Developing a Roadmap to a Smarter Utility

by John Dirkman, P.E.

Executive summary

The regulatory and operational landscape of Smart Grid technologies is highly complex. Conducting thorough research-based strategic planning is essential. Each utility must map its journey to becoming a Smart Utility based on its own unique business drivers and technology needs. This paper presents a proven five-step methodology for developing a cost-effective roadmap for achieving Smart Grid capabilities and maximizing their benefits.

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Introduction

Planning for grid transformation is critical. Virtually every utility in the world has requirements and aspirations that could be delivered through the Smart Grid. Some companies have extensive internal teams and consultants mapping out strategy, while many others are struggling to find the right place to start. The complexities of the regulatory environment, existing network operational context, and the adoption of emerging technologies can vary widely from one utility to the next, making the establishment of priorities and action plans anything but simple.

No matter where a utility finds itself on the Smart Grid planning continuum, the reality is the same: developing a Smart Grid roadmap in the midst of this complex and evolving environment is daunting. There is a lot at stake — the potential investments in and benefits from a Smarter Grid are huge. Aligning expenditures with the most critical business drivers in the environment is crucial. In order to ensure that investments are focused where they can do the most good, utilities must assess where they are — a starting point, in essence — along the complex continuum of building a Smarter Grid.

This paper discusses the main business drivers for Smart Grid investment and the technologies that the Smart Grid requires. Finally, a five-step plan for building a Smart Grid roadmap is presented. This methodology has proven to be effective in generating support and "buy-in" from all critical internal and external stakeholders.

Table 1
Determining what's driving the need for Smart Grid investment is a crucial first step.

Key business drivers for Smart Grid investment
Regulatory environment
System capacity, expense, and reliability
Generation resources
Media and customer involvement

Assess business drivers

Regulatory environment

Both U.S. and international utilities are heavily influenced by multiple regulatory agencies. In the United States, utilities are influenced by agencies on both state and national levels. At the state level, utilities must assess their compliance with changing requirements for reliability, renewable portfolio size, and time-of-use or critical-peak pricing. At the national level, various administrations have created grants, acts, and initiatives to promote and stimulate clean energy, energy efficiency, research, energy independence, and security. In addition, there are multiple national and international agencies that have published cyber security standards and recommendations. All utilities — no matter where on the continuum they are with regard to the age and reliability of their infrastructure and accessible capital for improvements — are required to comply with applicable standards, and noncompliance may result in fines. Utilities must assess their status with regard to regulatory compliance to ensure that Smart Grid improvements satisfy and do not jeopardize or delay compliance with applicable state, national, or international standards.

System capacity, expense, and reliability

A look at past, current, and planned future transmission and distribution system capacity, operating expense, and reliability can help determine what is needed to meet standards and growth requirements and lay the foundation for a Smart Utility. It is no secret that electric power networks in many nations are deteriorating, unreliable, and costly to operate and maintain. Demand may be increasing, but available funding options are limited. A close review of the utility's existing grid's strengths and weaknesses, in light of load growth and renewable penetration projections, can bring the general problem into more specific focus. And an honest assessment here helps prioritize next steps according to the utility's short- and long-term financial capacity.

Generation resources

Growing peak demand already has utilities evaluating and deploying alternative energy sources. As utilities assess their current generation capacity and options for expansion (including smaller distributed generation sources), they also need to consider consumers' and regulators' priorities. Conservation and advocacy groups, consumers, and shareholders are calling for and in some cases installing environmentally friendly alternative energy sources, while regulators seek to reduce consumption and carbon emissions through energy efficiency, reneables, and demand response. Assessing generation resources through this lens helps avert reactive and often costly measures once the utility's current capacity limit has been reached.

Media and customer involvement

"Smart Utilities must be aware of their key audiences' perceptions and expectations."

As much as one might like to execute such honest (and often humbling) assessments in a vacuum, it would be naïve to underestimate the scrutiny with which the government, media, and consumers are continuously evaluating utilities' actions. Residential, commercial, and industrial consumers have come to depend and insist upon highly available, consistent, low-cost electrical energy for all loads, not only those deemed mission critical. Regulatory pressure in the form of service level or performance-based rate structures adds to the business drivers for reliable supply. Increased government investment in Smart Grid capabilities also has increased expectations and media interest in how utilities are spending taxpayer dollars. Smart Utilities must be aware of their key audiences' perceptions and expectations in order to better navigate the inevitable obstacles and criticisms along the way to a Smarter Grid.

Table 2
Smart Grid capabilities require various new technologies.

Required Smart Grid Technologies
Wide area networks (WAN), communications and security infrastructure
Advanced metering infrastructure (AMI)
Meter data management (MDM) system
Distribution automation (DA)
Distributed generation, energy storage, electric vehicles, distributed energy resources, microgrids
Demand response (DR)
Building management systems (BMS) and home area networks (HAN)
Advanced distribution management system (ADMS)
Integration framework and architecture

Assess technology needs

The roadmap to a Smarter Grid also must include various new technologies that can keep pace with fluctuating demand and the increased need for utility-customer interface and interaction. At its foundation, the Smart Grid requires the following technologies:

Wide area networks (WAN), communications and security infrastructure

Linking the large variety of smart devices distributed throughout the network requires secure communications. Each utility that envisions a Smart Grid needs to build a communications network that parallels and can monitor, operate, and optimize the electrical grid. But the technology and drivers that determine the right WAN for each company can vary widely. Should the core infrastructure be internally owned? Or should a public provider be relied upon? Can a single network technology meet the needs of advanced metering infrastructure (AMI) and all the other smart devices in a utility's network? Is there existing infrastructure that can be leveraged, and if so, how? What are the requirements for redundancy and security? These and a myriad of other questions must be addressed to get this core piece of the Smarter Grid right.

More Smart Grid white papers

For more information on Smart Grid technologies and considerations, see the following Schneider Electric white papers:

Security
Creating a Reliable and Secure Advanced Distribution Management System

AMI
The Three Pillars for an Efficient AMI Operation

Leveraging AMI for Outage Management

Distribution Automation
Improving MV Network Efficiency with Feeder Automation

DER
Preparing for Distributed Energy Resources

Advanced metering Infrastructure (AMI)

AMI can enhance meter operations by reducing the cost and improving the accuracy of reading/collecting energy usage information while providing a mechanism to both inform and empower customers as they choose better energy consumption patterns. This is a large topic, but in general a utility needs to look at its current metering status and gain at least a high-level view of the requirements for the future. What are the main areas of concern with the current metering system (manual or automated)? Besides reducing read costs, what are the key drivers? Are there regulatory requirements such as time-of-use or critical-peak pricing rates to be considered? Are there system operating efficiencies to be gained through more/better end point data? What data should the AMI collect: usage, status, voltage, power quality, etc., and with what frequency and accuracy?

Meter data management (MDM) system

MDM software focuses on properly managing and integrating all meter-generated data: historical data for analysis, as well as billing, power quality, and system events data. This integration tool is the hub that shares data with other critical applications such as customer information systems (CIS)/customer relationship management (CRM) systems, advanced distribution management systems (ADMS), and outage management systems (OMS). Effectively implemented and integrated MDM can provide vendor-neutral solutions allowing the utility to integrate whatever technologies are needed (consumer, industrial and/or multi-utility) into one cohesive system, now and in the future.

"Effectively implemented MDM can integrate whatever technologies are needed into one cohesive system."

Distribution automation (DA)

Distribution automation (DA) involves devices and secure communications between devices in the distribution network. DA is a broad topic that can be broken down into substation automation (SA) and feeder automation (FA). SA enables electric utilities to remotely monitor, control, and coordinate the distribution components installed in the substation, typically breakers, switches, transformers, and load tap changers using sensors, meters, controllers (often referred to as intelligent electronic devices [IED]), remote terminal units (RTUs) and supervisory control and data acquisition (SCADA) systems. FA extends to circuits beyond the substation fence, and typically includes reclosers, sectionalizers, switches, capacitor banks, voltage regulators, and fault indicators, plus their associated monitoring and control equipment and SCADA systems.

Distribution automation is very beneficial in improving system reliability, safety, and efficiency — especially when used in conjunction with other Smart Grid technologies. Systems like ADMS can help manage and optimize DA and provide guidance on best locations for placing DA devices.

Distributed generation, energy storage, electric vehicles, distributed energy resources, microgrids

Of all the Smart Grid technologies, arguably the one emerging the most rapidly with the most profound impact is the growth of distributed generation (DG), energy storage (ES), electric vehicles (EV), distributed energy resources (DER), and microgrids within distribution networks

Smart Grid technologies defined

For definitions of DG, ES, DER, and microgrids, see John Dirkman's blog post The Future State: Growth of Distributed Energy Resources and Microgrids

The growth of these technologies within distribution networks presents some major challenges, including reverse power flows, more complex protection schemes, altered voltage profiles, and impacts to system stability. However, they also offer benefits like improving customer reliability, avoiding losses in both transmission and distribution, meeting requirements for reduced emissions, flattening of load profiles, and peak load shaving — operating in this way as virtual power plants.

These new and emerging technologies create a number of questions for utility companies. What are the regulatory drivers? What are the expected growth/penetration rates? Where in the distribution network will these technologies be located? How will they impact the distribution network? How can utilities work with customers to manage, monetize, and optimize these technologies that are changing the transactive energy environment?

Demand response (DR)

According to the Federal Energy Regulatory Commission, demand response (DR) is defined as "changes in electric usage by end-use customers from their normal consumption patterns in response to changes in the price of electricity over time, or to incentive payments designed to induce lower electricity use at times of high wholesale market prices or when system reliability is jeopardized."

"It is essential that Smart Utilities consider and plan for demand response and make it part of their Smart Grid roadmap."

Demand response is a very broad topic that can include other technologies described in this paper such as AMI/MDM systems, distribution automation, energy storage, electric vehicles, distributed energy resources, microgrids, building management systems, home area networks, and advanced distribution management systems. One challenge of demand response is to find ways to minimize the impact on customers as required. It is essential that Smart Utilities consider and plan for demand response and make it part of their Smart Grid roadmap.

Building management systems (BMS) and home area networks (HAN)

A building management system (BMS) is the software, devices, and communications that monitor and control equipment — both electrical and mechanical — in a building, typically larger commercial and industrial buildings for occupant comfort, energy efficiency, and security purposes.

HAN technology is an evolving market and plays an important role in controlling and managing residential power consumption. HAN is characterized as a network contained within a customer's home that connects an individual's digital devices, from multiple computers and their peripheral devices to telephones. Networked devices can include televisions, home security systems, smart appliances, and other digital equipment, as well as larger equipment such as pool pumps, HVAC, water heaters, and appliances (like

More on BMS and HAN

For additional information on building management systems, see these Schneider Electric white papers:

Making permanent savings through Active Energy Efficiency

The Key to Cost-Effective and Sustainable Buildings: Intelligent Energy

From Theory to Reality: 3 Steps to Implementing a Sustainability Programme

Best Practices for Securing an Intelligent Building Management System

refrigerators and washing machines) connected to and communicating with smart meters as part of AMI/MDM systems. HAN requirements and opportunities vary at each utility, so a careful assessment is required. Also, HAN technology can also be applied to larger commercial properties as part of the BMS.

Both BMS and HAN can be part of a utility's overall demand response plan. Utilities must determine the growth patterns for these technologies within their distribution networks and work with building owners to determine options for monitoring and control of these systems.

Advanced Distribution Management System (ADMS)

Solutions like ADMS — which combine systems like SCADA for monitoring and control, a distribution management system (DMS) for distribution power applications, outage management system (OMS) for resiliency, energy management system (EMS) for transmission power applications and generation control, and demand-side management (DSM) for managing demand-side resources — communicate directly with AMI/MDM systems, distribution automation (DA), distributed energy resources (DER) and microgrids, demand response, and BMS/HAN controllers.

"ADMS solutions are at the integration point between traditional operations technologies (OT) and information technologies (IT)."

ADMS supports system analysis, operations, and optimization, providing visualization; situational awareness; and monitoring, forecasting, and control of local generation and load throughout distribution networks. ADMS also allows system operators and engineers to forecast, manage, and mitigate voltage changes, reverse power flows, and more complex protection schemes required by distributed generation (DG), DER, and microgrids. ADMS serves as an analytical engine, managing DA and providing a resource for utilities to coordinate with customers, especially for forecasting peak load and managing demand response. ADMS, when integrated with an accurate weather forecasting system, can provide more reliable load and renewable forecasts, promoting further system optimization. In addition, ADMS enables distributed systems to operate autonomously but coordinates these distributed systems to optimize overall power flow and economics. Lastly, ADMS can also provide many other supporting applications like volt/VAR optimization; fault location, isolation, and supply restoration (FLISR); reliability analysis; switch management and network reconfiguration; outage management and crew management; load shedding; network planning; optimal device placement; and transmission EMS functions. All in all, ADMS solutions are at the integration point between traditional operations technologies (OT) and information technologies (IT) and are powerful engines for optimizing the Smart Utility.

For further discussion on how a complete, correct and current ADMS real-time model — based on accurate underlying Geographic Information System (GIS) data — enables utilities to implement Smart Grid strategies, see the Schneider Electric white paper Best Practices for Creating Your Smart Grid Network Model.

Integration framework and architecture

Each component system of this new technology offers a competitive advantage to the enterprise. Implemented as stand-alone systems, each of these critical technologies would fall short of delivering the maximum business benefit that they could if implemented and integrated together. Putting the Smart Grid components together in an integrated and secure way enables Smart Utility managers and operators to answer some key questions, such as how they can optimize asset use in near-real time, improve customer reliability through better data access, or streamline operations by giving operators a more seamless, simpler user experience with a more comprehensive view of the network. The design of an integrated Smart Grid has to address architecture, including integrating technologies as well as planned and legacy systems. A detailed analysis and design prior to implementation is a must if costly mistakes and premature obsolescence are to be avoided. And, of course, utility stakeholders

"If for no other reason, most utilities will need a Smart Grid roadmap to navigate the cultural changes necessary to become a fully integrated, communications and customer-centric operation."

all realize that more technological integration implies more organizational integration as well. For an industry historically splintered into silos among generation, transmission, distribution, and operational categories, implementing two-way, real-time communication (both internally and externally) is no small task. If for no other reason, most utilities will need a Smart Grid roadmap to navigate the cultural changes necessary to become a fully integrated, communications and customer-centric operation.

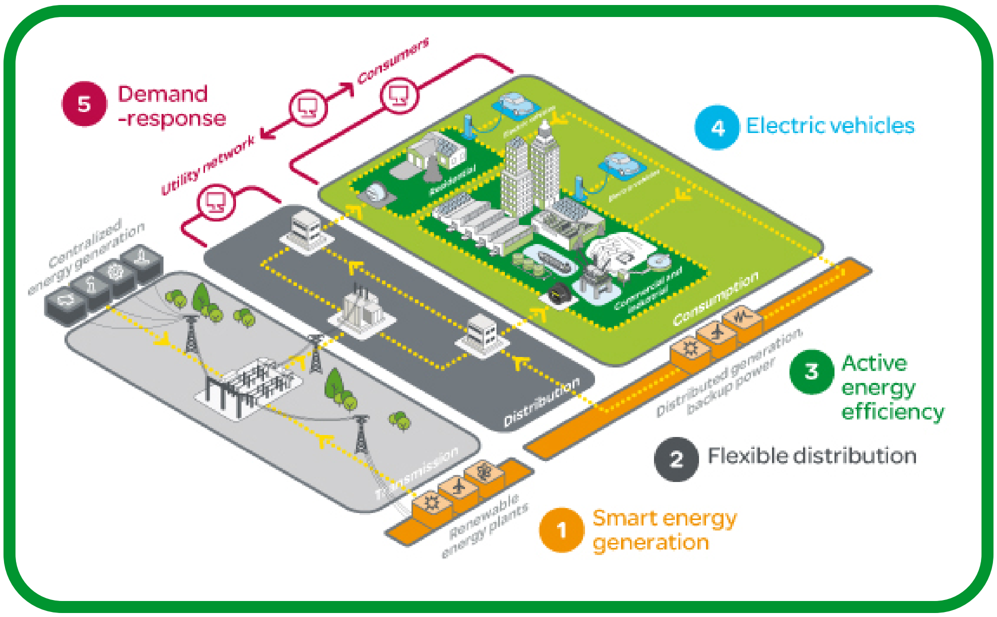


Figure 1
Major components of a Smart Grid that must effectively interoperate

Five steps to a Smart Grid roadmap

After gaining a high-level view of where it stands in terms of regulatory compliance and infrastructure and integration capacities, a utility has a starting point from which to map its journey to a Smarter Grid. Schneider Electric's experience has shown that the following five steps not only provide utilities with cost-effective, customized directions for achieving Smart Grid success, it does so in a way that generates support and ownership among critical internal and external audiences.

Table 3
These five steps have proven to be a cost-effective methodology for developing a Smart Grid roadmap.

Five Steps to Smart Grid Roadmap
1. Define internal roles and responsibilities
2. Conduct workshops to discuss drivers and requirements
3. Define priorities through a business case
4. Document the plan
5. Communicate

A brief outline of each step follows. This approach may need to be tailored to a specific situation. A utility may have already done some work in each of these areas, some steps might have to be divided into smaller sections, or the sequence might need to be altered.

Step #1: Define internal roles and responsibilities

The first key step is to define the roles and responsibilities of utility management and staff in building the roadmap. Below are seven key roles to be considered:

- Executive sponsor(s) — providing long-term vision and organization resources
- Business leaders — from each affected business area
- Subject matter experts — domain knowledge, as directed by the business leaders
- Project manager or coordinator — to put the effort together
- Regulatory liaison — optional, but potentially important
- Customer liaison — coordinates with customers for DA, BMS/HAN, and DG/ES/EV/DER/microgrid monitoring and control
- Internal advocate/communicator — could be a separate role, or combined with project manager

Working together, this team carries the responsibility to compile the information, express the key business drivers, articulate the priorities, and document and communicate the Smart Grid roadmap.

Step #2: Conduct workshops to discuss drivers and requirements

Workshops breaking the problem down into its four components — Smart Metering, Smart Networks, Smart Operations, and the central integration, communications, security, and business processes — help utilities identify the critical functionality and integration requirements for a comprehensive electrical network that is smarter and more efficient.

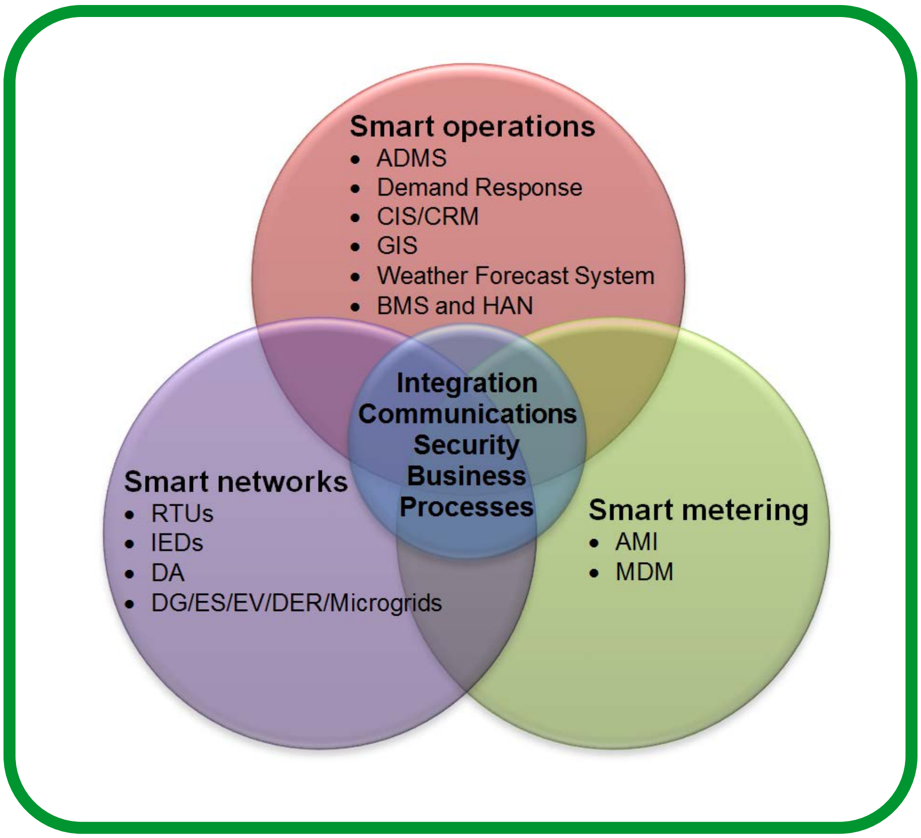


Figure 2
Breaking down the Smart Grid roadmap process into its components helps identify requirements.

Goal

The overarching goal of these workshops is to examine the utility's current operating environment and define a roadmap to move the utility further toward the Smart Grid. The information and ideas from the workshops help create a Smart Grid roadmap document that details the steps required to move the utility into the Smart Grid environment, identify the information technology (IT) and operations technology (OT) systems involved in the effort, discover business process changes affected during the implementation, and recognize benefits to be gained as a result of the implementation.

Structure

Each workshop begins with an overview of the subject matter to ensure that each participant has a unified view of the topic. The workshop then proceeds with a brief set of questions designed to assess the current state of Smart Grid technology at the utility. After these two background tasks, the next set of questions helps participants brainstorm to discover requirements for Smart Grid implementation. The concluding session for each workshop is a summation of the day's discussion, including the steps necessary to complete the first draft of the roadmap document.

Step #3: Define priorities through a business case

"Build a business case that strikes the best balance between components that the utility needs most and components that can provide quick return."

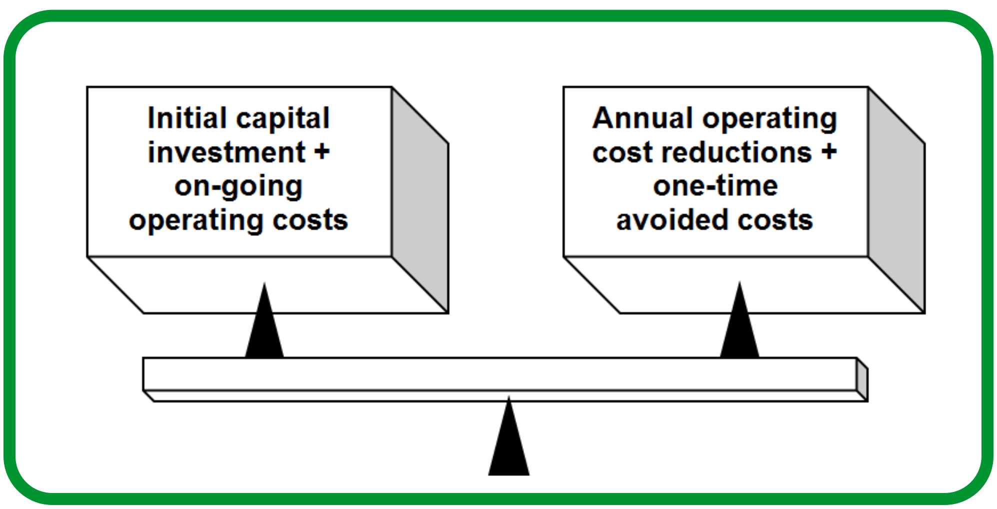
Once workshops in the four key areas have been completed, it is important to define the priorities for implementing Smart Grid technologies. The key is to build a business case that strikes the best balance between components that the utility needs most and components that can provide quick return.

First, assess and validate the business drivers for the Smart Grid investment, such as operational goals and objectives, regulatory requirements, and IT/OT requirements.

Second, estimate the costs for each Smart Grid component or alternative needed: data, hardware/equipment, software, implementation, process, etc. Remember, each cost component has initial and recurring values. For purchased components, be accurate. For estimated components, be conservative.

Figure 3

Financial analysis of each Smart Grid alternative compares initial capital investments + ongoing operating costs to annual cost reductions + one-time avoided costs.



Third, based on the workshops, evaluate the business benefits of Smart Grid implementation — those associated with the drivers of operational goals and objectives, regulatory requirements, IT/OT requirements, etc. — and what the utility stands to gain from the Smart Grid components, like reduced capital or operating costs, satisfaction of regulatory requirements, improved revenue, and improved customer service.

Finally, build a financial analysis, remembering that the costs and savings don't occur all at once. Common financial tools used for comparison are net present value, which puts all costs on the same basis (today), accounting for the time value of money; and internal rate of return, which describes the value of an internal investment so that it can be compared to the market.

Step #4: Document the plan

The best way to summarize the onsite workshops and use them to communicate and facilitate implementation is to develop a Smart Grid roadmap document. The roadmap document should summarize the results of the workshops and place the components of the Smart Grid solution into a framework that can be implemented by the utility. Knowing the form and content of that document may be helpful to the team in preparing for the workshops, so an outline of an approach to documenting the roadmap is shown in **Table 4**.

Table 4
Sample outline of a Smart Grid roadmap document

Sample Roadmap Outline
1. Executive summary
2. Roles and responsibilities
3. Workshop findings a. Workshop process b. Assessment results, assumptions, and action items c. Conclusions
4. Smart Grid drivers a. Regulatory imperatives b. System capacity and forecasts c. Generation resources d. Customer involvement e. Media involvement
5. Smart Grid plan a. Required technologies b. Business case summary c. Plan for execution d. Communication plan e. Revision plan
6. References

The utility's master Smart Grid plan should identify the key participants/stakeholders and summarize the findings of the workshop process and business case to provide context. Then, the plan itself should contain a brief description of the business drivers for each project or phase of implementation, including potential pilot projects, summarize the business case for each, and detail the execution plan, including which stakeholders it will impact and how and when.

Step #5: Communicate

"The importance of organization-wide communication to successful Smart Grid implementation cannot be overemphasized."

While communication certainly is not the last step in the "roadmap to success," its importance to successful Smart Grid implementation cannot be overemphasized. From the beginning, communication has to be organization-wide, which in theory sounds simple, but again — for an industry historically separated into silos of generation, transmission, distribution, and operational categories — implementing two-way, real-time communication requires nothing short of a cultural shift. An assessment of (and necessary improvements to) current communications methodologies and media must be considered. Communications outreach also must include customers and regulators as required.

The following key message points should be prepared as part of the communications strategy:

- These are the business drivers
- These are the priorities
- This is the business case
- This is the roadmap

Part of a successful communications strategy is repetition. While the Smart Grid makes sense conceptually, it should not be assumed that the "reality" of it will be easy to process and/or execute. Repetition, patience, and taking advantage of consultants, peers, and industry resources make the journey to a Smarter Grid and Smarter Utility feel more deliberate and achievable.

Additional resources

The following resources can help you on your journey to becoming a Smarter Utility:

- U.S. Department of Commerce, National Institute of Standards and Technology (NIST), NIST Framework and Roadmap for Smart Grid Interoperability Standards, Release 2.0
- International Energy Agency, Technology Roadmap: Smart Grids
- International Electrotechnical Commission, Smart Grid Roadmap
- Schneider Electric, Energy Procurement & Sustainability Services

Conclusion

While there is a competitive “rush” to Destination Smart Grid, care must be taken in mapping the utility’s own individual journey. The regulatory and operational landscape of moving to a Smarter Utility is highly complex. Trying to keep up with other utilities at the expense of research-based strategic planning can result in costly missteps and repeated component upgrades as the electricity market continues to evolve.

A proven five-step methodology for mapping the utility’s unique journey ensures that the roadmap is clearly documented and communicated so that all stakeholders understand the objectives and business drivers behind building a Smarter Grid and are working from a common comprehension of the challenges.

In addition, as the Smart Grid technology landscape continues to evolve and change, a Smart Utility will periodically meet to reassess business drivers and available technology offerings, evaluate progress against the business case and roadmap, and evaluate the effectiveness of the communications strategy and use of implemented Smart Grid technologies.

About the author

John Dirkman, P.E., is Senior Product Manager, Smart Grid Global with Schneider Electric. He provides product and program management for advanced integrated Smart Grid systems, from concept through sales, design, development, implementation, and maintenance. John has served as product and program manager for a wide variety of Smart Grid implementations and currently is responsible for driving technical Smart Grid vision and strategy. He is an active member of the Institute of Electrical & Electronics Engineers (IEEE) and the IEEE Power & Energy Society.

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