Joint Webinar

Building the Future of Second-Life Energy Storage in Europe

Battery2Life

Cloud BMS for Battery Digital Passport with State of Warranty

George Konstantinidis, ICCS
g.konstantinidis@iccs.gr

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Project funded by
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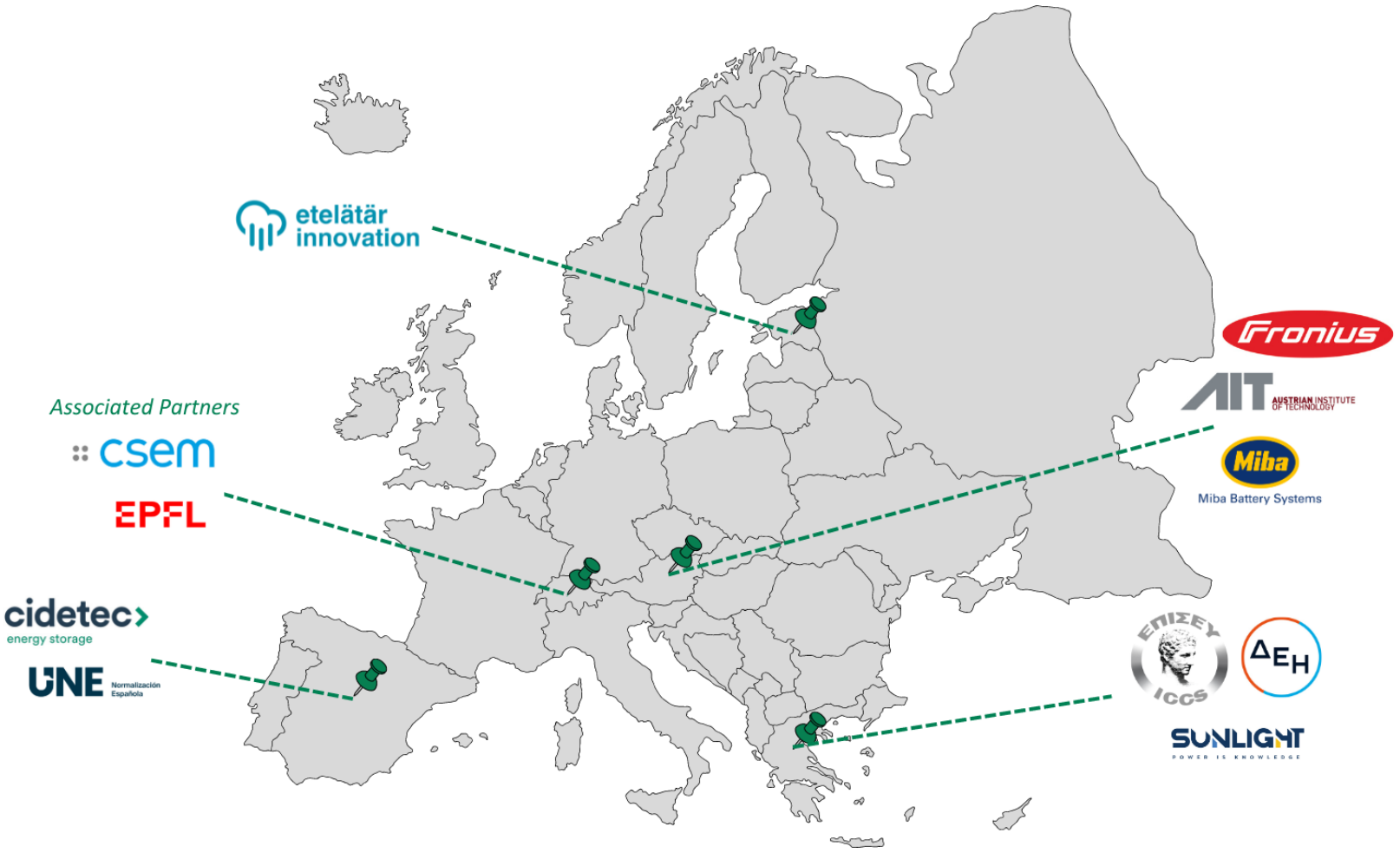
Batter2Life at a Glance

BATTERY2LIFE



Project Name: BATTERY Management system and System design for stationary energy storage with 2nd LIFE batteries

Call identifier: Cross-sectoral solutions for the climate transition (HORIZON-CL5-2023-D2-01)

Duration: 36 months (January 2024-December 2026)

Business Cases: Domestic storage in Austria and Industrial (grid-scale) storage in Greece

Project Coordinator: Dr Angelos Amditis, Institute of Communication and Computer Systems (ICCS)

Consortium: 11 Partners from 5 countries

Funding: ~4M€

Website: battery2life-project.eu

Social Media:

- @battery2life_eu
- BATTERY2LIFE Project

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Why This Discussion Matters Now

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- Regulation is changing the rules
  - EU Battery Regulation introduces the Digital Product Passport
  - Lifecycle traceability becomes mandatory
  - Performance transparency becomes enforceable
  - Responsibility extends beyond first life
- Massive growth of second-life batteries
  - EV battery volumes are increasing exponentially
  - Repurposing becomes economically attractive
  - Stationary storage demand is growing
  - Energy transition accelerates decentralised storage
- Need for bankable, insurable energy storage assets
  - Unknown degradation history
  - Unclear warranty liability
  - Insurance reluctance
  - Investor hesitation
  - Asset bankability concerns

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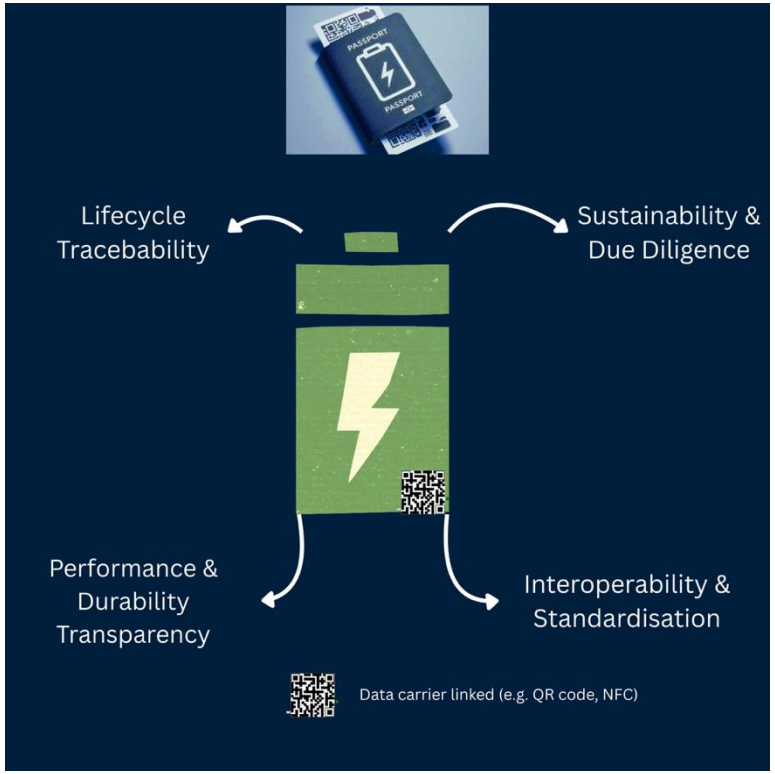
Digital Battery Passport (DBP)

- **Digital Battery Passport**
  - The regulation (EU 2023/1542) introduces a **Digital Battery Passport**, with detailed requirements defined through delegated acts and harmonized standards.
- **Key data categories:**
  - Unique battery identifier
  - Technical characteristics (e.g. chemistry, capacity)
  - Performance & durability parameters
  - State of Health (SoH) indicators
  - Carbon footprint & recycled content
  - Lifecycle and usage data



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The Second-Life Trust Problem

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Second-life batteries inherit **heterogeneous ageing histories** and operate under **new application conditions**, creating uncertainty in performance, safety, and warranty assessment. Key Challenges:

- Limited First-Life Transparency
- Changing Operational Context
- Static Warranty Frameworks
- Lack of Continuous Lifecycle Intelligence

Second-life batteries require **continuous condition monitoring and lifecycle analytics** to enable reliable warranty management and market trust.

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From Conventional BMS to Hybrid Cloud BMS

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Conventional BMS (Edge)	Hybrid BMS (Edge + Cloud)

• **Edge BMS**
  • On-board the battery system
  • Real-time control & protection
  • SoC estimation
  • Basic SoH
  • Safety functions (SoS)
  • Limited memory capacity
  • Limited computational power
	• **Edge BMS**
	  • Real-time safety & protection
	  • Embedded measurements (including EIS)
	  • Operational data acquisition
	  • Immediate fault response
	• **Cloud BMS**
	  • Long-term degradation modelling
	  • SoH refinement
	  • RUL prediction
	  • Fleet-level learning
	  • Repurposing validation
	  • State of Warranty calculation

The Cloud does not replace the BMS. It extends it from real-time protection to lifecycle intelligence.

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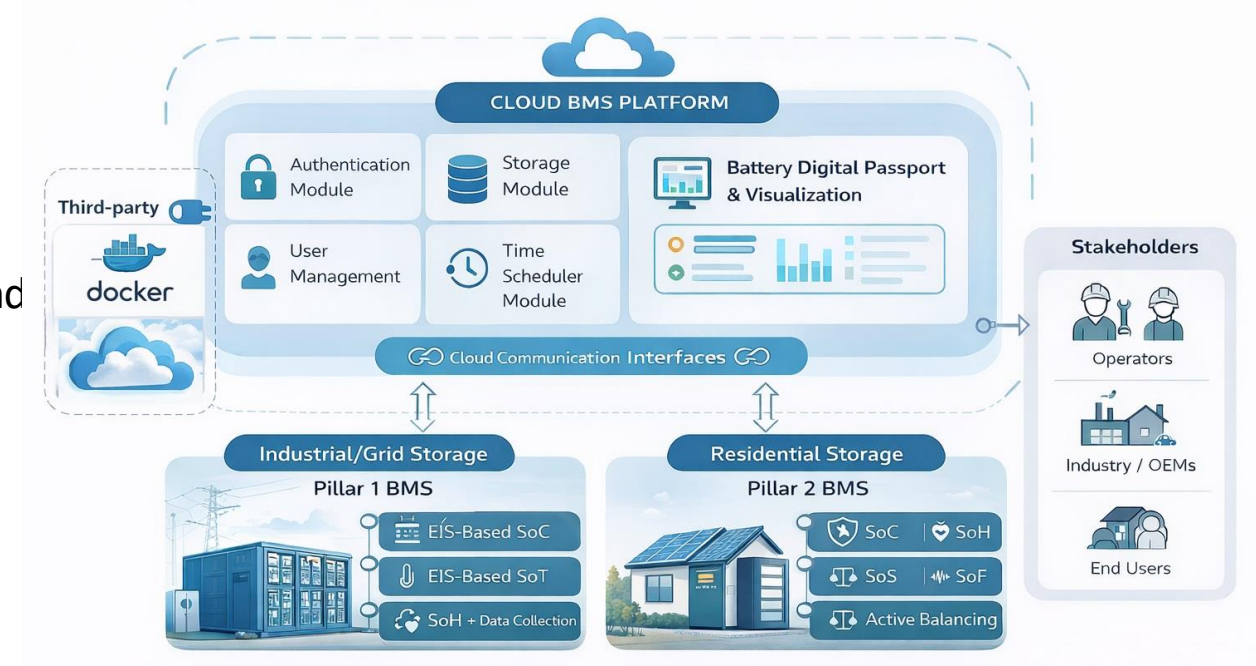
Cloud BMS Architecture - Battery2Life Approach (1/3)

- **A high-level representation of the architecture is:**
  - Cloud Platform Core
  - Embedded BMS Interface
  - Third-Party and Stakeholders Integration Layer
  - User Interface

- **Key data flows**
  - From edge BMS to cloud BMS and backwards
  - From Cloud to Third-Party Systems and Stakeholders and backwards

- **Six main modules:**
  - Data Ingestion Layer
  - API Gateway
  - Security Module
  - Data Processing and Analytics Engine
  - Database and Storage
  - Monitoring and Management Dashboard



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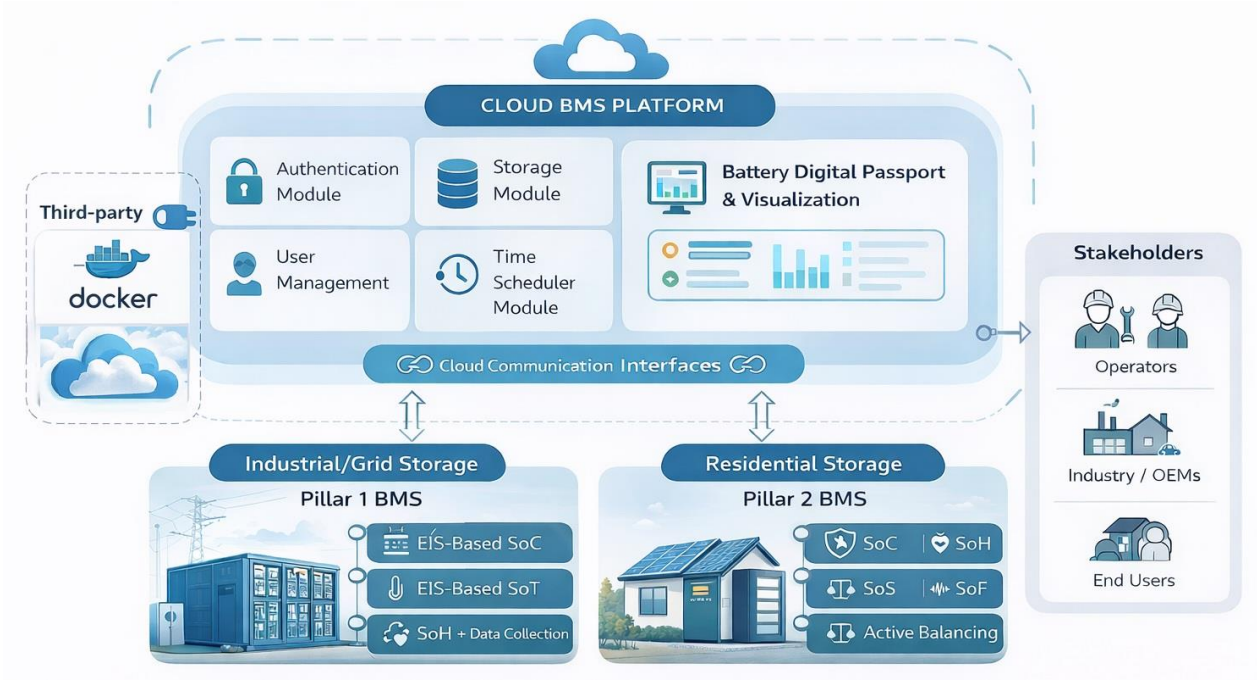
Cloud BMS Architecture - Battery2Life Approach (2/3)

- **Data Ingestion Layer**
  - Collects real-time battery data wirelessly from edge BMS units
  - Remote firmware updates for the edge BMS

- **API Gateway**
  - Provides standardised APIs for third-party systems and applications.
  - Ensures data access control and seamless integration with diverse platforms

- **Security**
  - Manages user authentication and role-based access control to prevent unauthorized access to the backend and to API endpoints
  - Implements backup and recovery mechanisms



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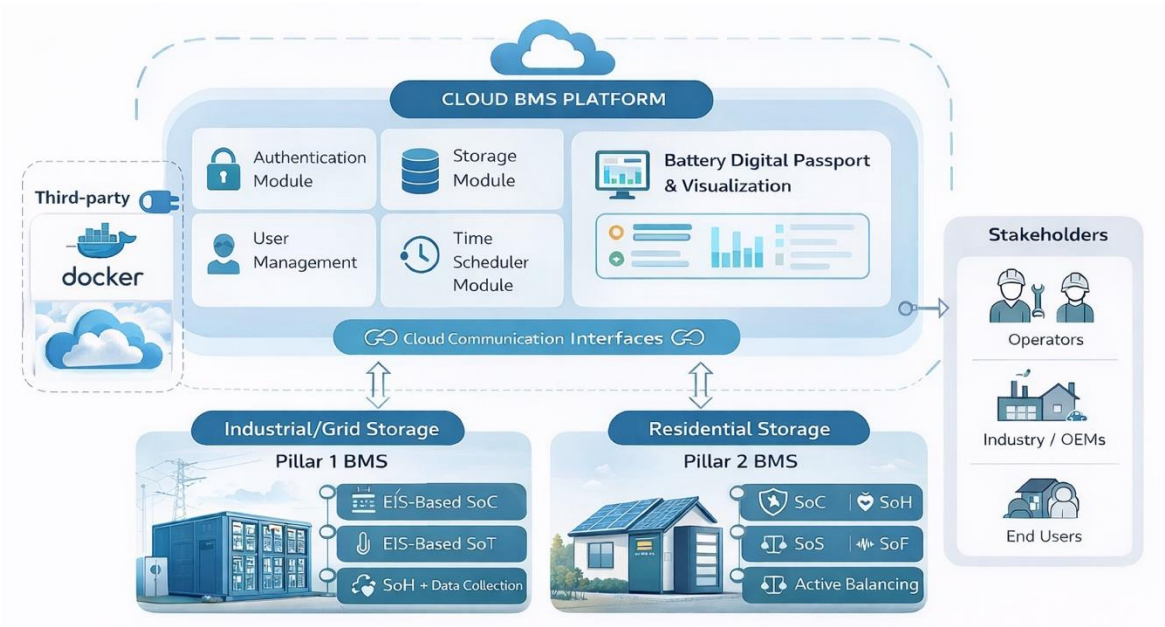
Cloud BMS Architecture - Battery2Life Approach (3/3)

- **Data Processing and Analytics Engine**
  - Implements diagnostic algorithms

- **Database and Storage**
  - Ensures secure and reliable storage of raw and processed data that are output from the cloud diagnostic algorithms.
  - Stores all data received from edge BMS units, third-party services, and battery manufacturers

- **Monitoring and Management Dashboard:**
  - Offers real-time visualization of SoX parameters, battery health, and operational analytics
  - Supports user-driven configuration and updates



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Static vs Dynamic Data in the Battery Digital Passport

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Static Data

→ Defined at manufacturing stage

Includes:

- Battery identifier (unique ID)
- Manufacturer information
- Chemistry and configuration
- Nominal capacity
- Manufacturing date
- Design parameters

→ These parameters remain **constant throughout the lifecycle**.

Dynamic Data

→Updated during operation

Includes:

- State of Charge (SoC)
- State of Health (SoH)
- Remaining Useful Life (RUL)
- State of Safety (SoS)
- Operational profile
- Repurposing events
- State of Warranty (SoW)

→ These parameters **evolve during the battery lifecycle**.

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State of Warranty (SoW)

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Prognosis: RUL → SoW

Adjusted prognostic algorithm. Necessary:

1. **Prior knowledge** → Expected use of the battery and aging model.
    - Aging model = power type equation built using aging data provided by battery manufacturers.
    - Equation's parameters are used as hidden states in the selected stochastic filter, which updates these parameters based on the provided SoH estimations.

2. **Real life SoH** → To learn the real ageing trend of the SoH.

3. **Stochastic filter** → Particle filter, it learns the real aging trend (it removes the noise, also considered all the uncertainties added in the SoH estimation that are not part of the aging trend).
    - Hyper-parameters of the particle filter were obtained by a machine learning optimization algorithm: a Bayesian optimization.

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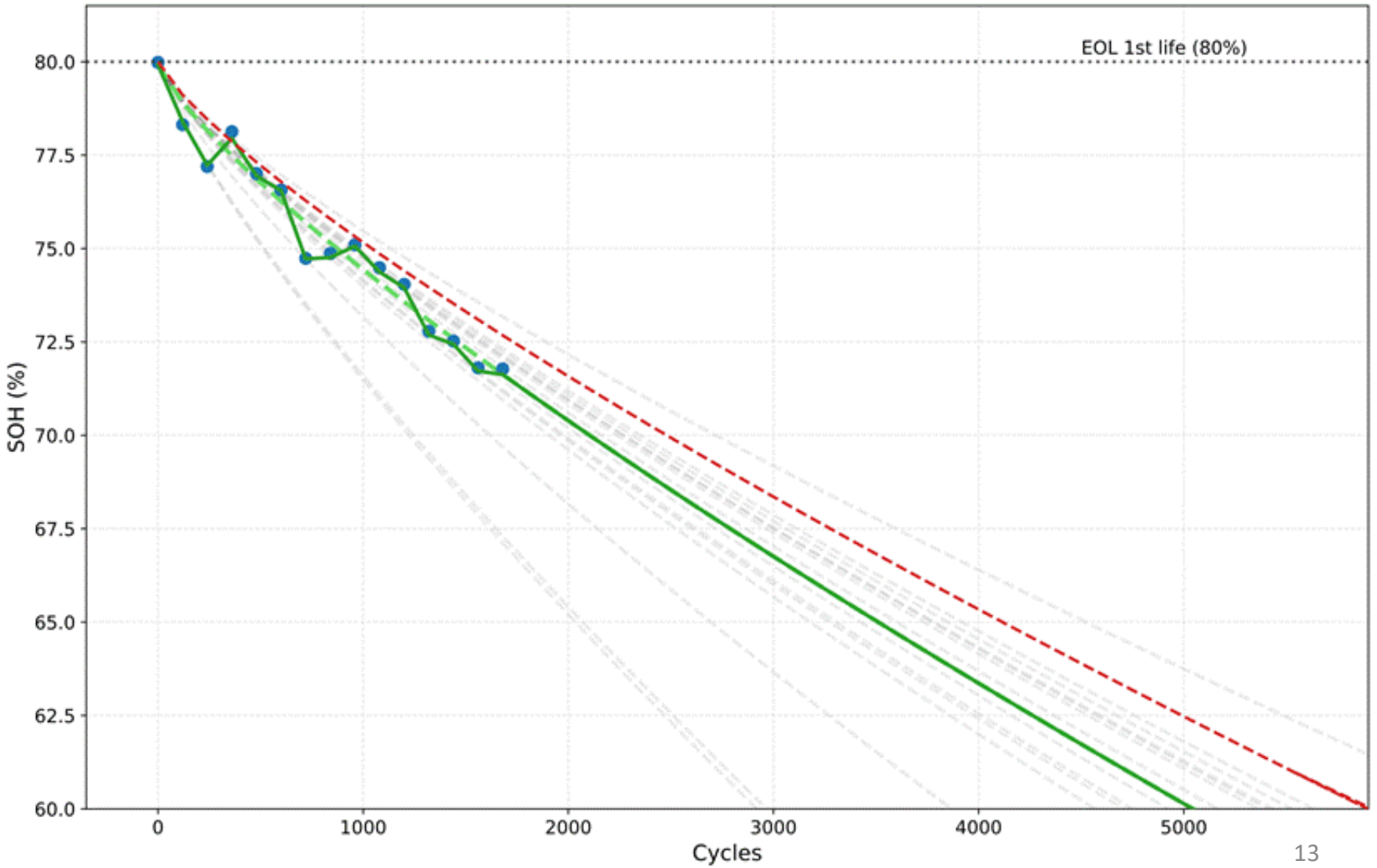
Prognosis: RUL → SoW

1. **Prior knowledge**
2. **Real life SoH (•)**
3. **Stochastic filter (PF)**
4. Model steps (previous PF models)
5. Final PF model



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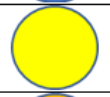
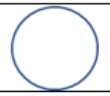
Prognosis: RUL → SoW

RUL estimation is key for the SoW → It provides the information regarding the predictive maintenance that allows early alerts from the SoW, before any significant damage is done to the battery (the SoH is not significantly reduced compared with the expected one in the prior).

SOW	Severity Description
	The warranty fulfilment level is correct.
	The warranty fulfilment level is correct, but the end of warranty is close.
	**ATTENTION**! Predicted 1 additional replacement. Early advice.
	**ATTENTION**! Predicted 1 additional replacement. Middle advice.
	**ATTENTION**! Predicted 1 additional replacement. Late advice.
	**DANGER**! Predicted 1 additional replacement. Irreversible damages.
	**DANGER**! Predicted 2 additional replacement.
EOL	**END OF LIFE**! The battery has reached the EOL.
	**Undefined scenario.** Something unexpected is happening.

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Thank you! Any questions?

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