ENERGY, HVAC & LIGHTING

Make building energy follow how the building is actually used

How connected energy data, equipment state, schedules, occupancy and environmental context turn HVAC and lighting from isolated systems into coordinated operating workflows — and how the result gets measured rather than assumed.

Energy waste is rarely one dramatic fault. It is thousands of ordinary operating decisions repeated every day. An HVAC unit starts before anyone needs the space. A guestroom stays conditioned after it becomes vacant. A conference room is cooled for an event that was cancelled. A garage stays fully illuminated with nobody in it. A rooftop unit follows the same schedule on a quiet Friday that it follows on a busy Tuesday. A plant keeps operating to static assumptions while loads, weather and occupancy move underneath it. The utility bill arrives weeks later showing what all of it cost in aggregate.

The equipment may be functioning exactly as designed. The problem is that the building is operating from incomplete context — meters report consumption, thermostats control rooms, lighting follows its own schedules, and central plant runs from another set of rules, none of them aware of the others.

Measure what the building uses. Understand why it is using it. Operate equipment for the condition that actually exists.

SCOPE

This application explainer owns the operating story around energy visibility, HVAC, lighting, schedules and occupancy-driven operation. Connection and normalization belong to Wireless Building Automation and Connectivity & Integrations; equipment diagnostics to Equipment Monitoring & Diagnostics; occupancy sensing to Occupancy, Environment & Facility Use; the authority governing physical actions to Protected Control & Resilience. Capability varies by equipment and deployment — see Current availability at the end.

A NOTE BEFORE THE ARCHITECTURE

Start with the simplest intelligence that solves the problem.

Most building-energy waste does not require a model to identify or eliminate. A schedule turns equipment off when a building closes. An occupancy state decides whether a room needs occupied conditioning. A setpoint rule keeps operation inside an approved range. A meter reveals an unexpected overnight load. Those are all forms of building intelligence, and none of them is machine learning.

The architecture supports a progression from explicit rules and context-aware automation toward more advanced analytics where the operating problem justifies it. The objective is not to apply AI to every control decision — it is to use the simplest appropriate intelligence to make the building operate better.

THE ENERGY OPERATING LOOP

Measure, contextualize, schedule, adapt, control, verify.

1 · Measure	Where and when is energy being used?
2 · Contextualize	Which building, zone, equipment and operating condition produced it?
3 · Schedule	When should the equipment normally operate?
4 · Adapt	Has occupancy, weather, demand or building use changed from the assumption?
5 · Control	What permitted operating change should occur, in HVAC and in lighting?
6 · Verify	Did the building respond, and what happened to energy and comfort afterwards?

Not every workflow needs every stage. One property begins with monitoring and submetering, another with occupancy-driven HVAC, a third with lighting schedules and common-area controls. The value comes from a shared operating context those applications can build on rather than each establishing its own.

1 · Measure

A monthly utility bill says how much energy was purchased. It rarely says why. Whole-building data is the end result of many loads operating across many conditions, so useful visibility combines whatever a property makes available: whole-building electricity or gas, interval meter data, floor, tenant, zone or circuit submetering, equipment-level meters where installed, HVAC runtime and operating state, lighting state, equipment command and feedback, temperature and environmental measurement, and approved occupancy context.

Not every deployment needs all of it. The objective is to measure at enough resolution to answer the operating question being asked. If the question is whether a property is reducing electricity consumption, a main meter may be sufficient. If the question is why HVAC consumption stays high overnight, equipment state, occupancy and schedule matter far more. If the question is whether a specific optimization changed anything, granularity becomes the deciding factor — and it is worth settling that before the measure is deployed rather than afterwards.

2 · Contextualize

A kilowatt is a measurement. A kilowatt tied to a space, a system and an operating condition is information:

> **RTU power = 18.4 kW → RTU-3 · serving Zone 3 · 18.4 kW · space unoccupied · cooling enabled · 22:42**

The electrical measurement has not changed; its usefulness has. Context supplies the equipment, the location, the time and operating period, whether the conditioned or illuminated space is actually in use, the environmental conditions, and the mode, setpoint, schedule or command that is active. Connectivity & Integrations establishes that context; this application spends it.

3 · Schedule

The first optimization is usually just operating equipment when it is needed, and schedules remain one of the most important control tools because many loads genuinely follow predictable periods. They are also one of the most persistent sources of waste, because they decay. Tenants change. Hotel occupancy varies. Events move. Retail hours change. Cleaning shifts. Seasons turn. An operator extends a schedule to settle a comfort complaint and never moves it back.

A connected operating layer makes scheduling observable rather than invisible: the intended schedule can be compared against actual equipment operation and actual building use, and the operating window refined against evidence. That applies to occupied and unoccupied HVAC schedules, zone-specific rather than building-wide periods, weekend and holiday scheduling, event or reservation-driven schedules where approved integrations supply that context, lighting by space and use, exterior lighting, and start and stop strategies around expected occupancy.

Scheduling is not obsolete because analytics exist. A good schedule is deterministic, understandable and frequently sufficient.

4 · Adapt

A schedule represents expected use; building context reveals actual use, and this is where a connected application becomes more than a time clock. A room scheduled occupied may be empty. A conference space expected to be empty may fill. A hotel may have entirely different occupied-room patterns two nights running.

The basic pattern is straightforward — space occupied means normal operating condition, space unoccupied means an approved energy-saving condition. For HVAC that is an occupied and unoccupied setpoint strategy or another configured reduction. For lighting it is extinguishing or dimming compatible fixtures after an appropriate vacancy period. For shared spaces, occupancy supplements the schedule rather than replacing it.

The occupancy signal does not need to carry more than the workflow requires. An application deciding whether a space needs occupied HVAC needs an occupied or unoccupied state — not raw sensing data, and not personal identity.

CONTROL

Align operation with the condition the building actually requires.

HVAC is usually the largest opportunity because it combines big loads with highly variable demand. The goal is not to turn HVAC down — it is to stop conditioning space that does not currently need conditioning. The inputs that make that possible are room and zone temperature, setpoint, occupancy state, equipment mode and status, schedule, outside conditions, runtime and power, and command feedback confirming that a requested change actually occurred.

The strategies that follow are mostly unglamorous and mostly effective: occupancy setback moving an eligible space toward an approved unoccupied condition and back when required; schedule refinement removing unnecessary pre-start, after-hours and weekend operation; bounded setpoint management inside defined comfort and equipment limits; room and zone coordination so decisions need not be made at whole-building granularity; scheduling, setpoint and operating-state strategies for connected packaged equipment; and, where sufficient points, sensing and control authority exist, plant-level strategies operating from actual load rather than static assumptions.

Lighting uses the same context

Lighting controls are usually deployed independently of HVAC even though both systems need answers to the same questions — is the space occupied, what is the schedule, does it need full output, is daylight already contributing, what happens after vacancy. Where compatible devices and controls exist, lighting can use the same building context for scheduling, occupancy-based control, bi-level operation in corridors and garages, daylight-aware dimming, event-space coordination and exterior operation.

That shared context is the point. An occupancy state installed to improve HVAC can support a compatible lighting workflow as well; the second application should not have to recreate what the first established. Consider a meeting space that empties early. Left alone, HVAC keeps conditioning until 22:00 because the calendar says occupied, lighting stays at full output because someone left the wall control on, and the energy system reports the total tomorrow. With shared context there is one condition — space vacant — and two coordinated responses. The systems do not need to become one controller. They need to operate from the same reality.

Comfort is a control constraint, not a variable to minimise

An energy application succeeds only if the building still does its job. A hotel room has to be comfortable when the guest needs it. An office has to support occupants. Senior living has different acceptable constraints from a warehouse. So the question is never how far a setpoint can move — it is how much unnecessary operation can be removed while preserving the required condition.

That is why energy optimization runs inside the protected-control model rather than around it. Configured boundaries include occupied and unoccupied setpoint ranges, permitted equipment, allowed control points, data-validity requirements, operator overrides and fallback conditions. If an occupancy input becomes invalid, an occupancy-dependent strategy must not keep assuming the room is vacant indefinitely. If an operator overrides a zone for a real operating reason, automation must not silently fight the decision. If equipment does not respond to an authorized command, the application needs to know the expected energy action did not happen.

> **Energy optimization is governed operation, not unrestricted minimization.**

VERIFY

A strategy is not an energy-saving strategy because software says it ran.

Three events get conflated and should not be: a decision was made, a command was issued, and the building actually changed. If an application requests unoccupied setback but the controller stays in occupied mode, the energy action did not occur. If a lighting workflow sends an off command and the circuit stays energised, the load did not disappear. If equipment responds but the space immediately falls outside an acceptable comfort boundary, the strategy needs changing rather than repeating.

Verification uses whatever feedback the deployment provides — controlled-point readback, equipment state, runtime, power or current measurement, zone temperature response, lighting state, meter interval data, occupancy condition, and the record of operator overrides and exceptions. Immediate feedback verifies operation; energy data evaluates performance over time. Those are different questions: did the building do what was requested, and did the change produce a measurable result.

When verification fails, the application does not assume the intended action occurred. Depending on the configured workflow, a failed or unconfirmed action raises an exception, inhibits further optimization, returns the affected equipment toward its defined strategy, or requires operator attention. Protected Control & Resilience governs the underlying authority and fallback behaviour.

> **A failed or unconfirmed action is an exception, not a savings event.**

CONSUMPTION AND DEMAND

Reducing kilowatt-hours is not the same as reducing the bill.

Many commercial electricity tariffs include both energy and demand charges, and the two behave differently. Energy charges are based on total electricity consumed. Demand charges are based on peak power over a defined interval, often the highest fifteen- or thirty-minute average in the billing period. Some tariffs also include demand-ratchet provisions under which a high peak can influence charges in later billing periods. In many commercial tariffs, demand can represent a substantial share of the total electricity cost.

The two respond to different actions, and conflating them is how an energy programme delivers real savings that barely show up on the invoice. Turning equipment off overnight cuts consumption and may not touch the peak at all, because the peak usually occurs on a hot afternoon with everything running at once. Occupancy-driven setback reduces both, but not in proportion.

Reduces consumption	Occupancy setback, schedule refinement, removing after-hours and weekend operation, lighting reduction in vacant space.
Reduces peak demand	Avoiding simultaneous equipment startup after an unoccupied period, limiting how much equipment stages up together, and — where supported — preconditioning or other load-shaping strategies that reduce operation during the peak window.

Reduces cost without reducing either	Moving flexible load into cheaper periods under a time-of-use tariff — the same kilowatt-hours bought at a different price.

The first column is where this application does most of its work. The second and third depend on how much equipment can be coordinated and how much notice the building has, and they are where an energy programme starts to look like grid participation rather than housekeeping.

This application focuses on how the building itself operates. Consumption reduction, peak-demand management and tariff-aware operating strategies depend on the loads available for control, the property tariff and the deployment configuration. Participation in external utility or grid programs is outside the scope of this explainer.

MEASUREMENT

Savings should be measured, not inferred from the presence of automation.

A building can install controls and still fail to save energy. Schedules may be wrong. Equipment may not respond. Comfort complaints may cause operators to override the strategy. Weather changes. Occupancy changes. Other loads obscure the result.

So energy performance needs a baseline and operating context: pre- and post-period energy data, matched equipment, rooms or operating periods, interval meter or submeter data, runtime comparison, weather and occupancy context where material, comfort measurements, equipment response data and control-event history.

The measurement method should match the claim being made. A whole-building utility comparison answers some questions. A room-level controlled comparison answers others better. A plant optimization may require dedicated metering and a formal measurement-and-verification approach. For projects requiring formal measurement and verification — particularly owner underwriting or utility incentive programs — recognized frameworks such as IPMVP can provide a structured basis for defining the measurement boundary, baseline and adjustment methodology.

> **Do not convert an engineering estimate into a measured result.**

FROM THE FIELD

51% average HVAC energy savings in the Scottsdale pilot.

An occupancy-driven guestroom HVAC deployment at the Hampton Inn Scottsdale, Arizona produced 51% average HVAC energy savings, measured by comparing same-size rooms on the same days.

Property	Hampton Inn Scottsdale, Arizona.
Measure deployed	Occupancy-driven guestroom HVAC setback.
Comparison method	Matched rooms — same size, same days — rather than a pre- and post-period comparison, which controls for weather and occupancy directly.

Sample and duration	[CONFIRM: number of rooms in each group, and the measurement period.]
What was measured	[CONFIRM: metered HVAC energy at the unit or submeter, or runtime-derived. State which.]
Comfort	[CONFIRM: how "no comfort impact" was established — guest complaint data, recovery time to setpoint on re-entry, or measured room temperature during occupied periods.]

The result matters because of the principle behind it rather than the number itself. The equipment did not become more efficient. The building became better at deciding when that equipment needed to run at all.

> **Scottsdale presents conditions that can favor occupancy-driven HVAC savings: a cooling-intensive climate, substantial daytime cooling loads and hotel rooms that may remain vacant for meaningful portions of the day. Results in other climates, occupancy patterns and operating environments can be materially different. 51% is a result from one deployment, not a savings promise for another building — outcomes depend on baseline operation, equipment, climate, occupancy, operating schedules, control scope and the measures deployed.**

A WORKED EXAMPLE

Hotel guestroom HVAC.

A hotel shows why actual use matters more than a static schedule. A room may be sold tonight or vacant tonight. A guest may leave for several hours. A room may be checked out but still being serviced. The HVAC equipment has no way to distinguish any of that unless building context reaches the control workflow.

Combining room temperature, occupancy state, current HVAC mode, setpoint and room or building operating context produces an operating decision. If the room is occupied, normal comfort policy applies. If it is unoccupied and eligible for setback, the application requests an approved energy-saving condition; protected control verifies the request falls inside the configured envelope; the equipment responds; the resulting state is observed. When occupancy returns — or another defined condition requires it — the room returns to occupied operation.

> **Context → operating decision → governed action → physical response → measured outcome**

ACROSS PROPERTY TYPES

Same operating principle, different sequences.

Hospitality	Guestroom HVAC, variable-use meeting spaces, common-area lighting and equipment schedules.

Office and CRE	Zone schedules, after-hours operation, occupancy-responsive spaces, lighting and central HVAC.
Multifamily and student housing	Common-area HVAC and lighting, selected in-unit strategies, central equipment and portfolio visibility.
Senior living	Energy management inside more conservative comfort and operating constraints.
Retail and distributed sites	Store HVAC schedules, lighting, after-hours operation and centralized portfolio visibility.
Industrial and warehouse	Zone-appropriate HVAC and lighting, operating schedules and large-load visibility.

The point is not one control sequence imposed across all of them. It is reusing the same connected-building model while applying the operating logic each environment actually needs.

CAPABILITY PROGRESSION

A property does not have to automate everything at once.

Level	What the building does	Primary value
Visible and contextualized	Measures energy and associates consumption with equipment, zones, schedules, occupancy and operating conditions.	Establish the baseline, find abnormal use, understand where energy goes.
Scheduled and context-aware	Automates approved schedules and adapts HVAC and lighting to actual building use.	Remove occupancy, calendar and after-hours operating waste.
Optimized and predictive	Applies analytics or models to thermal behaviour, demand, preconditioning or complex operating relationships.	Improve decisions where static rules stop capturing the problem.

These are capability levels, not mandatory phases. A property may stay at monitoring for some loads while running context-aware automation on others.

Where advanced models fit

Models earn their place when the application has to estimate something not directly observable, or reason across more variables than a rule can hold — forecasting demand, learning a building's thermal response, predicting a useful preconditioning window, recognising operating behaviour across many inputs. Even then the model is part of the application, not part of the authority model. A prediction that a room will soon be occupied does not itself grant permission to operate an HVAC unit, and a model that identifies an opportunity does not thereby widen the equipment it may control. Distributed Intelligence covers where those workloads run.

THE OPERATOR

Automation should reduce repetitive intervention, not hide the building.

Operators need to know what is running, what is scheduled, what changed automatically and why, what is using energy outside expected conditions, whether an automated strategy is active, whether someone has overridden it, whether the equipment responded, and what happened to comfort afterwards.

The value of automation is not that the operator disappears. It is that the building handles repeatable decisions consistently and surfaces the ones that actually need human judgement — which means an energy application is automation plus visibility, exception handling and operator authority, not automation alone.

WHAT THIS MEANS

For the people who own and run the building.

Building owners	Energy becomes an operating variable rather than a bill reviewed after the fact. Start with a high-value use case, measure the result, and extend the same infrastructure into further applications.
Operators	Schedules, occupancy, equipment state and energy data in one operating picture, with routine decisions automated while exceptions and overrides stay visible.
Systems integrators	The work remains grounded in actual sequences, equipment capability, sensing, control points and commissioning — but those systems participate in common energy workflows instead of staying isolated by vendor or protocol.

CURRENT AVAILABILITY

Deployable energy management, with sophistication where the equipment supports it.

> **The current application architecture includes energy monitoring and analytics, submetering, automated energy-management workflows, occupancy-aware control, HVAC optimization and lighting automation through compatible devices and integrations.**
>
> **What is available at a given property depends on the equipment, exposed control points, metering, sensing, Gateway and software configuration, integration scope and commissioning. Some deployments are monitoring-only; some support schedule and setpoint control; some add occupancy-driven operation; some expose enough plant information for further optimization. Lighting functionality depends on compatible controls and the available switching or dimming interface. Predictive strategies should be treated as deployment- and release-specific rather than assumed. Current project documentation governs the functions available for a given building.**

THE CORE IDEA

Stop operating the building from assumptions when it can tell you what is happening.

Energy visibility shows what was consumed. Building context explains where and why. Schedules establish the normal plan. Occupancy and other real conditions show when reality has diverged from it. HVAC and lighting workflows turn that into permitted physical action. Verification establishes whether the building responded. Measurement establishes whether performance actually improved.

> **Measure the load. Understand the context. Condition the space when it needs conditioning. Light it when it needs light. Verify the physical result. Measure the outcome.**

The result is not another energy dashboard. It is a building whose major loads increasingly operate according to actual demand rather than static assumptions.

Energy performance varies by property, equipment, baseline condition, climate, occupancy, operating schedule, control scope and deployment. Measured results from one property should not be treated as guaranteed results for another. Physical actions remain subject to configured permissions, equipment limits and operating policies.

Related · Wireless Building Automation · Connectivity & Integrations · Protected Control & Resilience · Occupancy, Environment & Facility Use · Equipment Monitoring & Diagnostics · Sustainability & Reporting · Distributed Intelligence