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State of the Art of Building Energy Management Systems: An Assessment

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Technical Update, December 2012

EPRI Project Manager

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ABSTRACT

This technical update report addresses the need in the electric utility industry for current information on building energy management systems (BEMS). Utility technical and program staff require current information for the BEMS industry, which is characterized as dynamic and as having constantly changing participants, technologies, and products. The aim of this technical update report is to present objective, current information on BEMS and to offer a basis for future updates. Utility technical and program staff can use this report to understand current market participants and products to make informed decisions for their companies.

An energy management system controls energy use within a building and can organize demand response participation, control distributed generation, manage electric vehicle charging and storage, and interface with retail electricity markets. A BEMS consists of hardware that is available commercially and that contains minimal controls strategies when purchased from the supplier. Typically, manufacturers supplement the hardware with software that is used to establish basic control strategies according to occupancy hours. The basic control strategies include scheduling of lighting, heating, ventilation, and cooling. A BEMS can store energy consumption data over time to allow review and benchmarking for improving energy use.

The technical update presents a representative sample of current suppliers of BEMS, software and component technology for BEMS, and organizations involved in infrastructure development; it also points to future research activities.

Keywords
Building energy management systems (BEMS)
Commercial buildings
Demand response (DR)
Energy management systems (EMS)
Intelligent buildings

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1
INTRODUCTION

This technical update addresses the need in the electric utility industry for current information on building energy management systems (BEMS or BMS). The utility industry need arises from technical and program staff requiring current information for the BEMS industry, which is characterized as dynamic and as having constantly changing participants, technologies, and products. The aim of this technical update is to present objective current information on BEMS and to offer a basis for future updates. Utility technical and program staff can use this update to understand current market participants and products in order to make informed decisions for their companies.

An energy management system (EMS) controls energy use within a building, and may organize demand response participation, control distributed generation, electric vehicle charging and storage, and interface with retail electricity markets [1]. A BEMS is hardware that is available commercially and which contains minimal controls strategies when purchased from the supplier. Typically, manufacturers supplement the hardware with software which is used to establish basic control strategies according to occupancy hours. The basic control strategies include scheduling of lighting or heating, ventilation, and cooling. A BEMS can store energy consumption data over time to allow review and benchmarking for improving energy use.

Figure 1-1 illustrates how a BEMS can relate to Software as a Service (SaaS), Smart Devices, Building Controls Systems, and Grid Integration. A BEMS can be connected to a building's smart devices such as thermostats, appliances, and electric vehicle charging. A BEMS's functionality is also frequently augmented through a building control system that provides additional features such as fire and security alarms and audio visual (A/V) surveillance. In addition, a BEMS can integrate to the electricity grid to receive information on the condition of the grid and to provide information on a building's energy use.

SaaS is a software delivery model that is experiencing a fast growth in sales. With SaaS, software and associated data are centrally and remotely hosted in the internet cloud. It is generally priced as a monthly or annual subscription fee and provides the potential to reduce information technology (IT) support costs by outsourcing hardware and software maintenance and support to the SaaS provider. SaaS solutions rely predominantly on the Web, require only an internet browser to use, and normally utilize a multi-tenant architecture in which the application serves multiple businesses and users.

Smart Devices include sensors and meters that optimize energy consumption and allow for demand response at the end-use level. As mentioned above, Smart Devices include thermostats, appliances, and electric vehicle charging.

Building Controls Systems provide services that have monitoring capabilities which include fire, smoke, carbon monoxide, carbon dioxide, refrigerant leak, and security risks.

Grid integration refers to the integration and inclusion of distributed energy resources into the distribution grid with the goal of improving the operation of the electricity grid. Full grid

integration occurs when technologies and programs such as demand response (DR) and other Distributed Energy Resources (DER) are included into a real-time decision-making process and the complete activities of distribution management [2].

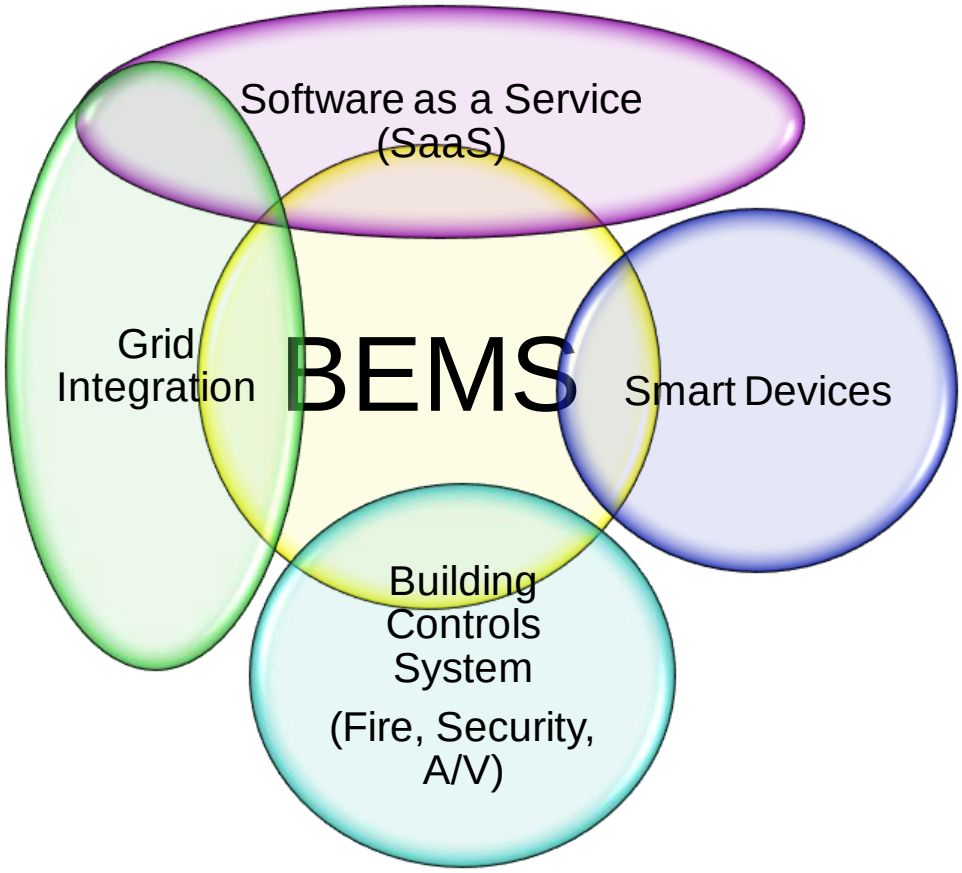


Figure 1-1
Diagram of building EMS relation to Software-as-a-Service, smart devices, building controls systems, and grid integration

In this technical update, Chapter 2 provides current information on energy management systems, and supporting communication protocols. Chapter 3 reviews the application of building energy management systems. Chapter 4 provides a listing and description of current suppliers of building automation, energy management, and demand response solutions. Chapter 5 reviews current suppliers of supporting software and technology. Chapter 6 lists organizations that are involved in infrastructure development and also lists industry alliances. Chapter 7 provides conclusions and recommendations for further studies.

2
BACKGROUND

This chapter provides information and description of the architecture of a building energy management system (BEMS) and how its architecture can be modified by Software as a Service (SaaS), and how it may achieve grid integration.

This chapter also contains information on the prevalent alliances and associations that support building protocols and standards.

Description of a BEMS

A building energy management system, or BEMS, monitors and controls energy consumption in a building for comfort, convenience, security, safety, and energy conservation [3].As described in Chapter 1, a BEMS is hardware that when purchased contains minimal controls strategies. Typically, manufacturers supplement the hardware with software that is used to establish basic control strategies such as turning end-use devices on and off, setting lighting schedules, adjusting the temperature and timing settings of HVAC systems according to occupancy schedules, adjusting the setting of boilers and fire sprinkler systems, checking the operational status of smoke detectors, fire alarms, and surveillance systems, etc. In addition, there are software vendors who specialize in energy efficiency and demand response software overlays that enhance the functionality of a BEMS through a Graphical User Interface (GUI) workstation. A BEMS can store energy consumption data for periods of time that are long enough to provide a benchmark for optimizing energy usage.

Figure 2-1 depicts a building and its BEMS architecture. The building's end-use loads are illustrated with air conditioning and thermostats, lighting, and elevators. Its controls are illustrated for access, security, and fire. The BEMS' communication with the end-uses and controls is represented by the green arrows. The communication between the thermostats and the air conditioning unit is represented by the blue lines In addition, the BEMS is connected to the GUI to allow building managers to interact with and manage their building. This connection is represented by the turquoise arrows. Finally, the BEMS' the communication to the electricity grid is shown as being achieved via a computer server.

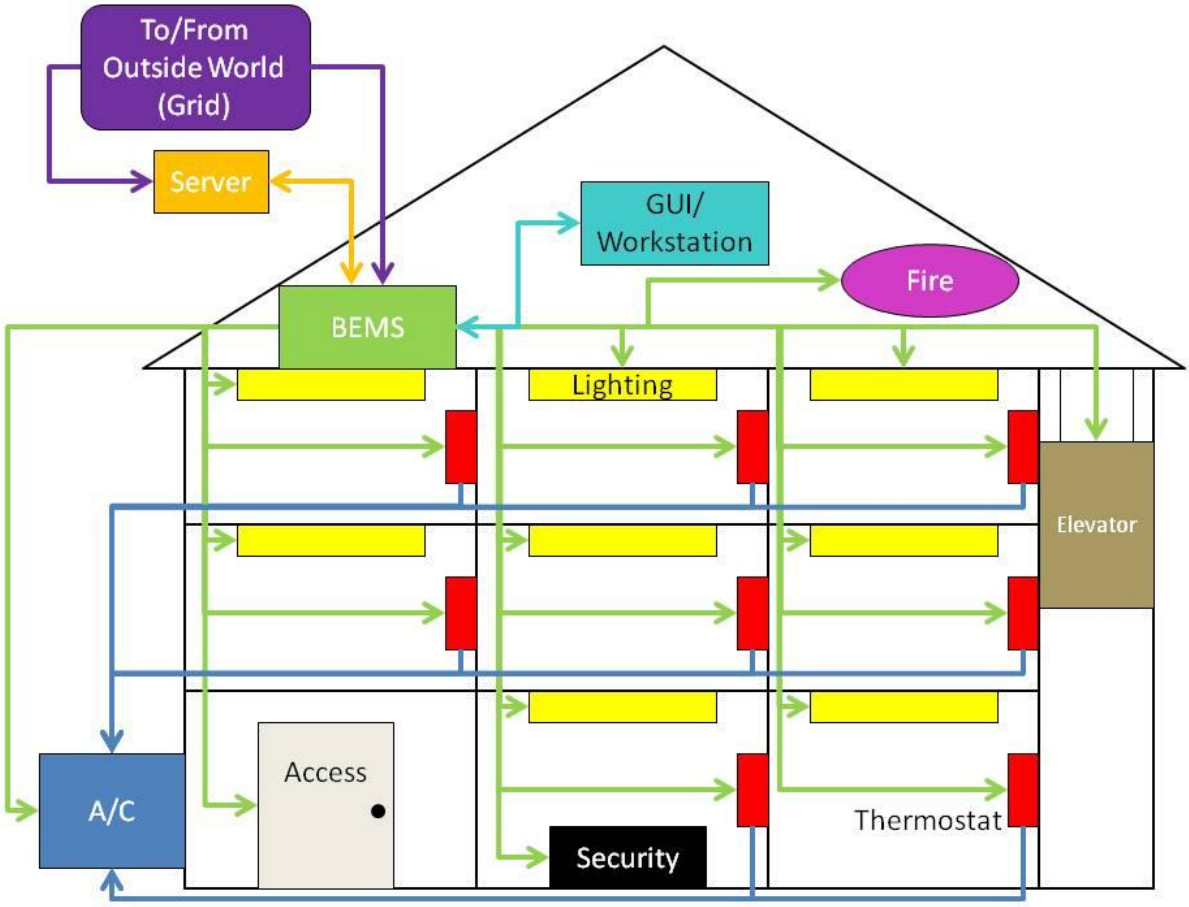


Figure 2-1
Building EMS (BEMS) architecture

When a building achieves grid integration, it is able to receive information on the condition of the grid and to provide information on its energy use in response to grid conditions. An example of grid integration is the two-way communication through Open Automated Demand Response (OpenADR), so that a building may change its electric usage from its normal consumption in response to changes in the price of electricity over time, or to incentive payments designed to induce lower electricity use at times of high wholesale market prices, or when system reliability is jeopardized [4, 5].

As described in Chapter 1, a BEMS can be enhanced with SaaS. This allows software and associated data to be centrally and remotely hosted in the internet cloud. This is shown in Figure 2-2. The EPRI report *Standard Interfaces for Smart Building Integration: A State of the Industry Update* (1026509) contains an assessment of utility-to-building and intra-building communication interfaces [6].

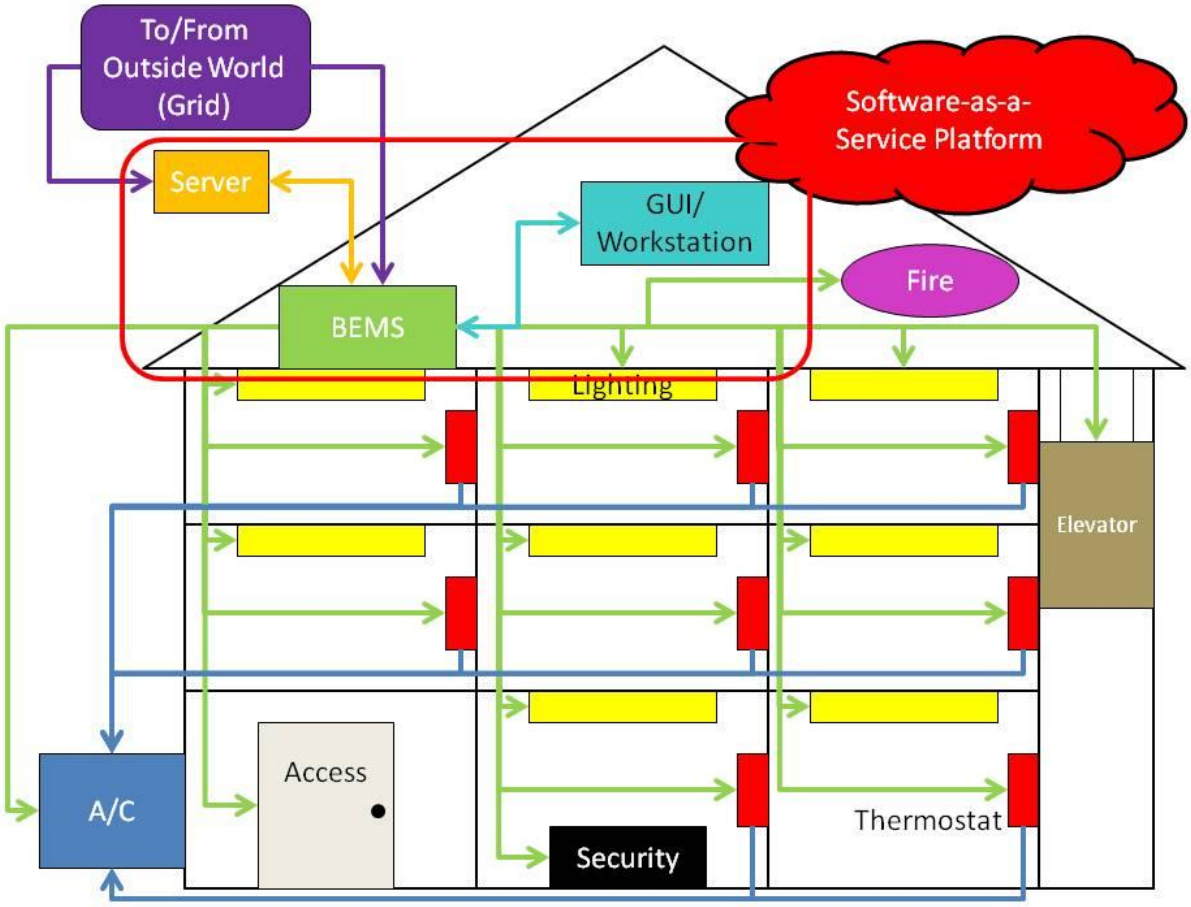


Figure 2-2
Building EMS (BEMS) architecture including Software-as-a-Service platform

Protocols and Standards

This section provides information on prevalent protocols, their standards, communication types, and resources on alliances and associations that support the protocols. Numerous protocols and standards are currently in use in the building sector for BEMS to manage end uses. Some protocols are based on open standards (e.g., BACNet, OpenADR), and others are based on semi-proprietary or proprietary standards (e.g., LonWorks, Modbus, ZigBee). The information is summarized in Table 2-1.

For a discussion of the history of protocols and automation and control protocols, see the EPRI report *Automation and Control Protocols in Residential and Commercial Buildings: A Scoping Study Leading to the Development of Open Standards Based Communications* (1016113) [3].

Table 2-1
Energy Management System Protocols

Protocol	Standards	Communication	Purpose	External Resources
BACNet	ASHRAE/ANSI Standard 135 ISO 16484-5	TCP/IP Ethernet ARCNET EIA-485 EIA-232	Standardize communications between building automation devices from different manufacturers, allowing data to be shared and equipment to work together easily.	BACNet International http://www.bacnetinternational.org/ ASHRAE SSPC 135 http://www.bacnet.org/
KNX	EN-ISO 14543 KNX	Twisted pair Wireless	Develop and promote KNX as the worldwide standard for home and building control. Oriented towards the development and promotion of an international communication standard for home and building electronic systems.	KNX Association http://www.knx.org/
LonWorks	ANSI/CEA 709.1 ISO/IEC 14908-1,-2,-3,-4	TCP/IP Ethernet EIA-709.1 (twisted pair) Power line	Promote and advance the business of efficient and effective integration of open, multi-vendor control systems utilizing ISO/IEC 14908-1 and related standards	LonWorks http://www.echelon.com/technology/lonworks/ LonMark International http://www.lonmark.org/
Modbus	IEC 61784-2	TCP/IP Ethernet EIA-485	Drive adoption of Modbus communication protocol suite and evolution to address architectures for distributed automation systems across market segments; provide infrastructure for information about the protocols, their application and certification to simplify implementation and reduce costs.	The Modbus Organization http://www.modbus.org/
OpenADR	OpenADR v1.0 OpenADR v2.0a OpenADR v2.0b (proposed)	TCP/IP Ethernet	Facilitate reliable and cost-effective automation of both electricity price and system grid reliability signals for demand response.	OpenADR Alliance http://www.openadr.org/ Lawrence Berkeley National Laboratory Demand Response Research Center http://openadr.lbl.gov/
ZigBee	IEEE 802.15.4	Wireless mesh network	Promote ZigBee automation and control communication protocol.	ZigBee Alliance http://www.zigbee.org/

3
APPLICATION OF ENERGY MANAGEMENT SYSTEMS

The commercial sector constitutes the second largest consumption and sales group for electricity. The most recent figures from the DOE's Energy Information Administration show the sector's figures at 1,328 billion kWh and $135,926 billion from retail sales in 2011 [7]. The energy information is displayed in Figure 3-1, and the sales information is shown in Figure 3-2.

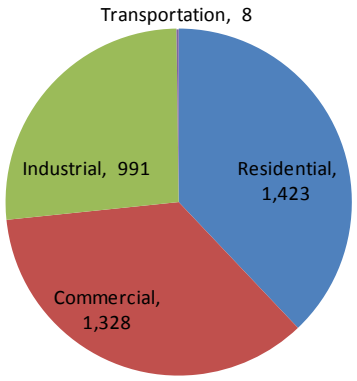


Figure 3-1
Retail sales of electricity to ultimate customers by sector (billion kWh), 2012

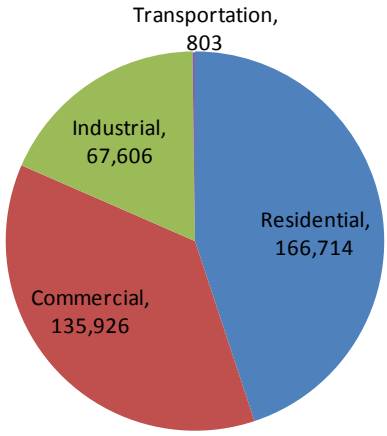


Figure 3-2
Retail sales of electricity to ultimate customers by sector (million $), 2012

The commercial sector has a sizable potential for optimizing energy consumption through Building Energy Management Systems (BEMS). This chapter discusses the various areas in which a BEMS can support optimization. These include energy efficiency, demand management, fault detection and diagnostics, occupant comfort, safety and security, and functioning of the grid.

Energy Efficiency

Implementation of energy efficiency measures reduces energy consumption and provides savings. BEMS provide solutions that can improve the efficiency of the building, whether the BEMS is part of a new building or part of a retrofit. Ways in which EMS improve efficiency include:

- Scheduling: Improved time of day scheduling paired with control algorithms can calculate the most effective time to start and stop systems like HVAC, which have pre- and post-cycles that consume energy. Scheduling allows these cycles to occur at off-peak times, but still in time to maintain the desired temperature during the business day.
- Occupancy control: Use of CO_2 and motion sensors to detect occupancy and turn off lighting and HVAC systems when a space is not in use.
- After-hours control: A BEMS can be programmed to minimize consumption when the building is not in full use, typically a period of time longer than the period of full use within 24 hours. HVAC and lighting represent the majority loads in a commercial building setting, neither of which needs to operate at full capacity when the building is unoccupied. Controlling these loads during unoccupied hours decreases a building's energy cost, and when paired with off-peak generation, such as wind power, can provide efficiency solutions.
- Daylight harvesting: Daylighting is a tangible, inexpensive way to reduce the use of electric lighting. This is most effective on the perimeter of the building, with the use of windows, but can also extend to spaces lit with skylights.
- Enhanced metering: Communicating panel-level or end-use sub-meters provide more precise data about energy consumption. This allows facilities managers to see the distribution of load across the different systems in the building.
- Energy information systems: Software systems can track real-time data obtained from sensors as well as sub-meters. They display this information in a user interface, or dashboard, to improve knowledge and awareness. As awareness increases, areas for improvement are elucidated and high consumption loads can be identified and targeted.
- Plug load control: Sensors and sub-meters can be used to shut off receptacles when spaces are not being used. For example, occupancy sensors can be connected to power strips to turn off sockets that supply power to office equipment after-hours. This will significantly decrease energy waste, as many devices draw a small amount of power even when turned off, a phenomenon known as phantom or vampire loads..

Demand Management

While a building should run as efficiently as is acceptable, there are certain circumstances when occupant comfort or building performance must be compromised to meet the needs of the grid. One such example is the emergency situation of curtailment, when a transmission line goes down or a power plant must shut down. A more common situation is peak demand, an observable phenomenon that occurs regularly as the total demand on the grid approaches its maximum supply. When these situations occur, Independent System Operators (ISOs) and utilities enter a demand response (DR) stage to alert consumers of the peak demand the grid is experiencing. With a BEMS, DR strategies can be programmed to proactively cut consumption. Furthermore, the OpenADR standard provides an automated protocol for engaging in 2-way communication

with commercial buildings to dispatch DR signals and receive feedback on demand reduction performance.

Fault Detection and Diagnostics (FDD)

There are several strategies to detect and diagnose faults, a problem that arises when buildings do not perform as well as anticipated during design [8] or whose performance degrades over time. When a system is running at subpar performance, it results in higher energy consumption as the system works harder to maintain the same status quo. A BEMS can provide data collection and analysis for fault detection and diagnostics and help achieve cost reductions.

FDD methods vary on what points to measure in a system, and on how to interpret measurements as distinct indication of particular faults [9]. The methods include direct measurement of temperature and pressures, electric power or vibration, and can identify faults based on operating history and signal patterns compared to nominal expectations. Some methods diagnose faults explicitly while others send alarm signals when there is a degradation of system performance. Each strategy has different cost effectiveness implications as well as technical energy savings.

FDD capabilities include detection of low airflow, sensor malfunction, non-functioning economizer, short cycling of compressor, excessive operating hours, performance degradation, unnecessary outdoor air, failed compressor, stuck damper, slipping belt, and leaking valves [9]. Furthermore, FDD can identify problems at the source pointing for example to a broken fan rather than an entire air-handling unit (AHU). Hence small, less expensive problems are detected early and addressed before they become bigger and costlier. Early detection helps facilities managers avoid expensive downtimes and permit them time to schedule maintenance during off hours.

Occupant Comfort Management

A BEMS allows the optimization of a building's comfort-related features. Examples include proper lighting, comfortable temperature, and adequate ventilation. Improved occupant comfort results in higher satisfaction and productivity. For a building manager, this means a reduction in complaint calls to the building operator. In addition, for tenant-occupied buildings, higher occupant comfort support prolongation of leases and can serve as a rental price differentiator.

Safety and Security

Similar to occupant comfort and as mentioned in Chapter 2, a BEMS allows for improved safety and security, through monitoring capabilities for fire, smoke, carbon monoxide, carbon dioxide, refrigerant leaks, and security risks. As with comfort, a healthier building environment that provides premium safety and security supports lease renewals and can serve a rental price differentiator.

Effect on the Electricity Grid

Through improved communication with the utility and the grid, a BEMS supports better communication of resources. Demand response provides the top example, as an adjustment in electricity usage that is coordinated with grid or market needs. DR can be induced through retail programs and rate structures. Retail contracts with DR provisions can enable customers to make informed and actionable choices about their electricity consumption and demand. The contracts

can incent them to modify their demand on the grid, particularly at critical times to support system reliability, reduce demand on critical assets, and improved cost-of-service economics [10].

Customers who implement BEMS that communicate to the grid are better equipped to respond to signals such as for Automated DR that could quickly and in automated fashion activate thermostat settings, dim lighting, or reduce power draw from pumps or appliances. Thus, electricity consumption and power demand on the grid would be modified during critical periods. Adjusting demand in this manner, when the power system is constrained or at risk of imbalance, can support the reliability and continuity of electric service and reduce service interruptions and their associated costs. Thus customers would be able to perform an active role in keeping the power system operating reliably. With sufficient penetration of BEMS that communicate with the utility and the grid, we can foresee improved alignment of retail and wholesale markets [11].

4
SUPPLIERS OF BUILDING ENERGY MANAGEMENT SYSTEMS

This chapter provides a representative sample of current suppliers of building energy management systems (BEMS). The suppliers offer contemporary capabilities and approaches to BEMS, energy management, and Demand Response (DR) solutions. The information includes incorporation of built-in control strategies, technology focus or strength, application of emerging technology, or industry-leading innovation. This chapter also provides a summary table that categorizes the building, communications, and grid integration capabilities of the suppliers that are featured.

The information listed in this chapter is derived from publicly-available, supplier-provided sources. Independent testing of the information provided by suppliers is beyond the scope of this EPRI technical update.

Supplier Profiles

This supplier list was compiled from a variety of sources. These sources include existing EPRI reports, paired with web research and supplier contact to ensure current information and to account for present-day product development. In addition, the technical expertise of several industry colleagues was employed for suggestions of new enterprises to consider. Finally, exhibitor lists of the 2012 and 2013 AHR Expos were cross-referenced to ensure that companies with large market share were included.

This chapter presents current information at the time of writing. It provides information on suppliers of BEMS that are currently active in the market. A summary of each supplier's focus, affiliations, product/system, and unique technologies or capabilities is listed and is followed by a brief description of the company. All information is derived from material made available by suppliers in their website.

Alerton

Focus:	Technology and software framework for connectivity and integration
Affiliations:	Acquired by Novar (Subsidiary of Honeywell)
Product/System:	Envision for BACtalk
Unique Technologies or Capabilities:	Open platform technology provider to Original Equipment Manufacturers (OEM) Compliant with ASHRAE's BACNet standard
Website:	http://www.alerton.com/

Alerton supplies OEMs with the platform needed to implement end-use devices in a commercial building setting. Because of the open architecture of the system, commercial buildings have the ability to choose end-use devices from different manufacturers, provided these devices are compatible with the BACNet standard communications protocol.

American Auto-Matrix

Focus:	HVAC controls systems Technology and software to support system
Affiliations:	Proprietary
Product/System:	AspectFT Matrix
Unique Technologies or Capabilities:	Supports BACNet and Modbus Integrated Graphical User Interface (GUI) Web-enabled Offers end-use product line of sensors and displays
Website:	http://www.aamatrix.com/aboutus.asp

American Auto-Matrix develops technology required by building EMS. Its control system communicates with the grid, and it has developed a comprehensive proprietary system. This includes software, HVAC controllers, sensors, and interfaces needed to implement a full management system. It also supports two major communications protocols for building managers to integrate other end-use devices.

Automated Logic Corporation

Focus:	Technology and software framework for connectivity and integration
Affiliations:	Subsidiary of Carrier
Product/System:	LGR Controller WebCTRL
Unique Technologies or Capabilities:	Technologically advanced and flexible platform for integration of building systems with strong support for mainstream IT practices Supports BACNet
Website:	http://www.automatedlogic.com/

Automated Logic has focused on the networking aspect of EMS. It manufactures hardware, such as routers with BACNet protocol, controllers for various purposes, and some basic sensors. It also provides software to support its own hardware. This web-enabled software includes programs to graphically display data from the automation system in a user-friendly fashion as well as to parse copious data into usable, manageable information.

Carrier

Focus:	Automated HVAC controls
Affiliations:	Proprietary
Product/System:	i-Vu Control System End-use HVAC product line
Unique Technologies or Capabilities:	Interoperable Compatible with BACNet
Website:	http://www.carrier.com/Carrier+Corporate+Sites/Corporate

With the recent rise in automated building systems, Carrier, an HVAC-focused corporation, has introduced its i-Vu Control System, which communicates with HVAC devices via BACNet protocol. Complete with plug-and-play controller, the system is scalable and flexible to meet the needs of a given building. The system is web-enabled for ease of use and can be integrated with lighting, security, and other building maintenance needs.

Convia

Focus:	Lighting and plug load controls as an integral part of the office environment, with emphasis on energy management
Affiliations:	Subsidiary of Herman Miller; Merged with Wiremold (Subsidiary of Ingersoll Rand)
Product/System:	Convia-enabled Wiremold (CEW) System
Unique Technologies or Capabilities:	Plug-and-play model for system flexibility Dynamic Load Balancing software for reduction of peak demand and compliance with DR programs
Website:	http://tools.wiremold.com/convia/

Convia approaches energy management from a unique perspective, having originated as part of Herman Miller, a supplier of furniture and fixtures for office, healthcare, education, government, and home settings. Convia provides control of lighting and plug loads and includes built-in sub-metering. The Convia architecture includes an integrated solution for DR.

Delta Controls

Focus:	Controllers for lighting, access, and HVAC
Affiliations:	Proprietary
Product/System:	Earthright Energy Management System
Unique Technologies or Capabilities:	Open architecture system Compliant with BACNet ISO 9001:2008 registered Compatible with OEM end-use products
Website:	http://www.deltacontrols.com/

Delta Controls offers service that spans system management to the end-use sensors and displays with which building occupants interact. It offers compliance with established protocols such as BACNet, making its systems interoperable with other systems. Delta Controls has diversified to include controllers for HVAC, lighting, and access devices, making it possible to manage a substantial amount of a building's loads through its products.

Distech Controls

Focus:	Building automation hardware
Affiliations:	Proprietary
Product/System:	EC-Net
Unique Technologies or Capabilities:	Interoperable ISO 9001
Website:	http://www.distech-controls.com/index.html

Distech Controls provides a grid-to-plug architecture for an energy management system. It provides wireless room devices, like thermostats, while also partnering with other product manufacturers supplying the peripheral products necessary for integration. The EC-Net management system supports protocols such as BACNet and LonWorks, and combines various standard building functions, like HVAC, lighting, and safety.

Echelon

Focus:	Technology and software framework for connectivity and integration Monitoring controls
Affiliations:	Proprietary
Product/System:	SmartServer 2.0 LonWorks communication protocol Networked Energy Services (NES) open metering infrastructure
Unique Technologies or Capabilities:	Renewable resources integration Interoperable
Website:	http://www.echelon.com/

Echelon is best known for the LonWorks platform. It also manufactures technology for metering within a building as well as software to utilize the data collected by the meters. It currently provides the network infrastructure for the world's largest Advanced Metering Infrastructure (AMI) comprised of over 27 million networked meters. Echelon outsources unitary controllers and edge devices from OEMs, and the interoperability of its routers permits options and combinations for building controls.

Emerson Climate Technologies

Focus:	Management systems, controllers, and components for HVAC
Affiliations:	Subsidiary of Emerson Electric Company
Product/System:	E2 Facility Management System
Unique Technologies or Capabilities:	Compatible with LonWorks, BACNet, and Modbus
Website:	http://www.emersonclimate.com/en-US/pages/default.aspx

Emerson Climate Technologies is a business segment of Emerson Electric Company, a supplier of power equipment. It is a worldwide supplier of HVAC equipment for residential, commercial, and industrial buildings. It has developed a building management system, the E2 BX Control System, which is capable of managing HVAC and lighting to optimize efficiency. Its open architecture is compatible with various protocols and can be interoperated with other suppliers' peripheral controllers and devices.

EnerNOC

Focus:	DR services offering performance-based incentives
Affiliations:	Proprietary
Product/System:	EnerNOC Site Server
Unique Technologies or Capabilities:	Communicates with EnerNOC's Network Operations Center (NOC) which in turn receives and communicates demand response information
Website:	http://www.enernoc.com/

EnerNOC supplies DR services, with more than 8,000 MW participating in its DR programs. DR solutions range from completely manual to automated. EnerNOC has also partnered with many utility companies to help control demand to meet supply. EnerNOC uses an in-house monitoring center to dispatch DR events from utilities and monitor demand reduction performance on the consumer side. Connection to the NOC involves integration of the EnerNOC Site Server into the BEMS.

Honeywell Building Solutions

Focus:	Integration of HVAC, lighting, and security management controls systems
Affiliations:	Subsidiary of Honeywell
Product/System:	Enterprise Buildings Integrator
Unique Technologies or Capabilities:	Supported by Tridium's NiagaraAX open framework Interoperable
Website:	https://buildingsolutions.honeywell.com/Cultures/en-US/

Honeywell Building Solutions is a subdivision of Honeywell International Inc. for providing commercial buildings with solutions to energy management. It supplies software for automation of HVAC, lighting, and security controls systems, which can replace individual systems for the above loads. This incorporation of automation aims to facilitate communication among the various building operations to increase efficiency and energy savings.

IPKeys Technologies

Focus:	Smart Grid communications and standards-based technology and software integration
Affiliations:	Proprietary
Product/System:	Energy Interop Server and System (EISS)
Unique Technologies or Capabilities:	OpenADR 2.0a compliant Interoperable Renewable resources integration
Website:	http://ipkeys.com/

The IPKeys technology is based on the OASIS Energy Interop and the OpenADR 2.0 standards, which are aimed at moving the industry toward a fully automated Smart Grid. The EISS gathers information on locational marginal price and dispatches DR reduction performance. It establishes 2-way is capable of implementing controls strategies, and its primary function is translating price signals into controls strategies. A separate building controller needs to be installed under the EISS box to distribute the commands throughout the building's systems.

Johnson Controls Inc.

Focus:	Building management systems Peripheral HVAC controllers and devices
Affiliations:	Proprietary
Product/System:	Metasys® Facility Explorer Energy Control System
Unique Technologies or Capabilities:	Wireless-enabled BACNet interoperable
Website:	http://www.johnsoncontrols.com/content/us/en.html

Johnson Controls Inc. (JCI) is a Fortune 100 company that manufactures auto parts as well as controls systems for commercial buildings and their HVAC systems. Metasys®, and Facility Explorer Energy Control System, its EMS products, integrate established systems within a commercial building (HVAC, lighting, fire, security, etc.) to decrease energy consumption. In addition, Johnson has edge systems for HVAC and security. Blue Ridge Technologies (please see Chapter 5) has been a supplier of lighting control systems to JCI.

Precision Edge Access Control

Focus:	Integration of security into building management systems
Affiliations:	Proprietary (Formerly Novus Edge)
Product/System:	EdgeProtect (EdgeConnector & eEdgeManager)
Unique Technologies or Capabilities:	Can be added onto pre-existing control systems Elevator controls IP-based communication with web-enabled software
Website:	http://www.precisionedgeaccess.com/

Precision Edge Access Control illustrates the application of a commercial energy management system to HVAC and lighting, security, fire, and other building needs. This integration allows other building functions to react as a result of the status of doors and windows throughout the building. For example, if the system detects an increase in open doors and windows, it realizes that continued air-conditioning will prove ineffective and decreases load accordingly. The implications for the future are extensive not only in terms of safety, but also cost-efficiency and load management.

Powerit Solutions

Focus:	Supervisory energy management and control systems
Affiliations:	Proprietary
Product/System:	Spara Energy Management System
Unique Technologies or Capabilities:	Wireless connectivity OpenADR compliant Supporting building management software
Website:	http://www.poweritsolutions.com/

Powerit Solutions focuses in EMS for industrial buildings. The Spara Energy Management System is capable of managing commercial loads and can be integrated with individual controls systems via Spara Konnekt, a wireless data communication technology. OpenADR certification allows its system to work with dynamic pricing. PowerIt's case studies describe electric load decreases over periods as long as five hours. Spara Konnekt EMS can predict fluctuations in plug loads and can control adjustable loads by cycling and shifting, to balance load. The Spara Konnekt EMS automates the process of balancing loads while allowing building managers to manually override the system.

Reliable Controls

Focus:	HVAC controllers and interfaces
Affiliations:	Proprietary
Product/System:	MACH-Pro Series
Unique Technologies or Capabilities:	BACNet compliant Integrated building controller, operator workstation, and web server that is BTL certified
Website:	http://www.reliablecontrols.com/

Reliable Controls provides interoperable HVAC controls systems for implementation in commercial buildings. Its main focus has been the development of open architecture systems based on the BACNet standard protocol. Its new MACH-Pro series, the new MACH-ProWeb series is web-enabled and has a built-in web server to store trending information. Reliable Controls worked with EnOcean Alliance (please see Chapter 5) to provide end-use interfaces for EnOcean's wireless energy-harvesting technology.

REGEN Energy

Focus:	Automated electrical demand management
Affiliations:	Proprietary
Product/System:	Swarm Energy Management System
Unique Technologies or Capabilities:	Wireless energy management solution for equipment that cycles on and off ZigBee wireless based on IEEE 802.15.4 OpenADR compliant
Website:	http://www.regenenergy.com/

REGEN Energy introduced swarm connectivity, a wireless technology, to the energy management system market. It shows potential as an automated DR solution, supports OpenADR standards, and can engage in 2-way communication with utilities. All REGEN Energy's peripheral components are wireless and communicate real-time data via a ZigBee Wireless Personal Area Network (WPAN). This enables a building to balance its net load, by monitoring how individual demands fluctuate over a given time interval. Case studies have described up to a 30% reduction in energy consumption during periods of peak demand.

Schneider Electric

Focus:	EMS for commercial buildings
Affiliations:	Proprietary
Product/System:	Andover Continuum TAC Vista
Unique Technologies or Capabilities:	Solutions for integrating HVAC, lighting, access, etc. Interoperable platforms
Website:	http://www.schneider-electric.com/site/home/index.cfm/ww/

Schneider Electric is an international manufacturer of electrical equipment. Its focus is energy management, and it has several commercial EMS that integrate the functions of the building for monitoring and control. The Andover Continuum energy management system is its most powerful processor, running on BACNet protocol to maintain interoperability. The system has its own controllers and software but is also compatible with third-party controllers, implementing LonWorks and Modbus via a special branch controller. The TAC Vista energy management system is scalable and operates via a LonWorks network. At the time of this writing, Schneider had recently announced a partnership with IPKeys, a maker of OpenADR devices for utilities and buildings.

Siemens Building Technologies

Focus:	Building automation systems and HVAC field devices
Affiliations:	Proprietary
Product/System:	APOGEE TALON
Unique Technologies or Capabilities:	Wireless capable Multiple communications protocol supported Comprehensive grid-to-plug system with BACnet Testing Laboratories BTL-certified peripheral controllers
Website:	http://www.buildingtechnologies.siemens.com/bt/global/en/pages/home.aspx

Siemens is a global supplier of integrated electronics for industrial purposes. Siemens Building Technologies, a subsidiary, focuses on building automation and controls for industrial and commercial buildings. Its solutions are described are as interoperable and scalable, and offering applicability for a variety of building types. The technologies of the unitary controllers, are presented as meeting the requirements for BACNet, LonTalk, and Modbus protocols. When installed in conjunction with Siemen's own Insight software, multiple EMS can be monitored and operated from a single, remote workstation.

Teletrol

Focus:	Building automation systems for HVAC and lighting
Affiliations:	Subsidiary of Philips
Product/System:	eBuilding
Unique Technologies or Capabilities:	BACNet compliant Internet-powered with software solutions
Website:	http://www.teletrol.com/

Teletrol, recently acquired by Philips, is a provider of building automation systems, incorporating HVAC and lighting controllers with internet-driven software to manage building functions. It supplies unitary controllers for functions such as thermostats for monitoring HVAC, actuators for variable air volume (VAV) purposes, and rooftop units for ventilation. Teletrol also offers various software applications for analyzing and manipulating real-time data and its products can be accessed, monitored, and controlled via internet.

Trane

Focus:	HVAC equipment
Affiliations:	Subsidiary of Ingersoll Rand
Product/System:	TRACER SC
Unique Technologies or Capabilities:	Several systems can be linked and controlled remotely to provide managers the ability to control an entire campus from one workstation
Website:	http://trane.com/Index.aspx

Trane specializes in HVAC equipment and also manufactures controls systems for its equipment. Trane's TRACER SC is a technology that integrates building components, like HVAC and lighting, and combines the controls for multiple buildings. This facilitates energy efficiency by balancing loads, allows for reduction of energy consumption, and facilitates Demand Response.

Trend Controls Systems

Focus:	Technology and software framework for EMS
Affiliations:	Subsidiary of Novar (Subsidiary of Honeywell)
Product/System:	IQ3xcite (IQ controller line) EnergySuite
Unique Technologies or Capabilities:	BACNet standard gateways and controllers Web-enabled, graphical interface displaying real-time information on the building's energy performance
Website:	http://ttc.trendcontrols.com/

Trend Controls Systems is a supplier of building energy management systems. It manufactures gateways, routers, controllers, sensors, and software applications to implement a comprehensive management system. The controls system components are compliant with BACNet and therefore can be introduced to established systems. EnergySuite, a software application, is meant to be displayed in high-traffic areas to promote energy consumption awareness in the workplace. This education, coupled with an intelligent management system, is intended to help buildings shave peak demand and balance their loads.

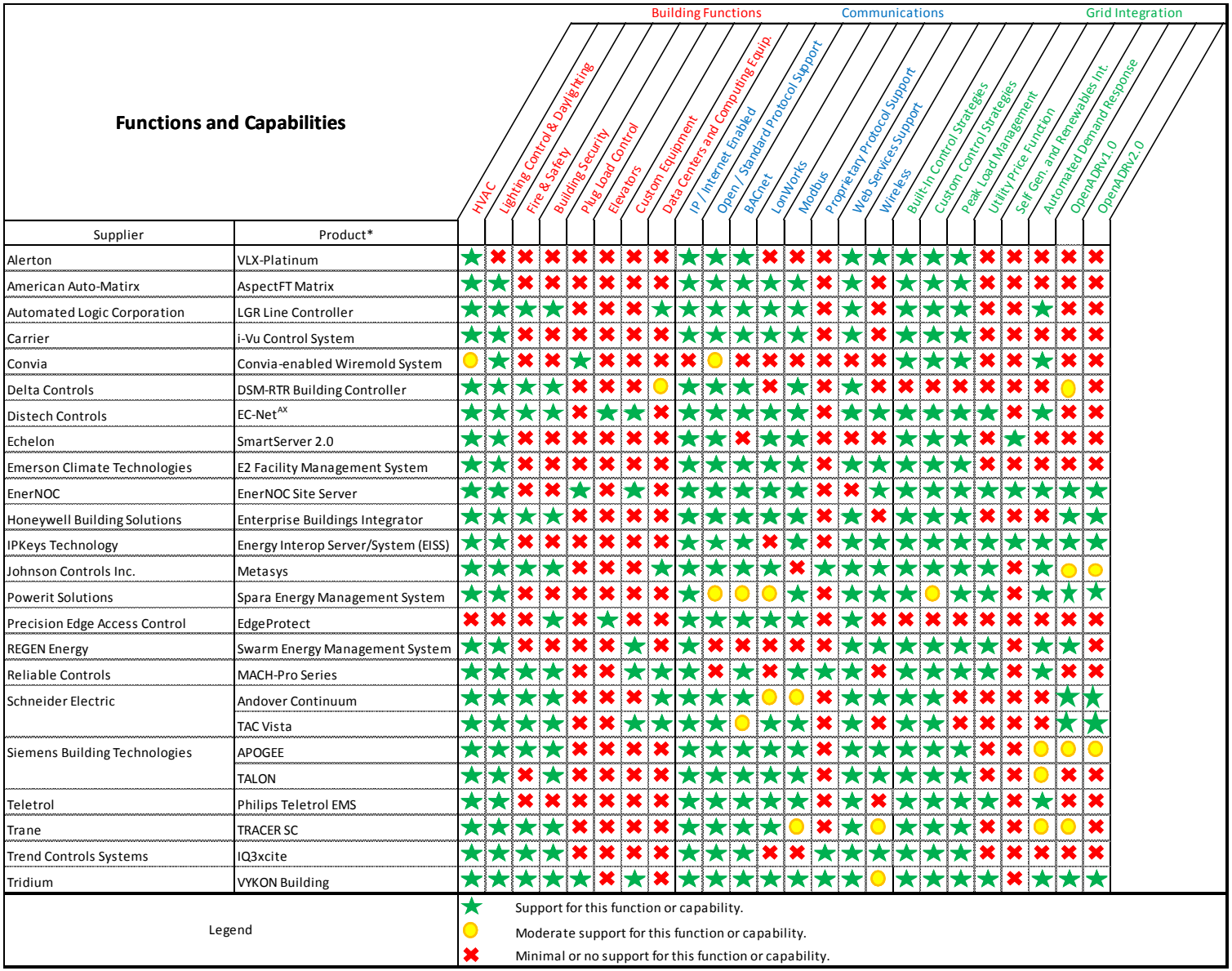
Tridium

Focus:	Technology and software framework for connectivity and integration
Affiliations:	Subsidiary of Honeywell
Product/System:	NiagaraAX VYKON Building
Unique Technologies or Capabilities:	Technologically advanced and flexible platform for integration of building systems with strong support for mainstream IT practices
Website:	http://www.tridium.com/

Tridium provides its NiagaraAX framework for a number of OEM adaptations with companies such as Honeywell, Distech Controls, Siemens, and Johnson Controls. In addition, Tridium's VYKON Building product line is distributed and supported by a network of independent system integrators and contractors. Tridium's technology is capable of supporting building control and DR solutions. Akuacom (please see Chapter 5), another Honeywell subsidiary, works with Tridium's framework and together offer support for Open Automated Demand Response (OpenADR), enabling 2-way communication with the grid.

Supplier Matrix

The matrix shown in Figure 4-1 summarizes the capabilities of the suppliers presented in the preceding section. The suppliers and products in the preceding section have been assessed for their current functions and capabilities in building functions, communications, and grid integration. Readers are reminded that the information in this chapter is sourced from supplier-provided brochures, product overviews, data sheets, and other secondary sources. Please note that this is not a product or supplier guide, with inclusion or omission having no implications about product stability or supplier qualifications.



* Product names refer to entire systems when marketed as such. Otherwise, product names reflect the network controller's model number.

Figure 4-1
Summary of energy management system suppliers

5 SUPPLIERS OF SUPPORTING SOFTWARE AND COMPONENT TECHNOLOGY

This chapter presents current information for suppliers of software and component technology for building energy management systems. In contrast to the suppliers of BEMS presented in the previous chapter, the firms listed below focus on providing software for BEMS or BEMS components.

The information listed in this chapter is derived from publicly-available, supplier-provided sources. Independent testing of the information provided by suppliers is beyond the scope of this EPRI technical update.

Akuacom

Focus:	Software vendor of DR messaging infrastructure
Affiliations:	Subsidiary of Honeywell
Product/System:	Akuacom DR Automation Server (DRAS)
Unique Technologies or Capabilities:	Technologically advanced and flexible platform for integration of building systems with strong support for mainstream IT practices Compliant with OpenADR
Website:	http://www.akuacom.com/

Akuacom provides a network structure for attaining high energy efficiency in a commercial building environment. Its open infrastructure facilitates communication between utilities and Independent System Operators (ISOs) and the Original Equipment Manufacturer (OEM) controllers and sensors necessary for Automated DR. Its web-based servers are able to consider dynamic pricing from utilities and ISOs while automating a building's energy management system.

AutoGrid

Focus:	Platform based on open standards
Affiliations:	Proprietary
Product/System:	Demand Response Optimization and Management System (DROMS)
Unique Technologies or Capabilities:	Lower-cost and lower-risk solution that expands user base for demand response and frequency of DR events\
Website:	http://www.auto-grid.com/

AutoGrid's demand management system utilizes standard protocols to communicate with other back-end systems, meters and sensors, across a wide variety of loads. A spinout from Stanford University, AutoGrid's business model is that of a purely software company. DROMS aims to reduce the cost of operating DR programs by eliminating up-front IT infrastructure costs, reducing end-point costs, and leveraging off-the-shelf communication technologies. Users receive up-to-date information on prices and real-time information.

Blue Ridge Technologies

Focus:	BEMS Components for lighting controls
Affiliations:	Formerly Lumisys
Product/System:	Lx5 Platform Lighting Tough Relays Zone Control
Unique Technologies or Capabilities:	A specialized lighting control product that enables DR for lighting systems Compliant with BACNet Can be integrated with other controls systems such as HVAC
Website:	http://www.brtint.com/index2.html

Blue Ridge Technologies manufactures lighting control systems to integrate with Metasys, the building management system from Johnson Controls Inc. Its products are designed to be integrated with pre-existing EMS already controlling HVAC loads. Its products show compliance with standards established by ASHRAE, IEEE, and IEC. Its product line contains lighting panels, relays, controllers, sensors, and switches for building management.

Danfoss

Focus:	HVAC controls
Affiliations:	Proprietary
Product/System:	Controllers for HVAC devices ADAP-KOOL evaporator controls End-use HVAC product line
Unique Technologies or Capabilities:	Valves, sensors, and controllers for heating, refrigeration, and air conditioning
Website:	http://www.danfoss.com/

Danfoss, an international corporation, has added automation capabilities to its product line of HVAC devices and it has introduced controllers for its end-use devices. Its case studies for its technologies such as ADAP-KOOL show reduced energy consumption and cost savings. Danfoss has systems that are compliant with LonWorks and BACNet.

KMC Controls

Focus:	Building control software and HVAC components (actuators and valves)
Affiliations:	Proprietary
Product/System:	FlexStat
Unique Technologies or Capabilities:	BACNet compliant Sensors for diverse functions
Website:	http://www.kmccontrols.com/

KMC Controls has been a supplier of parts to companies that include Schneider, Siemens, and Johnson Controls. Its FlexStat product combines the user interface controller with sensing capabilities. Examples include temperature controls with temperature and humidity sensing, air conditioning controls with occupancy sensing (via carbon dioxide and motion sensing), and smoke detectors with carbon monoxide sensing.

6
ORGANIZATIONS INVOLVED IN INFRASTRUCTURE DEVELOPMENT

This chapter includes information on associations, alliances, and research organizations whose focus has an effect on BEMS infrastructure.

Industry Alliances

EnOcean Alliance

EnOcean's product line focuses on two things: no batteries and no wires. The wireless features are similar to those of ZigBee and Z-Wave, following specifications of ISO/IEC 14543-3-10 which meets the requirements of IEEE 802.11 (WiFi), 802.15.1 (Bluetooth), and 802.15.4 (WPAN for ZigBee, RF4CE, etc.). The main difference in its application is that the sensor technologies exhibit energy harvesting functionalities that respond to changes in energy potential, such as light, heat, and motion, to power the devices.

National Electrical Manufacturers Association (NEMA)

NEMA was founded in 1926 and is the trade association of electrical equipment manufacturers. Headquartered near Washington D.C. in Arlington, Virginia, its member companies are manufacturers of products that that include power transmission and distribution equipment, lighting systems, factory automation and control systems, and medical diagnostic imaging systems. The products are used in utility, medical imaging, industrial, commercial, and residential applications.

NEMA publishes standards, application guides, white papers, and technical papers. Its Codes and Standards Committee reviews proposed standards, reports, or technical documents which represent NEMA positions when released. The positions aim to be in the best interest of the industry and users of products, and include safety, innovation, and interoperability.

ZigBee Alliance

ZigBee is a communication protocol that is compliant with IEEE 802, a standard for low-rate wireless personal area networks (LR-WPAN). It allows automated systems to communicate wirelessly with end-use devices such as HVAC sensors, fire detectors, lighting, and security systems. ZigBee has collaborated with BACNet to offer services with wireless capacities. ZigBee Alliance leads the development of the Smart Energy Profile (SEP) 2.0. The final public comment period has closed and development of SEP2.0 is close to completion. Please see Chapter 2 for information on the ZigBee protocol.

Z-Wave

Z-Wave is an alliance formed to manufacture household products with interactive control systems. It provides residences with the ability to remotely control systems such as HVAC, lighting, and security. Z-Wave uses radio frequency Wireless Personal Area Network (WPAN)

communication. All connected devices communicate with each other as well as a central controller. Its applications extend to small commercial settings.

National Lab Research

Lawrence Berkeley National Laboratory

The Lawrence Berkeley National Laboratory has done extensive research in the field of EMS and DR applications. To date, the lab has received upwards of $100 million in funding from the U.S. Department of Energy, in accordance with the American Recovery and Reinvestment Act (ARRA), for its energy research sector. Managed by the LBNL, the Demand Response Research Center, funded by the California Energy Commission's PIER program, has led integrated management systems and grid communications for nearly a decade. LBNL has worked closely with FERC, NIST's SGIP, and investor-owned utilities to develop OpenADR as a grid standard. By 2010, they implemented OpenADR v1.0, which served as a common language for advanced metering infrastructure (AMI) across the grid. LBNL continues to promote DR by providing solutions for EMS. In addition, it is performing case studies to educate building managers and contractors on the feasibility and benefits of implementing Automated DR systems, whether new or retrofitted. As standards have evolved, the lab has collaborated with the OpenADR Alliance to release OpenADR v2.0a, the active standard, with version 2.0b pending.

Pacific Northwest National Laboratory

Pacific Northwest National Laboratory's research includes making demand an active tool in grid management through its research in end-use efficiency and demand response. It also includes work to reduce pressure on the supply side and enable reliable grid management and reduced emissions. PNNL's Building and Energy Systems and Technologies group covers sustainable design and development, building systems and energy technology analysis, and carbon management. Examples of its current work includes FutureGen for performance measurement of sustainably designed buildings and ASHRAE guides for designing highly efficiency buildings. Its GridWise program focuses on developing information technology to modernize the U.S. electrical grid through communications architecture and standards, simulation and analysis tools, smart technologies, test beds and demonstration projects, and new regulatory, institutional, and market frameworks.

National Renewable Energy Laboratory

The National Renewable Energy Laboratory's focuses on renewable energy and energy efficiency research and development. Its recently inaugurated Energy Systems Integration Facility (ESIF) works on integrating renewable energy into the electrical grid. NREL's Buildings Research Program includes focus on improvements in residential and commercial buildings, building equipment and components, building energy analysis tools, and lighting and appliance standards. NREL's building research combines renewable energy with technologies aiming to reducing energy consumption in buildings.

Research Organizations

Several professional organizations support and advance research for BEMS. Table 6-1 provides a summary list of the organizations, describes their history, presents their purpose and scope, and lists their contact web site.

Table 6-1
Research Organizations Involved in Building Energy Management Systems

Name (Abbreviation)	Description	Purpose	Scope	Information
American Society of Heating, Refrigeration, and Air Conditioning Engineers Technical Committee 7.5 (ASHRAE TC 7.5)	• Merged with Technical Committee 7.4 (Exergy Analysis of Sustainable Buildings) in June 2008 • 4 subcommittees	• Develop and evaluate Intelligent Building Management Systems • Automated controls for dynamical systems, such as HVAC, lighting, and security can increase grid-building communication and increase cost-effectiveness of electricity	• Building operation dynamics • Fault detection and diagnostics • Wireless applications • Building/utility interface • Energy efficiency and sustainability	http://www.nist.gov/tc75/
American Society of Heating, Refrigeration, and Air Conditioning Engineers Standing Standard Project Committee 135 (ASHRAE SSPC 135)	• Incepted in June of 1987 • 13 subcommittees • As of May 24, 2012, 587 suppliers have sought BACNet Vendor IDs • BACNet also a standard ANSI and ISO protocol	• Maintain communications protocols for building automation and control network (BACNet) • Implement protocol across the grid	• Standardization of building management systems communication • Developing communications to integrate more controls systems	http://www.bacnet.org/
American Society of Heating, Refrigeration, and Air Conditioning Engineers Standard Project Committee 201 (Proposed) (ASHRAE SPC 201P)	• Proposed June 30, 2010 • Awaiting approval • 49 active members • Working in conjunction with ASHRAE TC 7.5	• Develop macro-models of the loads in the 3 major building sectors (residential, commercial, and industrial) • Assess how loads can be managed by automated systems and what the impact of these systems will be	• Model standardizes data transfer between control systems and end use devices • Provides the basis for consumers to manage, communicate, and forecast energy consumption	http://spc201.ashraepcs.org/
National Institute of Standards and Technology-Smart Grid Interoperability Panel (NIST-SGIP)	• Founded in Dec. 2009 • Currently close to 800 organizations are members • Of those, over 200 members have voting rights on the panel • Panel has 3 branches: governing board, standing committees, and working groups	• Promote industry collaboration to develop Smart Grid via Priority Action Plans (PAP) • Recognize standards, gaps in standards, and other technical issues that hinder the full implementation and efficiency of a Smart Grid	• PAP 09: DR/Distributed Energy Resources Systems – Construct model that guarantees support of load control, supply control, and environmental signals • PAP 19: Wholesale Demand Response Communications Protocol – Build profiles for ISO/RTOs to adequately address the evolving needs of a wholesale DR market	http://www.nist.gov/smartgrid/priority-actions.cfm http://collaborate.nist.gov/twiki-sggrid/bin/view/SmartGrid/WebHome

7
CONCLUSIONS AND RECOMMENDATIONS FOR FURTHER STUDY

Much has been achieved in the area of Building Energy Management Systems (BEMS), with a larger proportion of buildings expected to include automation systems.. This report notes that the BEMS industry is fast-changing in terms of technology, with frequent news of fresh partnerships.

This report also points to additional research activities. These include:

- Ongoing monitoring of the industry is necessary to maintain current information of the actors and the direction of technology. An online database is recommended for this monitoring.
- Active tracking and reporting on the advances promoted by research organizations and standards-setting bodies.
- Market research of the penetration, supplier market share, size and anticipated growth of the BEMS industry.
- Expansion of the industry review to further understand the BEMS activities and industries outside North America.
- Laboratory testing followed by field testing of selected BEMS products to fully comprehend capabilities and identify gaps.

8
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GLOSSARY

AHU	Air Handling Unit
ASHRAE	American Society of Heating, Refrigerating and Air-Conditioning Engineers
A/V	Audiovisual
AMI	Advanced Metering Infrastructure
BAS	Building Automation System
BEMS	Building Energy Management System
BMS	Building Energy Management System
CEC	California Energy Commission
CIM	Common Information Model
DER	Distributed Energy Resources
DR	Demand Response
DRAS	Demand Response Automation Server
EMS	Energy Management System
FERC	Federal Energy Regulatory Commission
FDD	Fault Detection and Diagnostics
GUI	Graphical User Interface
HVAC	Heating, Ventilating, and Air Conditioning
IEC	International Electrotechnical Commission
IEEE	Institute of Electrical and Electronics Engineers
ISO	Independent System Operator
IT	Information Technology
NIST	National Institute of Standards and Technology
OEM	Original Equipment Manufacturer
OpenADR	Open Automated Demand Response
PAP	Priority Action Plan

SGIP	Smart Grid Interoperability Panel
VAV	Variable Air Volume
WPAN	Wireless Personal Area Network
XML	Extensible Markup Language

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