WHITE PAPER

Making Battery Storage Assets Measurable, Recoverable, and Financeable

The EIPI Care + Cure Framework for Long-Term Asset Value

From hidden losses to value recovery

Executive Summary

Global battery storage deployment is entering a scaled operating phase. Thousands of projects commissioned in recent years are now shifting from construction and ramp-up to long-term operation across diverse markets, applications, and asset configurations. As the installed base grows, operators, owners, and investors are confronting a critical realization: **operational availability does not guarantee economic performance. Storage assets need to become measurable, recoverable, and financeable.**

1. **Global battery storage deployment is entering a scaled operating phase.**
   The industry has moved beyond early adoption. Storage fleets are now active in wholesale markets, capacity mechanisms, renewable firming, and behind-the-meter applications. The focus must shift from building more assets to operating existing assets better.

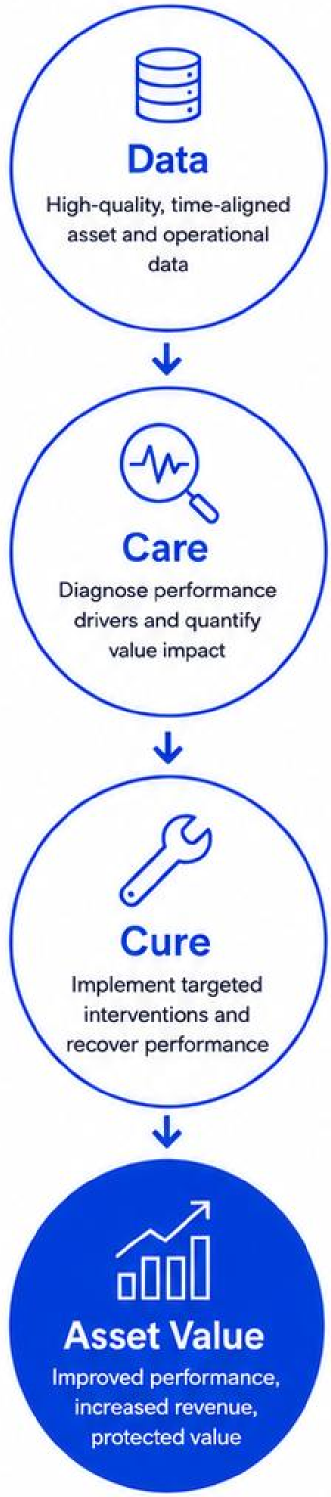
2. **Long-term asset value management is becoming the next challenge.**
   Degradation, market volatility, and evolving revenue stacks are creating persistent pressure on margins. The difference between expected and realized value is becoming the defining issue for asset owners.

3. **Online operation does not guarantee realized economic value.**
   Assets can be online and compliant while still losing money due to hidden performance gaps, suboptimal dispatch, latent degradation, or unresolved system issues.

4. **Traditional monitoring approaches cannot explain value loss.**
   Conventional SCADA and alarm-based systems report symptoms, not causes. They lack the diagnostic depth, correlation, and forward-looking insight required to determine economic impact and recovery potential.

5. **Care + Cure provides a methodology from diagnosis to recovery.**
   EIPI Energy's Care + Cure framework combines data intelligence, engineering diagnostics, and performance recovery services to identify value loss, quantify impact, and implement targeted interventions that restore performance and protect long-term value.

ASSET PERFORMANCE MANAGEMENT FRAMEWORK



Key Conclusion: The battery storage industry must evolve from simple operation monitoring to asset performance value management.
Care + Cure is the practical pathway to ensure storage assets deliver the reliability, profitability, and bankability that the energy transition demands.

The Hidden Problem After Commissioning

Commissioning is not the finish line. Most BESS assets begin to lose value the moment they go online.

For years, the industry has relied on availability and uptime as the primary indicators of asset health. If a system is online and alarms are clear, it is considered to be operating as intended.

However, real-world data tells a different story. Even when systems appear healthy on the surface, they often lose significant value due to suboptimal operation, slower response, hidden degradation, and capacity fade.

These issues are not always visible in traditional monitoring systems, but their impact is felt in lower revenues, higher operating costs, and shortened asset life.

The challenge is no longer just about building more assets, but about understanding and managing the long-term economic performance of the assets we already have.

> ### Key Conclusion
> Operational availability does not guarantee economic performance. The hidden value gap is real, measurable, and growing.

Operational Availability ≠ Economic Performance

The System Looks Normal

- The BESS is online.
- Alarms are normal.
- No critical faults.

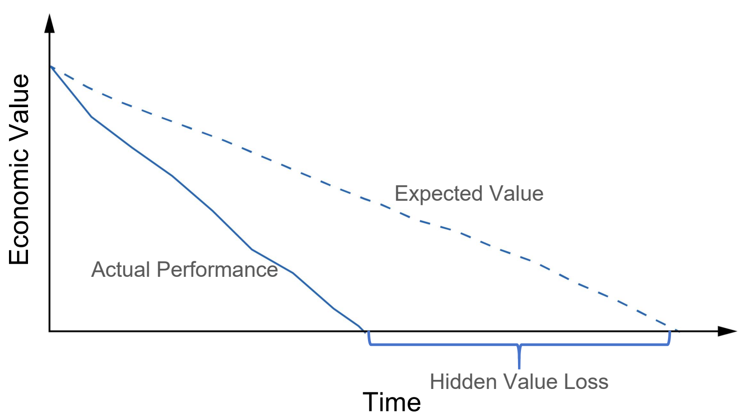
But Performance Is Degrading

- Slower response.
- Lower discharge power.
- Capacity fade.
- Increased degradation.
- Suboptimal dispatch.

Value Is Quietly Lost

- Lower revenue.
- Higher O&M cost.
- Shortened asset life.
- Reduced project IRR.

The Hidden Value Gap



Where BESS Value Is Lost

The gap between expected and realized storage value is created by multiple interacting loss mechanisms.

Revenue loss is not caused by a single issue. It results from combined limitations across strategy, operational response, available capacity, and degradation behavior.

Understanding where value is lost is the first step toward recovery.

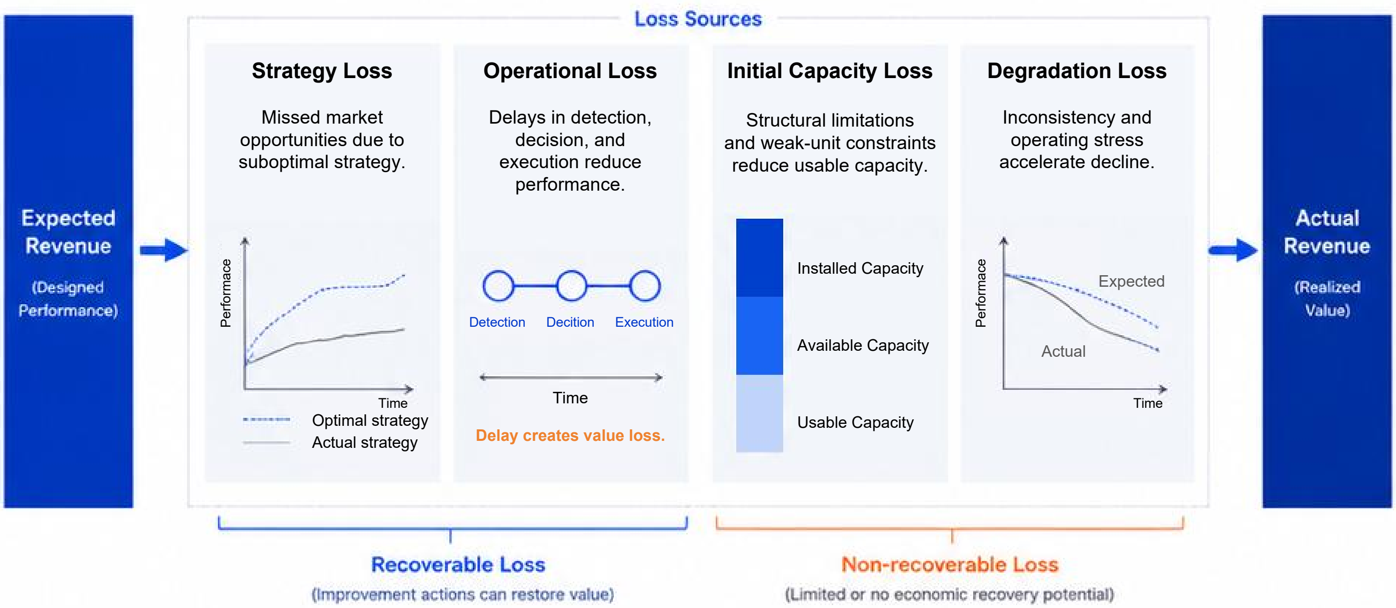
EIPI evaluates loss sources across multiple dimensions to identify where performance deviation occurs, how much economic value is affected, and which losses are potentially recoverable.

Not all losses have the same recovery potential. By distinguishing recoverable losses from non-recoverable losses, asset owners can prioritize improvement actions based on measurable economic impact.

Key Takeaways

- Value loss is created by multipleinteracting performance limitations.
- Losses emerge across strategy, response, capacity, and degradation.
- Not all losses are recoverable.
- Revenue recovery begins with accurate loss attribution.

Revenue Loss Attribution Model



Revenue recovery begins with accurately identifying where value is being lost.

Why Traditional EMS Is Not Enough

Traditional EMS platforms are essential for operational control, but they were not designed to explain asset-level economic performance.

1. Strong on Monitoring, Limited on Meaning

EMS systems excel at real-time operations. They display device states, alarms, setpoints, and dispatch execution, and ensure the plant responds as commanded. However, these signals alone do not explain why revenue deviates from expectation, why some responses earn less than others, or why usable capacity degrades over time.
EMS observes what happens; it does not quantify the economic consequences of why it happens.

2. Owners Need Answers, Not Just Data

For asset owners and operators, the critical questions are not only what happened, but why it happened, how much value was lost, and what action should be prioritized. Conventional monitoring does not connect device events to market outcomes or translate operational behavior into financial impact. Without this layer of interpretation, teams face longer investigation time, uncertain root causes, and slow decision cycles—all of which reduce long-term asset value.

What Traditional EMS Does Well (Monitoring)	Dimension	What Asset-Performance Platforms Deliver (Interpretation)
Live states, measurements, and topology	**Device status**	Converts live states into performance context
Alarms and faults are visible	**Alarm visibility**	Links alarms to economic impact and urgency
Revenue deviation not attributed	**Revenue-loss attribution**	Quantifies revenue loss by root cause and market effect
Capacity degradation not quantified	**Capacity-loss visibility**	Measures usable-capacity loss and drivers
Issues must be manually investigated	**Action prioritization**	Recommends and ranks actions by value impact

Typical EMS View

Asset Performance View

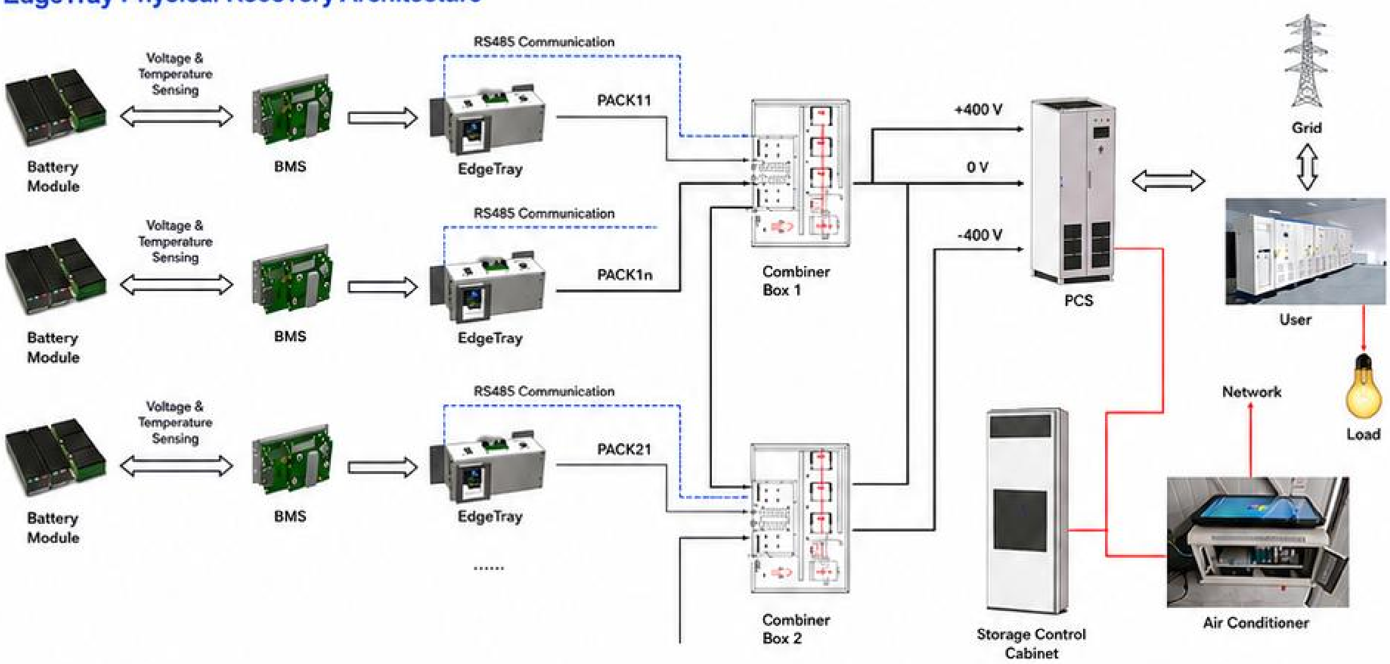
> *A BESS that is electrically visible is not necessarily economically visible.*

EIPI Cure: Physical Recovery of System Capability

Identifying performance loss is only the first step. Recovering asset value requires a physical pathway that can modify the system operating boundary and restore constrained capability.

EIPI Cure transforms performance diagnosis into physical recovery through a controllable execution layer designed for practical retrofit deployment. Unlike replacement-based approaches, Cure focuses on recovering stranded capability by addressing the physical constraints that limit battery system performance.

EdgeTray Physical Recovery Architecture



1. Energy Path Reconfiguration
Optimizing electrical pathways to improve system-level energy utilization.

2. Weak Unit Stress Reduction
Reducing stress on degraded or constrained units.

3. Power Redistribution
Allowing stronger units to contribute more effectively.

4. Current Path Optimization
Improving electrical balance and reducing unnecessary thermal and electrical stress.

5. Local Isolation
Preventing degraded components from creating system-level limitations.

6. Usable Capacity Reorganization
Recovering stranded capacity without full system replacement.

EdgeTray deployed on a battery storage cluster in the field.

Scalable Retrofit Deployment

1. Factory Testing
1 Cluster: 1 person × 4 hours
N Clusters: 4N person-hours

2. Retrofit Installation
1 Cluster: 2 person-days
N Clusters: 2N person-days

3. Commissioning
1 Cluster: 2 people × 7 days
Large systems: 2 people × (7 + N/12) days, N > 12

Key Conclusion

EIPI Cure provides a practical physical pathway to convert diagnosed performance loss into measurable asset recovery. By combining physical intervention capability with scalable deployment, Cure enables storage assets to recover value without full system replacement.

EIPI Care: Making BESS Performance Visible

Battery storage assets generate large volumes of operational data, but data availability alone does not guarantee asset understanding.

The key challenge is transforming fragmented operational signals into measurable performance insights that explain where value is created, where value is lost, and where improvement opportunities exist.

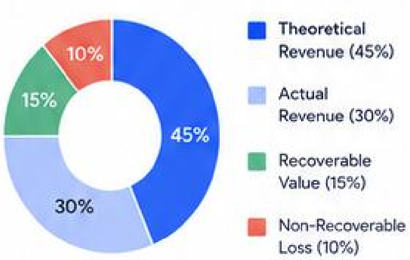
Care provides an asset-performance interpretation layer that connects operational behavior with economic outcomes. Rather than simply displaying telemetry, Care evaluates battery assets across four critical dimensions:

- **Revenue visibility:** Understanding the gap between theoretical revenue and realized economic performance, while identifying recoverable value and the underlying drivers of loss.
- **Operational visibility:** Connecting operational events, response efficiency, recovery time, and repair duration to measurable performance impact.
- **Capacity visibility:** Quantifying rated capacity, available capacity, and recoverable capacity to reveal how much usable energy remains constrained by system limitations.
- **Degradation and inconsistency visibility:** Identifying cell, module, and pack-level variations that accelerate degradation and reduce long-term asset value.

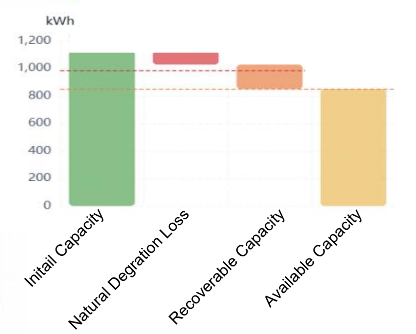
Care transforms complex operational information into actionable performance intelligence.

By linking technical conditions with economic impact, Care establishes the foundation for targeted recovery actions and enables the transition from performance diagnosis to physical value restoration.

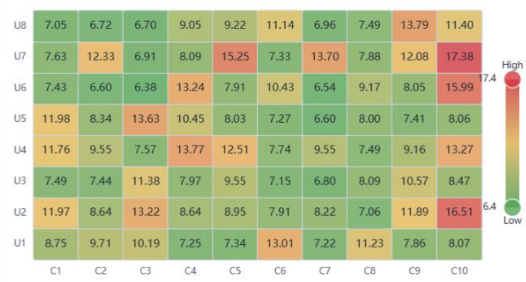
A. Revenue Visibility Breakdown



C. Capacity Visibility (Example)



D. Degradation & Inconsistency Heatmap



> ***Care is not a monitoring layer.***
> ***It is an asset-performance interpretation system that makes economic impact measurable and creates the foundation for targeted recovery through Cure.***
> Care identifies where asset value is lost. Cure defines how that value can be recovered.

Why the Framework Is Credible

A credible battery asset performance methodology requires more than analytics. It requires engineering principles, physical execution capability, and validation across real-world operating conditions.

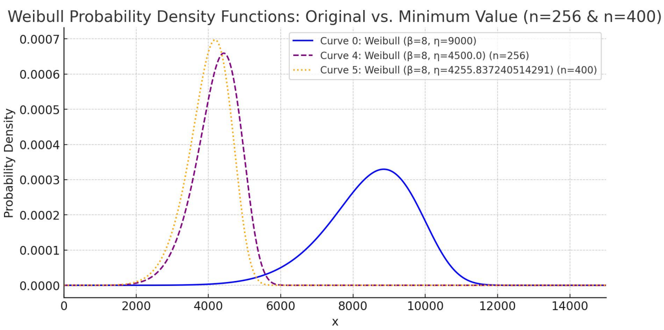
1. Scientific Foundation

EIPI combines degradation modeling and asset-performance analysis to understand long-term battery value loss.

- Weibull-based degradation modeling
- Cell-level inconsistency analysis
- System-level performance evaluation

$$F(t) = 1 - e^{-(t / \eta)^\beta}$$

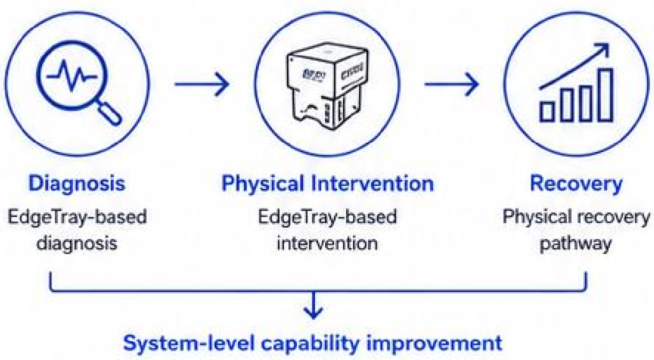
$$m \approx \mathrm{Weibull}(\beta, \eta/256^{1/\beta})$$



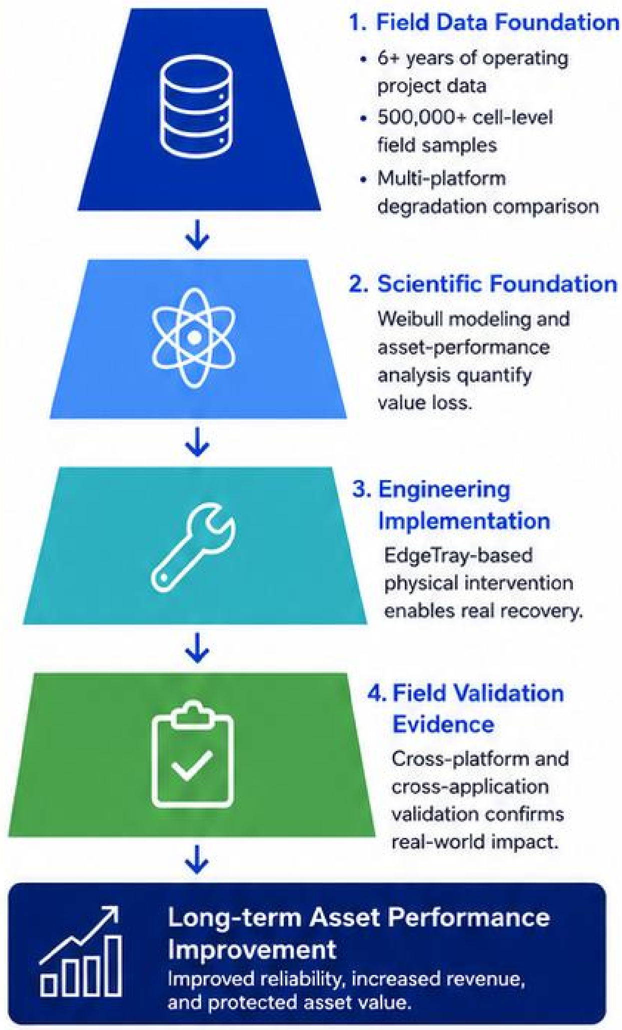
Balanced systems degrade more slowly; inconsistent systems shift the effective Weibull curve forward.

3. Engineering Implementation

Unlike monitoring-only approaches, EIPI integrates physical execution through EdgeTray-based intervention.



The Evidence Stack



4. Field Validation Evidence

Battery Platform	Application Scale		Validation Evidence
	Commercil Storage	Utility-scaleStorage	
86Ah LFP	✓	✓	Validated
280Ah LFP	✓	✓	Validated
314Ah LFP	✓	—	Evaluated

✓ Validated (Field Proven) ○ Evaluated (Pilot / Early Field) — Not Applicable / Pending

82.5MWh field deployment validation

Key Conclusion: EIPI is not a monitoring overlay or a software optimization layer. It is a validated asset-performance methodology combining data-driven diagnosis, physical recovery capability, and field-proven performance improvement.

Case Study 1: Recovering Hidden Capacity Loss in a 2MWh Commercial BESS

The effectiveness of the EIPI framework is demonstrated through a commercial-scale battery storage project where hidden performance loss was identified and recovered.

Project Background

System Size	2MWh user-side batteryenergy storage system
Use Case	Peak-valley arbitrage
Cell Type	86Ah LFP cells
Application	Commercial BESS application
Monitoring	Existing EMS/BMS monitoring environment

Challenge Identification

Although the system remained operational, EIPI Care identified hidden performance constraints:

- Capacity limitation
- Inconsistency-driven constraints
- Performance deviation from expected operation

1 Before

System operational, but performance significantly constrained.

- Limited usable capacity
- Higher internal resistance
- Reduced operational flexibility

2 Diagnosis

EIPI Care identified measurable and recoverable performance gaps by analyzing:

- Operational behavior
- Capacity availability
- Degradation characteristics

3 Intervention

EIPI Cure applied targeted physical recovery actions to improve usable capability, focusing on:

- Energy-path optimization
- Weak-unit stress reduction
- System-level capability recovery

4 Recovery

Post-intervention results confirm significant and measurable recovery.

- Usable capacity restored
- SOH improved
- Performance constraints reduced

Verified Results

Recovered Usable Capacity

+262 kWh

SOH Improvement

87%

- ✓ Improved operational flexibility
- ✓ Reduced performance constraints
- ✓ Validated recovery potential

Key Conclusion: Measured diagnosis combined with targetedphysical intervention can convert hidden technical loss intorecoverable asset value.

Case Study 2: Field-Validated Performance Improvement in an 82.5MWh Utility Asset

Large-scale energy storage assets require performance management approaches validated beyond individual commercial projects.

1. Project Background

A utility-scale 82.5MWh battery storage project using 280Ah cells was evaluated to compare degradation behavior with and without EIPI intervention.

Asset Scale	82.5MWh utility-scale BESS
Cell Platform	280Ah LFP
Validation Scope	With vs. without EIPI intervention
Use Context	Long-cycle field operation

2. Field Validation Evidence

- 6 years of operating project data
- 500,000+ cell-level field samples
- Long-cycle operational performance analysis

The validation is supported by long-term field data and cross-platform operating evidence.

3. Validation Methodology

Cell-level data analysis → Degradation behavior modeling → Cross-platform comparison → Long-term performance evaluation

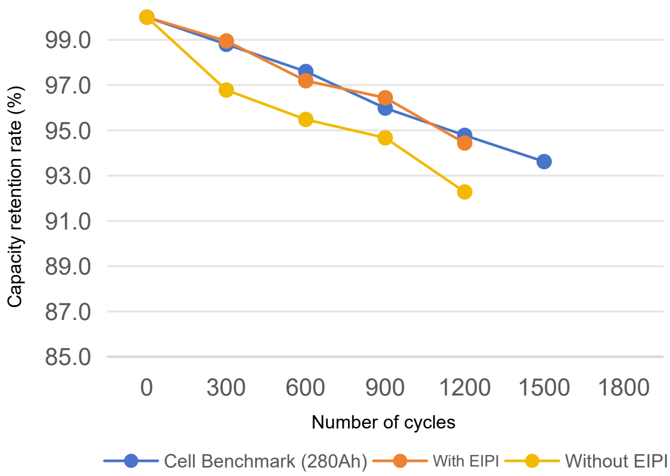
Battery degradation is influenced not only by cell chemistry, but also by operating conditions, inconsistency evolution, and system-level constraints.

4. Scalability

The validation demonstrates applicability across different battery platforms, different asset sizes, and different operating environments.

- Different battery platforms
- Different asset sizes
- Different operating environments

Observed Degradation Trajectory



Observed comparison based on long-cycle operational analysis of utility-scale field data.

Cross-platform Validation

86Ah LFP	Commercial storage
280Ah LFP	Utility-scale storage
314Ah LFP	Platform evaluated

Cross-platform validation supports scalability across asset classes and operating environments.

Key Conclusion: EIPI demonstrates scalable asset-performancemanagement capability across commercial and utility-scalebattery storage applications.

Value for Asset Owners and a Practical Path to Start

For asset owners, battery storage performance is not only an equipment challenge. It is a long-term asset management and investment confidence challenge.

EIPI enables asset owners to move from equipment monitoring toward measurable asset performance management. By making asset condition, performance deviation, and recovery opportunities visible, EIPI supports more informed operational and investment decisions.

Asset Challenge
↓
Performance Intelligence
↓
Investment Decision

Performance Transparency

Unified understanding of:

- Asset condition
- Performance gaps
- Operational risks

Recoverable Value

Identification and execution of:

- Lost value recovery opportunities
- Capacity improvement opportunities
- Performance optimization actions

Financeable Infrastructure

Improved confidence through:

- Transparent asset condition
- Measured performance imporvement
- Evidence-based decision making

Practical Path to Start

1 Historical Data Diagnosis

Analyze historical operational data to identify performance gaps and degradation patterns.

→

2 Care Online Monitoring

Deploy EIPI Care for real-time monitoring and continuous performance visibility.

→

3 Care + Cure Validation

Validate recovery opportunities and quantify potential value improvement.

→

4 Portfolio Deployment

Execute targeted interventions and scale across the asset portfolio.

Key Conclusion: EIPI provides a practical pathway from asset transparencyto measurable recovery and long-term value realization.

EIPI Energy develops battery storage asset-performance solutions combining data-driven diagnosis with practical recovery pathways, helping asset owners improve long-term value realization.