Renewable Systems Interconnection
Grid Integration Program Activities

Dan Ton
Grid/Building Integration Team Lead
Solar Energy Technologies

September 18, 2008
Presentation Outline

- Program Drivers
- Program Plan Development
- Program Focus Areas
- Program Funding
- Current Activities
- FY09 Planned Activities
- Summary
Drivers for Grid Integration of PV Systems

Climate change concerns, renewable portfolio standards, energy independence, incentives, and accelerated cost reduction are driving steep growth of grid-tied PV in U.S., i.e., 45%↑ in 2007 from 2006.

DSIRE: www.dsireusa.org

Renewables Portfolio Standards

September 2008
Relevance to the Solar America Initiative (SAI)

- SAI should produce high growth in the number of installed PV systems.
- The **Grid Integration** work supports the goals of SAI by conducting R&D to reduce barriers for high penetration of solar technologies into the electric power system.
- This work addresses both technical and economic issues and develops solutions for grid integration.
Issues Associated with High Penetration
- Affected by utilities' existing generation mix regulating capabilities, load characteristics, resource availability, and market structure
- Additional systems costs may go up with increasing penetration due to variability and uncertainty

Solution Pathways
- Spatial diversity of the resource
- Flexible conventional generation
- Grid operations and control
- Load management
- Energy storage

Technical Challenges
- Documented in Renewable Systems Interconnection (RSI) Reports
Grid Integration Program Plan Development

• Guided by the 14 RSI reports available at:
  http://www1.eere.energy.gov/solar/solar_america/rsi.html

  • Advanced Grid Planning and Operations
  • Utility Models, Analysis and Simulation Tools
  • Advanced PV System Designs and Technology Requirements
  • Development of Analysis Methodology for Evaluating the Impact of High Penetration PV
  • Distribution System Performance Analysis for High Penetration PV
  • Enhanced Reliability of PV Systems with Energy Storage and Controls
  • Transmission System Performance Analysis for High Penetration PV
  • Renewable Systems Interconnection Security Analysis
  • Solar Resource Assessment: Characterization and Forecasting to Support High PV Penetration
  • Test and Demonstration Program Definition to Support High PV Penetration
  • Value Analysis
  • PV Business Models
  • Production Cost Modeling for High Levels of PV Penetration
  • PV Market Penetration Scenarios
DOE has developed a Multi-year Research Plan structured into six areas:

1. **Distributed PV System Technology Development**
   - Solar Energy Grid Integration Systems (SEGIS)
   - SEGIS-Energy Storage → CREST

2. **Advanced Distribution Systems**

3. **System Level Test and Demonstration**
   - High penetration PV at distribution grid

4. **Distributed Renewable Energy System Analysis**

5. **Solar Resource Assessment**

6. **Codes, Standards, and Regulatory Implementation**
Funding Allocations, by Focus Area

FY08

- Distributed PV System Technology, $4,004
- Distributed System Analysis, $800
- System Test & Demo, $0

FY09

- Distributed PV System Technology, $7,370
- Distributed System Analysis, $1,200
- System Test & Demo, $2,400

* Enhanced budget level, pending appropriations
Current Activities: Distributed PV System Technology
Solar Energy Grid Integration Systems (SEGIS)

- SEGIS is a “System” development program focused on new requirements for interconnecting PV to the electrical grid.
- SEGIS is the intelligent hardware that strengthens the ties of Smart Grids, Microgrids, PV, and other Distributed Generation.

Advanced Distribution Infrastructure with SEGIS Functionalities
SEGIS Industry Solicitation & Awards

Up to $24M DOE Investment over 3 Years (FY08-10); 27 Proposals Responded for 3-Stage Development

($40M total including industry cost share)

- Stage 1 (9-mo feasibility): 12 awards in June 2008; avg. $238K DOE funding per award
- Stage 2 (1-yr engineering development/prototyping): avg. $2.67M DOE funding requested per award
- Stage 3 (1-yr toward commercialization): avg. $2.56M DOE funding requested per award
SEGIS Phase-I Awards

Addressing solar energy integration application needs for smart grid, microgrid, demand response, zero-energy homes/buildings, communication portals, PHEV integration

- Apollo Solar
- Enphase Energy
- Nextek Power Systems
- Petra Solar
- Premium Power Corporation
- PVPowered
- VPT Energy Systems

- Edison Materials Technology Center (EMTEC)
- General Electric Global Research
- Princeton Power Systems
- SmartSpark
- Florida Solar Energy Center at UCF
**Highlight of SEGIS Phase-I Project:**

*Grid Integration of High-penetration Solar Energy*

(General Electric Global Research)

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**Technologies Addressed**

- Advanced Inverter Controls
- Energy Storage
- Demand Response
- Residential Energy Management
- Utility Distribution Automation

**Description**

GE and its team will advance residential PV generation coordination with energy storage, responsive loads, and demand side management programs. Enhanced three-phase inverter and distribution system controls will be developed to meet anticipated new requirements for grid connectivity.

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**Participants**

**Lead**

General Electric

**Resources ($)**

<table>
<thead>
<tr>
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<th>DOE Max (3 stages)</th>
<th>DOE Stage 1 (max)</th>
<th>Cost Share per stage</th>
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<td>$6,250K</td>
<td>$250K</td>
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**Rayette Fisher**

Sentech

NM Tech

AEP

Duke

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**Diagram**

The diagram illustrates the integration of solar power systems with existing distribution networks, highlighting components such as dispatchable PV homes, DG capable distribution system controls, and substation components.

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**Segis Solar Energy Grid Integration Systems**
Highlight of SEGIS Phase-I Project: 
*Economically Viable, Integrated, Modular SEGIS Architecture* 
(Petra Solar)

**Technologies Addressed**

Smart Grid Interconnection, System Cost, Modularity, System Reliability, Safety, and Advanced Scalable Inverters

**Description**

Petra Solar and its team will advance grid interconnection, cost reductions, system reliability, and safety through low cost, easy-to-install, modular and scalable inverter power architectures that are scalable from 5kW to 20kW. Advances include multi-layer control, communication architecture, monitoring and controlling a cluster of AC module inverters, and a strategic EMS switch junction box.

**Resources ($)**

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**Participants**

**Lead**
Petra Solar
Adje Mensah

**Engagement**
Florida Power Electronics Center
Florida Solar Energy Center
Lakeland Electric
Echelon
BP Solar
Evergreen Solar
Significance of SEGIS Development

Addressing the grid integration issue with:
• the highest unscheduled maintenance event
• the highest unscheduled maintenance cost

Unscheduled maintenance: events (left) and costs (right)

Current Activities: Distributed PV System Technology
SEGIS-Energy Storage

• SEGIS-ES Concept Paper Published
  • Augments SEGIS program
  • Describes storage needs to enable high penetration PV
  • Provides summary of current storage technologies
  • Identifies some future R&D needs

Figure 1: Measured and modeled PV system output on a day with frequent passing clouds.
Current Activities: Distributed System Analysis

Analyzing distribution system data to understand effects of high penetration of PV on the electric power system

• SMUD: Installing DAS and monitoring on distribution feeder in Rancho Cordova, CA; over 600 homes will have 2kW of PV

• Alamosa, CO: Working with Xcel Energy and SunEdison on monitoring effects of 8MW PV system on distribution feeder
Supporting Hawaii Clean Energy Initiative with data collection planned for large arrays and high rooftop penetrations

**Kauai**
Characterize benefits and costs of variable renewable integration solutions, ownership options, and implementation for KIUC.

**Oahu**
Assist Forest City with renewable options for military housing

**Lanai**
Assist Castle & Cooke and MECO with analysis and implementation for 1.5MW PV array. (Total 5MW load)
Grid Integration Program  
Looking Forward

FY09 Planned Activities
FY09 Funding Opportunity 1*: System Level Demo

Objective: Analyze and demonstrate effects of high-penetration PV systems on varying designs and operations of distribution feeders

- Working group with members from electric utilities, system integrators, and research institutions being assembled to define:
  - Feeder characteristics for high-penetration demonstrations
  - High-penetration targets
  - Data monitoring and analysis requirements
  - Modeling & analysis tool development/validation requirements
- Integrated team approaches (industry lead, with national lab partner) to be solicited
- Solicitation targeted for release in January-February 2009, with awards made by August 2009
  - DOE funding: $2M each year for 3 years
  - # Awards: TBD

* Pending FY09 budget appropriations
FY09 Funding Opportunity 2*: SEGIS-ES

Objectives: Energy storage R&D for SEGIS-ES applications in residential, small commercial, and commercial sectors

- Three sub-working groups being assembled to define:
  - Energy storage requirements for distributed PV integration applications
    - Energy, power, size, cost, efficiency, lifetime, cycle life, charge and discharge rates, maintenance, reliability, etc. and their tradeoffs
  - Codes and standards governing SEGIS-ES applications
  - Energy storage gap areas and their priority R&D requirements
- Solicitation targeted for release in March-April 2009, with awards made by October 2009
  - DOE funding: $450-750K in FY09; outyear funding TBD
  - # Awards: TBD

* Pending FY09 budget appropriations
FY09 Planned Activities: CREST

• Plan to work with the EERE/OE team to jointly develop the DOE CREST strategy document by January 2009
  • Grid integration Program ready to lead the part on storage strategy development for distribution grid integration
  • Strategy development will be followed by defining requirements for each study area for distribution grid integration identified in the draft Study Plan
    • Utility/customer value propositions and analysis
    • Modeling and analysis
    • Storage technologies and systems integration
    • Test & demonstration programs
    • Regulatory enablers
Summary

Grid Integration has engaged and will continue engaging stakeholders in developing requirements definition and R&D agenda

- RSI Study → SEGIS → System Level Demo, SEGIS-ES, & CREST
  Stakeholders: renewable system manufacturers and integrators, electric utilities, energy storage companies, research institutions, and regulatory entities

- Public/private partnerships to implement jointly developed R&D agenda
  SEGIS projects in FY08 → System level demo and SEGIS-ES projects in FY09

Participation from all stakeholders currently sought for SEGIS-ES, CREST, & system level demo solicitation planning