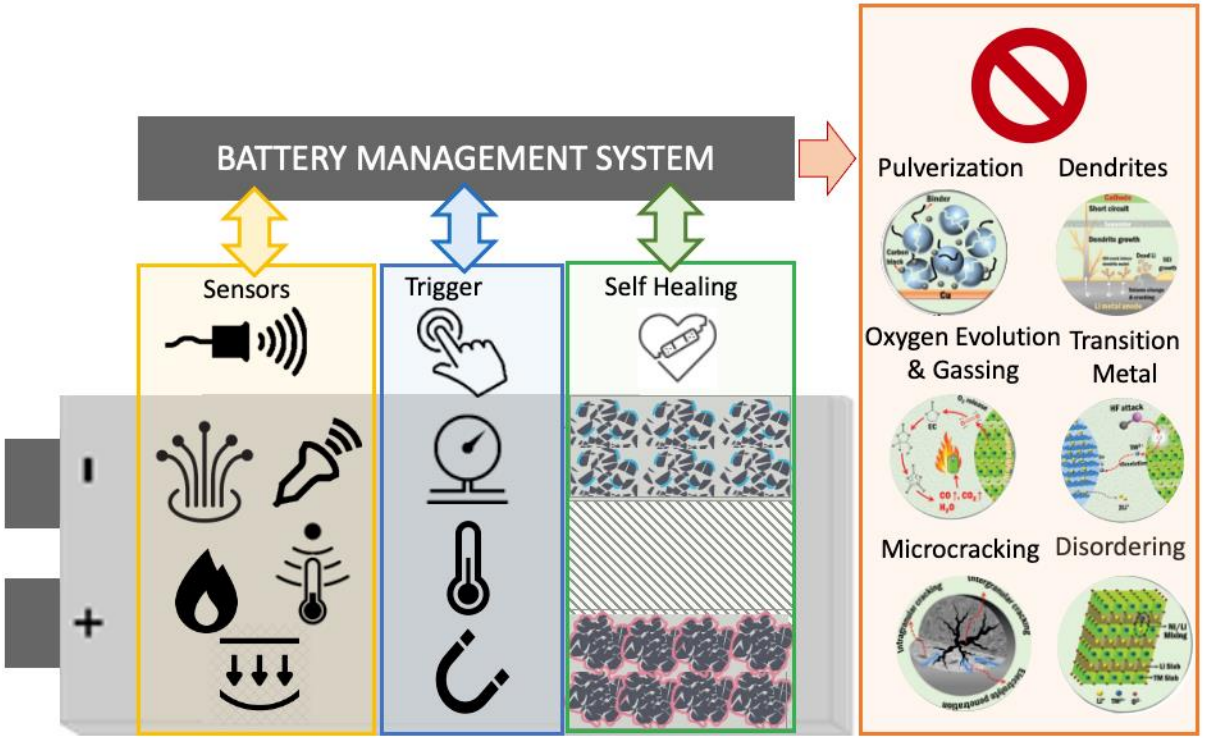
✓ **Triggering devices** to activate self-healing mechanisms

✓ **Proof of concept** of coupling sensors and self-healing agents via **BMS**

✓ Detection of the **critical degradation processes** during cell electrochemical or chemical ageing

✓ Assessment of **environmental sustainability**

✓ Adaptable approach to battery **cells mass production** processes



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NEMO

- Objectives:

✓ Demonstration of **improved sensor signal** acquisition and increased computational resources for BMS

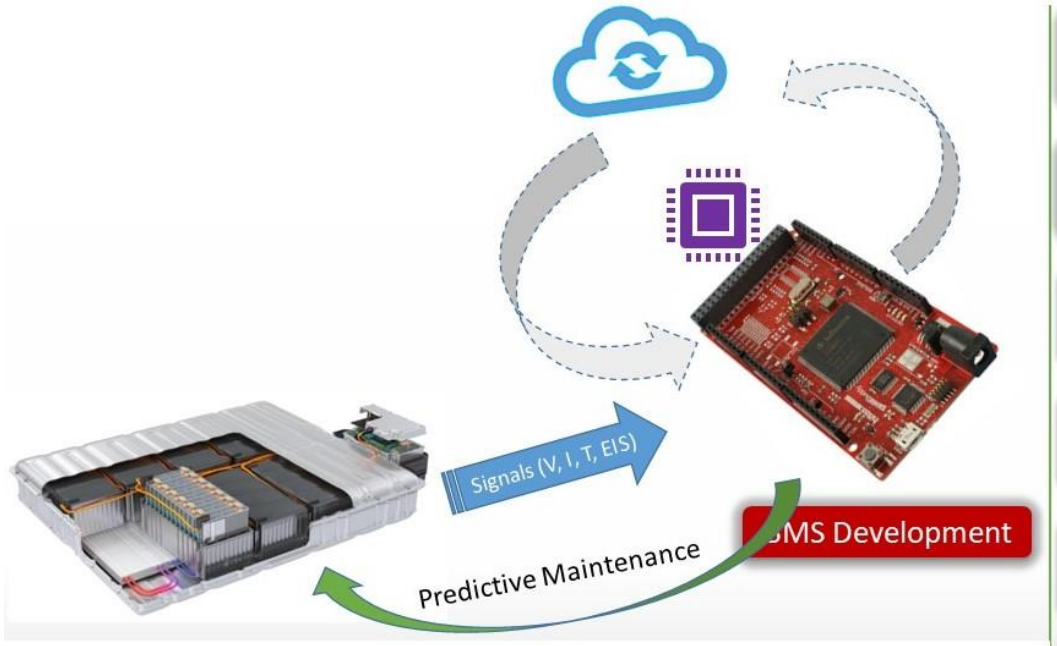
✓ Validation of improvements stemming from an automatic model update on **SoC estimation**

✓ Validation of improved lifetime modelling via **advanced SoH and RUL algorithms**

✓ Demonstration of **battery lifetime extension via SoH-balancing** at the cell level

✓ Validation of **early failure detection** via cell pressure and core temperature estimation under load

✓ Demonstrating **data management performance** and providing FAIR data for the research community



Physics-based and data-driven aging model (RUL, Lifetime)

Adaptive model from field data

State estimation (SoC, SoH, SoE, SoP)

Early failure prediction

Sensor-based solutions (Battery system)

Special Situation: Unbalanced/dysfunctional cell

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THOR

- **Objectives:**

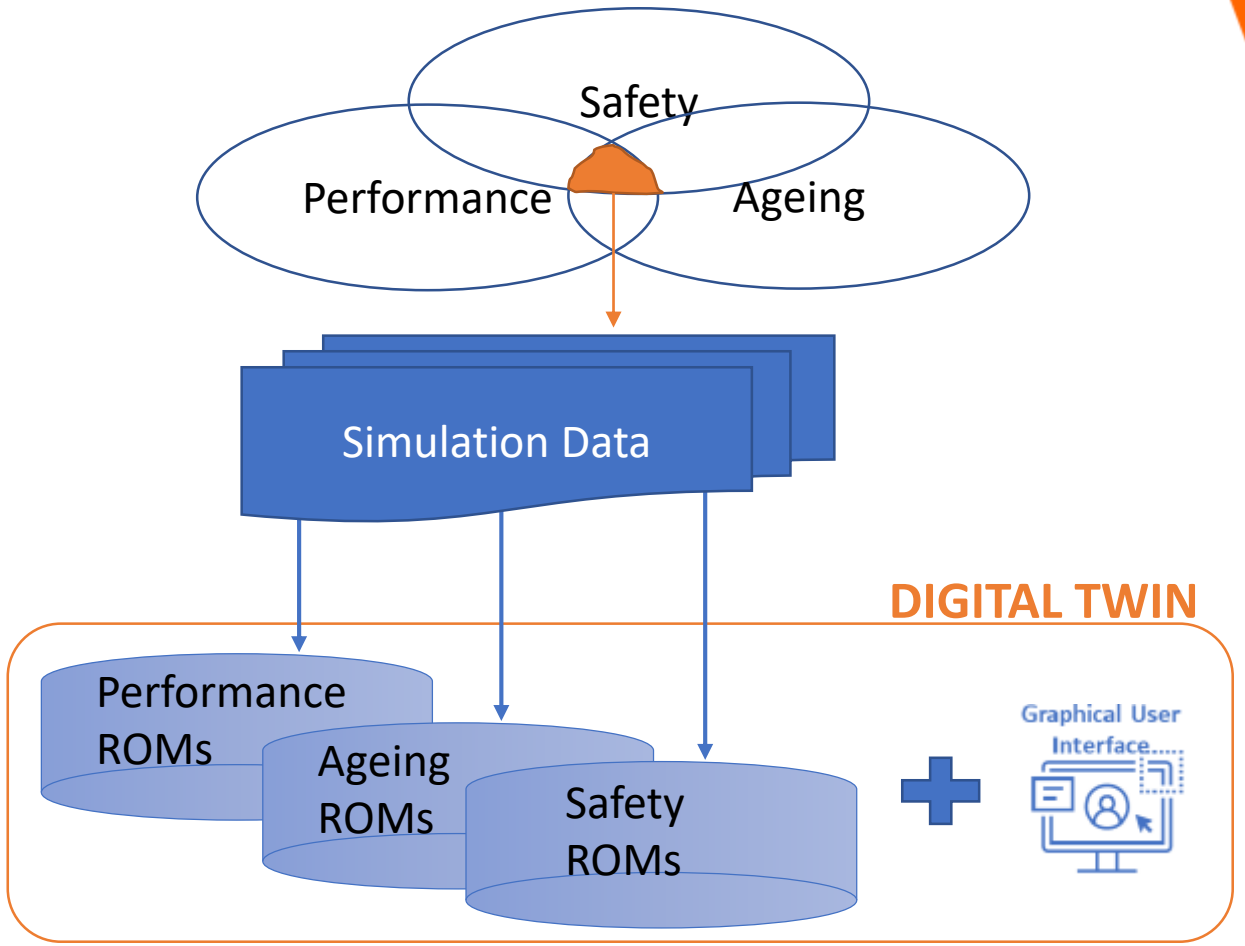
✓ Develop a **highly predictive performance model** at cell, module and pack level;

✓ Develop a high-fidelity **physics-based ageing model** at cell, module and pack level;

✓ Develop a **2D model**, at cell, module and pack level, capable of anticipating thermal (heat release) and toxic (gas emissions) hazards consecutive to **thermal runaway** of a battery;

✓ Build a **multi-scale real-time Digital Twin** at cell, module and pack scale, with a user-friendly graphical user interface;

✓ Generate **smart design of experiments** (DoE) and **methodologies to support identification** of the most influential parameters for each model;



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Our Research Activities & Lab Facilities

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Raw Materials
- Social aspects
- Life Cycle Assessment
- Eco-Design and cost evaluation

Next Generation Battery Technologies:
- Si based, Solid state, Li Metal, other
- Self Healing

Manufacturability
- Upscaling
- Fabrication and Optimization
- Sensing

2nd Life & Recyclability:
- Post Mortem
- Adaptation of Modelling
  Evaluation of Second Life:
  - Repair
  - Reuse
  - Remanufacture
  - Recycle
- Safety Task Chair at Batteries Europe

Usage
- E-Mobility & Stationary
- Modelling: Electrochemical, Thermal, Electrical, Lifetime
- Smart State Estimations: SoC, SoH, SoF, other
- Thermal Management & Cooling Strategies
- Standardization: TC69 (secretary), TC21 (expert)

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BIC Infrastructure

More than 300 channels

- Cells, Module, Pack Testing
- 5 V, 80V, 1000V (16kW)

12 climate chambers

- 50L, 250L, 350L, 3 Walking chambers
- -40 to 180 °C

42 impedance spectroscopy channels

- High Frequency testing

Thermal imaging equipment

- -40°C to 150°C

Thermal management platform

- Cooling System prototyping

dSPACE

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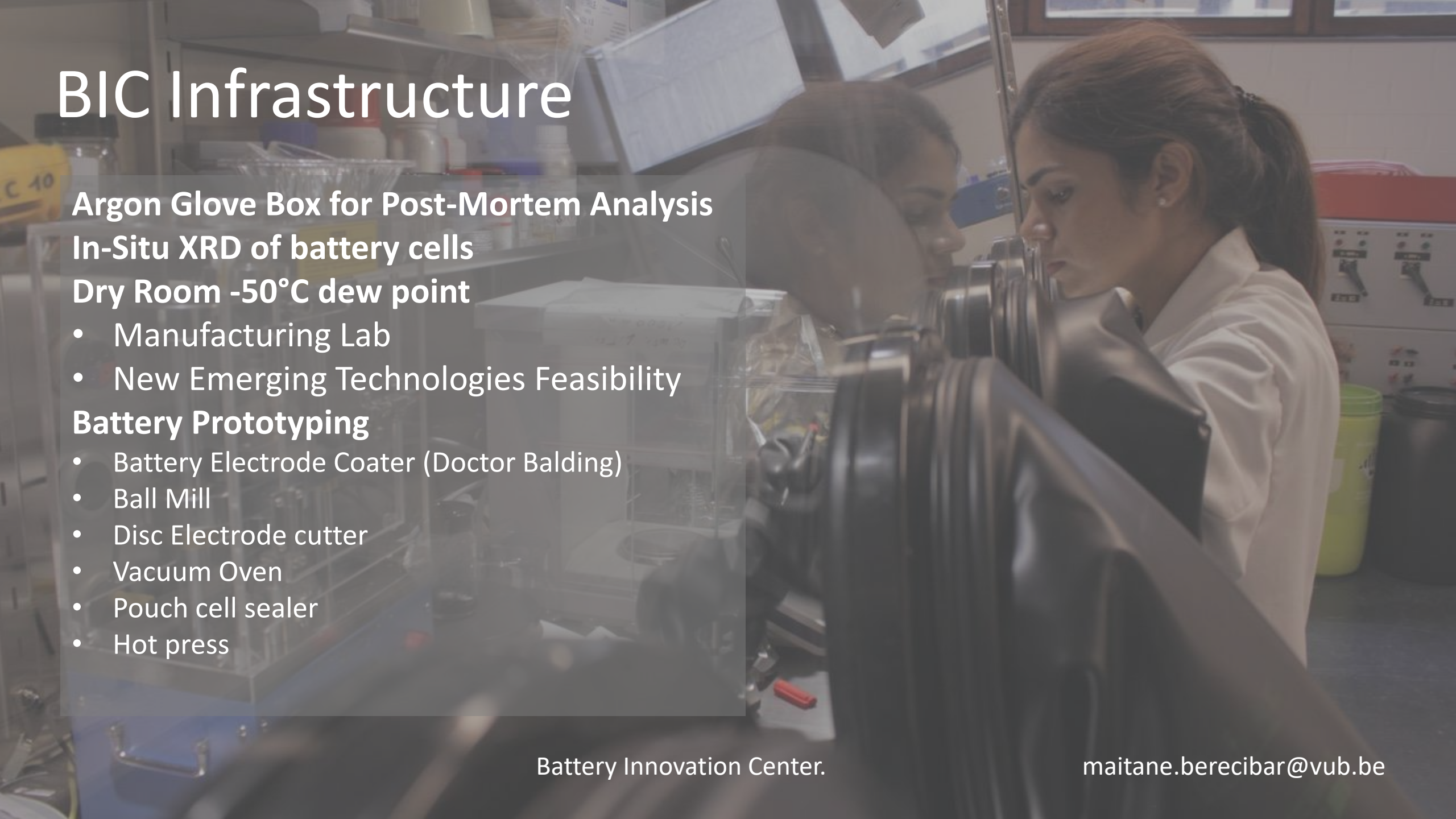
BIC Infrastructure



Argon Glove Box for Post-Mortem Analysis
In-Situ XRD of battery cells
Dry Room -50°C dew point

- Manufacturing Lab
- New Emerging Technologies Feasibility

Battery Prototyping

- Battery Electrode Coater (Doctor Balding)
- Ball Mill
- Disc Electrode cutter
- Vacuum Oven
- Pouch cell sealer
- Hot press

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Ongoing Projects

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45 m²
-50°C dew point
MSK-800-2K

THANK YOU

WELCOME TO OUR

BATTERY INNOVATION CENTRE

https://mobi.research.vub.be/battery-innovation-centre-homepage

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