Solar Energy Grid Integration Systems
“SEGIS” Overview
for the
International Photovoltaic Reliability Workshop (IPRW) II

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This Program Overview Presents

- The Mission of the DOE Solar Program
- The Goals of the SEGIS Project and Solicitation
- The Stages/Timetable of the Projects
- The Contractor Information
- Future Directions and Impacts
The mission of the US DOE’s Solar Program is to: “Accelerate” the wide-spread adoption of solar electric technologies across the United States.
Solar Energy Grid Integration Systems (SEGIS)

- Captured the result of 3 industry workshops that identified and prioritized technical issues related to high penetration PV
- Described the goals and requirements of the SEGIS program
- Conveyed detailed program requirements to SEGIS solicitation bidders
VISION

ENABLE HIGHLY INTEGRATED, INNOVATIVE, ADVANCED INVERTERS, CONTROLLERS, CRITICAL BOS CONCEPTS & ENERGY MANAGEMENT FOR RESIDENTIAL AND COMMERCIAL PV APPLICATIONS

All Non-module costs must be reduced. Brackets show magnitude of improvement needed

Without dramatic non-module cost improvements, the goals ($0.05-$0.10/kWh by 2015) will not be met even if PV modules are given away!

SEGIS = “VALUE ADDED”
SEGIS focus is to develop the intelligent hardware that interconnects PV to the evolving “Smarter” electrical grid.
SEGIS Stages & Time Table

SEGIS is a 3-Stage Solicitation ($24M)

12 Awards

Today

5 Awards

SEGIS INITIAL PROPOSAL
✓ Stage 1 Complete Technical & Cost
✓ Stage 2 Complete Technical & Cost
✓ Stage 3 T&C (Brief Overview)

END OF STAGE REPORTS and STAGE 3 PROPOSAL
✓ Stage 1 Technical Report
✓ Stage 1 Market Analysis Report
✓ Critical Program Review
✓ STAGE 3 DETAILED TECHNICAL & COST PROPOSAL

END OF STAGE REPORTS
✓ Stage 3 Final Technical & Market/Cost Report
✓ Critical Program Review
✓ Stage 3 Peer Reviewed Conference Paper
✓ Final Program Review

Stage 1
Concept and Feasibility
Proof of Concept/Feasibility
Research and Development
Advantages and Disadvantages
Barriers and Needs
Likelihood of Success
Market and Cost Analysis
Value-Added Analysis
Market and Tech Impacts

Stage 2
Prototype Development
Prototype Design and Testing
Control Strategy Development
Electrical and Mechanical
Energy Balance Calculations
Reliability Calculations
Operational Characterizations
Performance Measurements
External Interaction Validations

Stage 3
Pilot Production (Toward Commercialization)
Pilot Production Design
Hardware Delivery
Test & Evaluations
Validations and verifications
Production Analysis
Bill of Materials
Final Cost Analysis
Hardware Commercialization
The Needs

- High PV Penetration
- “Smart Grid” Integration
- High Reliability/Lifetime
- Value Added PV Systems
  - Communications
  - Performance Optimization
  - System Concepts
12 awards began in June 2008 for 9-mo proof of concept/feasibility (avg. $238K DOE funding per award)

### SEGIS Stage 1 Contractors

<table>
<thead>
<tr>
<th>Micro-Inverter</th>
<th>Residential</th>
<th>Commercial</th>
<th>Commercial/Integration</th>
<th>System Integration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Enphase Energy</td>
<td>GE</td>
<td>VPT Energy</td>
<td>Princeton Power</td>
<td>UCF/FSEC</td>
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<tr>
<td>Smart Spark (Solar-Bridge)</td>
<td>Apollo Solar</td>
<td>Nextek Power</td>
<td>Premium Power</td>
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<tr>
<td>Petra Solar</td>
<td></td>
<td>PV Powered</td>
<td>EMTEC</td>
<td></td>
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</tbody>
</table>

Proposals in May 2009 for Stage 2 & 3 prototypes, testing, commercialization (avg. $2.67M DOE funding per award)
“SEGIS” Contractor’s R&D System Ratings*

- <1kW Represents Micro-inverters
  - All are unique topologies
  - All are Integrated with PV modules
- 1 – 10 kW Represents Residential Systems
- 10 – 100 kW Represents Commercial Systems
- >100 kW Can be Commercial or Utility Systems

*Some contractors proposed multiple developments
Contractor Locations

Stage 1 Subcontractor Locations (15 States)

Primary Contractors

- Apollo
  - Bethel, CT
- EMTEC
  - Delaware, OH
- Enphase
  - Petaluma, CA
- GE
  - Niskayuna, NY
  - Nextech
  - Haupauge, NY
- Petra Solar
  - Somerset, NJ
- Princeton Power
  - Princeton, NJ
- PVPowered
  - Bend, OR
- SmartSpark
  - Champaign, IL
- Premium Power
  - North Andover, MA
- UCF-FSEC
  - Orlando, FL
- VPT Energy
  - Blacksburg, VA
All SEGIS Stage 1 Contracts Include:

- Inverter Design
- Controller Design
- Energy Management
- 12 Electrical EMS
- 9 Building EMS (HVAC etc)
- Total or Partial System Integration/Optimization
- Communications/Comm Protocols and Methods
- Utility Support

NOTE: Several SEGIS developments will require changes in interconnect standards for maximum interconnect benefits
Communications Method Studied Does NOT Mean It Was Selected as a Preferred Method
Numerous Communications Pitfalls and Incompatibilities were Uncovered
Communication Levels from Internal Controls to Utility Interactive Controls
Speed of Response and Communication Reliability Are the Main Issues
SIGNIFICANTLY Advance Inverters, Controllers and Energy Management Systems and the required Communications to maximize PV system value for Utilities and Consumers.

Scope

- PV Systems for High-value Residential and Commercial Applications (100W – 250kW)
- PV Systems using Advanced Energy Management
- Building/Structure PV Systems AND Hybrid/Micro-grid Applications that Utilize Energy Storage
- Does NOT Include Development of PV Cell/Module or Energy Storage Technology.
Moving from Today’s Installation Methodologies

Today’s Typical Utility Interconnection

- PV Array
- Inverter
- Service Panel
- kWh Meter
- Utility Grid
- Loads

Anti-islanding
AC and DC Voltage Trips
Over- & Under- Frequency
Power limit
Over Temperature
A Future Conceptual Intelligent PV/Utility Interconnection

- **PV Array**
- **Energy Storage**
- **Internet (Weather Forecast)**
- **System Controls**
  - Inverter & Charge Control
  - Adaptive Logic System
  - Energy Mgmt System
- **Service Panel**
- **kW-kWh Smart Meter & Energy Portal**
- **Utility Grid**
- **Sub-Panel**
- **Power Control Unit**
- **Critical Loads**
- **Loads**
- **Smart Loads**

- **Electric Power**
- **Value Information**
- **Operations Information**
Advanced Communications Applications With “SEGIS”

Energy Management and Communications Methods

- I/O protocols
- Wireless/PLC/Ethernet
- Value-added Sensors/Detection to Improve Utility Acceptance
- Advanced Communications Devices, Sensors and Methodologies
- INTEGRATION with Storage for Performance Optimization
Advanced Component Development and Applications

Advanced Component Applications Through “SEGIS”

- Advanced Semiconductor Uses
- Highly-integrated Custom ICs
- Integrated Communication
- Micro-grid Controls & AMI
- MEMs & SiC Applications
- Integrated Cooling/Packages
- Advanced Surge Suppression
- Diagnostics/Gateways
- Interactive Monitoring
- Innovative Packaging
- Internal Protection/Longevity
- Magnetic Materials
  - Lower cost, higher performing
  - Planar & integrated devices
  - Nano-crystalline materials
Advanced System-Integrated Inverters Controllers and Energy Management Hardware that utilize communications and advanced algorithms and controls for complete system optimization

- Significantly Improved Value and Performance of PV Systems with energy storage options
- More Complex Inverters/controllers, but with higher reliability & lower overall costs
- Further SEGIS advances will enable HIGH PENETRATION of PV Applications using energy storage and/or micro-grid controls and optimization
Future Directions

- **SEGIS Developments to be Prototyped in Stage 2 and Commercialized in Stage 3**
- **Device & System Self Protection/ High Reliability**
  - Advanced Adaptive systems with Communications to Optimize PV System Values
  - **Hardware and Software advances to protect the inverter and components to provide high reliability/lower LCOE**
  - Predictions of System STATUS/HEALTH/LIFETIME
- **Improved Inverter AND System Modeling to Facilitate Predictive Advanced Adaptive Controls**
- **Customer Friendly Layouts and Aesthetics**
• Apollo Solar of Bethel, CT: with
  – Saft Batteries (Valdosta, GA),
  – Electric Power Research Institute (EPRI) (Knoxville, TN)
  – California Independent System Operator (Folsom, CA).
• This project creates innovative inverters utilizing energy storage and two-way communications between solar electrical systems and utilities.
• PVPowered of Bend, OR: partnered w/
  • Portland General Electric (Portland, OR), South Dakota State University (Brookings, SD), Northern Plains Power Technologies (Brookings, SD), Schweitzer Engineering Lab (Pullman, WA), and SENSUS (Raleigh, NC).

• The project will reinforce the fundamental objectives of the SEGIS program to optimize interconnections across the full range of emerging PV module technologies through innovative systems integration.
• Petra Solar of South Plainfield, with
  – University of Central Florida (Orlando, FL)
  – Fifteen Electric Utilities with service in NJ, PA, OH, DE, MD, DC, FL, TX:
• This project complements the mission of the Solar Program to achieve widespread adoption of solar energies. It supports improving reliability and resiliency so that high levels of PV integration can be adapted.
• **Princeton Power of Princeton, NJ: with**
  – Transistor Device Inc (TDI),
  – LaGuardia Community College (New York, NY)
  – Idyllwild Municipal Water District (San Diego, CA)
  – National Oceanographic & Atmospheric Administration (Princeton, NJ)
  – Princeton Plasma Physics Laboratory (Princeton, NJ)
  – Premier Power
  – SPG Solar (Novato, CA)
  – Spire (Bedford, MA).

• **This project focuses on lowering manufacturing costs through integrated controls for energy storage and develops new inverter designs.**
• Florida Solar Energy Center/UCF: with  
  – Satcon Technology Corporation, (Boston, MA)  
  – SENTECH, Inc. (Bethesda, MD)  
  – SunEdison (Beltsville, MD)  
  – Cooper Power Systems EAS (Minneapolis, MN)  
  – Northern Plains Power Technologies (Brookings, SD)  
  – Lakeland Electric Utilities (Lakeland, FL)  
• This project focuses on solving technical challenges that must be overcome to include higher PV penetration levels in larger electrical systems.
Questions & Follow-up:
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Resources:
DOE Solar Energy Technologies Program:
www1.eere.energy.gov/solar/

System Integration:
www1.eere.energy.gov/solar/systems_integration_program.html

Sign up for Newsletter & Market Analysis: Send email to solar@ee.doe.gov
Thank You

References:
http://www1.eere.energy.gov/solar/systems_integration_program.html
http://www.sandia.gov/solar