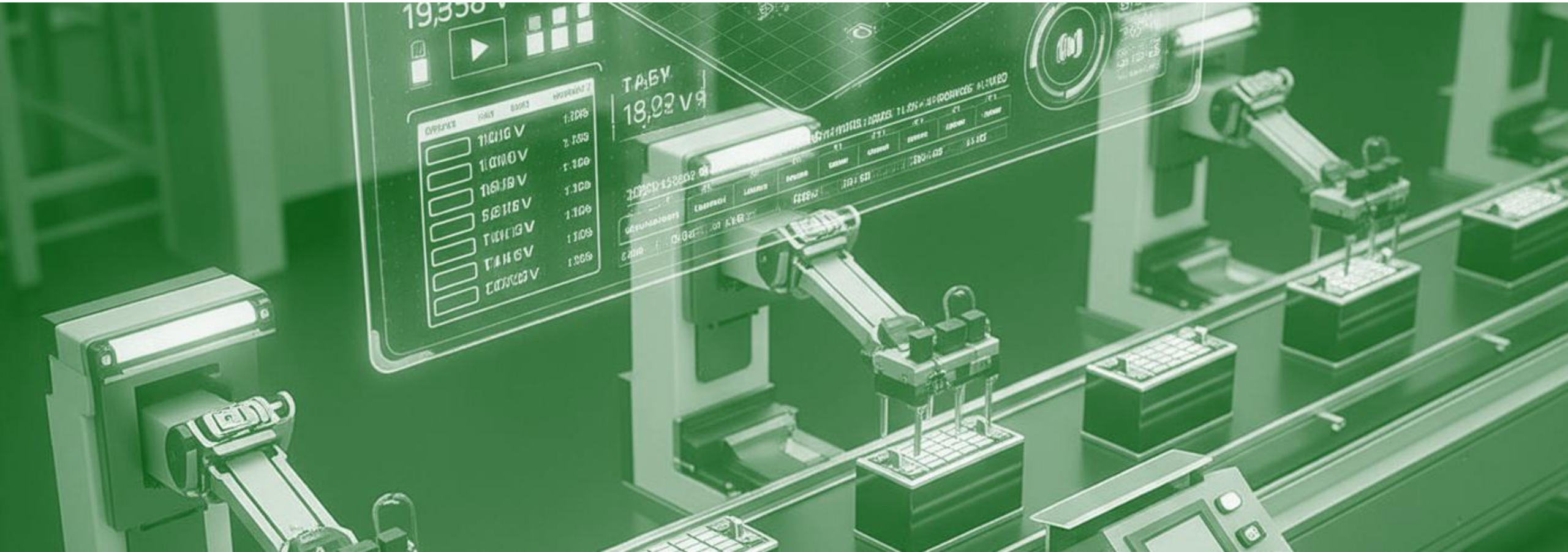


Onbridge: Excellence in Battery Inspection and Performance Evaluation

# AI Quality Management for Safer Battery Manufacturing



# Founded on Hands-On Experience in Battery Performance Evaluation

## Energy Management System

#EMS #VPP #FEMS #PMS



## Battery Reuse

#HybridESS #ReuseESS



## Battery Performance Evaluation

#ResidentialESS #BatteryRUL



From overseeing the development of energy management systems to leading battery reuse and performance evaluation platforms, have gained a deep, hands-on understanding of industry trends and technical needs within the battery sector.

# Can we truly evaluate batteries properly?


From QC processes that rely on visual inspection to the lack of comprehensive performance evaluation technologies, the battery industry lacks a solid technical foundation for precise diagnosis and evaluation throughout the entire battery lifecycle.

 The New York Times

## A Mercedes-Benz Fire Jolts South Korea's E.V. Transition

Security video footage released by news outlets shows smoke coming out of the




 East Asia Forum

## China's EV success faces a battery recycling problem

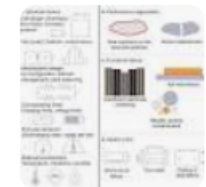
China must overcome the challenge of EV battery recycling dominance in green transport.



 Nature

## Challenges and opportunities for high-quality battery production at scale

Here we highlight both the challenges and opportunities to enable battery quality at scale. We first describe the interplay between various battery failure...



The lack of reliable battery evaluation technologies risks the entire secondary battery industry  
—solving it is both an innovation and a market opportunity

# Now is the time for solution enabling precise inspection and evaluation

Manufacturing can become safer, electric vehicles more reliable, and used batteries more efficiently reused.

All of these changes begin with one thing: the ability to evaluate batteries properly.



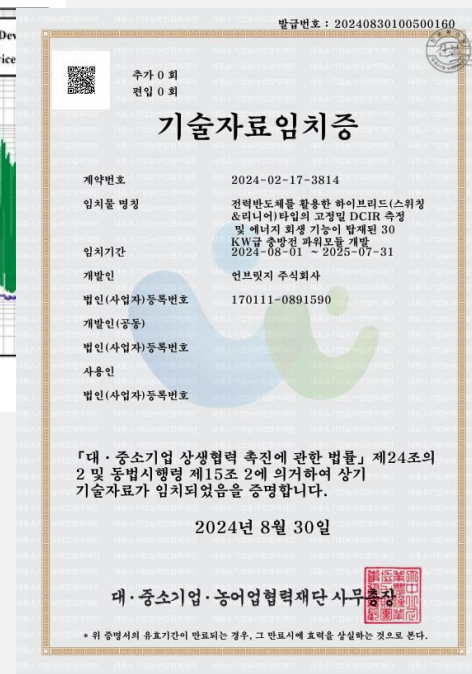
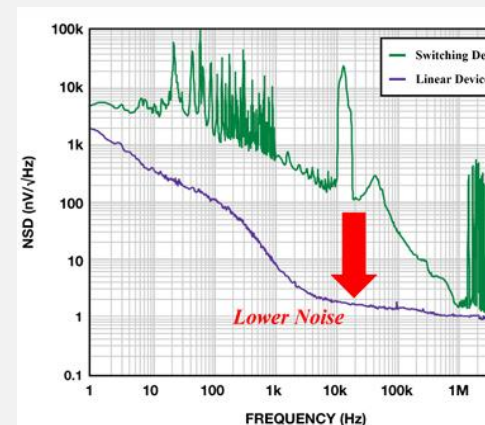


# [HW] Expertise in Developing and Controlling Measurement Equipment

## High-Voltage Charge/Discharge Power Module



## Hybrid Control Technology



# [SW] Expertise in Battery Database and Solution Architecture Development

## Data Processing & Solution Architecture Development

```
class CycleCNNLSTM(nn.Module):
    def __init__(self):
        super().__init__()
        self.conv1 = nn.Conv1d(3, 16, kernel_size=3, padding=1)
        self.relu = nn.ReLU()
        self.pool = nn.MaxPool1d(2)
        self.lstm = nn.LSTM(input_size=16, hidden_size=32, batch_first=True)
        self.fc = nn.Linear(32, 1)

    def forward(self, x):
        x = x.permute(0, 2, 1)
        x = self.pool(self.relu(self.conv1(x)))
        x = x.permute(0, 2, 1)
        _, (h_n, _) = self.lstm(x)
        return self.fc(h_n[-1]).squeeze(-1)
```

### 4. 학습

```
dataset = BatteryDataset(X, y)
dataloader = DataLoader(dataset, batch_size=16, shuffle=True)

model = CycleCNNLSTM()
criterion = nn.MSELoss()
optimizer = torch.optim.Adam(model.parameters(), lr=0.0001)
epoch_number = 5

train_loss_log = []
```

## Battery Chemistry & Form Factor Database Ownership

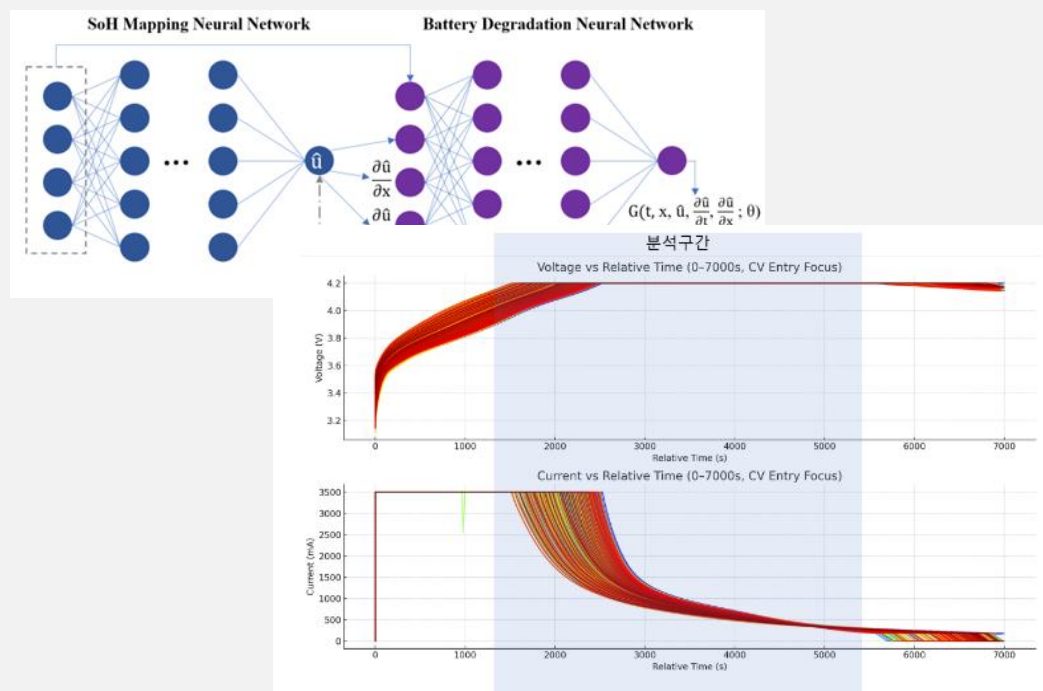
Dataset	Batch	Chemical component	Nominal capacity (mAh)	Cut-off voltage (V)	Experiment temperature (°C)	Number of cells
Xi'an Jiaotong University	1-6	LiNi <sub>0.9</sub> Co <sub>0.2</sub> Mn <sub>0.3</sub> O <sub>2</sub>	2000	2.5-4.2	Room temperature	55
Tianjin University	1	Li <sub>0.86</sub> Ni <sub>0.86</sub> Co <sub>0.11</sub> Al <sub>0.03</sub> O <sub>2</sub>	3500	2.65-4.2	25, 35, 45	66
	2	Li <sub>0.84</sub> Ni <sub>0.82</sub> Co <sub>0.11</sub> Mn <sub>0.07</sub> O <sub>2</sub>	3500	2.5-4.2	25, 35, 45	55
	3	Blend of 42 (3) wt.% LiNiCoMnO <sub>2</sub> and 58 (3) wt.% LiNiCoAlO <sub>2</sub>	2500	2.5-4.2	25	9
The Hawaii Natural Energy Institute	-	NMC-LCO 18650	2800	3.2-4.2	25	14
University of Oxford	-	LCO/NCO	740	2.7-4.2	40	8
Stanford University	-	NMC (INR21700-M50T, Nickel-Manganese-Cobalt), Graphite/Silicon Anode	4850	2.5-4.2	Room temperature	The number of cells varies by batch.
Massachusetts Institute of Technology	-	LiFePO <sub>4</sub>	1100	2.0-3.6	30	125
Hanoi University of Science and Technology	-	LiFePO <sub>4</sub>	1100	2.0-3.6	30	77
University of Cambridge	1-8	LCO/graphite	2000	2.5-2.5	25	8

## User-Friendly Interface Implementation

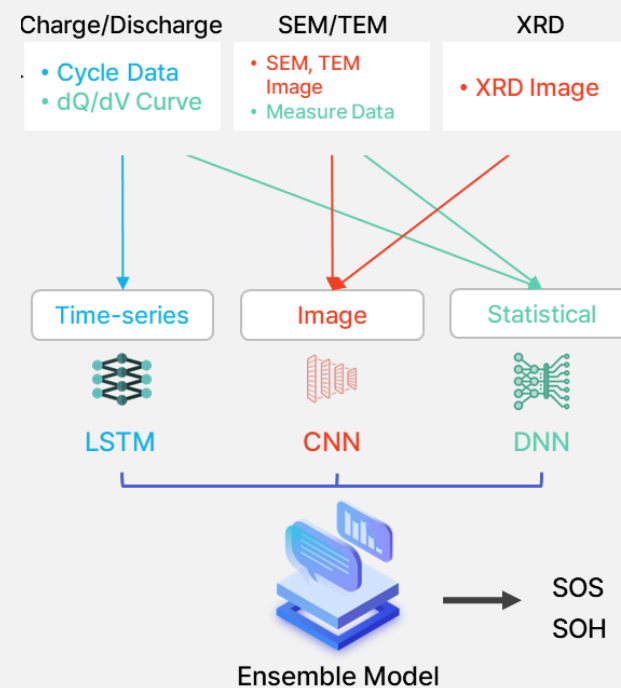


# [AI] Expertise in Developing AI Models, Including PINN

## PINN Model



## AI Model Development Expertise



# Electrification Is Advancing, but Battery Quality Control Lags Behind

Battery cells are the driving force and safety backbone of electrification industries—ranging from EVs and energy storage systems (ESS) to mobility and aviation. Nevertheless, most manufacturing processes continue to depend on manual checks and piecemeal inspections for quality control.

Frankly, **it's unsettling** that we're expected to **ensure quality based only on voltage, current, and resistance measurements.**

Libest CEO Mr. Kim

**For smaller companies** like ours, predictive testing that **covers both safety and performance** still feels like wishful thinking.

BEI Lab CEO Mr. Bae

In cell manufacturing, where **time literally means money**, even **inspection time** feels like a burden.

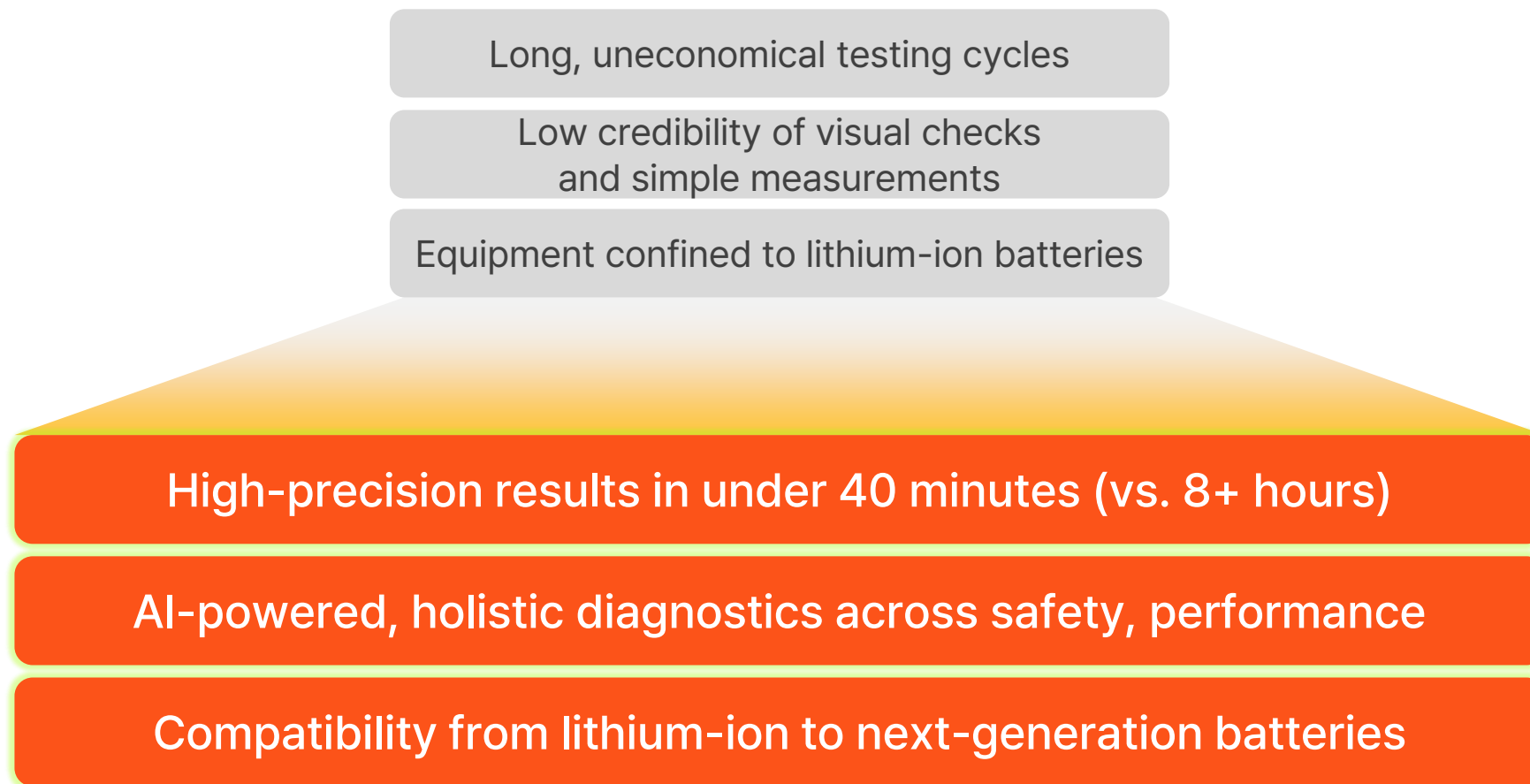
Encam CEO Mr. Oh



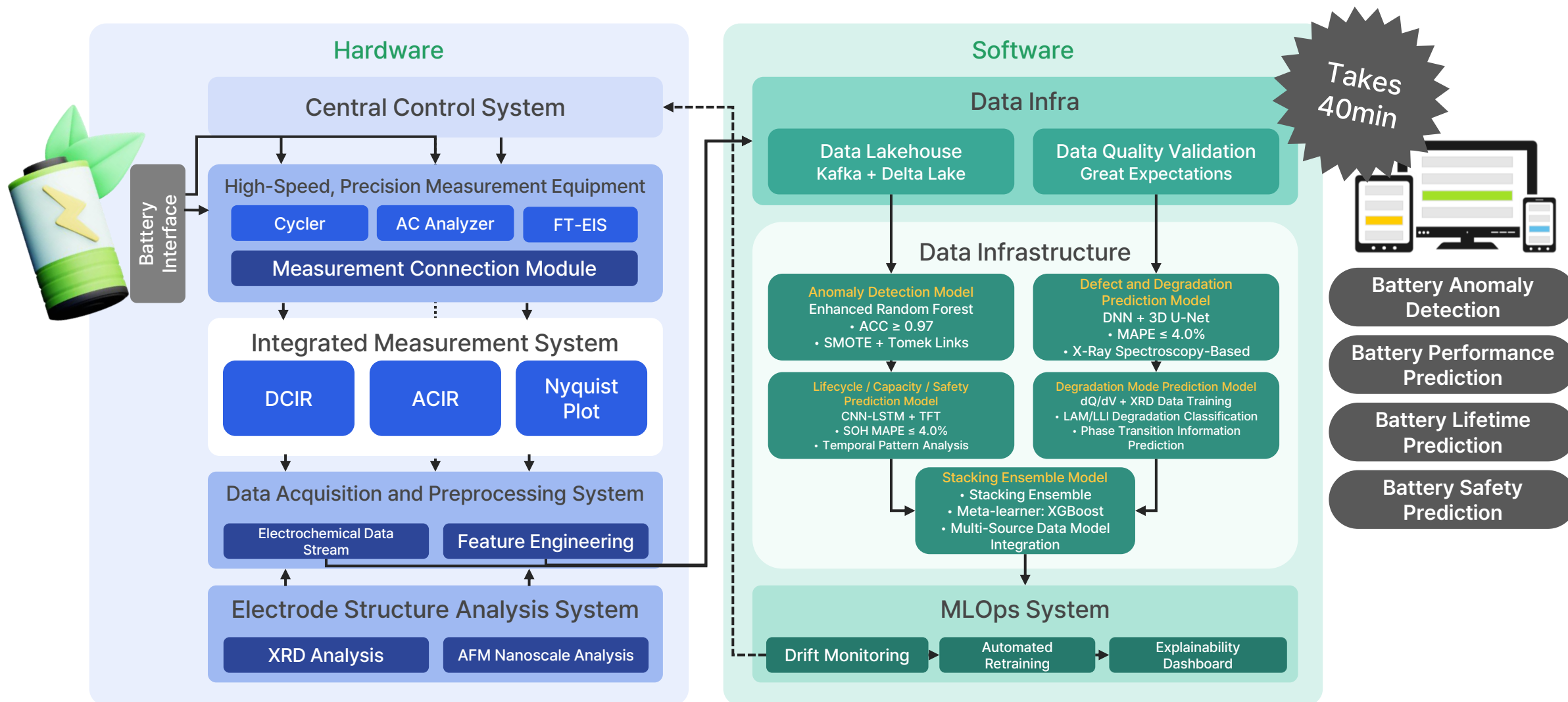


# Leading the Leap: From Basic Testing to AI-Integrated Diagnostics

Traditional QC methods suffer from low trust and slow turnaround. Onbridge sets a new standard with AI-driven diagnostics that cover lifespan, performance, and safety—built for today's lithium-ion and tomorrow's next-generation batteries.

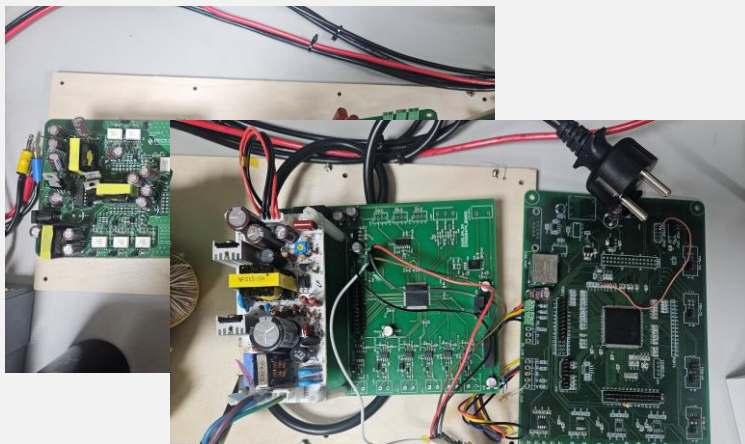


# Reinventing Battery Quality Inspection with AI-Driven Management



# [AI Quality Management System] High-Precision Hardware Development

## Cell Cycler



- 1kW-Class Cell Cycler Converter & Inverter Development
- A hybrid control technology is being implemented, which uses linear components exclusively during DC-IR measurements—ensuring high efficiency while enabling highly accurate readings.
- In collaboration with Professor Byung-Chul Han's research team at Kyungpook National University.

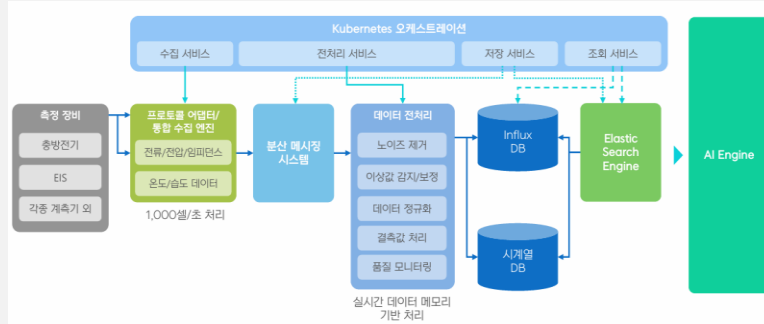
## FT-EIS



- Advancing an ultra-fast EIS system capable of applying multiple frequencies simultaneously, with Fourier transform analysis separating and evaluating responses for each frequency.
- In collaboration with Professor Taek-Dong Chung's research team at Seoul National University.

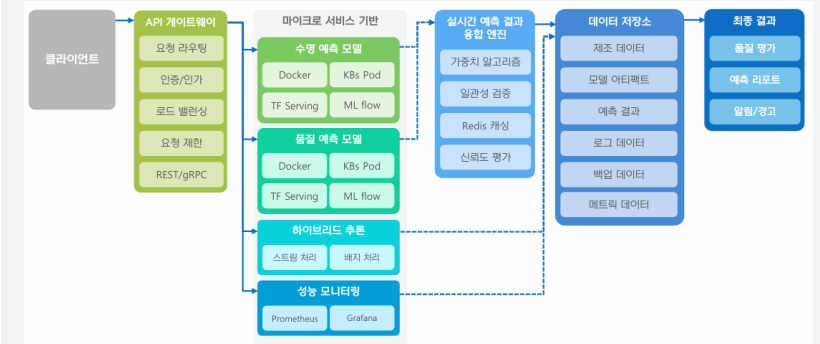
# [AI Quality Management System] Software Development

## Data Collection & Processing System Develop



- Designed to process over **1,000 data points per second**—including current, voltage, temperature, and speed—through protocol adapters and an integrated collection engine.
- Pre-processed data is **stored in Influx DB** for time-series analysis and in Elasticsearch for efficient search and analytics.
- The entire workflow is managed within a **Kubernetes orchestration environment**, ensuring both scalability and reliability.

## AI Solution Architecture Design

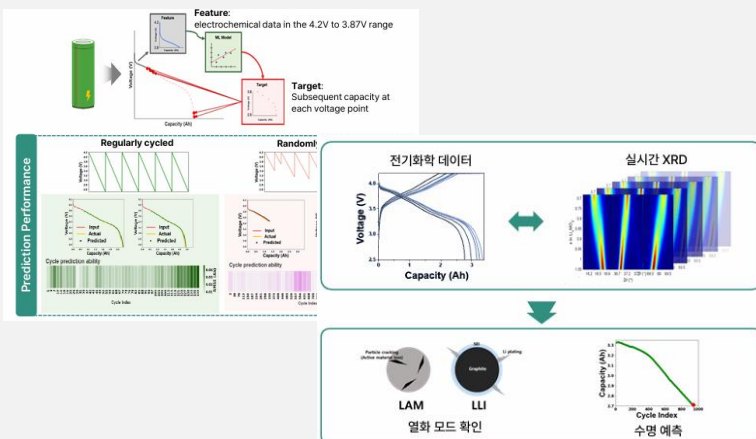


- Built with **hybrid routing**, enabling flexible choice between real-time streaming and batch processing.
- Continuous monitoring and optimization supported by Prometheus and Grafana.
- Incorporates **degradation algorithms based on DC-IR, AC-IR, Nyquist plots, chemical composition, and form factor**.
- Post-processed data—corrected quality metrics, predictive outcomes, and other key indicators—are securely stored.
- Delivers results in the form of reports



# [AI Quality Management System] AI Development

## AI Model Develop for Lifetime Prediction



- Developed a ML model that predicts capacity using only electrochemical data as features, achieving a prediction accuracy within 2% error margin.
- Building a diagnostic framework that links real-time XRD results with electrochemical data, enabling the prediction of electrode structural information solely from electrochemical signals.
- In collaboration with Professor Jong-Woo Lim's research team at Seoul National University.

## AI Model Develop for Quality Prediction

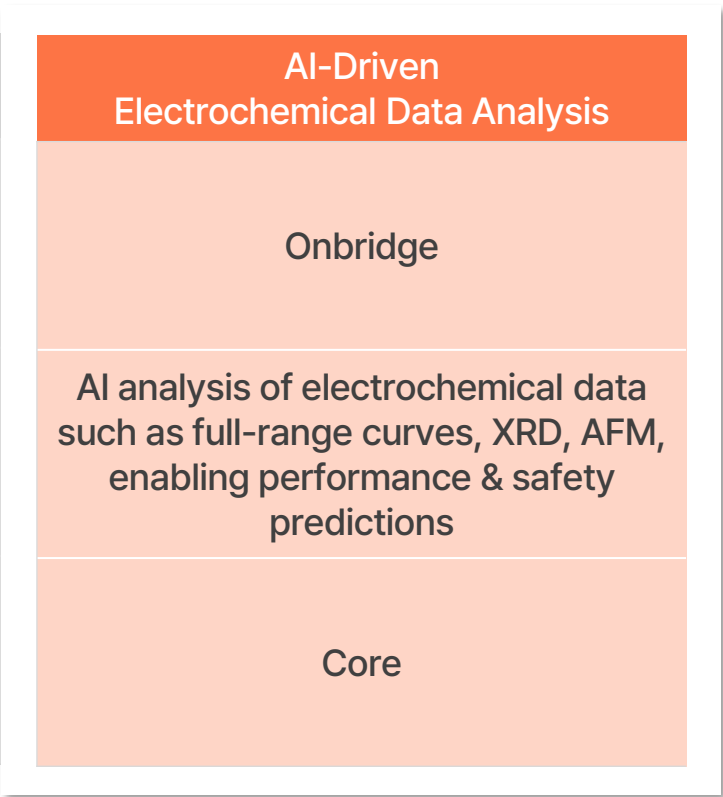


- Advancing an AI model that combines AFM-derived degradation indicators with electrochemical data to predict battery quality and performance in advance.
- Enables high-confidence, quantitative predictions that go beyond simple trend analysis.
- In collaboration with Professor Seung-Beom Hong's research team at KAIST.

# Bringing AI to End-of-Line QC—The Battery Industry’s Uncharted Territory

While End-of-Line inspections in battery manufacturing are still dominated by hardware-based physical and visual checks, Onbridge sets itself apart with AI-driven electrochemical diagnostics that rigorously validate both performance and safety of finished cells.

Type	Hardware-Based EOL	Automation + Partial AI Integration
Representative Companies	HORIBA, A&D, ATS Industrial Automation, Gantner Instruments, BBS Automation	h-kon, Hahn Automation, Bosch Rexroth, AVL, A&D(Partial)
Core Technologies	High-voltage & current test equipment, insulation tests, BMS flashing, charging/discharging hardware, PLC-based control	Hardware-based EOL devices with added sensor data, machine learning, predictive maintenance & anomaly detection
Level of AI Utilization	None (hardware-centric)	Partial



# Scalability Across the Full Battery Lifecycle

From precise quality inspections at the manufacturing stage, to real-time performance and safety diagnostics during operation, and residual capacity evaluation with predictive insights for second-life use—Onbridge's solution delivers scalability that spans the entire lifecycle of the battery.

## STAGE 1 Battery Manufacturing

- Battery cell quality inspection (QC)
- Battery module performance testing
- Battery pack performance testing

## STAGE 3 Reuse & Remanufacturing

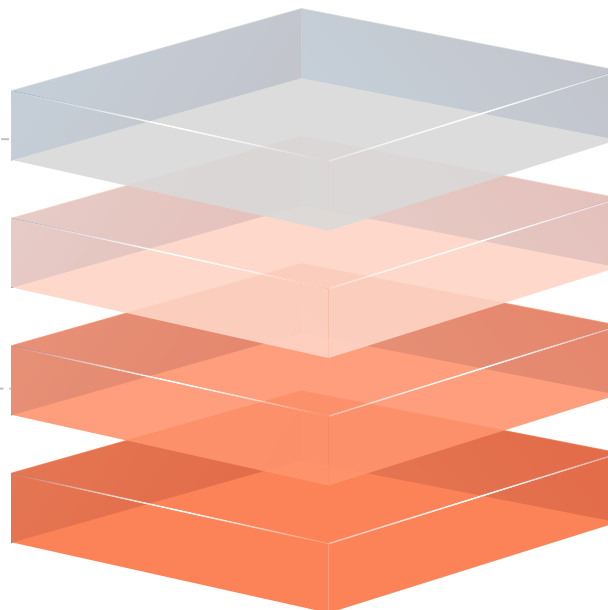
- Residual capacity evaluation
- Future performance prediction
- Classification and utilization strategy based on battery condition

## STAGE 2 Battery in Use

- EV and mobility battery performance testing and safety diagnostics (based on V2G technology)
- Decision-making for replacement

## STAGE 4 Recycling

- Complete neutralization based on safety control
- Monitoring of abnormal signals during stabilization process



# Building an R&D-Centric Team for Deep Tech Ownership



CEO

**Chiwon Kim**Energy management  
systemBattery reuse  
businessBattery performance  
evaluation

Head of Research

**Chihwan Lee**

- Ph.D. in Electronic Engineering, Kyungpook National Univ.
- Former Professor, Department of Electronic Engineering Yeungnam College of Science & Technology, Uiduk Univ.



Principal Researcher

**Donggwan Seo**

- M.S. in Electronic Control & Instrumentation, Sungkyunkwan University
- Experienced EV BMS and hardware platform, EV DCDC converter, Portable EV charger, Wireless charging infrastructure development

## Team Composition

HW Dev.	4
SW Dev.	2
Business, Sales	3

## Advisory

Power Electronics



Materials Science



Artificial Intelligence





# [HW] High-Precision Battery Inspection Equipment

## 1 Cyclor



- Equipment that charges and discharges modules and packs to balances and measures capacity and resistance to analyze battery condition and performance

Latest spec

User-friendly UI/UX

Remote CS

4-6M lead time

## 2 Diagnostic & Evaluation



- Equipment for basic performance testing, lifecycle evaluation, and reliability assessment of batteries, equipped with built-in diagnostic and evaluation solutions

All-in-one HW

Integrated evaluation  
solution

Test reports provided

# Pack Cyclor Specification



Category	Item		Specification	Remarks
Output	No. of Channels		1,000V/300A - 1ch.	
	Voltage	Setting / Reading Range	100 ~ 1,000V	
		Resolution	100mV	16bit
		Setting(D/A) Accuracy	± 0.1 %	
		Reading(A/D) Accuracy	± 0.1%	
	Current	Setting / Reading Range	0 ± 300A	
		Resolution	100mA	16bit
		Setting(D/A) Accuracy	± 0.1%	
		Reading(A/D) Accuracy	± 0.1%	
		Range	Upt to 4 divisions	TBD
	Power		± 300KW	
	Time	Switching Time	20 ms	
		Rising/Falling Time	10ms	
	Operation Mode		Pattern, CC, CV, CP, CR	
	Switching Frequency		15kHz	
Input	AC Input Voltage		3Phase 380V ±10%	
	AC Input Current		App. 456Arms	
	AC Input Frequency		60Hz ±2Hz	
	AC Input Power		App. 332KVA	
	Power factor		≥ 0.98	
	Efficient		≥ 93%	
Other Features	Contact Method		4-Terminal (Kelvin)	
	Protection Features		OVP, OCP, OT, EMG stop	Fuse & MCCB, SPD
	Communication Method		CAN, Ethernet	
	Parallel Connections		2 Parallel	
	Size(W x D x H)		2500 x 1200 x 2000 mm	TBD
	Certifications		KC	

# Module Cyclr Specification



Category	Item		Specification	Remarks
Output	No. of Channels		100V/300A - 1ch.	DC Rated
	Voltage	Setting / Reading Range	30 ~ 100V	TBD
		Resolution	100mV	16bit
		Setting(D/A) Accuracy	± 0.1 %	
		Reading(A/D) Accuracy	± 0.1%	
	Current	Setting / Reading Range	0 ± 300A	
		Resolution	100mA	16bit
		Setting(D/A) Accuracy	± 0.1%	
		Reading(A/D) Accuracy	± 0.1%	
		Range	300mA (rms)	
	Power		± 30KW	
	Time	Inverter Switching Frequency	15Khz	
		Converter Switching Frequency	20Khz	
		Transient Response	Within 20 ms	
Input	Operation Mode		Pattern, CC, CV, CP, CR	
	AC Input Voltage		3Phase ① 380V, ② 440V	
	AC Input Current		App. ±50Arms	
	AC Input Frequency		① 50Hz ±2Hz, ② 60Hz ±2Hz	
	AC Input Power		App. 33KVA	
	Power factor		≥ 0.98	
	Efficient		≥ 94%	
Other Features	Contact Method		4-Terminal (Kelvin)	
	Protection Features		OVP, OCP, OT, EMG stop	Fuse & MCCB, SPD
	Communication Method		CAN, Ethernet	
	Parallel Connections		2 Parallel	
	Size(W x D x H)		850 x 850 x 1860 mm	
	Certifications		KC	

# [SW] Battery Diagnostic & Evaluation Solution

**Test Report**

No. 20037170 (sample)

**Basic Information**

Vehicle Manufacturer	Hyundai-KIA	Capacity	78.80Ah
Vehicle Model	IONIQ	Maximum Voltage	398.40V
Configuration	2P96S	Minimum Voltage	288.00V
Voltage	355.20V		

**Inspection Information**

Inspection Type	Quick Inspection	Inspection Date	2024.09.01
Start Time	11:40:00	End Time	12:00:00
Duration	00:20:00		

**Inspection Results**

01/09/2024

SOC (State of Charge)	SOH (State of Health)	Battery Grade <b>B</b>
69.91%	88.25%	
SOP (State of Power)	SOB (State of Balance)	
80.15%	100.00%	

1. This report reflects the test results for the samples provided by the client and does not guarantee the quality of the entire product batch.  
2. This report cannot be used for promotion, advertisement, or litigation without prior consent from our test lab and is strictly prohibited from any unauthorized use.  
3. Copies of this report are considered invalid.

OnBridge.

A comprehensive solution that diagnoses and evaluates battery performance from multiple angles using degradation algorithms based on battery mechanisms

## Battery Degradation Algorithm

### 1 DC-IR

Assess battery aging by measuring DC internal resistance

### 2 AC-IR

Estimate degradation levels by measuring AC internal resistance at specific frequencies

### 3 EIS

Analyze phase shifts and impedance between voltage and current across different frequencies

### 4 Form factor

Evaluate impact of form factor characteristics on performance

### 5 Chemical Composition

Identify degradation factors caused by variations in battery material composition

### 6 BMS Data

Track battery usage history through BMS data