Smart Grids Need Smart Design

How utilities benefit from model-based design

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Many utilities are in the midst of planning and deploying smart grid programs and related technologies. In principle, the Smart Grid is a simple upgrade of 20th century power grids, which generally "broadcast" power from a few central power generators to a large number of users. The new grid will be capable of routing power in more optimal ways to respond to a very wide range of conditions, such as intermittent wind or solar generation or concentrations of plug-in electric vehicles. These Smart Grid programs will enable fundamental changes in the efficiency of electric transmission and distribution operations. They will also allow consumers to control their demand and usage patterns from a price-signal enabled smart phone rather than a manual on/off switch.

The Smart Grid

Expectations of the Smart Grid vary by region and utility, but a few common capabilities include outage prediction and response or self-healing grids; improved reliability and power quality; improved asset utilization, operations and maintenance; accommodation of distributed and renewable generation; and increased demand response.

At the same time – and as more and more utilities initiate smart grid programs – the range of projects that fit under the Smart Grid umbrella continues to grow. Advanced metering infrastructure, substation automation, superconductive transmission lines, new communications networks to manage device interoperability, and integration of renewable energy sources are just a few examples of the types of technologies being deployed. Not only do these projects require detailed planning and design work, they need to be designed to the utility's standards and incorporated into the utility's records management system to form the basis of the network model that will drive smart operations.

The numbers associated with some of these projects are staggering. For example, in order to deliver solar and wind generation to market, one estimate calls for 19,000 new miles of transmission lines to be built in North America. Another example is substations in North America. As many as a third of them are near the end of their useful lives and due for major upgrades. Projects of this scope involve multiple firms – the utility, their engineering and construction contractors, data collection vendors, and various equipment suppliers. The complexity of this work and the need to coordinate closely with local and regional constituents is driving many utilities to take a closer look at their planning and design processes and technologies.

Image courtesy of Üz Lülsfeld, Germany

Smart Planning and Design

While the impact that these new Smart Grid programs will have on operations, customer engagement, billing, and demand response have all been well debated, less has been documented about how they will affect the process that utilities and engineering firms must undergo to design the new network.

For every transmission and distribution project, utilities must adhere to rigorous design and engineering standards. Many have pre-defined workflows and business processes in place that help ensure quality and accuracy, as well as cost controls. Smart Grid projects, with their greater emphasis on planning and delivering initiatives and projects faster and more economically, also often include ambitious new environmental mandates and call for more sustainable design.

Building Information Modeling

These basic utility design challenges are similar to those faced in the building and transportation industries, where Building Information Modeling (BIM) is being widely adopted as a process to create smarter designs and make better, more informed decisions. 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 enables engineers to validate design ideas very early in the design process – long before construction begins – and achieve more predictable outcomes. With BIM processes in place, 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.

"Using information in a model-based geospatial context has become an essential element for performing work at electrical utilities," says Marshall Hibnes, GIS Manager in the Asset Management Division, Seattle City Light. "It provides an intuitive framework for understanding complex engineering tasks and leveraging the tremendous amount of data becoming available through modern, enterprise technologies such as smart grid. Utilities have an opportunity to work more efficiently integrating GIS, engineering design, system analysis and asset management - resulting in higher quality service to customers."

Distributed generation

In this context, a new set of questions faces utilities as they review their design processes and standards. What if designs could be validated sooner in order to have less impact on the actual construction? What if coordinated and consistent information could improve planning and assessing innovative and sustainable alternatives? What if it were possible to visualize and simulate real-world infrastructure and performance versus cost? What if more design alternatives could help to improve the accuracy and sustainability of the designs?

The process continues when the design goes to construction. For the utility owner-operator, it is important that the model-based design process also informs planning, maintenance and operations decisions across the lifecycle of assets. Once the new systems are in place, utilities must manage the as-built information in a system of record that has the following ideal characteristics: it is spatially enabled; is kept in a database environment; and is linked with other operational systems. Such a system of record helps to form the basis of the network model that lists each asset's attributes, location, design documentation, maintenance history, connectivity and topology—all of which utilities can use to drive smarter operations.

A Day in the Life

To accommodate distributed renewable energy generation, smart buildings, smart appliances, and plug-in electric vehicles, utilities will need to be keenly aware of how they design their networks, analyzing multiple "what if" scenarios before selecting the appropriate transformers, breakers, and other grid devices for a circuit.

For example, consider a street on which half of the residents will purchase plug-in electric vehicles within five years or a new commercial building that will include rooftop solar on a feed-in tariff. The best way to optimize design decisions in scenarios like these – involving tremendous amounts of dynamic information – is to employ a model-based design process. And, the best way to understand how these changes impact the design and management workflow is to examine a typical utility planning and design process.

Planning

The process begins with a request for new service or internal planning that requires upgrades to the network. In the case of a smart grid upgrade project, the process may start with a service order generated by the smart grid project manager. In either case, the planner brings together relevant data to create a project base-map. Data might include the existing utility network model from GIS or circuit mapping records; land base and parcel information from a local agency's GIS; survey and LiDAR data; and aerial photography imagery to provide real-world context.

With this integrated information in a model, the planner can make critical decisions, such as the optimal route or corridor, impact on local stakeholders, and right of way information. Building and sharing compelling visualization based on this model allows designers and developers to not only accelerate the public acceptance of a project, but also allows the planner to incorporate changes much more quickly.

Design

Once the project planning is complete, more detailed design starts with a designer creating a layout of the network, calculating material estimates, and creating construction work orders and bills of material. In order to engineer the project, the designer relies on the base-map information as well as the utility's design standards to size network elements – transformers, cables, poles and towers. Typically this process involves estimates or default values for commercial, industrial, and residential loads. These default estimates are based on building type and square footage, climate information, and the designer's own experience. Often, a designer chooses one size larger than needed to cover any variances in estimates.

With model-based design, the designer can add greater value since the commercial office park, residential subdivision, or industrial facility most likely is no longer just a 'load'. Instead, this location is likely to be a very dynamic grid participant, with renewable generation (e.g., rooftop solar), a building energy model created with BIM, and managed appliances and devices (e.g., plug-in electric vehicles) within the facility.

Although much more useful, such a system is more complex than a traditional, static load-based design – and also much more challenging to create. To complete the new dynamic model, the designers need to factor in many additional data sources before making final design and sizing decisions. Engineers developing the design standards for the utility need to consider questions like these:

- What are the demographics of the neighborhood? (e.g., are the residents likely to be early adopters of plug in electric vehicles?)
- What is the existing and planned distributed generation in the neighborhood or office park?
- What does weather and other geographical data tell me about seasonal peaks, protection and environmental conditions?
- What does the building load model tell me about expected peak and coincident loads?
- What are the corresponding telecommunication requirements?
- What are the transmission interconnection impacts on protection schemes and substation design?
- Will the utility have direct control over any appliances or equipment in the facility?

According to Paul Joseph, IT & Business Integration Manager for TDBU/Non-Energy, at Southern California Edison… "The designers will need to design to these new standards. The key is having the ability to configure these evolving standards within the design tools being used so that the data collected and the results produced are both standardized. Model based standards allow engineers to quickly assess evolving field conditions, environmental impacts, and regulatory mandates and modify standards that can be immediately analyzed, approved and implemented."

Once detailed information is available and aggregated, the designer can make much more informed layout and sizing decisions. With model-based design, the designer can quickly compare alternative designs and adjust results as new data comes in, without having to redraft or start from scratch. These more informed decisions help the utility optimize materials and devices on the grid, creating a truly "smart" grid and more sustainable design practices.

Managing more assets means more complexity

Smart grids also introduce more complexity to the utility's network model. There are more devices to track – ranging from smart meters and communications networks to sensors and switches, and even appliances and other devices beyond the meter. Each has attributes originally created in the design process. Some need to be considered part of asset management (e.g., accounting for network assets, depreciation, reporting, etc.); all have associated location and connectivity attributes. Accurate and complete engineering information becomes an increasingly important part of the model for operations and future planning.

A more complex grid

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Once new facilities are in service, there are often significant backlogs in making network data available to operational systems. Before the updated data reaches the outage management or the distribution management system, operators may be working from older data, potentially compromising quality and safety.

A model-based design process provides a more complete network model, helping the utility maintain the integrity and currency of this engineering data. Better data makes better information possible because precision design does not get discarded once the project is complete. By integrating design models into utility workflows and systems as they are created, operators can work from more accurate and current as-built data and can manage information about the planned project along with their existing records. With integrated model-based design, utilities are able to reduce and, in some instances, eliminate the backlog between the asset being operational and fully in sync with GIS, engineering, inventory, and operations.

Reducing backlogs is important to the utility in any case, but with Smart Grid programs, it is even more important.

According to SCE's Paul Joseph, "The need for data to be available to multiple business disciplines simultaneously – public affairs, planning, engineering, grid operators – makes modeling and data restriction based on role paramount."

Summary

Smart Grid programs are transforming the way utilities are looking at operations. They are also beginning to drive changes in business processes covering the planning, design, and management of the grid. Model-based design provides the context for utilities to make significant process improvements and deliver a smarter, more sustainable grid. ■

ABOUT THE AUTHOR

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