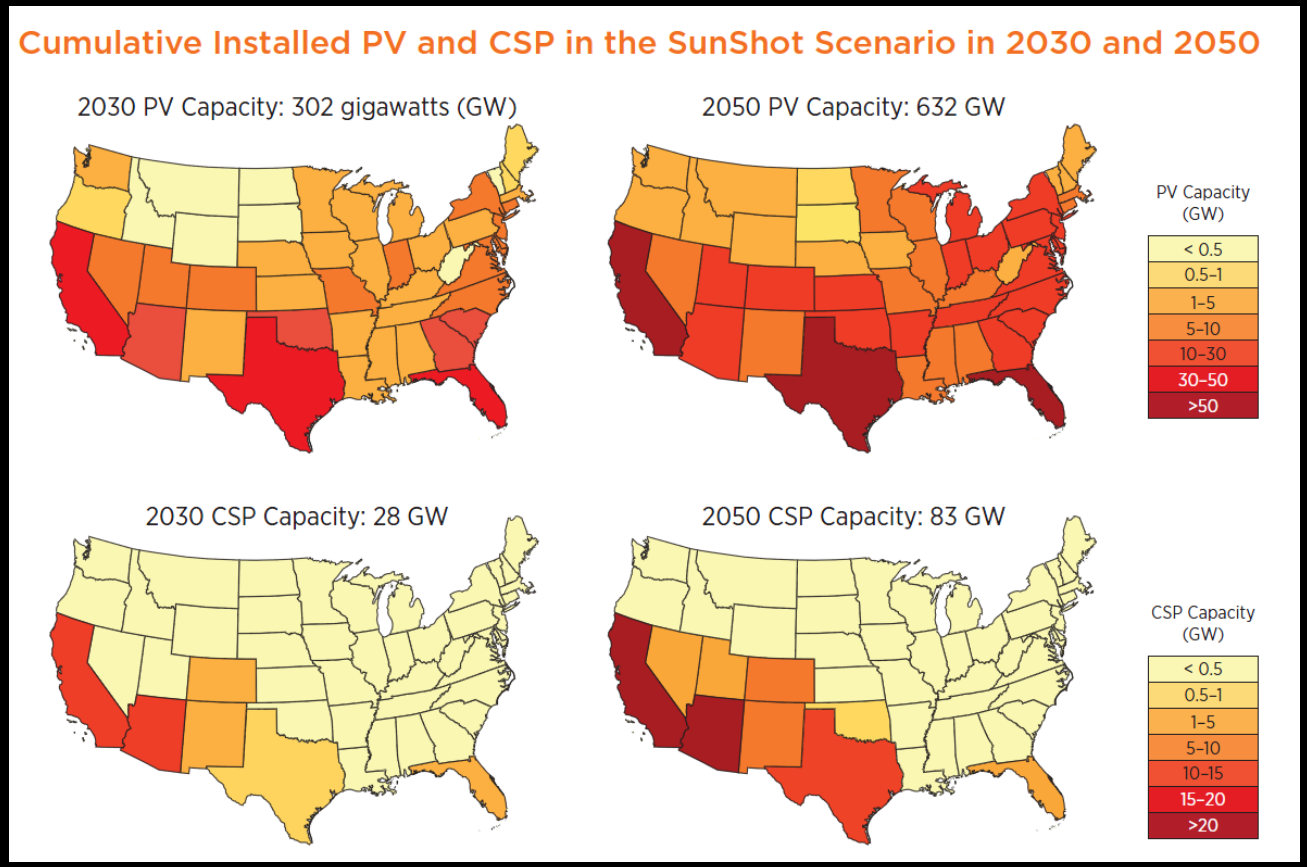
DOE/CPUC High Pen Forum
Grid Integration Activities in SunShot/DOE

SunShot
U.S. Department of Energy

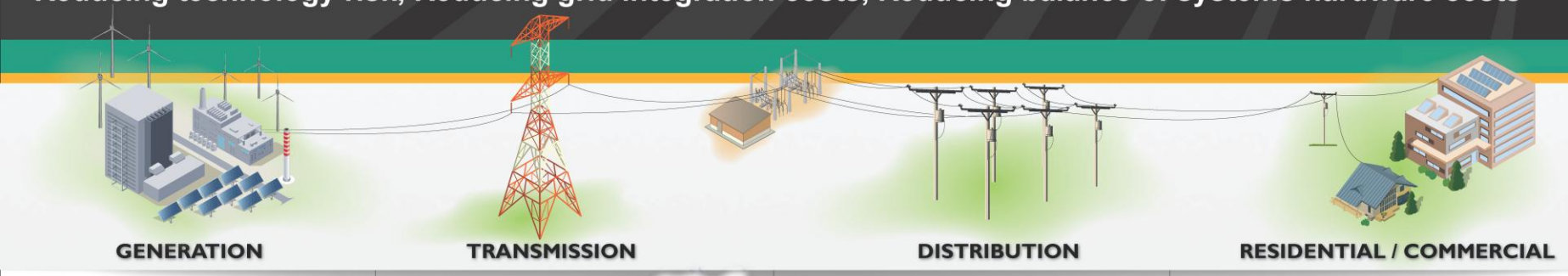
Systems Integration

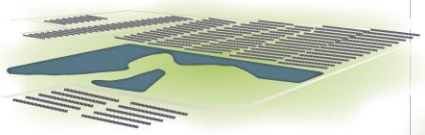
- **Grid Integration:** Establishing a timely process for integrating high penetrations of solar technologies into the grid in a safe, reliable, and cost-effective manner while providing value to the system owner and the utility grid.



Systems Integration:

Reducing technology risk, Reducing grid integration costs, Reducing balance of systems hardware costs

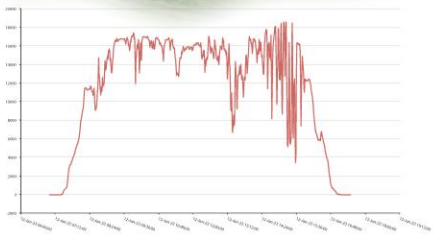




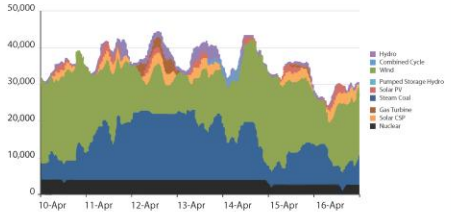
25 MW DeSoto Next Generation Solar Energy Center

BOS-X:
Racking innovations reduce hardware balance-of-system costs

Regional Test Centers:
Increasing bankability through performance validation

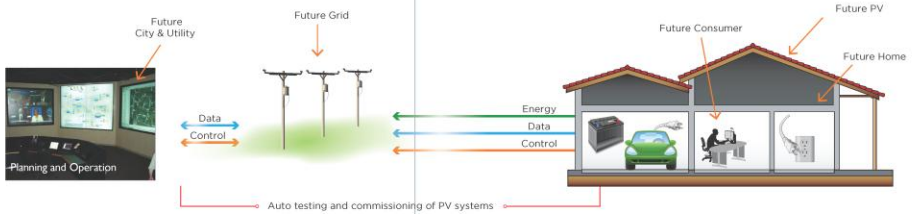


Improving the accuracy of solar forecasting



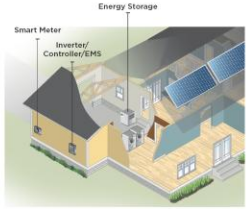
Western Wind and Solar Integration Study:
Understanding the impact of high penetration of renewables on the grid

High Penetration Solar Deployment:
Modeling tools enable widespread deployment of PV



Plug and Play Photovoltaics:
Reducing soft costs with a commercial off-the-shelf photovoltaic system

BOS-X:
Building-integrated photovoltaics



SEGIS-AC:
Advanced function technologies for grid reliability

SunShot
U.S. Department of Energy

Solar Energy Grid Integration Systems – Advanced Concepts (SEGIS-AC)

Objectives

- Reduce overall PV costs
- Allow high penetration
- Enhance performance

Awards

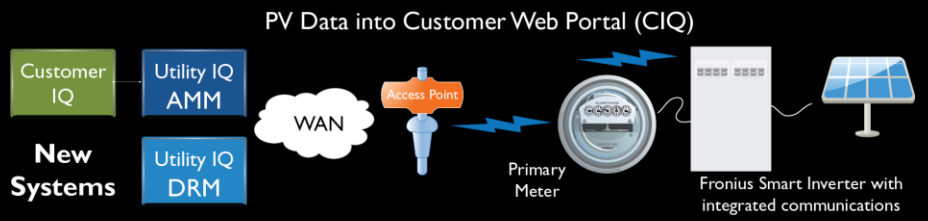
Eight projects; three years;
$25.9 million

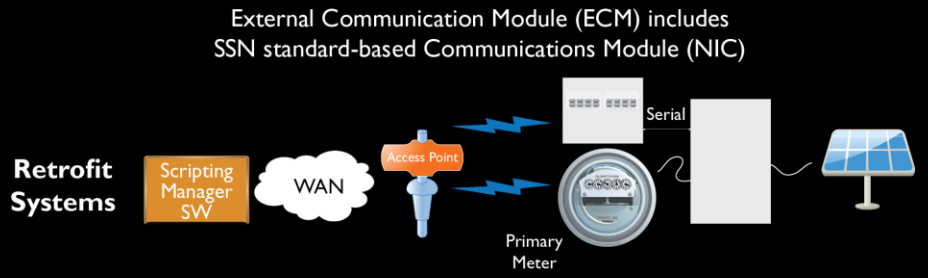
Topic 1: Smart-Grid Functionality

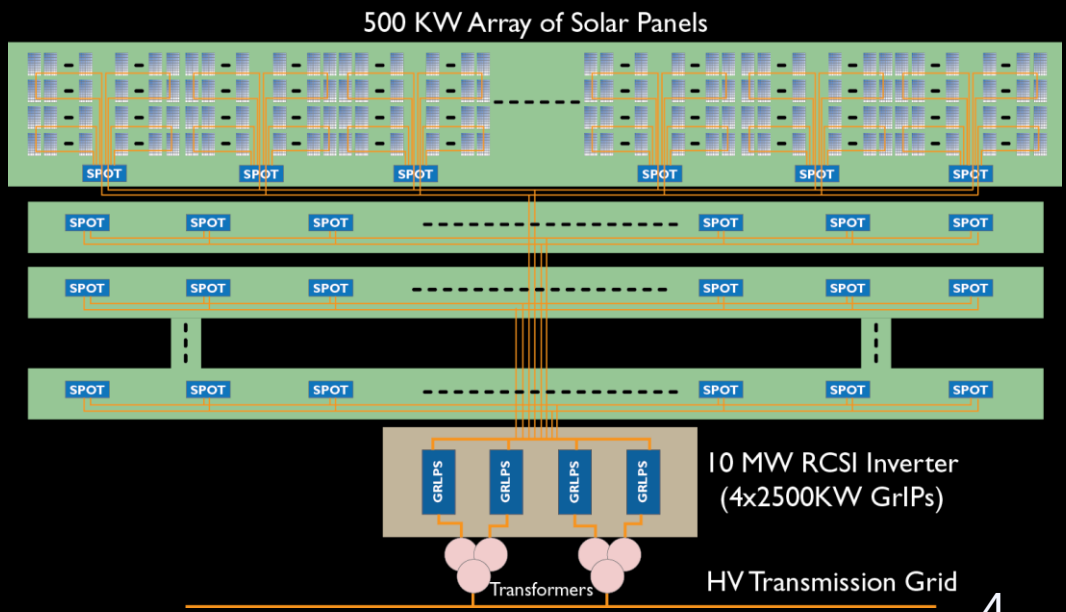
- **University of Hawaii** ($6,100,000) – Residential scale
- **EPRI** ($4,400,000) – Utility scale demo
- **Advanced Energy** ($3,100,000) – PMU-based control
- **Satcon** ($3,000,000) – Automatic voltage control

Topic 2: Reducing Costs

- **SolarBridge** ($2,300,000) – Microinverter
- **General Electric** ($2,100,000) – Plug-and-play
- **Alencon** ($3,000,000) – MW inverter
- **Delphi** ($1,900,000) – kW inverter







SunShot U.S. Department of Energy

High Pen FOA Projects

AWARDEE	PROJECT TOPIC
TOPIC: Improved Modeling Tools Development	
University of California – San Diego	Improved Modeling Tools for High Penetration Solar
TOPIC: Field Verification of High-Penetration Levels of PV into the Distribution Grid	
Arizona Public Service company	Impacts of High Penetration of PV with Energy Storage at Flagstaff AZ
Virginia Polytechnic Institute and State University	Field Verification of High-Penetration PV and Advanced Power Conditioning Systems
Alliance for Sustainable Energy LLC/NREL	Modeling and Analysis of High Penetration PV in California
Florida State University, Center for Advanced Power Systems	Modeling and Analysis of High Penetration PV in Florida
TOPIC: Demonstration of PV and Energy Storage	
Sacramento Municipal Utility District	Managing High Penetration PV and Energy Storage for Smart Grids

Solar Resource Forecasting

Objectives:

- Improve accuracy of solar resource forecasts
- Enable widespread use of solar forecasts in power system operations

Impacts:

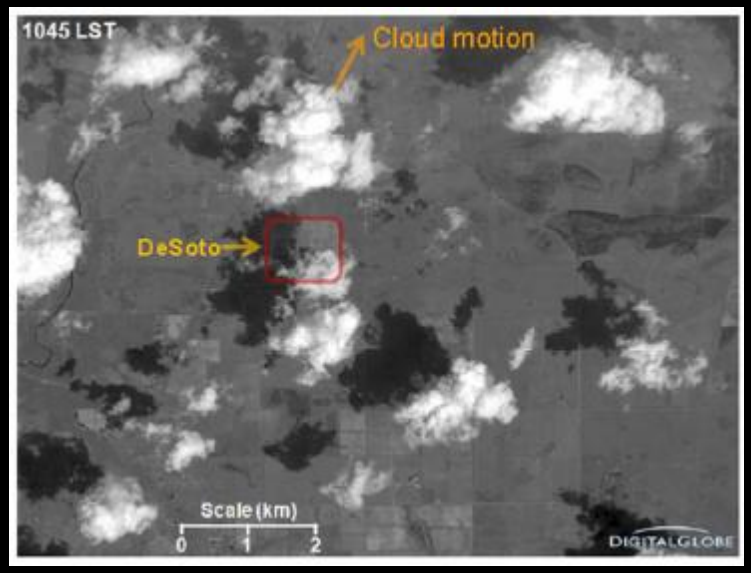
- Increase dependability of power output prediction
- Prepare for impending intermittencies to minimize grid impacts

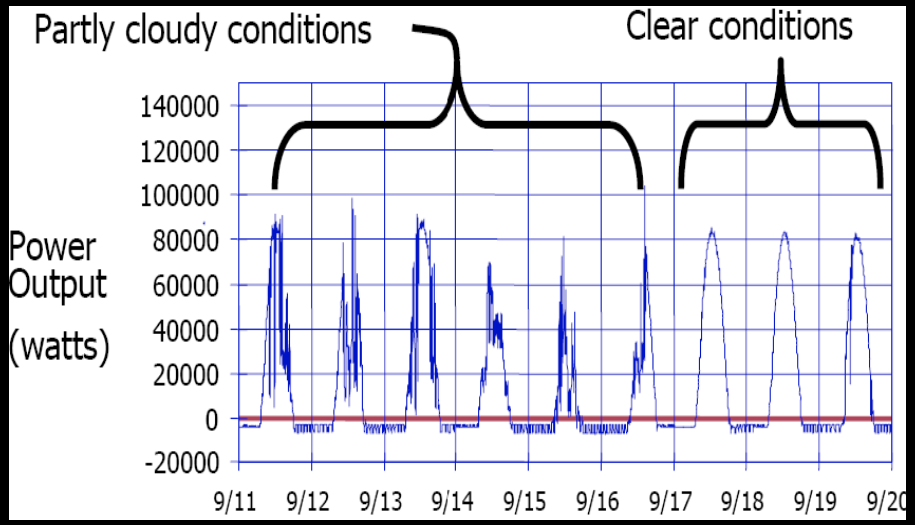
Proposed Focus Areas:

1) Develop Standardized Target Metrics
2) Develop Innovative algorithms and validate
3) Demonstrate value with utilities/system operators

Next Steps:

1) Solar Forecasting workshop
2) Develop key milestones to address gaps
3) Determine specific projects



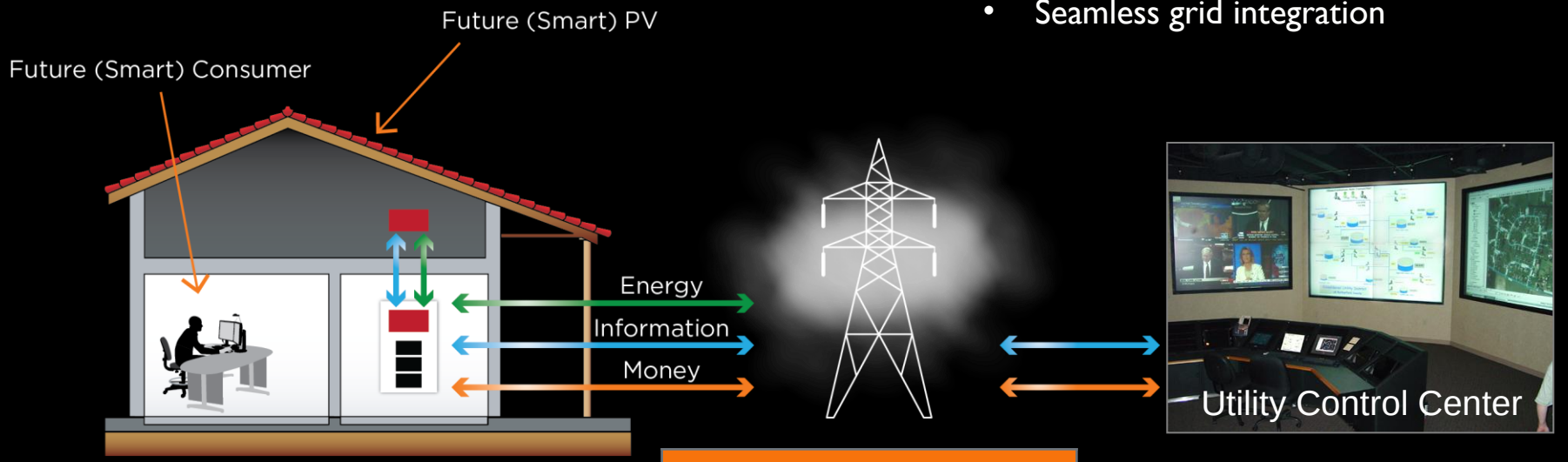


SunShot U.S. Department of Energy

Plug-and-Play Vision

Vision: PV as an Appliance

- No permitting required
- Easy installation
- Seamless grid integration



Future (Smart) Home

- Smart outlet
- Smart circuit
- Smart breaker panel
- Smart appliances
- Home area network (HAN)

Future (Smart) Grid

- Distributed generation
- Two-way power flow
- Communication and control
- Rich energy information and transactions
- Microgrid

Future (Smart) City

- Integrated grid and city planning

SunShot U.S. Department of Energy

FY13 Distributed Grid Integration DGI-LPDP
INCREASING PV PENETRATION - NREL

PROJECT SUMMARY

Provide critical research and development activities that address the technical barriers confronting the hi-pen interconnection of PV.

1. Improve small-generation interconnection processes (**SGIP)** with a focus on high-penetration PV regions and develop **advanced feeder hosting capacity metrics and interconnection screens**.
2. Develop **advanced** distribution system modeling, monitoring, and visualization **tools.**
3. Lead development of **interconnection standards and codes.**
4. Utilize **megawatt-scale PV integration test laboratories** for testing, characterization and validation of advanced inverter functions and control schemes.
5. Provide **technical educational material, training, and guidebooks** for utility engineers, universities, policy makers, and PV stakeholder groups.
6. Engage **key stakeholders** such as electric utilities, state public utility commissions, PV manufacturers, PV developers and installers, and others.

KEY MILESTONES & DELIVERABLES

FY13	• Develop **prototype** advanced feeder monitoring system. Perform analysis of utility technical screens. • Build real-time model library of inverter control algorithms. Develop university-level course on PV integration best practices. • Lead IEEE 1547 and other standards development.
FY14	• Develop best practices for secondary network interconnection and transient overvoltage issues. • Develop test protocols using the HIL test-bed. Deploy next generation monitoring systems and tools for utility feeder. • Draft guidebook of best practices in monitoring, modeling, visualization, and PV integration.
FY15	• Focus on stochastic, time series, and hosting capacity of hi-pen circuits. Test megawatt-scale laboratory distribution system. • Industry roll-out of the advanced monitoring system,

KEY PERSONNEL – NREL and DOE

Michael Coddington Ben Kroposki Ph.D

Barry Mather Ph.D. Jason Bank Ph.D. Alvin Razon (Sunshot)

Key Project Impact- *Reduce barriers to integration of hi-pen PV on distribution circuits with reduced or simplified studies, resulting in lower installed costs and improved interconnection procedures while maintaining safe, reliable, and cost-effective distribution system operation.*

SunShot U.S. Department of Energy

Transmission Grid Integration Activities

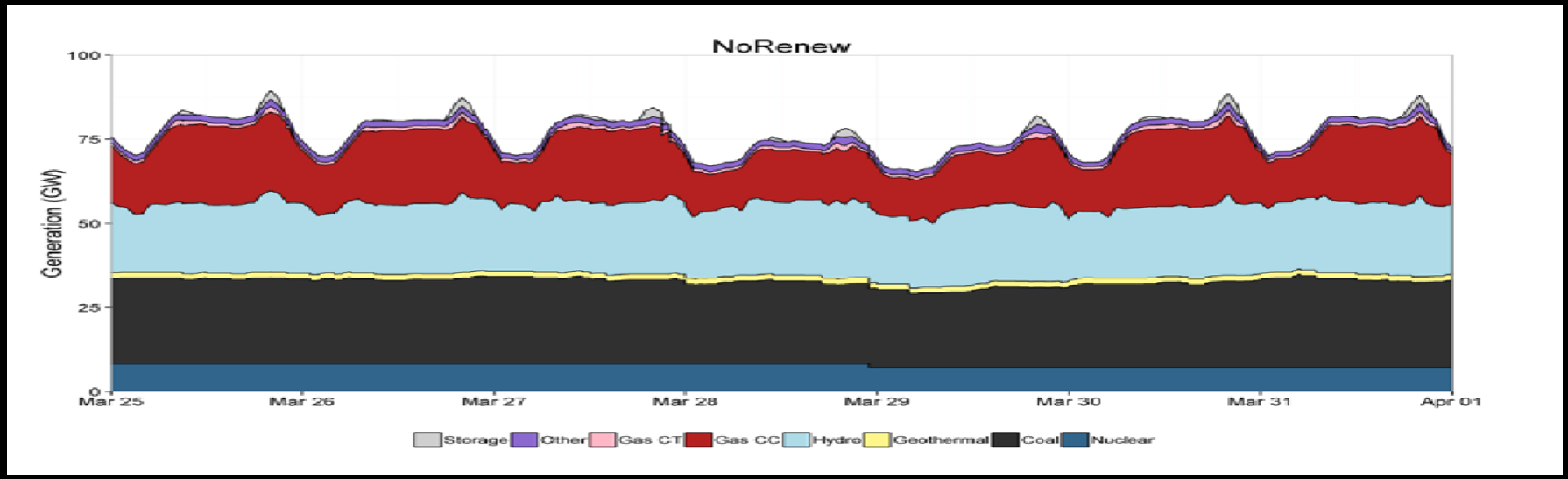
Objective:

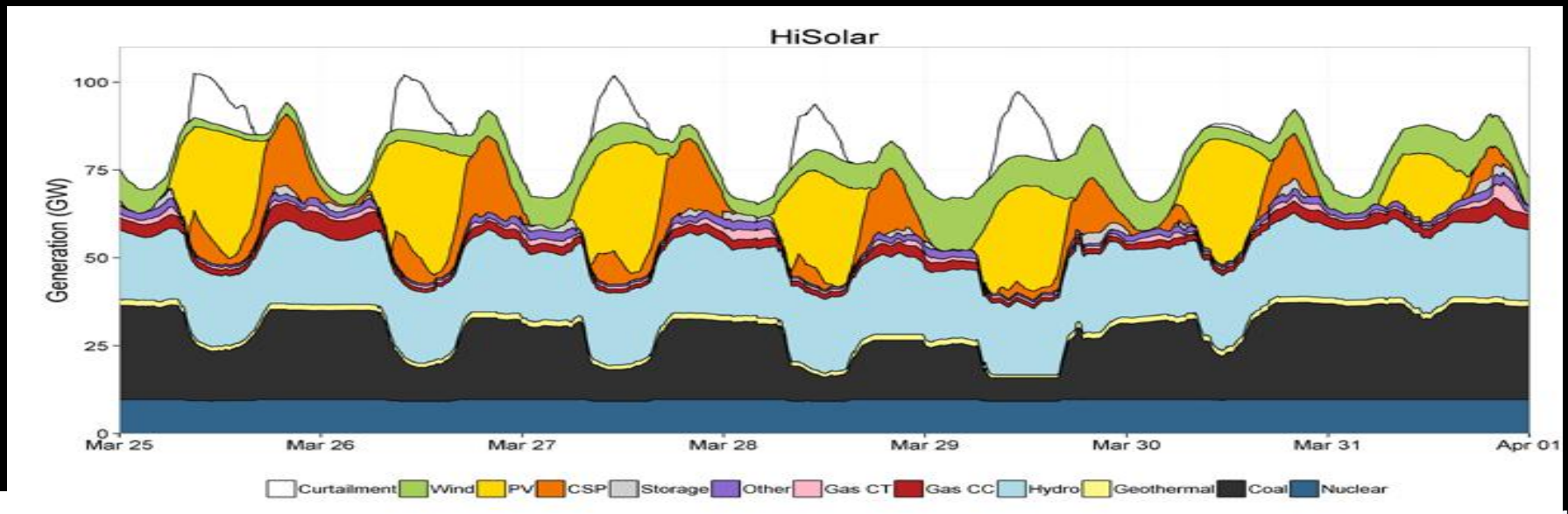
- Address the technical, operation, market, and regulatory challenges associated with integrating high penetration levels of utility-scale solar energy generating plants (both PV and CSP) into the grid.

Key Projects:

- Eastern Renewable Grid Integration Study (ERGIS) & Western Wind and Solar Integration Study (WWSIS)
  - Help achieve large-scale deployment of solar generation by demonstrating the effective integration into the nation's electricity grids
- Sub-Hourly Reserves and High Time-Resolution Modeling
  - Understand the sub-hourly operational implications of integrating PV into utility systems.
- Demonstrate advanced control capability on a utility-scale PV plant
- Improve simulation models for solar generation interconnection and grid planning
- Develop an accurate, sophisticated, nationwide, multi-year, solar power performance database

Western Wind and Solar Study II





EERE: New Priority Program Thrusts

- U.S. Clean Energy Manufacturing Competitiveness
- EV-Everywhere: A Grand Challenge in EV's
- Grid Integration
- Wide Band Gap Semiconductors for Clean Energy

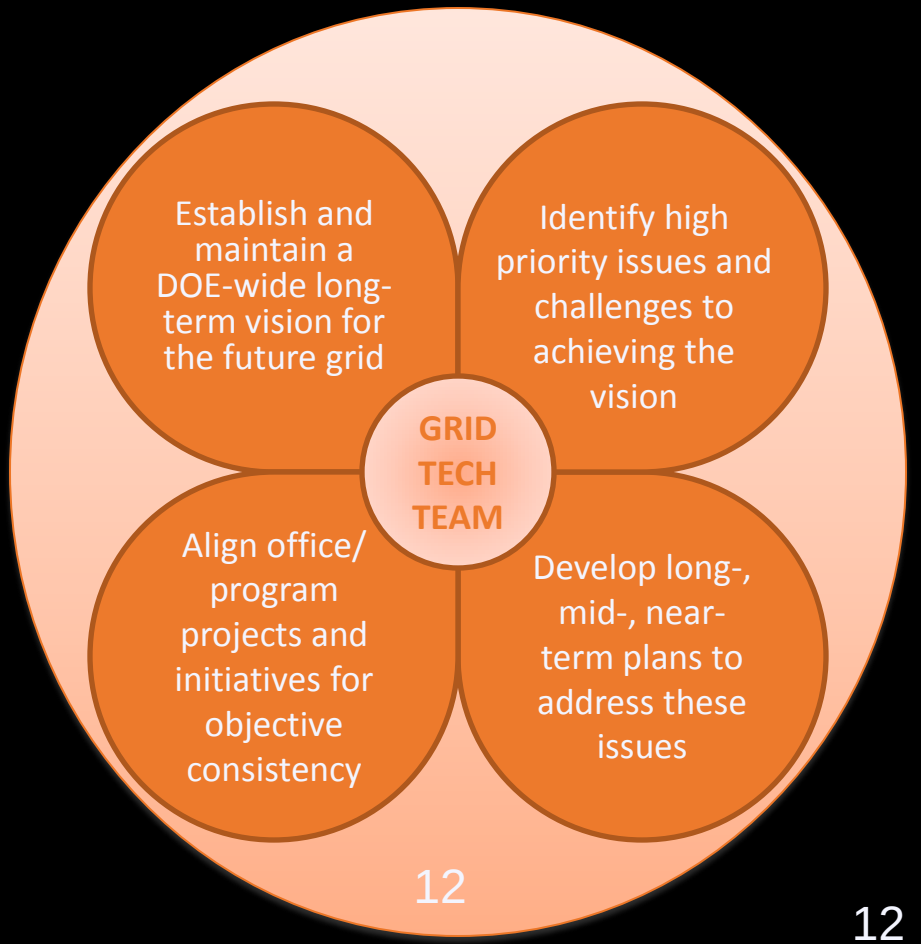
- Energy Data Initiative
- Coordinating EERE's Deployment Efforts

The Grid Tech Team

The Grid Tech Team (GTT), with DOE-wide representation, is responsible for leadership within and outside DOE on grid modernization through strategic thinking and improved communication, coordination, and collaboration.

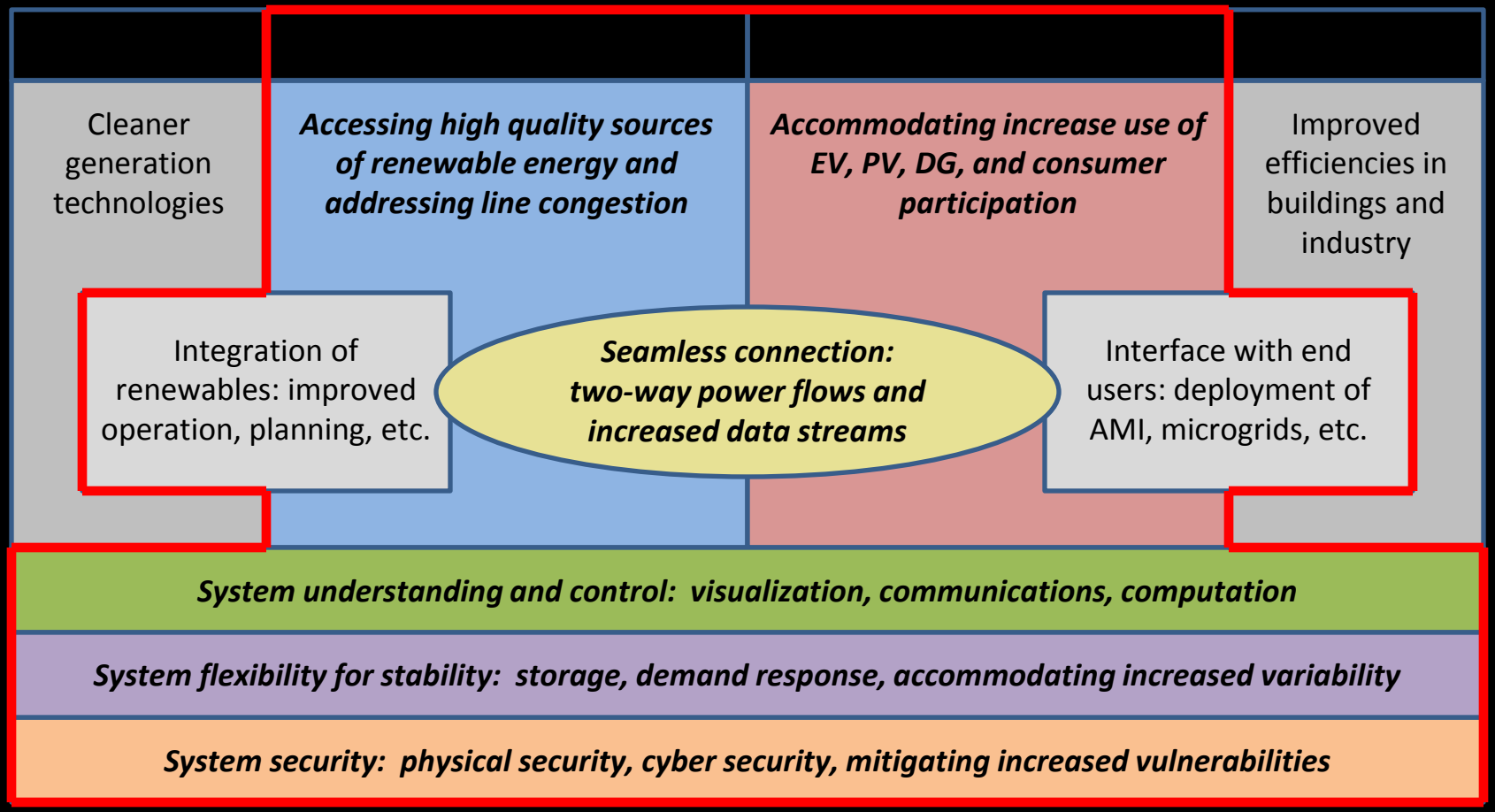
DOE REPRESENTATION

- Office of Science **(SC)**
- Office of Electricity Delivery & Energy Reliability **(OE)**
- Office of Energy Efficiency & Renewable Energy **(EERE)**
- Advanced Research Projects Agency – Energy **(ARPA-E)**
- Chief Financial Office **(CFO)**
- DOE Senior Management **(S1)**



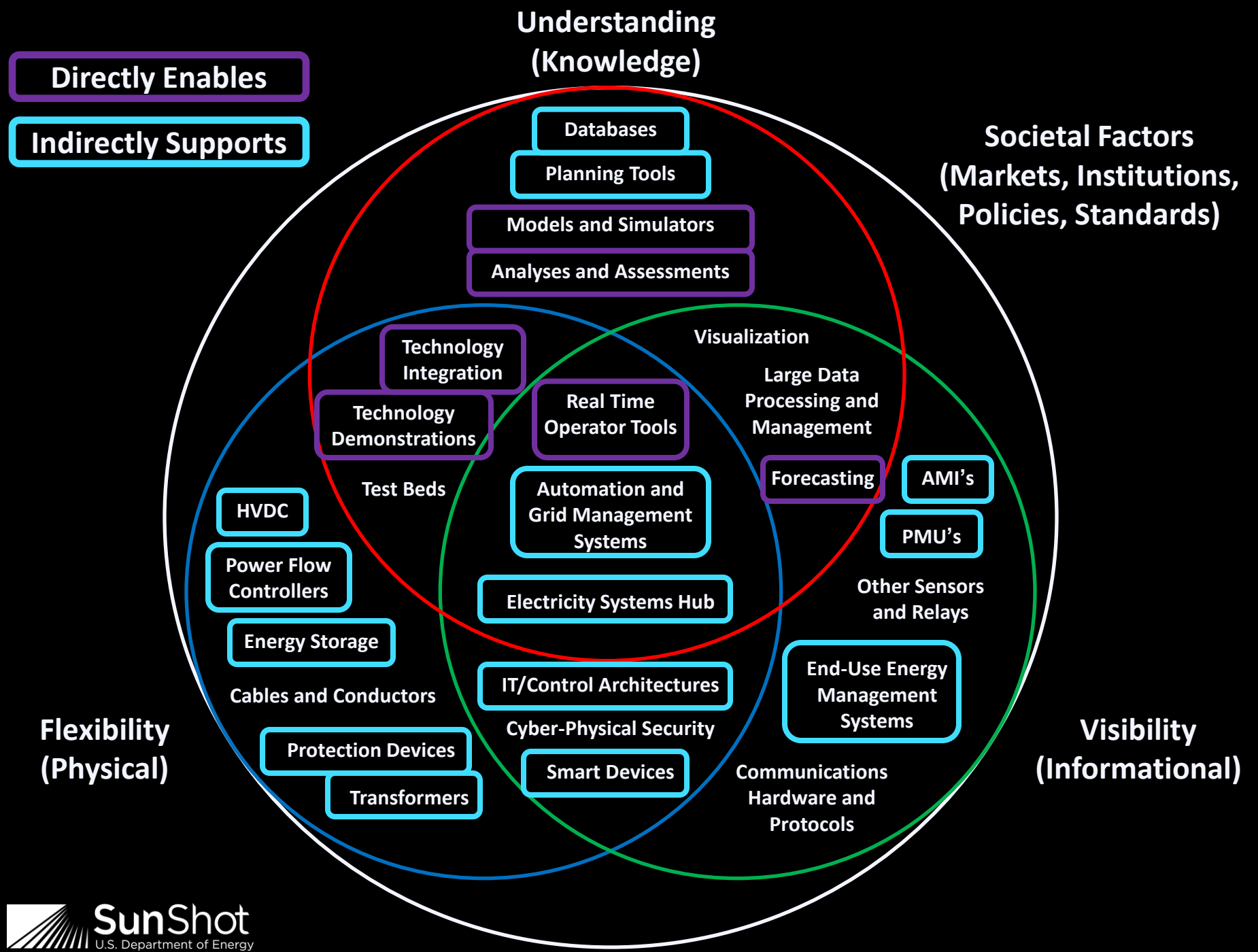
SunShot U.S. Department of Energy

Grid Tech Team Space



There are institutional issues/solutions that must be considered in conjunction with these technology needs

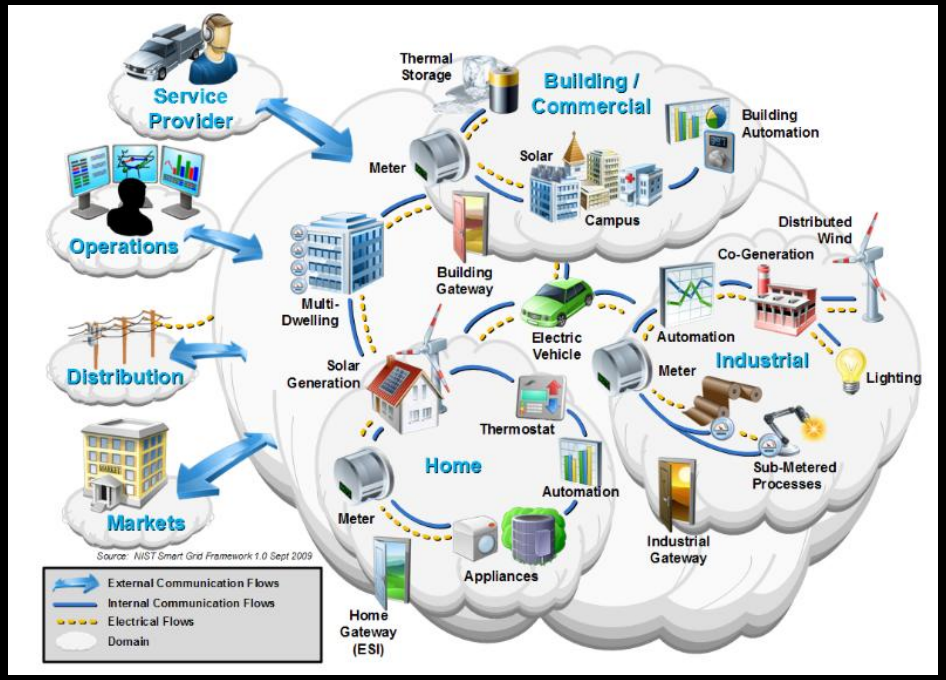
SunShot U.S. Department of Energy


Directly Enables
Indirectly Supports
Understanding (Knowledge)
Societal Factors (Markets, Institutions, Policies, Standards)
Flexibility (Physical)
Visibility (Informational)
Databases
Planning Tools
Models and Simulators
Analyses and Assessments
Technology Integration
Technology Demonstrations
Test Beds
Real Time Operator Tools
Automation and Grid Management Systems
Electricity Systems Hub
IT/Control Architectures
Cyber-Physical Security
Smart Devices
Visualization
Large Data Processing and Management
Forecasting
AMI's
PMU's
Other Sensors and Relays
End-Use Energy Management Systems
Communications Hardware and Protocols
HVDC
Power Flow Controllers
Energy Storage
Cables and Conductors
Protection Devices
Transformers
SunShot
U.S. Department of Energy

Distribution Workshop

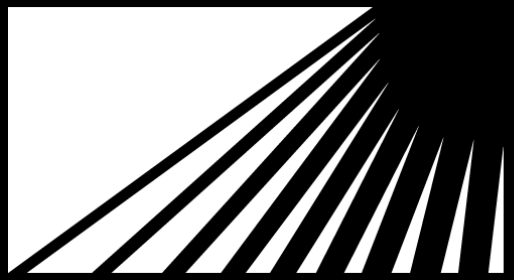
During the DOE Distribution Workshop on September 24-26 in Washington, D.C., stakeholders emphasized the need to develop a more flexible distribution system. Elements of this system include

- Modeling, Simulation & Optimization
- Advanced Components, Controls & Interoperability
- Communications & Database Architecture
- Protocols, Codes & Standards
- Business Case, Demonstrations, Risk & Valuation



High Penetration Solar Portal

Sharing the results of our work with the California Public Utilities Commission, EPRI, High Pen Projects, and SEGIS-AC. **https://solarhighpen.energy.gov/**



SunShot
U.S. Department of Energy

Thank You

Kevin Lynn
Kevin.Lynn@ee.doe.gov

February 13-14, 2013