LumeTrax
Architecture Brief

TECHNICAL BRIEF
For architects, engineers, IEs

ARCHITECTURE BRIEF

One operating layer. Every plant. Every vendor.

Technical architecture of the LumeTrax platform — unified multi-tenant operating layer for utility-scale and hybrid renewable assets. OT/IT separation, vendor-agnostic ingestion, financial-grade methodology, disciplined intelligence layer, and four deployment shapes.

DOCUMENT	Architecture Brief — v1
AUDIENCE	Architects · engineers · lender's IE · integration leads · CISOs
SCOPE	Platform architecture, ingestion, modules, deployment shapes, integration
RELATED	Customer Security Pack (procurement-grade) · Vision sample · Audit sample
CONTACT	info@lumetrax.com (subject: Architecture question)

This brief covers the technical architecture you need to scope LumeTrax against your portfolio. It assumes some familiarity with industrial control (SCADA / PLC / RTU / IEC 61850 / Modbus / OPC UA) and renewable-asset operations. For commercial overview see the Brochure; for procurement-depth security documentation see the Customer Security Pack.

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1. Executive overview · what LumeTrax is, technically

LumeTrax is **one unified multi-tenant platform** with module-based feature activation — not five separate apps duct-taped together. Every module reads the same plant under the same tenant hierarchy. Mission-critical control stays in the deterministic OT layer; analytics, workflow, optimization, and assurance run above the boundary.

Five technical anchors

1. One tenant hierarchy

Client Organization → Portfolio → Plant → Subsystem → Asset → Tag/Point/Event. Enforced at ingestion, not at presentation. The same hierarchy on every screen, every report, every API.

2. OT/IT separated by architecture

Mission-critical control (supervisory commands, interlocks, safety-critical sequencing) stays in the on-site SCADA / PLC / RTU. Adding features above the boundary never compromises the deterministic side.

3. Vendor-agnostic by architecture

Protocol-first integration (Modbus, IEC 61850, SunSpec, MQTT, OPC UA, OEM APIs). Mixed-OEM portfolios run under one tenant. New ecosystems are added inside ingestion, not inside control.

4. Financial-grade by methodology

Every operating claim traces to a time-stamped record. Source classification (measured / calculated / assumed / judged) carried through to lender-grade outputs.

5. Module activation, not module installation

Core, Asset Manager, Vision, Optimizer, Audit & Assurance share the same data, same identity, same audit trail. Activation is a subscription change, not a deployment.

2. Tenant hierarchy · the data model that runs everywhere

Every screen, every report, every API call uses the same six-level hierarchy:

Client Organization → Portfolio → Plant → Subsystem → Asset → Tag/Point/Event

Add a plant under an existing tenant and your portfolio view, your KPIs, your audit trail, and your access control update on the same login. No second instance. No second contract. No second login.

Level	Example	What it represents
Client Organization	Acme Power Group	Top-level customer entity. Contracting party. Identity and access boundary.
Portfolio	MEA Solar Portfolio	A collection of plants — typically by region, asset class, or contract regime. Cross-p
Plant	Plant 04	A single asset (PV, BESS, hybrid). Carries its own commissioning record, PPA refe
Subsystem	MV Bus 02	A logical group within a plant — switchgear bus, inverter block, BESS stack, tracker
Asset	Inverter Block 02	A specific piece of equipment — inverter, BESS module, transformer, tracker.
Tag / Point / Event	IB02_PWR · trip event 2025-12-08T03:44:32Z	A single data point or event — measured value, alarm, control action, work-order en

Multi-stakeholder access

RBAC is scoped to the hierarchy level. Owner sees the portfolio. Operator sees the plants in scope. O&M; contractor sees the assets they're contracted to maintain. Lender / IE sees a read-only portfolio view with audit-log access. **Cross-tenant access is structurally blocked** except where authorised in writing by the customer.

3. OT/IT separation · the architectural commitment

Renewable assets sit on infrastructure that has to fail safely. Supervisory control, interlocks, and safety-critical command sequencing are the responsibility of the OT layer — SCADA, PLC, RTU, on-site controller — where determinism is provable and the failure mode is engineered, not negotiated. Analytics, workflow, optimization, and assurance run above the boundary, in shared platform services. Useful, valuable, increasingly intelligent — never the layer protecting the asset.

What stays where

OT layer (deterministic)	Shared platform services (above the boundary)
Supervisory control commands (breaker open/close, setpoint write)	Real-time visibility (read-only dashboards)
Interlock enforcement (electrical interlocks, safety chains)	Alarm-to-ticket workflow (Asset Manager)
Sub-second safety-critical logic	Performance analytics, loss attribution (Vision)
Local fallback on connectivity loss	Hybrid dispatch optimisation (Optimizer)
Authority matrix enforcement at command time	Independent technical review (Audit & Assurance)
Protective trip logic (over-current, over-voltage, etc.)	Lender-grade reporting and evidence packs

On connectivity loss

If the network link to the cloud / private-cloud platform fails, the on-site PLC / RTU continues to run protected operation against its locally-configured logic. The plant doesn't depend on LumeTrax to stay safe. Edge gateway buffers ingestion locally; sync resumes when connectivity recovers, with documented gap handling. **This is a hard architectural rule, not a soft preference.**

4. Data ingestion · protocol-first, vendor-agnostic

LumeTrax connects to every major inverter, BESS, switchgear, tracker, met station, and DG controller ecosystem over the protocols those ecosystems publish. We don't sell custom-OEM-SDK adapters back as a premium tier. New ecosystems are added when the field requires them; the integration cost lives in the deployment plan, not in a perpetual licence line.

Protocol	What it covers	Asset classes
Modbus TCP / RTU	The lingua franca of industrial control	Most inverters, BESS PCS, tracker controllers, weather stations, meters, ge
IEC 61850	Substation automation, switchgear, protection relays	Switchgear, protection relays (often required for utility interconnection)
SunSpec	Standardised data model for solar inverters, meters, BESS	Modern PV inverters, meters, BESS — vendor-independent within standard
MQTT	Lightweight pub-sub for distributed-asset telemetry	Edge / gateway-layer telemetry; some modern hardware exposes MQTT di
OPC UA	Modern industrial connectivity	Newer-build BESS, modern PCS, plant-controller (PPC) integrations
OEM APIs	Vendor-published documented APIs	Used per-ecosystem when standard protocols don't expose required data; c

Asset coverage by class

Asset class	Typical protocols
PV inverters	SunSpec · Modbus TCP/RTU · OEM APIs
BESS / PCS	Modbus TCP · OPC UA · IEC 61850 · OEM APIs
Switchgear / protection relays	IEC 61850 (GOOSE, MMS) · Modbus TCP/RTU
Trackers	Modbus RTU/TCP · OEM APIs
Met stations / weather sensors	Modbus RTU · MQTT · OEM APIs
Meters	Modbus TCP/RTU · IEC 61850 · DLMS (where applicable)
DG / genset controllers	Modbus RTU · CAN · OEM APIs
PPC / plant-level controllers	IEC 61850 · OPC UA · Modbus TCP
Existing SCADA / historian (transition only)	OPC UA · ODBC · API export · CSV import

5. Edge gateway · topology and operation modes

Core ships with an industrial-grade edge gateway that handles ingestion, local supervisory functions, offline buffering during network outages, and tenant-side data normalisation before sync. Hardware is sized to the deployment in the Core questionnaire — environmentally rated, redundant-power, often dual-NIC for OT/IT segregation. The gateway is a real industrial control device, not a Raspberry Pi.

Topology variants

Variant	When to use it
Single-site gateway	Standalone plant; gateway pinned to local OT network with one upstream sync path.
Multi-site gateway with regional aggregation	Portfolio of plants with regional infrastructure; gateways aggregate to a regional historian before central ter
High-availability (HA) gateway pair	Mission-critical sites where gateway redundancy matters. Failover handled at the OT layer; pair runs in act
Air-gapped gateway	No upstream connectivity. Full operations run inside the customer perimeter. Patch delivery via signed bun

Gateway responsibilities

- Protocol translation — connect to OT-layer devices over standard protocols, normalise into the LumeTrax tenant model
- Local historian buffering during cloud-connectivity loss (configurable retention; typical 30-90 days at high resolution)
- Local supervisory function (where deployment includes Core supervisory control)
- Time-stamp source identification (gateway clock, GPS-disciplined OT clock, OEM-controller clock — recorded per signal)
- Network segmentation enforcement (dual-NIC OT/IT separation; allow-list for cross-boundary flow)
- Identity bridge (customer IdP authentication for local console access)
- Health monitoring (gateway-side observability sent up to the platform; local alarm if uplink lost)

6. Module architecture · how modules share the same plant

Five modules. One platform. Every module reads the same tenant data; every module writes to the same audit log; every module respects the same RBAC.

Module	Reads	Writes	Sold as
Core (SCADA & plant control)	OT-layer telemetry, control inputs	Supervisory commands, alarms, event logs, tag history	Capex (gateway) + subscription
Asset Manager (O&M workflow)	Alarm events from Core, work-order context, spare parts, BOM	Work orders, downtime classification, SLA records	Subscription
Vision (performance analytics)	Historian data from Core, weather data, contractual availability	PR / availability / loss-attribution reports, benchmarks	Subscription
Optimizer (hybrid EMS)	Historian + forecast inputs, PPA tariff schedules, equipment constraints	Dispatch setpoints (streamed only — OT layer enforces)	Subscription (premium)
Audit & Assurance (independent service)	All of the above, plus contract documentary	Independent technical reviews, source-classified deliverables, conflict-screening re	Engagement fees

How modules reinforce each other

Optimizer dispatches setpoints; Core's OT layer enforces them. Optimizer's dispatch decisions write to the historian; Vision attributes the resulting performance. Vision's loss-attribution waterfall identifies recoverable losses; Asset Manager opens the corresponding work order. Asset Manager's classified downtime records become the evidence pack Vision and Audit & Assurance both read for lender-grade reporting. Each module is more useful with the others active.

7. Financial-grade layer · the LumeTrax Ledger

"Financial-grade" means every operational claim can be traced back to time-stamped plant data, classified events, documented assumptions, and exportable evidence packs that owners, operators, lenders, and technical advisors review against the same source. It is a methodology constraint as much as a feature.

The LumeTrax Ledger

Standard SCADA / monitoring	LumeTrax Ledger
kWh delivered	Energy delivered against PPA · contracted-vs-actual deviation
Availability %	Availability decomposed by attribution category — PPA / OEM warranty / O&M / weather / grid
Performance Ratio	PR vs weather-normalized expected · DSCR-relevant operating metrics · degradation-adjusted yield
Outage hours	Recoverable vs permanent loss · evidence pack per claim window
Maintenance log	SLA-tracked work orders · spare-parts evidence trail · warranty-claim assembly
Forecast (best-effort)	Source-classified forecast (assumed inputs documented) · scenario bands (P50, P90)

Source classification

Every figure carries one of four source classes — **MEASURED** (direct historian / metering record), **CALCULATED** (derived via documented methodology), **ASSUMED** (named, sourced, bounded), **JUDGED** (reviewer interpretation). Disagreements between counterparties typically resolve at the assumption-or-judgement layer, where they belong. Audit & Assurance reports never blend the classes.

8. Intelligence layer · disciplined ML, source-linked traceability

Performance analysis in power assets starts with physics, operating context, and source-linked data. We use statistical and machine-learning methods where they measurably improve detection, forecasting, or anomaly classification — not as decoration.

Where machine learning earns its place

Application	What it does	Where it runs
Forecasting	Day-ahead / week-ahead production forecasts; feeds Optimizer dispatch and Vision performance reporting	Vision · Optimizer
Fault detection & diagnostics (FDD)	Export-drift detection; pattern matching against documented degradation modes; confidence-scored output	Vision
Anomaly classification	Distinguishes weather variability from equipment degradation from O&M issues	Vision · Audit
Dispatch optimisation under volatility	Probabilistic price and demand inputs into hybrid PV+BESS+DG dispatch decisions	Optimizer

What we don't claim

LumeTrax does not claim agentic operations, autonomous resolution, self-healing, or self-managing capabilities. Those words don't appear in the platform. We don't decorate with AI. Lender-grade evidence requires traceability — every figure in every Vision report and every Audit & Assurance deliverable is auditable to the underlying historian record, alarm event, or work-order ID.

Methodology versioning

Statistical and ML model versions are pinned per engagement. When a model updates between periods, the change is disclosed in the methodology section of the next report. Period-over-period comparability is a methodology property, not a coincidence.

9. Deployment models · cloud, private, on-prem, air-gapped

Same software, four deployment shapes. Selection at engagement initiation through the Core questionnaire. Subsequent shape changes supported as commercial requirements evolve.

Shape	Where it runs	Who chooses it	Trade-offs
Cloud (multi-tenant)	Managed cloud region	Most asset owners and operators	Fastest to deploy and update · cost-efficient · region-pinned b
Private cloud (single-tenant)	Isolated cloud deployment per customer	Customers requiring single-tenancy or specific regional hosting	Tenant isolation · provider-managed · slightly higher cost
On-prem	Customer / partner datacentre	Regulator- or contract-driven on-prem requirements	Customer controls compute and data fully · slower update cad
Air-gapped	On-prem with no inbound/outbound connectivity	Sovereign entity or restricted-network projects	Maximum isolation · patch delivery via signed bundles · no off

Backup, RPO/RTO, and incident response are documented per shape. See the Customer Security Pack §3 and §8 for detail.

10. Integration approach · custom connectors, downstream systems, exit

Custom connector policy

Where a deployment requires a connector outside the standard protocol set — a closed proprietary protocol, a legacy serial protocol, or a vendor-specific API extension — a custom connector is sized at engagement and quoted separately. The connector is documented (input format, normalised output, fail-safe behaviour, supported version range), maintained as part of the platform, and made available to other customers if it becomes broadly applicable. **Custom connectors are not the default path**; they are the considered path when the asset's economic value justifies the engineering investment.

Outbound integration

Mechanism	Use case
REST API	Read access to KPIs, events, work orders, audit log per tenant
Webhook events	Push notifications on configurable triggers (alarm, work-order state change, KPI threshold)
Scheduled exports (CSV / Parquet)	Customer-owned storage per documented cadence (typical: nightly)
SIEM integration	Audit-log export to customer security infrastructure (real-time or batched)
Data warehouse sync	For customers running their own analytics stack on top of LumeTrax operating data

Implementation timeline

Phase	Typical duration
Scoping (Core questionnaire)	2–4 weeks
Engineering design (per-asset register maps, OT/IT segmentation, gateway sizing)	4–8 weeks
Field commissioning per site	2–6 weeks
Operator hand-off (training, runbook delivery)	1–2 weeks

Exit and data portability

Customer data is exportable in standard formats throughout the customer's tenancy and at exit. Historian data, work-order trail, asset registry, and configuration are exportable as documented. There is no data-lock-in that depends on a renewal — exit terms are contractual and operationalised in a runbook.

11. Where LumeTrax fits with other systems

LumeTrax is the operating layer for renewable assets. It does not replace the customer's enterprise stack — it integrates with it.

Customer system	How LumeTrax integrates
Existing SCADA (legacy migration)	Standard ingestion via OPC UA / API export / CSV during transition. New integrations move to native proto
CMMS (e.g. enterprise maintenance systems)	Asset Manager integrates via API for asset registry exchange, work-order push, and downtime-classificatio
ERP	API export of operating metrics for inclusion in financial close (revenue recognition, OPEX-per-MWp, depre
BI / data warehouse	Tenant-side data export (Parquet / CSV) on customer cadence; LumeTrax does not gate analytics behind i
SIEM	Audit-log export to customer security infrastructure — real-time or batched
Identity provider (IdP)	SAML 2.0 / OIDC integration; customer's IdP is the source of truth for users, groups, MFA
Lender / IE platforms	Read-only viewer access scoped to the relevant portfolio; evidence-pack export in lender format

Appendix A — Protocol reference and glossary

Industry standards referenced in this brief

Standard	Scope
IEC 61850	Communication networks and systems for power utility automation (substation, switchgear, protection)
IEC 61400-26-1	Time-based availability for wind/solar/storage assets — capacity-weighted variant
IEC 61724-1	Photovoltaic system performance monitoring — guidelines for measurement, data exchange, analysis
IEC 62443-4-1	Industrial automation and control systems — security for product development lifecycle
NIST SP 800-82 Rev. 3	Guide to operational technology security
SunSpec Alliance specifications	Vendor-independent data models for solar inverters, meters, BESS
OPC UA (IEC 62541)	Platform-independent industrial machine-to-machine communication standard
Modbus TCP / RTU	De-facto-standard industrial protocol; no formal IEC equivalent but globally adopted
MQTT v3.1.1 / v5	OASIS-standard publish/subscribe messaging protocol
IEC 62443-4-2 / 3-3	Component-level and system-level security capabilities (referenced as future certification path)

Glossary — key terms used in this brief

- **BESS:** Battery Energy Storage System.
- **BYOK:** Bring Your Own Key — customer-managed encryption keys.
- **CFADS:** Cash Flow Available for Debt Service.
- **DSCR:** Debt Service Coverage Ratio.
- **FDD:** Fault Detection & Diagnostics.
- **HMI:** Human-Machine Interface.
- **IE:** Independent Engineer (lender's technical advisor).
- **IPP:** Independent Power Producer.
- **O&M:** Operations & Maintenance.
- **OT/IT separation:** Architectural boundary between deterministic operational technology (SCADA, PLC, RTU) and shared platform IT services (cloud / app layer).
- **P50 / P90:** Production exceedance probabilities (50% / 90%).
- **PCS:** Power Conversion System (BESS-side inverter).
- **PLC / RTU:** Programmable Logic Controller / Remote Terminal Unit — programmable industrial control devices.
- **POA irradiance:** Plane-of-Array irradiance — sunlight measured at the orientation of the panel.
- **PPC:** Plant-level Power Controller.
- **PR:** Performance Ratio — measured energy / theoretical at STC.
- **RBAC:** Role-Based Access Control.
- **RPO / RTO:** Recovery Point / Time Objective.
- **SCADA:** Supervisory Control And Data Acquisition.

- **SCC:** Standard Contractual Clauses (EU data transfer mechanism).
- **SLA:** Service Level Agreement.
- **STC:** Standard Test Conditions for PV (1000 W/m², 25 °C, AM 1.5).
- **Tenant:** The top-level access scope inside LumeTrax — typically one customer organisation.
- **W-PR:** Weather-normalized Performance Ratio.

End of brief.