High Penetration Solar Forum

March 2011

DOE Perspective on High Penetration PV

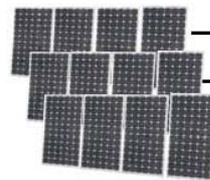Kevin Lynn

U.S. Department of Energy

Solar Energy Technologies Program

What is SunShot?

- **Price and date targets**
  - $1/W (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

BASE CASE

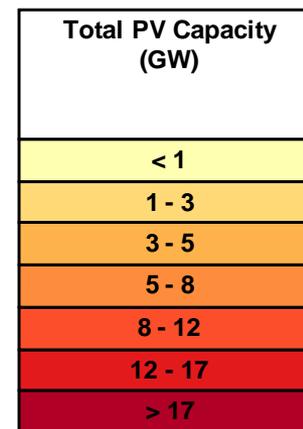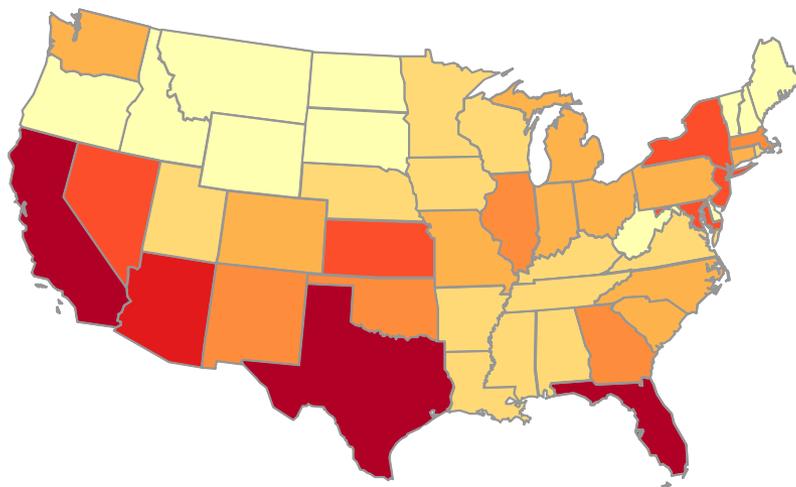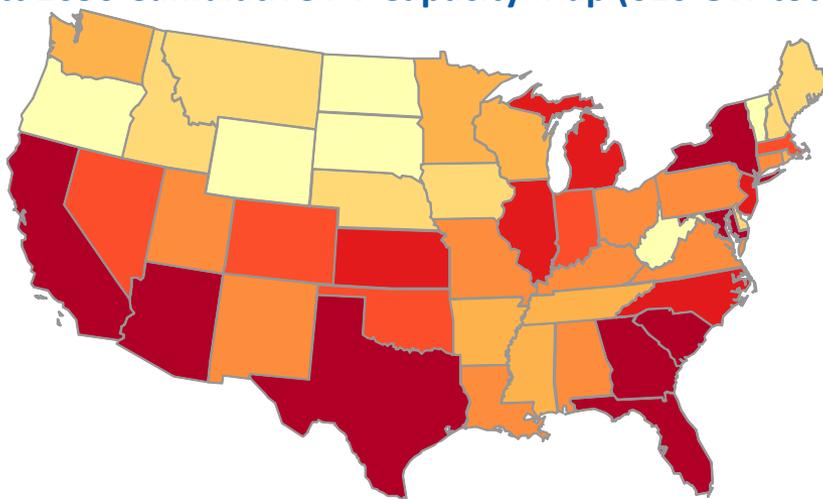PV Strings — Combiner — Central Inverter — Transformer — Utility Grid

$1/W enables unsubsidized deployment of solar energy
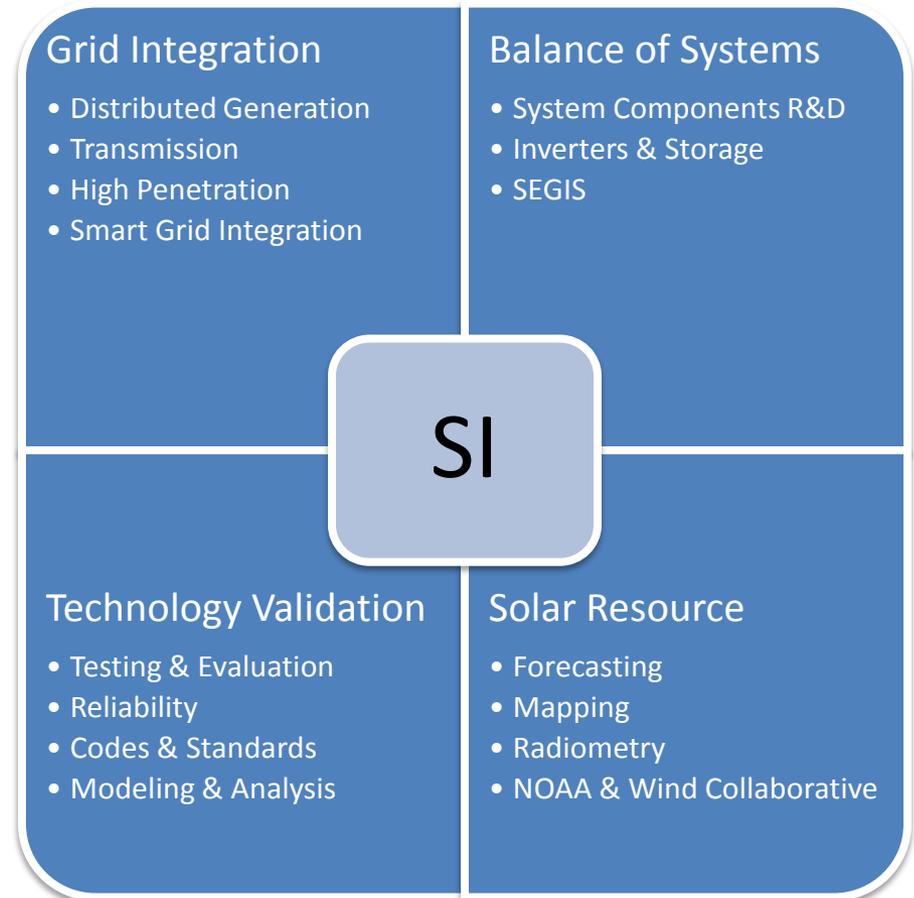
$1/Watt 2030 Cumulative PV Capacity Map (375 GW total)

$1/Watt 2050 Cumulative PV Capacity Map (610 GW total)

Total PV Capacity (GW)

- < 1
- 1 - 3
- 3 - 5
- 5 - 8
- 8 - 12
- 12 - 17
- > 17

Vision for Systems Integration

- Grid Integration
  - There will be a well established, timely and cost effective process for integrating high penetrations of PV into utility transmission and distribution systems while providing maximum value to the PV system owner and utility.

Grid Integration
- Distributed Generation
- Transmission
- High Penetration
- Smart Grid Integration

Balance of Systems
- System Components R&D
- Inverters & Storage
- SEGIS

SI

Technology Validation
- Testing & Evaluation
- Reliability
- Codes & Standards
- Modeling & Analysis

Solar Resource
- Forecasting
- Mapping
- Radiometry
- NOAA & Wind Collaborative

Vision Statement
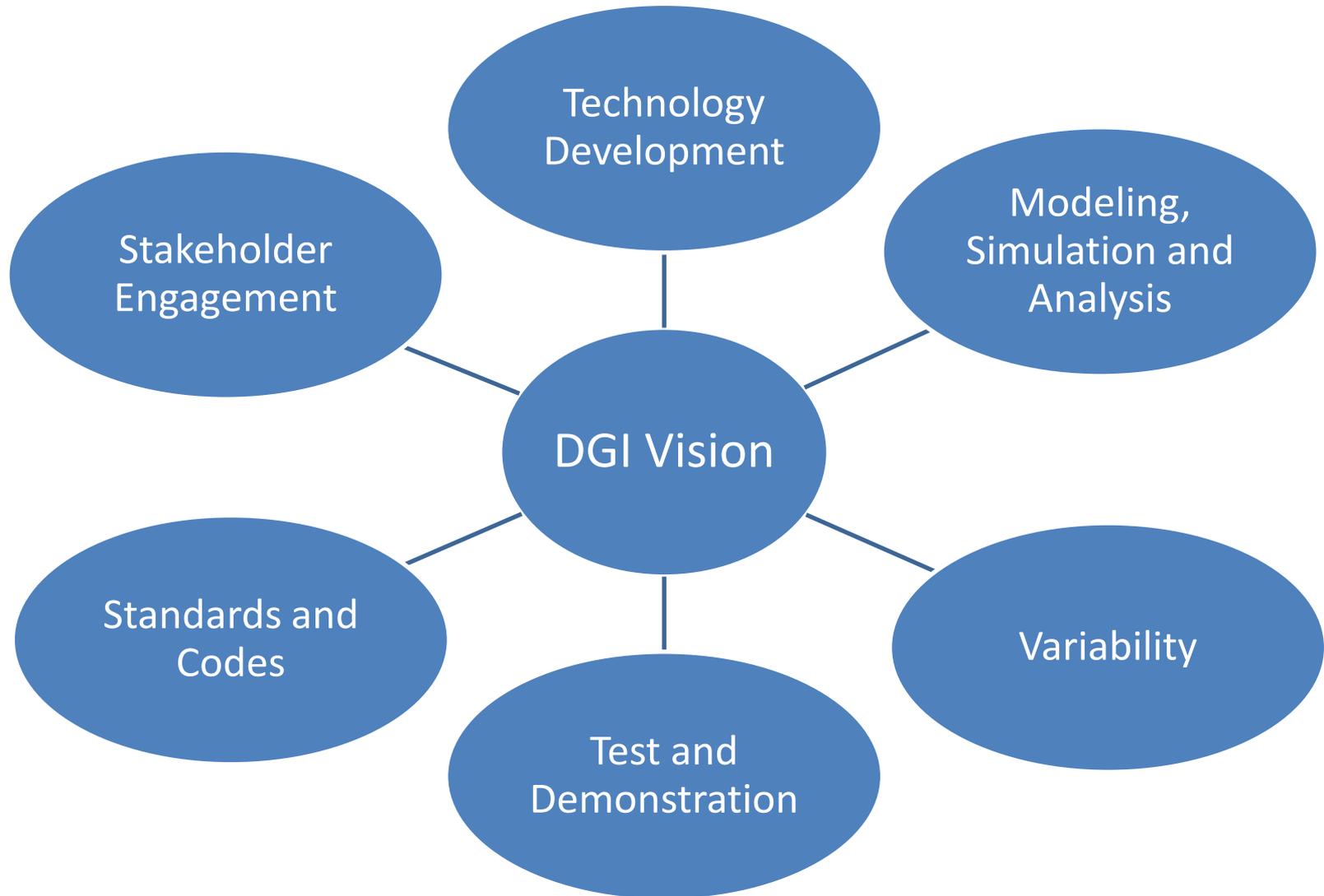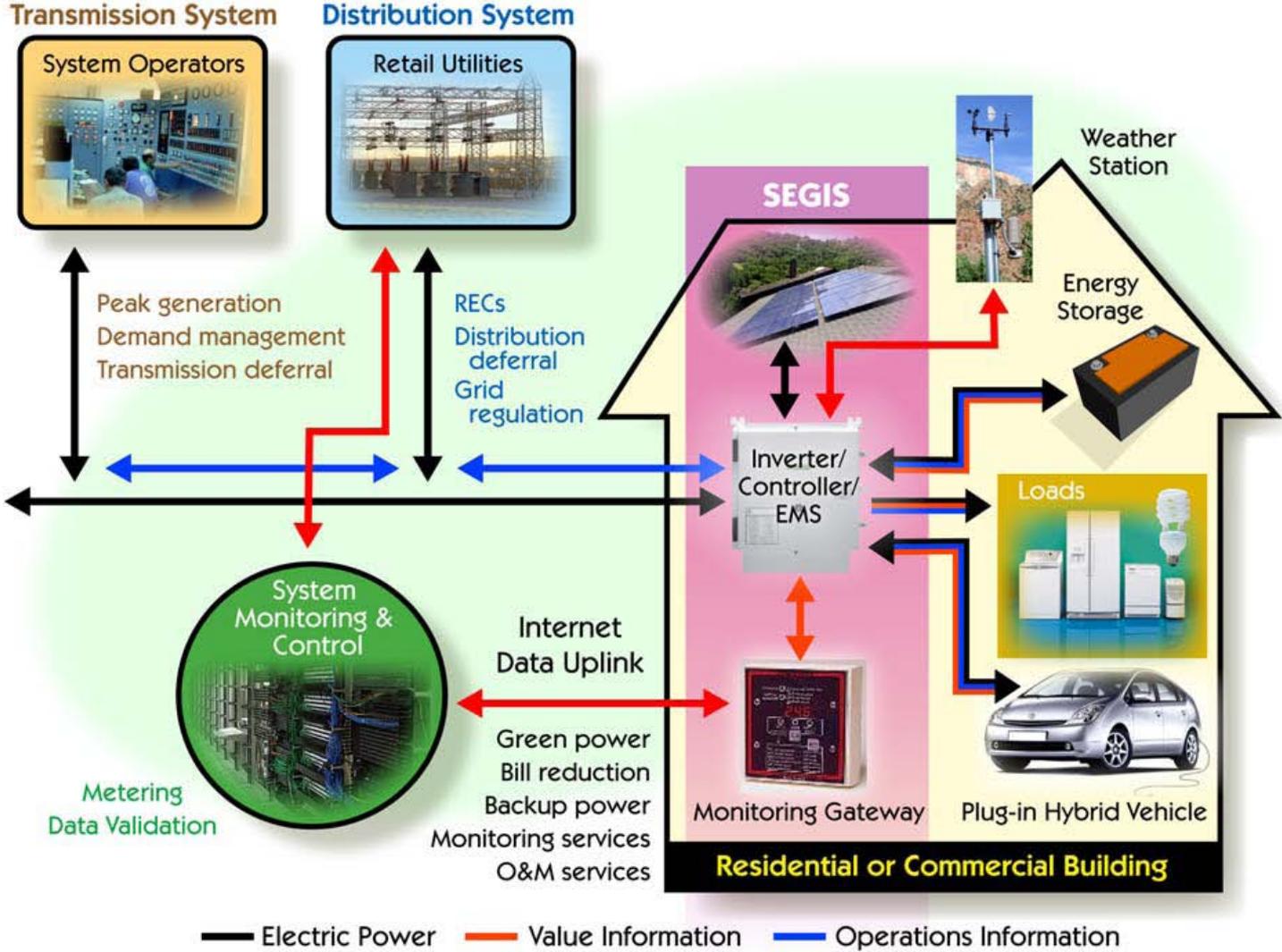
- There will be a well established, timely and cost effective process for integrating high penetrations of PV into utility distribution systems while providing maximum value to the PV system owner and utility.

- 2012 – 2016 targets toward the goal of meeting 10-20% solar energy penetration by 2030

Mission for Distributed Grid Integration

- Technology Development
- Stakeholder Engagement
- Modeling, Simulation and Analysis
- DGI Vision
- Standards and Codes
- Test and Demonstration
- Variability

Solar Energy Grid Integrations Systems (SEGIS)

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SEGIS Stage 3 Downsized from five to four Contractors

Lead Company	Short Project Title
Apollo Solar	Advanced Grid-tied Inverter, Charge Cont, Energy Monitor, Internet Gateway
EMTEC	SEGIS - Emerson PV Inverter Development
Enphase	Nano-inverters with VAr Control and EMS
GE	Grid Integration of High-penetration Solar Energy
Nextek Power Sys	PV Interface Providing Concurrent AC & DC Power Network Support
Petra Solar	Economically Viable, Highly Integrated, Highly Modular SEGIS Architecture
Premium Power	Intelligent PV Inverter
Princeton Power	Demand Response Inverter
PV Powered	MPPT and EMS Advancements
Smart Spark	Alternating Current PV Module with System Interface
U Central FL –FSEC	Grid-Smart Inverters
VPT Inc	Inverter Cont Card (ICC), Bidirectional Power Conversion(BPC), Power Hub Control (PHC), Integrated Power Hub (IPH)

Grid Integation: High Penetration Solar Deployment

Awardee	DOE Funding	Description
Arizona Public Service	$3,328,000	This project will develop, construct, manage, and study a high penetration of 1.5 megawatt (MW) of distributed photovoltaic generation on a typical residential feeder in Flagstaff, Arizona, including a mix of residential and commercial systems, as well as a 0.5 MW utility system. The model and evaluation will be according to utility standard practice.
Florida State University	$3,599,957	The project will characterize the variation and impact of solar power as a function of system size (both kilowatt and MW), location, installation type and technology, including examination of variation within larger systems. The result will be technical solutions, from protection and control strategies and technologies, to converter, converter control, and PV system technologies, to address any issues identified with high-penetration levels of grid-connected photovoltaics
NREL	$3,600,000	This project will utilize modeling and simulation, laboratory testing, and field demonstrations to determine the effects of high penetrations of up to 500 MW of mostly commercial-scale rooftop PV on electrical distribution systems, including prototypical distribution circuits and a circuit with SmartGrid functionality.

Grid Integration: High Penetration Solar Deployment

Awardee	DOE Funding	Description
SMUD	$4,300,971	This 1-year project will evaluate the value of advanced metering infrastructure, PV, and storage for homes with advanced metering infrastructure and PV along with the variables of no storage, home-based storage, or community-based storage. Actual utility-collected data will be available to assess the performance and market impacts of these options.
UCSD	$1,750,000	This project will develop advanced modeling tools and electric power control strategies to optimize electric power value and remove or reduce the impact of PV-sourced electricity on existing microgrids and the SmartGrid. Factors to be modeled and evaluated include monitoring of micro-climate effects and sky imaging systems to enable 1-hour-ahead PV-sourced electric power output forecasting in conjunction with a utility's dynamic price signals.
Virginia Polytechnic Institute	$3,206,108	The project will evaluate existing and Virginia Tech prototype power conditioners to identify cost-effective approaches to address issues associated with high-penetration PV systems, such as voltage regulation, reverse power flow, unintentional islanding, false inverter trips, reactive power control, fault contribution, protection, communications, and intentional islanding operation.

- $1/W Photovoltaic Systems

- *Balance of Systems (BOS)*: DOE is requesting information on Building Integrated Photovoltaic (BIPV) concepts, roof and ground mount innovations, software design tools, and BOS transformational concepts.

- *Solar Energy Grid Integration Systems – Advanced Concepts*: DOE is requesting information on new inverter technologies and demonstration projects that can reduce inverter costs and enhance greater penetration of solar technologies on the grid.

Purpose for the High Penetration Forum

- Inform the public of the advancements being make by the DOE and CPUC in Grid Integration

- Receive feedback from stakeholders on the current direction of our programs and help identify gaps to address in future programs

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QUESTIONS?