Intelligent Energy Management for Data Centers

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This paper describes how Ampcontrol's energy management system keeps critical loads within site limits and lower energy costs, combining a local microgrid controller with load forecasting and day-ahead and spot price optimization.

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More information: www.ampcontrol.io

1 Executive Summary

Data center developers can start operations years before a full grid connection is available, keep critical loads within site limits and lower their energy costs, if battery storage, solar, backup generation and the grid connection are controlled as one system. This paper describes how Ampcontrol's energy management system does this, combining a local microgrid controller with load forecasting and day-ahead and spot price optimization. A reference site with illustrative values is used to explain the concept.

THE CONCEPT AT A GLANCE		
Faster power	**32 months earlier**	Run 12 MW of IT on a flexible grid connection before the firm upgrade
Reliability	**Grid limit held at all times**	Local AmpEdge control, independent of cloud connectivity
Cost efficiency	**6–10% lower energy costs**	Load forecasting with day-ahead and spot price optimization
Microgrid	**One platform**	Battery storage, solar, generators and grid connection

Reference Site

Type	Colocation and AI/HPC data center
IT load (final)	16 MW, ramping up in phases
Total facility load (final)	~20 MW average, ~23 MW peak, including cooling
Grid capacity available today	8 MW firm, 20 MW flexible (curtailable to 8 MW, assumed ≤ 300 h/year)
Full grid connection	25 MW firm, expected in ~38 months
Energy assets	Battery storage 12 MW / 48 MWh, rooftop solar 2 MWp, backup generators 10 x 2.5 MW
Energy market	Dynamic supply contract indexed to day-ahead and spot prices

Reference site used in this paper (illustrative values)

2 The Problem

Demand for AI and cloud capacity is growing faster than grid operators can build new connections. In many markets, a new data center can be completed long before the grid can supply its full load, while wholesale energy prices have become more volatile. Developers and operators face three problems.

1) Limited grid capacity delays the start of operations

The reference site needs about 20 MW on average and 23 MW at peak at full build-out, while only 8 MW of firm grid capacity is available today. Without a way to stay within that limit, the developer has to wait for the full grid connection before energizing most of the IT halls, and the building and its customer contracts stay idle.

IT load (phase 1 to final)	4 MW to 16 MW
Cooling and building load	1 MW to 4 MW (up to 6.5 MW on hot days)
Solar generation	2 MWp (rooftop)
Battery	12 MW / 48 MWh
Grid capacity today	8 MW firm, 20 MW flexible (curtailable to 8 MW, assumed ≤ 300 h/year)

Planned load exceeds the grid capacity available today

2) Reliability requirements for critical loads

Data center customers expect continuous power under strict SLAs. Each new energy asset on site (battery, solar, generators) adds another system that must work together with the grid connection, UPS and building management. Managed separately, with fixed setpoints and manual intervention, these assets increase the risk of exceeding the grid limit or running generators unnecessarily.

3) Volatile energy prices

Energy is the largest operating cost of a data center. With a supply contract indexed to wholesale prices, costs depend on when the site draws power from the grid. Without load forecasting and price integration, the battery and generators cannot be used to shift consumption away from expensive hours.

3 Proposed Concept

The concept has three objectives:

- start operations before the full grid connection is available
- keep critical loads powered within all site limits
- reduce energy costs through forecasting and market-based optimization

The concept combines four building blocks:

MICROGRID
Battery, solar, generators
AmpEdge controls all assets at the grid connection point in real time, also offline.

FORECASTING
Load and solar forecasts
IT, cooling and solar forecasts from history, weather and ramp-up plans.

MARKET
Day-ahead and spot prices
24-hour schedule, re-optimized during the day with spot and intraday prices.

MONITORING
Alerts and 24/7 support
One platform for all energy assets, with instant alerts and 24/7 monitoring.



Component 1: Microgrid with battery storage, solar and backup generation

Ampcontrol sets up a local microgrid that manages the energy flow across the site.

- **Asset integration:** All energy assets are connected locally to the Ampcontrol AmpEdge controller, which measures the grid connection point in real time and controls the battery, solar inverters and generator dispatch.

- **Networking and connectivity:** Ampcontrol deploys a secure networking setup with redundant connectivity to keep a reliable data connection to the Ampcontrol Cloud.

Typical integration protocols:

Battery storage	Modbus TCP/IP
Solar inverters	Modbus TCP/IP
Meters	Modbus TCP/IP
Generators and switchgear	Modbus TCP/IP
BMS / DCIM	REST API

Energy management integration and communication

The AmpEdge controller can operate entirely without internet if necessary, so control of the grid limit does not depend on cloud connectivity. When connected, it links to the Ampcontrol Cloud for monitoring, forecasting and price optimization. The site's UPS and protection systems remain responsible for instantaneous failover; Ampcontrol coordinates the energy assets around them.

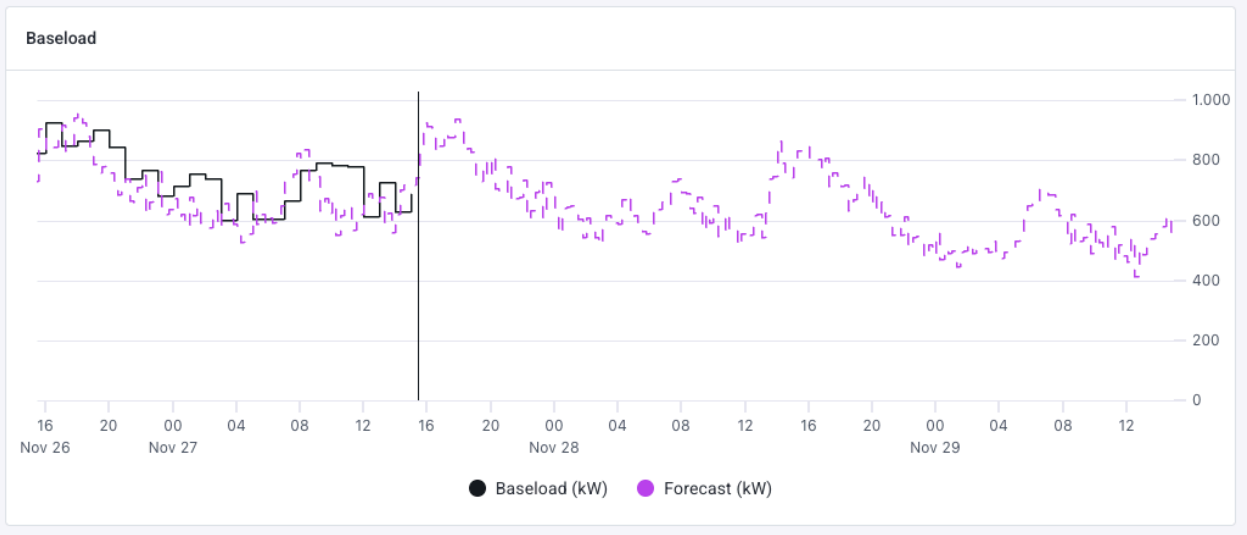
Component 2: Load forecasting and day-ahead and spot price integration

The optimization has to account for both the physical limits of the site and the cost of energy. The Ampcontrol Cloud connects to the site's operational and market data:

- **Load forecasting:** Ampcontrol forecasts IT and cooling load from historical consumption, weather data and planned capacity ramp-ups, together with expected solar generation.
- **Market integration:** The platform receives day-ahead prices each day and updates with spot and intraday prices during operation.
- **DCIM integration:** Data from the operator's DCIM and building management system gives the platform real-time visibility of IT and cooling load.

The software uses this data to plan and control the site automatically:

- **Day-ahead scheduling:** Each day, Ampcontrol creates a 24-hour schedule for battery charging and discharging, solar use and grid import, based on the load forecast and day-ahead prices.
- **Reoptimization:** During the day, the schedule is updated with real-time load, solar generation and spot prices, so the plan stays accurate when conditions change.
- **Peak shaving:** When site load approaches the grid limit, the battery discharges first and generators are dispatched only when needed, keeping grid import within the contracted capacity, including during curtailment events under a flexible connection.



Ampcontrol view for the site operator (load forecast, price curve and battery schedule)

Component 3: Monitoring and alerts

All energy assets are monitored in one platform. The alert center notifies the operations team of faults, communication losses or deviations from the schedule, and Ampcontrol's 24/7 monitoring supports the team in resolving issues.

4 Expected Benefits

For the reference site, the concept is expected to deliver the results below. Actual values depend on each site's load profile, energy contract and asset sizing.

Start operations 32 months before the firm grid connection

With a 20 MW flexible grid connection, and grid import held at the 8 MW firm limit during curtailment events through battery discharge, solar and controlled generator dispatch, the developer can energize 12 MW of IT capacity 32 months earlier. The remaining 4 MW follow once the firm connection is in place. The site can sign and serve customer contracts while the grid upgrade is still in progress, and adds capacity as more grid power becomes available.

Critical loads supplied within grid limits at all times

Real-time control at the grid connection point keeps the site within its contracted capacity. Coordinating the battery, solar and generators in one system reduces manual intervention and generator runtime, and gives the operations team one view of all energy assets.

Energy costs reduced by an estimated 6–10%

Load forecasting and day-ahead and spot price integration let the battery charge in low-price hours and discharge during price peaks. Together with higher solar self-consumption and avoided peak demand charges, we estimate energy cost savings of 6–10% for the reference site, or roughly €0.8–1.3M per year at an average price of €100/MWh. Part of the battery stays reserved for curtailment events, which limits the savings from price arbitrage.



5 Next Steps

Ampcontrol can validate this concept for a specific site with a feasibility study. The study analyzes historical load and energy price data, sizes battery storage and solar, assesses the available grid capacity, and compares energy costs and time to operation with and without the energy management system. To discuss a feasibility study for your site, contact us at contact@ampcontrol.io.

About Ampcontrol

Ampcontrol is a provider of energy management and optimization software for energy-intensive sites, including data centers, logistics depots and ports. Its software and hardware connect batteries, solar, generators, chargers and grid connections in one platform, with real-time monitoring and intelligent control. Ampcontrol's Energy Management system accounts for each site's constraints, such as transformers, grid connections, energy tariffs and wholesale prices, and uses load forecasting to plan and optimize energy use. Ampcontrol is certified to ISO 27001 and SOC 2 Type II.





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