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BUILDING INFORMATION TECHNOLOGY AND MANAGEMENT

Issue Brief

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INTRODUCTION

Commercial buildings in the U.S. consume 20 percent of our total energy and 40 percent of our electricity. Existing and newly constructed commercial facilities have substantial potential to improve energy efficiency and performance by integrating new information technology (IT) into building operations.

IT adds intelligence to buildings from the earliest design stage to the end of the building's useful life. This intelligence comes from visible and actionable information on energy use and performance and brings new opportunities for smart building management. New technologies have automated the process of acquiring, storing, and retrieving data from across multiple buildings and building sub-systems and make that data readily available to different users.

People in a variety of roles are interested in energy and building data and the factors that influence it. Through IT, C-level executives evaluating investment options, sustainability directors looking to understand the environmental impact of their facilities, and operations staff determining optimal operating conditions are all empowered with new levels of visible and timely information. Additionally, building occupants may be more comfortable and productive through smart efficient systems that make them more energy-aware while also providing more control. Technologies that provide seamless communication, user-friendly interfaces and built-in analytics enable faster and better decision-making.

This paper will review the technologies that make a building smart and discuss how these newly automated tools enable improved performance through information. The first section focuses on the technology, looking at the role of IT convergence and providing an overview of different building components and how they function. We then introduce the Intelligent Energy Management triangle, which focuses on the synergies between three key building information functions – energy information management, fault detection and diagnostics, and measurement and verification of savings. Combining these functions greatly enhances decisions related to energy and the asset.

Optimizing Energy Efficiency in Buildings – Definitions

- High performance buildings are designed and built to minimize energy usage and environmental impacts, while maximizing comfort, health, and safety;
- "Smart" buildings leverage technology to provide enhanced performance and are connected and responsive to the "smart" power grid, which is emerging as information technology is applied to the infrastructure that delivers our electricity.

CONTEXT – IT CONVERGENCE AND HIGH-PERFORMANCE BUILDINGS

Modern buildings contain complex mechanical devices, sophisticated control systems and a suite of supporting applications to improve the safety, comfort and productivity of occupants. Many of these systems involve machine-to-machine communication, but because the data is general in nature and the communication protocols have been proprietary, information only flows along certain paths. The movement toward interoperable, connected devices and systems within a building has emerged from voluntary collaboration among many partners (and business competitors) over the past two decades and has led to the adoption of open communication protocols such as BACnet,® Modbus,® and LonWorks.®[1]

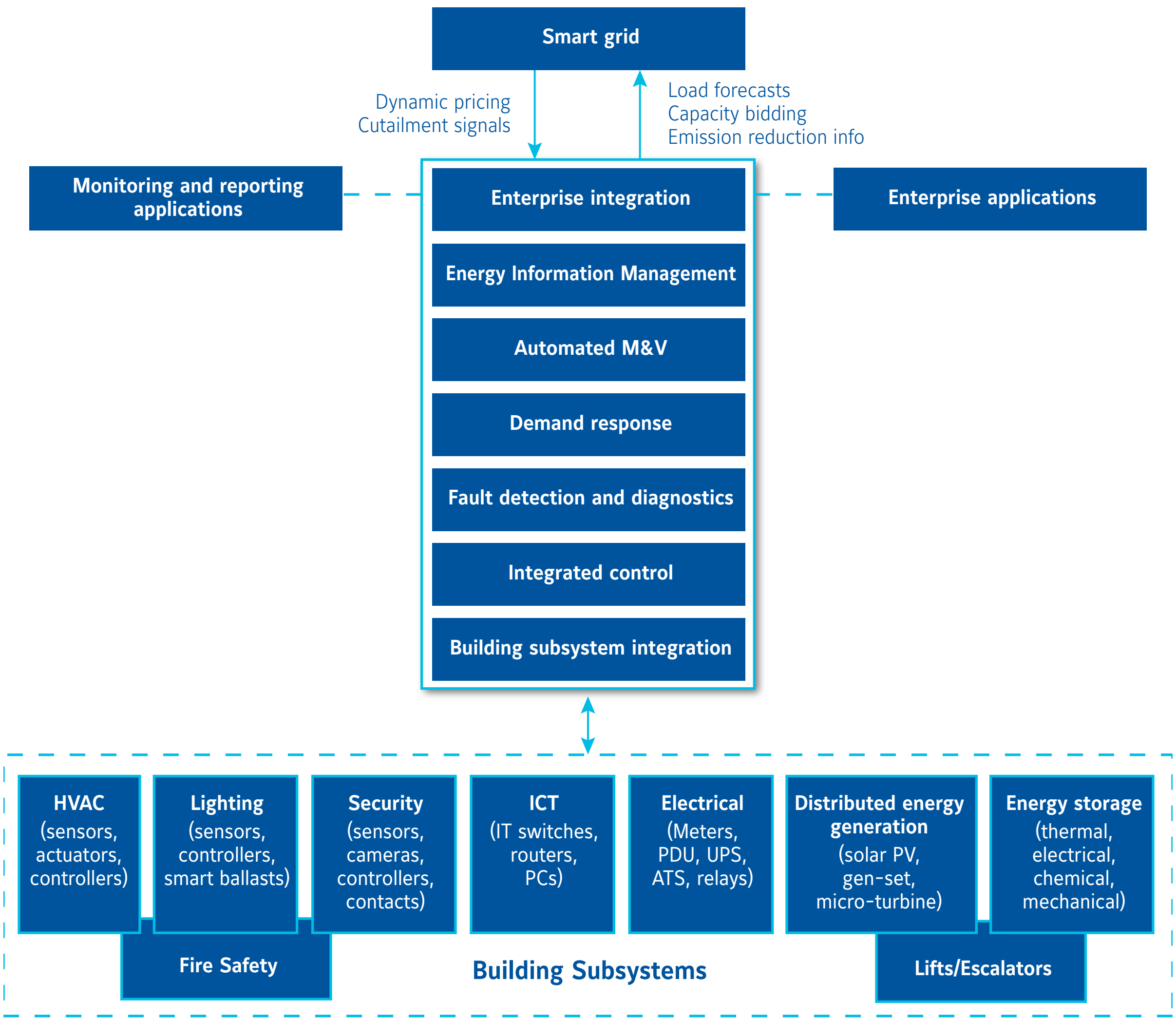
[1] BACnet is a registered trademark of the American Society of Heating, Ventilating and Air Conditioning Engineers, Modbus is a registered trademark of Schneider Electric, LonWorks is a registered trademark of Echelon.

The integration of building automation systems (BAS)[2] and IT infrastructure provides standard methods for collecting, storing, naming and retrieving data in a secure environment. Today, data or information from disparate systems can be easily shared or used as input for powerful analytics, and results can be shared with other applications for reporting, planning, scheduling and dispatch. IT in buildings allows users to perform value-added activities that historically have not been economically feasible. In the same way that web applications are born from the information available on the internet, open access to information in buildings allows for the development of new tools that save time, energy and operating costs.

Figure 1 provides an overview of the different components and functionalities of a smart building in relation to the various building subsystems, enterprise applications, and external data sources that IT integrates.

[2] A Building Automation System (BAS) is a computer-based control system installed in buildings to control and monitor the building's mechanical and electrical systems such as heating, cooling, ventilation, lighting and power.

Figure 1: Smart Building Technology Stack



Moving from bottom to top, **building subsystem integration** fuses sensor data and controllable outputs across all building subsystems, such as lighting, HVAC, and security. **Integrated control (IC)** takes advantage of the open, standardized, seamless information platform by combining sensor data and control capabilities in new ways to deliver more energy-efficient and grid-responsive building performance. **Fault detection and diagnostics (FDD)** enables ongoing monitoring-based commissioning of building systems to save energy and extend equipment life. **Demand response (DR)** communicates to energy loads, storage devices, and generation systems to minimize total energy expenditure in response to real time price or curtailment incentives from the utility grid. The system includes rigorous automated tools to **measure and verify** energy cost savings, hourly DR fulfillment, and avoided GHG emissions. The system also includes tools that support the **management of energy information** and infrastructure to **integrate enterprise applications** for monitoring, reporting, and enterprise-wide control of business systems.

All components or layers act together to enable a smart, high-performance building that uses the full potential of the smart grid. The section below goes into more detail on each layer, starting from the bottom.

Building Subsystem Integration: Buildings contain a collection of autonomous subsystems that at present do not cooperate to reduce energy usage. Each subsystem has its own design intent: comfort, lighting, security, communications, information management, or power distribution. For applications such as IC and DR to be effective, it is critical to integrate these subsystems into a common interoperable information platform.

Integrated Control (IC): The IC layer sits on top of the building subsystem controllers and enhances their core functions, including the maintenance of occupant comfort and safety, while minimizing energy consumption and costs. Current subsystem controllers have limited capabilities to fully apply all of the data that comes with their integration. The integrated controller is supervisory to these subsystem controllers and can help overcome many of their limitations. In the end, IC functions are executed by both the subsystem controllers and the IC layer, while monitoring of these enhanced functions occurs primarily at the IC layer.

The IC layer sits below the demand response layer and greatly enhances the effectiveness of DR by enabling a far greater number of subsystems and equipment to be controlled in a coordinated fashion. At the same time, the IC layer provides feedback to the DR layer to ensure that constraints are properly maintained. These constraints include occupant comfort and safety, equipment operating limits and performance, and additional constraints defined within fire, electrical, and energy codes.

Once the building subsystems have been integrated, inputs from multiple subsystems can be used together to save energy and improve comfort. Enhanced control by the BAS combined with new control functionality from the IC layer can typically produce energy use savings of 10 percent compared to buildings without IC capabilities.[3]

[3] Chapman, R.E. (2001). "How Interoperability Saves Money." ASHRAE Journal. Volume 43: pp. 44-48; Rubinstein, Johnson, and Pettler (2000). "IBECS: An Integrated Building Environmental Communications System – It's Not Your Father's Network." Proceedings of the American Council for an Energy Efficiency Economy Summer Study, August 2000; CABA (2004). "Life Cycle Costing of Automation Controls for Intelligent and Integrated Facilities." Continental Automated Buildings Association.

Fault Detection and Diagnostics: Fault detection and diagnostics (FDD) is an analytics tool that recognizes when a problem has occurred or is likely to occur and pinpoints one or more root causes of the problem so that corrective action can be taken. Automated FDD uses input from sensors or derived measures of performance. A fault does not have to be the result of a complete failure of a piece of equipment, but could be non-optimal operation or a product that is outside specifications.[4] FDD methods use classification and pattern recognition methods to detect and diagnose faults. The FDD approach must be robust (minimize missed faults and false alarms) and present actionable information.

Inefficient equipment operation attributed to inadequate initial commissioning, operational issues, and real time performance degradation is estimated to increase energy consumption by 15 to 30 percent in commercial buildings.[5] Reliability can also be compromised and greater costs incurred to fix problems if faults are not identified and resolved expeditiously. Automated FDD can be used to identify faults and monetize them to help facilities minimize energy and maintenance costs.

Demand Response: The DR Control (DRC) layer actively initiates control actions that minimize energy costs over a prescribed time horizon based on dynamic pricing or curtailment signals, subject to constraints necessary to protect equipment and to ensure occupant comfort, productivity, and safety. Determining DR policies to manage the balance between energy savings and impacts on the building environment requires close consultation with the building owners. The DRC must be configured with information on equipment that can be cycled on/off, how long it can be turned off, what set points can be changed, and what the allowable setpoint adjustment range is. DR will coordinate with on-site energy generation and energy storage sub-systems.

Peak energy demand is projected to grow at roughly 2 percent annually under business-as-usual conditions. As a result of shrinking capacity margins, wholesale power prices skyrocket during peak hours, and massive capital outlays for additional generation and transmission capacity are looming on the horizon for utilities. Leveraging automated technology to manage on-site generation and curtail end-use loads has potential by itself to reduce peak demand by 13 percent of average in commercial and industrial buildings.[6] That potential peak reduction will increase as thermal and electrical storage become more cost effective and prevalent in buildings.

Automated Measurement & Verification (M&V): M&V is a set of activities that demonstrate to a customer that a project implementing energy conservation measures is working as intended and generating agreed-upon savings. Credible M&V approaches provide a strategy to calculate energy savings accurately by comparing the post-installation measured energy use or demand to a prediction of how much energy would have been used if the energy conservation measures had not been installed, given the same conditions (the baseline). This includes adjusting for routine fluctuations in weather and building occupancy and use. New analytics and automation offer the potential to lower costs and improve confidence in estimated savings attributed to building energy efficiency investments. Additionally, an automated approach enables M&V personnel to receive earlier notice of fluctuation in usages.

Energy efficiency is starting to be recognized as an effective approach for addressing global energy supplies, energy security, and climate change. Automated M&V can be uniquely applied to create a "negawatt meter," which reliably measures the energy savings and fluctuations resulting from major building renovations, retrofits, facility improvements, and operational and behavioral changes. Low-cost verification is critical for monetizing and creating new markets and financing mechanisms for energy efficiency.

Energy Information Management: Energy information management is the useful visualization of information resulting from data mining and other analytics. Some examples of basic energy information are load profile analysis, internal and external energy usage benchmarking, utility rate benchmarking, end-use analysis, and energy budget tracking.

[4] Greg Stanley and Associates (2010). "A Guide to Fault Detection and Diagnosis."

[5] Katipmula S., and M.R. Brambley (2005). "Methods for Fault Detection, Diagnostics, and Prognostics for Building Systems – A Review, Part I. International Journal of Heating, Ventilation, Air Conditioning and Refrigerating Research Vol. 11, Number 1.

[6] Faruqui, A., R Hledik, S. Newell, J.Pfeifenberger (2007). "The Power of Fiver Percent: How Dynamic Pricing Can Save $35 Billion in Electricity Costs." Brattle Group Discussion Paper.

Enterprise Integration: Enterprise applications are integrated with advanced building applications and building subsystems using standard IT platforms and interfaces.

Enterprise Applications: Enterprise applications refer to all software related to running the core business or institutions that the building supports. This may include financial, personnel and capital assets. Integrating business software systems for HR, room scheduling, capital planning, lease data, maintenance management and utility and fleet bill data into the other smart applications provides one central control point for all of the building's operations, and allows for the most efficient use of resources. The linkage of all enterprise applications fully enables a dynamic and functional system that optimizes total building performance.

Monitoring and Reporting Applications: These tools present data collected from each of the performance applications layers in the Stack. Three of these layers are discussed in the next section as the enablers for smarter energy management decisions.

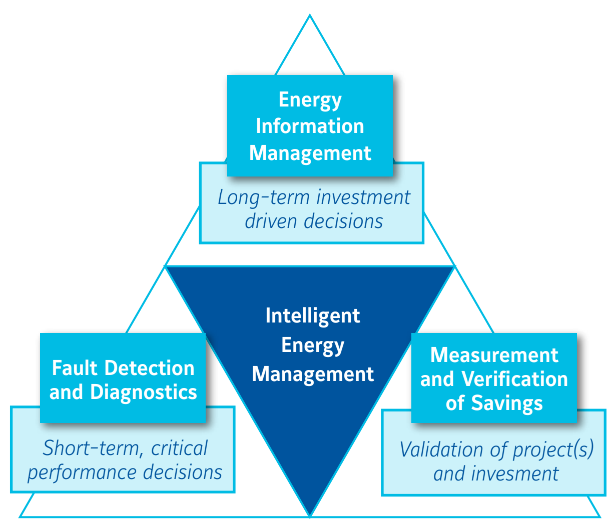
INTELLIGENT ENERGY MANAGEMENT TRIANGLE

The previous section went through the technology suite behind smart buildings. This section focuses on how users interested in intelligent energy management can use the building performance information provided by new technologies in decision-making. The Intelligent Energy Management Triangle is comprised of three of the different layers in the Technology Stack in Figure 1 and dives deeper into the types of performance and energy data that enable smart decision-making around energy management. While not every building will be enabled with each layer in the technology stack discussed in the previous section, every building can benefit from the improved decision-making capacity offered by energy information management, fault detection and diagnostics and the measurement and verification of energy savings.

Even with the most sophisticated software and hardware, people are the most crucial component in the operation of a smart high-performance building. The greatest value of technology is in the potential for more timely and better-informed decisions.

The Intelligent Energy Management Triangle (Figure 2) illustrates the synergy among three key building information functions. Energy information management, fault detection and diagnostics (FDD) and measurement and verification of energy savings (M&V) have significant impacts on building operation. Taking full advantage of this information brings a better understanding of what is going on inside a building and contributes to better decisions that have immediate impacts on business and operational performance. Each concept brings stand-alone value, while also complementing the others, to optimize building performance and ultimately save energy and money. The multiple uses of building performance information leverage investment in the underlying assets.

Figure 2: Intelligent Energy Management Triangle



Energy Information Management

Energy information is the presentation of data related to a building's energy consumption that allows for more comprehensive energy management. New technology allows dynamic energy information to be displayed on user-friendly dashboards so that building owners and occupants, who are not energy professionals, are able to monitor and track energy usage. These dashboards bring together the often separate worlds of financial decision-making and facility operations, helping to drive better decisions around capital upgrade investments and operating expenditures.

Fault Detection and Diagnostics

Energy information drives a longer-term view of energy management, while FDD influences day-to-day actions. FDD allows more efficient operation of building systems and equipment by identifying inefficiencies or operational problems quickly. This allows good performance to be sustained over time, or provides tools to attain a high-performance state. FDD may also display equipment failures or inefficiencies in financial terms in addition to signaling technical issues. This allows operations staff to monetize faults and prioritize actions.

When the predictive maintenance and performance feedback capabilities of FDD are used in conjunction with energy information, building managers have the information they need to make informed long-term asset management and investment decisions.

Measurement and Verification of Savings

Determining savings from an energy-efficiency retrofit project is important in helping to justify or fund energy improvement or equipment purchase decisions. M&V can be done on many small measures identified from an ongoing commissioning program or on capital-intensive whole-building retrofit projects. In all cases, the ongoing verification of estimated savings validates the investment and might even determine payment to the service provider, depending on the contract structure.

Measuring and monitoring information also adds value to a project by providing another form of performance feedback. Improvements in building performance and efficiency are much more likely to persist when measured. Combining M&V with FDD enhances the ability to detect equipment problems that affect a building's energy usage. Like energy information and FDD, M&V is valuable to multiple users in charge of building operations and asset management.

CONCLUSION

Technology that can integrate into both high-performance and smart buildings provides intuitive tools designed to leverage the capabilities of people operating and working within the building. Intelligent decision-making enabled through building performance information is the major value-add of new building IT.

Energy use and occupant comfort are crucial to any organization, and technology is the key enabler that gives building operators the tools and information they need to make smart choices. Beyond day-to-day operations, smart-building tools propel long-term financial planning and asset management.

As the smart building evolves, the sharing of information between building and enterprise systems will provide a continuous platform for innovation. Future applications will appear as facility managers interact with tools and technology to do their jobs better – providing more comfort, more safety, and more security with less money, less energy, and less environmental impact.

The Institute for Building Efficiency is an initiative of Johnson Controls providing information and analysis of technologies, policies, and practices for efficient, high performance buildings and smart energy systems around the world. The Institute leverages the company's 125 years of global experience providing energy efficient solutions for buildings to support and complement the efforts of nonprofit organizations and industry associations. The Institute focuses on practical solutions that are innovative, cost-effective and scalable.

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