CASE STUDY

BETTER WORKFLOWS FROM BETTER DESIGN

DUKE ENERGY

WORKFLOW IMPROVEMENTS USING MODEL-BASED DESIGN TOOLS

"Let us raise a standard to which the wise and honest can repair."
George Washington

Arnold Fry
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A superior engineering design standard is like the standard borne at the head of an army. It leads the troops.

Duke Energy has been able to raise the standards to which everyone involved in utility O&M work can "repair" by increasing its reliance on intelligent model-based design tools. Optimal utilisation of engineering standards-driven design tools has played a key role in Duke's unifying, aligning, and memorialising best practices and the collective wisdom of experienced employees.

Many utilities are interested in having a single environment of databases to capture all of their assets, or having "one version of the truth." For Duke Energy, having one version of the truth is only the first step in a series of important process improvements. On this path, intelligent model-based design standards play a vital role in deriving maximum value from the one database environment by linking it more deeply to a range of optimised workflows.

To use Washington's phrase, model-based engineering design standards have helped keep Duke Energy's asset data "wise and honest."

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OUT OF MANY, ONE UNIFIED DESIGN PHILOSOPHY

Duke Energy is the largest utility in the United States and has utility subsidiaries in multiple states under three prior holding companies – Duke Energy, Cinergy, and Progress Energy. In 2005, Duke installed a platform of common software tools in T&D and Substations for Work Management, Design, and GIS. Benchmarking and cross-pollinating best practices helped Duke create a unified enterprise.

This article will first review the benefits gained from the unifying impact of model-based design following the improvements begun in 2005. Second, we will examine the deeper benefits discovered since then that are being applied. Finally, we will look at the impact of Duke's deepening experience with model-based design in facing future capital project workflow challenges.

INITIAL IMPROVEMENTS TO DESIGN AND MODELLING TOOLS

At the time of its earlier improvements, Duke Energy became one of the first utilities to make the transition from 2D to 3D modelling environments. One of its initial efforts was in substation design, where Duke Energy used Autodesk® Inventor™, AutoCAD® Electrical, and Autodesk® Vault Manufacturing software. These CAD-based modelling and design solutions automated work assignment processes that previously required designers to manually enter new data. Throughput and accuracy were improved by means of the new solution's better integration of design work with Duke Energy's enterprise and asset management systems.

Work is now scoped much more easily by designers as a result of Duke's original improvements. Duke has benefited from the system's ability to fine tune prospective designs and perform "what if" analysis when needed. Costly requirements for duplicate data entry have been eliminated through integration with the purchasing and materials management system and automatic generation of Bills of Materials for each job.

As a result of this automation, QA processes that previously were much more time consuming are now being completed more rapidly and accurately. Similarly, design libraries in the system have increased the accuracy and efficiency of the design process by providing selections of existing designs as optional starting points. Processes in some cases were made 50% more efficient, with some of those efficiency gains creating direct cost savings and others enabling designers to use some of the extra time to improve upon their designs and related processes.

Parametric modelling capabilities in the system incorporate changes automatically, with the solution dynamically changing elements that are introduced. For example, the system reacts to a change in a design electrically (e.g. kVA size of a piece of equipment) by automatically calculating all cascading impacts of the change on other elements (e.g. structural, civil, system protection, or others) and notifying responsible personnel to adjustments that they can then review and comprehend in the new design.

EXTENDING THE BENEFITS BEYOND EFFICIENCY OF DESIGNERS

Years ago, when management teams first debated whether to invest heavily in improving the design function, there was a lack of confidence in whether the investment would pay off. What happens when you make engineering design processes more efficient? How beneficial will it be?

In spite of the initial hesitations, the improvements these investments have brought Duke Energy in terms of better productivity and work accuracy are now justifying our proceeding with deeper use of the latest design and visualisation tools. Duke Energy has realized direct and indirect savings across the organisation by making the design process more efficient.

Admittedly T&D designers only represent about five percent of total T&D salaries and wages so, superficially at least, it seems reasonable to ask how big of an impact can be made with more efficiency in T&D.

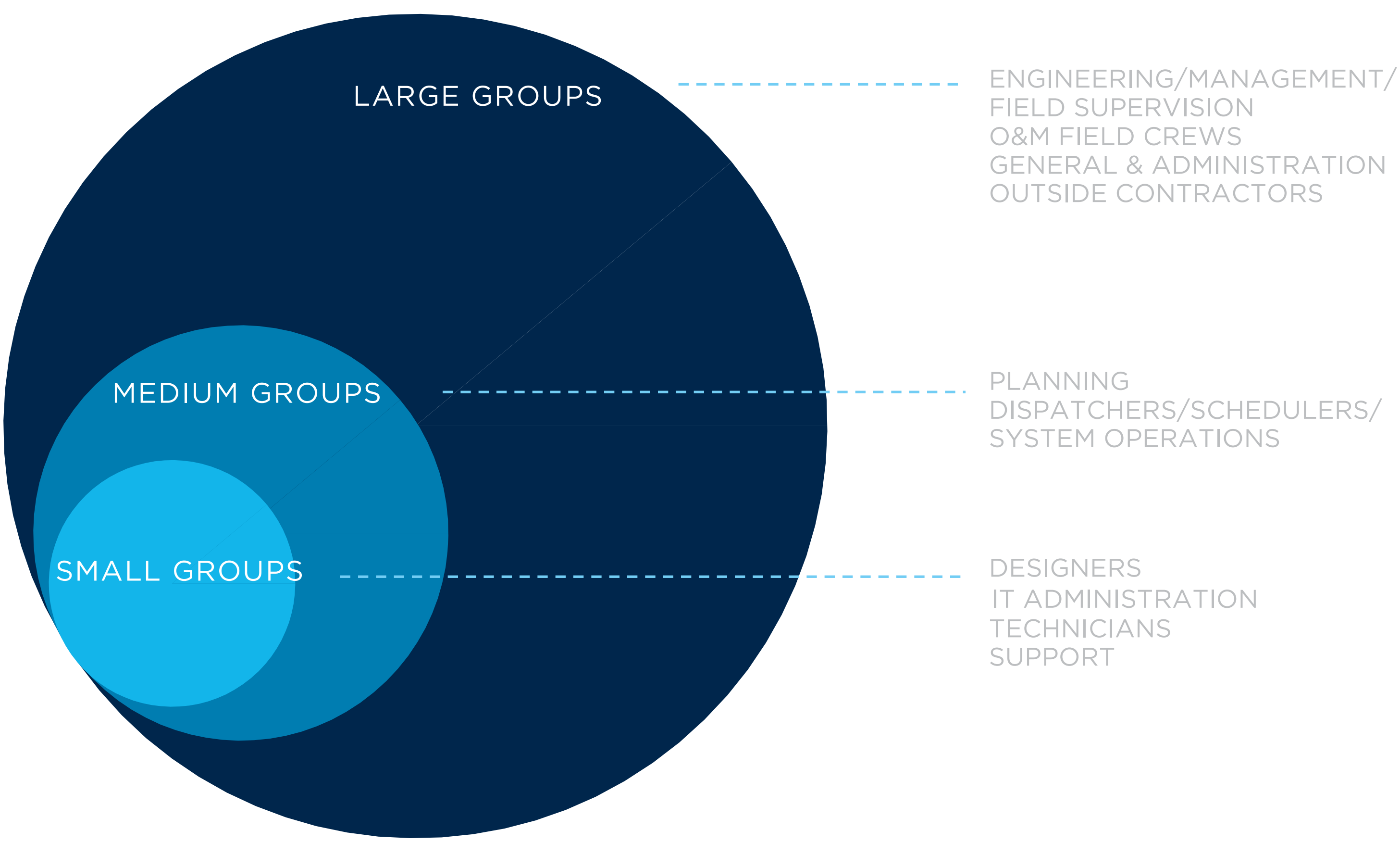
Below, the relative size of various groups within a hypothetical utility's T&D organisation is shown.

When design tools make direct labour contributors more efficient, a portion of those efficiency gains are directly realised as a cost savings in terms of the collective salary budget for a group of designers. Even larger portions of those efficiency gains are realised indirectly, because of the impact better designs have on the performance of the other job functions outlined above.

For perspective, a typical U.S. investor-owned utility has billions of dollars of installed assets on its system and spends hundreds of millions per year in associated O&M activities to maintain those assets, including salaries and wages of employees, expenses associated with installing new equipment, and the direct capital expenditures for the new equipment itself.

A utility with £5.8 billion in existing T&D assets (or so-called "Plant in Service" from a FERC accounting point of view), typically has about £290 million in new T&D additions to plant in service every year.

Consider a hypothetical £290 million capital project. The improvement in design tools yields efficiencies for designers and engineers, but the resulting direct savings has been on the order of £600,000 to £1.2 million annually in terms of labour cost reductions. This is off of a design and engineering labour component which overall only amounted to perhaps five percent of the capital budget (i.e. £15 million out of £290 million).



INCREASED REVENUE

1 Reducing the time to close out work orders, thereby bringing customers on line faster and accelerating related cost recovery.

2 Connecting new electric service sooner and increasing associated electric sales revenue.

3 Higher customer satisfaction.

REDUCED CONSTRUCTION COSTS

1 Lower rework (fewer false starts on jobs due to lack of all the necessary equipment, materials, staff/certifications on hand).Reworks can be very expensive, even if they occur only one percent of the time.

2 Better work execution due to improved work plans and more useful drawings and job packages, thereby lowering construction budgets and associated expenses.

3 Less frequent cost overruns due to fewer instances of not staying on schedule or going over budget.

REDUCED RELIANCE ON 3RD PARTY CONTRACTORS

1 When in-house employees become more efficient, headcount is maintained, but overflow work that was previously done by outside contractors can now be brought in-house.

2 Work handled by outside contractors still involves a lot of paperwork for it to be tracked and administered by in-house personnel, making it a higher expense than 100 percent in-house work.

REDUCED ONGOING O&M COSTS

1 Easier to use design tools reduce the time to train new design staff, yielding more efficiency for the design team as a whole.

2 Better design and work packages increase job satisfaction among design and field personnel and free up personnel to engage in critical thinking that previously would have been more difficult due to the overloaded schedule. You also have efficiency gains because personnel collaborate more widely and deeply. (These gains also raise the realisation levels of many of the other benefits already mentioned.)

USING BENEFITS TO MEET NEW CHALLENGES

As Duke Energy's efficiency gains and work improvements across substation design and T&D design functions are maintained and increased, the benefits are now being leveraged across a more dynamic and complex business environment. As a result, deeper usage of newer versions of these tools is now under way to gain a set of new benefits and meet new challenges.

The new challenges for Duke Energy include efforts to support ongoing improvements in engineering, technology, business, personnel, and customer service-related areas. These challenges include:

- Supporting real-time DMS and EMS systems by performing more timely and more accurate updates of the as-built asset model and as-operated network connectivity models
- Tracking and demonstrating compliance with standards in more detail and with greater accountability
- Benchmarking and implementing best practices between subsidiaries that increase the efficiency of O&M and customer service activities
- Lowering O&M costs whilst continuously striving to improve safety, reliability, cost of service, and customer satisfaction levels
- Communicating more e ectively with an increasingly complex stakeholder and shareholder community

Prioritising these challenges is quite a challenge in its own right. Even though compliance and model accuracy are interdependent and of primary importance, a necessary condition to achieving and maintaining them is to attract and retain talented personnel, and equip them with the best possible tools.

The design function and related workflows play a key role in meeting new challenges, by ensuring model accuracy not only during the initial design phase, but through the whole life of the O&M cycle. It is essential to maintain and improve upon asset and connectivity model accuracy, and speed of updates throughout the process. By improving speed and accuracy of the connectivity model updates, we optimise the use of real-time data for EMS, DMS, OMS and WMS to support Duke Energy's sustainability goals, including deeper integration of renewable energy sources.

Among other new challenges, the workforce is changing dramatically. Experienced, seasoned designers and other engineering staff are retiring. Employee turnover is becoming a greater trend among relatively new hires, and the use of third-party contractors is increasing.

In this regard, several significant benefits should be pointed out with respect to model-based design standards:

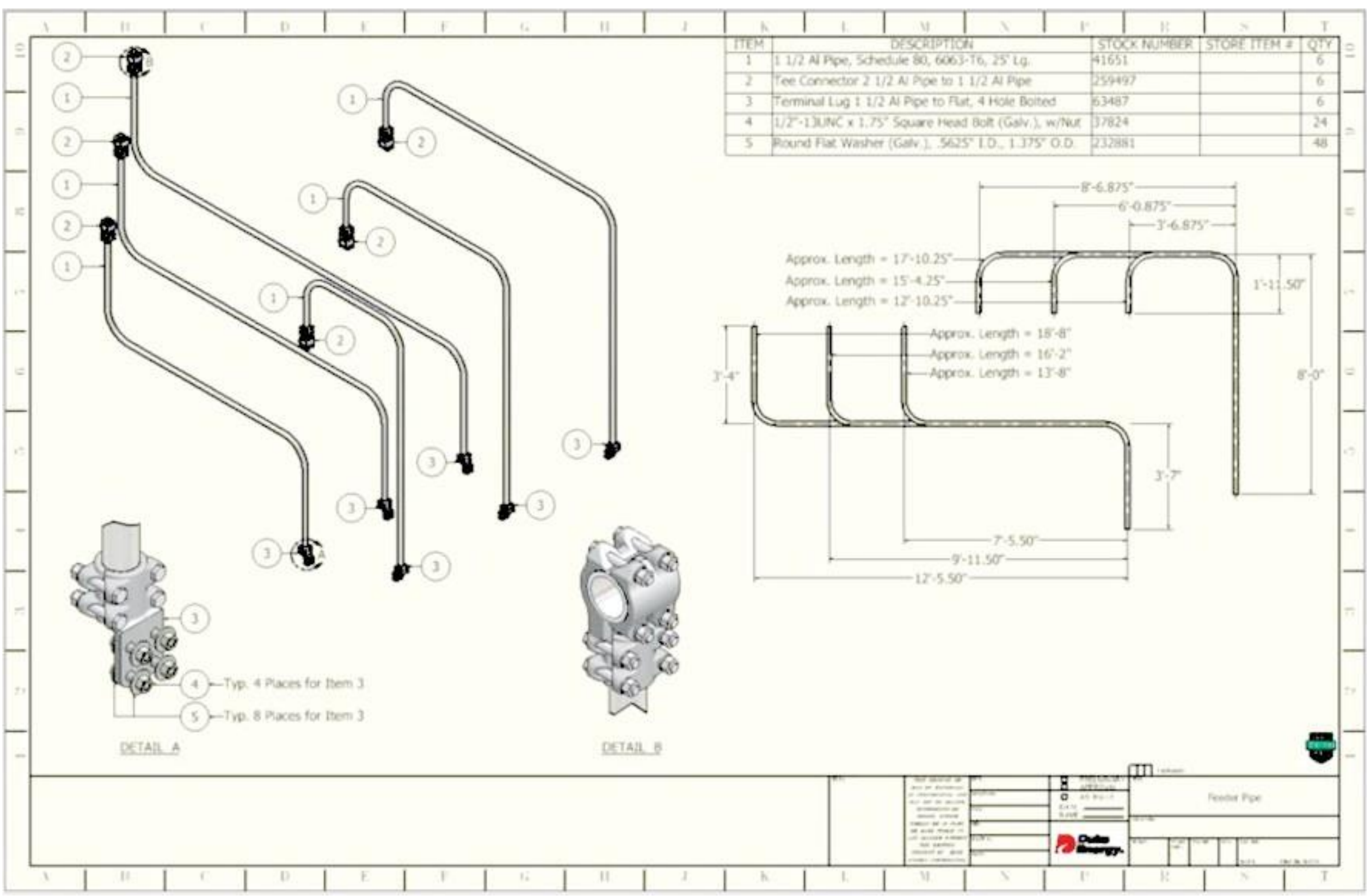
Model-based design standards optimally capture the knowledge of seasoned employees. These tools are deeply interactive during the design process, in ways that reduce training time and maintain best practices and expertise. In contrast, design tools that rely upon templates or look-ups of static models are not interactive, and although they may mimic optimised model-based design solutions, they are not learning and adjusting as conditions change. Some jobs will involve "one-off" exceptions to the criteria-based selection templates. Although these jobs may be the "20" in the "80/20 rule," they can end up taking more and more of the designer's time, forcing manual modifications to various blocks in certain compatible units that become expensive to maintain and update.

calculations and pushes design recommendations to the designer, which can include calculations for sizing of equipment, voltage drop, and context-specific calculations related to hardware, fixtures, and attachments to accompany selected pole-mounted equipment (e.g.cross-arms, supporting fixtures, and guy wires).

Having a model running these optimisation algorithms based on engineering standards during the design process involves a depth of capability and accuracy level that goes beyond what is available with systems based on databases overlaid with drag and drop tools and template-driven menu selections.

Designers utilise the new CAD-based 3D visualisation and modelling tools not only to perform so-called "what ifs" to optimise designs within the design department, but also to collaborate with construction crews more easily. Using 3D visualisation tools better enables "build-ability" of prospective designs to be understood in advance by enabling personnel to see what the completed project will look like, and to get buy-in where needed with other stakeholders before finalising prospective designs.

Even though some individuals consider themselves good at visualising final results based on 2D drawings (whether in the substation or transmission context or also in a distribution environment where assets may be "crowded" together), the consensus with complex projects is that 3D visualisation tools improve everyone's capacity to understand what results will look like, and to help determine which design option is the best one for a particular project.



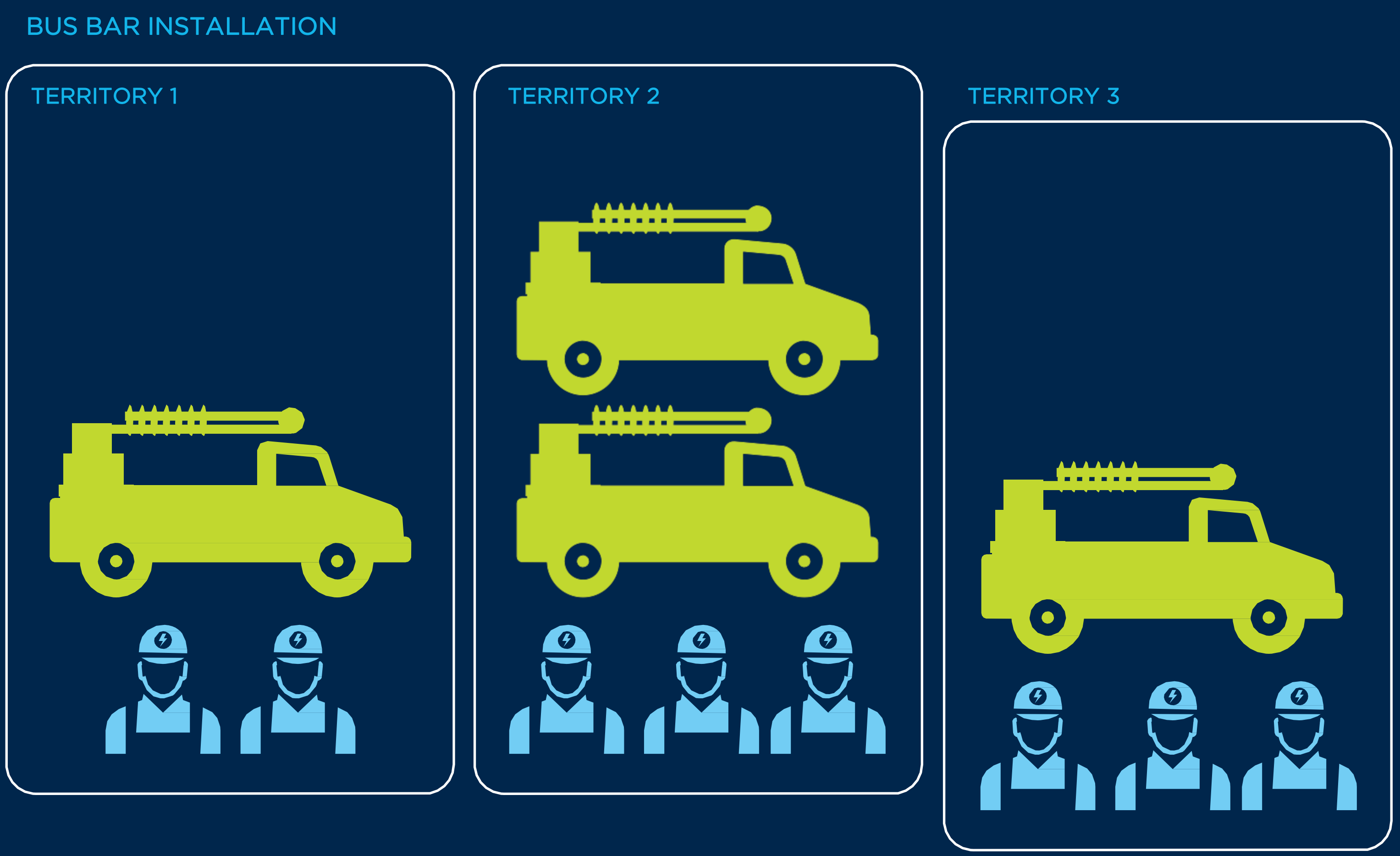
Common software tools for design and work management and their linkages to ERP, including labour/job costing estimations and accompanying bills of material (BOMs), still need flexibility for allowing a wide range of diverse work practices and regional or departmental differences.

As an example, consider a job involving installation of a new bus bar and associated supporting structure. The same work plan, in three different operating territories, may have to be carried out in three different ways.

With Duke Energy's new intelligent model-based design solution, the job costing estimate in the standard for installing these structures accounts for these types of jurisdictional differences found across various geographic service territories.

As a result, the standard becomes a flexible tool, where Duke Energy, at the holding company level, can have the standard, whilst its various subsidiaries can tailor their designs, work packages, job estimates, and accompanying BOMs to it. Benchmark-based optimisation of work processes is better enabled as a result of the single standards. In addition, day-to-day IT, periodic upgrades of the solution, and other systems support costs are minimised.

In contrast, without model-based design standards, having "equally" common software tools across all these subsidiaries could still yield higher overall costs in terms of daily support, training, and periodic upgrades, because of time consuming customisation work required to address numerous "one-off" real-world situations that do occur.



Significant savings and benefits were found with the more widespread standardisation of design tools, beyond the substantial benefits of efficiency improvements within the design function itself. Another tier of benefits, based on additional cross-pollinating of best practices and standardising of design tool usage, is in the process of being realised.

As mentioned, improving the designer's efficiency directly results in savings, given the fact that hundreds of designers are involved. Not only have these improvements within the design function made these Design departments more efficient and improved their work output, but other benefits are also being enjoyed.

1 IMPROVING RETENTION OF DESIGN STAFF

Among other new challenges, the workforce is changing dramatically. Experienced, seasoned designers and other engineering staff are retiring, employee turnover is becoming a greater trend among relatively new hires, and the use of third party contractors is increasing.

RETAINING WORKERS

Improving the retention level of design staff has become increasingly critical with new designers coming on board in recent years. Generation X, Millennials, and younger tech-savvy new hires at utilities, like new hires at other companies, no longer expect a guarantee of lifetime employment and, unlike past generations, they do not feel tied to their employer. If they get bored they move on to jobs elsewhere where they feel they have access to the latest and greatest design tools. The increasingly evident employee retention benefits from optimised design tools are driving Duke Energy to upgrade and improve these tools. Specifically, by adding newer 3D modelling capabilities for Building Information Modelling (BIM) projects, along with interactive visualisation and real-time 3D walk-through capabilities, young designers who had been ready to leave their jobs were excited about staying on board when they saw what the new CAD-based intelligent design, visualisation and modelling and tools could do.

ATTRACTING WORKERS

Younger, more tech-savvy new hires are attracted to jobs using the latest design tools with 3D and modelling/visualisation/virtual reality capabilities. Their expectations for software tools at work are continually being raised by comparisons they make to software tools they use outside the office, including gaming and web-based tools that they have been using for recreation as well as research and study. The ability of intelligent model-based CAD tools to mimic the capabilities of these familiar systems already in the new designer's skill set reduces training costs and increases employee engagement.

2 FURTHER REDUCTION IN CONSTRUCTION COSTS

Just as in the first tier of improvements, Duke Energy saw reduced occurrences of reworks and errors, in the new tier benefits continue and deepen improvements in this area.

BETTER PLANNING

The use of the latest visualisation, modelling and design tools will better enable engineering personnel to anticipate and avoid potential interferences or clearance issues. Designers also use these tools to simulate complex 3D situations involving multiple utility services in dense urban areas, both above and below the street. These tools also facilitate creation of detailed project plans that more dynamically comprehend construction-related logistics, schedules and complex site planning issues.

OPTIMAL USE OF CONTRACTORS

Regarding the so-called General & Administrative (G&A) expenses, a typical investor-owned utility has a large expense in this category, including salaries. Along with direct utility employees, expenses associated with outside contractors represent an additional design-related expense. At Duke Energy, outside contracted designers use the same design tools as in-house designers. Even if one were to only look at the benefits of improving the in-house design function, given the fact that designers typically are a costlier asset than the average T&D employee, efficiency improvements for in-house design staff represents greater potential savings (particularly when the improvement allows these in-house designers to take on "overflow" work that otherwise would have continued to be done by outside contractors). Remaining contractor work can often be more focused on specialised areas where there is greater overall benefit at relatively lower incremental costs.

3 INCREASING SCALE OF ONGOING O&M COST REDUCTIONS

Duke Energy has been benefiting from ongoing opportunities for cross-pollinating and benchmarking best practices. Every time a design is improved and makes field crews more efficient or lowers the error rate, the benefits can be many times larger than the benefits of the designer's direct labour contribution to the annual expense.

AVOIDED WORKFORCE REPLACEMENT	Costs of hiring and training replacement designers are avoided as employees stay on board to use newer technologies.
REDUCED PRODUCTIVITY RAMP	New design staff becomes fully productive more quickly because of better design tools and efficiency is greatly increased.
INCREASED ACCURACY & EFFICIENCY	Errors (such as false starts on jobs) are decreased because of better design tools, crew efficiency is increased, and significant benefits are realised from lower labour costs and better utilisation of associated equipment
IMPROVED CUSTOMER RELATIONS	New construction projects are completed sooner, resulting in a relative increase in overall revenue as the residential or commercial/industrial customers move forward, helping to attract new customers to the service territory and promoting better retention of existing customers.

Optimal use of tools that enable, support, and track compliance with engineering and design standards is vital to Duke Energy's continuous improvement efforts.

Intelligent, model-based CAD design solutions are a key element of these efforts and will continue to play a vital role in standards within Duke Energy's design tools to ensure continuous improvement efforts are successful.

Duke Energy will continue to reduce cycle time whilst increasing the accuracy of as-built asset and as-operated network models for O&M field work. It is optimally supporting engineering design standards through deeper use of intelligent modelling tools, along with greater utilisation of 3D visualisation and modelling capabilities that will enable these ongoing improvements.

Arnold Fry has 22 years electrical industry experience, including 16 years with Duke Energy, where he is currently manager of Engineering Standards and Transmission Asset Management. Arnold has served as the Business Project manager for development and implementation of the Substation Design Solution, which will be used in multiple design offices including North Carolina, South Carolina, Ohio and Indiana. His newly expanded role includes managing the Transmission Standards group, which is responsible for service territory in Indiana, Ohio, Kentucky, North Carolina, South Carolina and Florida.

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