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Smart grid starts with smart design

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Introduction

The smart grid is placing many remarkable - but different - components out on the grid. And, as often happens on the reality TV shows that so many people can't seem to get enough of, bringing together a diverse group often results in some tense interactions. Plugging multiple electric vehicles into a single circuit could stress an undersized transformer, risking outages for a neighborhood or even larger portion of the grid. Overlaying communications infrastructure and smart meters on the grid may radically alter the way field crews manage, repair and update grid infrastructure. Installing distributed generation introduces bidirectional power flow on a grid built for one-way power flow. Every new component could affect so many other parts of the grid. Can all grid components - both old and new - successfully coexist?

Essentially, how can we smartly accommodate all of the smart changes on the grid? It all starts with design - using rich, intelligent information in a model-based design process. To borrow a phrase from architecture and civil engineering domains, the model-based design process extends into what is known as building information modeling (BIM). With BIM, changes to one component are reflected in the model and inform the design of other components. This integrated process vastly improves project understanding and allows for predictable outcomes. All project team members can stay coordinated, improving accuracy, reducing waste, and making informed decisions earlier in the process - helping to ensure a project's success. And, for the utility owner-operator, it is important that this process inform planning, maintenance and operations decisions across the lifecycle of assets. This paper reviews some of the challenges with moving toward a smarter grid, and the role played by smarter design in overcoming those challenges.

Changes - and challenges - with a smarter grid

Before discussing the link between smart grid and smart design, we need to revisit a few smart grid fundamentals. The utility industry is moving toward a smarter grid, but it faces challenges when it comes to getting the many components of a smarter grid to work together.

Very quick review of smart grid definitions

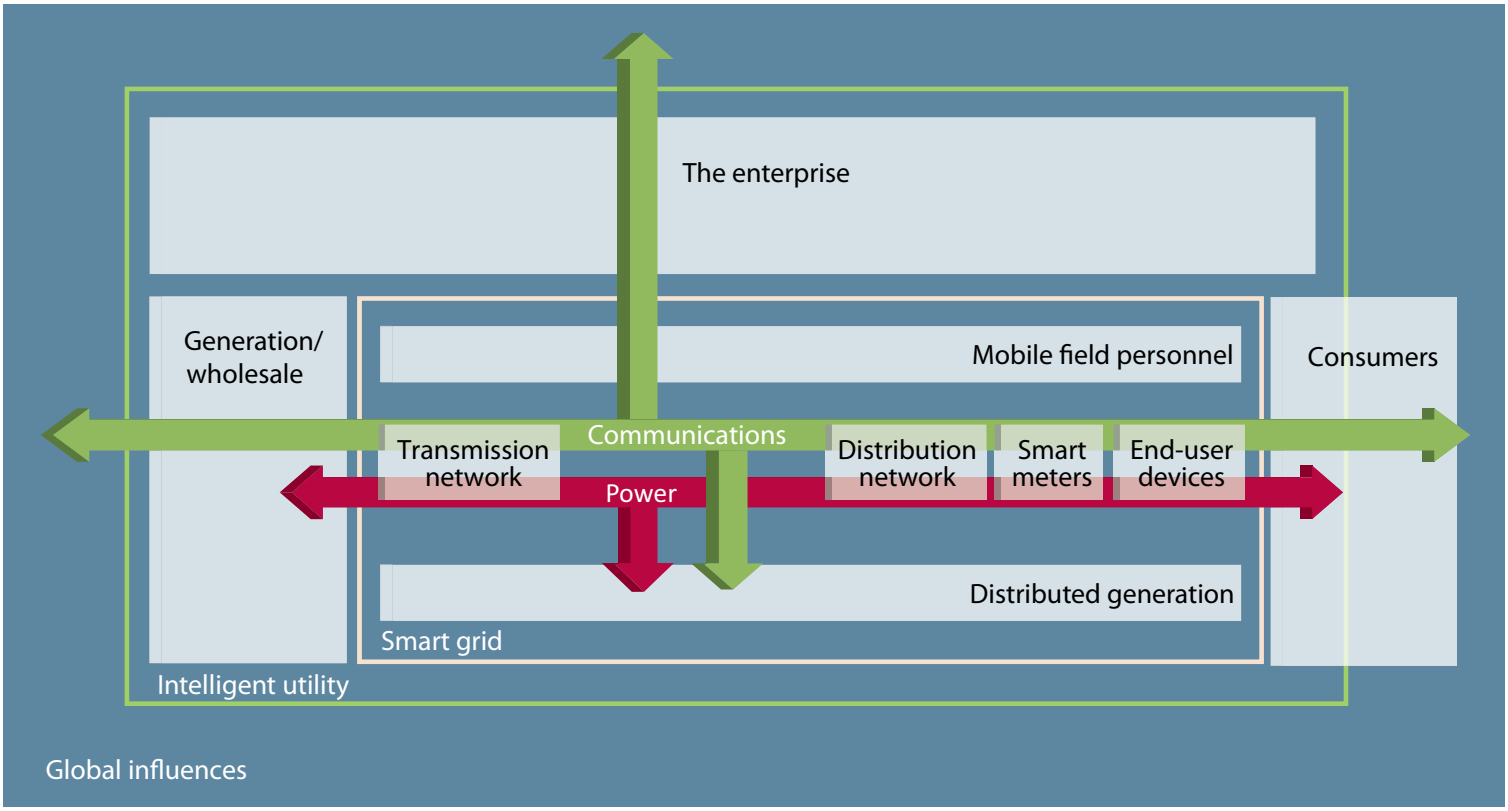
First, let's take a quick look at the smart grid definition. Everyone seems to have his own definition, however, no matter what technologies you include in your definition or what areas matter most for individual utilities, there is a common theme. A smarter grid and a more intelligent utility are really all about applying information to energy, thereby maximizing its reliability, affordability, and sustainability - all the way from generation to customers. A few of the technologies that can help support this definition include:

- Smart meters and advanced metering infrastructure (AMI)
- Communications networks to link smart devices and systems
- Customer systems and devices, including home energy displays, smart appliances, home area networks and energy management systems
- Renewable and distributed - including electric vehicles - generation resources and their supporting integration systems
- Transmission and distribution automation, including synchrophasers
- "Traditional" intelligent systems, including supervisory control and data acquisition systems (SCADA), work and asset management systems, customer information systems, geographic information systems and network design applications

Opportunities with a smarter grid

Numerous technologies can improve the grid's intelligence; and there certainly has been a lot of talk about them. That talk is finally turning into action as the utility

Defining the intelligent utility



industry moves toward turning the smart grid concept into a reality. This movement is due to the fact that utilities are finding real benefits to taking smart grid beyond just a concept. A few of those reasons include:

- Deferring carbon-emitting generation investments through better managing peak demand, integrating renewable generation and supporting the electrification of transportation, which includes not just electric vehicles, but also rail and other modes of public transportation.
- Achieving greater operational efficiency through minimizing line losses, more efficiently using field crew time and reducing costs associated with meter reading and maintenance.
- Equipping energy customers with the tools they need to better understand and manage their energy consumption. Improving power reliability, quality and security through enabling more grid control and automation.
- Leveraging granular, real-time metering and other data sources to improve design decisions and ultimately help designers right-size transformers, service connections and other materials. As the smart grid rolls out, utilities will no longer have to make assumptions about the energy needs of buildings and infrastructure. They will have access to actual consumption patterns.

Challenges to effectively realizing the smart grid

Of course, every opportunity brings new challenges with it. Smart grid is no exception to this rule. A variety of challenges can affect smart grid deployments - from regulatory and legislative actions to financing and customer acceptance.

Electric vehicles: Are they really plug-and-play?

Is charging an electric vehicle really as simple as plugging it in? It is today, if you are one of the few people using an electric vehicle. Add a few more electric vehicles - the Electric Power Research Institute estimates 10 million by 2020 - and plugging in becomes more complicated. Although electric vehicle use may be confined to specific neighborhoods at first, today's grid isn't designed to handle electric-vehicle "hot spots" or the eventual onslaught of electric vehicles heading its way. Think about the surge in electricity demand when people get home from work and plug in their vehicles, each equivalent to the power need of large home with air conditioning or about 6 kilowatts, all at about the same time. This timing could overwhelm distribution systems that weren't designed to handle the needs of electric vehicles. And even when electric vehicles start to spring up in specific neighborhoods, heavy concentrations of electric vehicles may not allow transformers adequate time to cool off overnight, which could result in an increasing number of transformer failures.

Moreover, additional infrastructure is needed to support electric vehicles at places other than our homes, such as the office, the mall or the movies. Public electrical outlets are already seemingly overwhelmed (think about airport outlets), so imagine the operational challenges of businesses as customers search for an outlet to plug in their electric vehicles. Buildings may need redesigns of their electrical infrastructure to accommodate the needs of electric vehicles. As a result, utilities are likely to have to build additional infrastructure to accommodate the power needs of electric vehicles hitting the road.

Smart buildings: A natural extension of the grid

Electric vehicles are new components tapping into the grid, but other components that have long been attached to the grid are going to add complexity. Think about energy customer premises and the movement toward smart buildings and their supporting systems to better manage energy use. Many commercial and industrial properties have had some sort of building automation and energy management systems, but the sophistication of those systems continues to increase. Many of today's commercial buildings are built or renovated using BIM - with intelligent, coordinated, design information used to visualize and simulate a project's performance. With a BIM foundation, owners and lessees can leverage the information in the 3D design model to better predict and manage energy use. Building systems are not only becoming increasingly complex, but there are more and more opportunities for utilities to interact with those systems. On the residential side, the addition of smart meters, thermostats and appliances, along with home energy management systems, is giving customers new opportunities to manage their energy. With all of these new opportunities to manage energy beyond the meter, utilities will be considering how to manage those interactions and how far the utility extends into the customer premise.

Distributed and renewable generation: Making it easier to be green

Other components coming onto the grid are distributed and renewable generation resources. Residential, commercial and industrial customers will be adding electric vehicles, building smarter structures and installing solar panels or wind turbines on rooftops and parking decks, or even out in the landscape. This means that traditional energy consumers can now become energy producers, or as some in the industry call it, "prosumers."

Distributed generation resources, such as solar panels and wind turbines, bring more than just new power to the grid. They can also introduce new issues such as:

- Introducing a two-way power flow on a grid designed for one-way flow
- Requiring careful dispatching of these resources to maintain the balance of the grid
- Tracking and managing new data associated with consuming and dispatching power

- Leveraging data for different organizations, such as planning departments, that may find it beneficial

On top of distributed generation, as you take renewable generation from rooftops to large-scale generation sites, accommodating this scale of generation can require investments in grid infrastructure, such as new transmission networks to reach remote wind farms.

Digitizing the grid: The old and new need to effectively coexist

Whether supporting electric vehicles or enabling demand response, a smarter grid requires overlaying existing analog grid infrastructure - things such as poles, wires, transformers and even substations - with new digital technologies. This overlay can create additional complexities. First of all, the new infrastructure design must take into consideration existing infrastructure. For example, a company may design a "last-mile" communications network for its distribution system, but it could also consider how existing infrastructure such as substations, transformers or even buildings might benefit from adding communication capabilities that provide information back to the utility. Once a digital system is designed and installed, then utilities face the tasks of documenting and maintaining the new infrastructure. How will utilities track new infrastructure and how will field crews manage and maintain these new systems? What kind of information can utilities use to better manage their networks?

The link between smart grid and smart design

The items mentioned here are a few of the complexities involved with bringing together the many smart grid components. And they demonstrate that these components won't come together by themselves. In fact, how the industry brings these components together is as important as the smart components themselves. This is where smart design and BIM come into play.

Design and maintain: Critical to success of a smarter grid

The grid is already carefully designed and extremely sophisticated, but it is still very sensitive to new influences. When designing for smarter grids, utilities will need to carefully weigh the effects of new smart systems. In particular, utilities will have to consider and design for factors beyond their own grids. New grid designs will have to account for actions beyond the meter, whether it is a consumer plugging in another electric vehicle or installing new solar panels. And utilities will have to rethink, and most likely, redesign existing parts of the grid to accommodate these end-user changes and bidirectional power flows.

Utilities will also have to consider where their design efforts stop. Do utilities work with customers at the residential and commercial and industrial level to develop smart systems within customer premises? Do they work with electric vehicle or smart appliance manufacturers to design systems that will work with the smart grid? These are design questions that each utility must sort through as it approaches the smart grid concept.

Even when smart systems and components are designed and installed, the work is still not over for utilities. Utilities must maintain these new, more advanced systems. Utilities will also have to constantly review and update the grid to keep pace with the rapid changes in the smart grid space. Out in the field, this means that crews will face new complexities with maintaining and repairing more advanced digital infrastructure. And, depending on how far the utility extends into the customer premises, field crews may have to take on new knowledge about maintaining technologies for customers.

Smart design tools: More than pencil to digital

With the need for smarter design comes a need for smarter design tools. Smart design tools are no longer just about digitizing pencil drawings; these tools should assist utilities with making smart design and maintenance decisions in an increasingly complex environment.

A few key elements that utilities should consider for smart design tools include:

- The ability to bring in and manage new data inputs: As the grid grows smarter, more and more data about the grid will become available - whether additional data about an existing distribution network or new information from a distributed generation source. Smart design tools should be able to effectively aggregate these data and make them available to planners, designers and personnel maintaining the system.

- Better connections between customers and the grid: Given the need for utilities to consider influences beyond the grid and the increasing sophistication of customer energy management systems, smart design tools should begin to connect the information available at the customer-level with utility-grade systems.

- Improved analysis capabilities: Not only is making data available important, but analysis capabilities are becoming increasingly important as well. Utilities should look for smart design tools that provide them with opportunities to use new and existing data sources to model how these new systems and components will impact the grid.

- The smart grid is a diverse group of components that need to act as an integrated system, which in turn requires utilities to think beyond a requirement for smart design tools. Utilities must now think about BIM as an integrated process that can enable them to capture all of the planning, design and as-built information in an accurate, complete and current model. This iterative process can now be used to support enhanced communications with customers as well as further analysis and refinement of the grid. For example, how will transformer, circuit and substation design requirements change as electric vehicles spread across a service territory, and which transformers will need to be replaced and when?

In essence, smart design should do more than just make it easier for utilities to draft their designs to support smart grid build out. Instead, utilities should embrace a smarter design process, BIM, that will enable them to make better decisions, so that all grid components - old and new, smart and perhaps not so smart - can successfully coexist and thrive in a smart grid.