Electricity Advisory Committee

TO: **Honorable Patricia Hoffman, Acting Assistant Secretary for Electricity Delivery and Energy Reliability, U.S. Department of Energy**

FROM: **Electricity Advisory Committee**
Susan Tierney, Chair

DATE: **June 7, 2017**

RE: **Distributed Energy Resource Valuation & Integration**

Executive Summary: Key Findings and Recommendations

The way in which electricity is generated and delivered throughout the electricity grid is in the midst of significant transformation. Distributed Energy Resource (DER) penetration has increased noticeably in the past few years, and is now a significant and growing part of the power system. The Department of Energy (DOE) has played an important role in modernizing the grid to manage this deployment by supporting the development of frameworks, methods, and tools for DER integration. These will help ensure continued reliability, security, and efficiency for the nation's power system in the face of change. This paper reaffirms the important work currently underway by DOE and identifies additional work that should be done in support of these efforts.

Findings

To date, Federal and state regulation have not fully integrated DERs. Existing markets often fail to provide incentives for the efficient use of DERs. However, with advanced metering, more granular price signals could effectively indicate where and when DERs could efficiently contribute to power system operations. DOE should develop tools to support efficient wholesale markets that include DERs and should coordinate with the Federal Energy Regulatory Commission (FERC) and state regulators to identify technical and policy barriers to more efficient markets.

DOE has played a positive role, and continues to provide essential leadership, in both basic research and forward-looking applied research and development (R&D) for modernizing the power grid; this includes addressing the challenges presented by DERs. Such research will continue to be needed.

The oversight and operation of the nation's electric grid is divided between the Federal government, utility regulatory authorities, regional transmission system operators, and utilities. DOE has a unique and important role as an unbiased source of information in providing technical assistance, and in using its convening authority to facilitate coordination and information exchange among the various regulatory authorities, utilities, and stakeholders involved in grid oversight and operation. DOE should continue performing these functions to advance grid modernization and the appropriate valuation and integration of DERs.

Recommendations

Based on the findings, the Electricity Advisory Committee (EAC) recommends that DOE continue—and expand where relevant—its work to support appropriate valuation and integration of DERs by:

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1. Continuing support for the Grid Modernization Initiative Multi-Year Program Plan;
2. Collecting and harmonizing the various valuation frameworks under development in leading states;
3. Supporting research that approaches integration and valuation from both a customer and a grid or utility perspective;
4. Supporting additional R&D on methods and tools to ensure appropriate time-, location-, and product-specific valuation of DER, efficient integration of DERs into power system planning and operations, and improved market models for more efficient pricing of the electric products and services that DERs provide;
5. Continuing and expanding support for regulatory authorities considering policies and rate structures that advance innovation and economically efficient integration of DERs into markets and grid operations;
6. Continuing to support R&D of enhanced tools including: improved computational methods for managing system operations with more dynamic and distributed grid models; simulation tools to understand system behavior in high DER environments; and research to examine the interactions and balance in markets that include DERs.

Distributed Energy Resources in the U.S. Power System

The electric power industry is experiencing a significant transformation in the way electricity is generated and delivered throughout the grid. DERs are a significant part of the power system and will become more important as consumers and states increasingly value choice, resilience, and clean energy resources. For example, today:

- More than 14 million electric customers are supplying power back into the grid.[1]
- More than 80 GW of combined heat and power generation facilities, accounting for more than 8% of total U.S. generating capacity, are operated by commercial and industrial customers.[2]
- More distributed solar capacity is coming online, nearly doubling from 7.3 GW in 2014 to 13.8 GW in February 2017.[3]
- More than 16 million customers participate in wholesale or utility demand response or time-varying rate programs.[4]
- Millions more consumers maintain back-up generators or are implementing energy storage systems.

Additionally, there are roughly 535,000 electric vehicles in the United States.[5] Managing the charging cycles of these vehicles provides yet another set of potential DERs. Additionally, a growing number of utilities are relying on distributed generation or storage to avoid more costly grid investments.[6] Some are also relying on distributed power electronics, operating on a sub-cycle basis, to optimize voltage and reduce generation requirements.

This is a period of significant innovation and development of new technologies. Still, the nation's electricity grid remains the backbone of our ability to deliver electricity. Households, businesses, and other organizations rely on this essential public service to live, study, produce goods/services and, ultimately, to thrive. Safety, reliability and affordability are still the core principles that guide decisions on electricity generation, transmission, and delivery. In this era of transformation, these core principles remain guideposts for decision-making, even as the ability to satisfy them becomes more complex.

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[1] Energy Information Administration, *EIA Form 826 – Net Metering 2016.*

[2] U.S. Department of Energy. 2016. *Combined Heat and Power Technical Potential in the United States.*

[3] Energy Information Administration, *EIA Form 826 – Small Scale Solar 2014 and February 2017.*

[4] Federal Energy Regulatory Commission, *Staff Report – Assessment of Demand Response and Advanced Metering* (December 2016).

[5] See: https://www.recode.net/2016/12/21/14041112/electric-vehicles-report-2016.

[6] Examples include: Consolidated Edison's Brooklyn Queens Demand Management program and Southern California Edison's Preferred Resources Pilot.

The growth of DERs presents opportunities to improve power system reliability, affordability, and sustainability. However, it also introduces key challenges. For example, ensuring the cyber security of the grid has grown more complex given the development of the "Internet of Things" and increasingly global supply chains.[7] Further, the notion of reliable service has expanded to include the importance of a resilient grid, particularly in response to extreme weather conditions and widespread and sustained outages. Affordability is a constant concern, even in an era of declining or stable energy prices. For customers, the cost pressure of repairing and replacing aging infrastructure is coupled with the cost pressure of incorporating "smart" technologies and DERs onto an existing system while simultaneously ensuring the system remains safe, cyber-secure, and reliable.

Development of Valuation Frameworks

Electric grid modernization is of great importance to the nation. DOE's Office of Electricity "recognizes that our Nation's sustained economic prosperity, quality of life, and global competitiveness depend on access to an abundance of secure, reliable, and affordable energy resources" in its vision. The Office of Electricity's mission "drives grid modernization and resiliency in the energy infrastructure," and "leads [DOE's] efforts to ensure a resilient, reliable, and flexible electricity system."[8] This mission has been pursued and accomplished in part through research, partnerships, and development of modeling and analytics that assist state authorities and utilities. This assistance is critical in ensuring the safety, security, and reliability of our electricity grid.

In this vibrant era, there are countless new business ideas and technologies competing for attention and customer dollars. Not every new technology or potential resource can or should be adopted. Yet, it is recognized that many DERs can provide real value to the operation of the electric grid, as well as to customers and to providers themselves. Some states have already acknowledged the need to plan for a grid that harmonizes DERs with individual state policy goals, and deploys and operates DERs in a manner that enhances the net value of the power system. Other states will likely face similar planning needs in the near future.

Appropriate valuation of DERs is a key concern and essential building block for ensuring DERs do in fact provide net value to the system. A number of states have initiated state-level proceedings, studies, and pilots to address matters of grid modernization, particularly related to DERs and grid integration. These states are geographically dispersed and include Arizona, California, Hawaii, Illinois, Maryland, Massachusetts, Michigan, Minnesota, New Hampshire, New York, Ohio, Rhode Island, and Vermont. Additionally, utilities including Avista Utilities, ComEd, SMUD, and Xcel Energy, among others, are engaged in DER assessment and deployment efforts. Public power entities and electric cooperatives across the country have been very receptive to their customers' and members' interest in DER, particularly rooftop and community solar. Other states and utilities are in the early stages in terms of the DER penetration levels.

Regardless of where such states or utilities are located, they could benefit from DOE assistance with DER valuation and integration. State policymakers, utilities, and other state-level stakeholders have repeatedly asked for assistance in the valuation of DERs. These requests further validate the need for better tools to evaluate specific deployments and uses of DERs and their potential impact on the electric grid. This creates an opportunity, and a legitimate need, for DOE to support the development of tools and other mechanisms that can help policymakers, utilities, and other stakeholders understand when, where, for what purposes, and whether different forms of DERs may be cost-effectively deployed.

Bringing together emerging and existing frameworks will broaden the research to include various considerations put forth by each of the individual efforts. Actions to draw connections to harmonize these approaches can help

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[7] Prof. Bill Sanders, *The Internet of Risky Things,* Presentation to the EAC Smart Grid Subcommittee (January 2017); Vint Cerf, *Internet of Things,* Presentation to the Electricity Advisory Committee (March 2017).

[8] Office of Electricity Delivery & Energy Reliability, *Mission and Vision.* See https://energy.gov/oe/mission.

build a decision tree for specific regulatory entities and utilities to identify their particular situation, making it easier to apply the guidance, and include factors that may not have been originally contemplated.

In addition, the adoption of a common terminology and analysis structure as part of this framework will help guide policy development and evaluation criteria for grid investments across a variety of utilities and jurisdictions. In turn, these will contribute to the strengthening of the electricity system. For example, the term “distributed energy resources” (DERs) needs to be clearly defined. In general, it represents the specific technologies and the assortment of devices that collectively help manage the production, storage, delivery, or use of electricity within the local distribution system or behind the customer meter. DERs include:

- Solar PV and other types of distributed generation
- Electric vehicles
- Energy efficiency
- Distributed energy storage including electric and thermal storage
- Voltage optimization and other power electronics and distribution control technologies
- Flexible demand that utilizes the thermal inertia in buildings or flexibility in the timing of power demand to shift usage to lower cost times much like a battery
- Wholesale or retail demand response programs

The resources are “distributed” since they are connected to distribution-level voltages.[9] Each of these technologies and solutions contribute different operational characteristics and values depending on location and timing of operation. Additionally, when DERs are combined, they bring a different set of characteristics due to their cooperative operation.

While the framework is primarily focused on providing support and guidance for policymakers and utilities, DOE should also include the customer perspective. Consumers may have different reasons for adopting DER technologies, including whether a DER can reduce their electricity bills. Ensuring a reliable and resilient power supply, support of clean energy, and concern about climate change also can be important factors for some consumers. Utilities primarily focus on how DERs will impact and contribute to safe, reliable grid operation. Utilities also face increasing pressure to engage their customers directly. These two perspectives can find common ground if consumers have an incentive to pursue investments that also provide valuable grid services, and if utilities facilitate efficient customer choices. Approaching valuation from both the consumer *and* utility perspective is important. These decisions may have been separate and distinct in the past, but due to safety and reliability concerns, as well as customer desire to maximize their return on investment, they need to be considered together.

DOE support is vital for the development of a comprehensive valuation framework that can be used in states with widely differing circumstances. The framework would help to ensure that the integration of DERs will advance the key goals of security, reliability, and affordability. DOE has already commenced this important work through its Grid Modernization Initiative (GMI). This initiative is a DOE-wide collaboration, funded through its Office of Electricity Delivery and Energy Reliability as well as the Office of Energy Efficiency and Renewable Energy (EERE), to support the modernization of electricity grid infrastructure.[10] The GMI is being carried out through the Grid Modernization Multi-Year Program Plan (MYPP) and the Grid Modernization Lab Consortium (GMLC). The MYPP is described as a strategic roadmap of the GMI, and includes a vision and priorities for the development of the

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[9] To understand the meaning of distribution-connected, it is helpful to refer to the NERC definition of the bulk electric system, “defined by NERC all Transmission Elements operated at 100 kV or higher and Real Power and Reactive Power resources connected at 100 kV or higher. This does not include facilities used in the local distribution of electric energy.” See http://www.nerc.com/pa/RAPA/Pages/BES.aspx.

[10] The GMI followed up on the assessments in DOE’s first installment of its Quadrennial Energy Review, “Transforming U.S. Energy Infrastructures in a Time of Rapid Change,” (April 2015), https://energy.gov/sites/prod/files/2015/08/f25/QER%20Summary%20for%20Policymakers%20April%202015.pdf.

modern grid. The GMLC is a consortium of 14 DOE National Laboratories and partners that are coordinating their areas of expertise to further develop and implement the MYPP. The GMLC includes 88 specific R&D projects to support grid modernization.[11] The EAC separately submitted feedback on the GMI effort holistically.[12]

The MYPP has identified a "cross-cutting" activity of "institutional support" for regional and state-level stakeholders, including state energy regulators and utilities, to enable them to manage large-scale integration of emerging technologies as well as identify opportunities for consumers to participate in the energy market.[13] Within this, DOE identified DER valuation as a key concern of state regulators, so that the potential costs and benefits are identifiable and quantifiable.

For example, DOE has included a project on "Grid Services and Technologies Valuation Framework (Project 5)" among its GMLC core projects.[14] The project's objective is to develop a widely accepted, well-tested valuation methodological framework for evaluating the net benefits that can be provided by different grid-related technologies and services.

Another example is a GMLC project on "Definitions, Standards and Test Procedures for Grid Services (Project 18)."[15] This project will enable the grid integration of DERs by defining a test protocol to characterize their ability to respond to grid signals and to define a standard set of grid services and "drive cycles" that describe the capabilities DERs must have to provide them.

These projects represent only two examples from the GMI to help illustrate the important work in progress. However, the GMI projects must be taken as a whole to result in the development of a comprehensive, transparent, and flexible analytical framework for DER valuation that can be used by states and utilities with a variety of needs and interests. As described in the sections below, DOE should pursue additional R&D on methods and tools to ensure appropriate time-, location-, and product-specific valuation of DERs and efficient integration of DERs into power system planning and operations.

Development of Tools and Methods for Valuation of DER

There is no single value of DERs in the distribution system. The value of any specific DER will depend on a number of factors (including but not limited to):

- **Location of the resource:** The Locational Marginal Price for the distribution circuit where the DER is located, its marginal value within the distribution circuit given distribution constraints and losses, its proximity to any network constraints, and its ability to reduce the need for distribution investments.
- **Time the resource operates:** Its coincidence with system or distribution peak demand, its ability to dynamically shift demand out of high price periods, its impact on distribution power factor and losses, and the variability of its output.
- **Electric products the resource provides:** Its ability to provide real power, reactive, and various forms of reserves; its ability to shift between and optimize the products it provides; whether its output can be coordinated or dispatched by the operator to meet distribution needs; and the speed of its response.
- **Distribution circuit characteristics:** Whether the DERs require additional distribution investments; the extent of pre-existing DERs and the combined impact on system requirements; the sensing, communication, coordination, and/or control of the circuit and the DERs' integration into this cyber/physical system; and the cyber and physical security of the system.

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[11] DOE conducted a Peer Review of the GMLC projects on April 18-20, 2017.

[12] This can be found at https://energy.gov/oe/services/electricity-advisory-committee-eac/electricity-advisory-committee-reports-and-memos.

[13] MYPP, Section 7.3, page 104.

[14] See https://gridmod.labworks.org/projects/1.2.4.

[15] See https://gridmod.labworks.org/projects/1.4.02.

- **Provision of customer value:** Whether it enhances local system resilience and reliability, the value that the customers it serves place on reliability, whether it provides clean energy or other attributes that customers value.
- **System interactions:** Whether the resource participates in wholesale power markets and the coordination between the transmission system operator (RTO or ISO), DER aggregator, and Distribution System Operator.

Developing an accurate estimate of the value of DERs at different locations in a distribution system, operating at different times, and providing different products, is a complex problem. Some leading utilities have analyzed the extent to which their systems could accommodate DERs, their “hosting capacity.” However, this is not itself an assessment of DER value.

Traditional distribution planning practices of developing periodic investment plans to meet forecasted demand growth and replace aging infrastructure are proving inadequate for addressing dynamic impacts of DERs in systems with growing penetrations of DERs. The industry needs planning and forecasting tools that provide more complete and accurate estimates of the location-, time-, product-, circuit-, and customer-specific value of DERs, including models that can better account for:

- Forecasted changes in demand and distribution requirements at the circuit level and within individual distribution circuits;
- The variation in output of variable distributed generation;
- Real and reactive power flows in the distribution circuits;
- The variability in distribution voltages resulting from changes in demand and DER output;
- Impacts of DERs that autonomously respond to changes in voltage or frequency;
- The effects of responsive demand that shifts the timing of customer demand in response to anticipated prices; and
- Interactions between ISO/RTO bulk power system markets, wholesale aggregation of DER, and the increasingly complex operation of distribution systems.

Moreover, distribution companies operate as regulated utilities. Their planning, purchasing, and pricing decisions will be subject to regulatory review. As a result, tools must be sufficiently transparent to enable regulatory oversight.

This is a complex problem that affects both the economics and the reliability of the power system. DOE, through its work on grid modernization, is playing an important role in the development of a framework and tools for the valuation of DERs. Based on presentations to the EAC by numerous experts[16] and the EAC’s review of ongoing DOE grid modernization projects, the EAC believes this work should continue with two key objectives:

- To develop increasingly detailed, accurate, and transparent models, methods, and tools for valuing DERs in the context of power system planning including the need for combinations of supply- and demand-side DERs and the consideration of DERs as an alternative or supplement to conventional grid investment; and
- To develop an increasingly granular market model that would support efficient pricing of the electric products and services that DERs provide, extending competition policies further into the power system and

[16] Erik Takayesu, P.E., *Planning for Distributed Energy Resources,* Presentation to the Electricity Advisory Committee (September 2015); Bill Kallock, *Maximizing the Utility Value of Distributed Energy Resources,* Presentation to the Electricity Advisory Committee (March 2016); Heather Sanders, *Valuation and Integration of Distributed Energy Resources,* Presentation to the Electricity Advisory Committee (March 2016); Dr. Lynne Kiesling, *Transactive Energy,* Presentation to the Electricity Advisory Committee (June 2016); Dr. Richard Tabors, *Valuing Distributed Energy Resources via Distribution Locational Marginal Prices (DLMP),* Presentation to the Electricity Advisory Committee (June 2016); Curtis Kirkeby, P.E., *Transactive Energy in the Northwest – An Avista Utility Perspective,* Presentation to the Electricity Advisory Committee (June 2016).

creating accurate price signals for the development and operation of DERs where and when it is economic to do so.

Development of Methods and Tools for Integration of DER into Grid Operations and Control Systems

Utility distribution systems were designed largely to accommodate one-directional power flows from the bulk power system to customers on local distribution feeders. With the growth in DERs, distribution systems have to manage multi-directional, often highly variable power flows and more volatile distribution voltages. Operations have become increasingly complex: requiring new protection schemes and safety protocols, optimization of distribution voltages, identifying power supplies located behind customer meters that may not have been previously known, as well as meeting customer requirements for reliability and resilience that would otherwise motivate the installation of costly distributed generation or storage.

The growth of DERs has magnified the ultra-large-scale complexity that already characterized the power system. What previously had been reasonably simple assumptions on distribution power flows and forecasts of net demand have become increasingly inaccurate. Actual distribution flows and net demand are more variable and uncertain. Ensuring the reliability and efficient operation of the power grid requires examining how to architect and design systems to operate the grid with significant DERs. The relationships between operation of the bulk power system and existing RTO/ISO markets and distribution operations and any distribution-level markets will need to be carefully defined. It would be computationally difficult to centrally dispatch both existing central station generation and large numbers of DERs. A new approach to system control is likely to be required for a grid with large numbers of DERs.

The EAC has heard expert recommendations on the need for:

- Improved computational methods for managing system operations, development of a full AC Optimal Power Flow Model, and research on data-driven approaches to power system operations, planning, and maintenance;
- Enhanced dynamic and distributed grid models and simulation tools to understand system behavior in a high DER environment;
- Research on the interaction of distributed autonomous assets with each other and with existing grid control systems; and
- Research to examine the interactions and necessary balance among markets that rely on centralized dispatch, mid-level distributed transactive markets, and autonomous devices operating at the edge of the grid.[17]

Existing regulatory models have limited innovation and private sector development of needed control systems and tools. Regulation in electricity makes any return on investment in the grid systems dependent on the expenditures and rates of return approved by various state utility regulators. Utilities often cannot undertake sufficient R&D or finance risky investments in innovation because utility commissions will not approve them, and returns comparable to those earned by successful innovations in competitive sectors are not available. Vendors also are limited in their ability to finance innovation because the markets for new products are regulated, often slow to develop, and reluctant to pay for efficiency improvements that could decrease utility sales. Absent

[17] Dr. Ralph Masiello, *National Research Council Committee Report: Analytical Foundations for the Next-Generation Electric Grid,* Presentation to the Electricity Advisory Committee (June 2016); Prof. Deepak Divan, *Valuation and Integration of DERs,* Presentation to the Electricity Advisory Committee (March 2016); Prof. Michael Caramanis, *Comments on the Extension of Dynamic Pricing Markets to Distribution Network Participants, "Smart Distribution Networks: Adaptive Flexible Loads and Resources",* Presentation to the Electricity Advisory Committee (March 2016); Dr. Jeffrey Taft, *GMLC 1.2.1 Grid Architecture,* Presentation to the EAC Smart Grid Subcommittee and Grid Modernization Working Group (July 2016); Paul Centolella and Clark Gellings, *The Power of Change: Innovation for the Development and Deployment of Increasingly Clean Electric Power Technologies – Report of The National Academies of Sciences, Engineering, and Medicine,* Presentation to the Electricity Advisory Committee (September 2016).

government participation, regulatory and structural barriers will unduly delay the development of tools that are essential, given the velocity with which DERs are entering the power system.

DOE is pursuing R&D around the architecture, control, and development of enhanced tools as part of the GMI as well as through the power grid-related advanced research programs. Such work should continue and be directed toward ensuring the continued reliable, stable, and efficient operation of the power grid as DERs play an increasing role in the power system.

Regulatory Policy

Industry stakeholders frequently express that regulatory policy lags technology development, and this condition creates barriers to innovation and the ability to realize and maximize the benefits DERs can provide. Policymakers, utilities, and other stakeholders need frameworks and tools to better understand when, where, for what purposes, and whether different forms of DERs may be cost-effectively deployed, and how they would impact the electric grid.

Recognizing this, policymakers, utilities and other stakeholders have repeatedly asked DOE for assistance in DER valuation and integration. The DOE GMI includes several activities that respond to these requests. For example, a project on "Distribution System Decision Support Tools (Project 27)" represents one important effort in addressing utility concerns related to grid planning. This project will develop tools, identify gaps, and provide technical assistance and training for state regulators and small/medium utilities (e.g., cooperatives and municipal utilities) on advanced distribution system planning for a modernized grid that incorporates high levels of DERs. The project on "Future Electric Utility Regulation (Project 29)" is another example that will help advance state public utilities commissions' understanding of DER impacts. It will also help enhance utility financial modeling tools focused on ratemaking and regulatory issues that arise with increased penetration of DERs.

Findings and Recommendations

As the nation starts to address important changes in the power system, it is useful to pause, recognize the basic character of the power system, and discuss the role that DOE has played in ongoing efforts to modernize the power grid. The EAC offers the following findings:

***Finding*: DOE will have an essential role in the development of frameworks, methods, and tools needed for DER valuation and integration into the power system.** The nation's electric power grid is one of the most complex engineered systems in existence. Generation and demand must be kept in continuous balance as power flows are instantaneously redistributed across vast regional power grids that include billions of components. This system of systems has been characterized as one of "ultra-large-scale" complexity. [18] DERs are making the power grid more distributed, dynamic, and challenging to plan and operate. Effective DER valuation and integration are likely to require fundamental changes in distribution planning, power markets and pricing, and system operations. No private sector firm or group of firms is well positioned by itself to undertake the R&D needed to enable these changes. This, of course, includes electric distribution utilities, which are regulated firms with little or no ability to profit from innovation and limited budgets to support R&D. Thus, DOE support for the development of frameworks, methods, and tools for DER valuation and integration is critical.

***Finding*: DOE should develop tools to support efficient wholesale markets that provide increasingly granular price signals to help integrate DERs and should coordinate with FERC and state regulators to identify technical and policy barriers to the development of more efficient markets.** Federal and state regulation have not fully integrated DERs. Existing markets often fail to provide incentives for the efficient use of DERs. Historically, this reflected the use of meters that did not record when consumers used energy. However, advanced metering has become the predominate technology; the percentage of customers with advanced meters increased from less

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[18] L. Northrup et al., *Ultra-Large-Scale Systems: The Software Challenge of the Future* (Pittsburgh, PA: Carnegie Mellon Software Engineering Institute, 2006).

than 5% in 2007 to 41% by the end of 2014.[19] Even where advanced metering is available, RTOs typically settle the load of wholesale markets based on average hourly and zonal prices, often based on old customer class load profiles. This is a roadblock to the development of increasingly granular markets that could provide price signals indicating where and when DERs could efficiently contribute to power system operations. DOE has the ability to develop necessary tools and collaborate with FERC to help overcome these challenges.

***Finding*: DOE has played a positive role and continues to provide essential leadership in both basic research conducted through the Office of Science and in undertaking forward-looking, applied R&D for modernizing the power grid and addressing the challenges presented by DERs.** These efforts have included and are not limited to the Office of Electricity Delivery and Energy Reliability's multi-year GMI, its Cybersecurity for Critical Energy Infrastructure program, and the Office's support for power system standards development, as well as the power grid focused research programs (ADEPT, GENI, Grid Data, NODES) initiated by the Advanced Research Projects Agency for Energy. Goal-directed and forward-looking R&D programs designed to address the emerging challenges created by DERs will continue to be needed to ensure the reliable, secure, and efficient operation of the power system.

***Finding*: DOE is uniquely positioned to convene the diverse entities involved in grid operations and control, and to facilitate the stakeholder dialog necessary to ensure appropriate valuation and integration of DERs. It also has a key role to play in providing unbiased scientifically supported information and technical assistance.** Oversight and operation of the nation's electric grid is divided between the Federal government and utility regulatory authorities in each state (and the District of Columbia) as well as among seven regional transmission system operators and more than 3,200 investor-owned utilities, electric cooperatives, and public power authorities. Our system of Federal and State regulation enables experimentation, enhances opportunities to integrate changing technology, and appropriately reflects various local perspectives. However, different regulatory authorities and stakeholders have different capabilities and levels of information. Facilitating cooperation and access to information is critical to advancing grid modernization and ensuring appropriate valuation and integration of DERs. DOE is uniquely positioned to play this convening role and should continue, and expand where necessary, its role as an unbiased facilitator. Further, DOE should continue to utilize its role as a neutral source of scientifically backed information to provide technical assistance to the states and other stakeholders. Going forward, it will be important for DOE to continue performing these functions, as grid modernization efforts and DER integration expands.

The EAC recommends that DOE continue and expand its efforts to support the appropriate valuation and integration of DERs by:

1. Continuing support for the GMI MYPP.
2. Collecting and harmonizing the various frameworks under development in leading states.
3. Approaching integration and valuation from both a customer and a grid or utility perspective.
4. Conducting additional R&D on methods and tools to ensure appropriate time-, location-, and product-specific valuation of DER, efficient integration of DERs into power system planning and operations, and improved market models for more efficient pricing of the electric products and services that DERs provide.
5. Continuing and expanding support for regulatory authorities in consideration of policies and rate structures that advance innovation and economically efficient integration of DER into markets and grid operations.
6. Continuing R&D of enhanced tools, including improved computational methods for managing system operations with more dynamic and distributed grid models, simulation tools to understand system behavior in high DER environment, and research to examine the interactions and balance in markets including DERs.

[19] Federal Energy Regulatory Commission. 2016. *Staff Report: Assessment of Demand Response and Advanced Metering.*