AI Is Reshaping Infrastructure. Most Energy Systems Aren’t Ready.

Why Operational Intelligence Is Becoming the Next Competitive Advantage Across Data Centers, Pharma, and Manufacturing

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Optimization Whitepaper

Executive Summary

AI is transforming the global economy, and with it the physical infrastructure that powers it.

Across industries, operators face a convergence of pressures: rising energy costs, grid constraints, stricter sustainability requirements, aging infrastructure, operational complexity, and a shortage of skilled technical personnel. At the same time, cooling, HVAC, and energy systems are becoming increasingly variable. AI workloads shift by the second, production environments change continuously, and weather, occupancy, thermal loads, and energy pricing all introduce real-time variability that static control systems cannot manage effectively.

Most industrial facilities still rely on fragmented data, rule-based controls, and manual intervention to manage highly interconnected systems. Yet modern infrastructure contains thousands of interacting variables across cooling, ventilation, pumping, thermal storage, and electrical systems. Even small inefficiencies accumulate into significant energy waste, higher operating costs, and increased resilience risk.

The traditional operating model is breaking.

etalytics delivers an operational intelligence layer for critical infrastructure. Using physics-based AI, real-time digital twins, and autonomous optimization, it dynamically and continuously analyzes system behavior, detects inefficiencies early, and optimizes interconnected energy systems. The result is a new operating model:

- Lower energy consumption and operating cost
- Improved resilience and system stability
- Reduced manual intervention and troubleshooting effort
- Faster root-cause analysis and reporting
- Greater transparency across complex infrastructure
- Rapid ROI without replacing existing systems

Already proven in production with organizations including **Equinix**, **Volkswagen**, **Merck**, and **Sanofi**, etalytics shows how operational intelligence is becoming a key competitive advantage across data centers, pharma, automotive, manufacturing, and other energy-intensive industries.

01 The AI Infrastructure Crisis

The infrastructure supporting the AI economy is entering a period of unprecedented operational pressure.

Data centers are rapidly becoming one of the largest and fastest-growing electricity consumers globally. AI workloads are dramatically increasing rack density, cooling demand, and power consumption. Facilities originally designed around kilowatt-scale compute loads are now managing megawatt-scale thermal behavior. Power availability has become a strategic bottleneck, while expectations around uptime, efficiency, and sustainability continue to intensify.

But this challenge extends far beyond data centers.

Pharmaceutical facilities must maintain tightly controlled environmental conditions while reducing emissions and improving operational efficiency. Automotive and industrial manufacturing environments are becoming increasingly electrified and interconnected, introducing new dependencies across HVAC, cooling, compressed air, process energy, and utility infrastructure.

Across all these industries, operators face the same underlying challenge: infrastructure systems are becoming too complex for manual optimization and static control strategies to manage effectively.

Modern industrial operations are no longer static environments. Equipment performance changes continuously due to weather conditions, production demand, occupancy behavior, equipment degradation, utility pricing, and system interactions. Yet most facilities still operate using predefined thresholds, fixed schedules, and siloed control logic.

This creates a growing gap between how systems are operated and how efficiently they could operate.

Ventilation systems frequently run above actual demand. Cooling systems compensate for avoidable thermal loads. Pumps operate at unnecessarily high speeds. Free cooling opportunities remain underutilized. Equipment degradation often remains invisible until performance problems or rising energy costs become operationally obvious.

The challenge is no longer isolated equipment control.

It is the orchestration of highly interconnected energy systems operating under continuously changing conditions.

02 The Traditional Operating Model Is Breaking

Traditional BMS platforms automate equipment. etalytics optimizes systems.

Most Building Management Systems (BMS) and Energy Management Systems (EMS) were designed to automate individual equipment behavior, not optimize entire infrastructure systems dynamically.

Conventional BMS environments are fundamentally rule-based. They execute predefined setpoints, schedules, thresholds, and alarms designed around relatively stable operating assumptions. While effective for maintaining baseline operation, these systems struggle to continuously adapt to changing real-world conditions across complex industrial environments.

In practice, industrial energy infrastructure behaves less like isolated equipment and more like a living operational ecosystem. Adjustments to one subsystem frequently influence multiple other systems simultaneously. Local optimization may unintentionally create inefficiencies elsewhere in the infrastructure.

For example:

- Lowering cooling temperatures may increase pumping energy unnecessarily
- Ventilation strategies may counteract heating or cooling optimization
- Thermal storage behavior may remain unmanaged
- Equipment staging may operate inefficiently under partial loads
- Utility pricing shifts may change optimal operating behavior throughout the day

Static control logic cannot continuously evaluate these interactions at system scale.

As operational complexity increases, manual optimization becomes increasingly reactive rather than strategic. Teams spend more time troubleshooting alarms, responding to inefficiencies, and correcting drift instead of proactively optimizing infrastructure performance.

Over time, these inefficiencies accumulate into structural operational cost.

The problem is no longer human-scale.

03

From Automation to Operational Intelligence

The next evolution of industrial energy management is not simply better automation. It is operational intelligence.

Operational intelligence platforms continuously model, understand, predict, and optimize infrastructure behavior in real time. Rather than reacting to alarms after problems occur, these systems evaluate how interconnected infrastructure behaves dynamically and determine how it should operate under changing conditions.

Power is the new currency of data centers. Operational intelligence determines how much of it you can actually convert into compute.

etalytics creates a real-time digital twin of industrial infrastructure using live telemetry data, thermodynamic system models, machine learning, weather forecasts, and operational context. This enables the platform to continuously orchestrate cooling, HVAC, heating, pumping, and energy systems as an integrated operational environment rather than isolated control loops.

The result is a transition from reactive operation toward continuously adaptive infrastructure optimization. Instead of relying on static assumptions, infrastructure systems dynamically adapt to:

- Real-time operational demand
- Ambient conditions
- Energy market pricing
- Thermal behavior
- Equipment condition
- Utility constraints
- Production variability

This allows industrial operators to move beyond maintaining stable operation toward continuously operating closer to the optimal system state. Importantly, this transformation does not require replacing existing infrastructure.

etalytics integrates directly into existing BMS, SCADA, EMS, historian, and operational environments using standard industrial protocols. No rip-and-replace projects. No large-scale hardware replacement. No disruption to existing operational control layers.

The intelligence layer sits above the existing infrastructure and continuously improves how systems operate together.

04 Why Physics-Based AI Matters in Critical Infrastructure

Not all AI approaches are suitable for mission-critical infrastructure environments.

Generic AI models excel at identifying statistical patterns. But industrial infrastructure requires more than pattern recognition. It requires physical understanding, operational transparency, and engineering reliability.

Cooling, HVAC, and energy systems operate according to thermodynamic principles, equipment constraints, and interconnected physical relationships. Effective optimization therefore requires understanding not only what is happening, but why it is happening. etalytics combines machine learning with physics-based digital twins grounded in thermodynamic system behavior. This enables the platform to evaluate infrastructure performance against expected physical behavior in real time.

The distinction is critical.

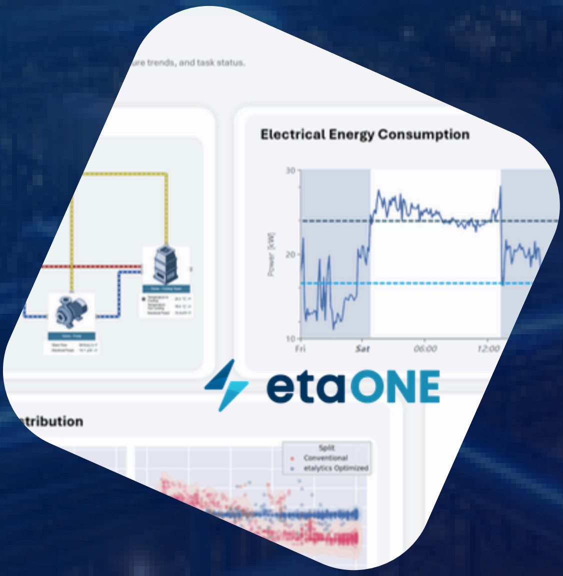
Physics-based AI allows operators to:

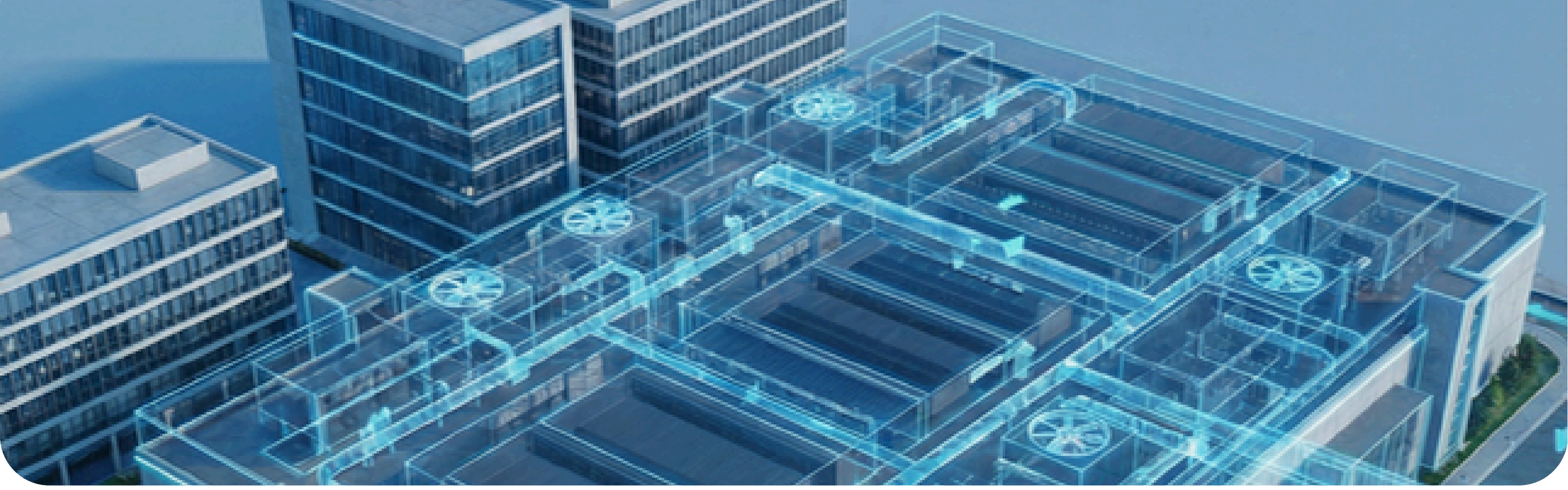
- Detect performance drift earlier
- Identify root causes more accurately
- Understand equipment interactions
- Predict failures before they escalate
- Optimize systems within safe operational boundaries
- Maintain explainability and operational trust

This becomes especially important in environments where uptime, resilience, and operational safety are non-negotiable.

The objective is not black-box automation. The objective is continuously optimizing infrastructure within transparent operational boundaries that operators understand and control.

> **If your infrastructure isn’t optimizing itself, it’s already the bottleneck.**





05 From Visibility to Autonomous Optimization

Operational intelligence creates value progressively across four connected operational stages.

Visibility

The first step is transparency. etalytics creates operational visibility into how systems behave in real-world operation. Operators can identify hidden inefficiencies, equipment drift, abnormal operating patterns, and root causes that remain invisible in traditional monitoring environments.

Prediction

Once infrastructure behavior is modeled, the platform can identify deviations before they become operational problems. Predictive insights allow teams to intervene before inefficiencies escalate into downtime risk or major energy loss. This includes:

- Fouling heat exchangers
- Underperforming pumps
- Chiller efficiency degradation
- Control instability
- Thermal drift
- Hidden equipment stress

Optimization

The platform continuously optimizes operational setpoints across interconnected systems. Instead of fixed operating logic, systems dynamically adapt to changing conditions in real time, enabling structural energy reductions while maintaining stable operating conditions.

Prediction

Operators can choose their preferred level of automation:

- Recommendation mode
- Bounded autonomy
- Full closed-loop optimization

In every case, operators remain fully in control while reducing manual workload and operational complexity significantly.

06 Proven in Critical Infrastructure

Operational intelligence is already delivering measurable results in production environments.

At **Equinix FR6** in Frankfurt, Germany, etalytics deployed autonomous optimization across critical cooling infrastructure supporting a large-scale data center environment.

The results included:

>900 MWh/a

Annual energy savings

49.3%

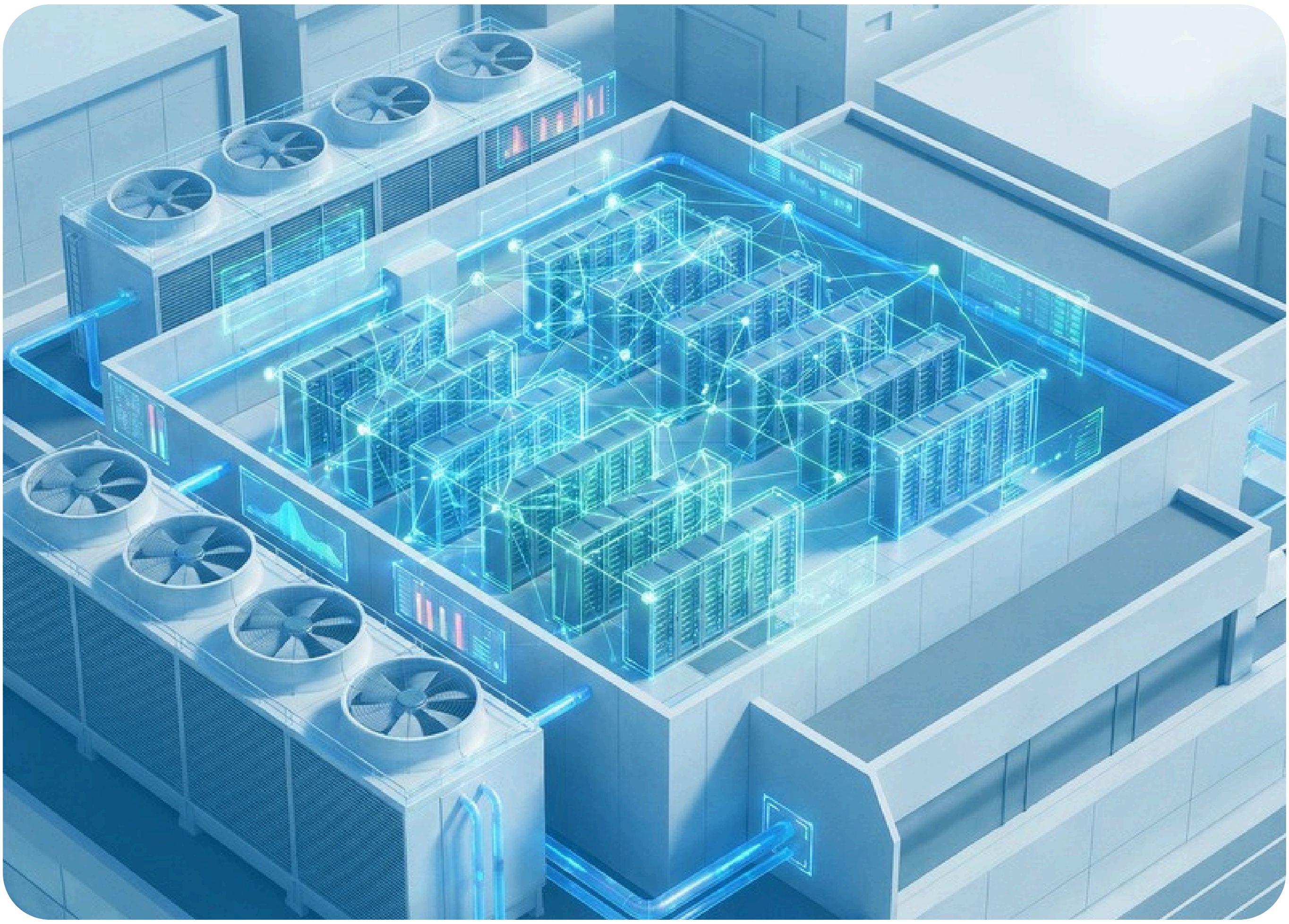
Projected reduction in cooling energy demand

<12 months

Payback period

>240t of CO_2

Emissions avoided annually



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Proven in Critical Infrastructure

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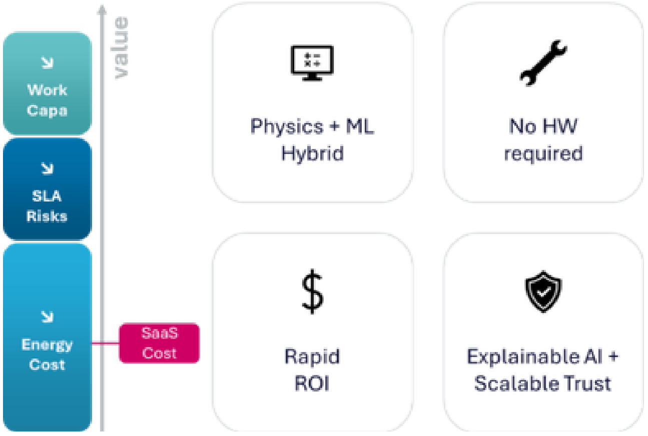

The project received the **German Energy Efficiency Award from Deutsche Energie-Agentur** and led to expanded collaboration across additional **Equinix** sites.

Beyond data centers, the same platform is already deployed across automotive, pharmaceutical, and manufacturing environments with organizations including **Volkswagen**, **Audi**, **Merck**, **Sanofi**, and **Stellantis**.

This demonstrates a broader industry reality: The optimization challenge is not unique to data centers. It exists anywhere complex energy infrastructure operates dynamically.

> Power is the new currency of data centers. Operational intelligence determines how much of it you can actually convert into compute.

07

Static Infrastructure Can’t Power a Dynamic Economy

As AI reshapes the global economy, operational efficiency is becoming a defining competitive advantage for industrial infrastructure.

Power availability is increasingly constrained. Energy costs remain volatile. Infrastructure complexity continues to rise. Skilled operational expertise is becoming harder to scale.

Organizations that can operate infrastructure more intelligently, automated, and optimized will gain structural advantages that compound over time:

- Lower operating cost
- Greater compute capacity per MW
- Higher operational resilience
- Faster scalability
- Reduced emissions
- More efficient use of existing infrastructure

Operational intelligence is becoming the foundation for that future.

Explore
What’s Possible

See how [Equinix reduced cooling energy demand by 49.3% with etalytics](#).

Visit [etalytics.com](#) to start a feasibility discussion.

Glossary

Core concepts in physics-based operational intelligence for industrial infrastructure

BMS (BUILDING MANAGEMENT SYSTEM)	A rule-based control system that executes predefined automation logic for individual building assets (e.g., HVAC, cooling, lighting). BMS platforms operate at the equipment level and are not designed to optimize system-wide energy interactions or adapt dynamically to changing operating conditions.
BOUNDED AUTONOMY	A control architecture where AI systems optimize industrial infrastructure within explicitly defined operational, safety, and performance constraints set by human operators. Enables automated decision-making while preserving engineering oversight and system governance.
COOLING EFFICIENCY (COP / PERFORMANCE RATIO)	A normalized metric describes how effectively cooling systems convert electrical input into usable cooling output. In advanced optimization contexts, it is used as a real-time performance signal to detect drift, inefficiency, and degradation across interconnected systems.
DIGITAL TWIN	A continuously calibrated, real-time computational representation of physical infrastructure that reflects system behavior across cooling, HVAC, and energy networks. Unlike static models, it evolves with live operational data and forms the basis for predictive and prescriptive optimization.
ENERGY BASELINE	A dynamically defined reference model of expected energy consumption under varying operating conditions. Unlike static baselines used in conventional reporting, advanced baselines account for weather, load, and system behavior to enable accurate measurement of optimization impact.
EMS (ENERGY MANAGEMENT SYSTEM)	A monitoring and reporting layer for energy consumption across facilities. EMS platforms typically focus on aggregation, benchmarking, and compliance reporting rather than real-time control or cross-system optimization.
FAULT DETECTION AND DIAGNOSTICS (FDD)	A data-driven capability that identifies performance degradation, inefficiencies, and abnormal system behavior, while isolating probable root causes across interconnected equipment systems. In advanced systems, FDD is continuous and physics-informed rather than threshold-based.

Glossary

Core concepts in physics-based operational intelligence for industrial infrastructure

FREE COOLING	An energy efficiency strategy that leverages ambient environmental conditions (e.g., outside air or water temperatures) to reduce reliance on mechanical cooling. Value is maximized when dynamically coordinated with system-wide operational optimization rather than static thresholds.
HVAC (HEATING, VENTILATION, AND AIR CONDITIONING)	A tightly interconnected set of thermal and air-handling systems responsible for environmental control in buildings and industrial environments. In modern infrastructure, HVAC systems are no longer isolated subsystems but part of broader energy and thermal optimization networks.
INTERCONNECTED SYSTEMS	Industrial energy environments where multiple subsystems (cooling, pumping, ventilation, storage, electrical distribution) continuously influence each other. Optimization requires system-level coordination rather than localized control actions.
LOAD SHIFTING	The deliberate reallocation of energy-intensive operations across time to improve cost efficiency, grid alignment, or system performance. In advanced systems, load shifting is executed dynamically based on real-time system state and external conditions.
OPERATIONAL INTELLIGENCE	A real-time software layer that transforms industrial infrastructure from reactive control systems into continuously optimized, self-adapting energy systems. Combines physics-based modeling, live data ingestion, and optimization algorithms to explain, predict, and improve system behavior.
PEAK SHAVING	A system-level optimization strategy that reduces maximum grid demand by dynamically smoothing or redistributing load. Unlike conventional demand management, advanced peak shaving considers full system interdependencies to avoid efficiency trade-offs elsewhere in the infrastructure.
PHYSICS-BASED AI	An AI architecture that integrates machine learning with thermodynamic and engineering principles to ensure system behavior remains physically consistent, explainable, and operationally safe. Unlike generic AI models, it is designed for control-critical industrial environments where reliability and causality matter.

Glossary

Core concepts in physics-based operational intelligence for industrial infrastructure

REAL-TIME OPTIMIZATION (RTO)	Continuous, closed-loop adjustment of system operations based on live telemetry, system constraints, and predictive models. Enables infrastructure to respond dynamically to changing conditions rather than relying on static setpoints or manual tuning.
SETPOINT OPTIMIZATION	Dynamic adjustment of control parameters (e.g., temperature, flow, pressure) across interconnected systems to continuously improve efficiency, stability, and cost performance under real-world operating variability.
THERMAL LOAD	The continuously varying heat energy profile generated by IT systems, industrial processes, occupancy, and environmental conditions. In advanced systems, thermal load is treated as a dynamic system input rather than a static design assumption.