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DESIGNING OPERATIONAL EXCELLENCE

Financial and Service Performance Improvements and the Role of Intelligent, Model-Based Design and Visualization Tools

December 2012

WHITE PAPER

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EXECUTIVE SUMMARY

Utilities are seeking to improve numerous workflows and address critical workforce issues to optimize their financial and service performance. Outside of capital equipment, fuel, and/or purchased power costs, personnel-related expenses are among the largest expense categories at the typical electric utility and equipping that workforce with the best possible tools is one of the strategies for achieving performance optimization across the organization.

Although personnel involved in the design function across T&D and substations are not a large group compared to other job functions at a utility, their activities have major impact on the efficiency of many of the utility's mission-critical workflows. Better design tools yield cost savings within the design function itself, but also play vital roles both in improving customer and stakeholder satisfaction and in enabling systems that are key to ensuring reliability, safety, and operational excellence.

This research surveyed the improvements in best-in-class design, modeling, and visualization tools and how they are contributing to overall change within the utility's critical design function that affects both service reliability and customer satisfaction and the management of their increasingly complex asset base and O&M activity mix.

FINDINGS

Participants universally recognized the importance of the design function, both for meeting internal transmission, distribution, and substation department goals as well as for meeting overall company goals.

In their relentless pursuit of optimized customer service, leading utilities described their efforts to use design and modeling-related improvements to provide better support for real-time operations and more accurate models of the T&D system.

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Utilities have had to fine-tune how they manage risks associated with their capital investments in response to today's greater dynamism in the business, engineering and regulatory landscapes. They can no longer rely on steady annual growth in the asset base to mitigate risk but they believe employing 3-D visualization tools to share potential designs with customers and stakeholders earlier in the approval process, to optimize processes for fine-tuning designs prior to final approval, and to more accurately predict project timelines will help in their overall risk management strategy.

There are additional business drivers for improving design and modeling tools, including better utilization of already lean-running staff, significant employee-related benefits associated with improved recruitment and retention, optimization of utilization of equipment and resources, greater uniformity of workflows and processes, more effective transfer of standards and best practices from experienced personnel nearing retirement, and shortened learning curve as newly-hired designers reach full productivity months ahead of plan.

Respondents highlighted the importance of the engineering uniformity in the various design tools being used across the organization, and process uniformity to link these design tools to ERP, Work Management, and other systems. For them, having the same design tool across distribution, transmission, substations, and production is not as important as having a consistent set of processes supporting the engineering standards embodied in the various design tools. Workflows that maintain and help track compliance with standards are helping these utilities meet operational excellence goals while minimizing costs.

Expanding on process uniformity benefits, respondents cited greater efficiency of field and construction O&M work, deeper benchmarking of best practices, reduction of costly "exceptions" out of O&M systems and processes, more accurate data essential to network connectivity modeling, and lower training, daily support, and integration/upgrade cycle costs.

Another benefit comes directly from the increasingly complex operating environment. For example, a large investor-owned utility with multiple

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subsidiaries in different states pointed out the importance of their uniform design tool in lowering costs even though some state laws created significant differences in labor costs for the same job. The standards-based design modeling engines calculate these cost differences while employing compatible units that maximize uniformity of other key processes and optimize material ordering, accounting, and reporting. Absent a tool that could build bridges by means of standards and compatible units, this company would still be facing higher expenses across most of the above-listed items, even though it has standardized its design tools as well as accompanying solutions associated with work order execution (ERM, EAM, etc.).

Utilities represented in the sample are seeking to increase the uniformity and efficiency of workflows that employ data from design solutions across their current mix of WMS/OMS/EAM/ERP and GIS solutions. All 31 participants recognized the key role played by better design solutions, whether in distribution, transmission or substations, emphasizing it as critical (55%), very important (40%) or important (5%) to achieving service excellence while minimizing costs.

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BACKGROUND AND GOALS OF STUDY

The goal of this research was to determine the value of optimized intelligent-model based design solutions in helping utilities meet key goals. The survey sought participant's views regarding their organization's use of design and related data models, visualization tools, workflows and data sharing in support of T&D and/or substation planning, design, and construction activities and in operations & maintenance (O&M) activities.

Aside from new design work, workflows of interest also involved responding to permitting requests and one-calls or the sharing/updating of drawings, schematics, models, or the output of other visualization tools in relation to existing assets or planned future designs.

The role of improved design solutions in helping utilities in their efforts to get more value out of their enterprise software systems (ERP, EAM, WMS, OMS, and new DMS and EMS systems) was also a focus area.

PARTICIPANT DEMOGRAPHICS

The participants in the 31 surveys represented a diverse mix, as shown in Figure 1.

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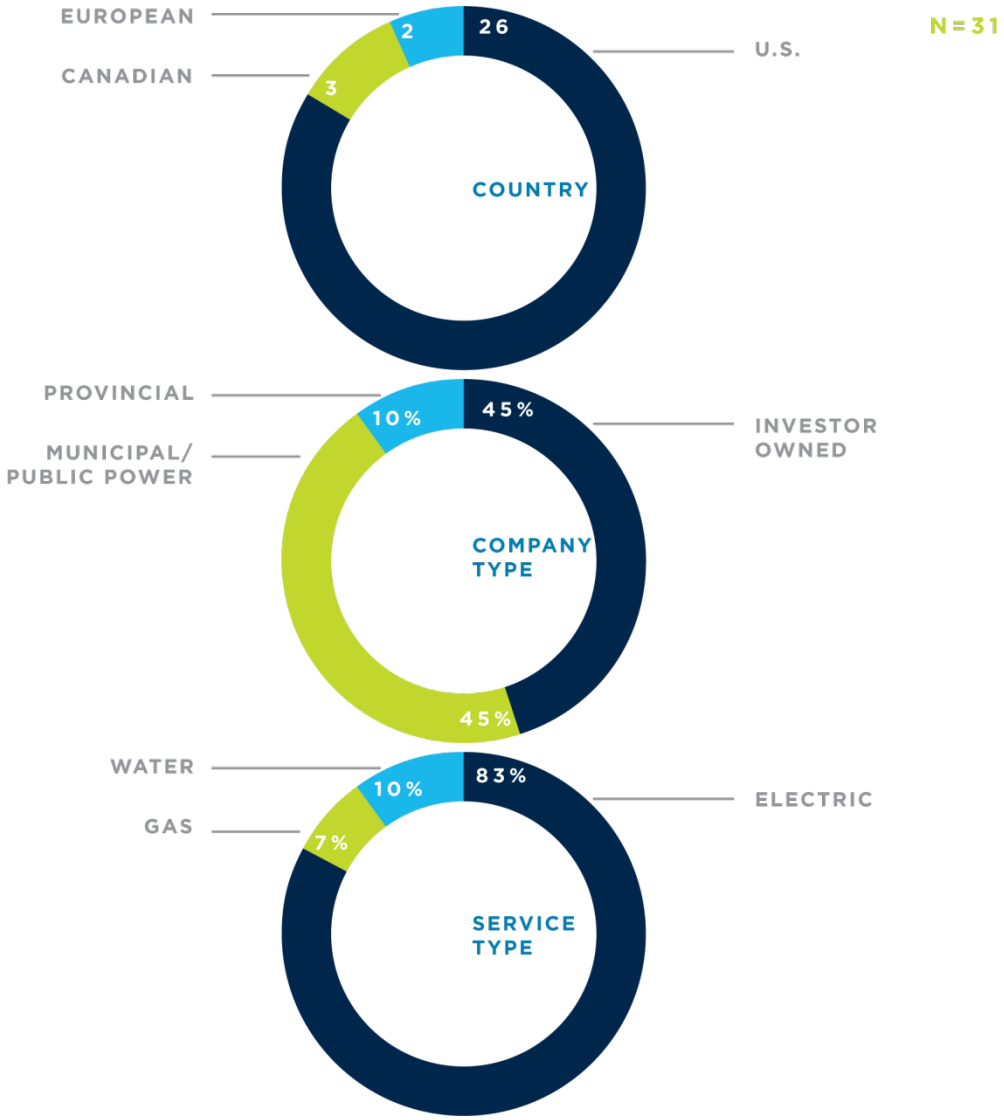
FIG 1: PARTICIPANT DEMOGRAPHICS



In terms of the individual design groups within these utilities, the survey sample consisted of a broad and comprehensive mix of small, medium, and large design departments.

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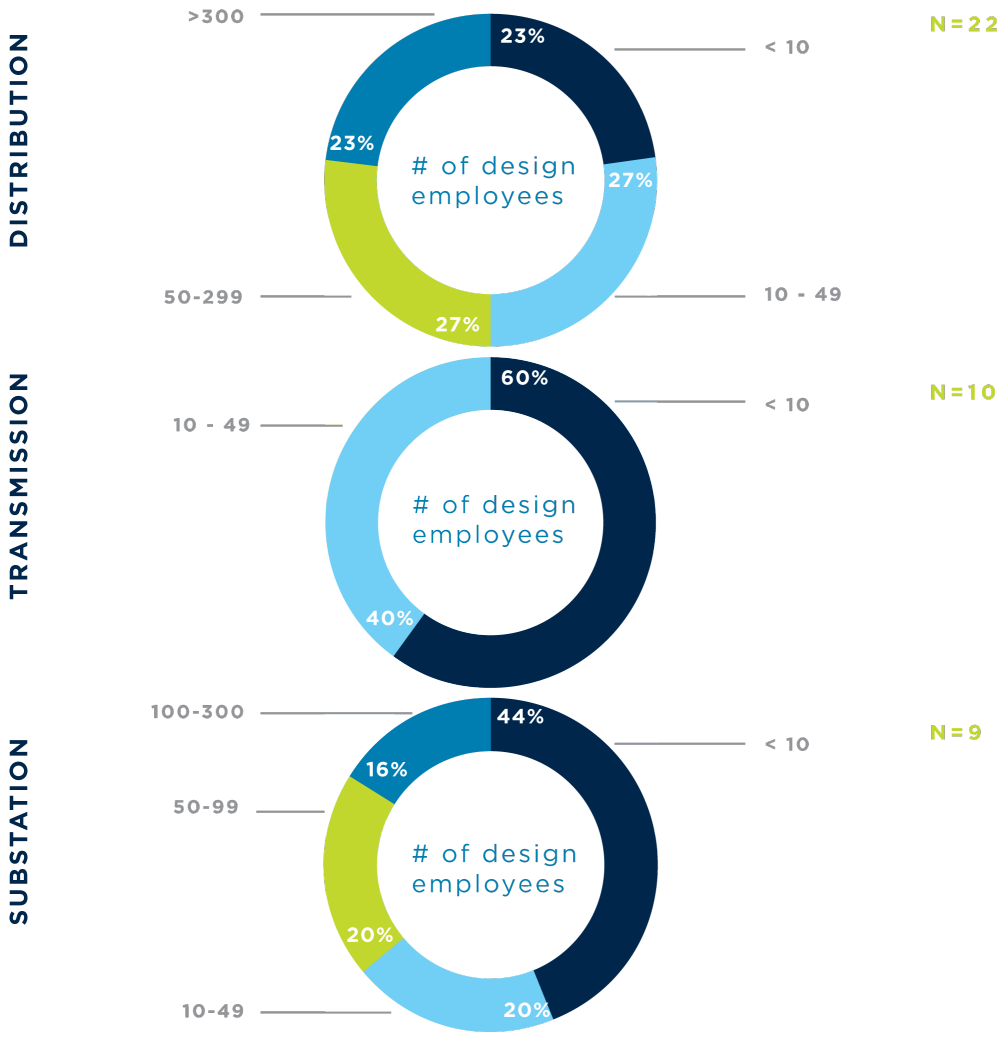
FIG 2: WHAT IS THE APPROXIMATE NUMBER OF IN-HOUSE EMPLOYEES IN YOUR DISTRIBUTION, TRANSMISSION, AND SUBSTATION SYSTEM DESIGN DEPARTMENTS?



As detailed later, aside from the fact that substation and transmission jobs are typically larger and less numerous than those in distribution, a key reason for differences between these groups is that a higher proportion of design work is outsourced to third-party designers in substation and transmission design than in distribution design.

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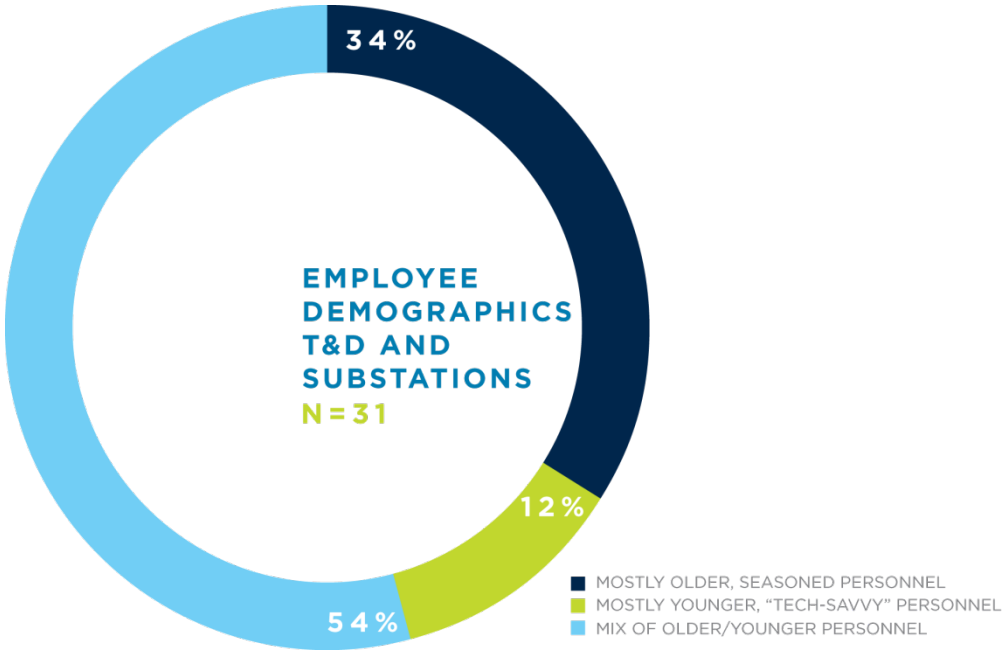
TODAY'S DESIGN LANDSCAPE

Across the different design groups, participants characterized the existing demographic mix of design employees in similar ways. Given the ongoing retirement of older, more experienced workers and influx of younger personnel, the ages of the typical design staff is relatively mixed. Whether respondents worked in distribution, transmission, or substation design (or in gas or water) the dominant demographic group was "mix of younger and older personnel" at 54% (n=31).

There was variation in the prevalence of the "mostly older" category, which averaged 34% across the three groups, but was significantly lower in distribution design (25%, n=31) than in transmission (44%, n=18). Substations were near the average of all 31 survey participants in terms of the prevalence of the "mostly older" category for design staff (at 33%, n=18).

FIG 3: HOW WOULD YOU DESCRIBE THE CURRENT DEMOGRAPHICS OF MOST OF THE PERSONNEL IN YOUR DESIGN GROUPS (ACROSS T&D AND SUBSTATION)?



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Comments indicated that the incoming personnel need to be equipped with the latest software for modeling, design and visualization not only because these tools will help them be more productive and easier to train, but also because job retention will be significantly increased, along with equally-important capabilities to capture the know-how of older, more seasoned engineering and design personnel, transfer it, and make it part of the institutional "memory" of the design team.

Numerous survey participants said that the level of sophistication of the design tools supporting these personnel can make a big difference in terms of the level of employee retention.

The more tech savvy younger newcomers having been surprised to see less than the latest technology...

These younger employees ... increasingly feel less and less loyalty to their employers. Anyone who thinks the utility industry is immune to this is living in a dreamland because I've been seeing it at many utility companies.

[They] are up on the latest technologies, and want to stay that way. They will move to other companies or industries if they do not feel they are staying up to date in their work by using the latest design technologies. They want to feel they are accomplishing something, and want to be challenged."

Improving employee retention and lowering training costs are made more significant by an additional research finding that distribution, transmission and/or substation design staffs are typically a more expensive resource than the average staff members of their respective organizations.

Specifically regarding relative costs, when asked to compare the costs of design employees in their department to the average employee's salary in that department, 53% of all respondents indicated a higher salary, 47% said it was about the same, and none said that designers had below-average salary levels.

Respondents indicated that within the design department, new design tools have also led to cost savings resulting from better job retention.

In terms of ROI, comments indicated that employee retention is becoming an increasingly important consideration. Departmental training costs are a great deal higher if employee turnover is higher. This creates a strong incentive (beyond efficiency and numerous other direct benefits) for upgrading to the latest technologies in design related software solutions.

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In terms of younger personnel learning from older ones, there were multiple instances of survey respondents who made comments about it being a two-way street. For example some participants referenced the ability of younger personnel to get up to speed faster than older ones who resisted new technologies. However another participant emphasized that the push-back against new technologies by older personnel was much more pronounced among field workers than among design staff.

In the past before we upgraded our design solution, if a work package's drawing was not 100 percent accurate, you knew since you had more experienced field personnel, that they could still do the work correctly and mark up the drawing to correct it and send it back. Now, as people are coming on board that have less experience, it becomes more important that the design be more accurate for the field workers. Also, now the work has to be done in a timelier manner, because you have very limiting construction schedules.

Regarding field personnel versus those working in the design function behind a desk, one participant mentioned that the brain drain in the field was as big of a loss as that in the office, and said their new design tool contributing to better knowledge transfer between older experienced employees and young new-comers was just as important outside the design department as inside it.

Our research clearly indicated that decision-makers who have seen the benefits of intelligent, model-based design tools view it as an opportunity that they can better attract and retain new designers by using leading-edge design tools as a way to help address the significant demographic shifts which are occurring in the work force. Design tool leadership has a good influence when it comes to dealing with to the influx of younger, more tech-savvy personnel:

"As you get new engineers coming on board if you have a really strong design system and you have good compatible units they become productive much sooner, instead of it taking two years for them figure out how we design our distribution system. We can use the technology to build the institutional knowledge into the application. So when they sit down at their desk they have all that knowledge built into it instead of their having to learn at the knee of a more experienced engineer."

Our questions in this section delved deeper into the make-up of utility staff, beyond age and salary comparisons, by getting participants to estimate the relative size of design staff compared to the groups being served by design teams. Specifically, respondents were asked to estimate what percentage of overall department headcount was represented by designers.

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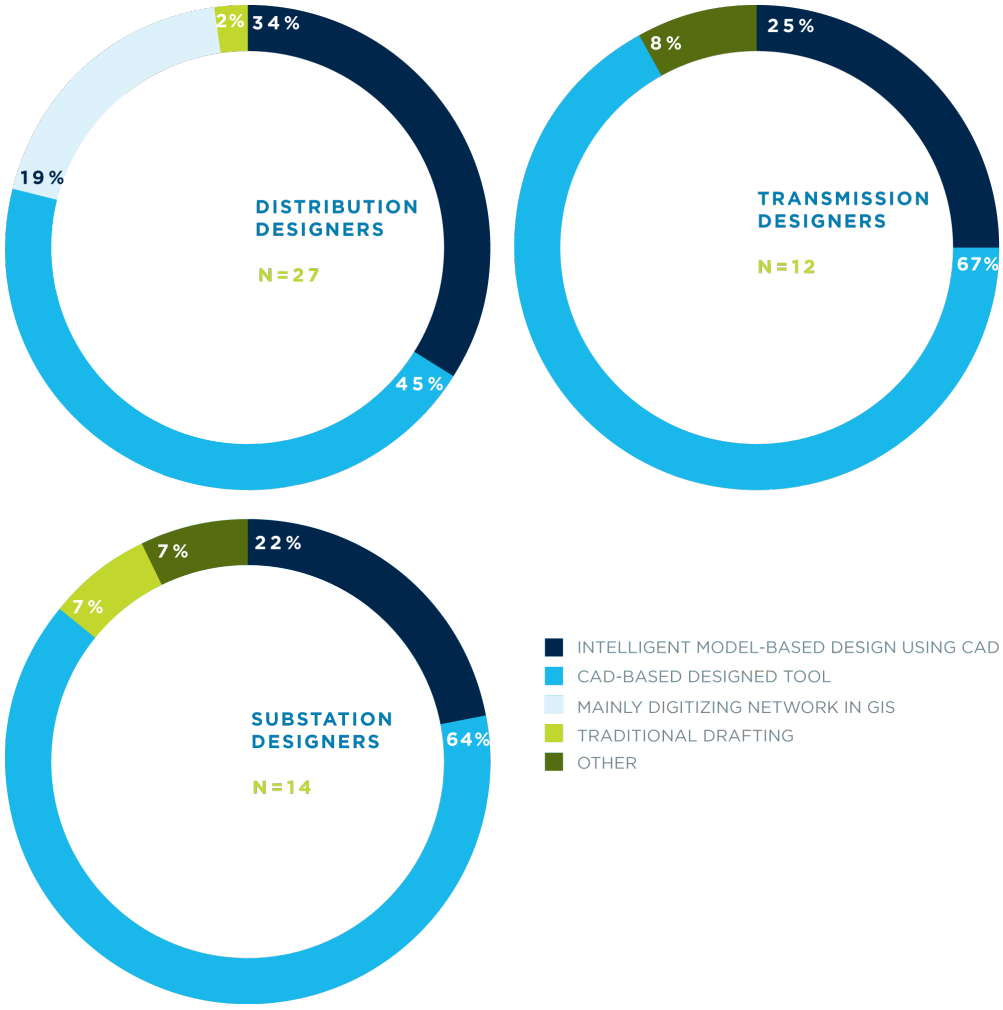
Estimates for distribution design staff as a percent of total distribution staff were slightly higher than that for substation and transmission, with the majority of the latter two groups being in the 2% to 5% range, while distribution design groups typically representing between 5% and 10% of overall distribution employees. In terms of participant's existing design tools, the following shows the mix for the distribution, transmission, and substation design areas:

FIG 4: HOW WOULD YOU DESCRIBE THE MAIN DESIGN TOOLS YOUR DESIGNERS ARE USING?



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As shown in Figure 4, transmission and substation design teams report a lower level of current use of intelligent-model-based design tools, and report no digitizing of the network in GIS. It was only in distribution that the GIS option was given.

We are bringing in data from the GIS as a starting point…so we do not have clipping issues or data age issues…once imported these become objects in a CAD drawing and in our connectivity model.

These respondents also indicated in some cases that they had partially completed a planned path to utilizing an intelligent, model-based design solution using a CAD tool.

Several participants described using blocks or CUs and are benefitting from having these CUs linked directly to materials in their purchasing system catalogue.

In addition, interest in 3-D design tools was high, with 92% of participants (n=26) saying there was interest in adding new 3-D capabilities or upgrading/expanding upon existing ones, and only 8% of decision-makers saying their companies saw no value in 3-D capabilities or were undecided about adding more of them.

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DRIVERS FOR CHANGE

Along with the dynamics of the changing workforce, other drivers for design solution improvements often focused on better serving customers and improving reliability and safety performance while optimizing costs, were made clear in the research.

Technological improvements in integration and data sharing will enable utilities to get more value out of their enterprise software systems that use GIS-based models. Our research findings that highlight key impacts of design and modeling tools on other parts of the organization become more significant given the fact that the comparatively small number of personnel directly involved in the design function is highly leveraged across the entire organization. Designers need to provide work packages, drawings, schematics, and other output that uphold engineering standards and help optimize downstream workflows.

Both the quantitative data, as well as comments by participants, confirmed the impression that it is foolhardy to do anything that yields sub-optimal designs in the name of potential cost savings based on increasing throughput in the design group. Mistakes in work packages and inaccurate designs are much more costly and can be much more detrimental to safety and reliability of service.

Having more accurate data and better real-time updates of the models built on that data was given a high priority by survey participants, who frequently referenced their initiatives to improve grid operations.

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In addition, the research brought to the forefront the importance leading utilities are placing on the need to better communicate about complex decisions and share real-time data more effectively within a wider network. Collaboration is becoming increasingly important, given the involvement of numerous stakeholders, external agencies, interested parties and diverse business participants, and the quality of the tools the utility employs for these collaborative activities becomes a very public element in the brand experience and image the utility builds in the wider community.

The quality of collaborative tools and related tracking capabilities has more direct impact on participants involved in the third party contractor community, due to extensive outsourcing of design and construction work in transmission and substations, and the desire for flexibility in outsourcing construction and O&M work in distribution. All of these things increase the need to share information in and out of the utility.

This might seem surprising but we are in a pretty good state already regarding design solution accuracy, integration and improved workflows, even though they can also be improved, but what really makes the difference in the real world is how clearly and easily you present information. When you use the best design and modeling tools to make those presentations to others, including high-level management, the presentations have wowed them.

We can always improve on integration and accuracy and workflows, but where the money continues to support the program because it is useful, comes down to the ways you display it, whether it is getting it out on notebooks to the crews in the field or reporting to board members and executive management, how it is shown and seen is critical.

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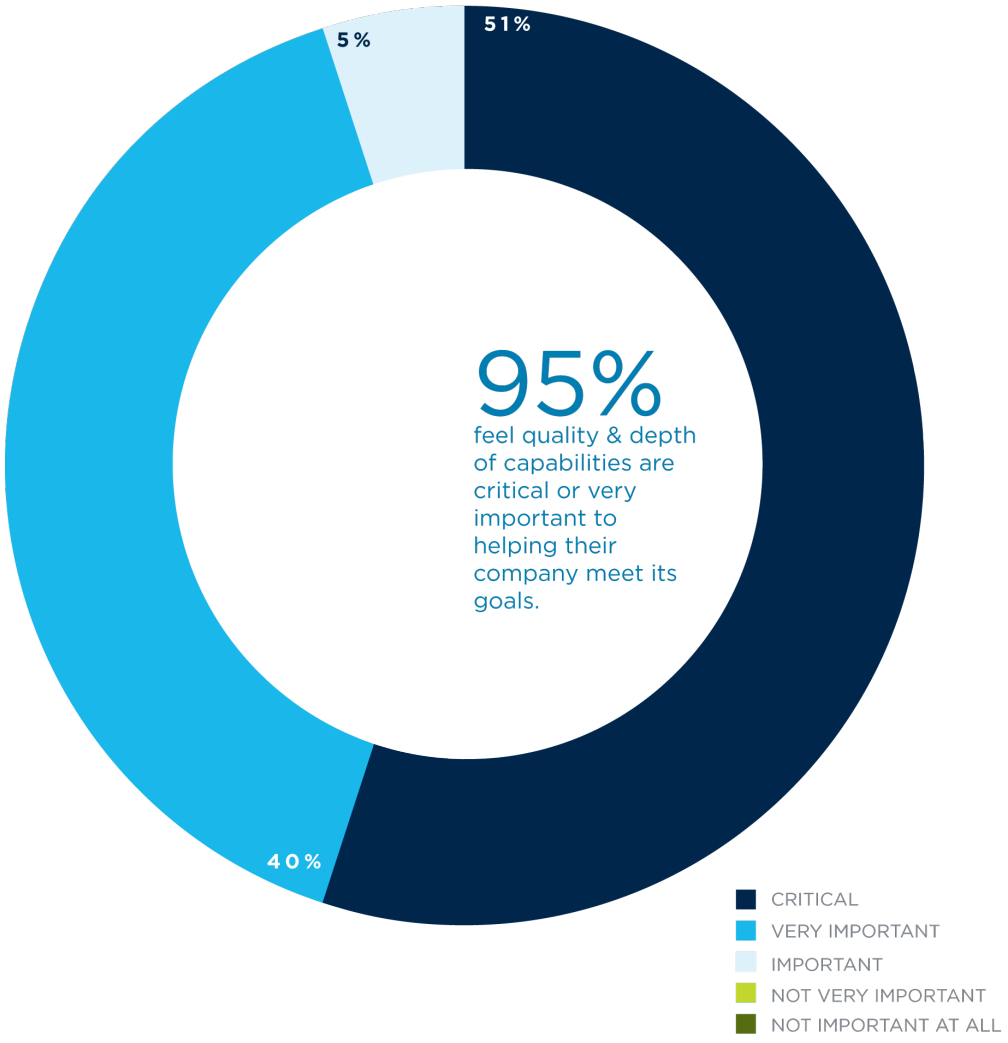
CRITICALITY OF DESIGN FUNCTION

When talking to design professionals, it is not unexpected that 95% of respondents indicated that the design function was very important or critical, with the remaining 5% rating it as important.

FIG 5: HOW IMPORTANT DO YOU CONSIDER THE QUALITY AND DEPTH OF CAPABILITIES OF YOUR DESIGN SOLUTION TO BE IN HELPING YOUR COMPANY MEET ITS GOALS?

N=31



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This recognition of the importance of the design function was clearly universal, not merely within the context of meeting department goals for T&D or substation O&M work, but in terms of meeting overall company goals as emphasized in this question.

Significantly, the above 55% criticality rating showed little difference between the three groups: 56% for distribution, 55% for transmission, and 58% for substations. None of the respondents ranked the design function as "not very important" or "not important at all".

The biggest thing you need right now are tools that are functional and reliable, that support not just throughput but quality and also enable you to more quickly get new people up to speed. Drawings need to communicate and translate into real world operational construction functions and real work. This way you don't get into those situations where the crews get out in the field and they cannot complete the work.

Drivers for this high level of importance for the design function include the need to optimize customer service by better supporting real-time operations and more accurate models of the T&D system, as well as better utilization of already lean-running staff, equipment, and resources.

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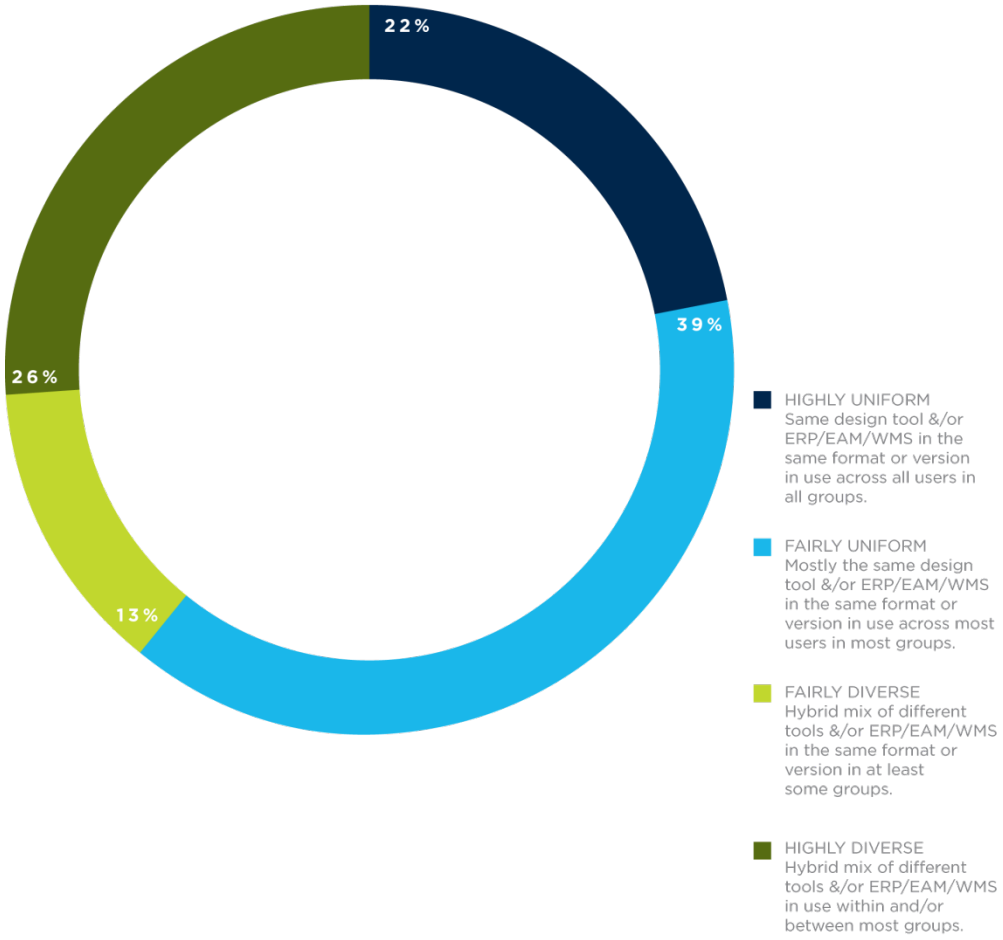
ADDRESSING UNIFORMITY AND DIVERSITY OF DESIGN SOLUTION AND RELATED WORKFLOWS

Participants were asked to characterize, across their key enterprise software solutions, the relative level of uniformity or diversity of the systems used to support design and subsequent O&M workflows and related databases. With a goal of understanding best practices for optimizing workflows, we asked participants to consider their processes for going from initial design work to creation of a work order and an accompanying bill of materials (BOM), to job execution and close-out.

FIG 6: HOW UNIFORM IS YOUR DESIGN ENVIRONMENT AND ITS ERP, EAM, AND WMS WORKFLOWS?

N=27



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The research showed that uniformity of these processes is seen as a key source of benefits in numerous areas.

Respondents highlighted the importance of the uniformity of their design solution and its linkages to ERP and other systems in helping them to meet their goals to optimize operational performance while minimizing costs. Key areas include:

- Uniformity of work orders and drawings, drives construction and field O&M efficiency
- Better benchmarking of best practices
- Wrings costly "exceptions" out of O&M systems and processes
- Ensures accurate data key to network connectivity modeling
- Reduces training, daily support and integration /upgrade cycle costs
- Optimizes material ordering, accounting and reporting
- Design tool support of consistent standards compliance

Our WMS, design tools, and our GIS system are common throughout all jurisdictions, but we still have a diversity of parts and pieces within that software. As an example we use Compatible Units to order parts and material and the related labor. The WMS is the same, and the wood pole may be the same, but we will have a different CU in each system, since in one region a crew that would set that same pole might be a digger derrick line truck with two employees, and in another two trucks with three employees. A good design tool helps the designers pick the right CU for their jurisdiction.

Respondents said uniformity benefits were key value drivers, even in the face of extremely complex environments. For example, a large investor-owned utility holding company with multiple subsidiaries in different states pointed out the importance of their uniformity of software tools in lowering costs.

This company's design tool builds bridges by means of standards and compatible units, so it can now keep costs down, not only with wholesale purchasing of the identical wood poles, but also in benchmarking best practices, optimizing software integration and upgrades, and minimizing costs for day-to-day support for the solutions.

Diversity was viewed as an undesirable necessity. Candid comments included reference to the fact that much of the diversity came from having installed systems in the past out of necessity. Such earlier systems

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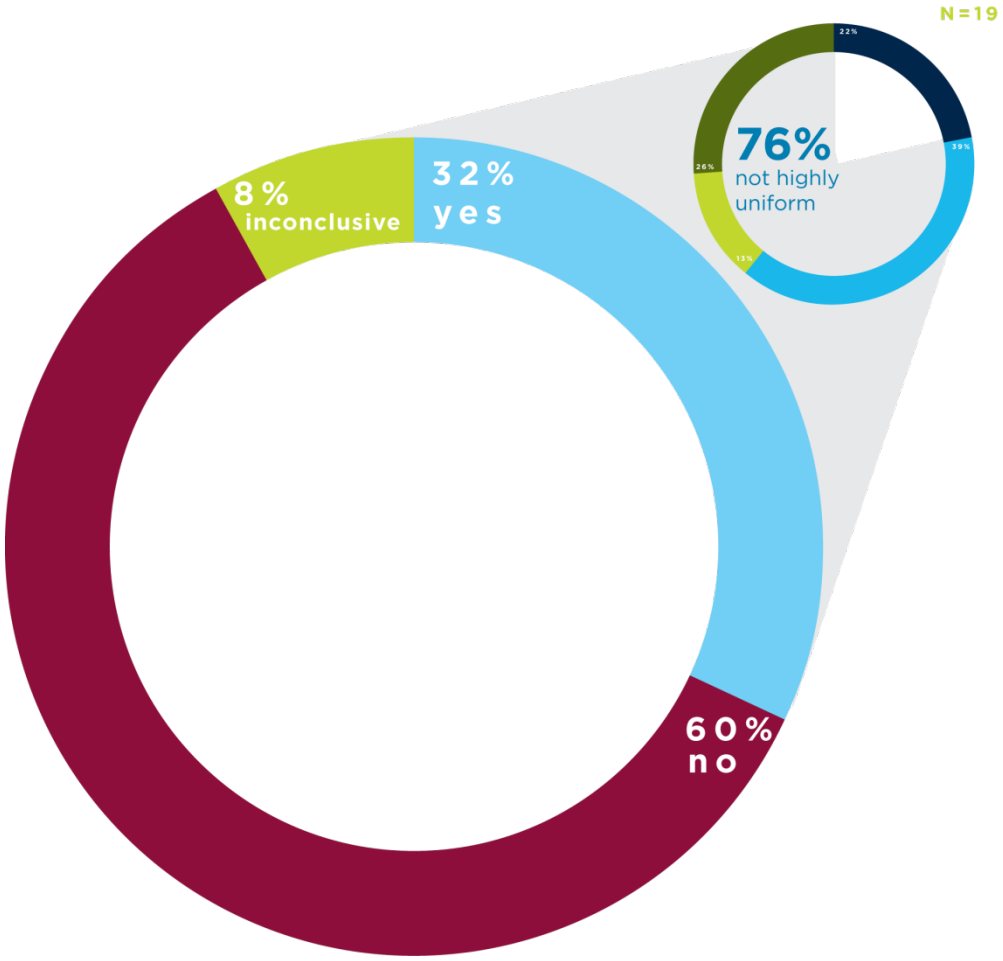
brought some benefits at the time, without there having been a perspective of the overall impact.

As of follow-on to the initial responses given about uniformity between design and other solutions described above, the following question was posed as a follow-up for the 19 respondents who said they had less than "highly uniform" design environments.

We are now operationalizing best practices, while in the past 20 or 25 years, the earlier systems had benefits of IT itself that were such a big benefit we did not have to be as process oriented. Now we are getting a next-generation set of benefits.

FIG 7: FOR THOSE NOT HIGHLY UNIFORM, HAS THE RELATIVE LEVEL OF DIVERSITY BEEN BENEFICIAL?



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I would say the biggest point of diversity is in our graphic design processes, across distribution, transmission and substations. But as you progress further along in the work order processes it merges and goes into a more consistent flow, when you proceed from the design creation to subsequent material ordering, to construction to field accounting and reporting in those systems. So it becomes more consistent in those later stages of the workflows.

Respondents highlighted the strategic focus of reducing diversity going forward and that uniformity of these processes will be critical to achieving company goals. And even when there is diversity (e.g. between enterprise systems in one area such as distribution, versus transmission or substations), there are benefits to minimizing diversity. As one participant put it:

There is value in the idea of seeking to establish uniformity as high "upstream" as possible, to integrate closer in the workflow to where the job was being done. A result is to have given workflows a higher uniformity. Flexibility of the standards-based design tools in this regard allows greater benefits to be derived from the mix of diversity and uniformity unique to each particular utility's situation.

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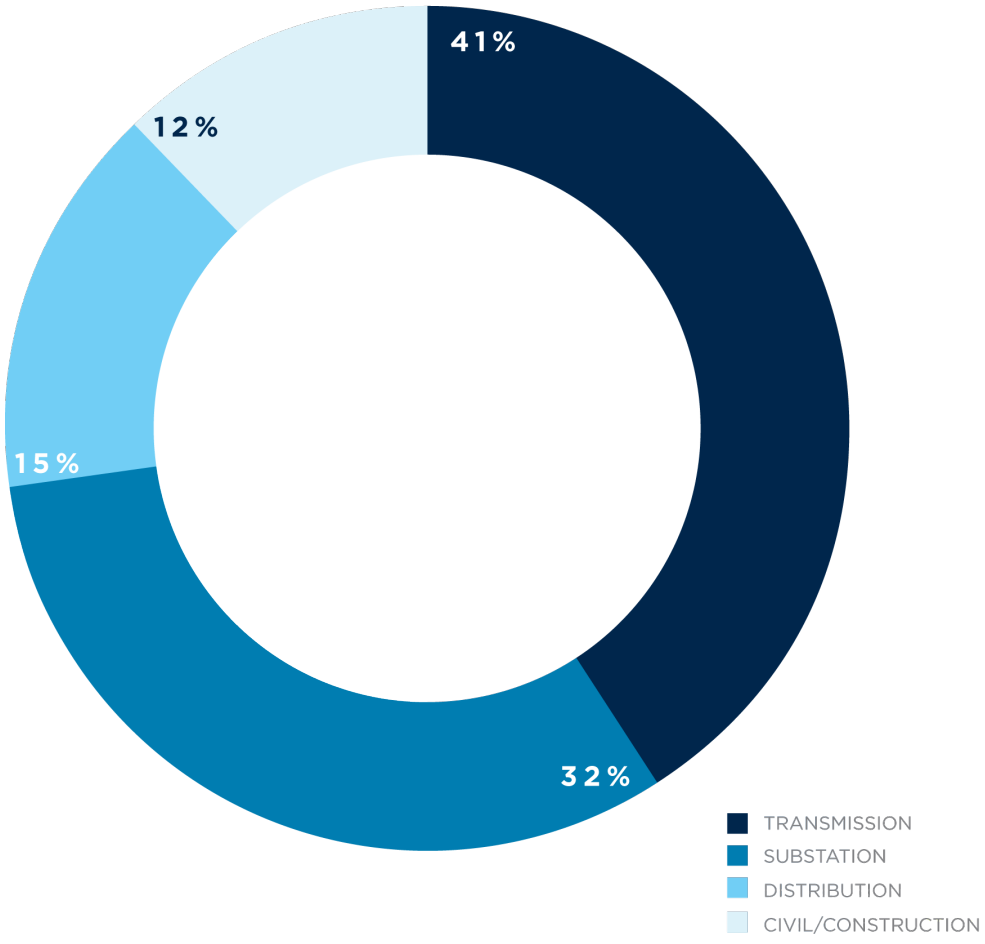
INTEREST IN IMPROVED 3-D DESIGN, MODELING AND VISUALIZATION TOOLS

Distribution system design teams are starting to increase their use of 3-D design tools, but currently remain at much lower usage levels for 3-D work compared to their counterparts in other areas of utility design work. Specifically, distribution design participants use 3-D design capabilities in only 15% of areas as shown in Figure 8, with substation more than double that amount (32%) and transmission usage levels of 3-D almost triple (41 %).

FIG 8: IN WHICH AREAS ARE YOU CURRENTLY USING 3D DESIGN TOOLS FOR SOME OF YOUR DESIGN WORK?

N=17



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Demand for these tools is in part driven by the ability to see how designs will look in three dimensions and to rotate them and analyze them from different perspectives. An example of the typical comment by substation and transmission design decision-makers regarding the value of 3-D involved the following areas of importance among others:

- Substation rebuilds in constrained environments
- Clearances being better understood
- Being able to use 3-D to enable third-party stakeholders as well as internal utility staff better visualize how prospective designs will look, in advance of finalizing the design options.

Although current usage levels of 3-D in distribution are lower, as shown in Figure 9, interest levels are high, spanning both overhead and underground distribution as well as smart grid initiatives and other aspects on the low voltage side of the grid (e.g. renewables and other distributed generation).

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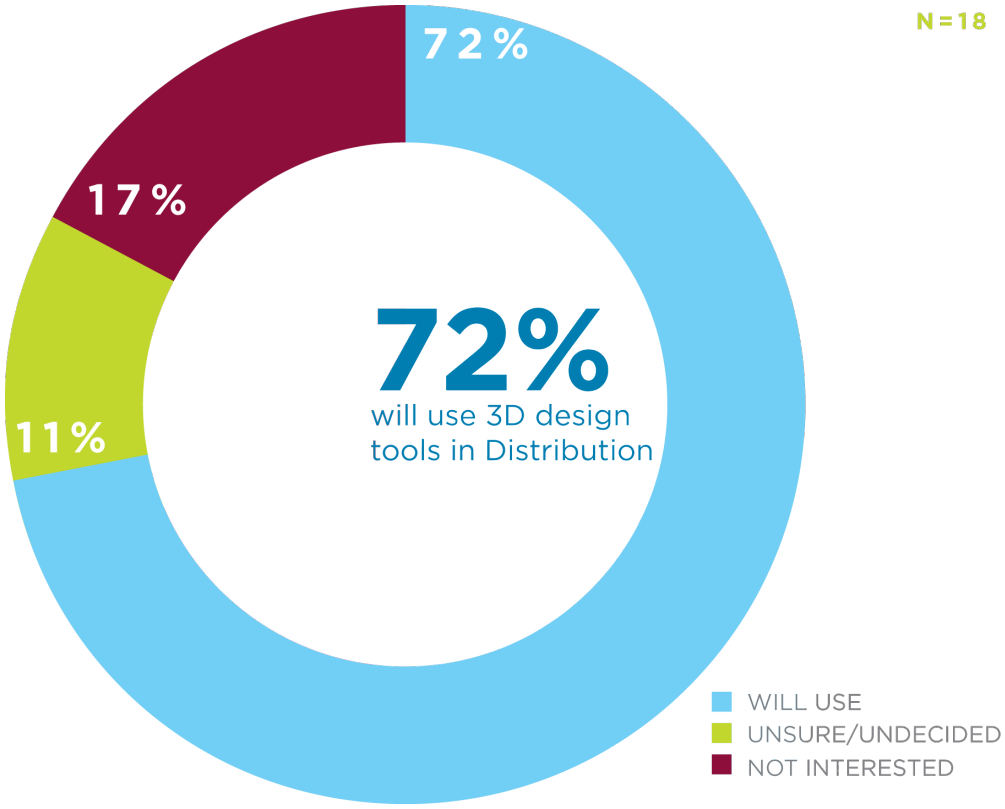
FIG 9: FOR ELECTRIC UTILITIES NOT CURRENTLY USING ANY 3D DESIGN, MODELING AND VISUALIZATION TOOLS IN DISTRIBUTION, ARE YOU INTERESTED IN MOVING TOWARD THE USE OF 3D DESIGN TOOLS?



Helping everyone see prospective designs is of great value. For example, a couple of times a month we do a design presentation showing every design and what we intend to build. If you can put that in 3-D it suddenly becomes very real for the participants versus 2D.

One commenter's utility is a leader in the level of installation of fiber optic on their distribution system--an area where high accuracy and 3-D capabilities are very important. The utility is doing a complete audit of all of its distribution assets, and will increase data accuracy, and create a 3-D BIM or network model, underscoring the increasing value and importance utilities are placing on 3D technology.

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OVERALL ORGANIZATIONAL IMPROVEMENTS AND DESIGN'S ROLE

The survey also sought to determine which areas provide the greatest value and benefit from improvement initiatives at utility companies.

The first question in this series did not focus on design solutions but instead was specifically worded to elicit responses regarding ***any*** important recent or upcoming improvement initiatives across T&D and/or substations. Participants were asked to consider the following five job functions for T&D and substations:

1. Utility O&M (including construction) Field Workers and Field Supervisors
2. Engineering and Planning
3. Designers and Design Engineering
4. Dispatchers, Schedulers, and Systems Operations personnel
5. IT Technicians, IT Engineering & Support (including GIS)

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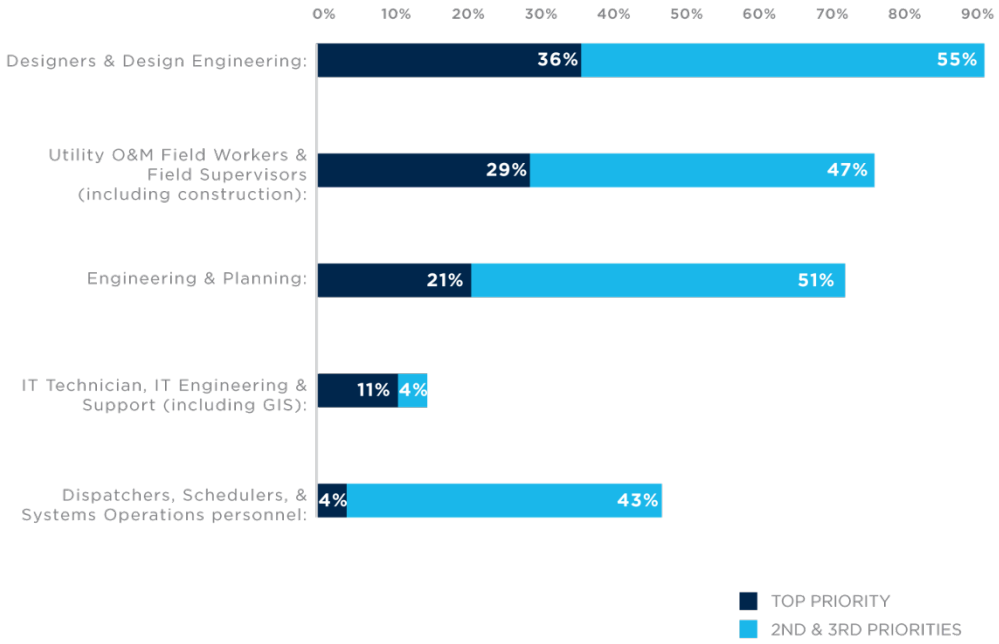
FIG 10: FOCUSING ON RECENT IMPROVEMENT INITIATIVES OR LOOKING FORWARD TO UPCOMING INITIATIVES, WHICH OF THESE FIVE JOB FUNCTIONS DO YOU THINK MAKE THE GREATEST IMPROVEMENT CONTRIBUTION?

N=27



Even though the design function represents a relatively smaller percentage of personnel across their organization in comparison to the large teams of utility O&M personnel, respondents gave designers and design engineering the top ranking. It is noteworthy that Engineering and Planning personnel are frequent users of the design tools and related standards, and the combination of their contribution with that of the top-ranking design function itself provides greater benefit (56% first choice, and an aggregated 104%--out of 200% maximum--for the total of all second and third choices) than that of the other three areas combined (36% and 98% respectively).

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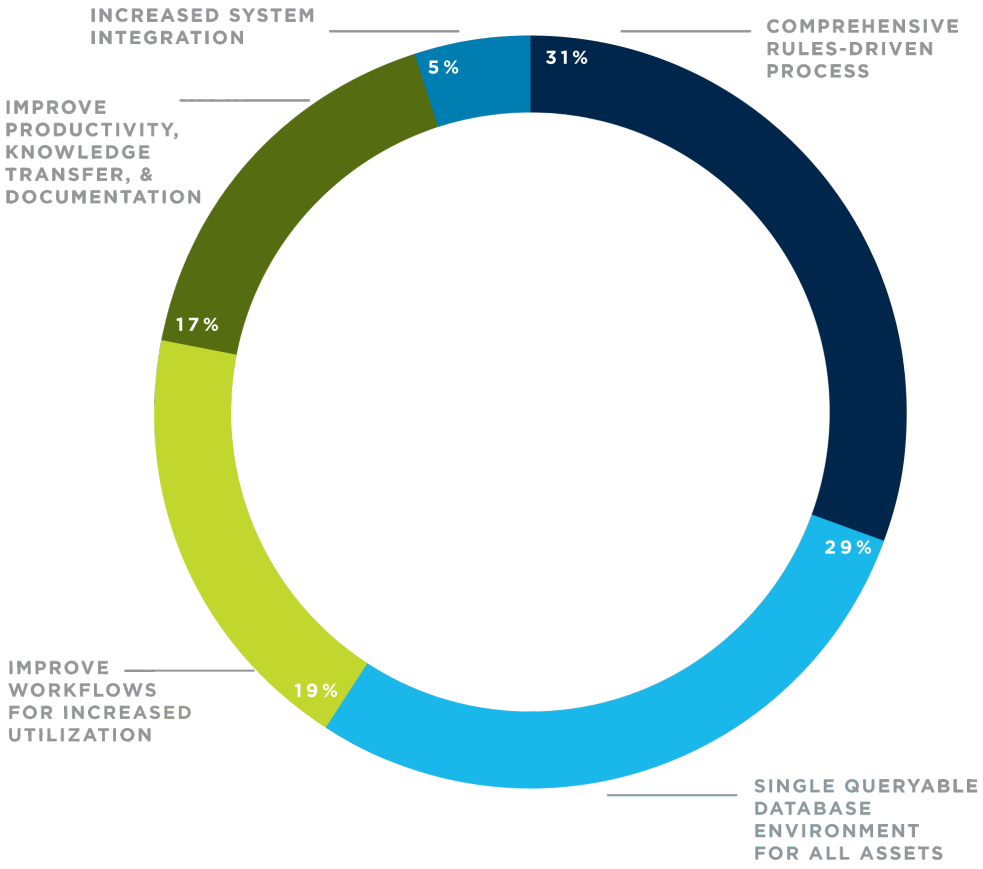
We want higher accuracy for our outage management systems to enable our people to work better during restoration and to have data that is more financially accurate.

Respondent comments frequently emphasized the importance of having accurate and up-to-date data. For example, one IOU respondent who selected "design" as their top choice described their focus on WMS and OMS/trouble ticket performance improvements and the challenges of getting distribution crews and supervisors to better use the new systems.

For each of the job functions respondents highlighted in their answers above, participants were then asked the following:

FIG 11: HOW DID OR COULD THESE JOB FUNCTIONS MAKE THESE CONTRIBUTIONS?

N=25



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One participant reported that 160 of its people had just spent three years cleaning up its GIS data, which involved more than 2,000 distribution feeders. Its subsequent roll-out of new engineering tools along with prior AMI installations will now enable them to focus on "true smart grid initiatives."

Along these lines, another participant said, "Ultimately you need good data or it is all meaningless. So having good data is paramount."

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CONCLUSION

Distribution system decisions are increasingly being driven by the need for greater accuracy and more robust processes to support real time updates and job tracking--capabilities that have already been leading transmission and substation and civil design teams to utilize more intelligent, model-based design tools.

As mentioned earlier, the way software systems have evolved at utilities, the benefits being sought now are often part of a more comprehensive planning process, while earlier software systems may have brought benefits without a strong need to consider the overall impact. A telling comment in this regard referenced the overall evolutionary context that helped create the current hybrid environments over the last few decades:

> We are now operationalizing best practices, while in the past 20 or 25 years ago, the earlier systems had benefits of IT itself that were such a big benefit we did not have to be as process oriented. Now we are getting a next-generation set of benefits.

The newer, intelligent model-based design tools are an important element of plans leading utilities are putting in place to address operating environments that have become increasingly complex. Capital improvements to plant in service are requiring greater design tool utilization to better track projects and to collaborate in an increasingly complex environment where stakeholders, customers, and third party contractors as well as utility personnel need access to real-time information that must be accurate and reliable.

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