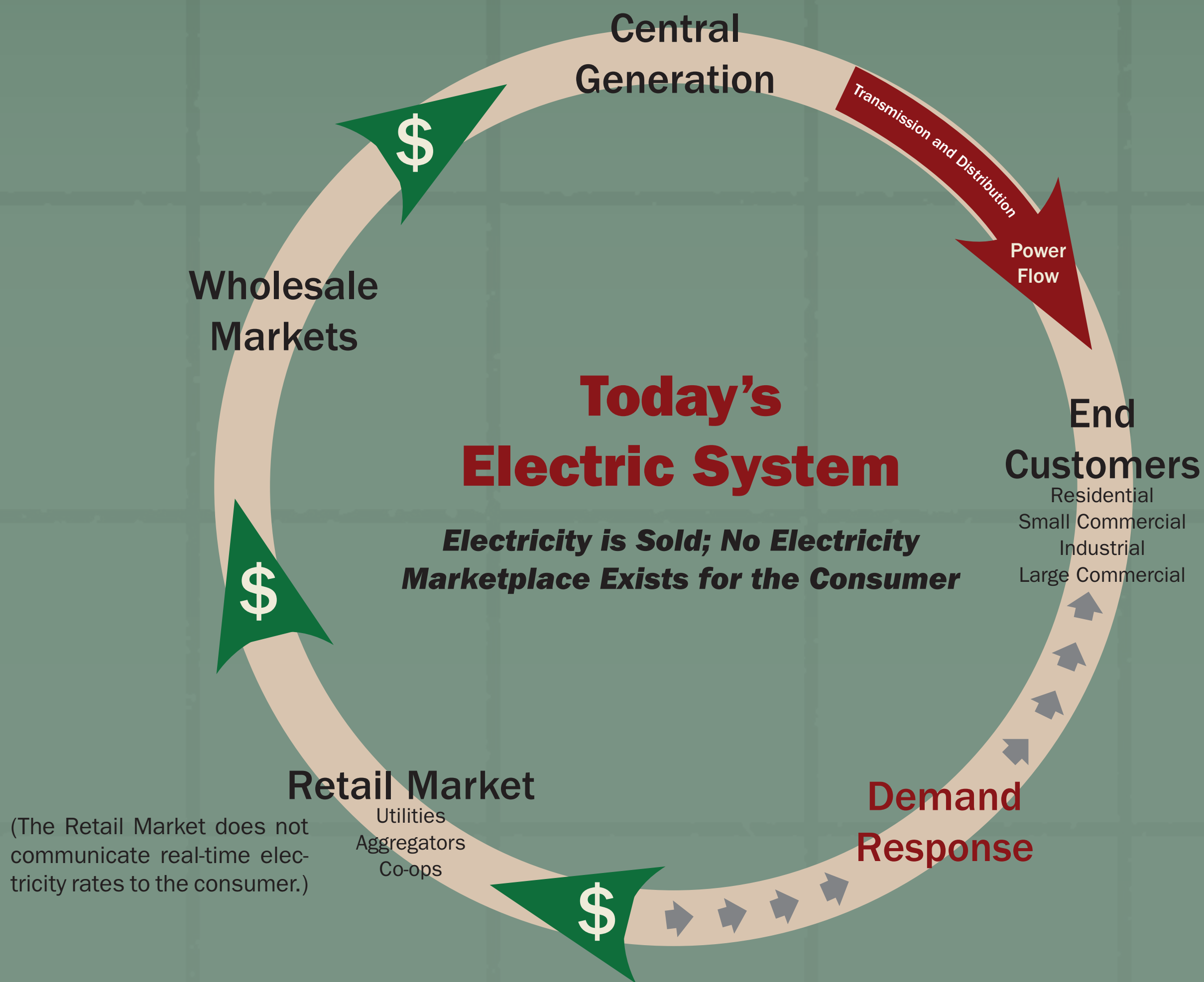

Figure 1: The electric system power and monetary flows today. Demand response signals communicate the need for customer load reduction during times of grid reliability events, and for consumers that have access to demand response programs.

BACnet® and the

By David G. Holmberg, Ph.D., Member ASHRAE; **Steven T. Bushby,** Fellow ASHRAE

Improved electric system control and reliability, integrated renewable energy and storage, and building control systems that adjust load, on-site generation, and storage automatically in response to changing grid conditions and electricity prices are all parts of a future smart grid. A smart grid is not simply more efficient operation of the current electricity system; it is a significant transformation of the electricity system as we know it.

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Dynamic electricity prices and the ability for customers and the utility to communicate and respond in real time are the keys to transforming the electricity system. These features will produce an environment that encourages developing technology to enable facilities to benefit from active load management including load shedding and shifting, energy storage, and on-site generation. This demand-side responsiveness (elasticity) then provides tremendous flexibility for grid operation, enabling buildings to absorb fluctuations due to intermittent renewable generation. Finally, renewables and other local generation capacity transform the grid from

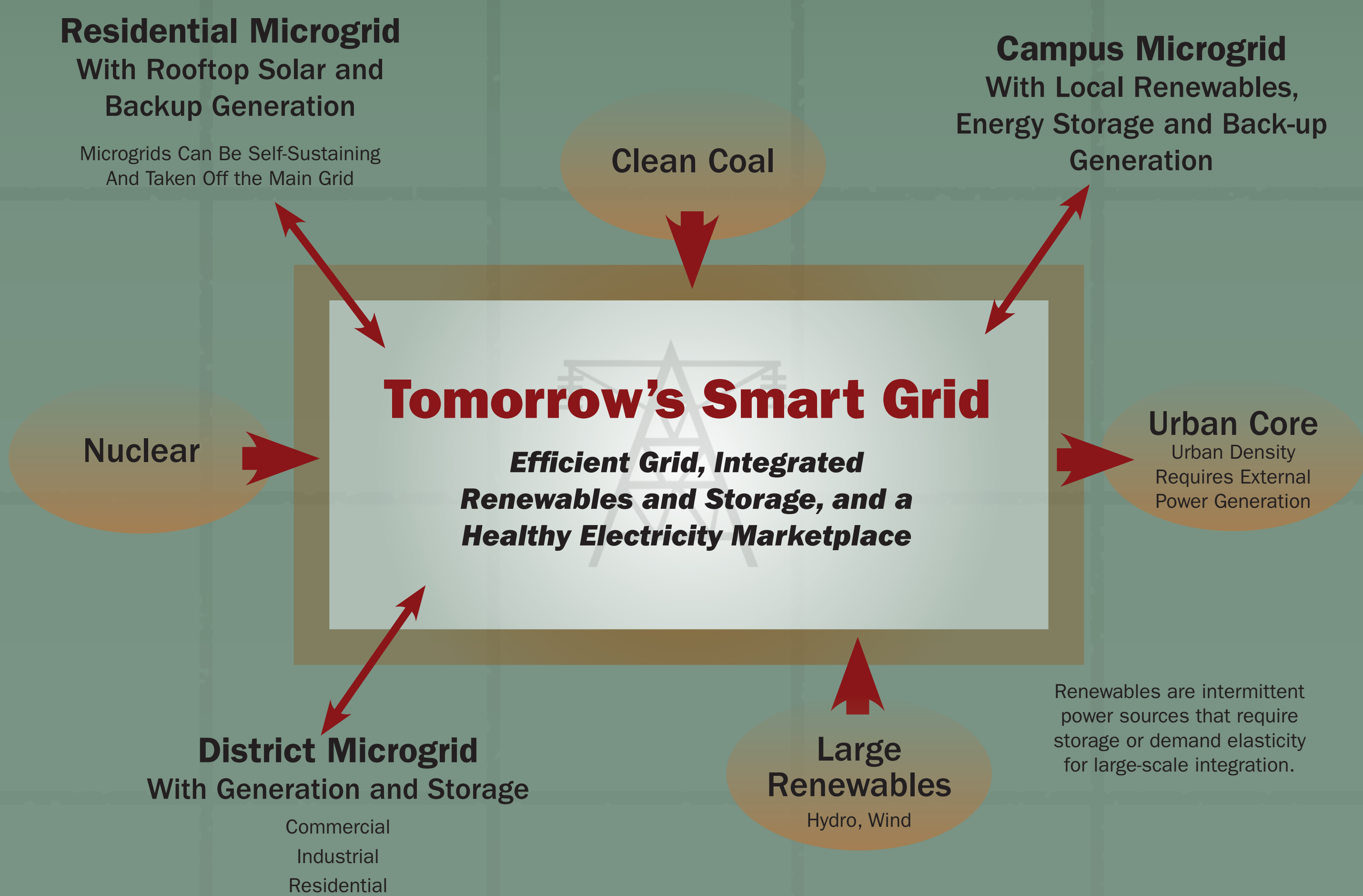

Figure 2: Tomorrow's Smart Grid with integrated microgrids, central and distributed generation, renewables, and storage, and a price-driven marketplace that drives new products and technology.

Smart Grid

a pipeline connecting central generation facilities to end use customers into a system that is more distributed and robust (see "What's New About Smart Grid").

This scenario contrasts significantly with the current system shown in *Figure 1*. The typical customer uses electricity with no indication of the real-time value, and pays a monthly bill. Except for a few customers subject to peak demand charges or participating in existing demand response (DR) programs, there is little incentive to use less energy at peak demand times, or more at night when the real market price is low. In effect, a market exists at the utility level, but not at the consumer level.

Today's system of regulated utilities offering flat-price sole-source contracts has developed, in part, because there was no way to communicate to the customer the dynamic value of electricity and no way for the customer to actively respond to that dynamic value. Instead, an artificial market was put in place that has resulted in a frequently under-utilized grid, non-competitive utilities, confused rate structures, under-development of infrastructure, and an inability to effectively integrate renewable energy sources. Because we need a more efficient and more robust grid with successful integration of distributed renewables, the system must be transformed. Commercial building load responsiveness is one of the key elements to enabling this transformation.

Figure 2 shows the future, smarter grid. As we build more efficient buildings and install local generation, the net energy coming into a building, campus, or neighborhood is reduced. As some buildings approach net zero energy consumption there is no longer a need for a big pipe, but rather the utility becomes a back-up power supply. With the addition of storage, a micro-grid may be able to produce and manage its own power needs independently of the grid. However, in many places population density demands power density that renewables cannot currently supply, so central generation will continue to serve a vital role.

The promise of a smart grid is cleaner and better quality power with a more efficient electricity distribution system. The accompanying increase in renewable energy generation, along with grid and building efficiency improvements, will significantly reduce carbon emissions, and integration of electric vehicles will reduce demand for foreign oil. Commercial buildings will play an important role in moving us along the path toward this future.

What's New About Smart Grid?

– **Technology** advances to enable profitable building energy management using intelligent control strategies combined with storage and local generation.
– **Microgrids** are small-scale grids (e.g., campus, neighborhood) with local renewable generation capability that interconnects with more conventional distribution systems.
– **Demand-Side Elasticity** reduces transmission, energy storage and central generation infrastructure costs.
– **Markets** that allow the customer to buy and sell electricity based on dynamic rates.
– **Two-Way Communications** that allow market signals to propagate to the consumer with load forecasts and generation bids going back to the grid controllers and market operators.
– **Electricity** product differentiation is buying electricity based on quality, carbon-content and other characteristics.
– **Opportunities** to participate in slow and fast demand response.

Buildings in the Smart Grid

Buildings account for 72% of all electrical energy consumption (40% commercial and 32% residential) and play a significant role in the smart grid.[1] Buildings should no longer be a dumb load at the end of the wire, but must become an integral part of the grid as virtual power plants, market participants, energy storage centers, and electric vehicle connection points.

Use of local renewable power generation along with load shifting and shedding technology can dramatically change the load shape on the entire grid, improving grid use with less infrastructure investment. Commercial buildings generally have more sophisticated mechanical systems and controls than residences that could make it easier to implement these strategies, but there is significant potential in both.

Multiple studies have demonstrated the potential for peak load reduction in commercial and residential buildings in response to DR signals. These studies show that automated tools have a large impact on potential response. Faruqui[2] examined 15 residential pricing pilots and found that "…critical-peak pricing tariffs induce a drop in peak demand that ranges between 13% and 20%. When accompanied with enabling technologies, the latter set of tariffs led to a drop in peak demand in the 27% to 44% range." Commercial building studies with enabling technology (DR signaling and energy management control system) have demonstrated 10% to 20% reductions in peak energy use.[3]

Barriers to Achieving a Smart Grid

Barriers to the smart grid are significant, as is the case for any transformation of a large system, but new federal government policies are helping to spur the process along. Congress passed the Energy Independence and Security Act (EISA) in December 2007,[4] calling for new federal buildings to be net zero energy by 2030 and, in Title XIII, calling on the National Institute of Standards and Technology (NIST) to coordinate the development of a standards interoperability framework. In November 2008, NIST held a workshop as part of the Grid-Interop conference, with a goal to gather stakeholder input on smart grid objectives and barriers to interoperability. Workshop attendees addressed these issues from different stakeholder domain perspectives, with commercial building to grid interactions represented in the "Building to Grid" (B2G) domain group.

For the B2G domain, the following objectives and barriers to achieving them were identified:[5]

Objective 1: National standards that enable automated demand response

Barriers:

- Lack of standard data models and services;
- State-to-state regulatory differences;
- Utility DR program variation; and
- Lack of building control infrastructure to enable DR.

Objective 2: Common data models for price communication

Barriers:

Uncoordinated utility DR and real-time price programs with no standard data formats.

Objective 3: Common data interface for distributed generation

Barriers:

- Mixed regulatory environment that inhibits innovation; and
- A lack of standards that results in every job being a custom implementation.

Objective 4: Tools for effective facility energy management

Barriers:

Legacy installations with nonstandard communication protocols combined with common construction practices that complicate system integration.

The barriers to integrating buildings with a smart grid can be summarized as regulatory gridlock, a patchwork of utility DR and real-time pricing programs with no data modeling consistency, and legacy controls and protocols.

BACnet's Role in the Smart Grid

BACnet is well established as an enabler for commercial building automation technologies and can play an important role in a future smart grid. BACnet already has the needed functionality for energy management and load control. The BACnet Committee's longstanding Utility Integration Working Group has been transformed into the Smart Grid Working Group and their efforts have been focused to align with the broader collaborations in the industry surrounding standards for the smart grid.

Standard BACnet objects can be used to monitor electricity consumption and track minimums and peaks in demand. In a typical demand response scenario, a load shed signal from an electric utility is received by the building automation system, which then commands different building subsystems or devices to reduce load based on pre-programmed strategies. The BACnet Load Control object (LCO) provides a general, high-level interface that allows a BACnet system to implement load shedding strategies and show feedback on load shed status.

Load Control objects can be linked in a hierarchical fashion throughout a BACnet system so that a single price or load shed signal can be distributed to LCOs that manage sub-systems or individual loads. Shed status feedback indications also can be passed back up the hierarchical structure to create aggregate views of the results. The definition of the LCO does not specify how the electrical consumption is to be reduced or how consumption baselines should be determined. Those decisions are made in advance by the facility manager and programmed into the systems.

Another tool in the BACnet smart grid toolbox is the BACnet Web Services (BACnet/WS) specification that allows external business applications to read and write data securely to the building automation system. BACnet/WS has been used successfully in the Open Automated Demand Response (OpenADR)[3] infrastructure to communicate load shed signals from a utility server to building clients. OpenADR is a Web-service based communications data model designed to facilitate sending and receiving of DR signals from a utility or independent system operator (ISO) to electric customers. The intention of the data model is to interact with building and industrial control systems that are preprogrammed to take action based on a DR signal, enabling a demand response event to be fully automated. Because the BACnet/WS data model is generic, it is possible to extend this success to non-BACnet systems.

The OpenADR effort originated at Lawrence Berkeley National Laboratory and has now migrated to a broader industry forum through formation of the Energy Interoperation Technical Committee (EI-TC)[6] within the Organization for the Advancement of Structured Information Standards (OASIS). The goal of the EI-TC is to expand the work begun with the OpenADR initiative. It will include developing a way for buildings to indicate a reserve capability to initiate on-site generation, storage, or load shifting in response to utility signals. The result of this work should be a standard that is adopted by utilities nationwide to support DR programs. The BACnet Smart Grid Working Group will be collaborating in this effort.

An additional committee has also been formed in OASIS to develop a standard definition of electricity price with associated context, e.g., schedule, quality, reliability, and generation source. This committee, called the Energy Market Information Exchange Technical Committee (EMIX-TC), will address clear and consistent communication of energy prices, bids, and energy characteristics that will apply to smart grid transactions. The definition of price becomes the input to the OpenADR specification, and that data is passed to the BACnet system. More information on the activities of the EMIX-TC can also be found online.[7]

The BACnet Smart Grid Working Group is also developing definitions for a common BACnet Meter object to make it easier to integrate building automation systems and applications with new smart meter technologies. The goal is to standardize a meter data set and the BACnet representation of that data. The meter object will allow the building and the utility to share time interval energy consumption data, support participation in demand response programs, and perhaps enable building energy consumption forecasts from the building automation system for presentation to the utility. This work will be coordinated with the evolution of existing meter standards being driven by the broader smart grid standardization efforts.

Path to a Smarter Grid

BACnet is only one piece of the larger smart grid. The Obama administration has made developing a nationwide smart grid infrastructure a priority. The recent American Recovery and Reinvestment Act (ARRA) of 2009[8] funds smart grid work outlined earlier in EISA, including $4.5 billion in grant funding for smart grid projects through the U.S. Department of Energy. The ARRA legislation has moved the NIST standards coordination effort into high gear, transitioning the focus from stakeholder communications toward a formal structure to develop and implement a standards roadmap.

NIST has taken a three-stage approach to expediting development and adoption of standards for the smart grid. The first phase identified an initial slate of consensus-based smart grid standards. BACnet and OpenADR were among those standards. The first phase also includes development of an interoperability standards roadmap. "NIST Framework and Roadmap for Smart Grid Interoperability Standards, Release 1.0 (Draft)" was released in September. These documents and additional information are available on the NIST smart grid program Web site at www.nist.gov/smartgrid.

The second phase of the NIST program will establish a formal public-private partnership to oversee ongoing work on additional standards development. The first meeting of the Smart Grid Panel entrusted with this work will be held as part of the Grid-Interop 2009 conference to be held this month. The NIST program third phase, still in formation, is the development of an overall plan for ensuring that smart grid devices and systems comply with standards for security and interoperability.

Conclusion

The federal government initiative to develop and establish a new smart grid offers the prospect of bringing sweeping changes to the national electricity generation and distribution infrastructure. These changes will bring new markets, communications, and technologies that will impact generation, distribution and consumption. Because buildings account for 72% of electricity use, they will be a critical component of any smart grid that emerges.

How Can Facility Managers Prepare for Smart Grid?

Where does the facility owner fit into this smart grid vision, and what can you do today to prepare for or impact the smart grid? Some initial steps are to install on-site generation, implement effective energy management strategies, and stay current about advances in demand response (DR) programs in your local area.

A smarter grid is dependent on smarter buildings. Price-based grid control cannot succeed without automated facility load and generation response. In other words, facility owners need to look at economical options for generation (renewable or otherwise) and storage (thermal or electrical), in addition to looking at strategies for demand and peak-load management. Some of these changes can be justified based on energy efficiency savings. Beyond that, utilities and states are pushing forward on DR programs, even dynamic pricing. As dynamic rate programs come on line, the facility owner will have a significant opportunity to save money with intelligent energy management.

The Federal Energy Regulatory Commission has released a National Assessment of Demand Response[9] and is working toward a national action plan for DR due June 2010. Facility owners should expect a significant increase in the availability of DR programs. Facility managers are encouraged to track DR program developments, and the following Web sites may provide some useful information:

- **www.dsireusa.org** tracks state and federal government incentives and policies supporting renewable energy and energy efficiency; and
- **www.eere.energy.gov/femp/financing/energyincentiveprograms.html** provides state-by-state analysis of existing energy incentive programs that include demand response/load management programs.

Years of independent piecemeal pilot projects and studies about the potential for building/utility interactions can produce successful results through the emergence of new standards and technologies.

Standards development will be an important enabler for a smart grid infrastructure. The load management and Web services features of the BACnet protocol already establish firm building blocks that will drive building automation system interactions with a smart grid. Newly established efforts in OASIS that bring together building industry, utility, and market regulation experts can complement the BACnet work by refining the communication needs for pricing exchanges and demand response signals, and establishing the broad-based consensus that will be needed for success.

The process is open and many opportunities exist for participation from parties with a broad range of interests. It appears that there is a critical mass of people and government policy support in place to make the vision of a new smart grid a reality.

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