EPRI | ELECTRIC POWER RESEARCH INSTITUTE

CONSUMERS ENERGY GRID MODERNIZATION ROADMAP ASSESSMENT

April 2021

Executive Summary

The distribution landscape is changing rapidly—introducing new opportunities along with increasing system complexity and uncertainty. This change is being driven by the need to accommodate and integrate distributed energy resources (DER), electric vehicles (EVs), changing customer expectations, shifting load patterns, increased stakeholder engagement, and advanced technologies. The result is a need to update the processes, methods, and technologies used to plan and operate the distribution system. To that end, almost every state has initiated regulatory or legislative efforts to modernize the distribution grid.

Michigan is in the early stages of this process. The Michigan Public Service Commission (MPSC) launched an initiative in 2017 focused on transparent and long-term electric distribution planning. The impetus for this initiative was to increase investment in electric distribution systems and aging electric distribution equipment, to incorporate advanced energy technologies to modernize the distribution system, and to address reliability concerns. In response to the Commission Orders, Consumers Energy (CE) developed its Electric Distribution Infrastructure Investment Plan (EDIIP) which describes a comprehensive distribution investment and maintenance plan spanning a five-year planning horizon. Much like grid modernization efforts nationally, the plan focused on providing safe, reliable, and affordable electricity to its customers.

EPRI has been working with the industry to develop a framework to help utilities with strategies to meet the evolving requirements of a modern grid, leveraging concepts described in the U.S. Department of Energy (DOE) Next Distribution System Platform (DSPx) project. The EPRI framework recognizes that enhancing existing capabilities or developing new capabilities is realized through multiple steps as new tools, processes, systems, and other resources become operationalized. By identifying these steps, a functional progression—a roadmap—can be developed that describes a set of actions a utility will need to undertake to develop the capabilities needed to meet new objectives.

This report describes the application of these frameworks and concepts for modern-day distribution planning and operations to assess the CE Grid Modernization Roadmap. EPRI's assessment looked at the CE plan across several dimensions—the underlying drivers and objectives, the key capabilities needed to realize the objectives, and the implementation plan—to offer insights into how the Roadmap compares with other industry plans. This report is intended to inform stakeholders of current industry practices on this topic. Below are highlights from the assessment.

Stakeholder Engagement

Overall, the CE followed leading practice for roadmap development. Of note, CE engaged stakeholders from across the company and at all levels to help ensure a broad range of perspectives and inputs were collected and a full range of business capabilities are addressed. Broad engagement also begins the socialization and change management process for the Roadmap as a guiding document.

Peer Benchmarking

A grid modernization plan is different for every company. How and when a utility moves from its current to a future state depends on its unique set of drivers and objectives. Benchmarking with peer utilities, however, can provide key insights into how others have structured their grid modernization plans and programs. As part of its roadmap process, CE conducted peer benchmarking to compare its approach with others and to identify lessons learned. Key learnings that CE was able to apply include how to address technology maturity, organizational readiness, and change management. The peer reviews helped to align the Roadmap with leading industry practices.

Roadmap Objectives

Objectives establish the basis for modernization and describe what CE plans to accomplish through the Roadmap. Through its Integrated Resource Plan, EDIIP, and Roadmap, CE has articulated a clear set of objectives ranging from customer experience, to system reliability and the clean energy transition. Objectives convey both scope and timing requirements and subsequently guide the

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Roadmap planning process. Central to CE's modernization approach is a Grid System Orchestrator (GSO) strategy. The GSO strategy outlines a set of future roles and capabilities that will be needed to meet objectives in the functional areas of grid operations, grid planning, grid infrastructure management, distributed energy resource management, and market operations. The GSO provides a comprehensive functional framework to guide the organization and prioritization of the Roadmap. The resulting Roadmap presents a clear logic that links the proposed implementation plan and priority back to the GSO strategy and stated objectives.

Business Capabilities

Capabilities are the collection of expertise, processes, tools, and technologies that a utility will need to execute a specific course of action. Identifying the capabilities needed to support grid modernization is an essential yet complex process. New or enhanced capabilities will be needed to support core utility functions (planning, operations, infrastructure), cross-cutting functions (telecommunications, cyber security, and data management) as well as business function (change management, work management, etc.). Defining the capabilities needed is perhaps the most important component of the Roadmap process. CE used an experienced-based reference model which describes a comprehensive inventory of 270 business capabilities needed to effectively operate an electric distribution business and created an accompanying logical architecture to identify the associated technologies needed to enable the capabilities ranging from the edge of the grid (customers and field devices) to back office systems. The reference model helps to ensure that all potential capabilities are considered; the architecture likewise helps to ensure that the associated technology and connecting infrastructure and networks are also identified. EPRI's experience would indicate that CE's use of a business capability model and architecture was an industry leading practice among utilities that are developing grid modernization plans.

Proportional Deployment Strategy

The DOE DSPx materials introduced the concept of a proportional deployment strategy (i.e., provide advanced grid capabilities where most needed first and/or initially improve grid function with known solutions, followed by more advanced approaches at a later time, as needed). The CE Roadmap applies this concept by focusing the first phase (0–2 years) on foundational capabilities that are expected to have the greatest impact.

CE articulates the importance of piloting applications in the first phase and learning-as-you-go approach. The Grid Mod Incubator initiative is a good example of this, providing an integrated platform for evaluating the safety, security, and interoperability of new technologies, without impacting customers or other equipment before deploying on the distribution system. CE's engagement with industry collaborative research, such as with EPRI, is another way in which CE is staying abreast of the technology trends and leveraging national research efforts to develop and apply new technology.

The second phase of the Roadmap (2–5 years) begins to focus on further developing core capabilities in operations, planning, and the supporting systems and processes needed to build out the GSO capability. The third phase (5–10 years) will depend on how market conditions and regulatory processes evolve. The Roadmap presents a measured approach to modernization, starting with core capabilities in the first five years that will provide value regardless of how the next five years evolve.

Data Governance and Management

Leading utilities, like CE, are beginning to treat data as a strategic asset and establishing enterprise-wide approaches to data governance and management. Accurate distribution system models will become more critical as DER penetration levels increase and as distribution grids grow increasingly complex. Data will come from across the enterprise; will be used across the enterprise; and will need to be managed across the enterprise with a much higher level of granularity, integrity, and speed. Recognizing the importance, CE has established roadmap initiatives to ensure the appropriate policies, procedures, and controls are in place to manage distribution data.

Asset Management

Distribution systems are composed of many assets that are distributed over a wide geographic area. Many of these assets are near or past their expected service life, while new electronic devices are also being added to the system. Each type or class of asset requires a strategy that defines the necessary actions over short-, mid-, and long-term time horizons to optimally manage the asset lifecycle—how and when the asset should be maintained, repaired, or replaced. With the Roadmap, CE lays out a comprehensive, industry-leading approach to leveraging data science approaches to improve system reliability and fleet management decisions.

Cyber Security

As grid modernization infrastructure is implemented with increasing connectivity and information flow internally and with others externally, the attack surface for any potential adversary increases. Recognizing this, modernization strategies should address the need to enhance and extend cyber defenses and evolve into a proactive deterrence rather than the traditional reactive defense. Through its modernization efforts, CE is establishing a cyber security standards and control framework from the start such that critical capabilities and gaps in operational technology cyber security are identified and incorporated into the overall design, deployment, and operation of each project as they are deployed over time.

Workforce

As the distribution system becomes more complex, the roles of distribution engineers, operators and field workers will also evolve. Utilities across the country are beginning to rethink job functions and define the new skillsets and tools that will be needed in the future to evolve the workforce. This aspect is not often addressed in utility roadmaps which tend to be more technology focused. Through its workforce related initiatives, CE has anticipated this change and is addressing how work is managed as well as the digital tools workers will need use to improve efficiency and performance.

Overall Summary

Developing a strategy for grid modernization is complicated. Investments are significant and must be sequenced over several years to achieve both the foundational requirements of safely delivering low-cost, reliable electricity service while also adding new capabilities. EPRI has worked with electric utilities to develop company-specific strategic roadmaps for more than 15 years. In comparison with other utility roadmaps, and with industry frameworks, such as the DOE DSPx and the EPRI Grid Modernization Playbook, CE has taken a comprehensive approach with its Roadmap. CE is addressing core capabilities in operations, planning and grid infrastructure as well as key supporting capabilities, such as telecommunication, cyber security, grid data, and work management which are essential to grid modernization.

Introduction

The distribution landscape is changing rapidly—introducing new opportunities along with increasing system complexity and uncertainty. The changes are being driven by several factors with common themes being the integration of distributed energy resources, changing customer expectations, decarbonization, increasing severity and impact of extreme weather events, and increasing stakeholder engagement. As a result, regulatory or legislative efforts are underway across the U.S. to modernize the distribution grid.

Some states, like California and New York, are several years into comprehensive modernization efforts and are actively integrating advanced grid technologies; defining new planning and analytical methods; defining and deploying new technologies to operate the grid; and developing processes to fully integrate DER. In other states, like Minnesota, the grid modernization efforts to date have focused more on future methods and tools for distribution planning. Ohio also recently completed an initial roadmap for grid modernization through a stakeholder process called Power Forward. In Illinois, the state commission initiated more comprehensive modernization efforts and asked utilities to lay out their plans for grid modernization over the next five years so that stakeholder input can be solicited.

Michigan is in the early stages of this process. The MPSC launched an initiative in 2017 focused on transparent and long-term electric distribution planning. The impetus for this initiative was to increase investment in electric distribution systems and aging electric distribution equipment, to incorporate advanced energy technologies to modernize the distribution system, and to address reliability concerns. In response to the Commission Orders, CE developed its Electric Distribution Infrastructure Investment Plan[1] which describes a comprehensive distribution investment and maintenance plan spanning a five-year planning horizon. Much like grid modernization efforts nationally, the plan focused on providing safe, reliable, and affordable electricity to its customers.

Looking ahead, CE expects to file its next EDIIP in June 2021. Its current grid modernization activities are at a point where adjustments and additional investments are needed to further enhance the capabilities, reliability, and resiliency of the grid and to also achieve ambitious clean energy goals. To help inform the next plan, CE developed a Grid Modernization Roadmap[2] which looks ahead to provide a more detailed and progressive strategy for the future investments needed over the next 10 years to achieve their objectives.

1 Consumers Energy Company's Electric Distribution Infrastructure Investment Plan, April 13, 2018.

2 Consumers Energy Grid Modernization Roadmap – Final Report, April 8, 2020.

CE asked EPRI to conduct an independent review of the Roadmap to compare how the plan aligns with broadly accepted frameworks for grid modernization (EPRI, DOE, other utilities, etc.); assess the key initiatives and associated capabilities; evaluate the timing and execution plan; and to provide insights into potential gaps or general areas of improvement. This report documents the finding from the assessment.

Grid Modernization Frameworks

U.S. Department of Energy (DOE)

The DOE Office of Electricity Delivery and Energy Reliability, at the request of and with guidance from several state commissions, began working with state regulators, the utility industry, and others to develop a foundational definition and understanding of a modern distribution grid. More specifically, the effort aimed to determine the functional requirements for a modern grid that would enable higher reliability and resilience while also enabling integration and utilization of DER. Called the "Next-Generation Distribution System Platform (DSPx) Project," the objective was to develop a consistent understanding of the requirements to inform investments in grid modernization toward those objectives.

The DSPx project results are a useful to understand and organize the interrelationship of technology investments needed in a modernized distribution system. In that regard, over twenty-four regulatory commissions and utilities have leveraged the Modern Distribution Grid reports[3] to inform regulatory proceedings. The DSPx framework provides a recognized industry reference for aligning and assessing utility grid modernization plans and communicating how it is sequencing investments to yield the greatest near- and long-term value and interoperability of utility systems while preserving the flexibility to adapt to an evolving customer and technology landscape.

It also developed the concept of the distribution system as a platform which describes how core infrastructure and advanced technology investments can build on each other to achieve primary

3 Based on various state commission requests and utility feedback and filings.

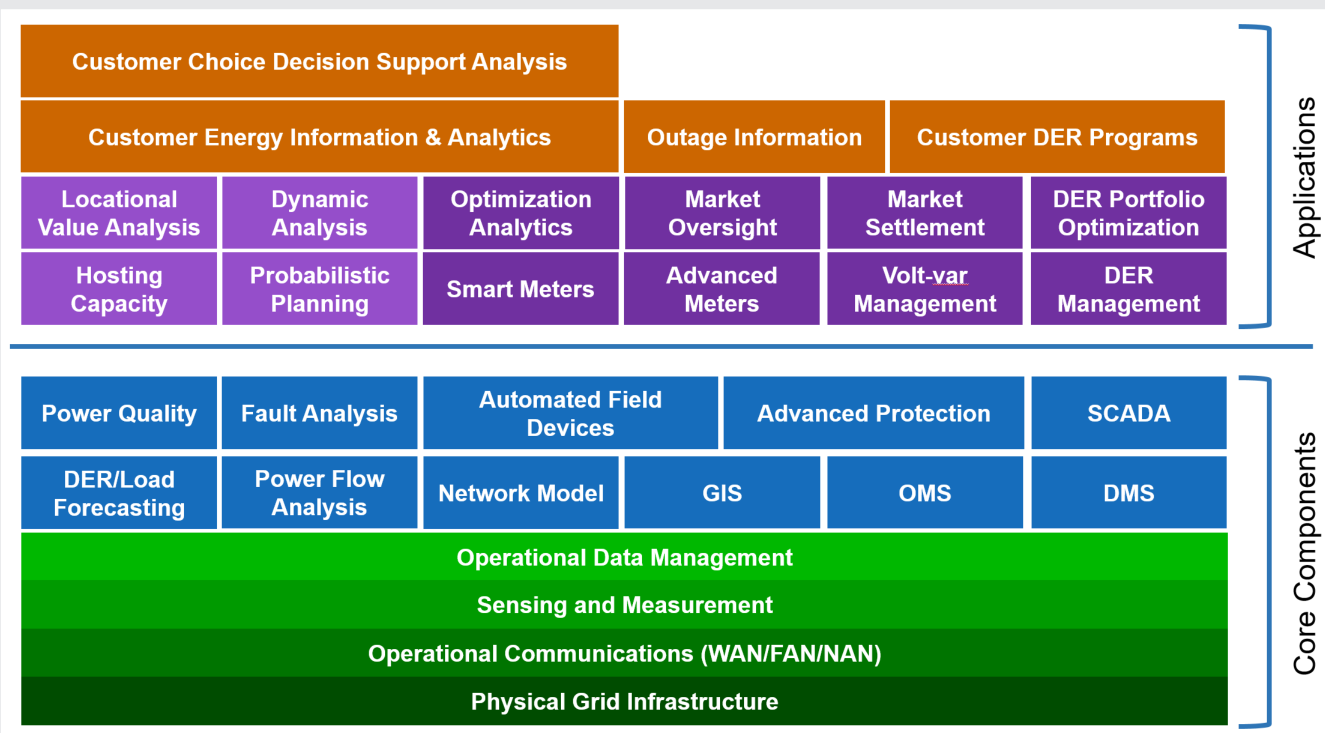

Figure 1. Next Generation Distribution System Platform and Applications

outcomes of improved safety, reliability, and cost while also preparing for a more complex future with a dynamic and integrated electric grid. This platform concept, illustrated in *Figure 1*, depicts a "building block" relationship between the core components, which form the foundation, and future applications that are dependent on the core.

EPRI Framework

EPRI has also been working with industry to develop a framework[4] to help utilities with strategies for grid modernization and developing the capabilities needed to meet the evolving requirements of a modern grid. Leveraging the concepts described in the DSPx project,[5] the EPRI framework describes a structured methodology and a set of tools to help utilities develop or assess plans to meet a company's unique objectives. It recognizes that enhancing existing capabilities or developing new capabilities is realized through multiple steps as new tools, processes, systems, and other resources become operationalized. By identifying these steps, a functional progression—a roadmap—can be developed to provide a set of actions a utility will need to undertake to develop the capabilities needed to meet defined goals.

EPRI's Integrated Grid[6] and Integrated Grid Benefit-Cost Framework[7] are additional industry resources which define the key steps necessary to move toward an Integrated Grid—one that enables utilities to realize the full value of DER, integrating DER into every aspect of grid planning, operations, and policy. The Benefit-Cost Framework presents a transparent, consistent methodology for assessing the benefits and costs of transitioning to an Integrated Grid.

Roadmap Assessment

Comparing the CE Roadmap with the EPRI and DSPx frameworks provides a good benchmark for assessing both the components and the timing and pace of its grid modernization plan. EPRI's assessment looked at the CE plan across several dimensions. First, it looked at the overall CE Roadmap process, the underlying drivers and objectives for distribution modernization, and the key capabilities needed to realize the objectives. Next, it assessed the plan with a focus on the technology modernization components in the context of how the capabilities align with and support stated objectives. And finally, the assessment identified gaps or overall areas of improvement and insights into how the Roadmap compares with other industry plans.

A first step in developing or assessing a grid modernization strategy is to understand the drivers and objectives for modernization. Drivers are the factors that are compelling change in current practices for which a utility currently plans, designs, operates, and maintains the distribution system. Drivers can be external, such as regulatory or legislative policy or changes in customer behavior or can be derived from corporate business strategy. Objectives define the specific result that the utility wants to achieve. Therefore, objectives drive the subsequent steps in the roadmap process and decisions in the system characteristics that must change, such as improving existing capabilities or adding new capabilities. With this as a foundation, modernization plans can then identify the capabilities needed to achieve each objective, as well as the roadmap to get there.

The CE Roadmap process followed leading practice for roadmap development. Key steps in the process are described in *Figure 2*. Of note, CE engaged stakeholders from across the company and at all levels to help ensure a broad range of perspectives and inputs were collected. Through a series of workshops with subject matter experts, leaders, front-line workers, and support organizations, CE gained insights into corporate vision and strategy, the current state of capabilities, and future needs of processes, systems, and organizational approach from across the company. The workshops identified existing capabilities, initiatives, gaps, and key findings which informed the subsequent capability prioritization and roadmap initiatives.

Engaging such a broad range of stakeholders helps ensure that the roadmap addresses a full range of business capabilities from core capabilities (grid infrastructure, operations, and planning) to supporting technology (cyber security, telecommunications, etc.). Broad engagement also begins the socialization and change management process for the roadmap as a guiding document.

Current State Assessment

The current state assessment was focused on areas that were expected to have the greatest impact on CE objectives, such as substation and distribution automation, DER integration, advanced distribution

4 *Grid Modernization Playbook: A Framework for Developing Your Plan*. EPRI, Palo Alto, CA: 2020. 3002018952.

5 Modern Distribution Grid, Volumes I-IV, U.S. Department of Energy, Office of Electricity Delivery & Energy Reliability. https://gridarchitecture.pnnl.gov/modern-grid-distribution-project.aspx

6 *The Integrated Grid*. EPRI, Palo Alto, CA: 2015. 3002002733.

7 *The Integrated Grid: A Benefit-Cost Framework*. EPRI, Palo Alto, CA: 2015. 3002004878.

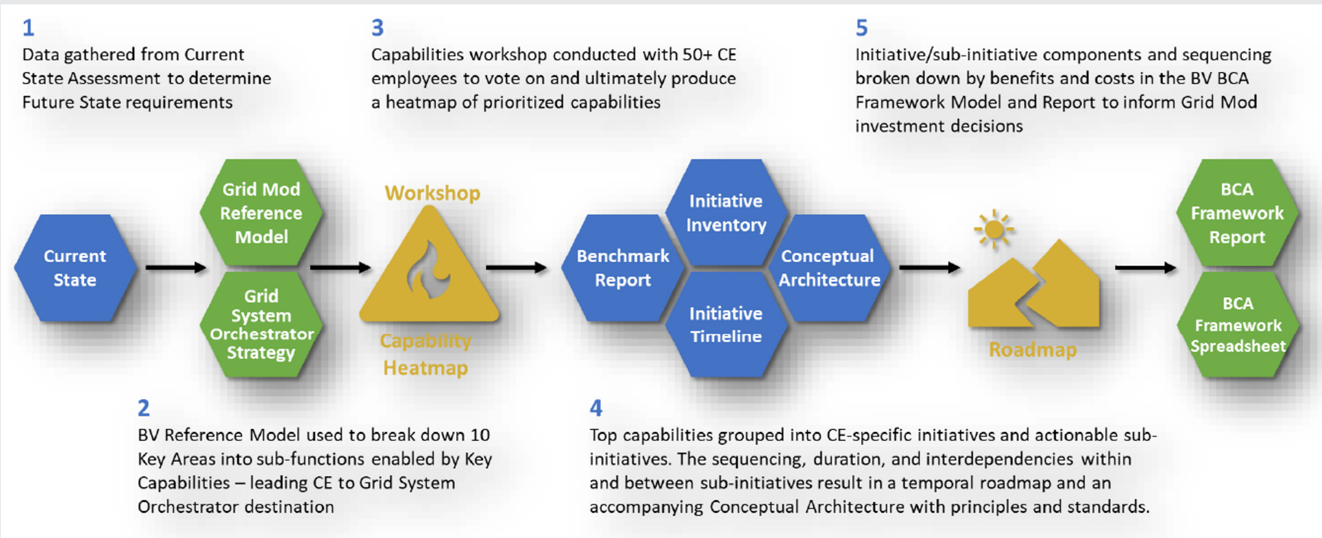

Figure 2. Roadmap Development Approach. (Source: Consumers Energy Grid Modernization Roadmap)

management systems (ADMS), and distribution asset/work management. Like many electric utilities, CE is still in the early stages of grid modernization, focusing on establishing the foundational infrastructure and improving overall system reliability. For example, CE has installed thousands of devices on the system which are already delivering reliability benefits to their customers. However, there were gaps in future technologies, processes, organization, and data management that limit the potential benefits of grid modernization. The current state assessment provided critical insight into areas where CE will need to focus grid modernization efforts.

Peer Benchmarking

A grid modernization plan is different for every company. How and when a utility moves from its current to a future state depends on its unique set of drivers and objectives. Benchmarking with peer utilities, however, can provide key insights into how others have structured their grid modernization plans and programs. As part of its roadmap development process, CE conducted peer benchmarking to compare its Roadmap approach with others and to identify lessons learned. Through this process, CE identified several key learnings—how to address technology maturity, organizational readiness, and change management—that were incorporate into the Roadmap. The peer reviews also helped to align the Roadmap with leading practices from across the industry.

Drivers and Objectives

The starting point for the Roadmap was alignment of modernization objectives with the CE's vision—the strategy that drives modernization decisions. With its 2019 Integrated Resource Plan (IRP),[8] CE established a triple bottom line strategy —People, Planet, and Prosperity— to balance the interests of customers with other stakeholders and to capture the broader societal impacts of its activities. The Plan describes aspirational goals to transition to clean energy resources by: ending coal use to generate electricity, reducing carbon emissions by 90 percent from 2005 levels, and meeting customers' needs with 90 percent clean energy resources by 2040. In addition, Michigan has recently launched a customer-focused, multi-year stakeholder initiative called MI Power Grid. MI Power Grid aims to maximize the benefits of the transition to clean, distributed energy resources with a focus on customer engagement, integrating emerging technologies, and optimizing grid performance and investments.

Objectives establish the basis for modernization and describe what CE plans to accomplish through the Roadmap. Through its 2018 EDIIP and Roadmap processes, CE developed a set of overarching objectives which are summarized below:

8 Consumers Energy Clean Energy Plan. 2019.

- Maintain and optimize the system; rehabilitate, replace, and rebuild existing infrastructure; respond to emergent and customer-driven work; and lay foundation for advanced grid capabilities.
- Transform and modernize the grid by developing new capabilities across the following five customer-driven objectives:
  - **Cyber security, physical security, and safety** – Design the system to ensure the security and safety of customers and employees are maintained and ultimately enhanced.
  - **Reliability** – Improve reliability of the system under normal operating conditions and resiliency under extreme conditions.
  - **Sustainability** – Continue to look for opportunities to explore sustainable options and reduce waste in the system.
  - **Control** – Provide customers with the data, technology, and tools to take greater control over their energy supply and consumption.
  - **System Cost** – Deliver the objectives above at an optimal, long-term system cost for all customers.
- Build for the future to enable a transition to a cleaner, more efficient, and more distributed energy system.
  - **Best in class service to all customers** – Provide customers with safe, reliable, and affordable electric service with best in class customer experience.
  - **Optimize supply and demand** – Optimize supply and demand using a fully integrated strategy for supply, demand-side management, and asset and grid management.
  - **Create the cleanest and most efficient energy system** – Shift to cleaner energy resources, in line with the Clean Energy Plan, and optimize operations to be leaner and lower cost for customers through use of a lean operating system.

It is important that grid modernization plans present a logic that links the proposed technology deployment roadmap back to stated objectives. Described above, CE has articulated a clear set of objectives that convey both scope and timing requirements and subsequently guide its planning process. The Roadmap then creates a cohesive plan to develop the capabilities needed to realize these objectives.

Identifying Capabilities

The next step in the process of developing a roadmap is to identify the capabilities needed to achieve objectives. DOE defines a capability as the ability to execute a specific course of action. A capability can be expertise, processes, tools, and/or technologies that a utility has. Every utility has a wide range of existing capabilities. A grid modernization plan either enhances those existing capabilities or adds new capabilities. Defining the capabilities needed is perhaps the most important component of the roadmap process.

Central to CE's modernization approach is a Grid System Orchestrator (GSO) strategy. The GSO strategy describes a set of future roles and capabilities that will be needed in the functional areas of grid operations, grid planning (short and long-term), grid infrastructure management, distributed energy resource management, and market operations. The GSO functional framework guides the organization and prioritization of CE's grid modernization capabilities.

CE then used a business capability model to provide a framework for determining the specific capabilities that would be needed to enable the GSO strategy. The capability model used, called the Grid Modernization Reference Model, is an experienced-based model focused on the business capabilities needed to effectively operate an electric distribution business. The Reference Model, shown below in *Figure 3*, describes six core utility business functions—grid operations, grid infrastructure, grid management, grid engineering, grid communications, and distribution markets—with each core function further broken down into five sub-functions. While not shown in the diagram, the thirty sub-functions are further broken down into a comprehensive inventory of over 270 business capabilities. *Table 1* illustrates the architectural structure for example business capabilities in grid engineering and grid operations.

The core functions in the Model are closely aligned with the GSO functional framework creating linkage back to CE's overall strategy. While nomenclature may have some differences, the core functions are also in line with the DSPx Next Generation Distribution System Platform and Applications diagram and EPRI's Grid Modernization Playbook.

To enable the GSO, CE also developed a technology-focused architecture, called the Grid Service Platform (GSP), which identifies the systems, applications, data communications, devices, integrations, and services required for its modernization plan. The GSP does an excellent job of describing how systems will fit together in the future, driving solutions based on future business models, and combining on-premises capabilities with cloud-based capabilities. The Reference Model helps to ensure that all potential capabilities are considered; the GSP architecture likewise helps to ensure that the

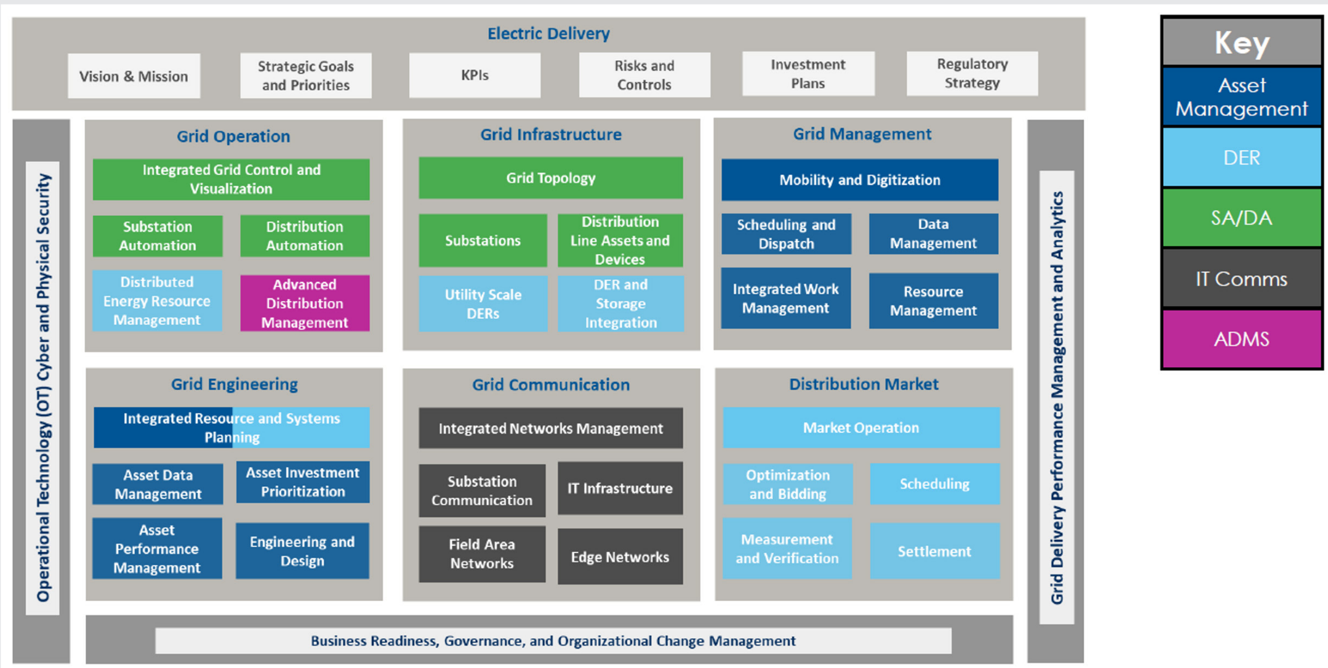

Figure 3. Grid Modernization Reference Model. (Source: Consumers Energy Grid Modernization Roadmap)

Table 1. Core Function, Sub-Function, and Business Capability

Core Function	Sub-function	Business Capability
Engineering	Asset Performance Management	Risk-based asset management
Operation	Distribution Automation	Provide Situational Awareness

associated technology and connecting infrastructure and networks are also identified.

Using the Reference Model, CE leaders and subject matter experts prioritized the 270 business capabilities across several dimensions: expected benefits, addressing identified gaps, business objectives, and timing relative to achieving the future state maturity. The capability prioritization also focused on areas that were expected to have the greatest impact on CE objectives, such as substation and distribution automation, DER integration, ADMS, and distribution asset management. Input was tabulated and prioritized to identify the most critical capabilities and the associated timing and pace for implementation.

Figure 4 is a high-level roadmap timeline illustrating priority capabilities and when they are enabled. The first phase (0–2 years) of the Roadmap focuses on foundational capabilities. Priorities in this first phase are in line with the core components of the DSPx framework. Priorities include areas that are expected to have the greatest impact, such as the ADMS and substation/distribution automation to improve grid situational awareness and control; advance communication network capability from field devices to operations center; developing standardized infrastructure designs that are robust and resilient; and piloting applications to manage utility-owned DER assets. Across the industry, the ADMS is an important technology to deploy early in the process as it can enable a host of decision support capabilities to monitor, control, and optimize the distribution system.

The second phase of the Roadmap (2–5 years) begins to focus on further developing core capabilities in operations, planning, and the supporting systems and the process needed to build out the GSO capability. The third phase (5–10 years) will depend on how market conditions and regulatory processes evolve. The Roadmap presents a measured approach to modernization, starting with core capabilities in the first five years that will provide value regardless of how the next five years evolve.

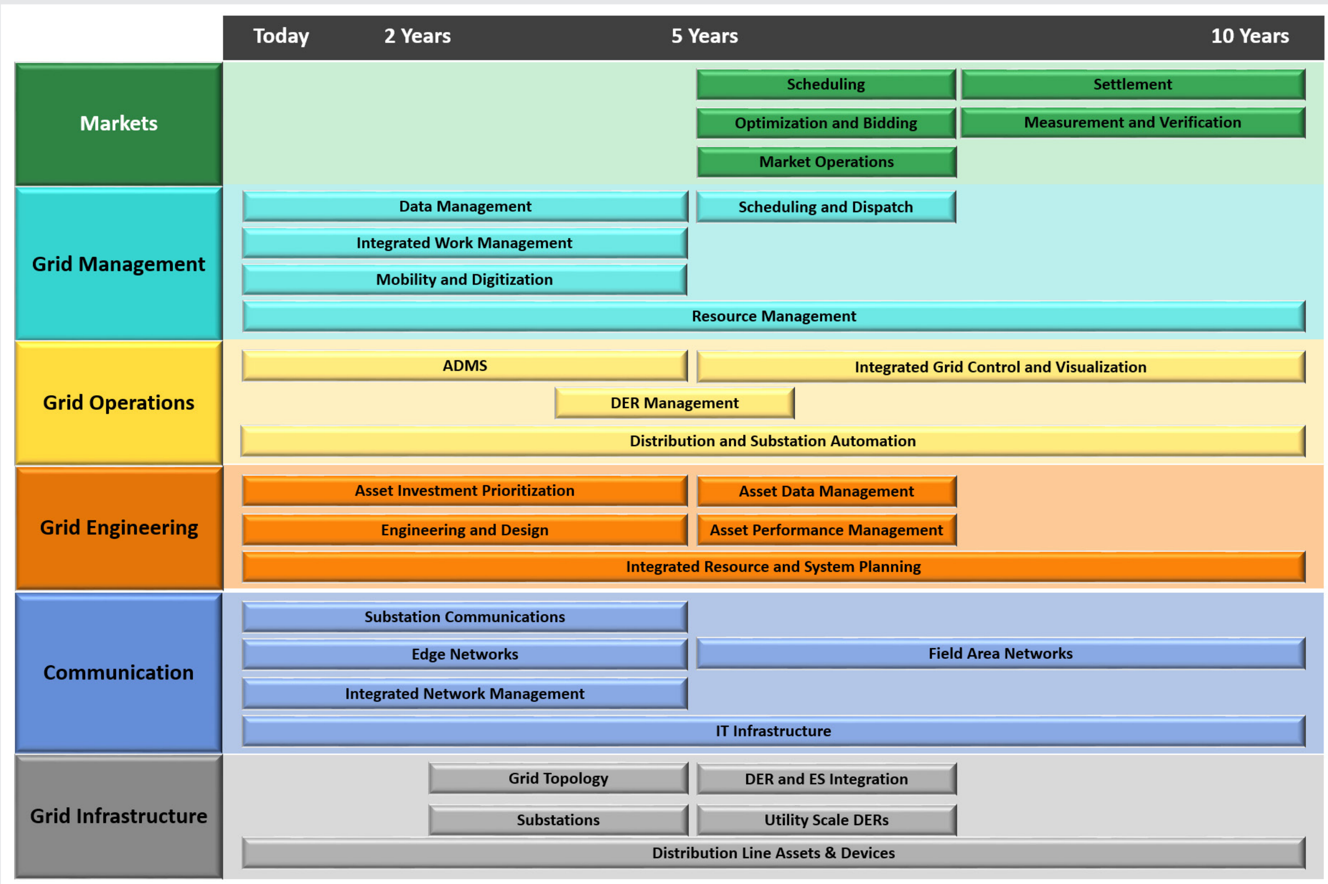

Figure 4. Implementation Timeline for Priority Capabilities

Twenty-two initiatives were then defined representing several categories of investments needed to move CE toward achieving the GSO strategy. The initiatives created traceability between the planned actions and the capabilities enabled, gaps addressed, and the expected benefits. The sequencing, duration, and interdependencies within and between the initiatives resulted in a high-level, temporal roadmap describing how CE intends to integrate the new capabilities into day-to-day operations.

The Roadmap identified cyber security as a cross-cutting capability. Through its modernization efforts, CE is establishing cyber security standards and control framework from the start such that critical capabilities and gaps in operational technology (OT) cyber security are identified and incorporated into the overall design and operation of each project as they are deployed over time.

Similarly, CE has also established distribution data governance and management as cross-cutting initiatives to ensure the appropriate policies, procedures, and controls are in place to manage it. Leading utilities, like CE, are beginning to treat data as a strategic asset and establishing enterprise-wide approaches to data governance and management. Accurate distribution system models will become more critical as DER penetration levels increase, and distribution grids grow increasingly complex. Data will come from across the enterprise; will be used across the enterprise; and will need to be managed across the enterprise with a much higher level of granularity, integrity, and speed.

EPRI's experience with other utility roadmaps and the DOE DSPx materials would indicate that the Reference Model used by CE was comprehensive, thus helping to ensure that all potential business

capabilities were considered in the prioritization process. Further, the priority business capabilities identified by CE leaders and subject matter experts through this process represent those needed to meet its GSO strategy. This practice has become an industry leading approach among utilities that are developing grid modernization plans.

EPRI subject matter experts then reviewed how the prioritized capabilities were being implemented through the Roadmap initiatives. The review encompassed the initiative scope, capabilities enabled, gaps addressed, benefits, and implementation. More than twenty CE and a dozen EPRI subject matter experts participated in this review. Overall observations and recommendations from the initiative reviews are included below, organized around the following initiative categories: strategy, operations, planning, grid infrastructure, work execution, and data management.

Initiative Review

Strategy

The GSO business strategy describes an incremental approach to implementation, focusing first on foundational technologies that are expected to have the greatest impact and value. At the same time, CE plans to conduct field pilots to evaluate key DER integration functions of 3rd party-owned, utility-owned, and customer-owned resources. Field testing will be complimented with a new laboratory capability to provide an integrated platform for evaluating the safety, security, and interoperability of new technologies, without impacting customers or other equipment before deploying on the distribution system. An important consideration may be FERC Order No. 2222 directives in key areas, such as participation models, locational and size limitations, bidding requirements, telemetry, metering requirements, as well as coordination requirements across the important entities. Depending on how (and how quickly) markets and regulatory processes evolve in Michigan will affect how CE will need to transform the GSO capability, but the incremental implementation approach combined with field and laboratory testing to gain experience with key applications is a good practice.

Planning

Integrated system planning is a key concept described in the CE Roadmap, recognizing the need to proactively address changes to the distribution planning process, including near-term and long-term planning considerations and how they are related to the development of grid modernization strategies and subsequent technology implementation plans. With its Integrated System Planning initiative, CE is at the forefront of utilities that are beginning to address these changes, for example Hawaiian Electric and Xcel Energy in Minnesota.

CE is further evolving its interconnection processes to meet aggressive DER and solar energy targets. Among planned activities is the expanded application of hosting capacity analysis[9,10] to CE's low- and high-voltage distribution circuits as more DER enter the queue. In addition, enhancements to PowerClerk are intended to allow the platform to better integrate with the company's existing and future work management processes and support interconnection efficiencies. Together, these activities are expected to improve the associated processes and procedures for both DER applicants (customers and 3rd party developers) as well as internal utility staff.

For all planning processes, system models will need more granularity to address the locational and temporal aspect of the changing generation, storage, and demand resource mix. Processes for collecting and validating system data, integration of applications that contain the system data, and governance processes to maintain data over time will be needed.

CE's engagement with industry collaborative research is one way in which CE is leveraging national research efforts to develop and apply a more integrated approach to distribution system planning. One example is using EPRI's Distribution Resource Integration and Value Estimation (DRIVE) tool to more efficiently conduct system hosting capacity assessments.[11]

Operations

At the center of the operations objective is the deployment of a state-of-the-art ADMS to integrate various utility systems and advanced applications into a common software platform over the next 10 years. The ADMS initiative is a continuation of an existing

9 Hosting capacity is defined as the amount of DER that can be accommodated without adversely impacting power quality or reliability under existing control configurations and without requiring infrastructure upgrades.
10 *Impact Factors, Methods, and Considerations for Calculating and Applying Hosting Capacity*. EPRI, Palo Alto, CA: 2018. 3002011009.
11 https://www.epri.com/DRIVE

project that seeks to implement, replace, enhance, and/or integrate existing systems and applications. The ADMS is essential to CE's transformation from a traditional dispatching-centric model to a real-time operation and optimization model with unified visibility and control across its grid. The ADMS deployment is a good example of the incremental implementation approach, first starting on a small group of circuits to gain valuable insights and experience with the core ADMS functions, next expanding the scope to include over 800 feeders and associated substations, as well as, additional functionality of the ADMS itself, and looking ahead to add the remaining feeder and substation models to the ADMS, add additional D-SCADA capabilities, integrate other major components, such as the outage management system (OMS), and to start the use of various advanced applications.

EPRI's experience has shown that maintaining GIS data—data quality and accuracy—will be paramount going forward. Also, the volume and complexity of alarms received through the ADMS will typically increase as grid modernization activities add new devices and sensors. Continue to innovate around alarm management and the data the distribution system operator sees to more effectively help the operator take the correct action at the correct time.

The ADMS will additionally provide monitoring, management, and coordination of grid devices as well as utility-, customer- and third party-owned DER, working in tandem with the distributed energy resource management system (DERMS) and the demand response management system (DRMS). CE has identified the necessity to integrate and coordinate the DERMS and DRMS solutions. Developing siloed DERMS and DRMS solutions can lead to duplicative efforts and overlapping system functionalities. To the contrary, the holistic integration of all DER types (including controllable loads/end-use technologies) improves operational efficiency, simplifies performance verification, and enables multiple services. Prior to considering at-scale implementation, however, CE intends to focus initially on smaller pilots to demonstrate DERMS and DRMS use cases and increase CE's knowledge base. For pilots involving behind-the-meter resources, utility pilots have shown that customer acquisition can be a challenge, significantly slowing down execution. Third party aggregators with existing customer portfolios (such as technology vendors) or with prior experience developing customer portfolios, can help accelerate the initial project stages. CE could consider complementing its DERMS and DRMS pilot projects with computer-based simulations, leveraging, for example, the Grid Mod Incubator or EPRI's DER integration test bed environment. The benefits of this approach can be twofold: evaluate vendor products prior to making final product selection and deployment; and explore additional use cases on a range of CE feeders simulated using a distribution modeling software.

The prioritization of use cases is an important step that should be completed prior to vendor selection, to ensure that product functionalities meet all use case requirements. Some use cases may focus on addressing grid challenges created by DER; others may intend to enable new grid programs such as non-wires alternatives (NWA). In any case, grid constraints can always be emulated for pilot purposes. Demonstrating DERMS/DRMS solutions on feeders experiencing actual issues (DER-related constraints, or with opportunities for upgrade deferral) adds significant value to the pilot project. In particular, this approach greatly facilitates the valuation of tangible benefits, and the cost-benefit analysis all together.

Finally, while CE's DERMS and DRMS use cases may primarily focus on distribution applications, it may be advisable to consider whether the recent FERC 2222 order could motivate exploring additional use cases requiring three-way interactions between CE, third party service providers, and Midcontinent Independent System Operator (MISO).

Grid Infrastructure

Within the infrastructure area, CE intends to modernize substation and circuit designs with digital intelligent devices and distributed automation to create the substation and circuit of the future. Additionally, the grid infrastructure includes practices for how distribution assets will be managed and maintained.

The substation modernization initiative aims to increase substation robustness and resilience. The initiative includes the modernization of standards and designs to incorporate and deploy new technologies in power equipment coupled with the deployment of new protection, control, and monitoring devices and communications capabilities. Similarly, distribution circuit modernization also intends to develop robust and standard designs for materials, power equipment, and distribution automation (DA) equipment. The new designs and technologies are essential to optimizing grid performance and supporting grid functions.

EPRI's experience would suggest that the expected increase in inverter based renewable energy resources will present new challenges for protection designs and that a systematic review of protective schemes and relay devices should be included in the plan. Resil-

ient data communication designs, as described in IEC 61850, and cutting-edge data communication technologies (such as process bus) should also be considered to prepare for the potential substation modernization needs in the future.

An additional component of CEs grid infrastructure initiatives is to ensure that the processes, policies, skills, and technology solutions are in place to operate a proactive asset management program for existing and future physical assets—transformers, poles, conductors, meters, reclosers, and regulators. The management of assets requires data from multiple disciplines, such as operations, planning, engineering, supply chain, and finance, to enable informed decisions on the actions to improve and maintain the operation and performance. This includes the capabilities of data capture and integration tied together for the explicit purpose of improving the reliability and availability of physical assets. It includes the concepts of condition monitoring, predictive forecasting, and reliability-centered maintenance and builds on the base of asset data generated from an enterprise asset management solution.

With the Roadmap, CE lays out a comprehensive approach to leveraging data science approaches to improve asset fleet management decisions. CE's engagement with industry collaborative research, such as with EPRI's asset analytics research, is also being leveraged to understand industry-leading practices for: industry accepted codes for consistent recording of information (e.g., problems found in the field); utilizing industry-wide asset performance databases; developing requirements to evaluate various enterprise-wide asset health platforms, and developing asset data models. Collaborative research also provides a conduit for lessons learned from other utilities.

CE has also made cyber security an integral part of this initiative. By addressing cyber security early in the planning process, CE can plan for future security controls that are optimized for emerging grid applications. CE's plans for intelligent electronic devices (IED) management involves both vendor-specific management tools in addition to multi-vendor remote access/IED management solutions. This approach should facilitate automated monitoring and management for a large portion of the individual assets in the roadmap. These management strategies are in line with industry best practices.

Work Execution

Through its work execution initiatives, CE is planning a leading practice optimization of its work force and the technologies that they use. From a field technology perspective, CE is making office applications readily available to the field workforce, both company and contract crews to improve workforce efficiency, to promote access to real-time operational data, to capture data while the job is performed, and to improve safety. This initiative ushers in a new paradigm for the field worker and unlocks a new level of situational awareness and flexibility.

Work execution initiatives are also planned to optimize all functions, including technologies and organizations, related to the scheduling and planning of short- and long-term work both from a worker and equipment standpoint. The technologies and associated processes enable the following capabilities: automation of some of the manual schedule and dispatch tasks, appointment scheduling, resource and work forecasting, and workforce flexibility. The initiative will align company and contract crews with common work management processes, systems, and technologies to provide up-to-date information on the tracking and status of work related to customer requests and storm response. Together, these initiatives will enhance the safety of the workforce by bringing all crews under the same set of standards and work processes, and through the use of a common work and asset management platform while improving overall workforce efficiency.

For the rollout of the work execution initiatives, CE will need to continue to adapt its training to effectively integrate the systems, applications, technologies into its workforce, to stay ahead of the interoperability challenges faced in rolling out new capabilities, to be mindful of the everchanging needs of the modern field worker, to continue to look for opportunities to automate and centralize processes, to layer in advanced cyber and access security practices, and to consider establishing data management practices improve data capture and accuracy.

Data Management

Leading utilities, like CE, are beginning to treat data as a strategic asset and establishing enterprise-wide approaches to data governance and management. Accurate distribution system models will become more critical as DER penetration levels increase and as distribution grids grow increasingly complex. Data will come from across the enterprise; will be used across the enterprise; and will need to be managed across the enterprise with a much higher level of granularity, integrity, and speed.

There are two essential ingredients to an enterprise approach to data management: a solid data management and integration design and

utility business processes and governance that leverage it. Recognizing the importance, CE has articulated a comprehensive vision for what data governance and management would look like and to ensure the appropriate policies, procedures, and controls are in place to manage distribution data. The use of a reference model will be critical for success for these initiatives moving forward; the utility Common Information Model (CIM) is a leading practice. Data architecture development is a critical capability that will need to be addressed early in these initiatives.

Overall Observations and Conclusions

From a broader industry perspective, almost every state in the U.S. has launched regulatory or legislative efforts to begin modernizing the distribution grid. As a result, many utilities are developing comprehensive plans, in many cases required by a regulatory commission, that lay out strategies for grid modernization over a multi-year time frame. Developing a strategy for grid modernization is complicated. Investments are significant and must be sequenced over several years to achieve both the foundational requirement of safely delivering low-cost, reliable electricity service while also adding new capabilities.

EPRI has worked with electric utilities to develop company-specific strategic roadmaps for more than 15 years. In comparison with other utility roadmaps, and with industry frameworks such as the DOE DSPx and the EPRI Grid Modernization Playbook, CE has taken a more comprehensive approach with its Roadmap. CE is still in the early stages of grid modernization with a primary focus on establishing foundational infrastructure and modernizing core grid technologies, operational and communications systems, and planning tools and processes. In alignment with its corporate objectives, the Roadmap advances those capabilities, while also addressing key supporting capabilities, such as telecommunication and work management, and cross-cutting capabilities such as cyber security and grid data, which are not addressed in detail in the DOE DSPx materials.

The DOE DSPx materials present **four key concepts** to consider when assessing modern-day grid modernization planning processes, The CE Roadmap addresses or expands upon these concepts as described below:

1. Does the plan have **well-articulated objectives** that convey scope and timing requirements that are essential to guide the planning process?

   Through its IRP and Roadmap, CE articulated a clear set of objectives that convey both scope and timing requirements that subsequently guide its roadmap planning process ranging from customer experience, to system reliability, and to the clean energy transition. The GSO strategy is central to the modernization approach and provides a progressive and comprehensive functional framework to guide the organization and prioritization of the roadmap. The resulting Roadmap presents a clear logic that links the proposed technology deployment plan and priority back to the GSO strategy and stated objectives. **CE's approach to establishing objectives is considered standard industry practice.**

2. Is grid modernization planning part of a **larger integrated distribution planning process** in which foundational investments are required to enable advanced grid capabilities?

   In the DOE context, grid modernization investment planning must be aligned with traditional asset planning and integrated with other planning objectives for resilience and reliability. Through the 2018 EDIIP, CE established an initial framework for grid modernization and has already made significant progress toward addressing traditional "asset planning" which focuses on proactively addressing safety, code compliance, and basic reliability issues over a 5-year horizon. Through the Roadmap, CE is planning to implement a more integrated distribution planning process, whereby asset planning is augmented and expanded to include a longer time horizon (10 years) and more robust application of advanced grid technologies, alternative circuit designs, and use of DER and microgrids to meet both customer and power system needs. **CE's approach to an integrated planning process is considered leading industry practice.**

3. Has a **systems engineering approach** been used to determine functional and structural needs in line with stated objectives?

   Systems engineering is a methodical, disciplined approach that examines key architectural considerations, the timing and pace of deployment, and interdependencies between business processes and enabling technology options for grid modernization. CE developed a conceptual architecture to identify the systems, applications, data communications, devices, integrations, and services required; how the architecture and technology/application landscape will evolve over time; and to inform the direction and pace of implementation of the Roadmap. **CE's approach addresses the systems engineering aspect and is considered leading industry practice.**

4. Do technology implementation plans adopt **proportional deployment strategies** that can provide advanced grid capabilities where most needed first and/or initially improve grid function with simpler solutions, followed by more sophisticated approaches later, as needed.

   The Roadmap applies this concept by first focusing on foundational capabilities and technologies that are expected to have the greatest impact. As CE moves to the next phase of implementation, it will further develop its core capabilities to build out the GSO capability. The final phase of the 10-year plan will depend on how market conditions and regulatory processes evolve. **CE's proportional development approach is considered standard industry practice.**

The following provides some additional observations for consideration as CE implements its plan over the next 10 years:

Keep an eye on DER: Distributed resources are a major driver for grid modernization efforts nationwide and are also a significant driver for the Roadmap and GSO strategy. DER adoption levels, however, are still relatively low in Michigan. This gives CE time to pursue a more deliberate, incremental approach to evaluating and implementing the tools and process that will be needed.

Focus on workforce is critical: Advancements in operations and planning will also require a closer look at workforce needs. As the distribution system becomes more complex, the roles of distribution engineers and operators will evolve. Utilities across the country are beginning to rethink job functions and define the new skillsets that will be needed in the future to evolve the workforce. Through its workforce related initiatives, CE has anticipated this change and is addressing how field work is managed as well as the digital tools field workers will use to improve efficiency and performance.

Develop data analytic capabilities: Data and analytics are becoming ever more important to inform daily business tasks, long-term investment decision, and continuous improvement. In some cases, utilities are creating a practice around data analytics comprised of data scientists that interface with all areas of utility operations. Data-supported decision-making will become integral to the planning, design, operations, and maintenance of the system to ensure reliability and service standards are met. With the Roadmap, CE is laying out plans to leverage advanced analytic capabilities, for example applying data science to its approach to asset management to improve system reliability and fleet management decisions.

Telecommunications: The industry is experiencing rapid growth and need for connectivity for both operational needs, as well as security. Having a secure, robust, and resilient communication infrastructure will be critical to the future grid performance at all levels. Advancing communication capabilities, from local device automation to central grid operations and control, are an integral, cross-cutting element of the Roadmap across initiatives. As a part of its Roadmap, CE is reviewing its long-term telecommunication strategy, especially regarding the security and resiliency aspects of its networks.

Technology maturity: Considering technology maturity in relation to CE's adoption strategy is a key consideration with respect to selection and timing. CE does a good job of articulating the importance of piloting applications in the first phase and learning-as-you-go approach. The Grid Mod Incubator is a good example of this, providing an integrated platform for evaluating the safety, security, and interoperability of new technologies, without impacting customers or other equipment before deploying on the distribution system.

Industry collaboration: CE's engagement with industry collaborative research, such as with EPRI, is another way in which CE is staying abreast of the technology trends and leveraging national research efforts to develop and apply new technology. CE's participation in EPRI collaborative research to develop and apply a more integrated approach to distribution system planning and advanced hosting capacity methods are two examples.

The Electric Power Research Institute, Inc. (EPRI, www.epri.com) conducts research and development relating to the generation, delivery and use of electricity for the benefit of the public. An independent, nonprofit organization, EPRI brings together its scientists and engineers as well as experts from academia and industry to help address challenges in electricity, including reliability, efficiency, affordability, health, safety and the environment. EPRI also provides technology, policy and economic analyses to drive long-range research and development planning, and supports research in emerging technologies. EPRI members represent 90% of the electricity generated and delivered in the United States with international participation extending to nearly 40 countries. EPRI's principal offices and laboratories are located in Palo Alto, Calif.; Charlotte, N.C.; Knoxville, Tenn.; Dallas, Texas; Lenox, Mass.; and Washington, D.C.

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Note

For further information about EPRI, call the EPRI Customer Assistance Center at 800.313.3774 or e-mail askepri@epri.com.

EPRI RESOURCES

Bruce Rogers, *Technical Executive, Distribution*
423.341.4606, brogers@epri.com

Jared Green, *Senior Technical Leader, Distribution Operations & Planning*
865.360.7967, jgreen@epri.com

Don Von Dollen, *Senior Technical Executive, Information & Communication Technology*
650.855.2210, dvondoll@epri.com

Distribution Operations and Planning

3002021433

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Electric Power Research Institute
3420 Hillview Avenue, Palo Alto, California 94304-1338 • PO Box 10412, Palo Alto, California 94303-0813 USA
800.313.3774 • 650.855.2121 • askepri@epri.com • www.epri.com