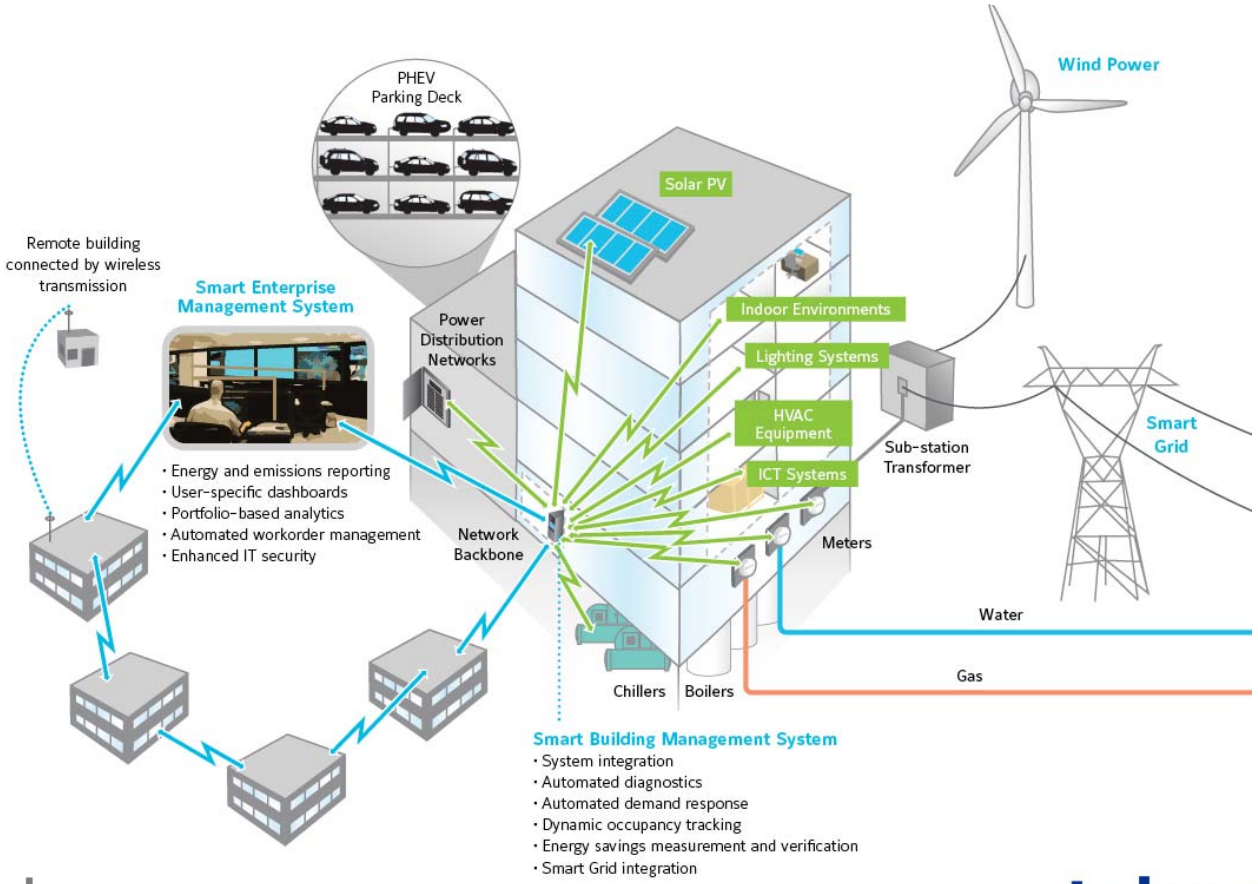
Smart Buildings for a Smart Grid

Technology & Services to Make Buildings Smart Grid Responsive



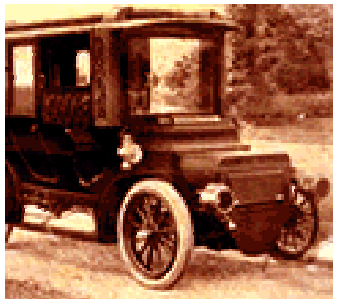
Carl Wouden

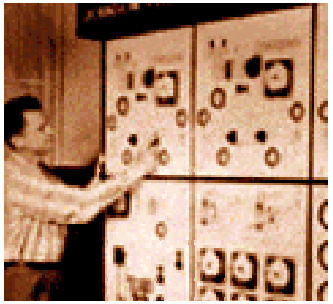
June 28, 2010

Johnson Controls

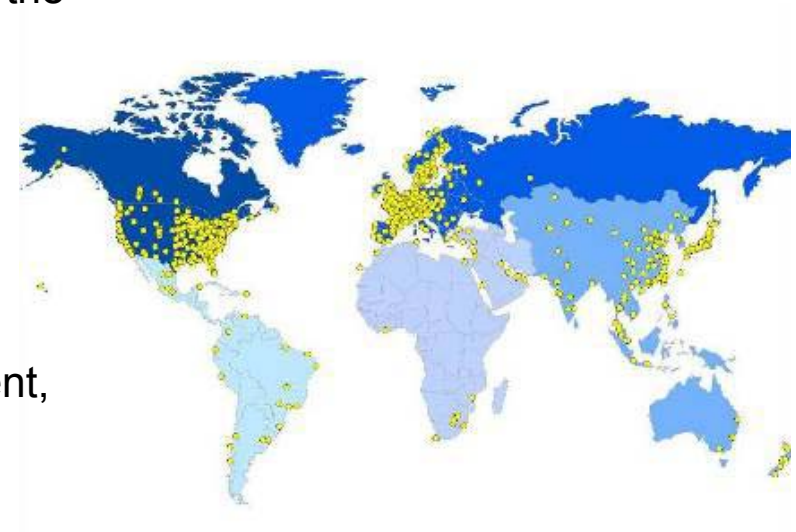
Intro to Johnson Controls

140,000 Employees | **Fortune 100** | **Multi-Industry Company**

- Founded in **1885** by Warren Johnson, inventor of the first electric room thermostat
- Over 40,000 employees dedicated to **building efficiency** in 500+ locations in 125 countries
- Market leader in **HVAC and controls** technology
- 13,000 **HVAC technicians,** 12,000 **facility mgrs**
- Over **1.4B sq ft** of space under direct management, with services provided to a further **20B sq ft**
- Largest ESCO in North America with over **$4.9 billion** of active cost savings guarantees



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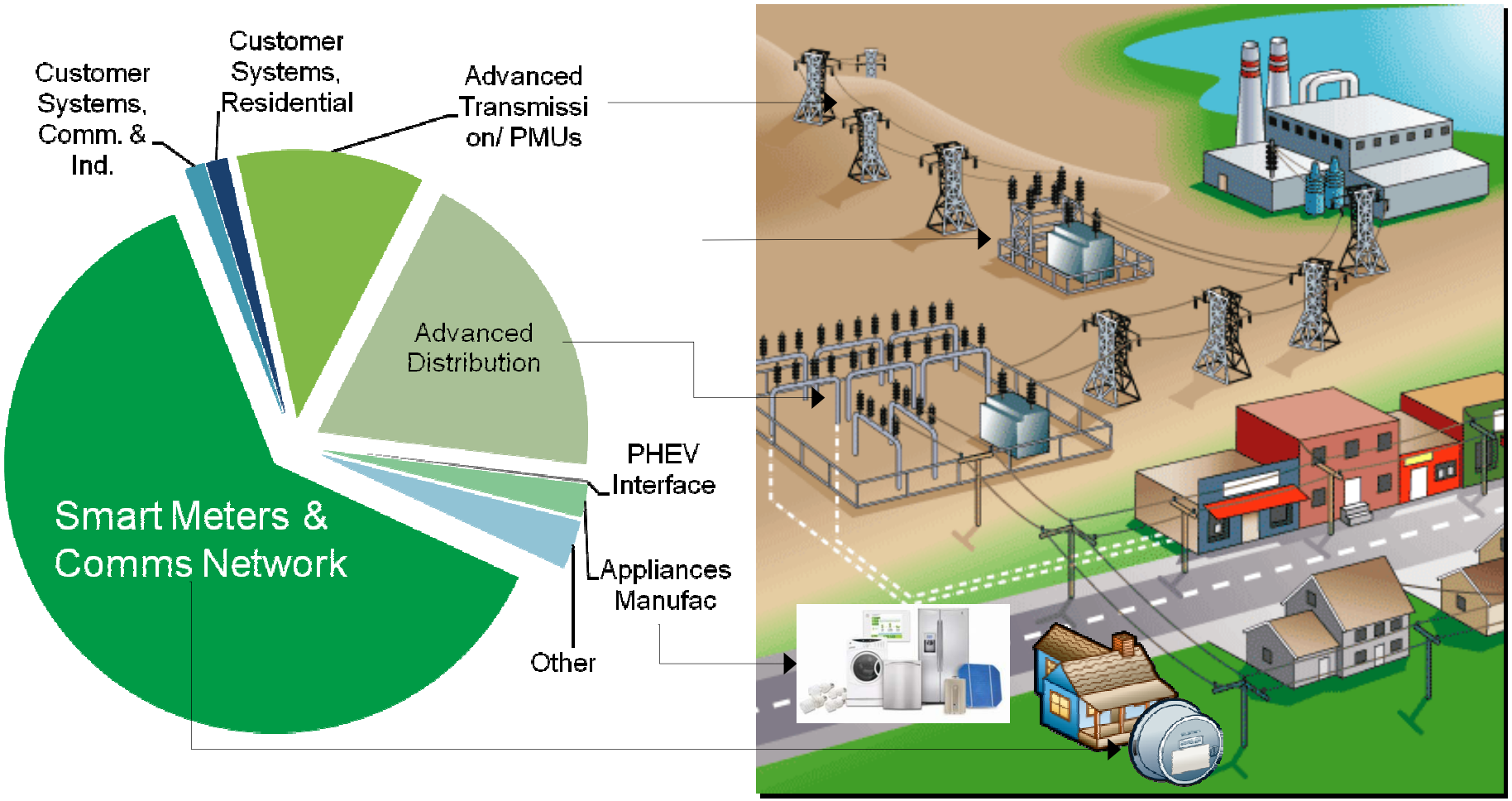
Most smart grid investment today is on deploying smart meters and communications infrastructure



Source: Johnson Controls analysis of **$3.4 billion** in SGIG awarded October 2009

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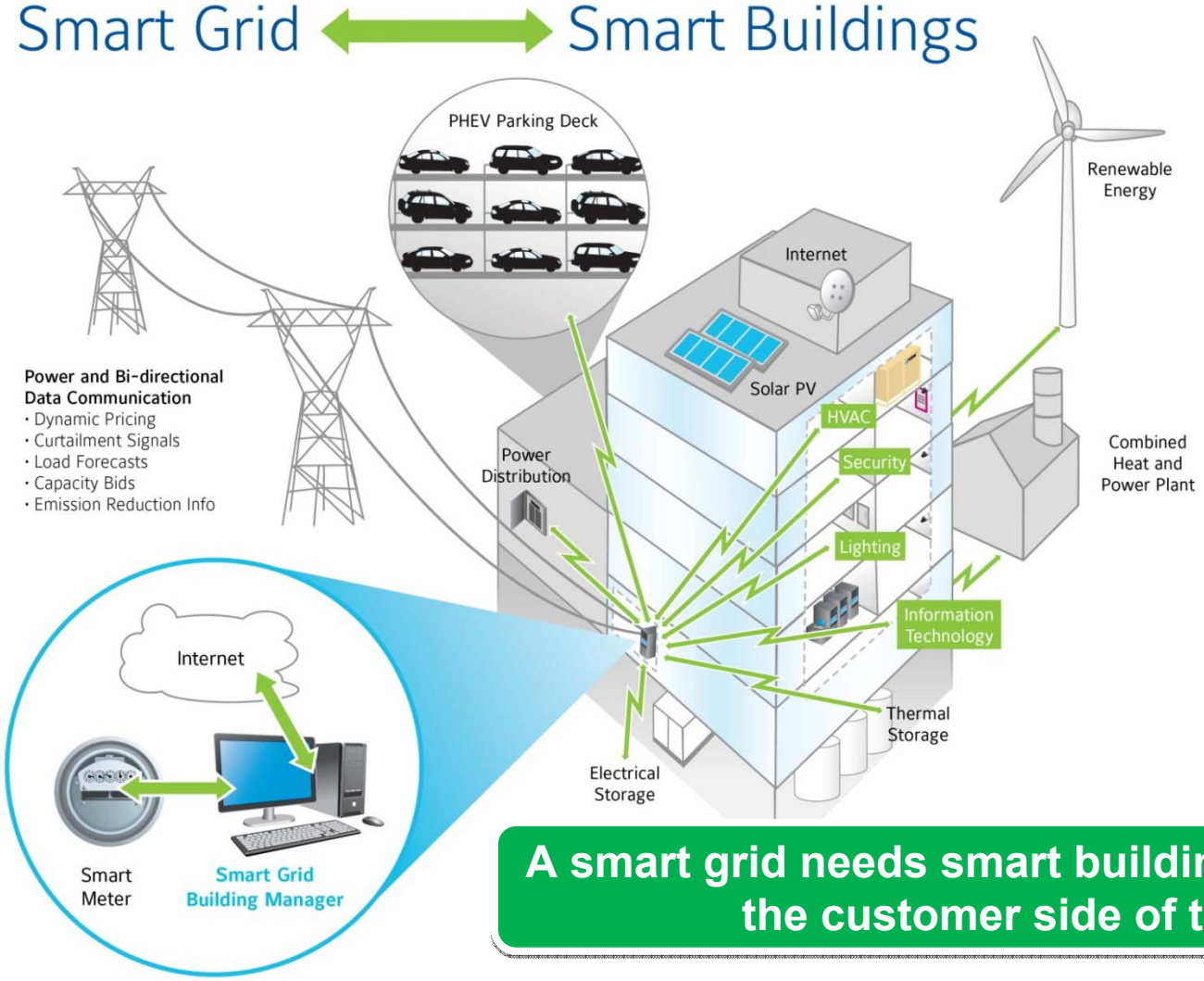
Grid response must be easy for owners and operators



5% load response without technology

vs.

13% load response with auto-DR technology

Technology also likely to dramatically increase DR participation rates

A smart grid needs smart buildings and devices on the customer side of the meter

Source: 2006 CRA SPP C&I Report; Demand Response Research Center

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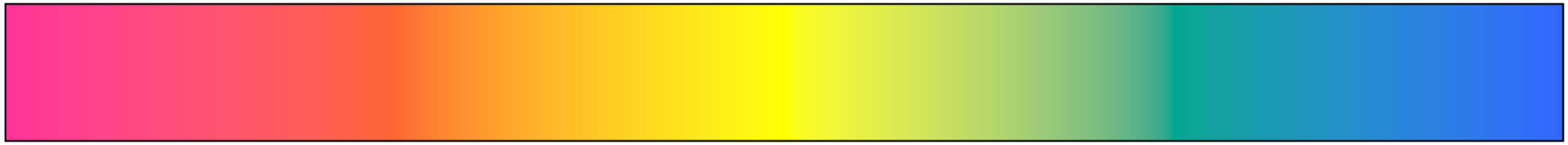
The “Spectrum” of Demand Response Control

Logic, decision-making and control can sit with the load-serving entity, the customer, or anywhere between (e.g. an curtailment service provider):

Central Control — **Autonomous Control**



Direct Load Control (AC Cycling)	Interruptible Rate Wholesale Capacity Programs Traditional “Aggregator” Model	Critical Peak Pricing Wholesale Energy Programs Voluntary Demand Bidding	Pure Real Time Price

93% of existing 40GW of DR resources in U.S. are **centrally dispatched event-based**

Energy labs & DOE FOAs suggest rapid evolution to **price-based autonomous** model

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Smart Building Manager

What is it?

A enterprise software application to make commercial buildings more energy efficient and responsive to the smart grid while ensuring a productive building environment…

….that can be sold in combination with Metasys, sold as stand alone software where Metasys is not installed, or used as a technology enabler to sell services, consulting, solutions…

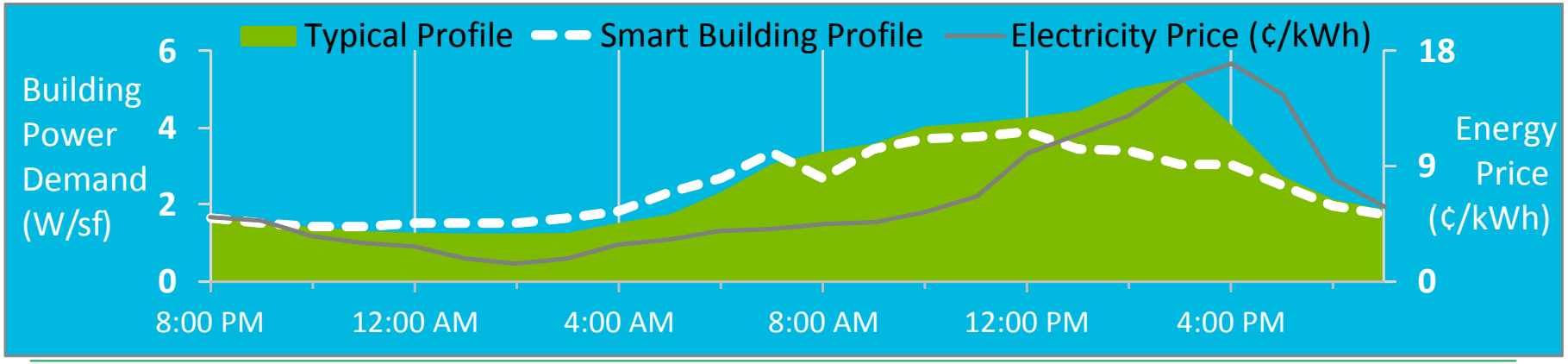
…for new and existing commercial buildings globally…

…paid for by building owners, utilities, and governments

Smart Buildings for a Smart Grid

A Day in the Life

How the **smart grid building manager** will create business value in, for example, a 500,000 sq. ft tenant-occupied office building on an hourly real time electricity pricing tariff



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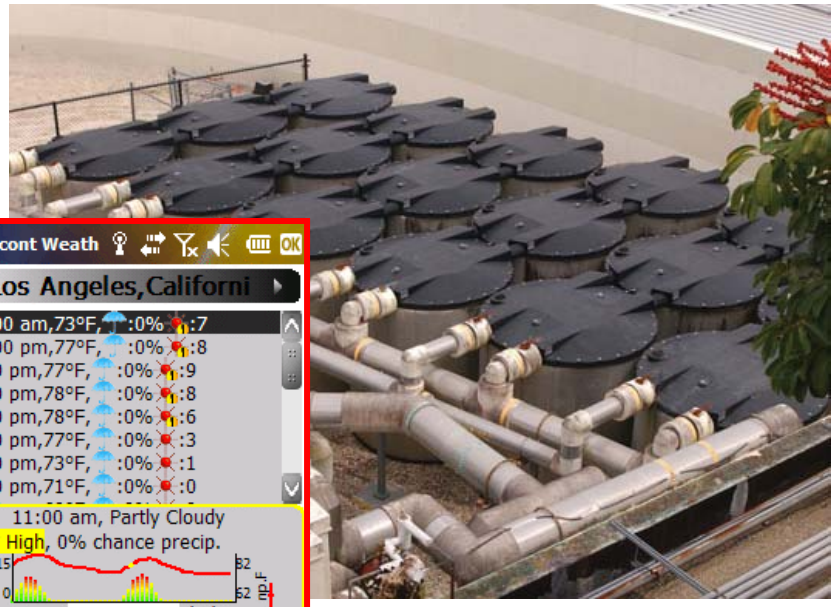
8:00 pm

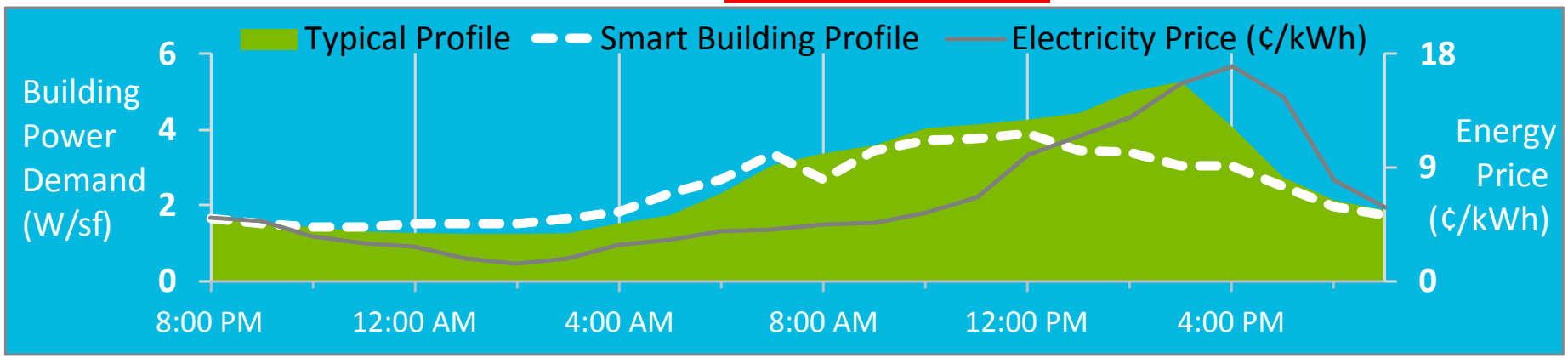
Smart planning for tomorrow

System accesses tomorrow's weather forecast from local weather station and models the building's hourly load profile

Real time price forecasts are received from the electric utility

Based on predicted high afternoon temps and prices, system schedules night time ice storage generation to take advantage of low night temps, improved efficiency, and off-peak prices





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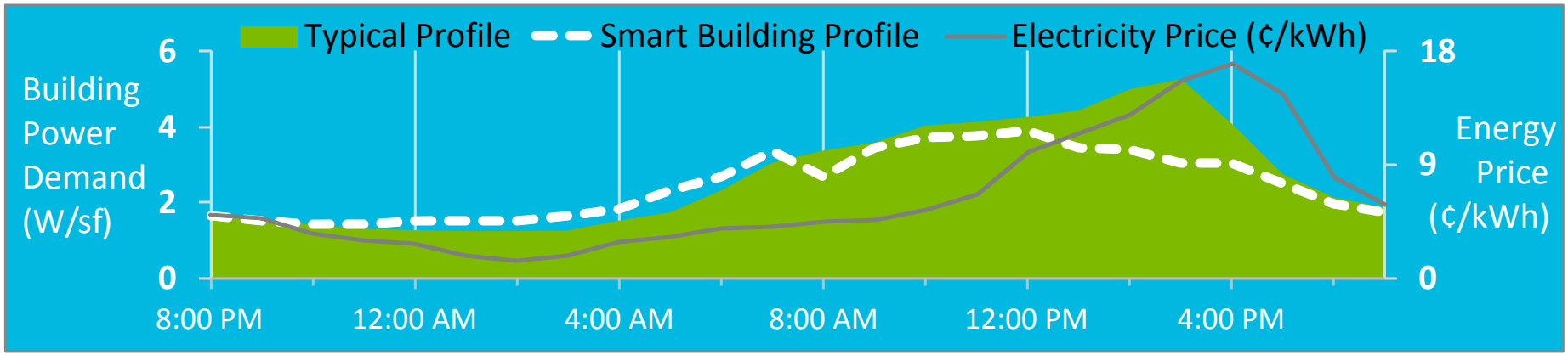
4:00 am

Chiller fault detected

During night time ice generation, the diagnostics engine determines a chiller valve has failed, resulting in a reduction in glycol flow, system efficiency, and ice storage charging speed

System calculates costs associated with this fault based on real time price forecasts

Due to the high projected cost impact, the system auto-generates a work order and notifies facility manager by smart phone for approval



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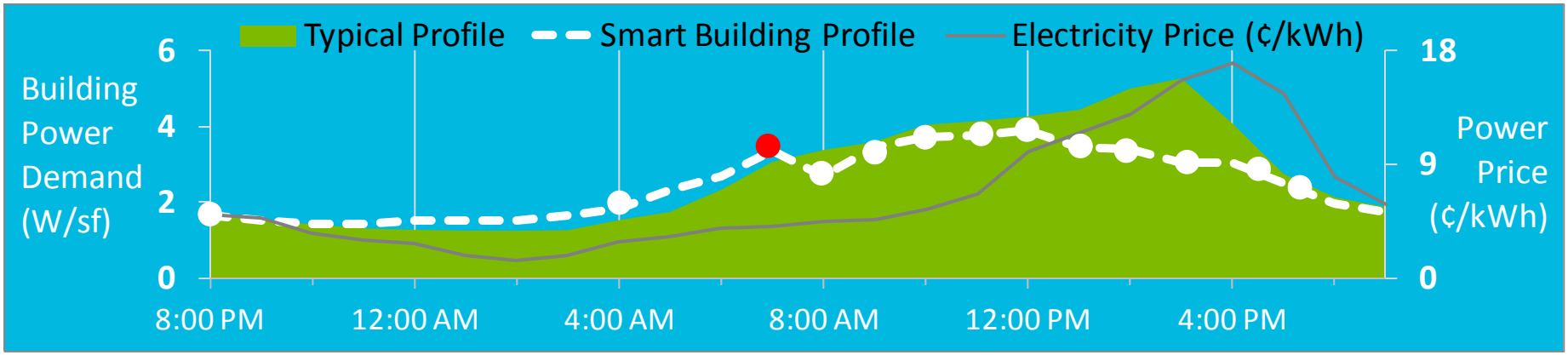
7:00 am

Chiller repaired

Service technician arrives after being dispatched automatically upon facility manager's approval

Technician quickly fixes problem knowing the source and the new parts required (e.g. a new transformer for the spring return valve)

Repair results in immediate load reduction and increase in ice tank charge rate. Allows system to generate enough ice prior to spike in prices anticipated later in the afternoon



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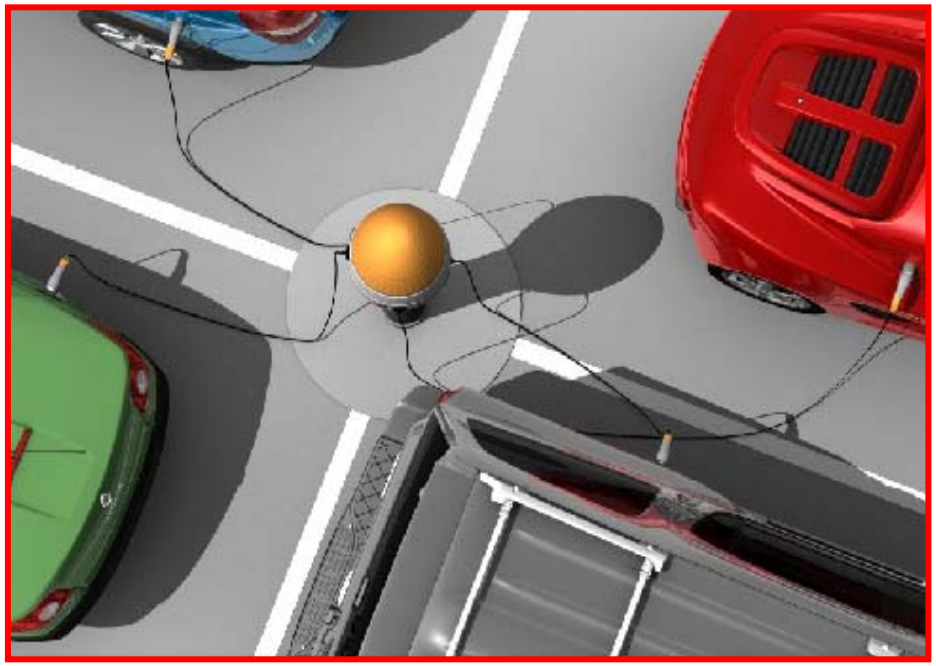
8:00 am

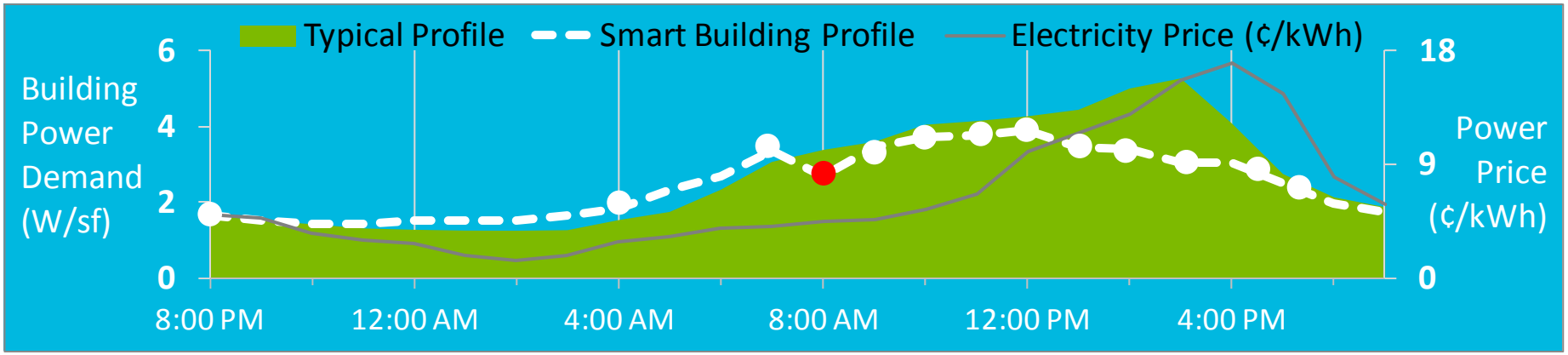
Employee plugs in vehicle at work

Electric or plug-in hybrid vehicles recharge when real time price of electricity is low or when onsite solar photovoltaic system's power production is high

Smart charging can also support voltage regulation for the local utility

Purchase or sale of power to building is automatically factored into payroll system





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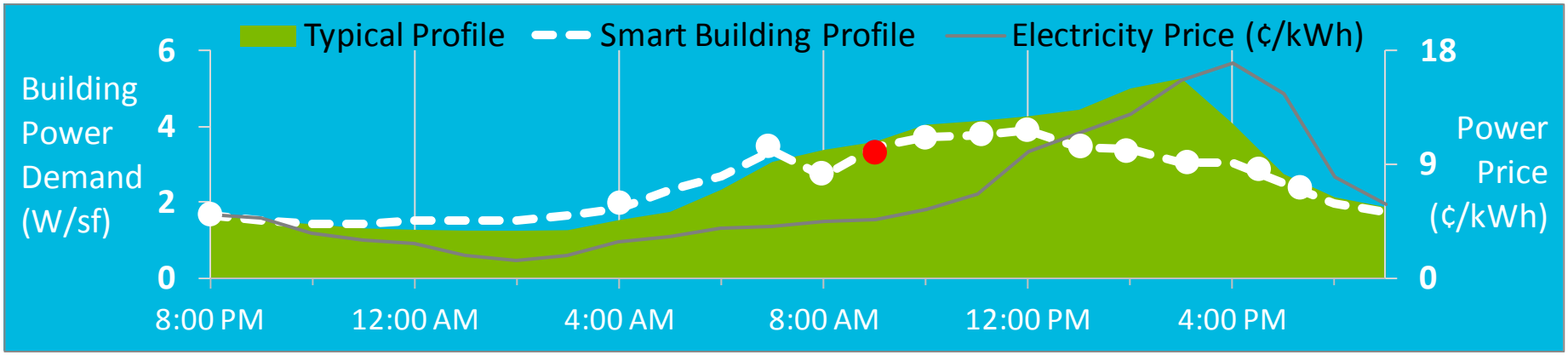
9:00 am

Meeting space is ready to go

Based on integration to Tenant A's conference room reservation system, the conference room environment is optimally prepared for a meeting with 15 people

Occupancy and CO_2 sensors provide an override to save energy in the case of a no show, or to ensure comfort in case more attendees end up joining the meeting



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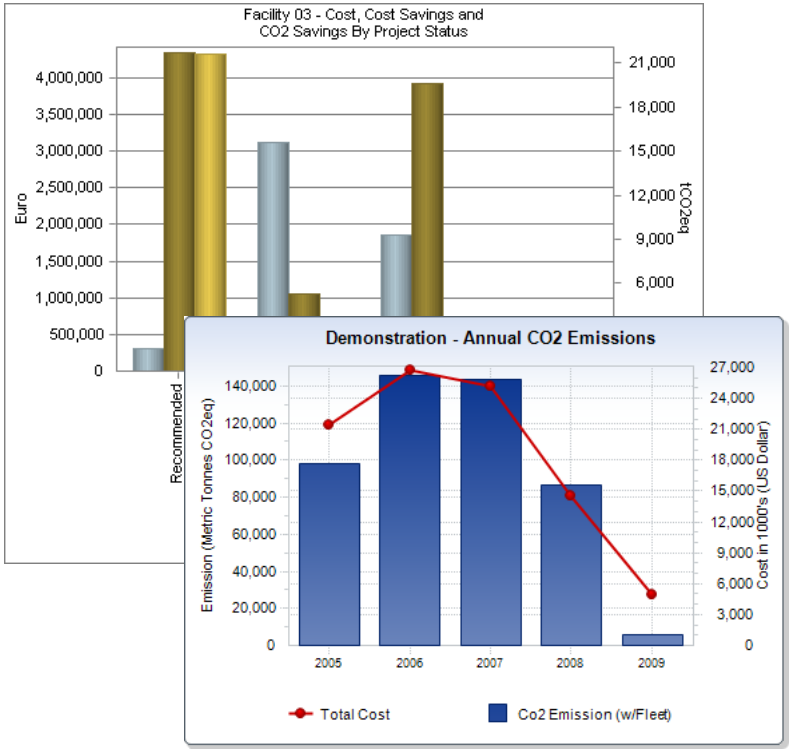
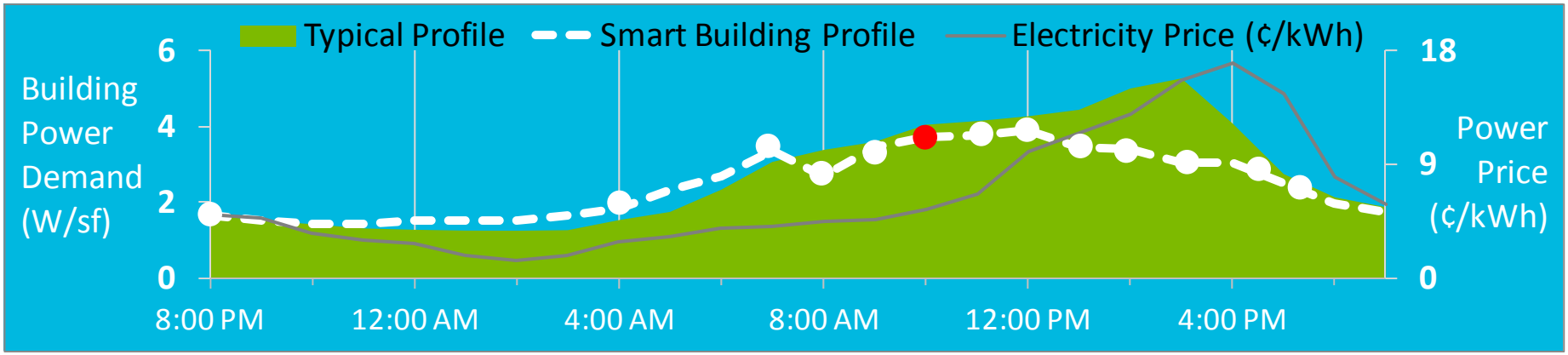
10:00 am

CFO calls for carbon reporting data

A market analyst firm has posed questions to a CFO about the business' carbon risk and strategies that have been implemented to reduce the greenhouse gas intensity of the economy

At the click of a mouse, real estate executive pulls up data in an enterprise application dashboard for carbon emissions for the most recent quarter and the verified carbon reductions the organization has achieved through programs and projects





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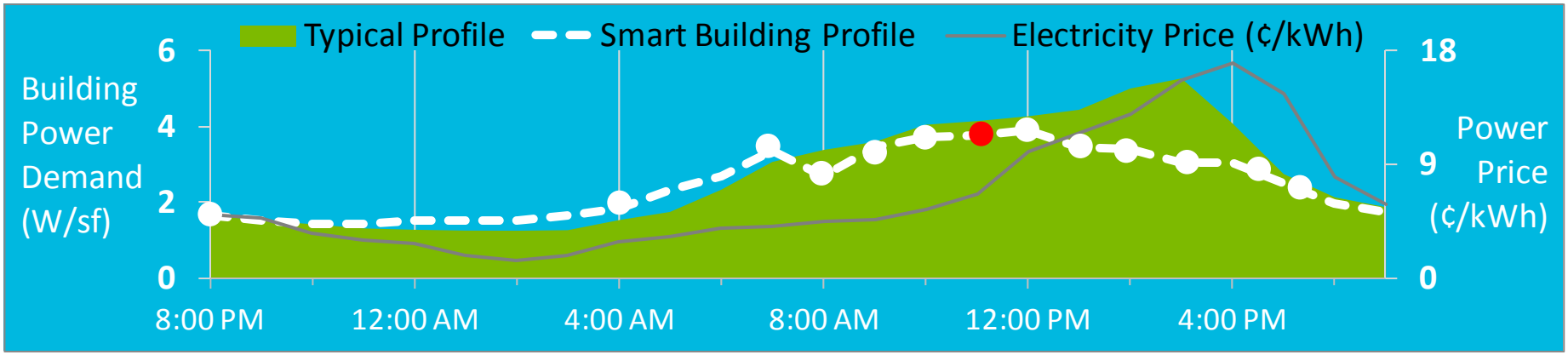
11:00 am

Utility power price triggers automatic demand reduction for tenant

The price for 12pm-2pm received from the utility exceeds the threshold pre-defined by the tenant, triggering the following actions to reduce power demand for that time period.

- reset space temps by 2°F
- reset static pressure of air terminal units
- slowly dim lighting 20% in occupant spaces

Actions and impact reported back to utility



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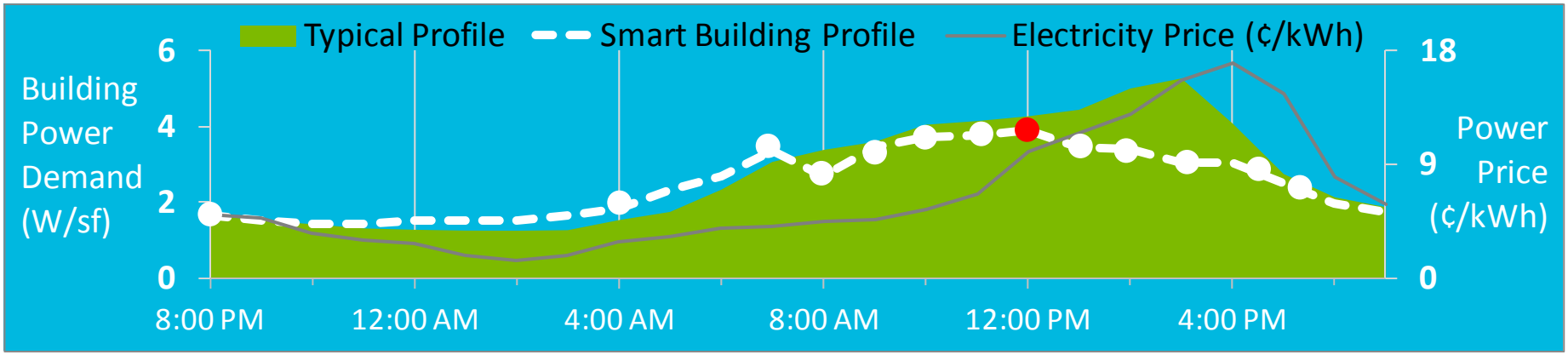
12:00 pm

Power price triggers automated demand reduction for building owner

Like the tenant, the real time prices from 12pm-2pm exceeds the pre-defined threshold for the building owner triggering power reductions in the central plant and common areas, including:

- dispatch ice storage cooling
- increase chilled water set point
- dim lighting in common areas by 20%
- variable frequency drive limiting

Actions and impact are reported back to utility



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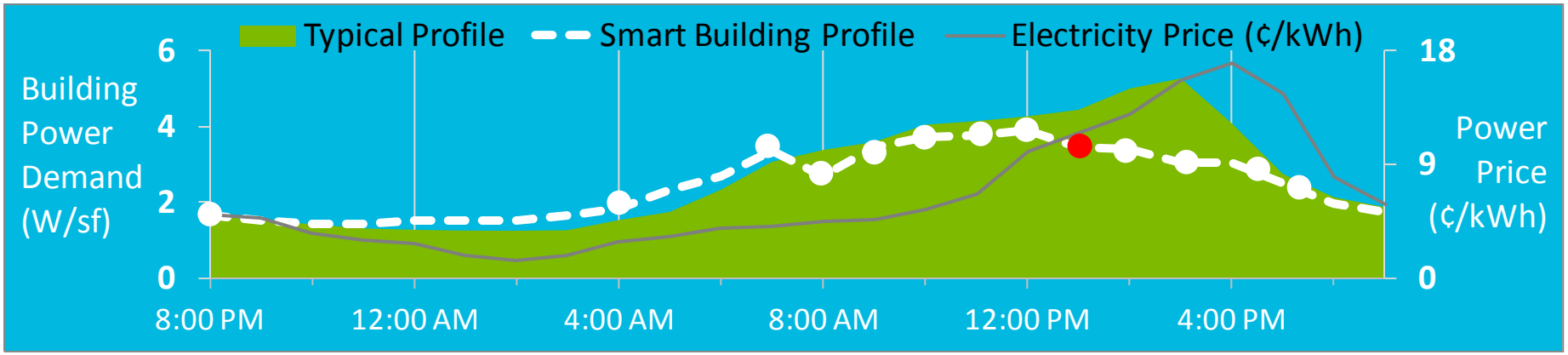
1:00 pm

Power price triggers more aggressive automated reductions for tenant.

The real time price for 2pm-5pm from the utility well exceeds the defined threshold for the tenant triggering more aggressive power reductions, including:

- dim lighting by 40%
- reset space temps by 4°F
- throttle non-production servers

Actions and impact reported back to utility



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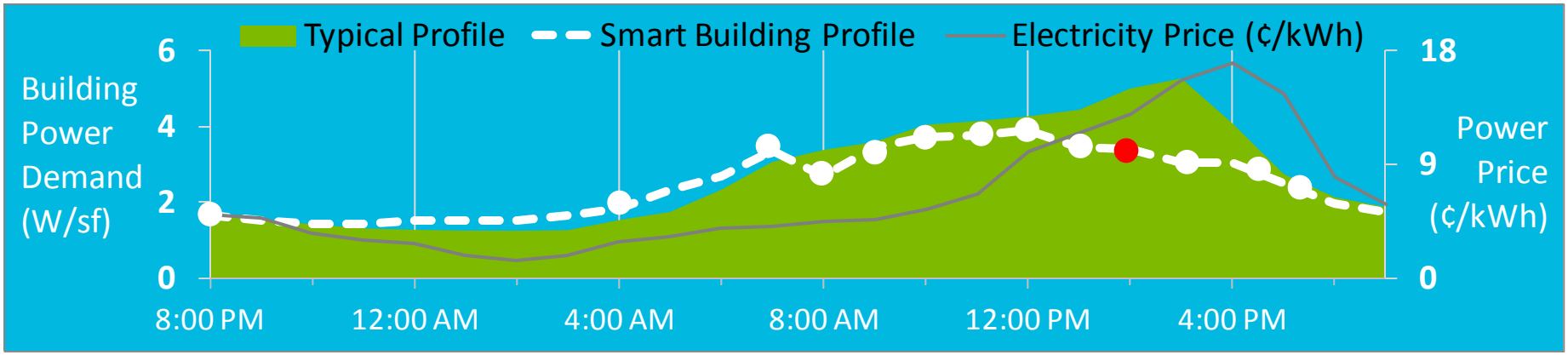
2:00 pm

Automated demand reductions leverage IT system integration

System alerts employees via email or instant message to unplug their laptops or automatically uses PC power management software agent so that laptops run on battery power from 2-4pm



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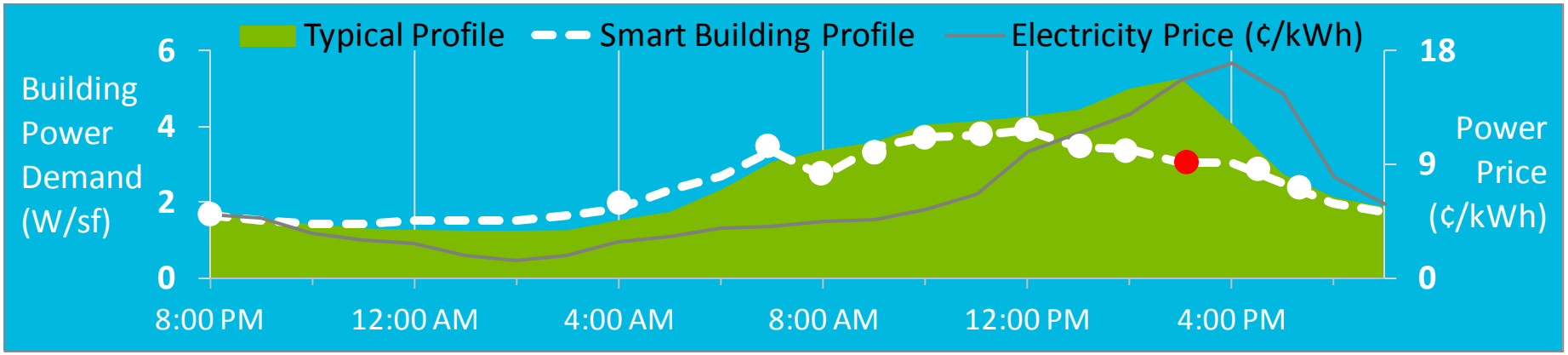
3:00 pm

Cloud cover causes solar photovoltaic generation to drop

Building owner received a demand limiting signal from utility to use no more than 1.5 MW during the 2pm -5pm period.

Building is relying on power from rooftop solar photovoltaic system to meet some load beyond that 1.5 MW being drawn from the grid.

When cloud cover causes solar production to drop, system dispatches onsite electric storage to meet contract obligations with utility.



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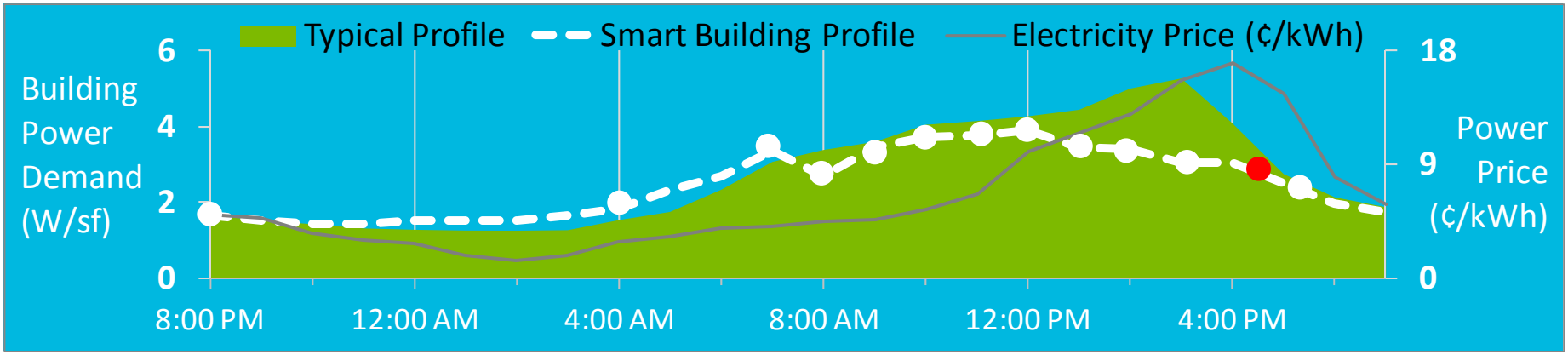
5:30 pm

Leaving the office

As employee badges out, the system recognizes that he forgot to turn off the lights and desktop computer in his office. It automatically turns off the lights and puts the computer into its lowest power stand-by setting

When he arrives to parking deck, his plug-in electric vehicle has been charged (during the low-price hours) enough for him to get home

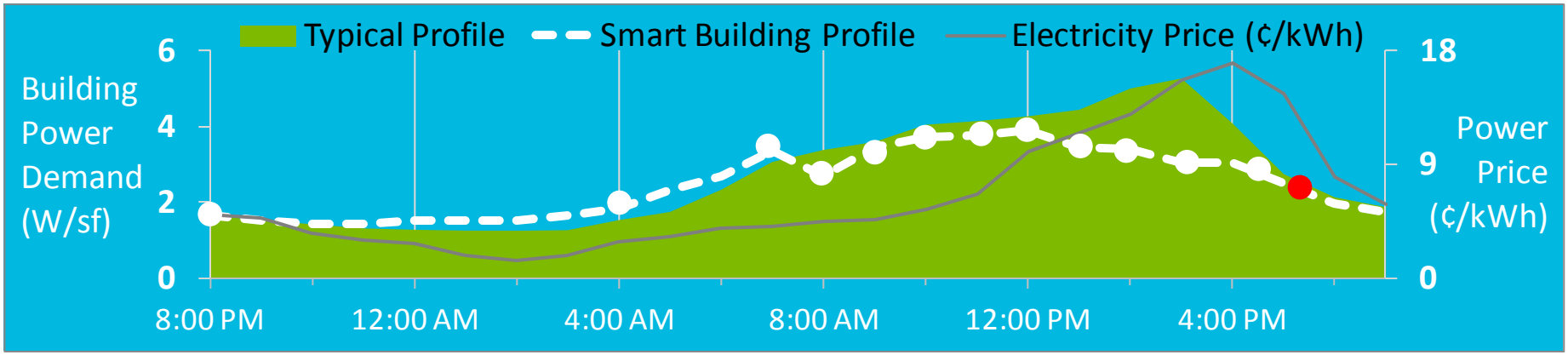


6:30 pm

End of the workday

System controls lighting and HVAC to follow janitorial staff in order to maximize convenience while only lighting the occupied spaced in building

Video surveillance system counts occupants remaining in each part of the building after hours and adjusts zone set points and lighting accordingly



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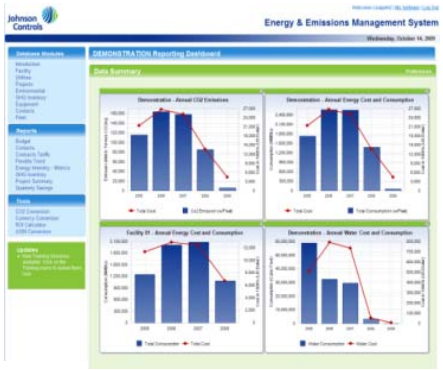
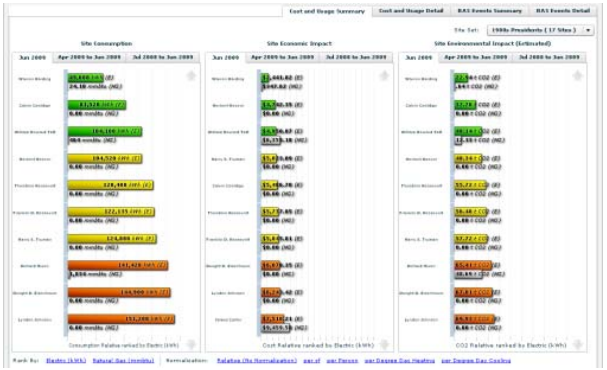
Utilities and Carbon Reporting

What it is

A web application that provides executives, energy managers, and/or building tenants with information related to energy and water usage, expenditure, greenhouse gas emissions, and savings achieved for a portfolio of buildings.





How it works

The application runs on top of a data platform that integrates a variety of existing data sources including utility bills, utility meters, and submeters at the tenant or even end-use circuit level (e.g. lighting). The application makes sense of this data and rolls up summary information in the form of configurable dashboards, portals, and reports. Calculation methodologies and reporting formats conform to international standards and are easily auditable down to the original data source (e.g. utility bill). Users customize dashboards and reports to meet the needs of internal management, governments, investors, customers, or other stakeholders.

Features

1. Allows various normalization factors and levels of aggregation to track key performance indicators
2. Multi-site comparison (ranking, quartiles) and benchmarking to external data
3. User-configurable dashboards and reports
4. Seamless treatment of all major global currencies and units of measure
5. Allows user definition of complex utility rates to estimate utility costs from interval meter data
6. Forecasts utility costs to assist with financial planning
7. Provides sliders and dashboard for what-if scenario simulation
8. Reporting web widgets for 3rd party enterprise platforms (e.g. Cognos, Sharepoint, iPhone, iGoogle, Android)

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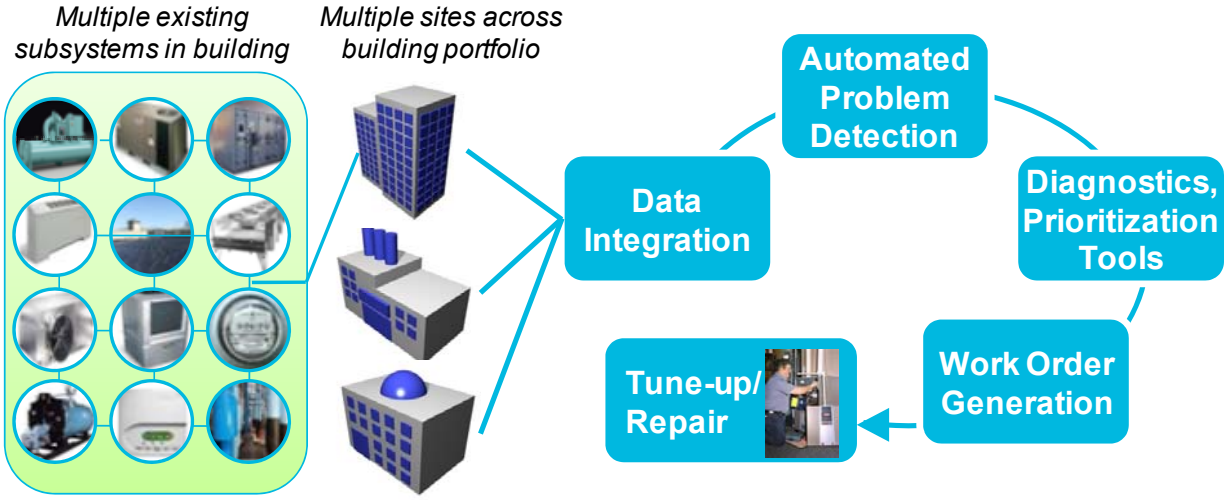
Continuous Diagnostics

What it is

A software application that automatically detects energy waste and comfort problems in buildings. It helps users to prioritize repairs & retro-commissioning activities in a building portfolio on an ongoing basis.



How it works

The application constantly monitors data from existing building systems and controls to detect problems that are wasting energy, creating comfort problems, or could lead to premature equipment failure. It helps users detect, diagnose, monetize, prioritize and initiate the maintenance process for faults in need of repair. Permitted users can access system information through any web browser to monitor performance of a single piece of equipment or the entire building portfolio.

Features

1. Automated detection of problems in chillers, packaged HVAC units, air handlers, VAV boxes, terminal units, boilers, and whole facility metered utility usage
2. Compatible with a wide range of equipment makes/types
3. Estimates the cost savings to be gained by correcting problems
4. Customizable dashboards and reports available through a browser window
5. Repair management integrated with facility maintenance tools (i.e. CMMS)

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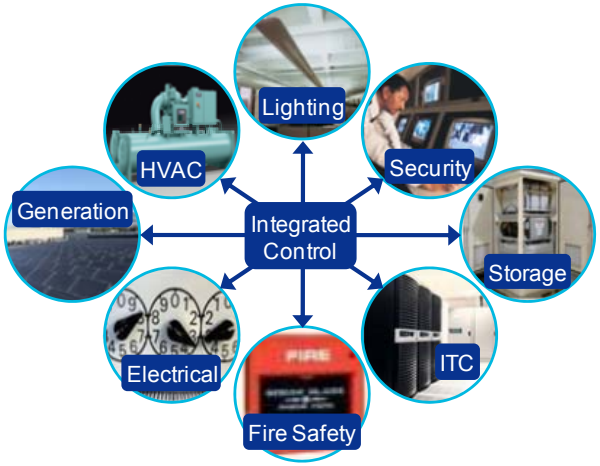
Integrated Control

What it is

An application that allows global control and interaction amongst a wide variety of building subsystems at the *enterprise* level



e.g.

• Weather forecasts	→ HVAC, Energy Storage
• Security access/video	→ HVAC, Lighting, ICT
• Lighting controls	→ HVAC
• HVAC CO_2 Sensors	→ Lighting, ICT
• Room reservations	→ HVAC
• Energy generation	→ Energy Storage, HVAC
• Fire safety	→ HVAC, Electrical
• Fire & life safety	→ Communications, Lifts
• Daylight sensors	→ Shades, Smart Windows
• Electrical	→ HVAC, ICT, Storage
• HVAC	→ ICT provisioning

How it works

Today, typical commercial buildings consist of a number of mostly autonomous subsystems that cannot communicate with one another. While each subsystem is effective in achieving its design intent (thermal comfort, illumination, physical security, power quality, etc), major improvements to building efficiency, comfort, safety, and lifecycle cost can be achieved through integration. This application leverages the Smart Building Manager's ability to fuse data from a wide variety of different building systems and adds *integrated control logic* that takes advantage of the additional inputs together in new ways. For example, if the security system is aware that an area is not occupied, the building controller could turn off lights, adjust set points and reduce ventilation in that space, enabling energy savings with no loss of comfort. The bottom-line result of this intelligent coordination is lower operational expenses and total cost of ownership.

Features

1. Supervises subsystem controllers and normalizes their data schema into a single enterprise system
2. Compatible with a wide range of equipment makes/types
3. Ability for application engineer to program custom supervisory control rules, without consistent controls products
4. More reliable and higher resolution occupancy-based control
5. Microgrid power management and coordination of energy loads, generation, and storage sources onsite

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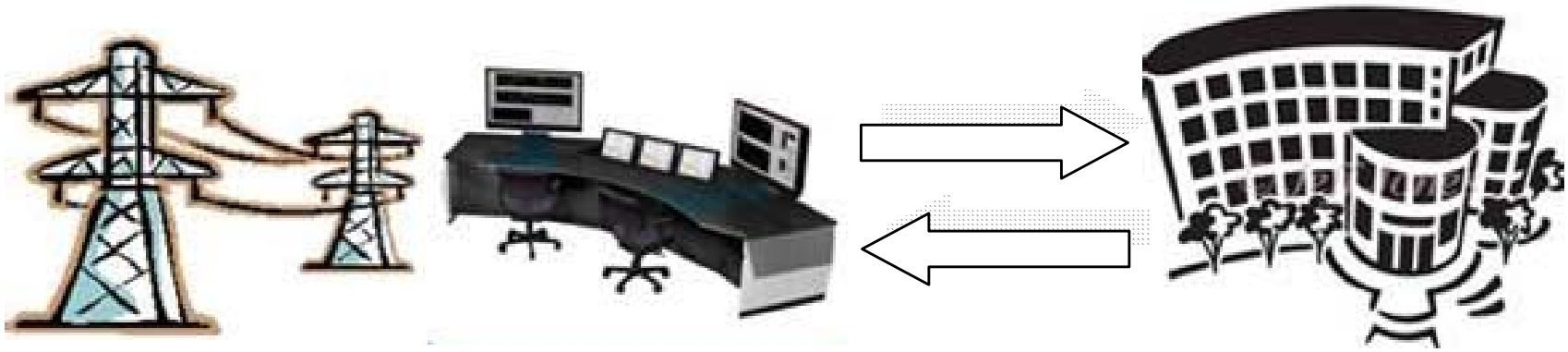
Automated Demand Response

What it is

An application that coordinates the automatic reduction of electrical loads upon receipt of a signal from energy markets.



How it works

When the facility receives a signal from the market or utility, it dispatches pre-programmed actions to shed loads by communicating with building systems. The application helps the building owner or operator make decisions in advance about which load-reducing actions will be taken during demand response events, managing the tradeoff between occupant comfort and financial incentives. Typical actions include increasing temperature set points, dimming or switching off lights, slowing fan speeds, and dispatching energy storage or generation devices. The system is equipped with a manual override, ensuring the ability to “opt out” of event participation at any time. This application could also allow the facility operator to interact with the utility or electric system operator, including bidding load reductions into energy markets and receiving payments directly.

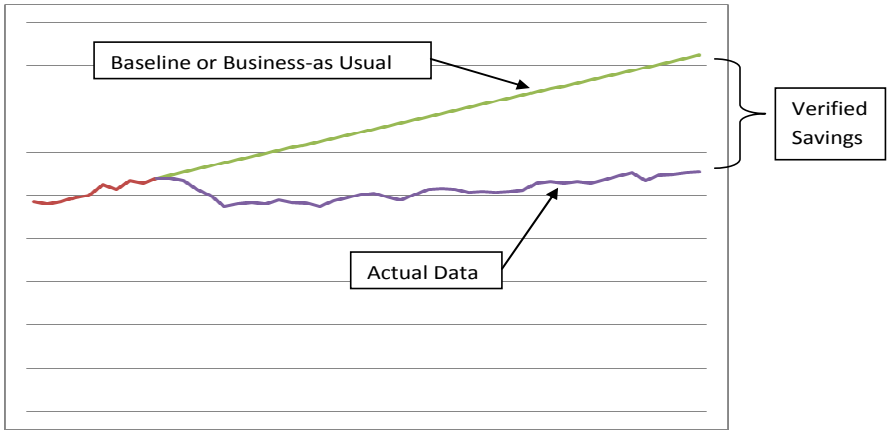
Features

1. Two-way communication between grid operator/market and the participating facility based on standard protocols
2. Pre-programming capability allows operator to define automated load shed strategies for building portfolio
3. Global control capability for multiple types of building subsystems
4. Ability for customer to override event participation
5. Supports building owner in participating in both “bid-in” markets or dynamic electric pricing scenarios

Automated Measurement & Verification

What it is

An application that automates the process of measuring and verifying savings in utility consumption, electric demand, cost, and carbon achieved through actions taken to improve energy efficiency or grid responsiveness.



How it works

The basic Measurement & Verification (M&V) process compares actual measured data and a “business-as-usual” baseline projection. Traditionally, M&V is performed manually. For example, an engineer might enter monthly utility bill data into spreadsheets and compare the values with a regression model of the baseline energy use created from historic data. This application draws upon data from utility meters , building systems and business applications to continuously update the baseline model and track the savings created by programs and projects. In addition, the application will calculate the avoided greenhouse gas emissions and other environmental impacts.

Features

1. Automatically develops baseline consumption model for portfolio, building, or single piece of equipment
2. Meets accepted standards and protocols for use in external interactions (greenhouse gas reporting, energy performance contracts, demand response payments)
3. Calculates savings values in both running total and project lifecycle formats
4. Provides savings in units of consumption, cost, and environmental impact

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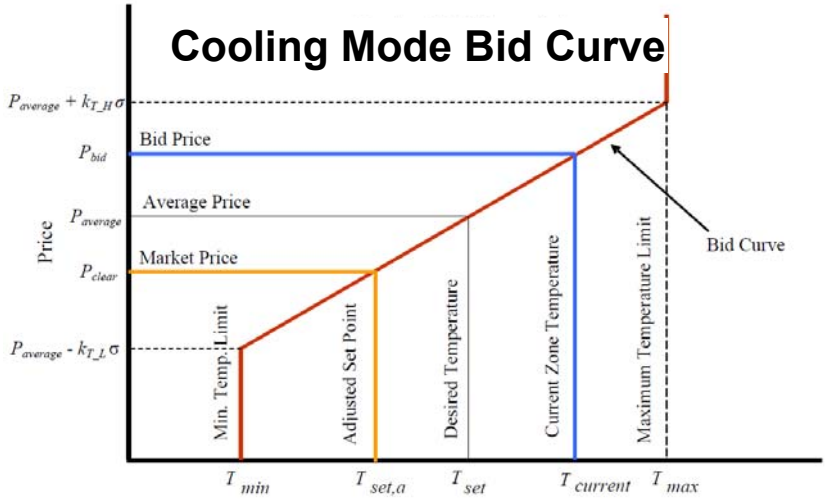
Gridwise Testbed on Washington's Olympic Peninsula

- Residential and commercial energy 5-min. real-time pricing demonstration project began in 2006
- Partners included Pacific Northwest National Labs, Bonneville Power Administration, IBM, JCI, etc
- Metasys used for automated "transactive" load control
  - VAV boxes submit bids ($) based on user-defined "bid curve" for chilled water
  - Municipal water pumps bid curve based on actual vs. target reservoir level
  - Diesel generators run during permitted times when cost to operate < RTP

- **Results**: Proves grid congestion can be effectively managed via decentralized market coordination vs. direct load hierarchal control by the utility
  - **15% reduction in peak on "virtual feeder"**
  - **Average energy bill cut by 10%**



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Georgia Institute of Technology RTP Program

- Georgia Tech selected a dynamic electricity tariff from their utility Georgia Power
- Metasys central server continuously reads and records hourly prices, updated each hour for next 48 hours, from utility's web service feed
- Manager of Facilities Engineering sets price threshold for automated load shedding mode

Savings during initial summer 2006 pilot

Week	Number of RTP Events	Amp-Hours Saved	Energy Saved (kWh)	Cost Savings ($)
July 16–21*	5	524	3772	438
Aug. 8–12	4	185	1335	155
Aug. 13–19	2	27	195	22
Aug. 20–26	1	60	431	50
Aug. 27–Sep. 2	3	150	1080	126
Total	15	946	6813	790

Observed a 1MW peak load reduction, ~7% of load for participating buildings.

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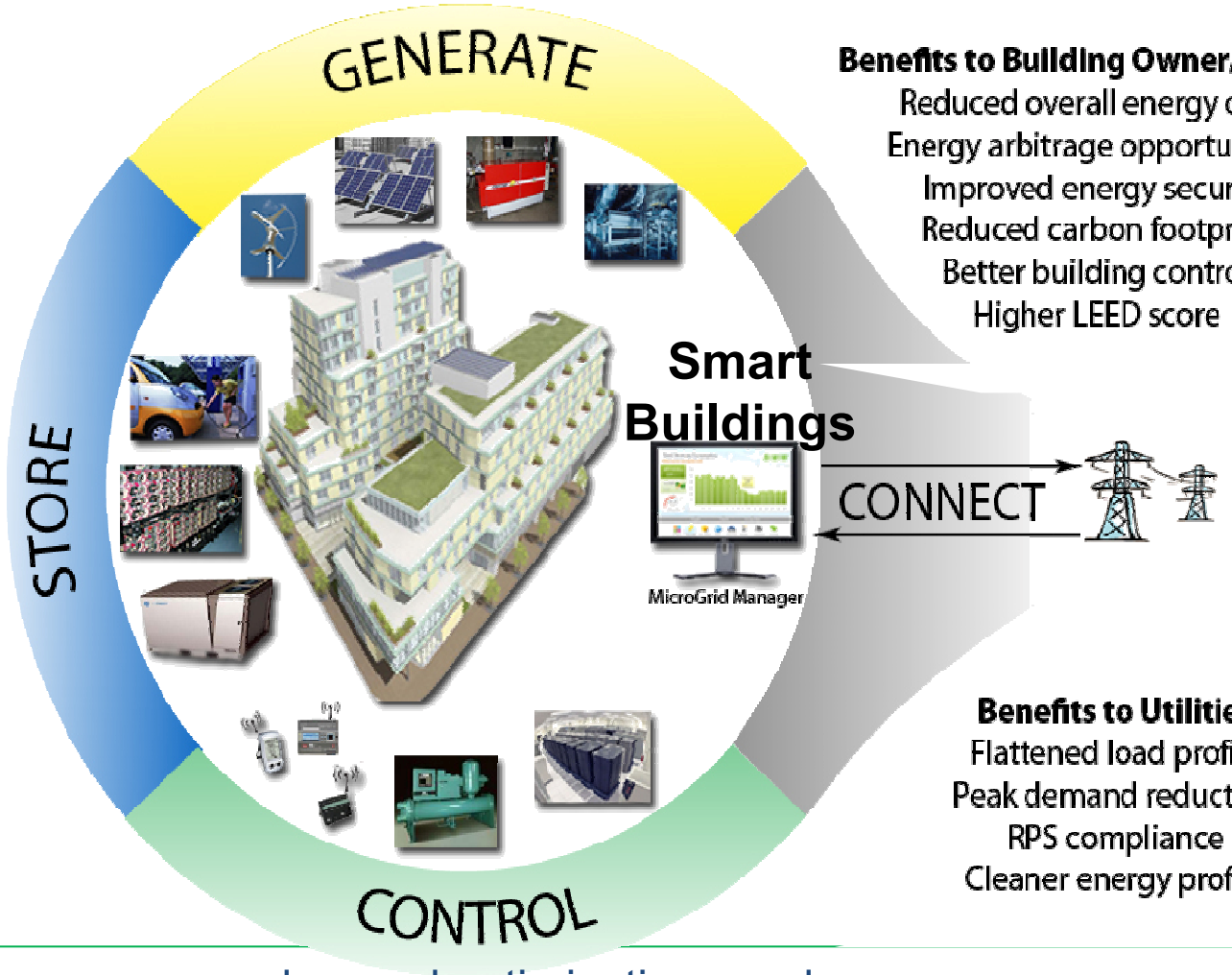
Looking forward, where is the industry headed?

cheaper and more onsite renewable energy

cheaper and more energy storage



Benefits to Building Owner/Tena
Reduced overall energy costs
Energy arbitrage opportunities
Improved energy security
Reduced carbon footprint
Better building control
Higher LEED score

Benefits to Utilities
Flattened load profile
Peak demand reduction
RPS compliance
Cleaner energy profile

more advanced optimization needs

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