The Parker Ranch installation in Hawaii

# High Penetration Solar Deployment II Workshop

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# The SunShot Initiative



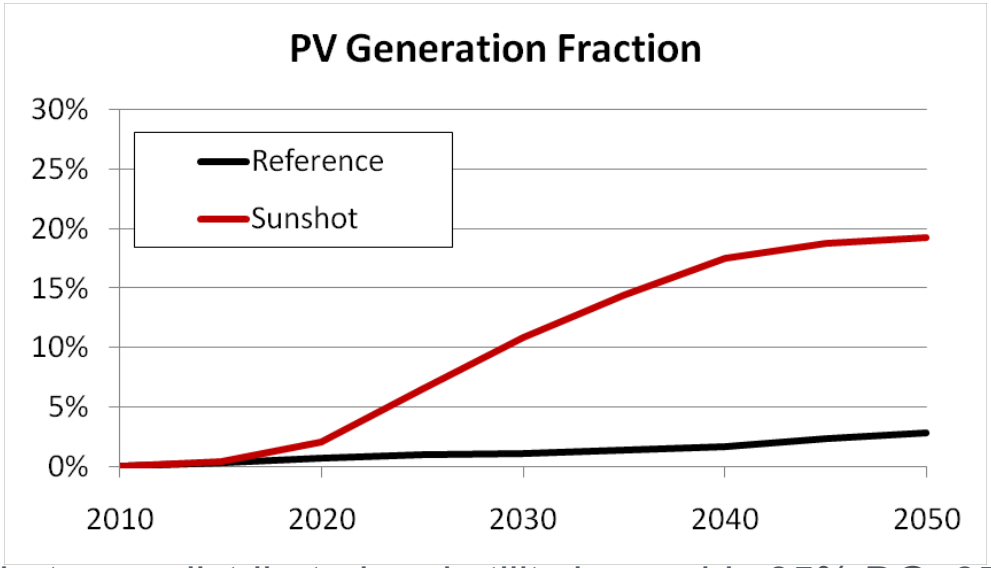
- **Price and date targets**
  - 5-6c/kWh installed at the MW scale by end of decade
  - Unsubsidized grid parity in residential and commercial markets by end of decade

- **Transformational technologies**
  - PV Modules
  - BOS
  - Power Electronics

# The SunShot Initiative
# High Penetration Solar Deployment



- ***Problem***: Lowering the cost of solar technologies does not necessarily allow greater U.S. market penetration. To reach 4% energy from distributed PV nationwide by 2030, we need to overcome the barriers to high penetrations of solar on the distribution system.




11% PV in 2030
19% PV in 2050

Split between distributed and utility is roughly 35% DG, 65% utility

# High Pen I vs II



- High Pen I Three Topics
  - Improved Modeling Tools Development - better model the effects of high penetration solar electricity generation on the electric distribution system.
  - Field Verification of High-Penetration Levels of PV into the Distribution Grid - model, field test, and validate high-penetration levels of PV on prototypical distribution circuits.
  - Demonstration of PV and Energy Storage for Smart Grids - integrate PV and energy storage into Advanced Metering Infrastructure pilot programs.
- Purpose for High Pen II
  - ***High Penetration***: There were very few (if any) feeders with high penetrations of PV on the grid. Now some exist. We need to investigate them and develop lessons learned.
  - ***Holistic Approach***: Very few of the awards are looking at how to utilize all of the tools together into address the issues as a whole.
  - ***Distribution and Transmission***: None of the current awards look at the intersection of distribution feeders feeding power back to the transmission system.
  - ***Storage***: Only one award uses energy storage, and the focus is not necessarily allowing the integration of more solar onto the grid.
  - ***Distribution Feeders***: We need to continually look at more distribution feeders that are representative across the grid and typically used for solar projects.

# High Penetration Solar Deployment II



- Very high penetrations of solar on a feeder (50-100%)
- Utilize a complete set of approaches
  - Modeling
  - Forecasting
  - Technology Development
  - Look specifically at the use of storage
- Look at a variety of representative distribution feeders
  - Long feeders with high penetration solar generators located at the end of the circuit
  - Circuits with high penetration solar generators and back-feeding capability
  - Secondary networks
  - Circuits with high penetration solar generators located close to the distribution substation
  - Circuits with highly distributed solar vs. centrally located solar on the circuit.

# Request for Information

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## Request for Information: SunShot Initiative Solar High Penetration

**Open Date:** 05/17/2011

**Close Date:** 06/06/2011

**Funding Organization:** Solar Energy Technologies Program

**Funding Number:** DE-FOA-0000526

**Summary:**

Reducing the total installed cost for utility-scale solar electricity to roughly 6 cents per kilowatt-hour (kWhr) without subsidies will result in rapid, large-scale adoption of solar electricity across the United States. Achieving the SunShot goal could enable PV penetration levels as high as 8% by energy production by 2020, 14% by 2030, and 18% by 2050.

The U.S. Department of Energy (DOE) is requesting information to develop a technology roadmap (i.e., multi-year planning) in this area. In the future, DOE may issue a Funding Opportunity Announcement (FOA) for research to define, evaluate, and test the effects of high concentrations of solar-generated power on electric power systems. Potential projects may include modeling, forecasting, technology innovations, new inverter technologies, energy storage, etc. DOE is specifically interested in determining the level of penetration at which technical problems are demonstrated to occur and how these impacts may vary based on distribution feeder topologies.

Respondents are asked to comment on questions in a Request for Information (RFI) to help shape DOE's multi-year planning and possible future FOAs. Respondents are also encouraged to comment on the value of a possible SunShot High Penetration Solar Deployment FOA, as well as your organization's anticipated interest in participating in such an opportunity.

For more information, see the full solicitation.

**Last updated:** 05/17/2011

**Funding amounts and schedules are subject to change.**

# About the RFI responses

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

- RFI issued 5/17/2011, response period closed on 6/6/2011
- 25 respondents, spanning the entire solar grid integration industry, including:
  - Manufacturing Industry
  - Utilities and Power Sector Consultants
  - Software Developers
  - Industry Nonprofit Organizations & Consortia
  - DOE National Laboratories
  - University-affiliated Organizations and Research Institutions
- The full questions and names of respondents are listed in Appendix A & B of this slide deck
- For each question, a tally of total # of responses, a tally of responses to each part of the question, and key comments are provided

*Note: Not all respondents answered a given question, and in many cases, only a part of the question was answered. This document is intended to provide a general picture of the RFI responses for the purposes of the High Penetration Solar Deployment II Workshop.*

# Question 1 – Part 1



**In this RFI, DOE has identified tools such as new inverter technologies, energy storage, forecasting, feeder modeling, etc. as a comprehensive set of tools to address high penetration issues.**

- **Is this a comprehensive list? What other tools would you recommend? Why?**

| # of responses: 24/25 | Responses |
|---|---|
| **Comprehensive** | 13 |
| **Not Comprehensive** | 11 |

## Additional Tools:

- Inverter functionality: Advanced communications and control tools.
- Advanced Protection and Distribution Automation (DA) schemes
- Scale: A clear distinction between the deployment of solar technologies as large-scale (centralized or decentralized) and small-scale (distributed) installations.
  - The two classes of deployment require a different set of integration tools.
- Microgrid specific tools and applications.
- Tool integration, particularly in the area of forecasting and feeder modeling.
- Tool to generate high temporal frequency simulations of PV system output, include enhanced solar irradiance and power output simulation.
- Tool to correlate solar forecast errors on a range of time and space scale for a given geographical area.

# Question 1 – Part 2



**Is there a recommended emphasis on particular tools? Why or why not?**

- **Not Just Tools** "Understanding how high penetrations of PV will impact the grid is broader than development of tools alone. Utilities will need to understand how large amounts of distributed generation connected to their distribution systems will impact how the plan and operate their systems, how the intermittency of PV interacts with the intermittency of load, and how different PV technologies interact with one another."
- **Solar Forecasting** "The German grid authority has disallowed the allocation of additional spinning reserve due to renewable energy resources, because it deems it unnecessary given the high accuracy to which solar generation can be forecasted now in Germany…without indirect costs for system operator."
- **Advanced Energy Storage "**Energy storage is essential to the success of the program due to energy storage's multifunctional capacity, and therefore should be emphasized in any high penetration solar application."
- **Electric Vehicles** Incorporation of electric vehicles and advanced energy storage as a system solution rather than discrete components.
- **Microgrid-Specific Issues and Applications**

# Question 2



**Individual high-penetration PV projects involving grid stability, voltage regulation, power quality, protection coordination, advance modeling and simulation, advanced inverter technology, communication control systems and storage have been performed independently in the past.**

- **Should there be a focus on a more consolidated approach? What other projects similar to this unified approach would you specifically recommend and why?**

**# of responses: 20/25**

| | |
|---|---|
| **Yes** | 16 |

**Comments:**

- **Staged approach** should be used to add capability in incremental steps. A development roadmap should be prepared and implemented.
- The solar energy industry is today quite fragmented with various technology solutions addressing separately the numerous challenges. We believe that this **fragmentation has significantly limited the potential of solar energy**.
- Integrate potentially disruptive technologies such as **distributed micro grids** and **electric vehicles**.

# Question 3



**Are the goals and timeline in Figure 1 appropriate to enable the market to demonstrate the SunShot goals of 8% solar energy as a percent of the total annual energy needs for the US by the end of the decade? Why or why not?**

**13/15 Respondents said that the SunShot goals are appropriate**

**Comments:**

- **Regional Penetration:** The DOE could consider a **more aggressive goal than 8%** for the South West region, given that the South West will lead the nation in deployments, and volume based cost reduction—benefits which should trickle down to other regions of the country that do not have superior solar insolation.
- No. The $1.00/watt SunShot goal will be difficult to achieve as balance of system components are increased (communications, data logging, storage etc.), albeit the value of the distributed resource will increase proportionately to the cost as these devices become grid interactive and supportive. **The SunShot goal must include grid optimization and consumer participation value as well as cost per generated watt.**
- **Achieving 8% penetration is a rather moderate goal**. Uniform input at 20% is above the threshold for stability and would push the need for the improvements outlined for storage, inverters, and feeders.
- We think it would be easier to meet SunShot's goals with **utility-scale PV**.

# Question 4



**How do you define high penetration? Should penetration levels be defined with respect to the peak load on the feeder, or the minimum load on the feeder? Why?**

- **Based on your definition of high penetration, how aggressive should DOE be when defining high penetration as part of this potential funding opportunity?**

| # of responses: 15 /15 | Peak Load |
|---|---|
| **Yes** | 9 |
| **No** | 6 |

**Comments:**

- Future research needs to focus on grid impacts and mitigations of high penetrations of PV where PV production exceeds either 100% of minimum daytime load on a given circuit or 30% of that circuit's peak load.
- We believe that the DOE should be more aggressive in its definition of high penetration to allow for advanced studies and breakthrough technologies to participate rather than raising the bar too low.

# Question 5



**What problems related to high penetration solar integration are the highest priority to you and your stakeholders? (19/25 responses)**

**Comments:**

- DOE/EPRI/PNNL need to decide/standardize on 5 or more **representative distribution circuit** topographies so all researchers are dealing with the same base lines.
- The **intermittency** of the solar resource, and instability—in both energy and voltage—that accompany rapidly changing energy supply on a distribution system are the key challenges in achieving high penetration of solar integration.
- It is becoming apparent that **local voltage issues** are likely to precede protection, load, fault, harmonic, and stability issues as penetration increases.
- **Reverse power flow**, and impact on operation of voltage control and regulation equipment (voltage-controlled capacitor banks, line voltage regulators and LTCs) due to moderate to high penetration levels are a high priority, particularly on long and lightly-loaded distribution feeders.

# Question 6



**If DOE were to utilize a similar program structure to the 2009 High Penetration Solar Deployment FOA, would this structure be appropriate?**

- **How else could we structure it? Should additional areas be included?**

**Comments:**

- **Move away from distribution system only** applications to include solar deployment at the bulk transmission level.
- Market adoption modeling in order to assess policy decisions and technology advancements, including improved levelized cost of energy (LCOE) metrics.
- Real-world component performance characterization for the validation of models.
- Modeling of interactions between solar and other types of renewables or technologies. (Storage, electric vehicles, etc.)
- Incentivize utilities to participate in more than one project.
- There should be a down select of projects.

# Question 7



**How would you recommend DOE elevate the lessons learned from these activities so that outcomes or findings can be more universally applied?**

**Should DOE continue to include modeling and simulation in efforts funded under this potential funding opportunity?**

**21/22 Respondents said that Modeling & Simulation are essential**

**Comments:**

- **Require participation in a Modeling Tools working group** to share best practices. This working group would also supervise selection of feeders and simulations for these feeders.
- Required use of published, standard variability models rather than developing custom approaches.
- Develop the previous modeling efforts to include the ISO/RTO and LSE stakeholders to develop cross boundary Locational Marginal Pricing structure modeling at the distribution feeder level.
- Emphasis should be placed on modeling and simulating distributed energy resources leveraging PV and energy storage when coupled together.
- DOE should make sure that it allows **private industry** to retain rights to this software. We view the approach that CSI has taken to this topic to be excellent.

# Question 8

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

**What funding level in total or per award is required to meet the DOE goals, taking into account investment from federal, state, and private entities?**

- **Would it be more productive to fund several awards at $800,000 to $1miilon per year for 2 to 3 years, or fewer awards at greater than $1 million per year for 2 or 3 years? Why?**

| # of responses: 21/25 | More/Smaller (~<$1M) | Fewer/Larger (~>$5M) |
|---|---|---|
| **Support** | 15 | 6 |

**Comments:**

- More awards, between $800,000 to $1 million range per year for 2 to 3 years.
- Fewer awards, greater than $5 million, with more industry and non-federal cost sharing.
- There should be a mix of the two funding levels noted above. Several large projects, and a host of smaller manageable projects.
- The role of the national labs to provide federal in kind services can unduly hamper utility, industry and academic bidders.
- Most respondents were comfortable with 2 to 3 years.

# Question 9



**What would be meaningful objectives for a FOA and multi-year planning? Can the objectives under some topics be developed in shorter periods?**

**Comments:**

- Market-driven Objectives (cost, reliability, meeting demands for energy, etc.)
- Tool Specific Objectives (Forecasts should reduce mean absolute percentage error
- Demonstration Objectives involving energy storage
  1. Evaluate **islanding a feeder** of a distribution system to enable PV plant production to continue while alleviating a heavily loaded feeder or substation.
  2. Evaluate the use of energy storage to store and shift energy delivery to match the load profile and the capacity value of renewable resources.
  3. Evaluate using energy storage for regulation during high solar-production time-of-day to **mitigate short-term intermittency** issues associated with solar PV plant operation.
  4. Demonstrate the ability of a PV plant to continue **operating through a real-power output curtailment** event by utilizing local and/or distributed energy storage assets.
  5. Demonstrate that the combination of intermittent, renewable-based, distributed generation and storage can mitigate voltage level fluctuations, as well as enable peak shifting
  6. Quantify and refine performance requirements, operating practices and cost and benefit levels associated with the use of advanced storage technologies to **turn distributed renewable generation into a firm, dispatchable resource**

# Question 10 – Part 1



**As new technical benchmarks are reached within the U.S. related to high penetration solar scenarios, the development or modification of codes and standards will be required and in some instances will be running in parallel (i.e. 1547.8, Rule 21, etc.).**

**Which codes and standards are affecting, or either will preclude or may potentially preclude, high penetrations of solar?**

- IEEE 1547.7 and 1547.8
- IEEE P2030 and P2030.2
- Reexamining the 15% standard or “Rule 21” in CA
- Several of the IEEE C37 standards
- Communications and security standards
  - Including IEC 61850, IEC 61970, IEC 61968, IEC 60870-6, IEC 62351, NISTIR 7628, NEC, UL, and state and local building codes.
- Tariffs associated with the value of mitigating storage

# Question 10 – Part 2



**Would support to accelerate the codes and standards process be helpful? How could DOE play a role?**

- DOE should support the **acceleration and harmonization** of codes and standards process to orchestrate the various agency in a highly coordinated manner.
- Support an industry standards working group to provide the long-term perspective in developing standards.
- DOE should support participation of parties that are not currently engaged.
- With respect to IEEE 1547.7 support development of modeling/simulation guidelines.
- Specific issues related to DC microgrid deployment
- DOE partnership with OSHA to evaluate product testing 'bandwidth' on a regional basis would show that there are significant areas in the US that would benefit from additional testing capabilities and that this would decrease both price and time to test for new products, allowing for higher penetration of PV systems.

# Question 11



**DOE anticipates that if a FOA is released, it would be open for 60 days.**

- **Is this a sufficient amount of time to respond adequately?**
- **If not, how much time will be required to prepare an adequate application?**

**# of responses: 18/25**

**Categorized response count not mutually exclusive*

| | |
|---|---|
| **Shorter period sufficient** | N/A |
| **60-day period sufficient** | 12 |
| **Longer period necessary** | 6 @ 90 Days |

**Comments:**

- An R&D project can take less time and effort to plan than developing a multi-party demonstration. Considering the emphasis on partnerships 60 days is a short time.

- Advanced notice should be considered, even if the open period stays at 60 days.

# Question 12



**What type of partnerships would be required or need to be involved to demonstrate high penetration scenarios?**

**Partnerships should include some or all of the following:**

- **Utilities or Electricity Provider -** Forward-thinking utilities that are eager to deploy PV panels and long-duration energy storage systems to support the changing panorama of the distribution grid are integral partners.
  - *Note: Utilities as a contractual participant should not be a requirement.*
- **Microgrid Operators & Independent System Operators**
- **Manufacturers, Developers and other PV Suppliers**
- **Universities & Research Institutions**
- **National laboratory, State and Local Governments**
- **Consulting/Technology Specific Firms**
- **Data acquisition and reporting firm -** An independent third party data acquisition and reporting firm is suggested in order to provide unbiased results

**# of responses: 19/25**

**Categorized response count not mutually exclusive*

# Question 13

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**What evaluation criteria should be included in a FOA to help measure the potential of a proposal? What evaluation criteria should DOE use to evaluate applicants' qualifications to ensure they meet the needs of the industry?**

**Criteria to Consider:**

- **Project Approach & Potential Impact:** Potential for results to advance the science of high penetration solar, reduce costs associated with deployment and operation of solar facilities and the distribution of generated power on the grid. Does the final product has the potential to change or benefit the market?
- **Project Team:** Strength based upon qualifications, experience, track record. Organization and management of the team, and ability to cope with unforeseen events.
- **Technical Knowledge:** Strength of the scientific/technical approach, IP management.
- **Access to Resources:** Access to feeders, feeder data with high PV penetration, availability of accurate solar forecasts. Capacity to implement mitigation measures to increase PV penetration. Cost share commitment.
- **Project Schedule:** LAB TO MARKET! The speed by which a team can move innovation into commercial markets is essential. Reasonableness of the proposed work schedule.
- **Creativity:** Creativity of the approach.
- **Outreach:** Plan for dissemination of the results to stakeholders and other interested parties.

**# of responses: 19/25**

**Categorized response count not mutually exclusive*

# Thank You



DOE Solar Energy Technologies Program
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