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Section 8008 Voluntary Model Pathways for Modernizing the Electric Grid

Expanded Recommendations for the U.S. Department of Energy

FEBRUARY 2023

ELECTRICITY ADVISORY COMMITTEE

Executive Summary

The ability to transform the electric grid to meet affordability, resilience, reliability, decarbonization, and equity goals will require coordinated strategies beyond those that exist today. Policymakers, regulators, industry partners, market participants, and energy consumers must all be engaged, and coordination efforts must be streamlined to allow policymakers to focus on priorities across the industry. Policy frameworks must enable collaborative efforts that advance modernization to meet consumer needs, identify barriers for underserved communities, and deliver benefits while, at the same time, adhering to industry standards for security and reliability.

Section 8008(a)(3) of the Consolidated Appropriations Act of 2021 aims to support this goal and requires that the U.S. Department of Energy (DOE), in consultation with a Steering Committee, initiate the development of voluntary model pathways for modernizing the electric grid. The Electricity Advisory Committee (EAC) was designated as the appropriate body to serve as the Steering Committee, with additional representation from the Federal Energy Regulatory Commission (FERC) and DOE National Laboratories.

The goal of this effort is to outline a path forward, including priorities that will shape the technical discussions and solutions contributing to a grid that meets the needs of the future. It acknowledges the complex interstate and state-federal jurisdictional boundaries and respects that the North American electric grid is interconnected. While the recommendations on a path forward do not prescribe specific technical solutions, they do anticipate driving and/or accelerating the necessary conversations that will lead to more informed voluntary policy decisions.

Voluntary model policy pathways will provide a wide range of policymakers with targeted resources that facilitate a rational transition to a decarbonized, resilient electric grid while ensuring safe, reliable power and equitable and just outcomes.

Findings

The Steering Committee undertook a scenario-based approach in order to understand the most important matters to be addressed in the pathways discussion. Key findings are as follows:

- Greater **industry coordination** across the transmission, distribution, and behind-the-meter domains, as well as customer engagement, are needed for a reliable and efficient energy transition.

- A **robust and well-planned transmission system** is necessary to support a cost-efficient and equitable energy transition to more renewable resources and electrification.
- A **distribution network** that better enables distributed energy resources (DERs) and energy storage utilization; evolving business, industry, and market structures; convergence with transportation and building infrastructures; and electrification is needed. This includes a distribution network that supports the interoperability and the efficient addition of centralized and decentralized assets.
- Incorporation of **flexibility and resilience** into grid operations and design is necessary.
- A glide path to the grid of the future requires the cost, effectiveness, and availability of **new technologies** to significantly improve in order to encourage widespread adoption.
- The transition to a low-carbon or zero-carbon grid poses a number of well-identified but, as of yet, unsolved challenges, particularly with regard to affordability and reliability, that must be taken on and addressed before we can achieve our goals.

Recommendations

The Steering Committee developed the following recommendations to forge a path forward. While the recommendations are meant to address impediments to a more robust energy future, it is important to note that many important and relevant conversations are already underway. To that end, the Steering Committee recommends the following, in order of priority:

1. Coordination

a. Develop and vet operational coordination framework guidelines that consider the roles and responsibilities of all participants and system requirements under all situations, recognizing that participants may have different roles and responsibilities depending on jurisdictional differences.
b. Develop a process that provides an avenue for industry leaders, regulators, and policymakers to ascertain where critical conversations are occurring on topics to prevent duplication of efforts across the industry.
c. Consider and educate industry leaders on the effect that the transition to a zero-carbon economy across all interdependent sectors of the economy will have, resulting in increased electric grid demand and utilization.

2. Transmission Planning

Develop a holistic, higher level planning capability at a regional, interregional, bulk power system and/or national level that evaluates and incorporates plausible future scenarios and potential reliability and economics options to inform state and regional planners and policymakers.

3. Distribution System Planning

Develop a shared understanding of strategies for building out distribution systems to meet the demands. Provide technical assistance, where required, to facilitate reliable, fair, and equitable integrated distribution planning processes.

4. Resilience

Establish formal methods for defining and incorporating resilience into integrated planning processes that can balance priorities across several objectives.

5. Flexibility

Review and develop gap analyses across the industry and educate key decision makers on metrics and necessary actions needed to ensure reliability, resource adequacy, stability, and recovery for a future utilizing more intermittent and other resources (e.g., demand side resources, microgrids). Develop a common language and business case for needed operational assets.

6. Advanced Technological Capabilities

Increase efforts to educate regulators and address interoperability gaps/standards. This also includes providing technical assistance, where required, as well as educating utilities (and their regulators) on how advanced technologies have been used reliably in the United States and abroad. Educate policymakers about ongoing technological gaps and the areas where significant additional research and development (R&D) are required in order to provide the technological tools needed to reach climate goals (e.g., long-term storage, small modular nuclear reactors, carbon sequestration, storage, re-use).

These recommendations can apply to one or many of the findings discussed. The recommendations boil down to increased levels of coordination, education, and technical support from DOE to educate and assist policy advisors and regulators, who can, in turn, make more informed decisions to advance the necessary policies that will lead to a transformed, resilient, and reliable electric grid for consumers.

Additional Information: Approach

Background

Section 8008 of the Consolidated Appropriations Act of 2021 requires that DOE, in consultation with a Steering Committee (EAC with FERC and National Laboratory representation), initiate the development of voluntary model pathways for modernizing the electric grid through a collaborative public-private effort that produces illustrative policy pathways for states, regions, and regulators, and facilitates the modernization of the grid and associated communications networks. The voluntary model pathways should accomplish the following:

- Produce illustrative policy pathways encompassing a diverse range of technologies that can be adapted for state and regional applications by regulators and policymakers.
- Ensure a reliable, resilient, affordable, safe, and secure electric grid.
- Acknowledge and account for different priorities, electric systems, and rate structures across states and regions.
- Facilitate the modernization of the electric grid and associated communications networks to achieve the following objectives:
    1. Near-time situational awareness
    2. Advanced monitoring and control
    3. Data visualization
    4. Enhanced certainty of policies for investment in the electric grid
    5. Increased innovation
    6. Greater consumer empowerment
    7. Enhanced reliability and resilience
    8. Improved integration of DERs, interoperability, and predictive modeling/forecasting
    9. Reduced cost of service to consumers
    10. Diversification of generation resources

Per the direction of Acting Assistant Secretary Patricia Hoffman,[1] a Steering Committee was established under the umbrella of the Electricity Advisory Committee to identify issues and challenges associated with the transformation of the electricity delivery system, as well as to provide recommendations for addressing them. The Steering Committee consisted of members drawn from EAC, FERC, and the National Laboratories.

[1] Memorandum for the Chair of the Electricity Advisory Committee from Patricia Hoffman, Acting Assistant Secretary, U.S. Department of Energy, Office of Electricity. March 26, 2021.

The Steering Committee discussed the nature, scope, and intent of Voluntary Model Pathways and concluded the following:

- Voluntary Model Pathways present a high level of intended outcomes, real-world policy, and physical constraints.
- They can be adapted for state, regional, and federal applications (i.e., encompass policymakers and implementers across multiple jurisdictions).
- They are meant to be meaningful, yet voluntary, noting that policymakers and stakeholders at all levels must have reason to enroll in and contribute to policy pathway efforts.
- They also aim to identify and begin to address institutional and technological challenges and remove barriers to a successful energy transition, as characterized in the Section 8008 legislation.

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Summary of Scenario Discussions

The identification of key challenges and recommendations were discussed within the context of the following six scenarios, which are not mutually exclusive:

1. The coordination of system planning, operations, and energy market design/operations across the transmission, distribution, and behind-the-meter domains
2. A robust transmission system that supports the following:
    a. Efficient use of remote renewable energy
    b. Electrification
    c. Efficient movement of power (e.g., along high-voltage backbones)
    d. Application of alternative configurations (e.g., microgrids)
    e. Utilization of DERs and energy storage
3. A distribution system that supports the following:
    a. The utilization of all forms of DERs and energy storage
    b. Evolving business, industry, and market structures
    c. Convergence with transportation and building infrastructures
    d. Electrification
4. Incorporation of resilience into grid operations and design through the application of the following:
    a. Energy storage, flexible operations, and alternative grid designs
    b. Planning approaches incorporating risk management methods that span community, state, and regional jurisdictions
5. Incorporation of flexibility into grid operations and design through the application of the following:
    a. Energy storage, flexible generation, and flexible demand
    b. Advanced control and computing technology for real-time operations
    c. Modeling and simulation tools for planning and design purposes
6. Mechanisms to enable the efficient adoption of needed technological solutions

For each scenario, the Steering Group discussions considered the following questions:

- Who would need to be involved in the decision processes associated with the scenario?
- What decision processes exist or need to be developed to address the key challenges associated with the scenario?
- What are the analytical requirements needed to support decision-making within the scenario?
- What technologies and system capabilities are needed to enable the scenario?

Scenario 1 – Pathways for Coordination Across the Transmission, Distribution, and Behind-the-Meter Domains

There are few frameworks for coordination across jurisdictions for markets, operations, and/or communications. Distributed, federated, hierarchical control structures are an opportunity for coordination, but lack development and/or standardization. Pathways could develop practical approaches for implementing coordination frameworks that address (1) the roles and responsibilities of all participants (including grid codes); (2) data and information flow requirements; and (3) observability, communication, computing, and control requirements.

Key Considerations

- How does the evolution of markets, consumer preferences, and technological options affect changes at the grid edge? How will evolution impact grid operations?
- How can different business models be accommodated? What conditions are required for business models to be sustainable for market participants?
- How do stakeholders and grid operators determine the system criteria that drive the need for grid services, including from DERs?
- What are the control strategies (e.g., pricing, direct control, autonomous control) that will shape coordination requirements across the transmission, distribution, and behind-the-meter domains, keeping in mind the requirement to maintain a reliable and resilient system?
- How will temporal and spatial (architecture) issues be addressed (e.g., tier-bypassing, conflicting control signals, laminar coordination) to permit co-optimization of local and system interests?
- How can the industry adjust to the lack of homogeneity in U.S. regional transmission organization (RTO)/independent system operator (ISO) markets or related state policies/regulations?
- How will interoperability evolve given grid-edge device manufacturers' proprietary strategies for their products/systems?
- What is an appropriate "level of consensus" by which the DER community determines how to work with utilities?
- How will stakeholders develop practical approaches for implementing coordination frameworks that address (1) the roles and responsibilities of all participants (including grid codes); (2) data and information sharing and information flow requirements; and (3) observability, communication, computing, and control requirements?

Discussion Summary

- Coordination of planning, grid operations, and market design/operations across the transmission, distribution, and behind-the-meter domains is needed, but nascent. There are no operational coordination frameworks in place to effectively utilize services from DERs across the system.
- Operational continuity under normal and contingency situations will be necessary. Weather forecasting must become more sophisticated across transmission and distribution domains. Concurrently, DER forecasting used for system planning remains nascent.
- There is a need to find a level of consensus on control architectures. What is needed is a control strategy that allows for automatic and local responses. Distributed, federated, hierarchical control structures are an opportunity, but lack development and/or standardization.
- Utilities are seeing FERC Order 2222 requirements as a reason to pursue distribution system operator business models; however, there is no appropriate federal agency/institutional role to impose any such model.
- Methods for determining resource adequacy that can factor in the contribution of DERs are nascent but evolving.

Scenario 2 – Pathways to a Robust Transmission System

Current planning processes are not well-coordinated across jurisdictions and/or regions. Transformation of the electric grid will require improved coordination of planning, operations, and markets across jurisdictions that factor in considerations at the local, state, regional, and multi-regional levels. Planning tools and analytical methods will need to consider key aspects of energy transition, including, but not limited to, the following:

- State and regional resilience concerns
- The application of alternative grid configurations to ensure reliability and resilience
- The impact of DERs on the resource mix
- Determining resource adequacy in a system with high variability
- Understanding how to apply flexible resources (including energy storage)
- Understanding how to build out the transmission system to support the electrification of transportation and buildings

The critical federal role in promoting integrated multi-level planning remains unclear. There is strong potential for developing Volunteer Policy Pathways to support both the planning and analytics needed to transition toward a robust transmission system.

Key Considerations

- Is it possible to institute multi-state solutions? How might that be done?
- How might the topology of the electric grid be optimized to enable the efficient transfer of power from remote renewable resources (e.g., from offshore wind locations) to population centers?
- In what ways can the grid support the electrification of transportation and buildings?
- Could there be application of high-voltage AC and/or DC backbones to address regional and interregional (seam) requirements? How would that be done with or without imposing additional reserve requirements?
- How is resource adequacy accounted for, given a changing resource mix?
- How are system resilience and flexibility improved? For example, might that occur through the application of microgrids and energy storage systems?
- How can a loss of system inertia be addressed as we increase reliance on inverter-based resources?
- How might policymakers and industry balance grid-control solutions versus/vis-à-vis market-based solutions?
- What observability, control, and coordination strategies are needed in order to integrate DERs into transmission system operations?
- How is cost recovery addressed for utilities?

Discussion Summary

- Current planning processes are not well-coordinated across jurisdictions and/or regions. Transformation of the electric grid will require improved coordination of planning, operations, and markets across jurisdictions that factor in considerations at the local, state, regional, and multi-regional levels. Multi-level and regional planning are necessary to address transportation electrification demands. The critical federal role in promoting integrated, multi-level planning remains unclear.
- Regulatory uncertainty poses problems for investments in critical system improvements (e.g., siting transmission lines). Transmission siting issues must be addressed. It is unclear which institutions are responsible for addressing uncertainty and what form(s) that takes.

- Differing state rules and policy goals pose a challenge to developing a comprehensive and coordinated approach to transmission and distribution planning.
- Interregional discussions will need to examine seam issues, as well as the application of high-voltage AC and/or DC backbones.
- Many of the modeling and simulation tools necessary for examining and comparing system options do not exist. In addition, analytical tools for transmission and distribution systems operate on different platforms, making the exchange and analysis of information difficult. Co-optimization of distribution and transmission system operations is an opportunity. Which actors and/or institutions should undertake a higher level planning function that undertakes scenario analysis and examines options?
    - Planning tools and analytical methods will need to consider key aspects of energy transition, including, but not limited to, the following:
        - State and regional resilience concerns
        - The application of alternative grid configurations to ensure reliability and resilience
        - The impact of DERs on the resource mix
        - Determining resource adequacy in a system with high variability
        - Understanding how to apply flexible resources (including energy storage)
        - Understanding how to build out the transmission system to support electrification (transportation and buildings)
- Focus is needed to understand ways to control inverter-based resources to provide essential services, including having the ability to address system inertia issues due to loss of rotating mass.
- Developing a better understanding of the application of energy storage and microgrid infrastructures, including the application of energy storage as an embedded grid asset, is needed.

Scenario 3 – Pathways to a Flexible Distribution Network

Methods and tools for modeling DER system behavior and impacts, including control schemes for orchestrating myriad inverter-based resources, remain nascent. Distribution-level grid interoperability will become critical for attracting innovation and growth. Two aspects of interoperability require consideration: (1) communication of data across systems and (2) the integration of physical components via some kind of common hardware for connecting devices (similar to a USB port).

The federal government has a critical role in leading interoperability between the systems and devices that help manage the grid. Volunteer Policy Pathways that drive interoperability can support the development of technology, the attainment of policy, and assurances for reliable system operations.

Key Considerations

- How could resilience, equity, and decarbonization policy goals be incorporated into implementable solutions and infrastructure investment strategies? How can decision makers prioritize between complementary and competing objectives with limited resources?
- How will interoperability be ensured between devices and systems?
- How will DERs be managed? How can inverter-based resources be controlled and utilized to support grid operations and wholesale markets?
- In what ways could grid modernization strategies be formulated with the appropriate functional and structural characteristics to address evolution at the grid edge, including convergence of the grid with transportation, buildings, and telecommunication infrastructures?
- How could system resilience and flexibility improve?
- How could distribution and behind-the-meter assets coordinate, and how do those assets coordinate with transmission system operations?
- How are DERs assigned value?
- How could customer optionality and equity be enabled?
- At what level of penetration of different technologies are different levels of technical or regulatory intervention required to preserve reliability and affordability?

Discussion Summary

- Behind-the-meter technologies will continue to evolve and planning processes will need to co-evolve.
- Methods and tools for modeling DER system behavior and impacts, including control schemes for orchestrating myriad inverter-based resources, remain nascent.
- Distribution-level grid interoperability will become critical for attracting innovation and growth. Interoperability discussions across industry and regulatory fields are not coordinated. Two aspects of interoperability require consideration: (1) communication of data across systems and (2) integration of physical components via some kind of common hardware for connecting devices (similar to a USB port).

- There is a discrepancy between what utilities say grid investment roadmaps will cost to implement compared with what regulators believe it will cost. Many jurisdictions are not pursuing integrated distribution planning associated with grid modernization for a variety of reasons.
- Methods for incorporating resilience and equity into distribution system planning processes are needed.
- There is a need for significant investment in utility and regulatory workforce development.
- Business models will be crucial. There will need to be business models that facilitate utilities' incorporation of DERs as a grid asset.

Scenario 4 – Pathways to Bolster Resilience

Developing consistent decision frameworks regarding resilience to inform planning processes is an opportunity. Coordination of processes related to resilience within jurisdictions and across jurisdictions remains limited. For system planners, this coordination is required across jurisdictions (e.g., city, state, federal) to set objectives and determine resilience strategies. To support planning, analytical needs include applying (1) threat-based risk assessment and prioritization of options and (2) multi-objective decision analysis.

One potential federal role and pathway is facilitating the development of a resilience framework involving key stakeholders to set objectives, as well as identify critical and priority infrastructure and populations. This may include identifying the roles and responsibilities of relevant stakeholders.

Key Considerations

- How could decision makers incorporate resilience goals into implementable solutions and infrastructure investment strategies? How does resilience need be addressed as industry scales from community-based domains to multi-state domains?
- How can supply chain risks be addressed?
- How can workforce issues be addressed?

Discussion Summary

- Formal methods that incorporate resilience into integrated planning processes are in development but are not institutionalized in a way that permits the formulation of investment strategies that are balanced with myriad objectives. Analytical needs include applying threat-based risk assessment and prioritization of options, and multi-objective decision analysis. This upfront process is not yet fully articulated within or across many jurisdictions. This analytical process would include setting objectives, performing system analysis, prioritizing options, and developing metrics.

- The "value of resiliency" in the context of comparing potential solutions via a benefit-cost analysis may not be the way to assess resilience projects. A more holistic approach may be to develop a consensus around resilience objectives and priorities, which then guide fundamental improvements in grid infrastructure.
- Are there federal and National Laboratory roles in supporting resilience planning? Could the National Laboratories provide services to RTOs?
- Coordination is required across jurisdictions (e.g., community, city, state, multi-state, federal) to set objectives and determine resilience strategies that mitigate the impact of threats. Such coordination exists with regard to bolstering emergency preparedness, but not for implementing advanced grid designs and functional capabilities.
- Cyber security continues to be a broad concern, in addition to supply chain risks.

Scenario 5 – Pathways for Flexibility

Developing consistent processes to discuss flexibility may help identify appropriate levels of standardization. For example, flexibility metrics are being considered but are not standardized across the industry. This may pose challenges in some areas (e.g., developing market products in ISOs/RTOs), and may be appropriate in other areas since distribution systems differ widely. Distinct objectives and metrics for flexibility may be helpful as applied to different domains and jurisdictions. Regulatory authority to require/ensure flexibility is dispersed and/or undefined. The characteristic of flexibility may be implied in existing regulations, but not explicitly defined and/or required.

The development of flexibility requirements and their incorporation into implementable solutions and infrastructure investment strategies requires more study. Planning is one potentially appropriate venue for flexibility analysis, however, new analytical approaches, including modeling and simulation tools, need to be developed. A potential pathway could be undertaking a flexibility gap analysis to identify current practices and future needs. Understanding to what extent flexibility concerns are already embedded in current markets and operations is critical.

Key Considerations

- How could industry institute a flexibility metric(s)?
- How might flexibility requirements be developed and incorporated into implementable solutions and infrastructure investment strategies?
- How might industry address policy and technological uncertainty?

Discussion Summary

- The scope of flexibility considerations needs definition within and across domains. Flexibility will interact with and may require some redefinition of resource adequacy and related issues.
- Developing consistent approaches to discuss flexibility may help identify appropriate levels of standardization. The characteristics of flexibility may be implied in existing regulations but not explicitly defined and/or required.
- The development of flexibility requirements and their incorporation into implementable solutions and infrastructure investment strategies requires more study. Planning is one potentially appropriate venue for flexibility analysis; however, new analytical approaches, including modeling and simulation tools, need to be developed.
- The pricing and incentives for flexibility products is nascent or undefined. How do markets price and incentivize flexibility? Do we need a distinct flexibility metric?
- There are multiple technological options for providing system flexibility, for example:
    - Energy storage, flexible generation, and flexible demand
    - Transmission solutions, for example, additional capacity (wires and topology) and devices to enhance power flow (dynamic line rating technology)
    - Advanced control and computing technology for real-time operations
    - Applying the default capabilities of devices that are able to support system operations
- It will be challenging to determine optimal approaches for incorporating flexibility into grid operations and design. Current modeling tools are insufficient to represent the contributions of all the assets.
- It is unclear how industry will address policy and technological uncertainty.

Scenario 6 – Pathways to Facilitate Technology Adoption

Regulators, utilities, and technology developers do not have a shared understanding of requirements and the steps needed for grid modernization and infrastructure investments. This lack of shared understanding impedes our ability to achieve decarbonization and resilience goals. In addition, interoperability remains a challenge across the industry and jurisdictions. Regulatory adoption of interoperability standards is inconsistent. Jurisdictional differences drive varied deployments, which ultimately may lead to inconsistent market development.

It also is important to provide pathways to help bridge the “valley of death” between grid technology R&D and its adoption by utilities. This bridging requires integrated system demonstrations which are underfunded.

Fruitful pathways can address both interoperability and opportunities to technology adoption, when and where appropriate. Providing resources and workforce development to regulators remains a strength across state and federal relationships. Strong relationships exist within the utility sector to enable pathways toward demonstration and adoption of promising technologies.

Key Considerations

- What information is needed for state policymakers and regulators of beneficial advancements in technology so that they can develop rational infrastructure investment roadmaps with utilities?
- How can the efficiency of technology adoption by utilities be improved?

Discussion Summary

- Regulators and investor-owned utilities do not have a shared understanding of requirements and the steps needed for grid modernization and infrastructure investments impeding our ability to achieve decarbonization and resilience goals. Significant increases in regulatory resources and training may be needed to meet forthcoming technology deployment challenges. Federal support of state commissions provides an opportunity for improved understanding and performance.
- State integrated distribution system planning is an opportunity for improved discussion of technology adoption.
- Interoperability remains a challenge across the industry and jurisdictions. Regulatory adoption of interoperability standards is inconsistent. Data processes and procedures, including data standardization, data flows, communications, and sharing, poses significant challenges to the deployment of solutions. Jurisdictional differences drive varied deployments, which ultimately may lead to inconsistent market development.
- Tension between open source and interoperability versus security (a trade-off conversation is needed). There needs to be a conversation about incentives. The lack of interoperability is a huge issue and underwriting of some sort may be helpful.
- Bridging the “valley of death” between grid technology R&D and promoting new grid technology adoption by utilities requires integrated system demonstrations that are currently underfunded.
- Utilities and other stakeholders must change their overreliance on their own pilot programs and instead rely on results from pre-existing pilots.