

BUILDING ENERGY MANAGEMENT: USING DATA AS A TOOL



Issue Brief

Melissa Donnelly

Program Analyst, Institute for Building Efficiency, Johnson Controls

Commercial building owners spend 30 percent of their operating budget on energy.¹ Costs can be reduced with improved building energy management practices. Optimizing building performance also reduces demand for energy from the grid, lowers carbon emissions from electricity generation and fuels burned on site, and can improve occupant comfort.

¹ http://www.energystar.gov/index.cfm?c=comm_real_estate.bus_comm_realestate

To get these benefits, property executives and facility managers increasingly consider the data they can collect in buildings and the analyses they can complete to inform decision-making. In the 2012 Global Energy Efficiency Indicator (EEI) survey conducted by the Johnson Controls Institute for Building Efficiency, 57 percent of building executives reported tracking and analyzing energy data, and 31 percent said they were planning to implement the practice (Figure 1). In addition, growing numbers of building executives said they reviewed and analyzed energy data weekly or monthly (Figure 2).

Figure 1: Energy management best practices implemented

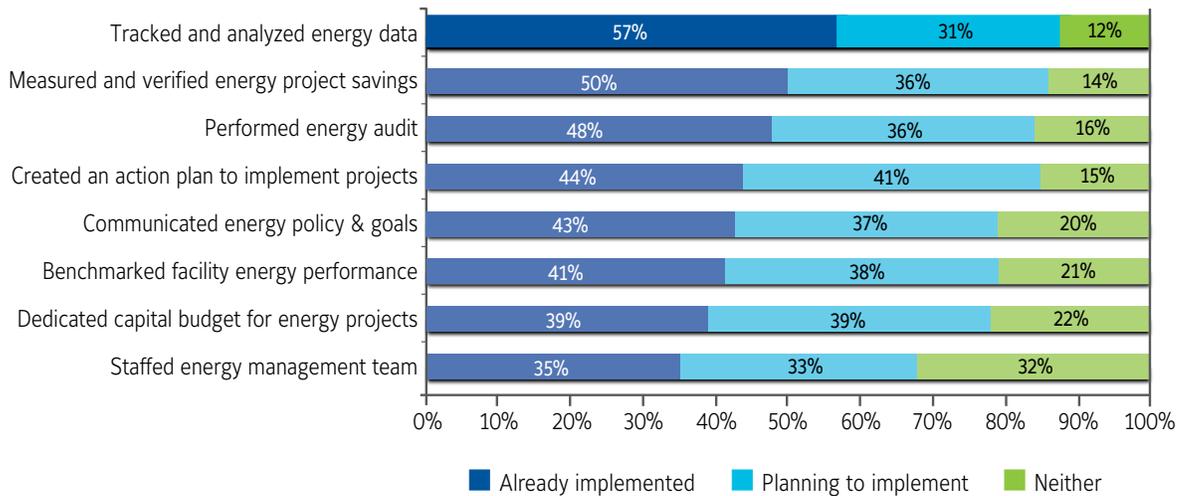
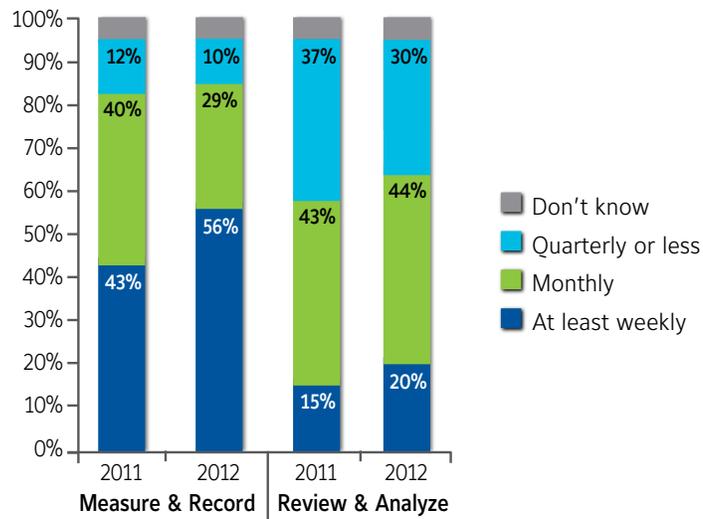


Figure 2: Tracking and analyzing energy data. How frequently does your company/organization measure/record and review/analyze its energy usage data?



Advanced information technology has expanded the volume, velocity and variety of data, or “big data,” that can be collected. With all the possibilities big data offers, it is challenging to focus the building data management conversation on the problems worth solving, the data worth storing, and the analysis worth sharing. Today, buildings can fall anywhere along the continuum of data management and analytics. With a closer look at the specific building and energy data being collected and the analyses being conducted, three categories can be defined in regard to data management practices: “simple,” “intermediate,” and “advanced.”

At all levels, there is great potential for value in the data collected and the analysis performed to improve building performance and identify energy efficiency opportunities that will save money, reduce carbon emissions, and improve occupant comfort. This paper looks at all three levels, identifying for each one which problems can be solved with the analysis that can be done, based on the data available.

SIMPLE BUILDING DATA MANAGEMENT

At the simple level, a building manager focuses on tracking monthly energy usage and cost data. Initial efforts often leverage utility bill data to develop a consistent process for tracking energy use. To understand basic building performance, owners can examine monthly utility bills, then add weather data and basic information on the building structure and use to provide an energy intensity metric. Several types of additional data reviews can explore:

Analyzing Trends

Trending, a form of data visualization, is the first level of building data analysis. With at least one year of past energy bills – enough to get a sense of seasonal changes – a building owner or manager can identify patterns in energy costs and usage. This creates a baseline view of the building’s performance. This type of utility data analysis also may identify billing errors, abnormal consumption, and the need for demand reduction in light of the utility rate structure.

Organizations can manually input energy usage data into a database or spreadsheets on a monthly basis. Then they can perform trending monthly or quarterly to identify usage changes in certain buildings or spaces. They can also correlate weather data with consumption data to help visualize weather-sensitive electricity or fossil fuel consumption.

Data worth collecting – definitions

- **Utility or energy bills** provide usage, demand, and cost data, as well as rates. This information can be tracked in common computer programs, like Excel.
- **Building structure** information can refer to the building type, the building envelope, equipment, the year the building was built, and any renovations that were completed. Operations and maintenance (O&M) staff can be engaged to collect this information and keep it up to date.
- **Building use** denotes what the building is used for (e.g., office space or manufacturing).
- **Weather** information, like temperature, humidity, and solar data in building locations, can be compared with energy usage data to show trends and identify outliers. Information can be collected from a local weather station.

Because relatively minimal data is needed to perform trend analysis, it is a very useful first effort to understand energy usage in a building or group of buildings. However, trending is done in a vacuum if there is no focus on comparing buildings with like attributes. Trending can identify extremes in usage and, combined with maintenance data and weather data, it can indicate where building systems may not be operating at optimum settings or where equipment needs to be replaced or upgraded. However, without benchmarking, trending does not contribute to an assessment of building performance.

Benchmarking

Benchmarking is a comparison of trends. Longitudinal benchmarking compares current energy performance with past performance to identify trends. Cross-sectional benchmarking compares a building's energy performance to that of other similar buildings.² An organization with a campus of buildings or a portfolio to manage can benchmark buildings against one another to identify outliers in like building types. Externally, benchmarking can include tools like the ENERGY STAR Portfolio Manager to compare buildings to industry standards. To obtain a building performance rating, Portfolio Manager requires:

- Twelve months of current usage data
- Space type (i.e., bank, office, hospital)
- Gross floor area
- Weekly operating hours
- Number of workers on the main shift
- Number of PCs
- Percent of the building that is heated
- Percent of the building that is air-conditioned

This type of benchmarking is the first step for many organizations to determine if a building has the potential to improve its efficiency. This analysis, done at the whole-building level, determines energy usage per square foot of space, or per person in some cases. These normalization factors enable energy performance comparisons.

Monthly energy usage data can be used to benchmark. Other necessary data points include:

- Building type (office, residential, manufacturing, etc.)
- Envelope (foundation, roof, walls, doors, and windows)
- Systems (HVAC, lighting, boilers, etc.)
- Year of construction
- Occupancy rates
- Climate zone
- Renovations

Benchmarking can also be completed with weekly or more regular energy usage data. Building performance is dynamic, and by correlating building improvement measures with usage data, a decision-maker can isolate and understand the variables driving building performance.

² Granderson, J., M.A. Piette, B. Rosenblum and R. L. Hu (2012) "Making the Most of Energy Data: A Handbook for Facility Managers, Owners, and Operators." Lawrence Berkeley National Laboratory and University of Toronto.

There is increasing interest in using data for benchmarking building performance at the community level, as seen in places like New York City, where building owners are required to report their building performance through the ENERGY STAR Portfolio Manager. There are many challenges, however, without a robust database that covers the unique attributes of individual buildings. For example, occupancy, usage, climate zone, age of infrastructure, and other parameters may mean there are few “like” buildings to compare. The increasing presence of data centers in many buildings makes benchmarking even more troublesome.

Problems solved at simple level of building data management:

- *Identify opportunities to save on utility bill cost by correcting billing errors.*
- *Evaluate whole-building energy performance in comparison to peers or historical performance.*

INTERMEDIATE BUILDING DATA MANAGEMENT

At the intermediate level, more detailed and more regular intervals of data can be collected to complete analyses on the performance of specific building systems, in addition to the analysis of the whole building’s energy usage done at the simple level. With more accurate, complete, and consistent data and analysis, energy management decisions related to specific building systems can be made proactively to run systems efficiently, lowering operating costs, extending equipment life, and improving occupant comfort.

After completing data collection and analysis at the simple level, a building manager should consider this next level of data management to identify specific energy efficiency projects that are the most cost-effective. In addition to the data collected at the simple level, a building manager should track weekly utility bill information, building maintenance information, data from the human resources department, and meter data.

With this level of data collected from the utility, a building automation or BMS system, and meters, several analyses can be completed to learn what equipment is running sub-optimally and to identify the types of energy efficiency projects in

Data worth collecting – definitions

- **Weekly utility data** includes usage, demand, costs, and rates. This information can be collected directly from the utility, usually through an online account, or through a software system that automatically collects bill information and may have a bill pay service associated with it.
- **Maintenance schedules** can track equipment and system changes over time and indicate when routine maintenance or equipment replacements are necessary to maintain optimal performance.
- **The human resources (HR) department** can supply information on number of employees, workspaces, hours of operation, and types of operations.
- **Electric power meters** can provide event-triggered high-resolution data capture, automatically detect anomalous energy usage, and easily integrate with building information systems.
- **A building management system (BMS), building automation system (BAS), or building energy management system (BEMS)** controls the mechanical, electrical and plumbing systems in a building. They can be programmed to track trends and record data over certain periods of time.

which to invest, at what level of investment. Analytical results should be shared consistently with building management staff to inform decision-making on building systems, like lighting, heating, and cooling, and to support choices of energy efficiency projects.

Fault Detection and Diagnostics (FDD)

FDD analysis enables ongoing monitoring-based commissioning of building systems to save energy and extend equipment life. A building operator can recognize when an equipment problem or fault has occurred, or is likely to occur, and pinpoint one or more root causes of the problem. Faults relate to a system's performance, meaning the system is operating but is performing sub-optimally.³ FDD methods use classification and pattern recognition to detect and diagnose faults.

FDD is an important type of analysis to complete because inefficient equipment operation attributed to inadequate initial commissioning, operational issues, and real time performance degradation can waste an estimated 15 to 30 percent of energy used in commercial buildings.⁴ Reliability can also be compromised and greater costs incurred to fix problems if faults are not identified, prioritized, and resolved.

Forecasting

An energy usage forecast is a measurement and estimate of historic, current, and projected energy use in a particular building or in a portfolio of buildings. Energy costs can also be included in this analysis to make comparisons, measure savings over time, and plan future budgets. Forecasting includes regression analysis, which develops a model that correlates energy consumption with influential parameters such as weather and occupancy. An organization can use these inverse models to understand building performance across a group of buildings. This analysis can identify what types of projects to invest in and at what level of investment.

Software Tools for Data Analysis

At the intermediate level of building data management, more advanced tools are needed to store, track, and analyze collected data. At present, most commercial and industrial buildings do not employ software solutions or information technology to track energy usage and identify opportunities for better energy management.⁵ A software solution that includes a dashboard can help building users understand where and how energy is being consumed. Dashboards can also be customized for particular users to display certain information at certain times, providing more visibility into building operations and energy usage.

For example, usage data can be integrated with HR data through a software tool to enable analyses of energy intensity per square foot, by building type, by time of day, or by number of employees or workspaces. This type of analysis can identify energy hot spots in buildings or spaces. Further investigation then can isolate the cause, and solutions can be devised to reduce usage.

Customized software applications can store and display data in various formats through reporting templates and dashboards, but they still rely on the user to consider the information being presented and use it to make energy management decisions. Also, without integration of real-time data, these applications cannot support real-time decision-making.

Problems solved at intermediate level of building data management:

- *Assess the energy usage of specific building systems.*
- *Identify what types of energy projects to invest in and at what level of investment.*

³ Sinopoli, J. (2012). "Inside the Killer App for Buildings & Energy Management: Fault Detection & Diagnostics." Smart Buildings, LLC.

⁴ Katipmola 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.

⁵ Jaffe, S., R. Nicholson, and C. Talon (2012). "Business Strategy: Smart Buildings Maturity Model for End Users." IDC Energy Insights.

ADVANCED BUILDING DATA MANAGEMENT

The third level uses more advanced building systems, devices, data collection and analytical tools. A building at this level employs advanced automation technologies and systems integration to measure, monitor, control, and optimize building operations and maintenance. In most buildings today, systems such as, lighting, HVAC, fire and security and on-site renewable power generation operate in isolation, making it challenging for users to understand energy performance and make decisions to optimize energy use in real time. These systems can now be integrated with an IP network that allows for data analytics, reporting, and control through a comprehensive building management system (BMS). Through a centralized BMS, users can translate building data into actionable information, track building performance against a baseline, and define automatic systems controls. A centralized BMS also allows users to respond to real-time changes in energy supply or demand caused by building occupants or through the smart grid.

Data worth collecting – definitions

- **Sub-meters** can be used to isolate the consumption or performance data of specific sub-systems or pieces of equipment.
- **Smart meters** allow for communication between a building and the utility.
- **Sensors** include a variety of devices that can measure parameters such as temperatures, pressures, flow rates, and power. Sensors also can measure room occupancy, occupant activity levels, light intensities on work surfaces, and plug loads. Sensor data can be recorded and collected through the BMS.
- **Occupant Surveys** can be used to gather data on comfort, air quality, acoustics, and lighting issues. Addressing such issues will often lead to improved system performance and occupant satisfaction.

At this level, interval data is important for making energy management decisions in real time. Sub-meters can collect day +1 or real-time energy usage data from specific building spaces and directly from building equipment. This data can be displayed in customized dashboards or kiosks to communicate energy information to building users.

With sensor data, day +1 or real-time energy usage data, and additional occupancy information, more detailed analyses can be completed to identify specific energy efficiency projects and weigh the costs versus the benefits. This makes it possible to prioritize projects and develop a strategic plan to achieve organizational energy and carbon reduction goals.

Scenario Planning or Modeling

Detailed building energy simulation models require a significant amount of building data, including building and system parameters, as well as monthly consumption data, to be calibrated. However, a calibrated energy model is a powerful tool. Modeling differs from other analytical tools because it can better analyze actual situations as it considers “what if” scenarios and can account for complex variable interactions. For example, an analysis can be built on a variety of factors like number of employees and employee growth potential, weather influence and variation, building energy consumption, and active energy reduction activities and, depending on whether a certain factor occurs or not, the outcome changes. Modeling can provide more detailed information than forecasting, benchmarking, and trending. Models can also be used to evaluate the cost/benefit of proposed energy conservation measures and assist with life-cycle

cost analysis. This analytical tool is especially helpful for strategic planning around established energy and carbon reduction goals across a diverse portfolio of buildings.

Measurement & Verification (M&V)

M&V is a set of activities that demonstrate whether a completed energy efficiency project is functioning as intended and is generating the agreed-upon savings. Pre-installation and post-installation energy consumption and demand data is collected to predict how much energy would have been used if the energy conservation measures had not been installed, as compared with the baseline. Adjustments can be made for changes in weather, occupancy, and use. For example, the convergence of building systems integration and information technology allows for data to be collected on occupancy that was once difficult to include in analyses. Occupants are the second largest driver of energy usage in buildings, next to weather. While M&V can be conducted at all levels of building data management, the expansion of data collected at this level allows for more detailed and accurate M&V.

Cloud Computing Data Analysis

Cloud computing can provide scale, storage and processing power to manage the big data that can be generated by building sensors, meters, and controls. It provides a platform to connect disparate data sources to generate actionable information and optimize building performance. By accessing new cloud-based data sets, users can combine public information like weather forecasts and energy pricing with private building information and energy usage to enable new insights into building energy management.

New applications and services built on open platforms enable building users to connect previously isolated systems, collect and manage the data generated by these systems, and turn that data into actionable information to improve energy efficiency. Cloud computing will enable building management solutions to deliver the storage, access to data, analytics, and applications services necessary to support massive data aggregation cost-effectively.

Problems solved at advanced level of building data management:

- *Identify energy efficiency projects based on customized scenarios.*
- *Accurately measure the costs and benefits associated with specific projects.*
- *Contribute to strategic planning to achieve organizational energy and carbon reduction goals.*

CONCLUSION

Today, modern commercial and industrial buildings can have intelligent devices and advanced, integrated building systems that generate significant real-time or near-real-time data on energy usage and occupancy. This expansion of data presents great opportunities for improved building energy management practices, but the data collected is valuable only if it is analyzed consistently and communicated effectively to building decision-makers and users. At any level of building data management – simple, intermediate, or advanced – it is important to focus on the data worth collecting, the analysis worth sharing, and the problems that are worth solving with data and analytical tools. Building data management and analytics help lower operational and maintenance costs, reduce energy usage, improve occupant comfort, and contribute to organizational goals to reduce carbon emissions. As buildings move along the data management and analytics continuum, it is important to identify a structured approach that addresses facility-level and organizational goals.

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.

If you are interested in contacting the authors, or engaging with the Institute for Building Efficiency, please email us at: InstituteforBE@jci.com.

institute
for **building**
efficiency
an initiative of Johnson Controls