Request for Information: Challenges and Opportunities for the American Solar Industry

DATE: December 7, 2018

SUBJECT: Request for Information (RFI)

**Purpose**

The U.S. Department of Energy Solar Energy Technologies Office (SETO) seeks information to help inform its research priorities, as part of its annual planning process. The purpose of this RFI is to solicit feedback from industry, academia, research laboratories, government agencies, and other stakeholders to identify areas of interest related to challenges and opportunities for the American solar industry that are appropriate for federal government funding. This is solely a request for information and not a Funding Opportunity Announcement (FOA). No funding applications are being accepted in response to this RFI.

**Topic 2: Systems Integration**

# The Systems Integration (SI) subprogram supports early-stage research and development that advances the reliable, resilient, secure and affordable integration of solar energy onto the U.S. electric grid. For more in-depth discussion of solar grid integration, please visit “Solar Grid Integration” <https://energy.gov/eere/solar/downloads/technical-background-2018-seto-funding-opportunity-announcement>.

In 2011, solar power comprised less than 0.1% of the U.S. electricity supply with an installed capacity of just 1.2 gigawatts (GW). Solar now supplies nearly 2% of the annual U.S. electricity demand[[1]](#footnote-2) with an installed capacity of approximately 47 GW[[2]](#footnote-3), and is continuing to grow. According to U.S. Energy Information Administration (EIA), in some states and regions, solar represents up to 15% of total annual electricity generation. Instantaneous solar generation can reach a much higher level, more than 40% in some cases.[[3]](#footnote-4)

The end-to-end electric power grids, their communications and control systems need to be well maintained and securely protected. Over the last two decades, power outages in the United States have increased in size and frequency[[4]](#footnote-5)-[[5]](#footnote-6). Several studies estimate that outages and power quality disturbances cost the economy several billion dollars4-5. Distribution networks are the most vulnerable parts of the electric grid[[6]](#footnote-7). In addition, it has been estimated that 90% of electricity customer outages in the United States are related to distribution network problems.5

There have been significant advances in smart grid technologies including information, communications, sensors, and controls. There is research on fault line sensors to help accurately detect fault types and locations[[7]](#footnote-8), research on micro-PMU technologies providing hundreds of measurements per second[[8]](#footnote-9), and research on smart inverter technologies providing sophisticated grid-support functions. [[9]](#footnote-10)-[[10]](#footnote-11) The Office of Electricity has also been funding several initiatives to develop and deploy new technologies to improve the reliability and the resilience of the US electricity grid[[11]](#footnote-12)-[[12]](#footnote-13). However, there are challenges to integrating these technologies in order to enhance local situation awareness of behind-the-meter (BTM) solar and distributed energy resources (DERs) for normal operating conditions as well as service recovery.

PV systems often communicate to utilities, aggregators, and other grid operators over the public internet. As a result, the power system cyber-attack surface has significantly expanded. At the same time, solar energy systems are being equipped with a range of grid-support functions that - if controlled or programmed improperly - present a risk of power system disturbances. The US power system’s defenses, situational awareness, and response and recovery strategies need to adapt to the growing experience and sophistication of cyber adversaries. [[13]](#footnote-14)\_[[14]](#footnote-15)

SETO is seeking information from industry, academia, research laboratories, government agencies, and other stakeholders on issues related to the following areas:

1. Integrated Planning & Operations for Distributed Solar and other Distributed Energy Resources
   1. Adaptive protection for distribution grids with high solar penetration
   2. Dynamic models for smart inverters
2. Grid Services from BTM Solar and other DERs
3. Advanced Inverter Controls, Sensors and PV Systems Cybersecurity
   1. Grid-forming inverter technologies to enable collaborative operation for enhanced resilience
   2. Sensor technologies to improve grid-edge visibility
   3. Cybersecurity technologies for high solar penetration challenges

1. Other topics of interest related to high solar penetration challenges

To streamline the processing of inputs a number of questions have been added that cover the subjects presented above. Please respond to as many of the specific questions or topics as may be deemed appropriate.

Categories and Questions

**Category 1**: **Integrated Planning & Operations for Distributed Solar and other DERs**

1. Adaptive Protection for Distribution Grids with High Distributed Solar Generation.  
   *Current protection systems operate in a static, predetermined mode. Operation that can adapt to grid conditions will facilitate reliable and affordable integration of solar and DERs into a resilient grid as their penetrations increase.*
2. What are the highest priorities for protection designs for circuits with high distributed solar penetration?
3. Should software or hardware solutions be prioritized, why?
4. Which critical parameters should be considered in creating protection solutions that improve system reliability and resilience (e.g. spatial and temporal resolution, size/location of DER, controllability of DER, circuit type, etc.)?
5. Dynamic Models for Inverters.  
   *Most currently available network models simulate inverters under static conditions. It is necessary to develop dynamic modeling to capture the interaction of grid and inverters under transient conditions.* 
   1. Which model(s) are being applied to simulate the dynamic behavior of inverters? What are the limitations of those models?
   2. What, if any, is the usefulness of generic and standardized models to simulate the dynamic behavior of a range of DERs, such as Behind the Meter (BTM) solar, solar with power plant controllers, etc.?
   3. What are the limitations of the power system network models currently used for transient analysis?

**Category 2**: **Grid Services from BTM Solar and DERs**  
*Grid services include, but are not limited to, primary frequency response, regulation up/down, spinning reserve, black start, voltage support, etc.*

What are the remaining technical challenges with regards to integration and aggregation of BTM solar?

Which grid services potentially offered by BTM solar and other DERs have the highest value, why?

What BTM devices or particular DER technologies should be considered for enabling these grid services? Are there any smart home technologies that should be included?

**Category 3**: **Advanced Inverter Controls, Distributed Solar Visibility and PV Systems Cybersecurity**

1. Grid-Forming Inverters.  
   *Currently most grid-tied inverters have to follow the grid in terms of frequency and voltage. Under very high solar penetrations, inverters that are capable to form a grid (i.e. supply frequency and voltage reference) can provide new opportunities to improve system reliability and resilience.*
2. Where would be the most beneficial impacts of grid-forming inverters to the overall grid operations in the next 3-5 years; distribution service restoration, resilient microgrids, essential reliability services, transmission congestion reduction, other?
3. What are the limitations of current control algorithms for grid-forming inverters? Are there any potential benefits from improvements in hardware design or components?
4. What grid services will benefit from grid-forming inverters?
5. What are the major challenges in the integration of grid-forming inverters into an energy management system that connects to a variety of generation sources, including conventional generation and grid-following inverters?
6. Advanced Sensor Technologies for Distributed Solar.  
   *Currently, the state of the grid near its edge is not observable due to low measurement redundancy. New sensor technologies that monitor distributed solar and other DERs, and make their behavior visible to the distribution management systems would mitigate this challenge. As an example, PV inverters deployed in BTM solar systems along with other hardware may provide better grid-edge visibility.*
7. What software algorithms and schemes are needed to integrate measurements by PV inverters into grid-edge observability processes?
8. What types of inverter integrated sensors (existing or newly developed) can be utilized to increase the measurement redundancy for distribution circuits?
9. What levels of performance would be required from telecommunication and information systems to utilize the PV inverter measurements? Which metrics should be used to assess the achieved performance levels?

1. PV Systems Cybersecurity.

*Sandia National Laboratories published in 2017 technical report* [*SAND2017-13262*](https://energy.sandia.gov/download/43738/)*, which outlines a 5-year Roadmap for Photovoltaic Cyber Security*

1. Is the above referenced roadmap complete with respect to the cybersecurity of PV systems? If not, which areas need additional development?
2. Would existing cybersecurity standards be sufficient to cover PV systems? If not, which areas need additional development?
3. What are the impediments regarding the implementation of existing technologies that would address the cybersecurity challenges for PV systems? Which new technologies could overcome such implementation challenges?

**Category 4**: **Other Topics of Interest**

1. Is there another applied R&D topic that is important for the cost-effective and reliable integration of PV systems into a resilient grid? If so, please list below and explain why federal funding is necessary to support it.

**Request for Information Response Guidelines**

To respond to **Topic 2: Systems Integration**, please email your response to [SETO.RFI.SI@ee.doe.gov](mailto:SETO.RFI.SI@ee.doe.gov) no later than 12:00pm (ET) on January 7, 2019. Responses to this RFI must be submitted electronically and provided as attachments to an email. It is recommended that attachments with file sizes exceeding 25MB be compressed (i.e., zipped) to ensure message delivery. Responses must be provided as a Microsoft Word (.docx) attachment to the email and have 12 point font and 1 inch margins. Only electronic responses will be accepted.

Please identify answers by responding to a specific question or topic if applicable. Respondents may answer as many or as few questions as desired at their discretion.

EERE will not respond to individual submissions or publicly publish a compendium of responses. A response to this RFI will not be viewed as a binding commitment to develop or pursue the project or ideas discussed.  
  
Respondents are requested to provide the following information at the start of their response to this RFI:

* Company / institution name;
* Company / institution contact;
* Contact's address, phone number, and e-mail address.

1. U.S. Energy Information Administration (EIA), Electric Power Monthly with Data for November 2017, published in January 2018. <https://www.eia.gov/electricity/monthly/current_month/epm.pdf> [↑](#footnote-ref-2)
2. Source: Solar Energy Industries Association (SEIA), <http://www.seia.org/> [↑](#footnote-ref-3)
3. For example, in the California Independent System Operator (CAISO) Monthly Renewables Performance Report, the 5-minute market data shows that at the maximum solar served almost 45% of the load in September 2017. See http://www.caiso.com/Documents/MonthlyRenewablesPerformanceReport-Nov2017.html [↑](#footnote-ref-4)
4. “Impact of Power System Blackouts”, M. M. Adibi, and Nelson Martins, Power Point Presentation at 2015 IEEE Power & Energy Society General Meeting [↑](#footnote-ref-5)
5. “Leveraging Distributed Resources to Improve Resilience”, R. Arghandeh, M. Brown, A. Del Rosso, G. Ghatikar, E. Stewart, A. Vojdani, and A. von Meier, IEEE Power & Energy Magazine, September/October 2014 [↑](#footnote-ref-6)
6. “Achieving Resilience at Distribution Level”, G. J.-Estévez, A. N.-Espinosa, R. P.-Behnke, L. Lanuzza, and N. Velázquez, IEEE Power and Energy Magazine, May/June 2017 [↑](#footnote-ref-7)
7. http://www.tdworld.com/smart-grid/florida-power-light-orders-20000-distribution-line-sensors [↑](#footnote-ref-8)
8. https://uc-ciee.org/downloads/i4E%20micro-PMU%20talk%20Oct%2019.pdf [↑](#footnote-ref-9)
9. "Synthesizing virtual oscillators to control islanded inverters", B. Johnson, M. Sinha, N. Ainsworth, F. Dorfler, and S. Dhople. IEEE Transactions on Power Electronics. Volume 31 (8). pp. 6002-6015. 2016. [↑](#footnote-ref-10)
10. “Frequency Response Assessment and Enhancement of the U.S. Interconnections towards Extra-High Photovoltaic Generation Penetrations — an Industry Perspective,” Y. Liu, S. You, J. Tan, Y. Zhang, Y. Liu, IEEE Transactions on Power Systems. In revision. [↑](#footnote-ref-11)
11. https://www.energy.gov/oe/articles/strengthening-security-and-resilience-nation-s-critical-energy-infrastructure [↑](#footnote-ref-12)
12. https://www.energy.gov/oe/articles/demonstrating-benefits-autonomous-decentralized-control-microgrids [↑](#footnote-ref-13)
13. “An Attack-Resilient Middleware Architecture for Grid Integration of Distributed Energy Resources", Y. Wu, G. J. Mendis, Y. He, J. Wei, and B.H. Hodge, IEEE Global Communications Conference, Exhibition and Industry Forum 2016 (GLOBECOM), December 4-8, 2016, Washington, DC. [↑](#footnote-ref-14)
14. “Roadmap for Photovoltaic Cyber Security”, J. Johnson, SANDIA REPORT, SAND2017-13262, December 2017 [↑](#footnote-ref-15)