Duke Energy Transforms Its Substation Design Process

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With the advent of CAD, work order management, and purchasing technology in recent decades, substation engineering underwent a transformation. Design, purchasing, and construction management transitioned from completely manual, paper-based tasks to being faster, digitally enabled processes. Substations that might have taken years to design and build can now be completed in under a year.

Virtually every electric utility in the United States relies on technology to complete critical pieces of the substation engineering and design process, but too often the pieces are not connected. Many companies use manual processes and time-consuming duplicate data entry to connect processes and systems.

Today, another transformation is underway. Electric utilities, including Duke Energy, are developing integrated workflows that automate key aspects of the substation engineering and design process. Soon these companies will have processes that are not only significantly faster, but also smarter and more intuitive.

The Case for Continuous Improvement

As one of the largest electric power companies in the United States, Duke Energy delivers energy to approximately four million customers in North and South Carolina, Ohio, Kentucky, and Indiana. Through its wholesale energy business, Duke Energy helps other companies meet the needs of their customers during peak usage times. The company's total U.S. generating capacity is 35,000 megawatts, and it relies on more than 3,500 substations to help safely transmit power to its customers' homes and businesses.

Duke Energy employs 18,000 people, each of who takes to heart the company's mission to make people's lives better by providing gas and electric services in a sustainable way. Success requires a constant effort to find better, more efficient ways of doing business. From customer service to outage management to power distribution, leaders in every area of the business are looking for opportunities to enhance efficiency. Recently, the substation design process has been the focus of a concerted process improvement effort at Duke Energy.

Traditional Processes Slow, Manual

At first glance, Duke Energy's substation design process might not seem like an ideal candidate for improvement. It's based around widely-used and well-regarded technology, and the quality controls supporting the process have done a good job of preventing significant errors, such as those that can negatively impact safety or construction costs. However, on more in-depth examination, challenges emerge.

Let's look more closely at the substation design process and workflow to gain an understanding of those challenges. Whether for new 'greenfield' projects or 'brownfield' retrofits and enhancements, the process begins with a request for a new substation in a given area. Requests are sent to the substation engineering services department via email, and a supervisor then routes the request to an estimator for scoping or directly to a designer, as appropriate. Most requests for new substations are thoroughly scoped before going to a designer, but many brownfield projects are routed directly to a designer. The estimator begins the process by creating a Microsoft Word template that details the project location, probable equipment requirements, desired completion timeframe, and necessary capacity. When the scope is established, the completed template is sent to a designer using email.

The designer reviews the email, and begins the design process in a traditional, 2-dimensional CAD (computer-aided design) application. Often, that requires incorporating elements from an existing paper network drawing into the design. The designer retrieves the drawing from the archives, scans it using an application that turns the raster image into vector data, which is the kind of data a CAD application creates and modifies. The designer then creates plans for the new substation.

Performing many calculations manually, the designer determines the specific capacity requirements for the substation, and emails a materials specialist who decides the types of transformers and other equipment that will be used. With the equipment specifics established, the designer creates a detailed plan that includes all the transformers, electrical connections, circuits, protective systems, and structural elements. The designer also needs to account for and order any necessary soil tests or survey work. Just as importantly, the designer must order any equipment that has a long lead time for fulfillment, meaning it's time to create a bill of materials (BOM) for the job.

Creating an accurate BOM is one of the most time-consuming aspects of the design process. Much of the time goes not into simply creating a list of needed materials; rather designers devote significant effort to following a quality assurance process that prevents over-ordering, under-ordering, and omissions. Over-ordering could add restocking costs to projects. Under ordering and omissions could lead to downtime and delays in the field. Duke Energy's quality assurance process does result in reliable BOMs, but currently, the process is highly manual, involving the counting and recounting of materials at key points in the design process. In fact, on a job that might take 200 engineering hours, managing BOM quality checks and entering BOMs into the purchasing system would represent as much as 40 hours of the total.

While its substation engineering process resulted in effective substations, Duke Energy recognized that its highly skilled designers were spending too much of their time counting materials and entering data across systems. The company decided to explore its options for connecting, automating, and accelerating the process.

Casting a Wide Net

Duke Energy approached the re-engineering of its substation design process with an open mind and a set of clear requirements. Any new solution had to:

- Link the business systems involved, such as work order management and purchasing
- Automate all or significant portions of the BOM creation process
- Enable designers to easily leverage existing substation plans in projects
- Improve or automate load and capacity-related calculations
- Streamline the communication of design intent to construction crews

The company issued a request for proposals from organizations with significant experience with design technology, the utility industry, and process integration. From among a number of strong proposals, one from Autodesk caught the attention of Duke Energy. It was notable not because it accounted for all the company's key requirements – all the proposals received were adequate in that regard. What stood out was the fact it proposed a solution that exceeded the company's selection criteria and, that it was based around model-based design concepts more commonly used in the manufacturing and building industries than in the utility industry.

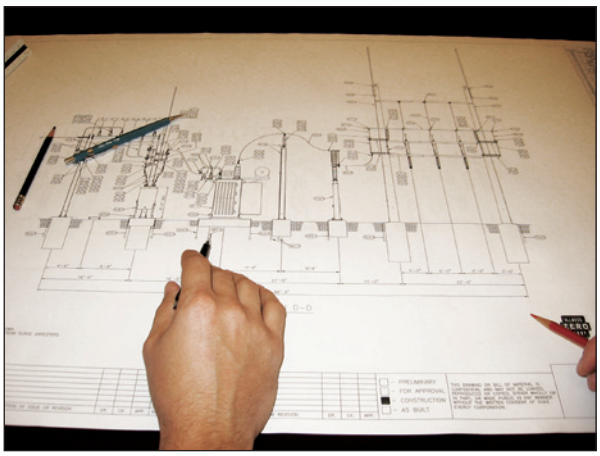
Duke Energy chose to build the Duke Energy Substation Design Solution (SDS) around Autodesk Inventor, AutoCAD Electrical, and Autodesk Vault Manufacturing software. In the solution, Inventor allows engineers to design using a 3D digital model, AutoCAD Electrical supports the design of electrical control systems, and Vault Manufacturing manages a library of reusable design elements. Each part of the solution allows for integration with other business systems. While it may seem unorthodox to use model-based design software to design electric substations, Duke Energy chose the solution because its leaders believed that the elements were all present to transform their disconnected design process.

Automation Saves Time

Duke Energy is currently in the final stages of developing and implementing the SDS. When it is rolled out to the substation engineering group, the design process will employ a significantly transformed workflow, one that heavily leverages process automation. Work assignments will come directly from Duke Energy's enterprise and asset management systems, and those assignments will be routed directly to designers' SDS interface.

Before work even begins on a design, the solution will scope the work and produce a basic estimate of parameters and materials, which the designer can then fine tune. If the estimate contains any equipment with a long lead-time for ordering, the designer can route that specific material for immediate or scheduled purchasing.

Throughout the process, the solution automatically maintains an accurate BOM, and because the solution integrates with Duke Energy's purchasing system, ordering materials no longer requires any duplicate data entry. The old quality assurance check involving endless counting and recounting of materials across 2D drawings will be a thing of the past, and the risk of ordering issues will be greatly reduced.



To speed the design process, the solution automatically selects potentially useful existing drawings from the design library. The designer can use those designs as a starting point for the new substation model. So before core design work even begins, the designer can pull together appropriate transformers, breakers, and structural information from past jobs. For very simple enhancement projects and new substations, the design will be almost complete just a few hours into the process. The designer may only need to do minor modifications to ensure the elements identified suit the project.

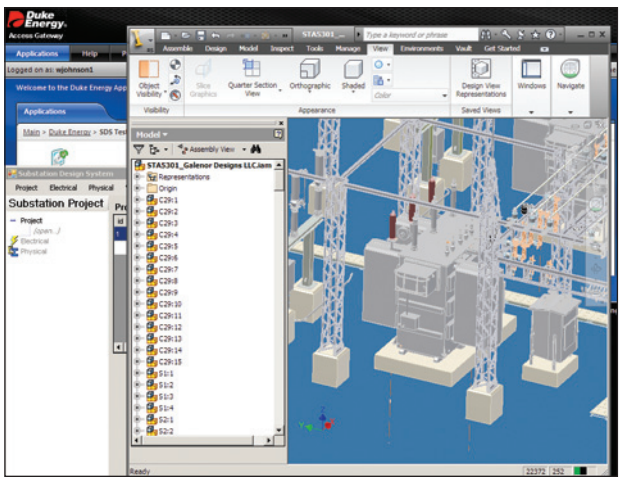
Enhancing the Design Process

As the job progresses, the solution automatically performs many routine calculations, including short circuit analysis, routing calculations, and bus calculations. When information that does not exist, such as the results of soil borings, needs to be incorporated into calculations, the solution flags it, so that the designer can find the information needed or order the relevant tests. Duke Energy expects that automating routine calculations will not only save time during design, it will also accelerate the quality control process by making it harder to generate inaccurate calculations in the first place.

Because the solution uses parametric modeling, it incorporates changes automatically. Basically, when one element of the 3D substation model changes, the solution dynamically modifies the parameters of the rest of the model to account for the modification. In contrast, with traditional 2D tools, users had to incorporate changes manually into each sheet within a design. Again, Duke Energy sees an opportunity for both timesavings and quality enhancement stemming from greater automation.

3D Substations

Duke Energy is looking forward to compressing design time by using automation to remove steps from the process, but the new process also includes an interesting addition: 3D visualization. As they work, designers will create an integrated 3D model of a substation that includes all the equipment, connections, and structural elements. They will see exactly how the whole substation comes together.



In a sense, they build a digital prototype of each substation before it's built. If a beam is impeding access to equipment, they see it immediately, and they can take steps to improve access. Duke Energy believes that 3D modeling has the potential to help enable better and more sustainable design. With 3D modeling, the designer will be able to easily explore how changes might improve substations or could lead to minimized waste and rework during construction.

Usability will take center stage in the design process. When designers ask "what if," they'll see the answer as soon as they make the change. For example, they can explore equipment placement with the comfort and safety of field crews in mind. A tiny modification in the placement of an equipment mounting bracket or a bus connection could make a huge difference in the time and risk involved in servicing nearby equipment. Buildability will also play a more prominent role in the new process. Construction crews will be able to see exactly how substations will look when complete.

It can be difficult for even the most experienced people to visualize the whole project, working only from lines on multiple design sheets – and that's what you get with 2D tools. The new 3D model-based design approach will allow construction crews to explore the big picture and the smallest detail of the design. This will help them to plan their work more efficiently and avoid rework due to misunderstanding some aspect of the design.

Looking Ahead

Every step of the way, Duke Energy is accelerating the substation design process with automation and integration. Soon, the company's substation design specialists will be able to devote virtually all of their attention to developing substations that are high-performing, safe, and cost-effective – instead of focusing on data entry, simple calculations, and counting.

The company estimates that the Duke Energy SDS will reduce overall design time by at least 50 percent on both greenfield and brownfield projects. With the time saved, the company believes that it will be better positioned to meet its customers' evolving capacity and service demands, including adding new substations to its network and completing the design work needed to enhance existing substations with smart grid technology. The Duke Energy SDS provides a clear example of how a technology that transforms one process – substation design – can help pave the way for more integrated, intelligent, and sustainable processes overall.

Smarter Substations for Smart Grids

Soon in Ohio, Duke Energy will begin the process of deploying smart grid technology, including 80,000 smart meters by the end of 2010. The meters will enable near real-time information which customers will be able to use to better manage their energy consumption. In a sense, energy efficiency has the potential to become a "fifth fuel" – along with coal gasification and advanced pulverized coal, nuclear, natural gas and renewables – by helping large numbers of people to easily and proactively manage their energy usage, save money and reduce their carbon footprint.

The Duke Energy SDS will come online just in time to support the move to smart grid technology. Smart meters require the support of smarter equipment in substations. With SDS, the company will be able to create a template for the new equipment required in existing substations. Designers will leverage the template to complete the repetitive portions of the designs and BOMs very quickly, enabling Duke Energy to undertake a massive number of substation enhancements on an ambitious schedule.