What Happens with a Lack of Long-Range T&D Infrastructure Planning?

H. Lee Willis and Richard E. Brown

A joke long popular among disaffected employees and humorists in the power industry asks, "What is the difference between an electric utility and a group of Boy Scouts in the woods?" Answer: The Boy Scouts have adult supervision. While that cynical humor is untrue, at least in the opinion of most utility executive management, there is one element of the comparison that many would admit is valid: the Boy Scouts have a map and a compass. They know where they are, where they need to go, and what direction to take. In contrast, today, at least with regards to their transmission and distribution (T&D) infrastructures, many electric utilities do not.

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Beginning in the late 1980s until recently, most electric utilities retreated from traditional levels of capital investment in T&D infrastructure, accommodating ever-expanding levels of system demand by pushing load/capacity ratios higher while making only the minimum additions needed to connect new customers to their system (**Exhibit 1**). There were many reasons for this trend: uncertainty about deregulation and if and how it would eventually reward T&D investment, doubts about the nature of future Federal Energy Regulatory Commission and power pool requirements for ownership and operation, and a search for greater financial efficiency and higher return on equity.

Inevitably, capacity ratios in utilities' T&D infrastructure (i.e., distribution substations and the transmission and subtransmission lines that feed them along with major distribution lines) rose throughout the industry (**Exhibit 2**), and local delivery systems and regional grids alike were pushed ever nearer to their absolute operating limits each summer. With the exception of some notable lapses in reliability and a few blackouts, the industry survived, largely because advancing technology in the form of online monitoring and improved control systems permitted utilities to trim operating margins significantly, partly because tighter and more focused operating procedures such as energized maintenance (working on lines and equipment while it is kept in service) extended availability of critical equipment, and partly because some T&D systems were, in fact, rather conservatively built up through the late 1980s.

Today, those intertwined trends of reduced capital spending and ever-increasing loading of equipment and lines have ended, as electric utilities across the industry realize that their T&D systems are truly at their limit. Technology that works well has been used. Operation is tight and

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focused 8,760 hours a year. Contingency margins are small or nonexistent. In spite of these gains, peak demand and customer count continue to grow, and existing facilities are growing older and, in some cases, deteriorating in condition: new infrastructure is needed and, in many cases, needed soon.

ATROPHIED PLANNING

Many utilities find the sudden need to spend significant capital on T&D again quite a challenge, not because the capital cannot be found, but because they have lost the ability to effectively develop and use long-range plans for their system infrastructure. During the nearly two-decade-long period of downsized capital budgets, utilities inevitably downsized their planning staffs, too, while letting institutionalized processes and T&D planning skills atrophy. In the late 1980s and early 1990s, the planning horizon, along with the comprehensiveness of any look at the long term, simply vanished throughout much of this industry (**Exhibit 3**).

To many, this reduction in planning focus was only common sense. Reduced capital spending meant there was far less to plan and all utilities were going through routine spasms of belt tightening and downsizing—planning departments seemed a logical place to cut back. One major metropolitan utility actually eliminated its T&D planning function altogether, letting Operations make the inevitable small additions needed as its demand and customer base evolved. Others planned with greatly reduced staffs who were assigned other duties, too. The little planning that was done focused on short-range, tactical "patches" —find a way to handle load growth expeditiously in the short term, spend as little as possible now, and avoid adding any major new facilities or lines.

As a result, today many utilities find themselves in a difficult situation. They know they must make significant capital investment in major T&D facilities and equipment—not only is growth continuing, but years of reduced budgets have created a huge "bow wave" of badly needed projects and additions they must install soon. Utilities want to add infrastructure in a staged, coordinated manner, and in a manner that the addition achieves synergy and leverages both old and new capabilities well. They know these new capital additions will last decades, and they want to get maximum value out of them, which means tailoring them closely to not just today's needs, but also to evolving future needs.

Exhibit 1. Annual Capital Spending per New Customer, Corrected for Inflation to 2007 Dollars

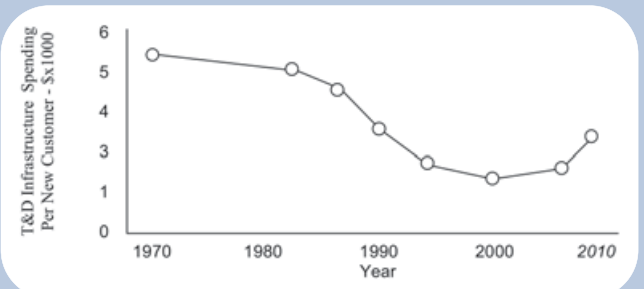


Exhibit 2. Average Power Transformer Loading Guideline—The Ratio of Summer Peak to Nameplate Capacity, Permitted by Eight Investor-Owned Utilities, in the Years Shown

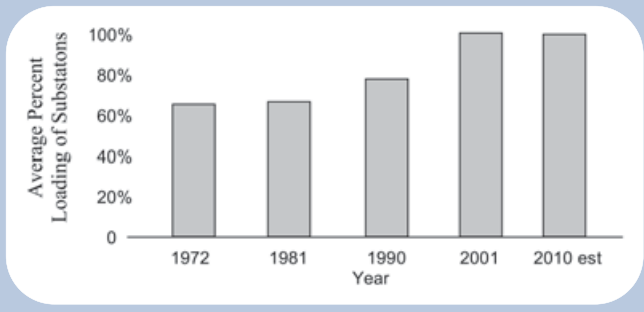
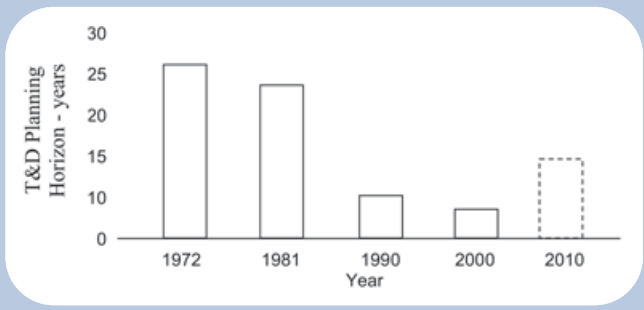


Exhibit 3. Average Planning Horizon—Years Ahead for Which Comprehensive Study of T&D Systems Needs and Solution Is Done—As a Function of Time for Eight Utilities



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They know that they will face challenges in communicating and selling the cost of their capital investment to stockholders, customers, and regulators alike. However, they lack the skills and resources—the institutionalized planning capability—they need to do this type of planning well.

FINDING THE WAY OUT OF THE WOODS

Why do long-range T&D planning? To many utilities, their recent interest in it has been spurred by a desire to identify future substation sites and rights of way (ROWs) far in advance, in order to obtain them in an effective, noncontroversial, and hopefully economical manner.

Site and ROW planning are important, but good long-range planning can and should go far beyond that. Most fundamentally, long-range T&D planning permits the utility to maximize the lifetime value of the equipment and facilities it buys with its capital investment. In order to assure that a major new facility will be a good investment, a utility must understand what its performance, cost, and interaction with the utility's values and goals will be during a significant part of its lifetime—certainly the first 15 to 20 years after it is installed.

For example, viewed against changing future needs including other planned additions and changes, should a new two-transformer substation and the lines feeding it be built with room for two additional units for the long run? As an alternative, could long-term needs be met nearly as well, or better, by leaving it at two transformers and building yet another substation that could be built even further in the future? How are all major additions and changes in the next decade going to be organized so that, taken together, they achieve a sound business case, maximizing return on investment and minimizing the utility's business risk? What are the uncertainties the utility faces, and how can T&D investment be shaped to minimize risk and assure stability in spite of them?

Answering these and similar questions, and making good use of the answers, greatly increases the effectiveness of every dollar spent, increases the likelihood the utility achieves its goals, and brings, in only a few years, stability, flexibility, and options to the utility's short-range plan. A long-range T&D plan also permits the utility to see the long-term implications of changes in its policies, use of technology, and other factors and commitments, and how those interact, for good or bad, with its T&D capital investments. Money works harder and is more effectively targeted. Coherency of policies, spending, and operations is improved, leading to greater T&D and customer performance and better financial results.

Beyond this, however, a good long-range plan shows what the utility needs to do to reverse the effects of nearly two decades of patches and short-term thinking. Today, many T&D systems are "distribution heavy"—relying on more lower-voltage and smaller facilities than is optimum for efficiency and reliability. Over the past two decades, a short-range, low-capital approach added distribution to reach new growth areas, with small module substations and low-voltage (34.5-kilovolt) subtransmission in easements when capacity was needed, and only the barest additions possible to the heavier levels of their systems. Many modern T&D systems lack sufficient anchor substations and transmission contingency strength for the most efficient and flexible operation and growth. Planning how to take the present system quickly back to that preferred state in a smooth, efficient manner is a challenge even for a staff experienced in long-range planning.

A good long-range plan is both a sales tool and a bit of armor plating for the capital budget.

Finally, a good long-range plan is both a sales tool and a bit of armor plating for the capital budget. Any utility contemplating major capital spending on infrastructure, particularly at levels different from recent spending patterns, should expect scrutiny and even some opposition from stockholders, customers, and regulators. Additionally, the need for new sites and ROWs is always contentious. By comparing alternatives, a comprehensive long-range plan provides a foundation for many recommendations, like justification of sites and ROWs, spending or not spending (how much is enough, and why?), here is what happens if you continue to push the problem into the future, this is the result of doing it that way instead of this, that policy leads to more of these

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types of expenses and problems but fewer of these, and so forth.

A MAP OF MORE THAN ONE NECK OF THE WOODS

A long-range plan is primarily a business tool to help the utility understand and assess all the implications of its T&D investment decisions, not just their cost and electrical performance issues. The plan provides many technical answers, but primarily business benefits (**Exhibit 4**). Certainly, the plan must assess and consider many highly technical issues related to the electrical flow, operation, costs, and performance of a complex system. However, the plan exists in order to help the utility understand and manage its T&D system's contribution to its business goals, and so the utility can understand decisions about what to build or not build, and how to build and operate it, affect everything from customer performance to labor requirements to storm vulnerability to investment needs. The long-range T&D plan is not about the T&D system; it is about how the T&D system fits into the future that the utility must deal with and contributes to the goals the utility wants to achieve.

The map the Boy Scouts use to lead them out of the woods may tell them where they are now, but to be useful it must cover far more territory than they can hike over in the next few hours. It must go beyond what can be done in the short run—showing them where they will be at the end of the day's hike, and what they will face tomorrow. The map must also have breadth, enabling the Scouts to understand their options, showing possible alternate routes, and identifying the challenges and opportunities each would bring, such as the following: this is the shortest hike but covers difficult terrain; this route is an easy walk but far longer; this has the most scenic views; this route leads to a wonderful campground by nightfall. Showing the path not taken can be as important as showing the one that will be taken.

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Similarly, a utility's long-range plan needs both length and breadth (see **Exhibit 5**). Obviously, it must look quite far ahead, beyond those projects and investments that will be committed in the next few years. It must provide a picture, in all its elements, of the long-term future of the T&D system and those elements affecting and affected by its performance and operation, so that the utility's planners, managers, and executives can see how investments in new facilities will or will not fit their goals and needs over their service lifetime.

The long-range plan's breadth must provide a responsive predictive capability, so that planners will understand the value of new additions,

Exhibit 4. Benefits of Long-Range T&D Planning

Area of Improvement	Typical Improvement
Increased return on investment: fitting capital projects well to long-term needs, not just today's	3% to 7% improvement in cost or capital effectiveness, as the utility wants
Stability of purpose/predictability of spending, *planned* capital budgets are even year-to-year	Budget volatility, and error in adhering to T&D budget forecasts five years ahead, cut by half
Flexibility: an ability to "bob and weave" both spending and focus when conditions change	Planned deferrable element of budget permits spending variations of ±5% without other impacts
Improved information on sites and rights of way for substations and key facilities	Accurate identification of key sites and ROWs, at least 90% of the time, at least 10 years ahead
Improved ability to defend sites, ROWs, and spending levels	Earlier and improved information cuts cost and failures by about 33%
Coherent understanding of future needs and opportunities, of where the system is going	Getting everybody on the same page requires having the page; then it's pretty easy
Compatibility and synergy of targets, policies, procedures, commitments and capital spending	Shows up as contributions to the first three benefits above

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Exhibit 5. Content of Good Long-Range T&D Planning

Long-Range T&D Plan itself: Description of the T&D system over time: what will be added, changed, retired, and reconfigured, in only enough detail to permit analysis of and support the items below.

Picture of the future in which the T&D system will interact and the utility must fit

- *Spatial customer base:* How many of what type of customers, located where?
- *Customer end-use:* How much power and reliability will different types of customers need? Why?
- *Infrastructure aging:* How long will existing equipment last? How and why will O&M escalate?
- *Technology:* What may become obsolete? What may work better? What will work together?
- *Political and regulatory:* What will the rules be? How could positions evolve?
- *Labor and cost:* How will expansion, aging, and changes in technology affect labor and skill needs?
- *Performance:* How will the T&D system perform? What can it do? What vulnerabilities will it have?
- *Risk:* What exposure is there to storms and outages, safety, and unexpected expenses?

Responsive prediction: Ability to answer two types of questions:

1. What within our picture of the future will change if we [do this or do not do this]
2. What is the cost, benefit, value, and risk associated with this [project, policy, change in our plan, change in external factors] as a function of time in the future?

how their value and benefits will change throughout their decades-long service life, and how changes in design, operating procedure, policy, or goals affect the system, and vice versa. In fact, the long-range plan itself is not the most valuable product of long-range planning. This ability to recast and answer questions is.

This leads to a fundamental point about long-range planning: the plan itself is not too important. As Dwight Eisenhower observed in the Second World War, "Plans are worthless, but planning is invaluable." Experience has proved that plans are always fluid and that the process of preparing and maintaining an up-to-date long-range plan produces not just a plan, but also an understanding of what the organization needs, how and in what ways it can and cannot react, what it will have to do, why one path may be better than the others, and how and why that could change if its situation or goals change.

GETTING OUT OF THE WOODS: MAKING AND READING THE MAP

This type of planning—in which the plan is not as important as the knowledge base it generates—is unfamiliar territory to modern utility planners, management, and executives. Certainly, there are technical challenges; long-range planning does require different types of study, tools, and analysis, and a different approach, to using results. However, more fundamental than that, its concept and format is completely different, something the majority of modern utility planners have little or no experience doing. Over the past decade and more, their companies have evolved a lean planning process that focuses only on executable projects: plans are the important product—in fact, the only product—of that process. That is what planning does: define, cost-minimize, authorize, and hand off to project management a well-defined, very specific list of projects to be built in the next year or two.

Long-range planning is quite a contrast to that. Nothing gets built. Nothing is even going to be authorized. Specificity is often not as important as breadth: a good deal of what is studied and reported is not meant to be built but is simply comparing alternatives. Alternatives and their pluses and minuses must be compared, and interactions and factors across a wide range of issues put in context. Things often cannot be specific, there is too much uncertainty, or one is comparing scenarios to show a contrast. However, questions must be answered.

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Exhibit 6. Reconstituting Long-Range T&D Planning Capability

- Determine the type of planning needed from a business needs perspective.
- Develop a long-range T&D plan: it will evolve over time and be useful for only a few years, but make an effort to make it a good one for now.
- Focus on the team and the process that will make that plan, and others, in the future: build an institutionalized process that listens to, plans, and responds to company needs.
- Realize that executives and management have as much to learn as planners.

FINDING THE WAY OUT OF THE WOODS

Perhaps the primary advice to utilities wishing to reconstitute their long-range T&D planning function is do not reconstruct what the company had in the past. Federal and state regulatory environments have changed a great deal. So, too, have utility cost structures and financial constraints, customer needs and expectations, societal values about energy and the environment, computing, data, enterprise-IT and system control technologies, available labor and its cost, workforce skills and attitudes, the capabilities and design of T&D equipment, and planning methods and techniques themselves. A modern utility needs a modern planning capability, one that matches and melds its business and technical needs.

Next, there is a very fundamental point the utility must keep as its top priority. If the utility wants the benefits of long-range planning, it has to develop the capability to do long-range planning internally. The utility can buy a long-range plan or hire consultants to help it develop a plan, but unless the utility does so in a way that helps it build the internal machinery to maintain and evolve future plans, and unless the utility puts processes in place to use the knowledge developed in that planning on a continuing basis, that outsourced plan will be of only transitory value.

Therefore, focus should be on building the institutionalized capability to create and use the type of long-range T&D plans the utility needs. Generally, the place to start is to identify the business drivers, and the benefits and value—monetary and otherwise—that the organization wants from its T&D planning. The next step is to just jump in and produce such a plan. Often, outside assistance from someone more experienced is invaluable—long-range planning is different and does require new tools, skills, and methods. Again, the effort should focus on helping the utility bootstrap its own capabilities and on making long-range T&D planning an effective part of its decision and policy processes.

Developing that long-range planning capability is both a technical and organizational challenge. Long-range T&D planning does require new tools and skills. However, it requires a different focus and way of handling uncertainty and the thinking about alternatives. Building the capability to do long-range planning is also about enabling the utility to use the knowledge that the process produces, effectively and routinely. Executives need to know what questions to ask and how to ask them, what long-range planning can give them and what it cannot, when to use long-range plans and how not to, and how to leverage their benefits to achieve corporate goals. Management needs to understand the basis for the plan's use and the executive's need for information and how to act as an effective bridge and communications channel. Planners need to understand why the plans are needed, how they are used, and how to listen to and respond to the questions and needs executive management will have.

Creating that first long-range plan will drive those issues forward, and if the utility is prepared to recognize them, respond, and build the appropriate machinery around the planning process, it will end up with an institutionalized long-range planning method and process that responds to its changing environment and needs—that is, its map and its compass. Once that is done, it is an easy walk out of the woods.

Exhibit 6 is a summary of the steps a utility should take to reconstitute its long-range T&D planning function.

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