Information Model Standard for Integrating Facilities with Smart Grid

By Steven T. Bushby, Fellow ASHRAE

The national electric grid has been called the supreme engineering achievement of the 20th century by the National Academy of Engineering.[1] In spite of its success and the tremendous impact it has had on our lives, the electric grid is under strain from increasing demand and aging infrastructure, and is in need of modernization. The Energy Independence and Security Act (EISA) of 2007[2] established a national policy to modernize the nation's electricity transmission and distribution system to maintain a reliable and secure infrastructure that can meet future demand growth and a range of other specific objectives. The legislation calls this modernization a "smart grid."

The present electric grid can be characterized as a top down system with one-way flow of electricity from central generating plants through regional transmission systems to local distribution networks and end loads. Market operations centers and the generation and transmission systems make control actions with limited situational awareness and information about customer interactions. There is limited automation and, in many cases, the utility is unable to detect a service outage unless reported by a customer. Part of the idea behind a future smart grid is to improve measurement and control technology used to manage electricity generation and distribution, but the most important concept is to transform the fundamental structure of the grid by combining an intelligence infrastructure with the grid that will enable two-way

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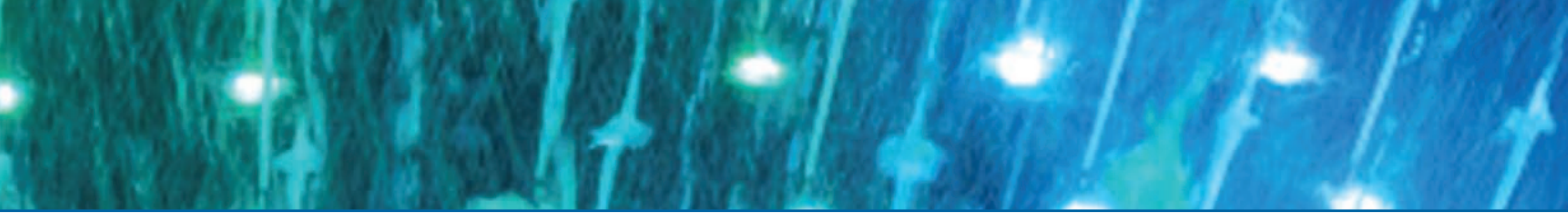

flow of both information and electricity (*Figure 1*).

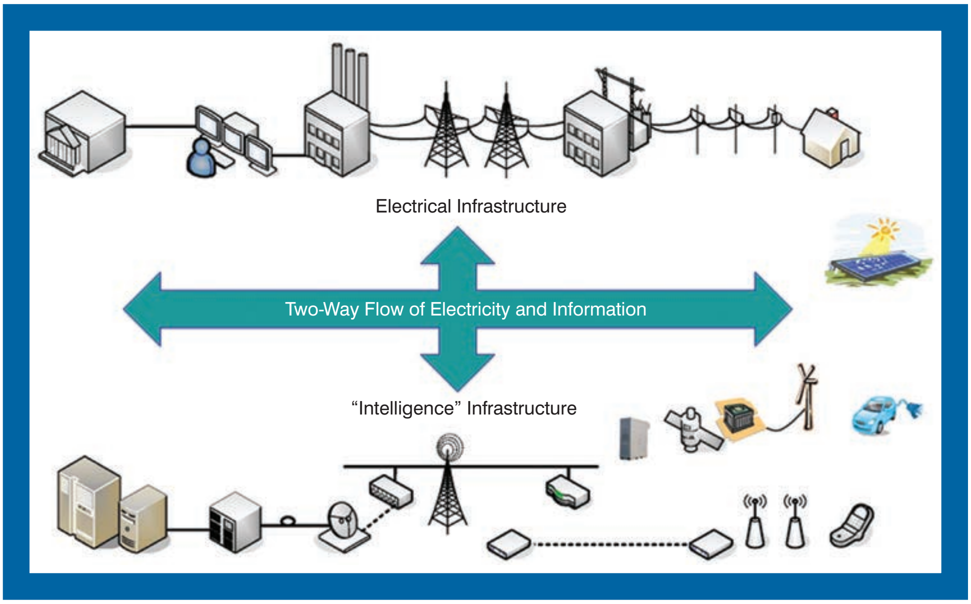

Figure 1: A smart grid will combine two-way communication infrastructure and local generation with the traditional electrical distribution system.

A Smart Grid Requires Smart Buildings

Residential and commercial buildings together consume 75.1% of our electricity and another 24.7% is consumed in industrial applications (transportation consumes only 0.2%).[3] *Figure 2* shows a daily load curve from a regional transmission operator in the northeast U.S.[4] This figure illustrates that one of the significant challenges for the electric grid is the wide fluctuation in load throughout the day. In this geographic region about 20% of electrical generation capacity is needed only 5% of the time to meet peak loads.[5] *Figure 2* also shows the availability of electrical power from utility-owned wind generation in the same region. This illustrates two challenges with increased use of renewable generation systems: a mismatch between the availability of the energy supply and the load, and the short-term variability in the output from renewable energy generation.

Efforts to promote the widespread use of electric vehicles could make matters worse for the grid if the vehicles are charged during the afternoon peak load. Electric vehicles will be plugged in for charging at people's homes, typically when the driver returns home from work. There is a need for incentives and controls to shift vehicle charging time away from peak periods.

The drive toward net-zero energy buildings, a building that produces as much energy as it uses on an annual basis, also has implications for the grid. Achieving net-zero energy requires significant improvements in energy efficiency combined with the use of renewable energy. Net-zero energy homes and buildings can help reduce the demand on the electricity grid and therefore the need for additional generation capacity. They will also increase the variability of loads because of increased renewable generation. Homes and buildings will at times be generators contributing to the grid and at other times consume from the grid.

The combination of all of these factors makes it clear why a communications infrastructure is critical to a smart grid and that smart buildings will be a necessary and critical component. Instead of being a dumb load at the end of a wire, homes, buildings, and factories will become full participants in managing a smart grid. Buildings will need to be able to help maintain stability in the grid by moderating loads or using energy storage systems in response to fluctuations in renewable energy generation. Buildings will need to be able to respond to signals that reduce peaks by shifting loads to non-peak times.

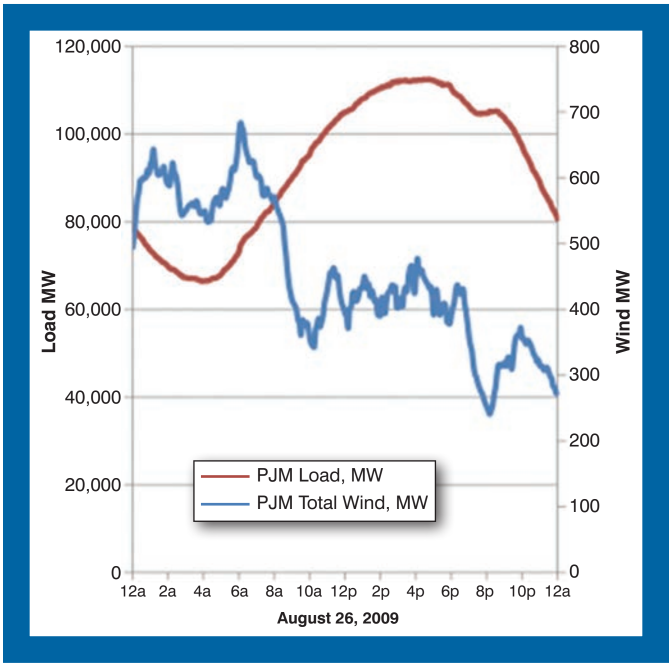

Figure 2: An example daily load and wind generation profile for a portion of the U.S. The data are from PJM, a regional transmission organization serving all or parts of 13 states and the District of Columbia, and no uncertainty was given.[4]

Utility suppliers will need reliable information about forecast demand from buildings. Enabling this collaborative arrangement between buildings and utility providers will require the development of industry standards. This need has been recognized in national efforts to develop a smart grid standards infrastructure.[6,7]

A Facility Smart Grid Information Model Standard

The National Electrical Manufacturers Association (NEMA) and ASHRAE have joined forces to develop one of the needed industry standards, a Facility Smart Grid Information Model (FSGIM). The purpose of the standard, being developed by ASHRAE Standard Project Committee 201P (SPC 201P), is to create a common information model to enable appliances, space conditioning systems, and control systems in homes, buildings, and industrial facilities to manage electrical loads and generation sources in response to communication with a smart electrical grid and to communicate information about those electrical loads to electrical service providers. The kinds of functionality that will be enabled by the model include:

- On-site generation management;
- Demand response;
- Electrical storage management;
- Peak demand management;
- Forward power usage estimation;
- Load shedding capability estimation;
- End load monitoring (sub-metering);
- Power quality of service monitoring;
- Use of historical energy consumption data; and
- Direct load control.

By combining their resources, NEMA and ASHRAE can take advantage of the expertise of their members in electric meters, electrical and electronic devices, heating and air-conditioning systems, and building automation and control systems. Also involved in the process are key stakeholders with backgrounds in home appliances, industrial control, manufacturing systems, electrical utilities, and end users.

One of the key concepts behind the standard is the idea of a "facility." A facility is broadly defined to be anything from a single family house, to a commercial building, an institutional building, or an industrial or manufacturing facility. From the perspective of an electricity provider all of these facilities can be considered as loads with responsive characteristics that need to be understood and forecast. They also all have some potential to be generators. From the perspective of a "facility manager," the kind of information that is needed to make operating decisions and the kind of actions that can be taken are similar regardless of the type of facility.

By developing a common information model for all of these kinds of facilities, utility providers benefit because they may be able to interact with all of their customers in the same way. A common model also benefits consumers because the dividing lines between these different kinds of facilities are not always clear cut. Using a common model will make it easier for a product designed primarily for one of these facility types to be used in other types as well. It may also create an opportunity for manufacturers to design products or software applications with features that intentionally make them desirable in more than one facility domain

What Will the FSGIM Look Like?

SPC 201P has adopted a set of use cases, based on work done by the Energy Information Standards Alliance,[8] that are being used both to shape the resulting standard and as a test to be sure the content of the standard provides for all of the needed information exchange. These use cases define a wide range of scenarios for interaction between a facility and an energy provider. They define specific actors for the transactions and the information that needs to be exchanged to carry out the scenario. In addition to these interactions between the facility and energy provider, the information model will also address information that is needed within the facility to make control decisions when managing loads and to develop load forecasts.

To meet the needs of a wide range of facility types, to enable the envisioned set of applications, and to address both internal information and information exchanges with the utility provider, the standard must be structured in a way that provides flexibility and enables creativity. The approach taken by SPC 201P is to define the information model in terms of building blocks that can be combined in multiple ways that provide flexibility and scalability. The ideas being deliberated by SPC 201P involve the definition of information components that define a load, generator, energy manager, and a meter. These building blocks can be combined to represent physical devices or systems. For example, storage has characteristics of both a generator and a load. The concepts can also be aggregated. A load may represent an individual device or a collection of devices or other loads. With this kind of flexibility it is expected that the information model components can provide all of the needed functionality.

The work of SPC 201P is occurring within the context of a much larger framework of standards development to enable a future smart grid,[6] and facility control systems will have to integrate with the resulting outside infrastructure. One way to help ensure that this happens is to make use of existing and developing standards where appropriate within the facility information model. The Generator model component is making use of portions of the IEC 61850[9] family of standards developed by the electric industry to meet their own needs for managing generators. The Energy Manager is built, in part, on draft standards under development by the Organization for the Advancement of Structured Information Standards (OASIS) that pertain to calendars (scheduling) and energy pricing information exchange.[10,11] Other source documents that are used in forming the FSGIM come from the North American Energy Standards Board[12] and the National Weather Service.[13]

The final product will be both a written documentary standard and electronic files describing the information content of the model using Unified Modeling Language (UML). Great effort is being made to ensure that the two are exactly synchronized. The documentary portion will be most useful to application experts and the UML files will facilitate the development of protocol specific implementations of the model.

Who Will Use the FSGIM?

An information model is an abstraction, not an implementation. There already exists well-established communication protocols used for automation and control in facilities, although these protocols vary with the type of facility. It is unrealistic to think that this installed base will just disappear. There are also practical reasons why protocols used in a manufacturing environment differ from those used in a commercial building or a home. The vision is that this common information model will be adopted by making extensions to the various communication protocols already used within facility markets. Each protocol will use its own existing mechanisms to encode and communicate the information within the facility. The relationship between the information model and the protocols used to implement it is shown in *Figure 3*. It is inevitable that the situation will arise where a product designed primarily for use in one of these environments will need to be used in another. This would require a protocol translation gateway but because the meaning of the information is based on the same information model standard, this task becomes much easier and more reliable than it otherwise would be.

BACnet and FSGIM

The ASHRAE BACnet standard[14] is an example of a target protocol standard that will make use of the FSGIM. Although many of the communication details in BACnet have no counterpart in an information model, the object oriented structure in BACnet does define an extensible information model that already has similarities to the information model components that will make up the FSGIM. In fact, the BACnet Load Control object type was used to develop features of the FSGIM Load model component. Although this example is a close one-to-one mapping of a BACnet object type with an FSGIM model component, generally, that will not be the case. Other parts of the FSGIM will eventually map to combinations of existing BACnet object types and perhaps new ones that must be created by the BACnet committee. It is expected that in most cases several BACnet object types will combine to form the functionality of a single FSGIM model component.

The BACnet committee is exploring an extension to the standard that would enable the creation of what are presently called "application interfaces." The idea is that an application interface would define a collection of parameters important to a particular application in a way that abstracts away the details of the underlying objects and properties that contain this information. This would enable developers to create software ap-

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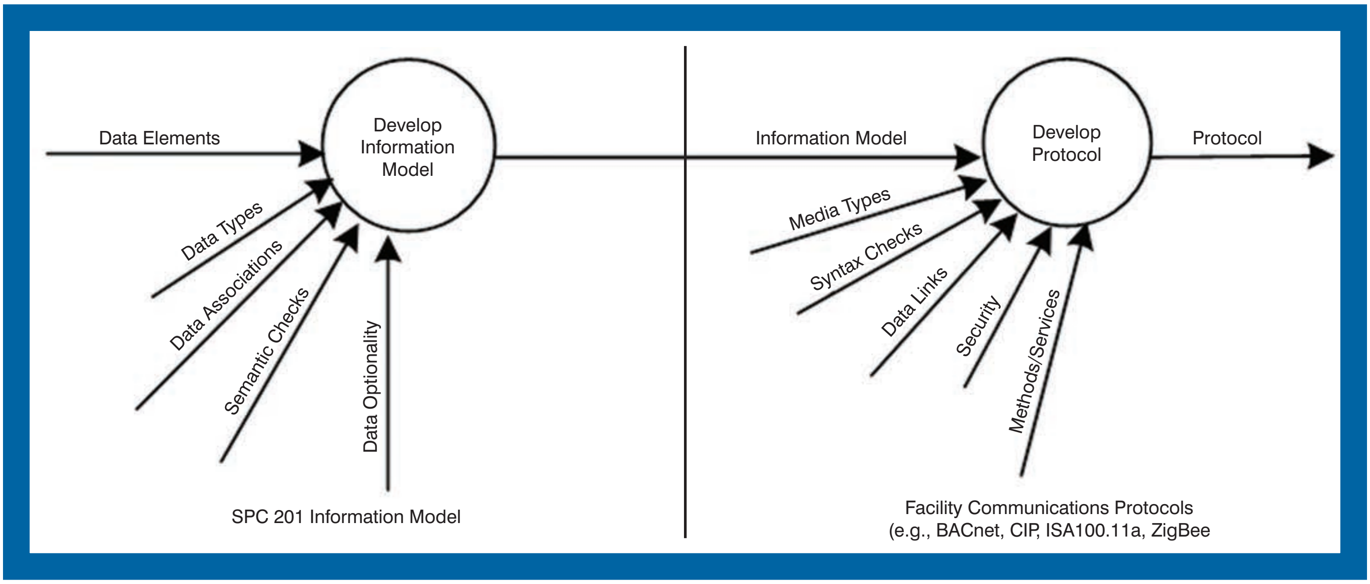

Figure 3: The Facility Smart Grid Information Model will be implemented through modifications to existing facility communication protocols.

plications based on the knowledge that certain information will be available when needed. The committee is exploring various automated ways to map the application interface parameters at "run time" to the underlying BACnet objects and properties as they are configured in a particular building control system.

The significance of this for smart grid is that application interfaces could be defined based on the FSGIM and BACnet's built-in application interface features would do the necessary mapping to specific BACnet objects and properties. Through a combination of existing BACnet object types, application interfaces based on the FSGIM, and, if needed, new BACnet object types, it should be rather straight-forward for BACnet to expand to incorporate the control needs implied by the FSGIM. The BACnet Committee is closely following the progress of SPC 201P and there is some overlap in membership. It is expected that this will facilitate early adoption of the FSGIM model in the BACnet protocol.

The path for other protocol specific adoption of the FSGIM would be similar. The information content of the FSGIM will be mapped to existing protocol constructs where possible. Where the FSGIM defines information content that has no exact counterpart in the target protocol standard, some type of extension will be needed to accommodate that information exchange.

Conclusion

This collaboration between NEMA and ASHRAE will result in a facility smart grid information model standard that represents the energy consuming, producing, and storage systems found in residential, commercial, and industrial facilities. When industry standard protocols are enhanced to implement this model and the information it represents becomes available in equipment and energy management systems, a facility owner will better be able to understand what factors influence the facility's energy consumption; energy consultants can determine how to effectively reduce the energy profile of a facility; architects and engineers can design facilities that optimize the energy profile; controls manufacturers can create products that monitor and manage the facility energy profile; and energy providers can more accurately forecast energy consumption and demand, as well as the reactions to energy supply constraints.

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