SymStudio

Product Requirements Document

Moyai: Verified Grid Relief for Host Communities

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Concept:	Moyai: Verified Grid Relief for Host Communities
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Process:	Symbiotic Co-Creation (SCC)

Executive Summary

Overview

Frontier AI data centers demand unprecedented power (250MW+) and thermal dissipation (120kW+ per rack), triggering fierce permit rejections, regulatory moratoria, and multi-year grid interconnection queues across host counties like Richland Parish and Memphis. Moyai bridges the chasm between hyperscale operators, municipal planning directors, and utility engineers. By serving as an independent, cloud-based Measurement, Reporting, and Verification (MRV) platform, Moyai transforms zero-sum resource battles into verified symbiotic utility partnerships.

The application ingests high-frequency operational telemetry directly from critical facility infrastructure—including medium-voltage switchgear, microgrid battery reserves, coolant distribution units (CDUs), and municipal water meters—and cross-references it with live grid congestion telemetry from regional ISOs/RTOs. When the electric grid experiences peak stress or local water tables drop, Moyai verifies autonomous load curtailment and waterless heat rejection compliance against dynamic baselines.

In return for proven flexibility and transparent community protections, utilities legally fast-track interconnection approvals for compliant operators while county planners enforce binding zoning covenants that guarantee residential electric rates remain unaffected. Moyai replaces opaque corporate NDAs with radical, verifiable transparency across all stakeholders.

Problem Statement

High-density AI data centers are stalled by 3-to-5 year utility interconnection queues, supply-chain bottlenecks for high-voltage transformers, and aggressive municipal permit bans driven by valid community fears of groundwater depletion and residential electric rate spikes. Hyperscalers currently operate behind opaque NDAs, while municipal regulators and under-resourced rural counties lack independent, real-time verification tools to monitor facility power draw, verify load curtailment promises, or ensure direct-to-chip closed-loop cooling systems do not consume municipal potable water.

Proposed Solution

Moyai is a verifiable Measurement, Reporting, and Verification (MRV) cloud platform that ingests real-time power, thermal, water, and weather telemetry to continuously validate hyperscaler grid relief against dynamic baseline models. Moyai provides four synchronized views: an Operator Control Room for facility thermal and electrical management, a Utility Queue Certification Desk for interconnection fast-tracking, a County Planning & Zoning Compliance Portal for enforceable resource covenants, and a Plain-Language Multilingual Community Transparency Portal for local residents.

Key Benefits

- Accelerates utility grid interconnection queue approvals from 48 months to under 18 months by proving automated, high-stress load curtailment capabilities.

- Protects host community ratepayers and groundwater tables by providing municipal planners with tamper-evident, real-time proof of zero-water cooling compliance.
- Eliminates permit deadlocks and NDA distrust through open-access, plain-language and multilingual community environmental dashboards with SMS alerts.
- Co-simulates dynamic thermal cooling loads (CDU/manifold telemetry) alongside grid capacity to prevent localized substation brownouts and hardware degradation.

Symbiotic Empathy

These personas represent the core users driving this solution, derived from deep empathy mapping.

Sun-Hee Park

Principal Thermal & Mechanical Architect at Cloud Infrastructure Provider

Key Insight: Traditional evaporative cooling towers trigger municipal permit bans in arid regions. Sun-Hee needs closed-loop, direct-to-chip telemetry that proves zero potable water draw while keeping 120kW racks below critical thermal thresholds.

Primary Need: Verifiable closed-loop cooling telemetry, universal CDU monitoring, and automated thermal throttling safeguards.

Xochitl Tenorio

County Development & Planning Director

Key Insight: County regulators are caught between developer NDAs and outraged constituents whose water tables and residential power bills are threatened by multi-hundred-megawatt server farms.

Primary Need: Independent, real-time, non-NDA resource telemetry, ratepayer cost-shift insulation, and enforceable zoning compliance tools.

Haruto Natsume

Principal Thermal Architect & Sustainable Cooling Strategist

Key Insight: Hardware engineers fear catastrophic coolant leaks destroying tens of millions in GPU clusters when retrofitting legacy halls for high-density liquid loops.

Primary Need: Standardized manifold telemetry, automated micro-leak pressure differential detection, and zero-evaporative water verification.

Elena Katsaros

Director of Critical Facilities Infrastructure at Tier-1 Cloud Provider

Key Insight: Grid queues take 3-5 years due to utility transformer deficits. Hyperscalers can bypass queues only if they mathematically prove automated curtailment during grid peak stress.

Primary Need: Real-time utility grid queue telemetry, dynamic co-simulation of cooling/electrical loads, and certified load-curtailment dispatch proof.

Strategic Signal

Innovation Direction

Transform data centers from community resource drains into symbiotic utility partners via transparent environmental telemetry and mutual infrastructure co-investment.

Constraints

- Must operate completely out-of-band and read-only without introducing cybersecurity vulnerabilities to critical facility BMS/SCADA infrastructure.
- Must adhere to strict municipal open-records laws while protecting hyperscaler proprietary compute topologies.
- Must function reliably in remote rural areas with limited broadband infrastructure for local residents and field planners.

Success Indicators

- Shortening average greenfield AI data center utility interconnection queue times by 50% (from 36-48 months to under 18 months).
- 100% elimination of municipal potable water consumption for cooling across deployed partner sites in arid zones.
- Zero residential electric ratepayer rate hikes attributed to data center grid upgrades in participating host counties.
- Over 90% positive community zoning approval ratings on initial permit applications for Moyai-verified facilities.

Concept Overview

Moyai: Verified Grid & Water Intelligence Platform

A dual-facing Measurement, Reporting, and Verification (MRV) SaaS application and public accountability portal. Moyai connects directly to data center SCADA/BMS systems, regional electric grid ISO/RTO telemetry feeds, and municipal water sensors to verify real-time load shedding, dynamic energy baselines, and closed-loop thermal water usage. It provides county regulators, local utilities, and community residents with tamper-evident audit logs and plain-language impact portals, enabling utilities to fast-track grid interconnection queues while ensuring host communities never bear the cost or resource depletion of frontier AI clusters.

Core Value

Cryptographically verified, multi-stakeholder resource telemetry that proves hyperscale grid curtailment and zero-water cooling compliance in exchange for expedited interconnection queues and binding ratepayer protection.

Key Differentiator

Unlike proprietary building management systems or opaque corporate ESG PDF reports, Moyai utilizes an open-standard, third-party auditable MRV engine with tamper-evident cryptographic logging, multi-stakeholder role separation (utility, county planner, hyperscaler, resident), and automated interconnection compliance certification tied directly to real-time grid stress and water table telemetry.

Scope of Work

In Scope

Real-time multi-protocol SCADA/BMS telemetry ingestion engine (power, cooling fluid flow, ambient weather).

Dynamic ASHRAE-normalized baseline demand modeling and automated curtailment delta verification engine.

Cryptographic hash-chain verification and compliance certificate generation module.

Four role-tailored web interfaces: Operator Command Deck, Utility Queue Certification Desk, County Zoning Compliance Portal, and Plain-Language Community Accountability Hub.

SMS and email emergency alert broadcast engine for community and municipal stakeholders.

Co-simulation module for thermal cooling distribution and dynamic electrical throttling.

Out of Scope

Direct automated write-access or remote control over high-voltage utility breakers or safety-critical cooling valves (read-only verification in Phase 1).

Billing and payment processing for commercial wholesale electricity settlements.

Physical hardware manufacturing of coolant distribution units (CDUs) or flow meters.

Assumptions

- Hyperscale operators permit read-only Modbus/BACnet/MQTT gateway access to facility electrical switchgear, CDUs, and water meters.
- Regional ISOs/RTOs and electric utilities expose API endpoints or automated webhooks for 5-minute pricing, reserve margin, and curtailment dispatch signals.
- Municipal county boards agree to recognize certified MRV telemetry as legally valid proof for zoning covenant compliance and permit milestone approvals.

Key Features

Real-Time SCADA & Grid Telemetry Ingestion Pipeline

P0

High-frequency telemetry ingestion engine supporting Modbus, BACnet, and MQTT protocols to capture rack-level thermal metrics, CDU fluid flows, and primary substation feeder loads alongside regional RTO/ISO grid stress indicators.

User Value: Provides Elena and Haruto with continuous, unified visibility across thermal cooling distribution and dynamic electrical grid capacity without hardware vendor lock-in.

Dynamic Baseline & Curtailment Verification Engine

P0

Machine-learning baseline engine that models expected facility power and water consumption based on compute queue density and ambient weather, accurately verifying the exact megawatts shed during grid stress events.

User Value: Enables utilities to legally certify automated load curtailment, allowing Elena to bypass the 4-year interconnection queue while proving no brownouts will hit local neighborhoods.

Tamper-Evident Water & Thermal Compliance Ledger

P0

Cryptographic, append-only ledger for all water meter feeds, coolant chemistry readings, and secondary loop pressure sensors, generating audit-ready compliance certificates.

User Value: Gives Xochitl and Sun-Hee undeniable, third-party verified proof that 120kW/rack GPU suites are operating with zero municipal water consumption and zero chemical groundwater runoff.

Municipal Planning & Zoning Enforcement Portal

P1

Dedicated dashboard for municipal planning boards and county commissioners showing real-time municipal resource consumption, ratepayer cost-shift index, and tax co-investment revenue tracking.

User Value: Empowers Xochitl Tenorio with concrete, un-redacted data to enforce zero-water zoning bylaws and defend community interests at contentious public hearings.

Plain-Language Community Accountability Hub & SMS Bridge

P1

Public-facing, WCAG AAA compliant, bilingual (English/Spanish) web portal with plain-language metrics, residential power bill protection guarantees, and SMS alert subscriptions.

User Value: Demystifies data center operations for host community residents (e.g., Memphis 38109, Richland Parish), eliminating NDA suspicion and fostering genuine civic partnership.

Thermal-Electrical Co-Simulation & Throttle Planner

P2

Co-simulation workspace that models high-density rack throttling (80kW–120kW) in response to grid curtailment signals without risking chip junction overheating or thermal throttling outages.

User Value: Allows Sun-Hee and Haruto to safely test dynamic load-shedding scenarios across hybrid direct-to-chip cooling loops before pushing changes to live production GPU clusters.

User Stories

US-01

As a Principal Thermal Architect (Sun-Hee/Haruto), I want to connect facility CDU and rack manifold telemetry to Moyai so that I can monitor 120kW liquid cooling performance and prove zero-water consumption in real time.

Acceptance Criteria:

- System establishes continuous polling of Modbus/BACnet endpoints with <1s refresh rate.
- Secondary loop flow rate, supply/return coolant temperatures, and pressure differentials display in real time.
- Automated alerts trigger within 500ms if fluid pressure delta indicates a micro-leak risk.

US-02

As a Director of Critical Facilities (Elena), I want Moyai to verify our automated power curtailment during regional grid peaks so that our utility can fast-track our 250MW interconnection queue.

Acceptance Criteria:

- Baseline model dynamically updates using ASHRAE dry-bulb/wet-bulb and server utilization data.
- Megawatts shed during curtailment dispatch are calculated against baseline and logged every 10 seconds.
- A downloadable, cryptographically signed IQAC audit package is generated immediately upon event conclusion.

US-03

As a County Planning Director (Xochitl), I want an independent, real-time dashboard of facility water intake and electrical load so that I can protect local groundwater, insulate residential ratepayers, and enforce zoning laws without relying on corporate NDAs.

Acceptance Criteria:

- Dashboard displays real-time municipal potable water intake in gallons/minute (showing 0 gal/min for compliant closed-loop cooling).
- System calculates and graphs the Ratepayer Protection Index showing dedicated utility infrastructure funding vs residential rates.
- Exportable one-click compliance PDF formatted specifically for County Planning Commission public hearings.

US-04

As a Host Community Resident in Memphis or Richland Parish, I want to access a simple, transparent, and mobile-friendly community portal in my language so that I can verify that the data center next door is not raising my electric bill or draining our water table.

Acceptance Criteria:

- Web interface achieves 100% WCAG 2.1 AAA automated compliance score.

- One-click language toggle between English and Spanish with persistent user preferences.
- MWh and gallon metrics are automatically translated into intuitive analogies ('powers 4,200 local homes for 4 hours', 'saved 12 olympic swimming pools of water').
- Users can enter a mobile number to receive instant SMS notifications when the facility initiates local grid support.

US-05

As a Sustainable Cooling Strategist (Haruto), I want to run co-simulations of thermal cooling loops alongside dynamic grid curtailment schedules so that I can prevent hardware overheating during extreme heatwaves.

Acceptance Criteria:

- Engine allows users to adjust simulated ambient dry-bulb temperature (from 70°F to 115°F) and grid curtailment depth (10% to 50%).
- Graphs render dynamic junction temperature (Tj) curves against rack thermal limits (120kW density).
- Verification engine flags any potential thermal overrun or secondary loop pump strain prior to live deployment.

Requirements

Functional Requirements

ID	Requirement	Priority
FR-01	The system shall ingest time-series telemetry via standard industrial protocols (Modbus TCP, BACnet/IP, MQTT, and OPC-UA) from facility CDUs, secondary cooling loops, sub-meters, and microgrid BESS with sub-second polling frequency.	P0
FR-02	The system shall ingest automated real-time LMP, 5-minute grid reserve margin, and emergency curtailment signals from regional RTO/ISO APIs (e.g., PJM, MISO, ERCOT, SPP, TVA).	P0
FR-03	The dynamic baseline engine shall calculate counterfactual power demand curves based on historical ASHRAE weather normalizations, scheduled compute workload queues, and ambient dry-bulb/wet-bulb temperatures.	P0
FR-04	The system shall compute real-time curtailment delta (kW shed) and generate tamper-evident, SHA-256 hash-chained verification logs signed by cryptographic keys for every curtailment event.	P0
FR-05	The system shall continuously monitor municipal potable water intake flow meters and secondary loop pressure differentials to detect micro-leaks or unauthorized evaporative water usage, automatically alerting operators and county regulators upon threshold violation (>0 gal/min baseline).	P0
FR-06	The platform shall generate automated Interconnection Queue Acceleration Certifications (IQAC) formatted as PDF/JSON audit packages for submission to state public utility commissions (PUCs) and regional ISOs.	P1
FR-07	The County Portal shall provide a Model Zoning Ordinance Generator and automated compliance scorecard tracking water intensity (L/kWh), PUE (<1.15 target), and local ratepayer insulation covenants.	P1
FR-08	The Community Public View shall render aggregated resource data in plain language (converting MWh to 'number of homes powered' and water metrics to 'family swimming pools saved') with full Spanish localization and low-bandwidth/mobile responsiveness.	P1

Non-Functional Requirements

Performance

- Telemetry ingestion pipeline must process 500,000 data points per second with under 250ms end-to-end ingestion latency.
- Real-time dashboard updates delivered via WebSockets with client-side UI render latency under 100ms.
- Dynamic baseline calculation and curtailment delta generation executed within 15 seconds of a grid event trigger.

Accessibility

- Full compliance with WCAG 2.1 Level AAA standards across the Community Public Portal.
- All visualizations must include high-contrast color palettes, screen-reader optimized data tables, and zero dependency on color coding alone.
- Complete localization support for English and Spanish, with plain-language readability targeting a 6th-grade reading level.

Security

• End-to-end TLS 1.3 encryption in transit and AES-256 encryption at rest for all sensor streams and operational telemetry.

• Role-Based Access Control (RBAC) ensuring municipal regulators see verified aggregate audit data without exposing proprietary IP, compute workloads, or server floor plans.

• Hardware Security Module (HSM) backed digital signatures for all generated compliance certificates and regulatory reports.

Reliability

• 99.999% platform uptime for core telemetry ingestion and verification APIs.

• Local edge-caching agent capable of buffering up to 72 hours of telemetry during wide-area network disconnects with zero data loss.

• Cryptographic audit ledger distributed across redundant multi-region storage nodes with automatic failover.

User Flow

1. **Elena or Sun-Hee connects Moyai Edge Gateway to facility BMS/SCADA protocols and configures baseline compute profiles and liquid cooling manifold parameters.**
   Operator Facility Onboarding & Telemetry Binding

2. **Moyai dynamically ingests live weather data, grid reserve signals from the regional ISO/RTO, and CDU thermal metrics to calculate the facility's rolling counterfactual baseline.**
   Dynamic Baseline Calibration

3. **Regional grid issues a high-heat alert; Moyai detects the emergency signal, captures the facility's battery discharge and compute throttling response, and computes real-time megawatts shed.**
   Curtailment Event Execution & Telemetry Capture

4. **The MRV engine cross-validates power shed and confirms zero potable water draw, minting a cryptographically signed Interconnection Queue Acceleration Certificate (IQAC).**
   Automated Verification & Certificate Minting

5. **Xochitl audits the unalterable compliance log on the County Portal, verifying zero water depletion and validating ratepayer protection covenants for the board meeting.**
   Municipal Zoning & Covenant Compliance Review

6. **Local residents access the Community Hub in English or Spanish, viewing real-time water savings and homes powered by facility load relief with optional SMS updates.**
   Public Transparency & Community Engagement

Success Metrics

Interconnection Queue Duration

Target
< 18 Months (compared to 48-month industry baseline)

Measurement
Average calendar months from initial utility interconnection filing to commercial energized status for participating facilities.

Municipal Cooling Water Consumption

Target
0 Gallons / Minute during steady-state and peak operations

Measurement
Continuous real-time metering of municipal potable water intake across all facility cooling operations.

Peak Grid Curtailment Compliance Rate

Target
> 99.5% compliance across all dispatched grid events

Measurement
Cryptographically verified percentage of committed megawatts shed within 10 minutes of an RTO/ISO emergency grid signal.

Ratepayer Cost Insulation Rate

Target
$0.00 data center infrastructure cost shifted to residential ratepayers

Measurement
Year-over-year residential electricity distribution tariff impact in host county sub-zones.

Risks & Considerations

Operators attempt to game the dynamic baseline model by artificially inflating baseline power demand prior to grid stress events.

High

Mitigation:

Implement multi-sensor cross-validation (correlating facility sub-meters with utility-side feeder telemetry and weather station data) and open-source, peer-reviewed counterfactual baseline algorithms.

Telemetry data feeds inadvertently expose sensitive facility security layouts or proprietary compute workload characteristics to the public.

High

Mitigation:

Deploy a strict zero-trust Role-Based Access Control (RBAC) architecture where community and county portals only display cryptographically verified aggregate resource metrics, completely air-gapped from proprietary compute workloads, customer metadata, and server floor topology.

Under-resourced rural county planning departments lack technical personnel to interpret complex industrial telemetry or act on audit logs.

Medium

Mitigation:

Provide a fully subsidized, turn-key 'Municipal Tier' with pre-configured plain-language dashboards, automated threshold violation SMS alerts, and dedicated technical onboarding for local county planning staff.

Network outages or cyber-attacks sever communication between facility SCADA systems and the Moyai cloud verification engine.

Medium

Mitigation:

Equip Moyai edge-gateways with local encrypted buffering capable of storing up to 72 hours of telemetry with automated hash-reconciliation upon reconnection.

Selection Rationale

Feasibility Score
10/10

Alignment Score
10/10

Selection Justification

Moyai utilizes mature industrial IoT protocols (Modbus, BACnet, MQTT) and proven counterfactual baseline methodologies derived from established demand response markets, making it immediately deployable without requiring unproven hardware inventions. By aligning the core economic and operational incentives of all four critical stakeholders—accelerated grid interconnection for Elena and Sun-Hee, zero-water compliance for Haruto, zoning enforcement and ratepayer protection for Xochitl, and resource transparency for residents—Moyai unlocks rapid commercial adoption and eliminates permit bottlenecks.

Ethical Considerations

AI infrastructure expansion must not exacerbate environmental racism or transfer systemic utility costs onto vulnerable host communities. Moyai directly eliminates the power asymmetry created by corporate NDAs by guaranteeing that the marginalized, low-income, and rural communities hosting 300MW server farms have uninhibited, verified, real-time access to the resource metrics that determine their water security and utility rates. Furthermore, the platform incorporates strict data sanitization to prevent proprietary hyperscaler surveillance while preserving public accountability.