IKKUNA WHITEPAPER

ONEDGE ENERGY

A Proposed Open Standard for Certified BESS Operational Evidence

Candidate Specification / Pre-TRL-7 Validation

Issuer:	IKKUNA SpA
Product / Standard:	ONEDGE ENERGY
Core Technology:	Embedded Convex Matching Engine Kernel / ECME Kernel
Version:	v0.0.2
Release Type:	Specification-hardening update
Supersedes:	v0.0.1
Status:	Proposed open standard; candidate specification; pre-TRL-7 validation
Document Type:	Strategic and technical whitepaper draft
Intended Audience:	Banks, OEMs, project owners, operators, regulators, auditors, standard institutions, and strategic infrastructure partners
Date:	May 5, 2026

Abstract

Chile and other renewable-heavy power systems are entering a battery-intensive phase in which the core bottleneck is no longer only energy generation, but the certified coordination of flexibility assets under simultaneous physical, financial, regulatory, operational, and warranty constraints.

ONEDGE ENERGY, powered by IKKUNA's ECMEKernel, is presented in this document as a proposed open standard and candidate specification for battery energy storage system operational evidence. Its central object is the Golden Record: a cryptographically committed operational evidence object that classifies each certified event as Compliant, Breach, or Opacity by binding asset state, dispatch context, telemetry provenance, operating-envelope constraints, state-transition logic, and verification artifacts into an auditable record.

The strategic principle is: **open standard at the interface, sovereign proof authority at the core**. This allows banks, regulators, project owners, asset manufacturers, operators, auditors, and system institutions to adopt a shared evidence language while preserving IKKUNA's sovereign proof engine against copycatting, commercial-layer capture, and premature standard claims.

Version Note

v0.0.2 is a specification-hardening update to the ONEDGE ENERGY whitepaper. It supersedes v0.0.1 and introduces stricter candidate-standard discipline: the three-state Golden Record model, explicit verification boundaries, conformance tiers, threat-model framing, document stratification, semantic-versioning governance, and a candidate extension for flexible-load and curtailment-provenance certification.

This version remains pre-TRL-7. It does not claim industry adoption, financial guarantees, OEM acceptance, regulatory approval, CEN endorsement, EPRI endorsement, or final standard status.

Changelog

v0.0.1	First controlled pre-release whitepaper. Introduced ONEDGE ENERGY as a proposed open standard and candidate standard entering TRL-7 validation. Defined the Golden Record as a compliant / breach / opacity evidence object.
v0.0.2	Specification-hardening update. Adds verification boundary, conformance tiers, threat model, candidate flexible-load / curtailment-provenance extension, document stratification, semantic-versioning governance, and tighter claim discipline. Clarifies pre-TRL-7 status.

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1. Executive Summary

Chile is entering a structurally new phase of its energy transition. The challenge is no longer only the deployment of renewable generation. It is the ability to coordinate large volumes of battery storage, renewable generation, heavy industrial demand, data centers, mining loads, and grid-firmness requirements under a common operational evidence language.

The CEN coordinates the Chilean National Electric System, the SEN, according to system-level objectives such as security, continuity, economic dispatch, and open access. That coordination protects the power system and indirectly protects investors by making grid operation institutionally predictable. However, the CEN's dispatch mandate is system-level. It is not designed to become the warranty arbiter, lender diligence agent, telemetry-provenance authority, or asset-degradation certifier for every BESS.

This produces a structural gap:

> **A dispatch instruction can be systemically correct and still create asset-level warranty, degradation, lender-legibility, or telemetry-provenance ambiguity.**

ONEDGE ENERGY proposes to address this gap by creating a certified operational evidence layer for energy-flexibility assets. It is not merely an optimizer. It is a candidate standard-setting framework for making battery operation financeable, warrantable, auditable, insurable, and institutionally legible.

The strategic proposition is:

> **ONEDGE ENERGY converts BESS operation into certified evidence: proving compliance when the asset respects its envelope, proving breach when it does not, and flagging opacity when telemetry cannot support a reliable conclusion.**

2. The System-Level Problem

Modern electricity systems increasingly depend on flexibility. High renewable penetration creates periods of excess generation, congestion, curtailment, steep ramping needs, and scarcity events. Battery storage is the natural physical answer, but storage assets are not passive wires or conventional generators. They are chemically, thermally, contractually, and financially constrained assets whose economic value depends on how they are operated.

A BESS can provide arbitrage, reserves, ancillary services, congestion relief, ramping support, capacity value, and renewable firmness. But every dispatch decision may affect:

- state of charge;
- depth of discharge;
- C-rate;
- thermal stress;
- cycle count;
- throughput;
- degradation;

- warranty compliance;
- residual value;
- refinancing assumptions;
- LTSA treatment;
- insurance treatment;
- and lender confidence.

The market therefore faces a coordination problem. The grid sees dispatch. The bank sees debt risk. The OEM sees warranty exposure. The owner sees revenue and asset life. The operator sees feasibility and control. The regulator sees system security and market transparency. These perspectives are individually rational, but they do not currently share a trusted operational evidence object.

ONEDGE ENERGY exists to propose that object as a candidate open standard entering TRL-7 validation.

3. The Hidden Cost of Operational Opacity

Operational opacity is priced twice.

Banks price opacity through a higher cost of capital. OEMs and LTSA providers price opacity through more defensive warranty and service terms. Project owners then absorb both premia, even where the asset may be operated prudently.

The hidden cost of opacity appears through at least five channels:

1. **Higher WACC:** lenders cannot verify whether dispatch behavior preserves asset integrity.
2. **Higher LTSA and warranty premia:** OEMs protect themselves against ambiguous or abusive operating patterns.
3. **Lower refinancing value:** historical operation is not lender-readable.
4. **Higher dispute cost:** degradation attribution is reconstructed after the fact.
5. **Lower system trust:** banks, OEMs, operators, owners, and regulators lack a shared evidentiary record.

For a reference utility-scale BESS asset of USD 100 million, even conservative risk compression is material. A 50 basis point reduction in WACC implies roughly USD 500,000 per year of financing-cost effect on a USD 100 million capital base, before considering compounding, refinancing, valuation uplift, or debt-service coverage effects. Similarly, a 10% reduction in LTSA, warranty-support, insurance, or technical-risk premia can create additional savings over the life of the asset.

These figures are not presented as guaranteed outcomes. They are directional proxies for the margin targeted by ONEDGE ENERGY: the risk premium embedded in operational opacity.

IKKUNA's internal scenario modeling treats the Golden Record as the repricing trigger: the moment where dispatch quality becomes lender- and auditor-readable evidence. The mature end-state is programmable warranty logic, where OEM-rooted telemetry and certified operational records reduce ambiguity between market operation and hardware degradation.

The financial thesis is therefore:

> **ONEDGE ENERGY does not merely improve dispatch. It targets the risk premium embedded in operational opacity.**

4. What ONEDGE Solves

ONEDGE ENERGY solves the lack of a trusted operational evidence standard for energy-flexibility assets.

The product is a certified operational evidence layer, implemented through IKKUNA's ECMEKernel and expressed through the Golden Record. It creates a repeatable way to answer the following question:

> Given the dispatch context, asset state, telemetry, declared constraints, and optimization result, did the asset operate in a way that is physically feasible, financially legible, warranty-defensible, and evidentially classifiable?

The ONEDGE ENERGY layer supports:

- dispatch optimization under physical constraints;
- operational envelope verification;
- telemetry provenance;
- state-transition consistency;
- Golden Record issuance;
- audit-supporting operational receipts;
- lender-readable evidence;
- OEM warranty-support records;
- OEM warranty-defense records;
- operator attribution records;
- breach classification;
- opacity-event classification;
- and standard-formation governance artifacts.

The objective is not to replace system dispatch, OEM monitoring systems, sensor hardware, BMS, SCADA, meters, inverters, or operator control rooms. The objective is to certify the operational evidence state that sits between them.

5. Day in the Life of a BESS Dispute

Consider a realistic scenario in Chile's SEN.

A 100 MW BESS asset is operating during a high-temperature summer afternoon. Solar output is falling, system conditions are tight, and the asset receives a dispatch instruction requiring rapid response to support grid stability and frequency control.

The operator follows the dispatch instruction. The asset performs. Revenue is earned. The system remains stable.

Three months later, the asset's degradation curve appears worse than expected. The owner files a claim under the warranty or LTSA framework. The OEM reviews the operating history and argues that the asset was stressed outside its intended operating profile. The operator responds that it followed dispatch. The lender becomes concerned because accelerated degradation may impair residual value, debt-service coverage, refinancing assumptions, or insurance treatment.

5.1. Without ONEDGE

The dispute becomes evidentiary.

The parties argue over ambient temperature, cell temperature, state of charge, depth of discharge, C-rate, throughput, dispatch order timing, inverter response, SCADA logs, BMS logs, operator conduct, OEM warranty exclusions, and whether the asset was physically abused or simply used as expected.

The owner hires forensic engineers. The OEM hires its own experts. The lender downgrades internal risk assumptions. The operator becomes exposed. The dispute may last months or years. Even if the claim is eventually resolved, the project suffers from uncertainty, reputational stress, higher financing friction, and weaker future refinancing value.

The core problem is not only degradation. The core problem is that no trusted operational evidence object existed at the moment of dispatch.

5.2. With ONEDGE: Compliant Operation

The same event produces a Golden Record.

The Golden Record records the dispatch context, the asset state before response, the declared thermal and operational envelope, relevant telemetry provenance, the feasible optimization path, the certified physical response, the state transition after dispatch, and whether the response remained inside the warranty-relevant envelope.

If the asset stayed within the LTSA-defined thermal and operational limits, the OEM has a clear evidentiary basis to honor the claim or avoid disputing it. The bank does not need to underwrite a narrative. It can review the certified operational record. The owner does not need to prove prudence after the fact. Prudence was recorded when the event occurred.

5.3. With ONEDGE: Abusive Operation

The Golden Record is symmetric. It does not exist only to support project owners.

If a project owner or operator cycles a BESS asset three times per day during high-temperature conditions, exceeds the LTSA envelope, violates declared C-rate limits, operates outside agreed state-of-charge windows, or otherwise stresses the asset beyond warranty-relevant limits, the Golden Record records that fact.

In that case, the Golden Record provides the OEM with objective evidence to rightfully deny or limit a warranty claim.

This symmetry is critical. A credible operational standard must protect both sides:

- owners and operators when the asset was operated inside the certified envelope;
- OEMs when the asset was operated outside the certified envelope.

The Golden Record therefore reduces ambiguity rather than reallocating blame.

5.4. With ONEDGE: Opacity Event

A third outcome is possible.

If the required telemetry is missing, corrupt, inconsistent, delayed, non-sequenced, or unverifiable at the hardware or ingestion layer, ONEDGE ENERGY does not certify compliance. It securely flags an **Opacity Event**.

That means the proposed standard does not produce false confidence where the underlying evidence is defective.

The design principle is:

> **ONEDGE ENERGY either proves compliance, proves breach, or flags opacity. It does not convert missing data into false certainty.**

6. Open Standard at the Interface, Sovereign Core at the Proof Engine

In a high-interest, copycat-prone environment, IKKUNA assumes that the vocabulary will be copied. Competitors may claim to offer "dispatch certification", "AI optimization", "battery health passports", "warranty analytics", or "lender-grade telemetry".

The defensive moat is therefore not secrecy alone. The moat is institutional embedding:

> **Everyone can describe the category, but the credible market implementation points back to IKKUNA.**

The correct structure is an open-standard architecture with a sovereign proof core.

6.1. Open or Semi-Open Layer

The following elements should be standardized and made institutionally legible:

- certificate schema;
- telemetry categories;
- data provenance requirements;
- operating-envelope fields;
- audit interface;
- API-level submission logic;
- conformance terminology;
- governance principles;
- antitrust-safe access criteria;
- reporting categories for lenders, OEMs, owners, operators, and regulators.

6.2. Sovereign Layer

The following remain protected by IKKUNA:

- ECME Kernel;
- deterministic optimization engine;
- physical state-transition verification;
- cryptographic proof architecture;
- Golden Record issuance authority;
- calibration methodology;
- certification methodology;
- reference validator;
- proof circuits;
- and StandardCo governance authority.

This produces the intended market structure:

> Anyone can understand the standard. Qualified actors can conform to the standard. IKKUNA remains the trusted issuer and reference validator of the standard.

7. StandardCo and MarketCo Roles

For specification purposes, this document uses abstract architectural roles rather than bilateral commercial identities.

7.1. StandardCo

StandardCo refers to the entity responsible for:

- the candidate standard;
- certification methodology;
- proof logic;
- Golden Record schema governance;
- conformance definitions;
- telemetry-provenance requirements;
- verification boundaries;
- and sovereign proof authority.

Within the current architecture, IKKUNA acts as StandardCo.

7.2. MarketCo

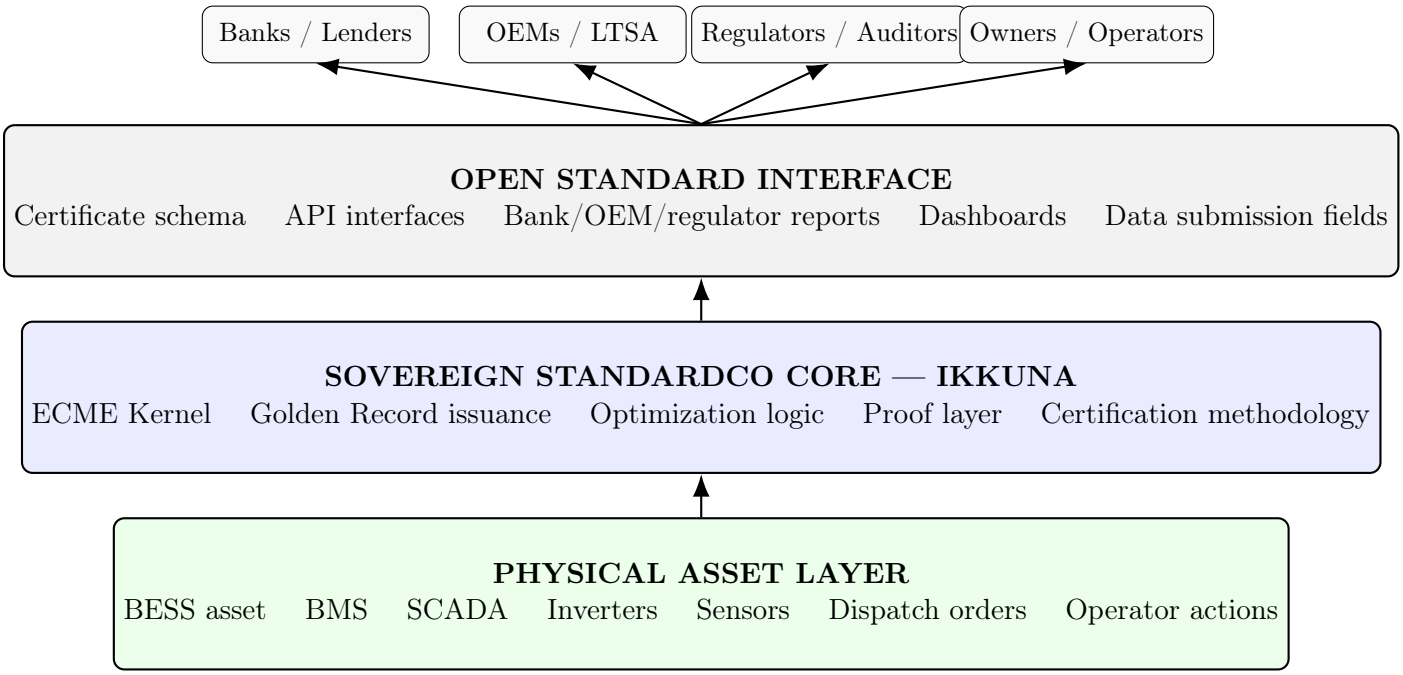
MarketCo refers to any commercial vehicle responsible for customer-facing deployment, commercial packaging, project origination, regional execution, or application-layer services.

MarketCo does not control the proof-generation core, Golden Record issuance authority, StandardCo conformance definitions, or the sovereign proof methodology.

This separation is the institutional expression of the principle:

Open standard at the interface. Sovereign proof authority at the core.

8. The ONEDGE Stack



The ONEDGE Stack: protecting the physical truth while standardizing the financial evidence.

This is the core of the Church & State separation. The market may adopt the open interface. IKKUNA preserves the sovereign proof core. The asset remains physically grounded.

9. Succinct Formalization of the Golden Record

Let a BESS asset be observed over an endogenous sequence of operational events indexed by $k \in \mathbb{N}$. The index k advances only when a new observable state transition occurs. No exogenous time assumption is required at the level of certification logic.

Let:

- $x_k \in \mathcal{X}$ denote the certified asset state at event k;
- $u_k \in \mathcal{U}$ denote the dispatch or control action;

- $d_k \in \mathcal{D}$ denote the external dispatch context, including system instruction and market condition;
- $\theta \in \Theta$ denote the declared asset model and warranty-relevant parameter set;
- $g(x_k, u_k; \theta) \leq 0$ denote the vector of physical, thermal, operational, warranty, and contractual constraints;
- T_θ denote the certified physical state-transition function;
- y_k denote telemetry observations from BMS, SCADA, meters, inverters, or other approved sources;
- $P(y_k)$ denote the telemetry provenance predicate;
- π_k denote a cryptographic proof or verification artifact;
- $h(\cdot)$ denote a collision-resistant commitment function.

The certified transition is:

$$x_{k+1} = T_\theta(x_k, u_k, y_k, d_k).$$

When convex dispatch optimization is used, the selected action may be represented as:

$$u_k^\star \in \arg\min_{u \in \mathcal{U}} C_k(u; x_k, d_k)$$

subject to:

$$g(x_k, u; \theta) \leq 0,$$

where C_k is the event-local cost, risk, degradation, or dispatch objective.

9.1. Telemetry Provenance Predicate

The telemetry provenance predicate is defined as:

$$P(y_k) = \begin{cases} 1, & \text{if required telemetry is complete, authentic, sequenced, and derived from approved asset-originated} \\ 0, & \text{otherwise.} \end{cases}$$

The operating-envelope predicate is defined as:

$$E(x_k, u_k; \theta) = \begin{cases} 1, & \text{if } g(x_k, u_k; \theta) \leq 0, \\ 0, & \text{otherwise.} \end{cases}$$

Let:

$$\sigma_k \in \{\mathsf{Compliant}, \mathsf{Breach}, \mathsf{Opacity}\}$$

denote the event classification.

Then:

$$\sigma_k = \begin{cases} \mathsf{Opacity}, & \text{if } P(y_k) = 0, \\ \mathsf{Compliant}, & \text{if } P(y_k) = 1 \text{ and } E(x_k, u_k; \theta) = 1, \\ \mathsf{Breach}, & \text{if } P(y_k) = 1 \text{ and } E(x_k, u_k; \theta) = 0. \end{cases}$$

The event-level Golden Record is defined as:

$$GR_k = h\left(x_k, u_k, d_k, y_k, \theta, P(y_k), E(x_k, u_k; \theta), \sigma_k, x_{k+1}, \pi_k, GR_{k-1}\right).$$

A daily, weekly, or project-level Golden Record may be represented as a Merkle or hash-chain aggregation:

$$GR_{\mathcal{K}} = h(GR_{k_1}, GR_{k_2}, \ldots, GR_{k_n}),$$

where $\mathcal{K} = \{k_1, \ldots, k_n\}$ is the relevant ordered set of certified events.

A valid Golden Record must satisfy five conditions:

1. **State consistency:** the recorded transition follows T_θ.
2. **Constraint evaluation:** the certified action is classified against $g(x_k, u_k; \theta) \leq 0$.
3. **Telemetry provenance:** y_k is traceable to approved asset-originated sources, or the event is classified as Opacity.
4. **Truth classification:** each event is classified as Compliant, Breach, or Opacity.
5. **Cryptographic integrity:** π_k verifies that the committed record was generated from the declared inputs and certification logic.

Thus, the Golden Record is not merely a report. It is a structured commitment to operational evidence:

> **A Golden Record is a cryptographically committed operational evidence object that classifies each certified event as compliant, breached, or opaque by binding asset state, dispatch context, telemetry provenance, operating-envelope constraints, state-transition logic, and verification artifacts into an auditable record.**

10. Verification Boundary: What ONEDGE Does Not Do

Institutional adoption requires precise boundaries.

10.1. ONEDGE Does Not

ONEDGE ENERGY does not:

- replace CEN or any system operator's dispatch authority;

- replace BMS, SCADA, meters, inverters, sensors, or OEM monitoring hardware;
- create telemetry where hardware telemetry does not exist;
- certify compliance where telemetry provenance fails;
- auto-resolve legal disputes;
- act as a legal adjudicator;
- replace lender diligence;
- replace OEM warranty terms;
- guarantee lower WACC;
- guarantee lower LTSA costs;
- guarantee warranty approval;
- prevent degradation;
- operate as a commercial dispatch monopoly;
- require market participants to access the ECME Kernel source code.

10.2. ONEDGE Does

ONEDGE ENERGY does:

- ingest baselined telemetry;
- evaluate declared operating envelopes;
- classify events as Compliant, Breach, or Opacity;
- produce audit-supporting certificates;
- reduce evidentiary ambiguity;
- support lender, OEM, owner, operator, auditor, and regulatory diligence;
- preserve the distinction between system dispatch authority and asset-level evidence.

The correct institutional claim is:

> **ONEDGE ENERGY does not manufacture certainty. It classifies the evidentiary state.**

11. Telemetry Provenance and Opacity Events

ONEDGE ENERGY does not replace sensor hardware, BMS infrastructure, SCADA systems, meters, inverters, or OEM monitoring systems. The proposed standard requires baselined data provenance from approved asset-originated sources.

The Golden Record is not designed to generate false certainty where the underlying telemetry is missing, corrupted, delayed, inconsistent, manipulated, or physically unavailable. If the required telemetry cannot be verified at the hardware or data-ingestion level, the Golden Record securely flags an **Opacity Event** rather than producing a false positive certification.

An Opacity Event may include, without limitation:

- missing telemetry;
- corrupted telemetry;
- inconsistent BMS/ SCADA/ meter values;
- unverified data origin;
- unexplained data gaps;
- sensor drift beyond accepted tolerance;
- delayed or non-sequenced data;
- mismatch between dispatch instruction and asset-response records;
- unavailable hardware-origin confirmation;
- unauthorized schema modification;
- or any data condition that prevents reliable certification.

In such cases, ONEDGE ENERGY does not certify what cannot be verified. It certifies the existence of operational opacity.

This is a core design feature. The purpose of the Golden Record is not to hide uncertainty, but to make uncertainty auditable.

12. Conformance Tiers

To make adoption incremental and institutionally legible, ONEDGE ENERGY v0.0.2 introduces conformance tiers. These tiers are preliminary and subject to refinement during TRL-7 validation.

Level	Description
Level 0	Telemetry observed, no certification. Asset-originated data may be collected or viewed, but no provenance baseline or event classification is asserted.
Level 1	Provenance-baselined telemetry. Approved asset-originated sources are identified, sequenced, and mapped to certification requirements.
Level 2	Event classification. Operational events are classified as Compliant, Breach, or Opacity.
Level 3	Lender/OEM report generation. Classified events are translated into reporting formats suitable for lender diligence, OEM warranty support, operator attribution, and owner review.
Level 4	Full Golden Record certification under StandardCo validation. The event sequence is committed, versioned, and validated according to the applicable Golden Record schema and StandardCo conformance rules.

These levels allow an asset owner, OEM, lender, or operator to adopt the standard progressively rather than through a single disruptive integration event.

13. Threat Model

As a candidate standard specification, ONEDGE ENERGY must explicitly identify adversarial, operational, and evidentiary failure modes.

The v0.0.2 threat model includes, without limitation:

- missing telemetry;
- corrupted telemetry;
- delayed or non-sequenced telemetry;
- sensor drift;
- manipulated sensor feeds;
- BMS / SCADA / meter inconsistencies;
- data replay;
- unauthorized schema modification;
- model drift;
- false curtailment claims;
- false compliance claims;
- false breach accusations;
- OEM data asymmetry;
- operator misreporting;
- dispatch-envelope mismatch;
- commercial misrepresentation;
- and attempts to treat opacity as compliance.

The three-state model is designed to reduce the impact of these threats by refusing to certify compliance where the evidentiary substrate is defective.

14. The Multi-Player Game

ONEDGE ENERGY operates inside a multi-player game. Each actor behaves rationally according to its own payoff function, but the uncoordinated equilibrium is inefficient.

14.1. Banks

Banks want lower uncertainty, stable debt service, covenant observability, and evidence for refinancing. Without ONEDGE ENERGY, their dominant strategy is to price opacity conservatively.

With ONEDGE ENERGY, banks can move from narrative diligence to evidence-based diligence.

14.2. Regulators and CEN

CEN's role is system-level coordination. It cannot be expected to become the warranty arbiter for every battery. Without ONEDGE ENERGY, system dispatch and asset warranty logic remain institutionally separate.

With ONEDGE ENERGY, CEN's dispatch authority remains untouched while asset-level consequences become certified and legible.

14.3. Project Owners

Owners want revenue, asset life, refinancing value, and warranty preservation. Without ONEDGE ENERGY, they may earn revenue today while creating hidden degradation or warranty risk.

With ONEDGE ENERGY, disciplined operation becomes a financial asset.

14.4. OEMs

OEMs want to avoid liability for degradation caused by abusive or non-compliant operation. Their default strategy is to write defensive warranty terms and preserve discretion.

With ONEDGE ENERGY, OEMs gain attribution evidence.

14.5. The Golden Record as an OEM Defense Mechanism

For OEMs, the Golden Record is not merely a claim-support mechanism for project owners. It is also an objective defense mechanism against abusive or non-compliant operation.

If a project owner or operator cycles a BESS asset three times per day during high-temperature conditions, exceeds the LTSA envelope, violates declared C-rate limits, operates outside agreed state-of-charge windows, or otherwise stresses the asset beyond warranty-relevant limits, the Golden Record records that fact.

In that case, the Golden Record provides the OEM with objective evidence to rightfully deny or limit a warranty claim.

This symmetry is critical. A credible operational standard must protect both sides:

- owners and operators when the asset was operated inside the certified envelope;
- OEMs when the asset was operated outside the certified envelope.

The Golden Record therefore reduces ambiguity rather than reallocating blame. Its function is not to favor the owner, the OEM, the operator, or the lender. Its function is to bind operational claims to verified asset behavior.

14.6. Operators

Operators execute control decisions under constraints and can be blamed by every other actor when outcomes are bad.

With ONEDGE ENERGY, operators receive exculpatory evidence: what state the asset was in, what dispatch was received, what constraints applied, and what feasible response was certified.

15. The Inefficient Equilibrium Without ONEDGE

Without a shared operational standard, the battery ecosystem risks settling into an inefficient equilibrium:

1. CEN dispatches assets according to system needs.
2. Operators follow dispatch and optimize revenue.
3. Asset owners lack standardized proof of operational prudence.
4. OEMs preserve broad warranty discretion.
5. Banks price operational opacity into WACC.
6. LTSAs and warranty premia remain defensive.
7. Each project uses bespoke diligence and documentation.
8. No reusable standard forms.

This equilibrium is stable because each actor is rationally protecting itself. But the system as a whole is inefficient.

> **The default equilibrium is high battery deployment with low operational legibility.**

16. The ONEDGE Equilibrium

ONEDGE ENERGY changes the game by introducing a shared evidence object.

With ONEDGE ENERGY:

1. CEN dispatch remains system-sovereign.
2. The BESS asset responds inside a certified physical and warranty-aware envelope, or the record classifies the event as breach or opacity.
3. The operator produces or participates in a Golden Record.
4. The owner converts operation into refinanceable evidence.
5. The OEM can distinguish compliant operation from abusive operation.
6. The lender can underwrite operational history.
7. The regulator gains better observability of flexibility assets.
8. The market begins to converge around a repeatable standard.

The new equilibrium is:

> **High battery deployment with high operational legibility.**

17. Why This Matters for Chile's Battery Industry Ambition

Chile's participation in the battery industry should not be limited to lithium extraction or BESS deployment. A country can participate in the battery value chain through:

- lithium extraction;
- cell or component manufacturing;
- BESS project development;
- grid integration;
- data standards;
- warranty intelligence;
- certification infrastructure;
- operational auditing;
- financeability protocols;
- and dispatch and telemetry governance.

ONEDGE ENERGY targets the higher-value layer: the operational intelligence and certification layer.

If Chile can show that BESS operation can be certified, financed, warranted, and audited under a shared candidate standard, it exports more than lithium. It exports operational intelligence.

18. Heavy Energy Usage and Firmness in the SEN

Chile's heavy energy users—mining, data centers, industrial loads, desalination, green hydrogen, and large infrastructure—require firm, reliable, and increasingly clean power. Renewable energy alone does not solve their problem unless it can be shaped into firmness.

BESS assets are central because they can:

- shift solar output into evening peaks;
- provide reserves and ancillary services;
- reduce curtailment;
- improve congestion management;
- support reliability;
- make renewable PPAs more credible;
- and provide resilience for heavy-load customers.

For a mine, data center, or industrial load, the question is not simply whether a battery exists somewhere in the system. The question is:

> **Can the battery-backed energy supply be relied on contractually, financially, physically, and operationally?**

ONEDGE ENERGY addresses that question through certification.

19. CEN Dispatch and Warranty Conflict

CEN dispatch protects the system. BESS warranties protect the asset.

That creates a structural conflict when system-level dispatch pushes the asset toward conditions that are commercially valuable but physically stressful.

Relevant stress variables include:

- temperature;
- state of charge;
- depth of discharge;
- C-rate;
- throughput;
- cycling frequency;
- rest periods;
- thermal conditions;
- availability obligations;
- grid-response events.

A dispatch order can create a later dispute:

1. CEN required response for system reasons.
2. The operator complied.
3. The asset experienced degradation.
4. The owner claims warranty protection.
5. The OEM argues the operating envelope was exceeded.
6. The lender worries about residual value.
7. The operator lacks certified attribution evidence.

ONEDGE ENERGY does not claim to override CEN. It makes the consequences of dispatch legible.

The role of the Golden Record is to answer:

> **Was the asset's response to dispatch consistent with its declared physical and warranty envelope, or did the event constitute breach or opacity?**

If compliant, the owner and operator gain evidence. If breached, the OEM and lender gain attribution evidence. If opaque, the record identifies the evidentiary gap. In all cases, the system becomes more legible.

20. Candidate Extension: Flexible Loads and Curtailment-Provenance

Recent institutional discussions have highlighted the need to certify curtailment-powered flexible loads, including grid-connected computational loads.

This document introduces flexible-load and curtailment-provenance certification only as a **Candidate Extension**. It is not part of the initial validated BESS warranty-certification claim set.

20.1. Use Case

A flexible load may claim that it is operating exclusively, preferentially, or conditionally on curtailed or excess energy. Such a claim may matter to:

- regulators;
- system operators;
- transmission owners;
- project owners;
- energy suppliers;
- lenders;
- sustainability auditors;
- and industrial counterparties.

The claim cannot be accepted merely as narrative. It requires evidence.

20.2. Primitive Shared with BESS Certification

Curtailment-provenance certification requires the same primitives as BESS certification:

- metered energy provenance;
- operating-envelope constraints;
- dispatch context;
- authorized system, settlement, or metering records;
- and classification of Compliant, Breach, or Opacity states.

A flexible-load event may be classified as:

- Compliant, if the load operated within the declared curtailment, contractual, grid-impact, and metering envelope;
- Breach, if valid telemetry and authorized context show that the load operated outside that envelope;
- Opacity, if metering, telemetry, curtailment attribution, or dispatch context is insufficient to certify the claim.

20.3. Boundary

The Candidate Extension must not imply that ONEDGE ENERGY determines curtailment status independently of authorized system, settlement, metering, or dispatch-context records. ONEDGE ENERGY classifies evidence against declared inputs; it does not replace the authority of system operators, market settlement systems, or applicable regulatory records.

This extension demonstrates the generality of the Golden Record as a flexible operational evidence object without expanding the initial TRL-7 claim set beyond its validated scope.

21. Standard-Setting Strategy in the SEN

ONEDGE ENERGY should enter the SEN as a candidate standard-setting layer, not merely as a commercial optimizer.

21.1. Phase 1: Define the Certification Object

The Golden Record must be legible as:

- dispatch compliance record;
- warranty-support record;
- OEM defense record;
- lender diligence record;
- operator attribution record;
- telemetry provenance record;
- asset-state continuity record;
- breach record;
- opacity-event record.

21.2. Phase 2: Reference Deployment

TRL-7 shadow-mode validation should show that the candidate standard can operate on real assets under real conditions.

21.3. Phase 3: Lender and OEM Legibility

The evidence must be converted into reusable diligence language for banks and OEMs.

21.4. Phase 4: Governance File

The standard-formation file should document that ONEDGE ENERGY is:

- open at the interface;
- merit-based;
- non-coercive;

- designed for interoperability;
- not a commercial foreclosure tool;
- useful across banks, OEMs, owners, operators, and regulators.

21.5. Phase 5: Institutional Adoption

Referenceability begins when:

- one bank recognizes the evidence;
- one OEM maps the record to warranty-support and warranty-defense logic;
- one owner uses the record for refinancing;
- one operator uses the record for accountability;
- one institutional validator recognizes the reporting format.

22. Frictionless Onboarding

A standard cannot succeed if adoption requires a multi-year hardware retrofit.

ONEDGE ENERGY is designed to minimize onboarding friction by treating existing BESS infrastructure as the starting point. The standard is not premised on replacing the asset's BMS, SCADA, inverter controls, meters, sensor hardware, or OEM monitoring stack. Instead, ONEDGE ENERGY ingests operational telemetry and dispatch context through a controlled software and data interface.

22.1. Typical Onboarding Path

1. **Asset and contract mapping.** ONEDGE maps power rating, energy capacity, thermal constraints, degradation assumptions, warranty conditions, LTSA parameters, dispatch obligations, and telemetry availability.
2. **Telemetry provenance baseline.** ONEDGE defines approved asset-originated data sources and baseline provenance requirements before certification begins.
3. **Telemetry interface setup.** ONEDGE connects to existing BMS, SCADA, inverter, metering, or operator data feeds through APIs, secure exports, data rooms, or other approved mechanisms.
4. **Envelope definition.** OEM, owner, operator, and lender-relevant parameters are translated into a certification envelope.
5. **Shadow-mode validation.** ONEDGE observes dispatch, telemetry, and asset-state transitions without taking direct operational control.
6. **Golden Record generation.** The system produces certified operational records classifying events as compliant, breached, or opaque.
7. **Reporting and conformance review.** Banks, OEMs, owners, operators, and auditors can review standardized outputs without accessing the sovereign ECME Kernel.

The adoption proposition is deliberately low-friction:

> **No rip-and-replace hardware requirement. No immediate operational control transfer. No forced replacement of OEM systems.**

The first adoption step is evidence generation, not hardware replacement.

23. Relationship to EPRI and Global Standard Institutions

ONEDGE ENERGY should anticipate collaboration with institutions such as EPRI and similar technical standard bodies. These institutions can help align telemetry, testing, data-submission, performance, safety, and warranty grammar.

The EPRI-facing message should not be:

> "Please endorse our proprietary optimizer."

It should be:

> "ONEDGE is developing a cryptographically verifiable operational certification layer for BESS. We want to align its telemetry, testing, data-submission, safety, and warranty grammar with emerging energy-storage standards."

Possible roles for EPRI-like institutions include:

1. protocol-alignment review;
2. independent technical collaboration;
3. safety and warranty interface analysis;
4. convening utilities, OEMs, storage experts, and researchers around a neutral certification protocol.

This allows IKKUNA to position ONEDGE ENERGY as a standard-conforming infrastructure layer rather than a unilateral vendor claim.

24. Chile-to-Global Path

Chile is the proving ground because:

- battery deployment is accelerating;
- the SEN needs firmness;
- renewable penetration creates flexibility stress;
- mining and data centers require reliable energy;
- institutional actors are sophisticated enough to value bankability;
- CEN provides a system-level dispatch context;
- OEM warranty conflict is real and economically material.

But Chile is not the final market. Chile is the reference jurisdiction.

The global path is:

1. **Chile:** produce TRL-7 evidence and SEN referenceability.

2. **Texas / ERCOT:** apply the standard in a high-volatility, high-temperature, merchant-energy environment.
3. **California / U.S. distributed solar-storage:** connect with tax-equity, solar, and storage finance.
4. **Australia / NEM:** replicate in a volatility-heavy battery market.
5. **UK / Europe:** enter as a financeability and standard-legibility layer.
6. **Data centers and mining globally:** sell certified firmness and operational evidence.

The Chilean SEN is therefore the first institutional stage in a global standard strategy.

25. Document Control and Versioned Governance

To execute the "open standard at the interface" strategy properly, IKKUNA maintains document stratification.

25.1. Document Stratification

The standard documentation is organized into three tiers:

1. **Public Specification Version:** sanitized, standard-facing, abstract definitions, including v0.0.2.
2. **Confidential Data Room Version:** deeper architecture, OEM strategy, legal mapping, TRL-7 scope, validation artifacts, lender diligence artifacts, and certificate samples.
3. **Internal StandardCo Version:** proof logic, patentable claims, implementation details, and trade-secret boundaries.

25.2. Semantic Versioning

This document introduces specification-level version discipline. Future Golden Record schemas, telemetry-provenance requirements, conformance definitions, and certificate examples should reference an explicit semantic version identifier and, where appropriate, a cryptographic hash.

This is intended to prevent silent schema drift during TRL-7 validation and future standard-formation processes.

25.3. TRL-7 Data Room

This whitepaper is not the Data Room itself. It functions as the public specification anchor.

The proposed TRL-7 Data Room should contain private validation evidence, legal scoping materials, OEM/warranty mappings, lender diligence artifacts, telemetry summaries, and certificate samples linked to the applicable v0.0.2 schema.

26. Next Steps for the Ecosystem

ONEDGE ENERGY is not asking the market to accept a black box. It is inviting ecosystem actors to help define and validate the evidence layer that battery-dense power systems will need.

26.1. For Banks and Lenders

Join the ONEDGE ENERGY standard review process to ensure the Golden Record schema aligns with credit committee requirements, refinancing diligence, covenant monitoring, and asset-performance review.

26.2. For OEMs and LTSA Providers

Partner with ONEDGE ENERGY to map warranty-envelope parameters into Golden Record logic, including both warranty-support and warranty-defense use cases.

26.3. For Project Owners and Asset Operators

Use ONEDGE ENERGY to convert operational discipline into financial evidence and to identify breach or opacity conditions before they become disputes.

26.4. For Regulators, CEN, and Public Institutions

Engage with ONEDGE ENERGY as an observability and certification layer that complements system dispatch without challenging dispatch authority.

26.5. For EPRI and Technical Standard Institutions

Review the telemetry, certification, and Golden Record approach against existing energy-storage data, testing, performance, and safety frameworks.

26.6. For Strategic Commercial Partners

Participate in TRL-7 validation as a reference deployment partner.

The ideal partner is not merely a customer. The ideal partner is an institution that benefits from making battery operation more legible.

27. Claims Discipline

Because ONEDGE ENERGY is a proposed open standard and candidate specification in pre-TRL-7 status, institutional claim discipline is required.

27.1. Claims This Whitepaper Makes

This whitepaper claims that:

- ONEDGE ENERGY is a proposed open standard for certified BESS operational evidence.
- ONEDGE ENERGY is a candidate specification in pre-TRL-7 validation status.
- ONEDGE ENERGY does not replace BMS, SCADA, sensor hardware, meters, inverters, or OEM monitoring systems.
- ONEDGE ENERGY requires baselined telemetry provenance.
- ONEDGE ENERGY can classify certified events as compliant, breached, or opaque.

- ONEDGE ENERGY is designed to support lender, OEM, operator, owner, auditor, and regulatory diligence.
- ONEDGE ENERGY is designed to reduce evidentiary ambiguity.

27.2. Claims This Whitepaper Does Not Make

This whitepaper does not claim that:

- ONEDGE ENERGY is already an adopted industry standard.
- ONEDGE ENERGY has completed TRL-7 validation.
- ONEDGE ENERGY guarantees lower WACC.
- ONEDGE ENERGY guarantees lower LTSA costs.
- ONEDGE ENERGY guarantees warranty approval.
- ONEDGE ENERGY prevents degradation.
- ONEDGE ENERGY replaces CEN dispatch.
- ONEDGE ENERGY replaces OEM monitoring systems.
- ONEDGE ENERGY proves compliance where telemetry is incomplete or unverifiable.
- ONEDGE ENERGY eliminates all disputes.
- ONEDGE ENERGY determines curtailment status independently of authorized system, settlement, metering, or dispatch-context records.

The correct claim is:

> **ONEDGE ENERGY reduces the scope and ambiguity of disputes by producing verified operational evidence, breach evidence, or opacity evidence.**

28. Conclusion

Chile's battery future will not be determined only by who owns lithium, who installs BESS, or who dispatches assets.

It will also be determined by who defines the trusted operational evidence layer through which batteries become financeable, warrantable, auditable, insurable, and firm.

ONEDGE ENERGY exists to define that candidate layer.

The open-standard approach is not an act of weakness. It is the defensive moat. By making the interface open, banks, OEMs, regulators, owners, operators, and auditors can adopt a shared evidence language. By keeping the ECME Kernel, Golden Record issuance logic, and proof methodology sovereign, IKKUNA preserves the trust engine that gives the standard value.

The result is a new coordination equilibrium:

- CEN preserves system dispatch authority.
- Banks gain lender-grade operational evidence.

- OEMs gain warranty-attribution and warranty-defense clarity.
- Owners convert operational discipline into financial value.
- Operators gain exculpatory records.
- Regulators gain transparency.
- Heavy-load customers gain confidence in certified firmness.
- Chile gains a higher-value position in the global battery industry.

The final market proposition is simple:

> **ONEDGE ENERGY turns battery operation, breach, and opacity into trusted financial and technical evidence.**

The strategic invitation is direct:

> **Help define the standard before operational opacity becomes the next bottleneck in the battery transition.**

Disclaimer

This document is a strategic and technical whitepaper draft prepared by IKKUNA SpA for discussion purposes. It does not constitute legal, financial, investment, regulatory, engineering, tax, or professional advice. Any numerical scenarios are illustrative and should be independently validated before use in investment, credit, regulatory, or commercial decision-making.

ONEDGE ENERGY is presented as a proposed open standard and candidate specification in pre-TRL-7 validation status. References to potential reductions in WACC, LTSA costs, warranty ambiguity, financing friction, curtailment-provenance ambiguity, or operational-dispute ambiguity are strategic hypotheses and illustrative scenario outputs, not guarantees.