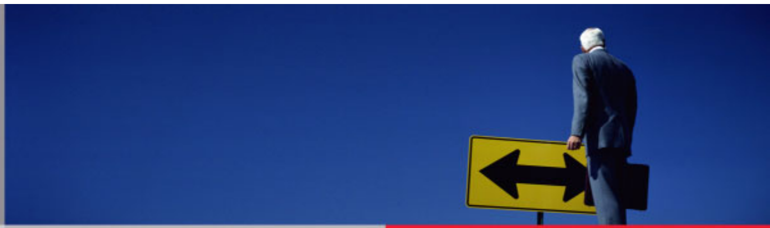
Smarter Cities Series: Understanding the IBM Approach to Efficient Buildings



Redguides
for Business Leaders

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- Learn how IBM solutions help reduce energy, operations and space costs
- Gain insight into the architecture and solutions for Smarter Buildings
- Understand the challenges and solutions for building operations

Redbooks

Introduction

Buildings are complex, multisystem entities with many individual control and maintenance systems. These systems include heating and cooling, lighting, communications, security and access control systems. These systems are intended to keep occupants safe and comfortable.

Worldwide, buildings consume 42% of all electricity, more than any other asset. By 2025, buildings will be the largest emitters of greenhouse gases on our planet.[1] In the US, buildings consume 70% of all electricity, up to 50% of which is wasted. [2]

Given these facts, it is no surprise that an effort is ongoing to address the efficiency and usability of buildings. IBM® envisions the Smarter Buildings initiative to deal with these challenges. Smarter buildings are well managed, integrated physical and digital infrastructures that provide optimal occupancy services in a reliable, cost-effective and sustainable manner. Smarter buildings help their owners, operators and facility managers improve asset reliability and performance that, in turn, reduces energy use, optimizes how space is used and minimizes the environmental impact of their buildings.[3]

Smarter buildings have the following characteristics:

- Are more cost-effective by reducing energy and operating costs
- Use active and designed-in techniques to achieve reliability, efficiency and environmental responsibility
- Provide visibility, control and automation to building systems
- Maintain a safer and more secure workplace
- Communicate in real time to supporting infrastructure (such as smart grid and broadband)

This IBM Redguide™ publication helps IT architects, city officials, building managers and owners understand ways to achieve Smarter Building concepts. It introduces the IBM Intelligent Building Management solution and other key solutions that IBM has available. This guide provides high-level architectures for these solutions, including key components and capabilities. This guide also highlights the linkages between partners, cities, and other external systems that influence building operations. This guide explains how real-time data

[1] Smarter Building website, Sustainability from the Earth up web page
http://www.ibm.com/ibm/green/index4.shtml

[2] Conversations for a Smarter Planet™
http://www.ibm.com/smarterplanet/global/files/us__en_us__overview__com03003usen.pdf

[3] Smarter Buildings web page Solutions tab
http://www.ibm.com/smarterplanet/us/en/green_buildings/nextsteps/index.html

can be seamlessly integrated with facilities management to assist owners and building management manage space, energy and operations.

To understand the broader picture of IBM Smarter Cities™, see the following Redguide publications:

- *Smarter Cities Series: A Foundation for Understanding IBM Smarter Cities*, REDP-4733
- *Smarter Cities Series: Introducing the IBM City Operations and Management Solution*, REDP-4734

Why Smarter Buildings

Healthy buildings improve life by providing comfortable, secure places to live, work and play. Most buildings are not tooled to take advantage of recent advances in technology. For example, sensors in buildings can monitor security, occupancy, and resource usage, and IT systems can perform decision making on that data to optimize energy use or other resources. It is estimated that Smarter Buildings can reduce energy consumption and carbon dioxide (CO_2) emissions by 50–70% and save 30–50% in water usage.

The implementation of energy and resource efficiencies requires adjustments to current processes and practices. The adjustments are required for the following transformations:

- A transformation from initially focusing on construction costs to the entire life-cycle efficiency and performance of a building
- A transformation that provides direct value to owners and tenants through improved service, incentives and performance

To make these transformations a reality, buildings must achieve the following results:

- Short term:
  - Meet energy and resource efficiency requirements from regulators and stakeholders.
  - Improve building efficiency through upgrades in equipment and materials that meet high energy efficiency ratings or certifications.
- Medium term:
  - Integrate decision support tools with existing building systems to identify cost savings and optimize performance
  - Provide near real-time monitoring, control and user interaction
- Long term:
  - Provide dynamic business models driven by real-time data and analytics to create energy-efficient, sustainable and secure buildings
  - Holistic optimization of the built environment, considering energy generation and usage in individual buildings, energy balancing and load shedding

> **Load shedding:** Load shedding is the act of taking low-priority loads offline for a period of time to meet a power consumption goal. Load shedding can be part of the optimization of the load among buildings within a district.

Building life-cycle optimization

Smarter buildings can be managed throughout their building life cycle, from design through demolition. For example, during the building design phase, it is critical to incorporate the energy and efficiency goals of owners and stakeholders.

The building life cycle consists of the following major stages:

- Design

  The well-defined and documented requirements of owners and stakeholders provide the basis for the building design. The requirements should include energy, sustainability, and quality goals and material usage considerations. Regulatory guideline verifications must be performed starting with the design and include all aspects of the building life cycle. Construction management, operability design, and the use of tools for analysis and performance simulation should be used to ensure that the design meets the requirements.

- Build

  The build stage is the translation of the building design and energy performance requirements into reality. By including tracking capabilities (such as RFID) building materials, products and assets can be traced and verified. On-site planning, scheduling and comprehensive build management processes are essential during this stage. Materials, components and interfaces (for communication with various systems) must be identified and documented electronically for future use.

- Operate

  Facility management plays a key role at this stage. Integrating facility management applications, building information modeling (BIM), and real-time data (from sources including sensors, actuators and wireless networks) is essential. This integration of real-time data provides facility managers with the information required to operate their facility more efficiently.

  The addition of decision support tools enables monitoring, simulation and analysis to help with decision making. Predictive maintenance and energy management are key ways to improve energy efficiency.

- Maintain

  Long-term maintenance of buildings ensures their longevity. Advances in technology can help in the following key areas:

  - *Collaboration support* helps create an integrated environment, open communication across teams, and integrated project management.
  - *Interoperability standards* enable the exchange and sharing of building information. These standards can be used to share technical and commercial information about products and services used for a building.
  - *Knowledge sharing* encompasses the shared access to reusable assets, guidelines and best practices. Access to product, service and supplier information enables better interaction and decision making. Applying adaptive and self-learning capabilities to systems can improve the response to problems and ensure consistency.

- Decommission and demolition:

  The decommissioning and eventual demolition of a building involves the selling of all viable assets and materials. This stage also involves management of the items that can have an environmental impact.

Smarter Buildings in action

Systems for Smarter Buildings use extensive sensor networks to gather data for analysis. Analysis occurs in real time, so that building systems can constantly adapt to the environment by sending directions or instructions to underlying facility systems. The sensor data collected over a period of time assists in the long-term planning of building upgrades and modifications. Information collection and analysis capabilities help in building operations and maintenance. Building operations should ensure the proper usage of resources while meeting the safety and comfort requirements of the occupants. By using the results of analytics processing, building owners and facilities managers can make well-informed decisions across building systems. The building systems include energy, heating, lighting, water, security and other specialized systems.

In the future, sophisticated algorithms can anticipate the needs of the building or its occupants, thus identifying or preventing issues before they occur. These algorithms can correlate information from various sources. For example, an approaching severe storm might trigger a notification to a Smarter Buildings system requesting the building take preventive action to avoid damage to the building or risk to occupants.

By integrating a building with other buildings, the city, and utility providers, the whole city environment can become smarter. When interactions between a city and buildings exist, the buildings can contribute to the health of the city. For example, during a heat wave, the city can request that buildings reduce their energy consumption to assist in the prevention of a brownout.

Smarter Building scenarios

This section covers example operational scenarios showing key challenges that affect buildings and the use of Smarter Buildings solutions:

- Energy and asset management
- Building operations management
- Effective space utilization

Energy and asset management

The need exists to analyze data about the historical and current building environment and to analyze device data to predict asset failure and generate services requests. These service requests can trigger investigation and maintenance tasks. Also fault detection and diagnosis routines are needed to monitor the performance of energy-consuming assets and to trigger alerts. These alerts can result in auto-generated work orders to reduce energy consumption, extend asset life, and reduce overall life-cycle cost. These alerts provide the following advantages:

- Two-way data exchange with local and remote building and asset management systems

  This exchange includes the real-time integration of facility equipment and control system information with existing facilities asset management. Work orders for facilities management that are based on real-time operating characteristics of the monitored equipment can be generated automatically.

- Analysis, alerts, and reports that compare the energy consumption of key equipment

  Energy consumption can be compared to time scheduled and occupancy. Also, computational analysis of air handling helps ensure that the most efficient systems are used.

Solution

Sensors spread throughout the building provide data to the building management system. After the data is collected and analyzed, it provides the opportunity to predict failures. With this feature, building managers can reduce expense and better direct facility engineers to operate and service the building environment.

By using available client assets and system data for building management, the solution generates reports that identify asset incident trends based on data collected from the equipment, its location and manufacturer information. The solution generates alerts on equipment that is targeted for investigation or maintenance. Alerts can automatically generate service requests for an asset work order.

Business value

The business value of this solution includes cost reduction through improved energy efficiency, reduced operational risks, and extended life span of equipment. This solution can help increase tenant satisfaction and retention through improved operational and service-level achievement.

Building operations management

Facilities management lacks the ability to easily use the volumes of utility usage data for cost management and planning. This team needs the ability to use electrical and gas data to perform analysis and report results. This team also needs the ability to track, benchmark and establish a baseline for utility usage. It needs rate structure analysis and reporting on several years of data. This analysis and the reports can identify trend lines for energy usage, project future energy costs, and provide reports on building energy efficiency.

Solution

The solution uses available asset and system data for building management to generate historical trending analysis reports. These reports are based on resource usage and provide recommendations on improving building efficiency.

The solution provides historical reports that demonstrate cost savings resulting from the system and procedural changes made by the client in the facilities. The solution can generate reports with building efficiency rankings, energy costs, green-house gas emissions, and carbon footprint tracking. The solution can report both monthly and annually on overall energy consumption on each monitored facility with all utility consumption, based on weather normalization. The solution can provide exception variance reports by facility and type. The solution can also create custom reports and provide the capability to import data feeds from online providers. By normalizing data (seasonal data versus typical year weather data), the solution can help manage and reduce carbon output and energy usage.

Business value

This solution reduces energy and resource use, waste, costs, and saves staff time and effort.

Effective space utilization

The lack of a global view of building space results in large amounts of underutilized space. This situation results in the inability to correlate building usage. The visibility of space usage across the enterprise portfolio of buildings, including the tracking of moves, occupancy, employee, and asset data, is essential. A means to identify underutilized space and suggested strategies for more efficient use of facilities is needed.

With the ability to plan moves and to handle adds and changes based on space, power capacity, and heat dissipation, the data center infrastructure benefits from optimal use at reduced operational cost and risk.

Solution

The solution shows an integrated global and local view of the space metrics. By using the solution, building managers can compare occupancy (over time) to identify and better understand the overall space utilization. This comparison provides the ability to adjust energy systems based on usage and occupancy. Also, the solution helps drive a strategy for lease management and the ability to adjust to dynamic work-style changes.

Business value

Space is the largest cost entity within a real-estate operations portfolio. This solution saves property costs by providing the information necessary to property owners so that they can adjust and negotiate leases. It also reduces energy costs based on dynamic usage patterns.

IBM Smarter Buildings solutions

IBM Smarter Buildings solutions ensure the reliability, efficiency and sustainability of buildings by offering the following benefits:

- Lowering energy costs
- Improving operating efficiency
- Ensuring occupant safety and satisfaction
- Providing higher and better utilization
- Improving revenue performance

Figure 1 provides an overview of the Smarter Buildings solution set.

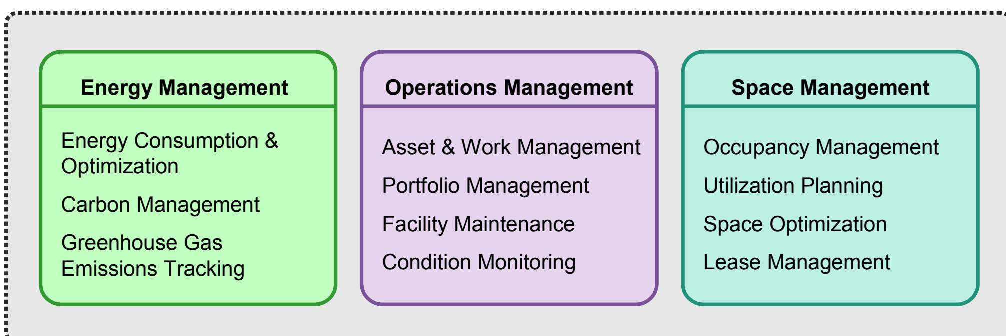

Figure 1 Smarter Building solution areas

The Smarter Building solution set has the following main areas:

- Energy management

  Energy management is the real-time monitoring of building and data center equipment. It reduces energy consumption and waste over the life cycle of a building and increases facility performance in a sustainable manner.

- Operations management

  Operations management includes asset management and performance, utilization, availability, and life-cycle management. The portfolio of building assets is optimized through asset visibility and operations management.

- Space management

  Space management provides visibility of space use across the enterprise portfolio of buildings. It identifies underutilized space and suggests strategies for more efficient space use in data centers and facilities.

Existing building systems are integrated with IBM solutions to create one holistic, adaptive system that can deliver reliable results. These solutions assist in information gathering and in determining key performance indicators (KPIs). By analyzing building data from the various sources, important information and trends can be identified. IBM solutions can use this information and source data to achieve a dynamic adaptive building environment to meet business objectives and handle changing demands and unanticipated external factors.

IBM Intelligent Building Management solution

The IBM Intelligent Building Management solution focuses on integrating and optimizing the physical and digital infrastructure of buildings. The solution helps create facilities that are more cost-effective, operationally efficient, productive, safe, secure, and environmentally responsible. Gathering data, managing assets, monitoring sensors, centralized analytics optimization, and distributed control are key IBM Intelligent Building Management architectural concepts.

The IBM Intelligent Building Management solution enables the following areas:

- Analytics for energy efficient management
- More reliable building performance through real-time monitoring
- Enterprise views of building status for improved user awareness and decision support
- Improved facilities operations efficiency
- Integrated energy, asset and work order management

The IBM Intelligent Building Management solution is a preintegrated and preconfigured solution that reduces deployment time and effort and speeds return on investment.

Architectural overview

The IBM Intelligent Building Management solution was built and designed around the elements of visualization, intelligence, interconnected, instrumented and physical as illustrated in Figure 2 on page 8.

Each layer identified in Figure 2 on page 8 provides an important aspect of the solution:

- The *physical layer* contains the actual equipment and physical elements that need to be monitored. A site assessment is made with the owner or operators to determine what systems to monitor. Usage of the assets by occupants or tenants is also part of the monitored resources of a building.
- The *instrumented layer* is provided by IBM Business Partners. This layer contains the building management system (BMS), which collects all of the real-time meter and sensor data. It aggregates this data into meaningful and actionable information. The BMS is configured to raise alarms based on client-defined thresholds.
- The *interconnected layer* contains two domain areas. One domain area uses open standards to collect the necessary metrics and alarms from the various BMS installed across the enterprise. The other domain aggregates BMS data into a single normalized format. With this aggregation, access is available to information that was unavailable previously from an enterprise perspective. This layer also contains the integration between

IBM products to provide analytics, maintenance, and operational activities through a common dashboard.

- The *intelligence layer* contains IBM products that provide the analytics, maintenance, and operational activities. IBM analytics transforms existing energy-rich data into intelligent information, enabling insight and well-informed decision making. This information enables the understanding of the optimum operating parameters for energy assets. It also enables management to act immediately in response to events, such as operational malfunctions. It provides ongoing visibility to energy efficiency over time, reducing energy waste.

  Maintenance and operational activities are enhanced with more information coming from BMS analytics and real-time alerts. This information enables technicians to identify the problem quickly, so that they can resolve it sooner.

- The *visualization layer* makes valuable cross-system information viewable on a single dashboard. Combining previously unrelated data and business logic from two or more sources can create new insights. The dashboard is role-based, with access control. KPIs allow information to be analyzed and compared at the local, regional and global levels. By using the dashboard, the operator can launch other applications that are appropriate to the context of the work that the operator is currently performing.

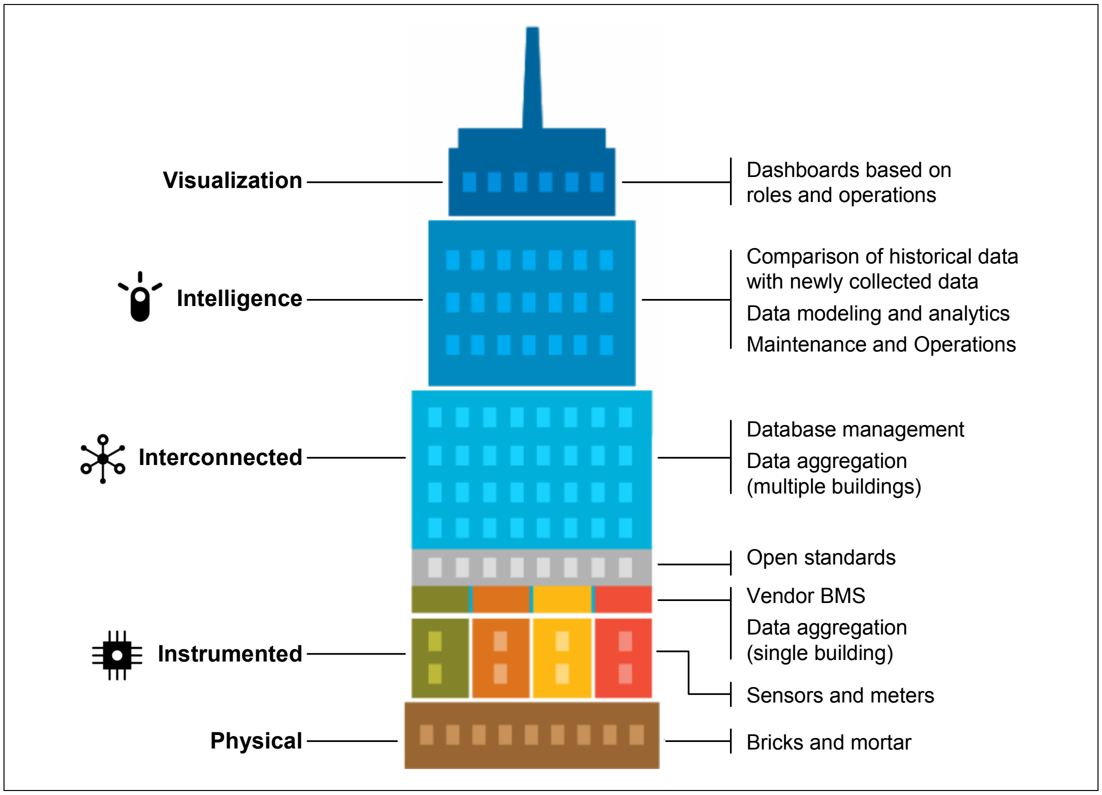

Figure 2 Architectural elements of the solution

Component view

The solution interfaces with the BMS for data gathering and command and control purposes. The data can also come from external systems, such as electrical grid systems, city infrastructure, and weather resources, to enhance the solution. The solution works with disparate BMS from various partners. Figure 3 shows the essential components of the solution.

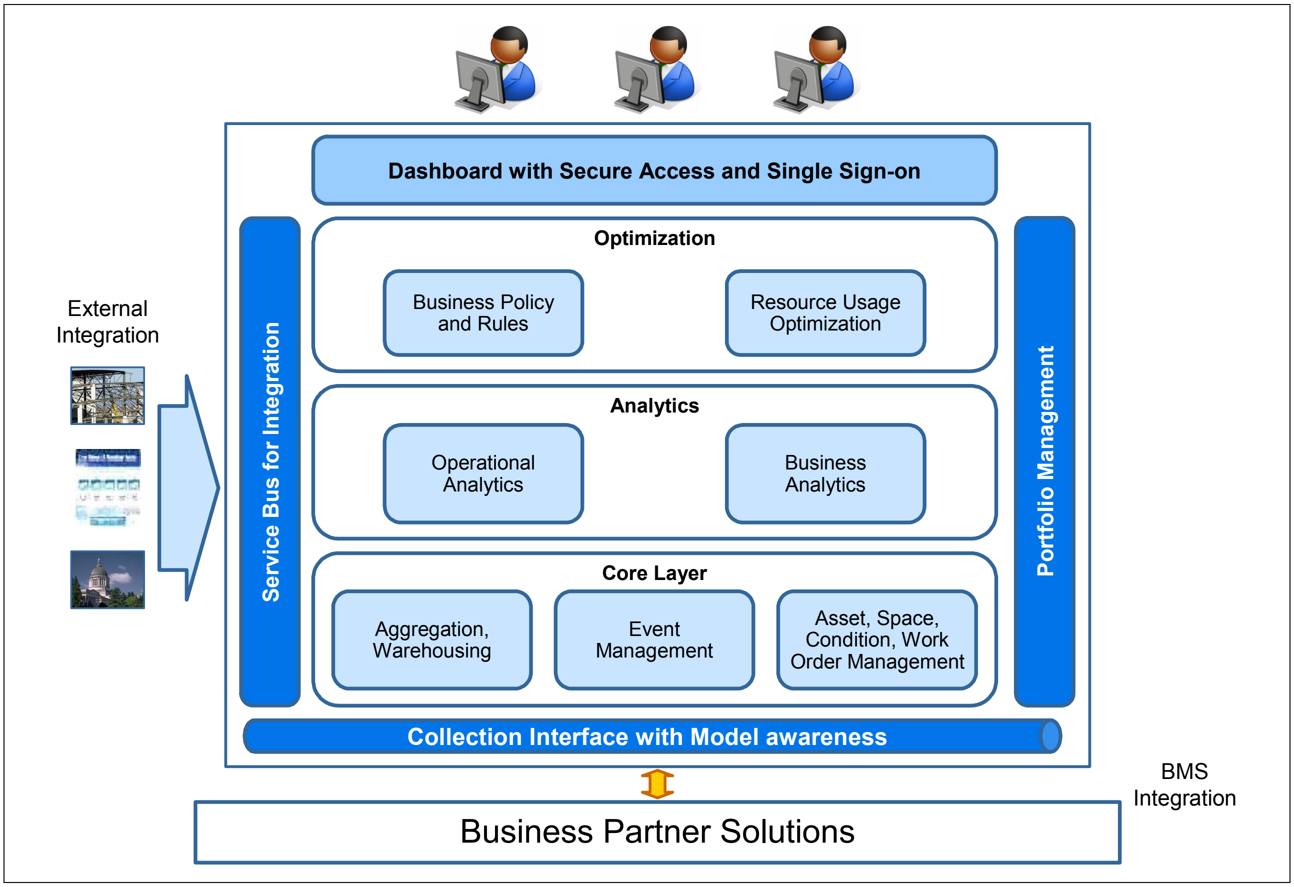

Figure 3 Layers of the basic and enhanced module of the BMS

The solution shown in Figure 3 includes the following capabilities:

- *Aggregation and warehousing* aggregates data from sources, such as building management systems, and populates a data warehouse to enable analytics, thresholding and reporting capabilities.
- *Event management* receives event data (in multiple formats from various alerting sources) and detects duplicates, filters out errors, and correlates relevant data. This data is input to root cause analysis, which is used to help identify the original cause of the event. Various alerting sources include BMS, internal and external monitoring tools, and analytical tools. Correlations are based on rules that are built upon defining the relationships between the resources. With this capability, you can open service requests and send notification for critical events.
- *Asset and work order management* are two functions. The asset management function contains information about a specific piece of equipment that operates at a physical location. It contains information including equipment maintenance history, installation date, warranty status, and preferred vendor.

The work order management function is helpful when the platform receives service requests for issues that need attention. The service requests are converted into work orders based on predefined rules and manual intervention.

- *Analytics* consists of advanced analytics, by using sensor-based data that is displayed on a dashboard. This function collects near real-time data for energy, water, CO_2 emissions and waste for analysis. It uses advanced statistical analysis and advanced analytics along with best practices to identify areas of improvement and the potential to optimize operations.
- *Dashboards* provide an enterprise-wide view of facilities data from global, regional, and local perspectives. They also provide a single sign-on platform to interface with the other components. A role-based dashboard provides an at-a-glance view of the critical operating alerts and KPIs of which the building owner and operator must be aware.

Monitoring and event management component interaction

Figure 4 illustrates the interactions among the monitoring, event management, and asset management components of BMS.

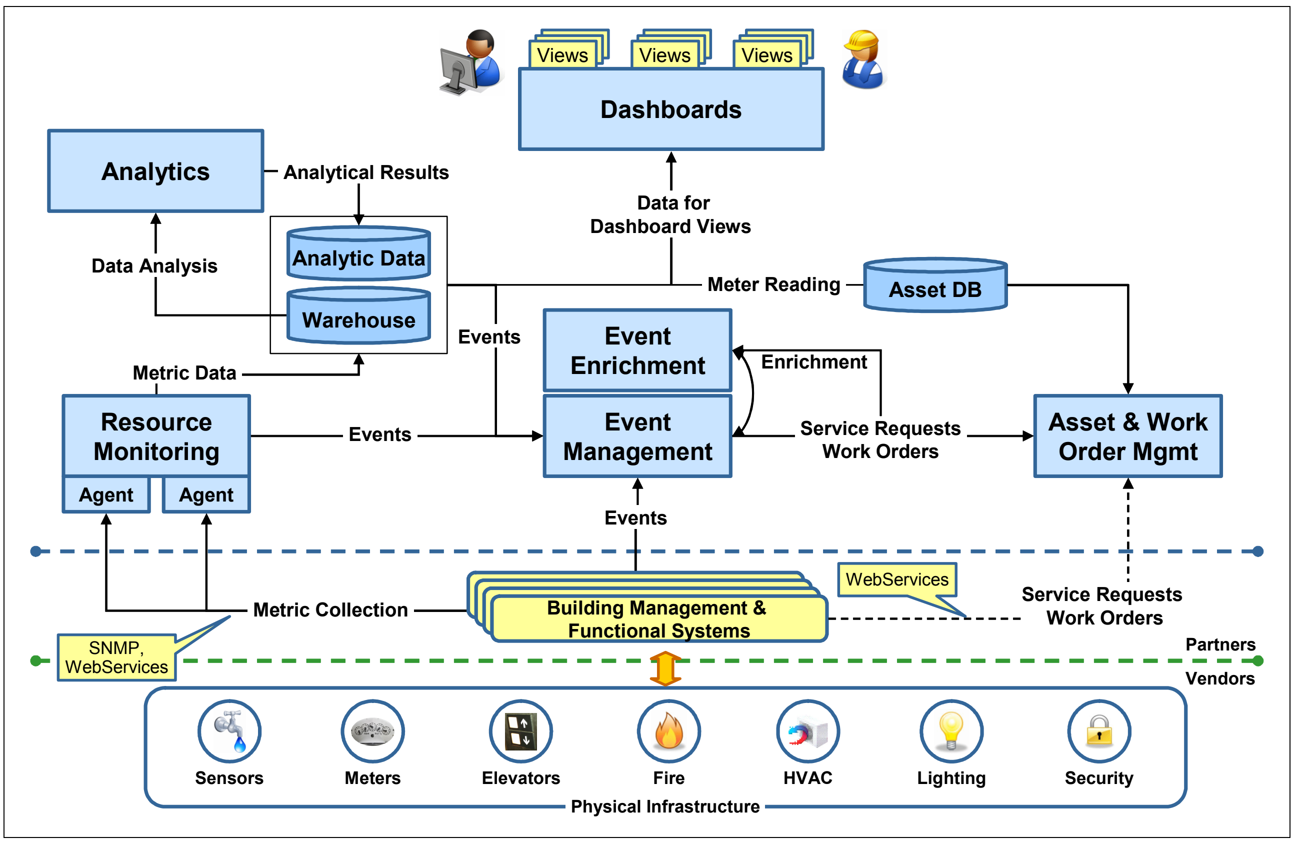

Figure 4 Architecture flow

Figure 4 illustrates the following interactions:

- BMS typically interfaces with the sensors and physical devices in a building and provides a central data and command interface at the level of one building or a group of buildings. The IBM solution also interfaces directly with sensor devices if an appropriate interface is available in the absence of a BMS.
- IBM Tivoli® Monitoring for Energy Management interfaces with various BMS to collect data at frequent or predefined intervals and stores the metric data in a data warehouse.

Tivoli Monitoring agents interface with BMS through either web services, Simple Network Management Protocol (SNMP), or any custom application programming interface (API). Tivoli Monitoring can set thresholds on the data that is being collected and send events to IBM Tivoli Netcool/OMNIbus, if needed.

- Events can be reactive (a real-time, asynchronous event) or predictive (the results of analyzes). Reactive events are typically sent from the BMS systems to notify Tivoli Netcool/OMNIbus of critical resources that need immediate attention. Predictive events are typically sent from analytical tools to notify Tivoli Netcool/OMNIbus of resources that might need maintenance or are operating inefficiently. The events are filtered, prioritized, and correlated, the potential root cause event is identified, and action is taken. Example actions are opening a service request or sending a notification.
- Service requests are opened in IBM Maximo® Asset Management to highlight issues with the operating environment. Service requests can be manually or automatically converted to work orders in Maximo Asset Management and assigned to the applicable staff member for action. The work order information can be integrated easily with equipment information, such as maintenance history, installation date, warranty status and preferred vendor.

Standards

Significant value can be realized by integrating building design and operational status information and providing a consistent way to access that information. This approach leads to improved operational and maintenance efficiency. With this information, potential building issues can be predicted before they occur, even before an effect is felt by building occupants. For example, operational data, such as daily CO_2 emissions and power usage, can be used in strategic planning to target problem areas, reducing the costs and environmental impact.

Standards are key enablers to Smarter Buildings. Data modeling, interface and communications standards provide a consistent way to access critical building information in a uniform manner. These standards eliminate the cost and inefficiency of accessing multiple proprietary data stores.

Given the overall complexity of a building and its subsystems, the following standards are required and must be defined at multiple levels and integration points:

- Device to and from BMS integration

  These standards are required to facilitate communications among the abundance of building devices, such as HVAC, lighting and utility meters, in building management systems. This space includes the following key standards:

  – Building Automation and Control Networks (BACnet)
  – LonWorks networking platform
  – Object Linking and Embedding for Process Control (OPC)
  – Modbus communications protocol
  – SNMP

  Generally, BMS systems integrate using Internet Protocols (IP) and open standards, such as SOAP and XML.

- BMS to and from Operations and Maintenance (O&M) integration

  BMS maintains information that is critical to asset management and business intelligence (analytics) solutions. It maintains both real-time and historical data for all devices and equipment in a building. It is also the means of controlling building equipment. Standard interfaces and data formats for obtaining equipment information and controlling equipment settings reduce the amount of cross-vendor integration work that is required. This information provides the mechanisms for directly controlling critical building devices.

The following standards are emerging standards:

  - OPC Unified Architecture (OPC-UA)
  - Open Building Information Exchange (oBIX)

- O&M integration

  A strong requirement exists to communicate operational insight on Smarter Building assets to asset management systems in a standardized manner. MIMOSA (an open information standard) is emerging to support operations and maintenance.

- Design & Engineering (D&E) to and from O&M integration

  Building information modeling is an important source of building information that is critical to monitoring and efficiency solutions. A BIM representation, which incorporates the physical and functional characteristics of a facility, is initially created during the design and engineering phase of a building. The BIM representation is updated throughout the building life cycle. Creation of a standardized, XML-based format for this information significantly enhances the effectiveness of analytics and asset management for buildings. The buildingSMART alliance is leading the effort to standardize BIM.

- Building to Grid (B2G) integration

  These information and interface standards enable buildings to communicate with the energy market and smart grid. They include standard methods for the exchange of demand, response, and pricing signals in a marketplace.

  Several key standards activities within the Organization for the Advancement of Structured Information Standards (OASIS) address this area, including the following standards:

  - Open Automated Demand Response Communications Specification (OpenADR)
  - Energyinterop (OASIS technical committee developing XML standards for energy interoperation)
  - Electronic Medical Information Exchange (EMIX)
  - Open Building Information Exchange

  The International Electrotechnical Commission (IEC), a segment of the International Organization for Standardization (ISO), has the relevant standards ISO 15045, 18012, and 15067. For more details about these standards, go to the ISO Standards website at:

  http://www.iso.org/iso/iso_catalogue.htm

- Leadership in Energy and Environmental Design (LEED)

  LEED is a green building certification initiative that provides third-party verification that a building or community has been designed and built by using strategies aimed at improving performance. LEED provides building owners and operators with a framework for identifying and implementing practical and measurable green building design, construction, operations and maintenance solutions.

  For more details about LEED, go to the US Green Building Council web page at:

  http://www.usgbc.org/DisplayPage.aspx?CMSPageID=1988

Monitoring and efficiency for Smarter Buildings

A primary focus of Smarter Buildings is ensuring that buildings are energy efficient and sustainable. IBM and its partners are working toward convergence of IT solutions with facility and energy systems, creating a comprehensive view of key systems and data.

Use of analytics

Existing energy data that is present in building management systems, along with other information sources, provides the input data for Green Sigma™ analytics. This data is used by Green Sigma analytics to provide building owners and facilities management with insight and understanding of the performance and efficiency of their energy consuming assets. These analytics (specifically root cause analysis) provide the information that is needed to respond to an operational malfunction. The use of analytics enables ongoing visibility of energy efficiency over time and provides condition-based monitoring at the asset level.

The use of analytics determines and assesses the base energy load for a building and identifies the system and operational drivers behind the base load. By studying fluctuations in energy use, clients can develop analytics reports and advanced analytical models. The results can also help the client understand the causes of inefficiencies that lead to remedial actions that improve energy efficiency. Figure 5 shows the types of analytics provided by Green Sigma with its suite of robust analytic tools.

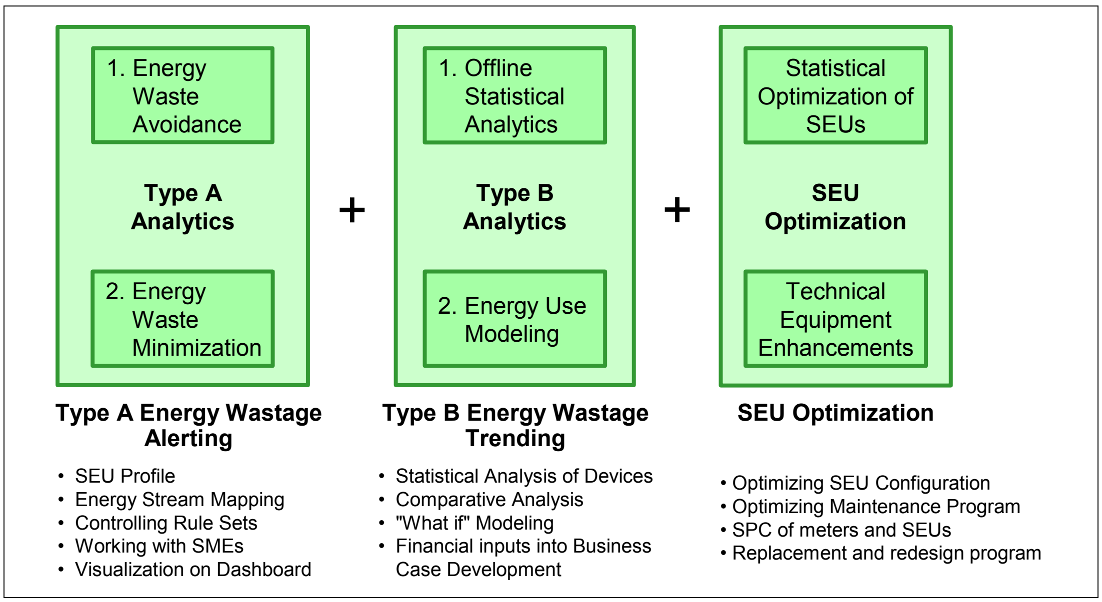

Figure 5 Summary of Green Sigma offering energy analytics touch points

Basic analytics: Type A analytics

The Green Sigma offering uses device modeling to model the devices within a facility. Beyond standard data mining principles, the Green Sigma offering provides contextualized data, which can then be analyzed. Operational and system relationships, both upstream and downstream provide a depth of understanding in relation to the operational demands and restrictions under which each device operates. For more details about the Green Sigma offering, see *Green Sigma: How to optimise your carbon management through Green Sigma* at:

http://www.ibm.com/ie/emerging_business_centre/pdf/Green_Sigma_final_Strategy.pdf

Advanced analytics: Type B analytics and SEU optimization

Advanced analytics provides an understanding of energy use and areas of inefficiency in buildings and their devices. The devices within a building include HVAC and chiller equipment and are usually the large energy consumers in a portfolio outside of a data center context. Devices identified as major energy consumers in proportion to other devices are identified as a significant energy user (SEU).

The rated SEU profile is generated based on estimates of combined electrical, cooling and heating loads. Analysis of the SEU profile is the starting point for the establishment of the most cost-effective and time-efficient way of gathering required and targeted data. This data ultimately has the greatest effect on energy savings in the shortest time possible.

Advanced analytics provides a deep and wide understanding of the energy use and areas of inefficiency. Advanced analytics provides the following information and reports:

- Statistical analysis of devices report on the efficiency and performance of a device
- Comparative analysis reports on the efficiency and performance of a device compared to an identical device
- Modeling tracks and reports on the relationship between tagged devices
- SEU optimization through smarter building analytics, which provides in-depth knowledge of the SEUs to enable the following functions:
  - Optimization of the SEU configuration
  - Optimization of maintenance programs
  - Replacement and redesign of programs
- Statistical Process Control (SPC), which observes discreet data points, catastrophic failure, or deviance from a set point and operating parameters
- Predictive analytics, which monitors the ongoing workload, detects patterns, and recommends remediation of the systems before an event occurs

By using more advanced modeling techniques, with the Green Sigma offering, clients can compare potential design options with technical enhancements, ensuring continuous improvement of the energy-efficiency posture of a site or building.

Business partners and interfaces

IBM partners with industry leaders in the areas of facilities components and Building Management Systems. IBM provides a range of value-add analytics, asset management, and management capabilities and acts as an aggregator of data from partner systems. Partners include Johnson Controls, Inc.; Eaton Corporation; Cisco Systems, Inc.; Tridium, Inc. (an independent business entity of Honeywell International Inc.); and Schneider Electric. The solutions enabled with partners are typically integrated into a partner's management system, which isolates direct communications with the individual, underlying facilities and building components.

The Green Sigma™ Coalition was launched by IBM to drive deeper integrations with partner systems. The Green Sigma Coalition is an alliance that continues to add new members, representing a range of specific disciplines in the smarter building space. For more details about the Green Sigma Coalition, see "IBM's Green Sigma Coalition: The First All-Star Team of the Low-Carbon Economy" by Stephen Stokes at:

http://www.ibm.com/services/us/gbs/bus/pdf/amr_research_0908asus-a-stokes1_tcm7-46629_ibms_green_sigma_coalition_the_f.pdf

IBM is also a member of the Internet Protocol for Smart Objects (IPSO) alliance, which is focused on the extension of IP networking.

Although the BMS and facilities interfaces have traditionally used specific protocols, such as Modbus and BACnet, a transition is underway to IP-type protocols. Modbus and BACnet are industry standard protocols that are used to connect supervisory control and data acquisition (SCADA) devices. The lack of standards creates the need to interface with individual management systems. The more ideal approach is to use a consistent data model across all management systems.

Energy-efficient data centers

Energy costs continue to rise, and data centers are large consumers of energy. Making these large users energy efficient is critical to making an entire building efficient. IBM energy efficiency solutions for the data center include products and services that are used to analyze and determine the necessary corrective actions.

Smarter Buildings support energy-efficient data centers and focus on the following major drivers:

- Cost reduction and avoidance:
  - Identify opportunities for energy cost reduction (operating expenses).
  - Reduce over-provisioning.
  - Delay facility expansion due to energy or cooling constraints (capital expenses).
- Remove operational barriers:
  - Manage power and cooling capacity to enable growth and flexibility.
  - Manage power control (modes, capping, and saving power).
  - Avoid service disruptions that are caused by energy-related outages.
  - Identify and react to energy fault events.
- Manage risk and streamline compliance:
  - Document and validate energy efficiency gains to stakeholders.
  - Ensure compliance with new and emerging regulations.
- Regulation:
  - Government regulations require greater energy efficiency.

Efforts at IBM to drive energy-efficient data centers start with the management enablement and efficiency of IBM products, including both hardware and software. This guide focuses on the management of software and how it provides solutions to clients.

The conceptual architecture layer diagram (Figure 6 on page 16) focuses on key data sources and provides information and resources for IT management. The architecture shown in Figure 6 on page 16 consists of the following levels:

- *Level 0* includes the drivers that gather data directly from equipment (both IT and infrastructure equipment), from external sensors and from other management software. It has its own drivers to gather data.
- *Level 1* provides access to the control interfaces of the management server. Because of equipment diversity, the management server uses direct and indirect drivers to control data center equipment. Level 1 provides the interfaces that set thresholds and create alert events on which the management system acts. It also provides the means to trend data, create historical views and provide sets of optimizations based on several points of monitored data.
- *Level 2* can monitor for thresholds and anomalies. Data from all of the collection points is normalized, stored in a data warehouse and made available for use by management applications.
- *Level 3* supports operations management. Physical optimizations are made here, based on the ability to meet workload service-level agreements (SLAs). This level includes the management of physical assets and licensing.

- *Level 4* provides the business context to the metric data that is collected. The business context can include accounting and reporting, compliance reporting and resource planning.

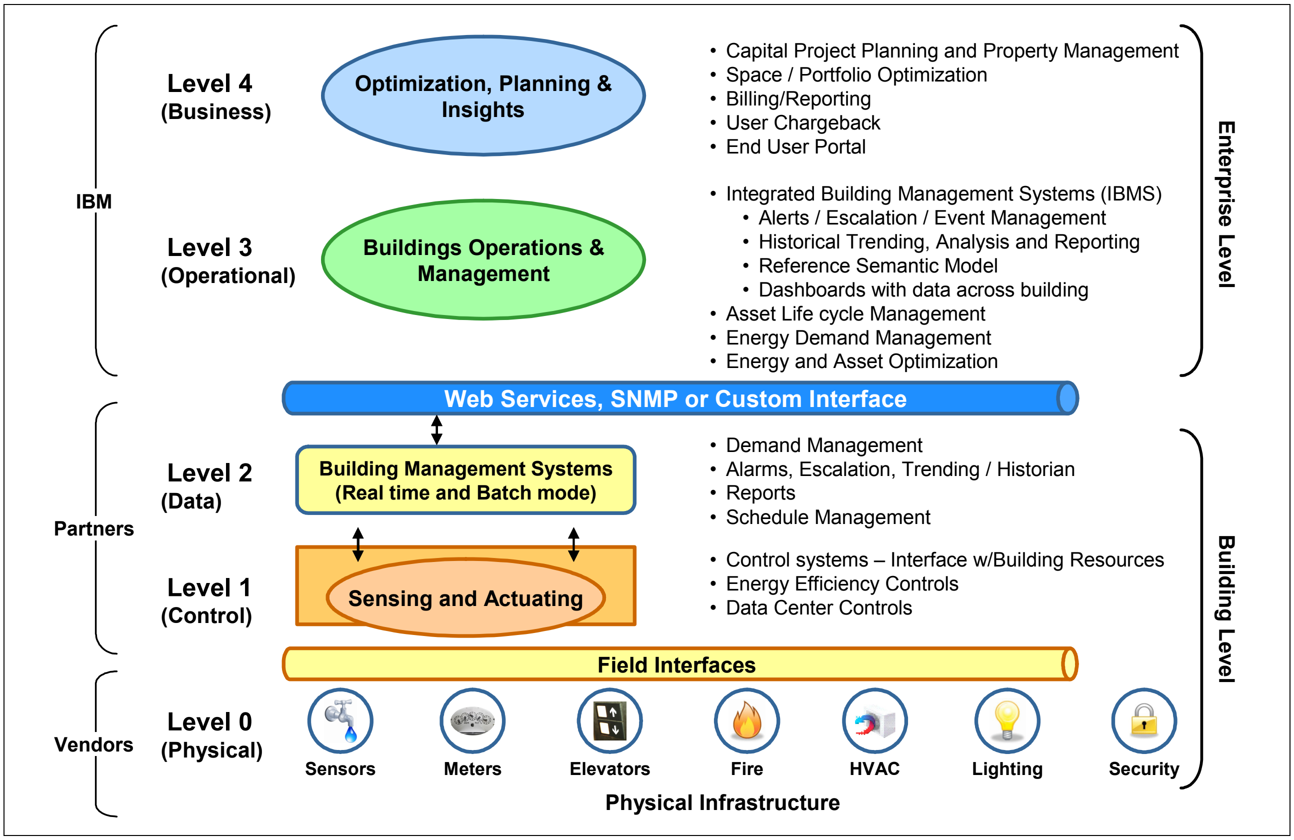

Figure 6 Conceptual architecture of data centers

The following IBM Redbooks® publications provide key information about IBM solutions for energy-efficient data centers:

- *The Green Data Center: An Idea for Today*, REDP-4523
- *The Green Data Center: Steps for the Journey*, REDP-4413
- *IBM b-type Data Center Networking: Design and Best Practices Introduction*, SG24-7786

Products for energy management

The major products in the energy management space are extensions to the normal data center management provided by IBM. The following key IBM products support energy-efficient data centers:

- Tririga® Real Estate and Environmental Sustainability (an IBM company) delivers the environmental sustainability software that is needed to lower energy costs and generate higher savings from carbon reduction projects. Powerful, flexible and easy-to-use features identify carbon-intensive facilities and processes, analyze the financial and environmental benefits of environmental sustainability investments, and automate carbon reduction actions. This solution enables streamlining of carbon accounting and environmental investment analysis, reducing energy costs and achieving carbon management strategies.

  For more details about Tririga Real Estate and Environmental Sustainability, go to the Tririga site at:

  http://www.tririga.com/products/environmental-sustainability-software

- IBM Systems Director Active Energy Manager™ monitors energy metrics from systems and support equipment, and performs monitoring, alert and threshold tasks on that data. In addition, it provides a single view of actual energy usage across systems and facilities within the data center.

  For more details about Systems Director Active Energy Manager, go to the Active Energy Manager page at:

  http://www.ibm.com/systems/software/director/aem/index.html

- Tivoli Monitoring for Energy Management monitors and helps manage energy usage of IT and facility resources for efficient data center operations. This product helps to provide insight into energy and thermal information for IT equipment, data center infrastructure and facilities equipment. It enables the optimization of a monitored environment from a centralized point of control. It provides energy metrics to other Tivoli products such as Maximo for Energy Optimization, Tivoli Usage and Accounting, and Tivoli Business Service Manager. It provides thermal views of data center and facility cooling dynamics and hot and cold spot analysis and alerts. It visualizes energy and environmental metrics to identify temperature hot and cold spots in a simple map overview.

  For more information, see the Tivoli Monitoring for Energy Management web page at:

  http://www-01.ibm.com/software/tivoli/products/monitor-energy-management/

- Maximo Asset Manager for Energy Optimization supports the convergence of energy data with asset and service management. It also provides energy visualization of both data center and facilities assets.

  For more details about Maximo Asset Manager for Energy Optimization, go to Maximo Asset Management for Energy Optimization page at:

  http://www.ibm.com/software/tivoli/products/maximo-asset-mgmt-energy-optimize/index.html

The use of a common database for metric data and policy rules provides an integrated and complete set of tooling to manage any data center. When the data center is in a smarter building, the solutions integrate, and the data center is treated as a special portion of the building.

Partners and interfaces

IBM has several partners at the data center infrastructure, facility, and property levels:

- Partners at the data center infrastructure level include Schneider Electric, Avocent Corporation, SynapSense Corporation, Raritan Computer, Inc., Emerson, Rittal GmbH & Co., Eaton Corporation, iButtonLink LLC., and Cisco Systems, Inc.
- Partners at the facilities and property levels include Johnson Controls Inc., Schneider Electric, Honeywell International, Inc., Siemens, and MatrikonOPC.

Infrastructure partners

IBM works with various infrastructure partners to provide solutions. The following key information is provided:

- Metric information about power and cooling

  The management server can retrieve the sensor data and normalize it for consistent use by management services.

- Energy monitoring

  Various devices, including distribution meters, branch circuit monitors, power distribution units (PDUs), and uninterruptible power supplies, provide energy monitoring of IT equipment. Monitoring at separate levels coupled with the management server provides a powerful tool to manage data center power. Cooling can be managed in the data center, although associations are less exact because of the typical use of common cool air distribution plenums. However, with cooling zones and other algorithms, useful associations are made in the management servers.

- Management server level

  A management server (such as the Emerson-Liebert SiteScan) collects data on several parts of cooling and power distribution. APIs enable data sharing of that data with IBM management tools to provide integrated information, leading to better operational support and energy optimizations. Together, the management servers for IT and infrastructure can provide a powerful operational, optimization and maintenance set of support to the data center staff.

Standards

Standards in this area are still emerging. Currently, energy and thermal data on hardware is not directly accessible. The Common Information Model (CIM), an open standard, defines how managed elements in an IT environment are represented as a common group of objects and the relationships between those objects. Research continues on how data center equipment should report energy and temperature information within the CIM. Most devices that report this information use nonstandard interfaces.

This topic is receiving much attention from The Green Grid, which is an industry consortium working on completing the CIM work, so that it includes IT and infrastructure equipment. In addition, a joint effort between The Green Grid and the European Computer Manufacturers Association (ECMA) is standardizing how all equipment in the data center must interact to provide a consistent data center management schema for overall management and optimization. Also at the data center level are standard metrics for measuring the efficiency of the data center infrastructure. For example, the US Federal Government stated that all new data centers must have a Power Usage Effectiveness (PUE) rating better than 1.5.

For more information about The Green Grid, go to The Green Grid website at:

http://www.thegreengrid.org

Facilities asset management

Facilities managers are under increasing pressure to provide a well-maintained building, while responding to increased budgetary constraints and ever-expanding regulatory requirements. They want to know the answers to the following questions:

- How can we better understand the condition of the building infrastructure and make decisions that align with the budget and business goals?
- How can we better implement maintenance practices to ensure communication between departments and meet health, safety and environmental standards?

Facility asset management is further complicated by the realization that many assets are distributed. For many organizations, the distribution of these assets results in multiple management applications and processes. This approach can translate into real costs, both in terms of business productivity and actual service costs.

IBM asset management solution

The IBM Maximo Asset Management solution provides a broad range of capabilities. These capabilities encompass facilities maintenance, space planning, data center infrastructure management, sustainability, service management and functionality supporting outsourcing facilities service providers. With this solution, facilities managers can meet their business goals around managing occupancy, meeting regulatory requirements, increasing energy efficiency, reducing costs and providing improved maintenance.

Maximo Asset Management provides facilities managers with the software needed to manage day-to-day operations, address shrinking budgets, and meet stringent regulatory requirements. With visibility into work plans and scheduling, Maximo Asset Management ensures the consistent delivery and execution of services, providing improved satisfaction for building occupants.

The benefits of this solution enable optimal maintenance of assets throughout their life cycles, increasing usable life, reducing costs and supporting sustainability goals. Maximo Asset Management provides the six key management modules—asset, work, service, contract, materials and procurement management—that you need to optimize the performance of every asset.

This solution offers comprehensive capabilities for inventory and contract management, activities that are critical to facilities managers due to their integrated role within maintenance activities. Accordingly, the ability to better manage vendor relationships and establish contracts for labor and materials across the entire enterprise allows for better cost control. Maximo Asset Management provides the ability to track current warranties and facilitates the recovery of funds through claims processing. It also manages vendor SLAs to monitor overall performance.

For more details about IBM Maximo Asset Management, go to the Maximo Asset Management page at:

http://www.ibm.com/software/tivoli/products/maximo-asset-mgmt/

Integrated communications services

The Smarter Buildings solution integrates major building systems onto a common network. It uses the information from these systems to offer significant improvements in energy efficiency, operational effectiveness and occupant satisfaction. This solution offers a practical approach to managing and optimizing energy assets. It also offers a strong security posture to help reduce costs, improve services and manage risks to cost-effectively embrace change and innovation without compromising security. By gathering, synthesizing, and applying information in new ways, industries and governments can enable shifts in operations and management of buildings within one or across multiple campuses. This action makes buildings more efficient, more intelligent and more sustainable.

Integrated communications services integrate the relevant systems that have been optimized into a converged network. These integrated communications services improve monitoring, control and performance, which ultimately increases tenant satisfaction and reduces network installation and maintenance costs.

Integrated communications services include the following areas:

- Integrated building systems that share information by using open standards, enhancing overall functionality
- Web-based monitoring, which allows for improved control and management of multiple systems within a building or across multiple buildings of a physical or logical campus
- Portals and dashboards, which provide real-time information and analysis both for the building occupants and management
- Integration of multiple building systems, which provides operators with the necessary feedback to optimize personal comfort and building security
- Building a vertical wiring infrastructure that distributes telecommunications and building automation systems traffic over an integrated IP infrastructure
- Converging broadband networks for building systems and providing Voice over IP (VOIP), video, and data

  This convergence eliminates the cost and confusion of multiple proprietary networks. Also, it allows clients to plug in phones and computers and start working seamlessly when they move in. It fosters competition from multiple telecommunications and data communications services, allowing the selection of best-in-class offerings for individual services.

Key components and framework

A building with a common building wiring infrastructure increases tenant satisfaction by improving tenant experiences with telecommunications and data communications services. An IBM Intelligent Building Management solution has the following benefits:

- Reduced telecommunications with order-to-service-commissioning intervals for tenants

  One of the longest duration activities associated with a telecommunications service order is ensuring that vertical building wiring is in place and connected to carrier facilities. A preinstalled building wiring system reduces the time that is needed for service commissioning.

- Reduced adverse effects of service provider lock-in

  Because the costs of switching from one telecommunications supplier to another telecommunications supplier are substantial, clients become locked into their supplier choice. This situation typically results in the client paying more for the existing service over the course of the contract. Buildings that employ flexible vertical wiring can significantly reduce the cost of switching service providers.

- Increased choices for telecommunications and data communications services.

  Greater carrier selection, coupled with low switching costs, allows agencies to choose best-in-class or niche offerings on a service-by-service basis. In contrast, federal agencies typically select one supplier that provides the best service bundle because selecting more than one supplier requires duplicate inside wiring.

- Improved tenant productivity.

  Although it is difficult to quantify, smarter building strategies can improve tenant productivity because of reduced operating costs. For example, smarter buildings can provide tenants with improved comfort and after-hours access to an office environment. Flexible vertical wiring supports VOIP, which, in turn, supports capabilities that fully implement mobile workplace strategies adapted to contemporary work styles.

Use of analytics

Analytics tools can be used to monitor the following areas:

- Energy usage for a given time period
- Energy usage trends
- Peak energy load by time period
- Energy usage for on-peak and off-peak time periods as defined by the power provider
- Energy usage for the duration of the demand response program period

For example, conducting data analysis by meter results in power analysis by meter. This analysis assists in identifying demand response opportunity. This data analysis includes the calculation and monitoring of load factors, which compares average usage and peak usage, to measure the effectiveness of the peak reduction and demand response initiatives.

The development and refinement of a power usage model can provide the following functions:

- Customized degree day analysis to build operational requirements
- Statistical analysis of peak power usage, including normal range of operation and outlier conditions
- Prediction of peak power and associated demand response requirements and opportunities with an advanced signal being provided to building locations and building systems for demand response initiation

Standards

The major standards initiatives support the use of IP for sensor and control networks within a building. This protocol is a well-known programming and networking model supported by various existing tools and significantly simplifies the development, deployment and maintenance of these applications. It helps deliver real-time information and asset intelligence from virtually every building device and sensor for improved decision support, regardless of location.

Connections to external systems

As the world of IT continues to integrate more with “clean technology,” we are poised for a major shift in the way that buildings are operated and, subsequently, how they manage energy. The future will involve a much more complex set of technology, systems and processes in buildings, which will require a new set of skills within the commercial and corporate real estate industry.

The potential of providing integration with B2G includes dynamic pricing, advanced building energy co-optimization (including distributed generation), storage, building thermal energy storage in building spaces, and dynamic co-optimization of building automation systems. It is expected to employ emerging open standards, such as Open Automated Demand Response (Open ADR). Also, anticipated is an integration of standards from the Building Automation System (or, distributed resources, such as regional B2G systems) and the International Organization of Standards (ISO), along with other cyber security measures. These standards groups want to employ these cyber security measures from the perspectives of the Critical Infrastructure Protection (CIP) standards (developed by the North American Electric Reliability Corporation (NERC)) and market integrity and information privacy.

Building to grid benefits

The application of B2G leverages existing structures found in many large cities. Distributed resources can be used to maximize system and building benefits. Advanced visualization techniques can be used to help building operators understand and adapt to B2G scheduling in order to maximize savings. This activity can be done while maintaining in-building, localized, ambient conditions, and to obtain detailed performance feedback to allow the B2G system to continuously adapt and improve its dynamic building models.

The *community* can achieve the following large-scale benefits of B2G projects:

- Maximize the economic and environmental benefits of distributed generation systems and demand management systems
- Convert energy use information into potential revenues
- Have the potential for revenue generation by selling curtailment services to the grid
- Provide tenants with the ability to have dynamic interactions with power providers, for example, solar, micro-wind turbines, ice storage, chillers, and personal electric vehicles (PEVs)
- Reduce power supply costs
- Experience cost savings by purchasing power during times when demand is low
- Attain smarter energy consumption and peak-load use with the visibility of real-time prices
- Receive tax credits and incentives
- Measure and achieve environmental goals
- Reduce carbon emissions for the provided services
- Move to the energy-efficient use of power supply resources
- Increase property value
- Improve on the reliability of resources by controlling available resources
- Improvements in load shape (smooth the peaks and valleys of loads to reduce the costs that are involved with peak generation)
- Make business-to-business (B2B) communications secure

The *utility system* can achieve the following large-scale benefits of B2G projects:

- Reduced utility costs due to the improved load factor
- Increased reliability of utilities
- Better outage management control
- Reduced emissions and carbon footprint
- Better capability to integrate renewable sources of energy into the system
- Engaged and enabled clients

This project can ultimately provide the following benefits:

- Reduced resource costs
- Job growth both directly and indirectly
- Improved environmental performance
- Increased reliability of the electrical system

Cross-geography building management

Cross-geography building management encompasses the management of all the buildings that are owned or used by an entity such as a corporation. These buildings can be in close proximity or around the globe. For example, some university campuses are focusing on highly efficient buildings that reduce waste and minimize the effect on the environment, while improving the quality of life at the facility.

The following considerations for cross-geography building management produce cost efficiency and overall sustainable design and management of cross-geography buildings:

- A *BMS* controls and manages mechanical and electrical equipment, such as lighting, power, fire, ventilation and security systems. These systems are inevitable for cross-geography (boundary-less) management and communications.
- The *assessment of risks and the effects of business decisions* on cross-geography campuses is imperative. However, it is easy to overlook these considerations and focus on the immediate decision. One way to mitigate this risk is by using automatic service management and monitoring tools that send notifications to users and make them aware of real-time events in an automated fashion. Common dashboard platforms, such as *portals*, can help stakeholders simulate business scenarios and the effect on the overall business performance.
- In our global society, it is important that *open standards* are applied in the design and delivery of systems so that interconnectivity is advanced, rather than hindered. Interoperability is the necessary factor in enabling digital communications across boundaries. Generally, BMS integrate by using Internet protocols and open standards, such as SOAP, XML and BACnet.
- *Cloud computing* (new consumption and delivery model) enables self-service, sourcing options, and economies of scale. Smarter Buildings can use cloud computing as a part of the business and data center strategies to promote cross-geography communications and to ensure the overall business performance and optimization of services.

  For example, analytical services that measure energy consumption levels can be cloud-enabled. This way, worldwide facilities use consistent applications to attain real-time insights into building and data center performance and the effects on other connected buildings and around the globe. In essence, and if adopted properly, a cloud is an enabler of cross-geography building interconnectivity and intelligence.
- *Self-service enablement* is a key consideration for cross-geography building management. Self-service empowers tenants, building administrators and occupants to operate independently, while remaining connected to a larger network of people, processes and technologies. Key consideration must be given to the self-service user interface, which must be self-explanatory and as simple as possible. In addition, the contents of the self-service catalog must be carefully considered.

  For example, will building administrators in region A be able to trigger an event that transfers equipment to or from region Z, and, if so, under what circumstances? Also, does the user interface provide controls so that it is difficult to transfer equipment to an incorrect destination?
- An *integrated network* is essential for effective cross-geography building management. Unfortunately, the performance of the network can sometimes be taken for granted. In addition to notable characteristics, such as bandwidth, Network Access Control (NAC) must be analyzed as a part of the integration and quality of service (QoS) strategy for cross-geography building management. NAC allows only compliant and trusted endpoint devices, such as personal computers, servers, and personal digital assistants (PDAs) onto the network. NAC controls access endpoints based on credentials. Such instrumentation

is standardized and can provide the security and QoS that are required to direct network traffic (regardless of geographic access points) to authorized zones.

Innovations for Smarter Buildings

IBM Research collaborates across disciplines to address some of the most complex problems of the world and promising opportunities. IBM believes that profound breakthroughs will come when businesses, governments, academic institutions and others work together to tap into diverse points of view and expertise. IBM Research helps clients discover new connections through exploratory research and gain competitive advantage through applied research. For more than 60 years, research has been one of the IBM key differentiators in the marketplace.

This section describes a selection of innovations for improving energy efficiency, design and operability of new and existing buildings. The topics that are presented include sustainable communities, building performance modeling and analytics, and building life cycle management.

Innovations for sustainable communities

In September 2009, IBM and the City of Dubuque, Iowa, a community of 60,000 residents, announced a collaboration to make the city one of the first smarter and sustainable cities in the United States.[4] Together they aimed to implement strategies and technologies for reducing the community's impact on the environment while addressing the increasing demand for vital energy, water and public transportation services. IBM and Dubuque set out to create an international, replicable model of sustainability for communities with populations of less than 200,000.

The first phase of the partnership focused on improving the understanding of water and energy use by the city and its citizens. The strategy was to use information such as the following examples:

- Obtain real-time coarse-grain water and electric meter data.
- Provide insights and community engagement to encourage water conservation.
- Identify and fix detected water leaks.
- Understand electricity consumption.
- Identify opportunities to reduce peak load and overall consumption and lower costs.

IBM has built a cloud-based platform to support information integration, monitoring and decision support to provide Dubuque with energy management views of its electric grid, water system and general city services.

In July 2010, IBM and Carnegie Mellon University (CMU) announced the creation of a Smarter Infrastructure Lab for collaborative research that aims to make cities and businesses more intelligent.[5] The new lab is part of the Pennsylvania Smart Infrastructure Incubator (PSII). PSII is a Commonwealth of Pennsylvania economic development initiative to create an incubator for advanced infrastructure technology in public-private partnership with city and state government and industry.

[4] "IBM and Dubuque, Iowa Partner on Smarter City Initiative: City Aims to Lead Sustainability to Drive Economic Growth," IBM press release from 17 September 2009 at: http://www.ibm.com/press/us/en/pressrelease/28420.wss

[5] "IBM and Carnegie Mellon University to Create Smarter Infrastructure Lab: Collaborative Research Will Aim to Make Cities and Businesses More Intelligent," IBM press release from 29 July 2010 at: http://www.ibm.com/press/us/en/pressrelease/32225.wss

The Smarter Infrastructure Lab is in the Department of Civil and Environmental Engineering on the CMU campus in Pittsburgh, Pennsylvania. This lab fosters cross-disciplinary research from the CMU engineering, architecture, public policy and business schools. Collaborative research projects involve the use of smart sensors, data acquisition and advanced analytics to solve problems of local, regional and worldwide interest such as energy efficient buildings, water and transportation.

Innovations for building performance modeling and energy analytics

Robust operation of integrated building systems is critical to achieving and maintaining energy efficiency and high performance building environments. Several factors must be considered to achieve optimal building performance. Such factors include seasonal variations in lighting requirements, temperature control, and occupancy patterns, combined with energy sourcing and associated price fluctuations, and well-designed and properly functioning control systems. The impact of poor building operation on energy usage has an estimated range 15%–30% compared to the intent during commissioning.[6]

IBM has developed comprehensive analytical tools for accurately assessing, tracking, forecasting, simulating and optimizing energy consumption in buildings to aid in decision-making. The goal is to support significant energy savings and a reduction of greenhouse gas emissions. The tools help to enable city agencies, building owners and operators, and facility managers to have greater insight into understanding and managing consumption of resources like electricity, natural gas, fuel oil and steam.

City University of New York engaged IBM to collect data about weather, energy and building characteristics and to perform extensive data analysis, modeling and optimization. The focus of the work was on the 1,400 K-12 public schools in New York City that serve 1.1 million students and cover 150 million square feet.[7]

McMaster University in Hamilton, Canada, engaged IBM to use real-time data from sensors, actuators and meters, dynamic energy pricing data, and IBM Information Management software. The goal was to perform extensive data analysis, modeling and optimization for 60 campus buildings that cover 10 million square feet.[8]

Innovations in building life cycle management

Building information modeling can be defined as the process of creating and using digital models for design, construction, operation, or all three on (building) projects.[9] Historically, the building industry is fragmented in nature and has a serial design and delivery process. Development and deployment of integrated design methods, tools and infrastructure are needed to empower a building project team to work in a cross-disciplinary fashion. This team includes architects, engineers, designers, contractors, the facility manager, and the building owner or operator. The ability to manage and seamlessly communicate electronic data and models between collaborating firms across the life cycle of a building, combined with workflow, is needed to achieve improved productivity, coordination and communication across

[6] Mills, E., Friedman, H., Powell, T., Bourassa, N., Claridge, D., Haasl, T., and Piette, M.A., "The Cost-Effectiveness of Commercial Buildings Commissioning: A Meta-Analysis of Energy and Non-Energy Impacts in Existing Buildings and New Construction in the U.S.", Lawrence Berkeley National Laboratory Report No. 56637, 2004.

[7] "City University of New York and IBM to Reduce Energy Consumption in Public School Buildings," IBM press release from 23 March 2011 at: http://www.ibm.com/press/us/en/pressrelease/34080.wss

[8] "IBM Works with McMaster University to Create First Canadian Energy-Smart Buildings on Campus, IBM press release from 28 February 2011 at: http://www.ibm.com/press/us/en/pressrelease/33838.wss

[9] SmartMarket Report on Building Information Modeling (BIM), McGraw Hill Construction, 2008 at: http://www.dbia.org/NR/rdonlyres/1631EDF1-8040-410D-BE1A-CF96AB1E9F84/0/McGrawHillConstructionBIMSmartMarketReportDecember2008.pdf

the stakeholders. Research envisions BIM data as an input to BMS to complete life-cycle management of a building.

The emergence of cloud and high performance computing power, web services, and service-oriented architecture, with new industry standards, will help the field to realize scalable, cross-disciplinary design and workflow. A common cloud or high performance computing-based platform aims to lower the total cost of ownership of software and hardware. This approach allows for plug-and-play assembly of individual tools for different tasks and provides an interoperable data exchange and simulation infrastructure. This approach will enable rapid analysis and robust optimization of building design, construction and operation in the presence of uncertainty.

On 24 August 2010, the US Department of Energy awarded up to US$122 million funding over 5 years for the “Energy Innovation Hub.” They stated the initiative will “bring together leading researchers from academia, two US National Laboratories and the private sector in an ambitious effort to develop energy efficient building designs that will save energy, cut pollution, and position the United States as a leader in this industry.”[10]

The Energy Innovation Hub is led by The Pennsylvania State University and is at the Philadelphia Navy Yard Clean Energy Campus, which will function as a living lab. It is the core investment in the Greater Philadelphia Innovation Cluster (GPIC), a public-private consortium that also addresses economic and workforce development. IBM is playing a leadership role in the Energy Innovation Hub in the area of integrated design processes and computational tools.[11]

Implementing an efficient building solution through an IBM alliance

IBM and Johnson Controls formed an alliance around Smarter Buildings and green data centers in March 2010. The objective was to provide an end-to-end preintegrated software and services solution that initially focuses on IBM facilities in Rochester, MN, and Armonk, NY. The following goals were defined to reach this objective:

- Reduce energy costs.
- Reduce operational costs.
- Account for and manage carbon emissions.
- Improve space utilization.
- Enhance physical and IT security.

Building data was used to perform energy analytics to identify abnormal operating conditions. These alerts drive corrective and preventive actions, including automatically creating work orders on high priority alerts. These alerts can be prioritized, duplication of requests can be eliminated, and root-cause analysis can be performed. An executive-level, enterprise-wide, strategic dashboard enables management to monitor building performance and prioritize investments and actions.

The implementation scope for the facilities is to better manage the building infrastructure for energy-efficiency, operationally efficiency, and space-efficiency. IBM worked closely with Johnson Controls at these facilities to provide a combined solution. IBM expects to see reductions in both energy and operational costs for both facilities.

[10] “Penn State to Lead Philadelphia-Based Team that will Pioneer New Energy-Efficient Building Designs,” US Department of Energy press release from 24 August 2010 at: http://www.energy.gov/news/9380.htm

[11] Energy Innovation Hub - Greater Philadelphia Innovation Cluster (GPIC) for Energy-Efficient Buildings at http://gpichub.org

The strategic view is divided into the major domains of space, energy and operations:

- The Space domain view shows the following information:
  - The Space cost window shows the breakdown of costs and the targets for the costs.
  - The Space utilization window shows the utilization of buildings in the region and the target utilization.
  - The Square footage window shows the percentage breakdown of the separate types of space configurations.
- The Energy domain view (Figure 7) shows the following information:
  - The Energy cost window shows the cost breakdown for the last six months and a comparison with the previous year.
  - The Energy conservation window shows the energy savings that are realized by the conservation efforts in a comparison with the previous year.
  - The Energy consumption window shows the breakdown of energy consumption compared to the previous year.

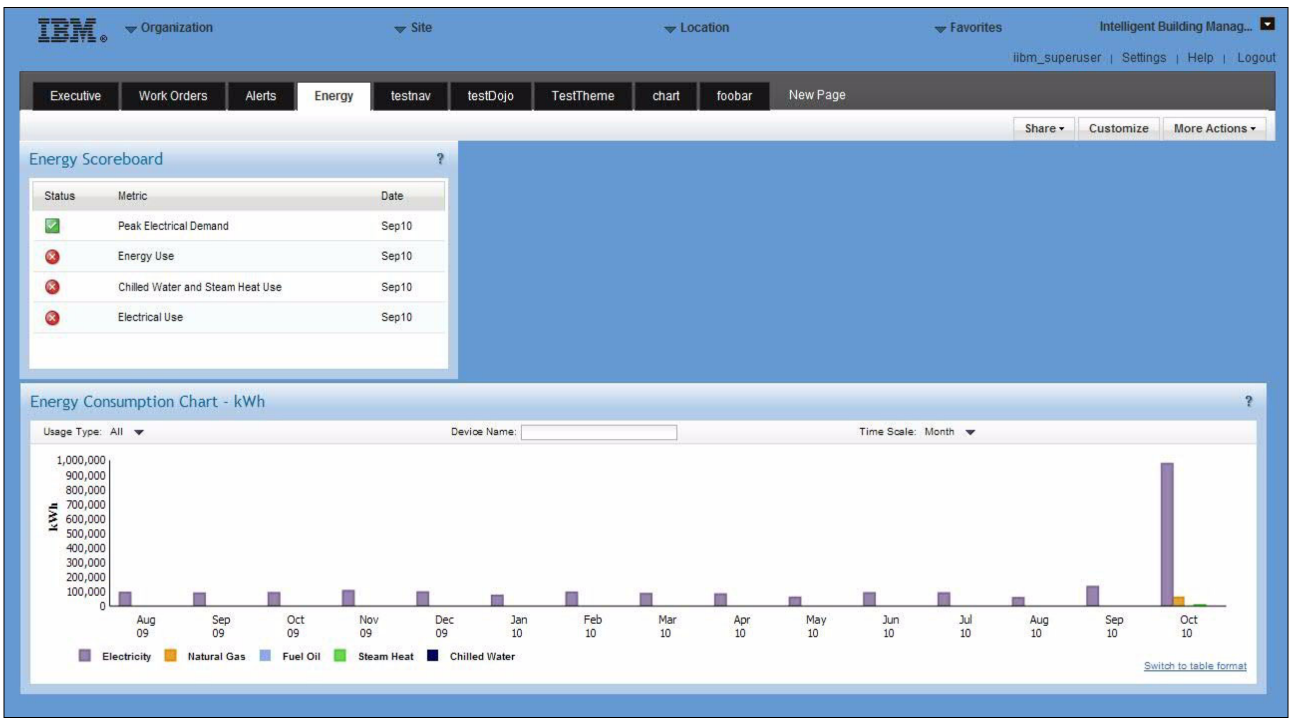

Figure 7 Energy view

- The Operations domain view shows the following information:
  - The Operations cost window shows the breakdown of the costs for the last three years.
  - The Work Orders analysis window (Figure 8) shows the comparison between reactive and preventive work orders.
  - The Facilities management supplier performance window shows the progress of the vendors' performance with respect to the SLAs that they committed.

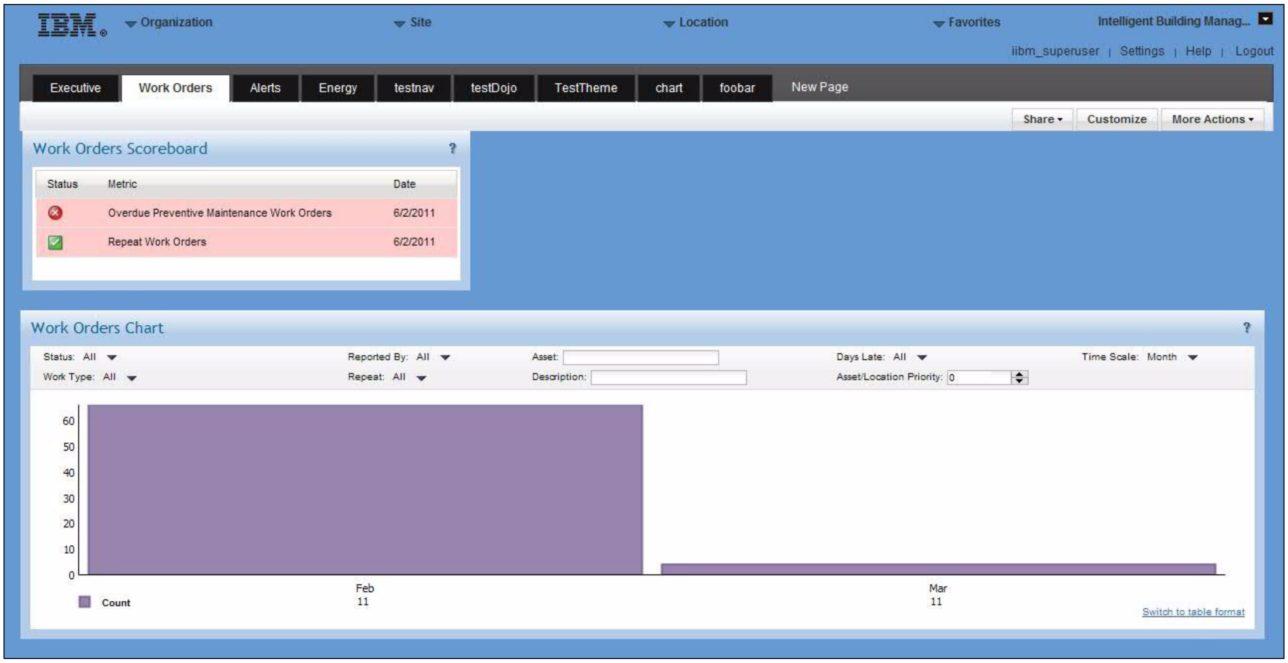

Figure 8 Work order view

A role-based dashboard supports key roles including executive, energy manager, facilities manager, and facilities planner or technician:

- The Executive view (Figure 9 on page 29) shows key data that relates to monitoring the performance of the site or building, including energy costs and consumption, space utilization, and CO_2 emissions measurement.

  Many of the views provide an easy comparison with last year's data so that the executive can monitor trends. By using the geographical navigational links, the executive can quickly look at global and regional data and compare the performance of that site with other sites within the enterprise.

- The Energy manager view provides details about energy consumption by the separate commodities. The view can be filtered based on energy type, asset, or building or be sorted by separate columns.
- The Facility operations view provides details about service requests for a site. The view can be filtered based on source, type, building or asset, and the data can be sorted by the various columns. The facilities planner can also view the details of a service request.
- The Facility planner or technician work orders view provides details about work orders that have been opened for a location. Filtering of the view is based on source, type, priority, building or asset. Work order details can also be viewed.

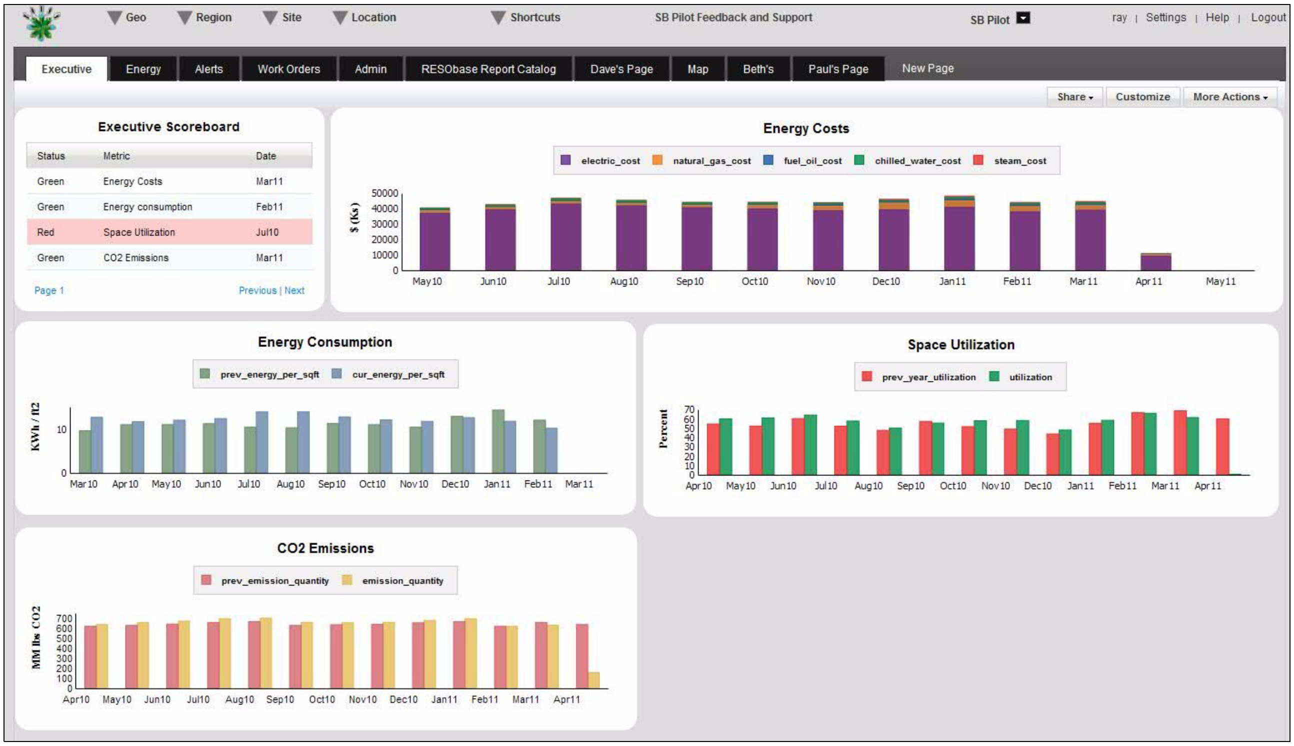

Figure 9   Executive view

For more details about this solution, see the case study "IBM's headquarters showcases solutions for Smarter Buildings: Improves efficiency and reduces energy costs in an already energy efficient building" at:

http://www.ibm.com/software/success/cssdb.nsf/CS/LWIS-8FFUP4?OpenDocument&Site=default&cty=en_us

Summary

IBM Smarter Buildings is all about the following concepts:

- Holistic energy management that enhances the efficiency of buildings and other assets
- Solving building systems shortcomings with the most appropriate, effective and energy-efficient approaches
- Integration of energy and asset management to lower operating costs

This guide provided an overview of IBM Smarter Buildings and Smarter Buildings solutions. This guide highlighted the high-level architectural elements of the IBM Intelligent Building Management solution and provided information the layers and components of that architecture. This guide provided insight into key Smarter Buildings solution areas such as the following areas:

- Smarter Building monitoring and efficiency
- Energy-efficient data centers
- Integrated communication services
- Facilities asset management
- Connections to external systems

Each solution includes a high-level architecture and the capabilities of the solution. Also, this guide included a case study on the energy-efficiency improvements at two pilot IBM sites.

The team who wrote this guide

This paper was produced by a team of specialists from around the world working for the International Technical Support Organization (ITSO).

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Thanks to the following people for their contributions to this project:

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