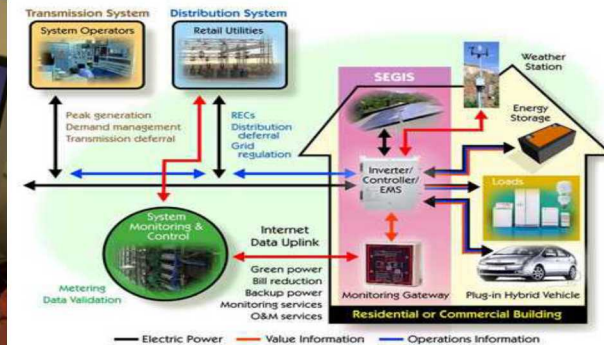


solar.sandia.gov



NMSU REU Students Visit – Overview of Sandia and Solar R&D

July 2016



Sandia National Laboratories is a multi-program laboratory managed and operated by Sandia Corporation, a wholly owned subsidiary of Lockheed Martin Corporation, for the U.S. Department of Energy's National Nuclear Security Administration under contract DE-AC04-94AL85000

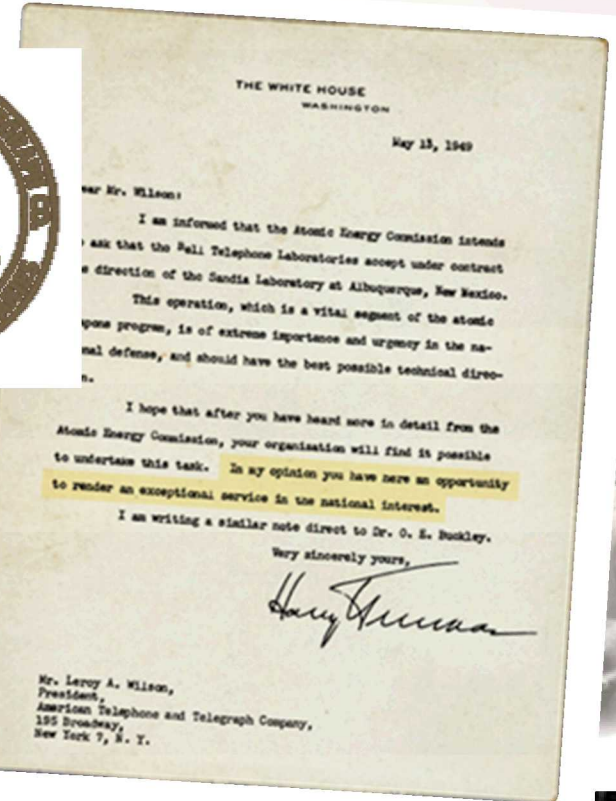
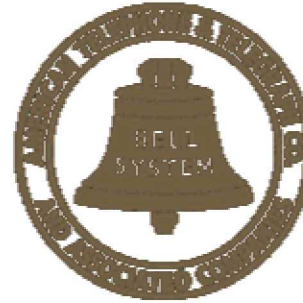
Sandia National Laboratories is a multimission laboratory managed and operated by National Technology & Engineering Solutions of Sandia, LLC, a wholly owned subsidiary of Honeywell International Inc., for the U.S. Department of Energy's National Nuclear Security Administration under contract DE-NA0003525.



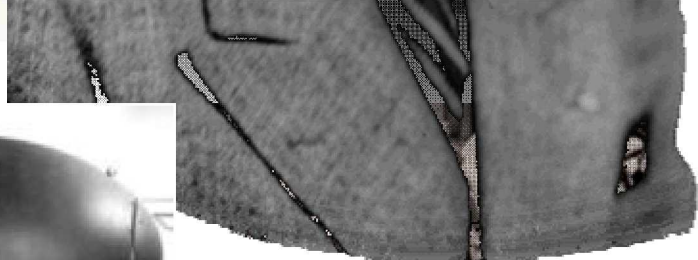
Sandia's History

Exceptional service in the national interest

- July 1945: Los Alamos creates Z Division
- Nonnuclear communications engineering
- November 1, 1946: Sandia Laboratory established



to undertake this task. In my opinion you have here an opportunity to render an exceptional service in the national interest.



Key Sandia Figures

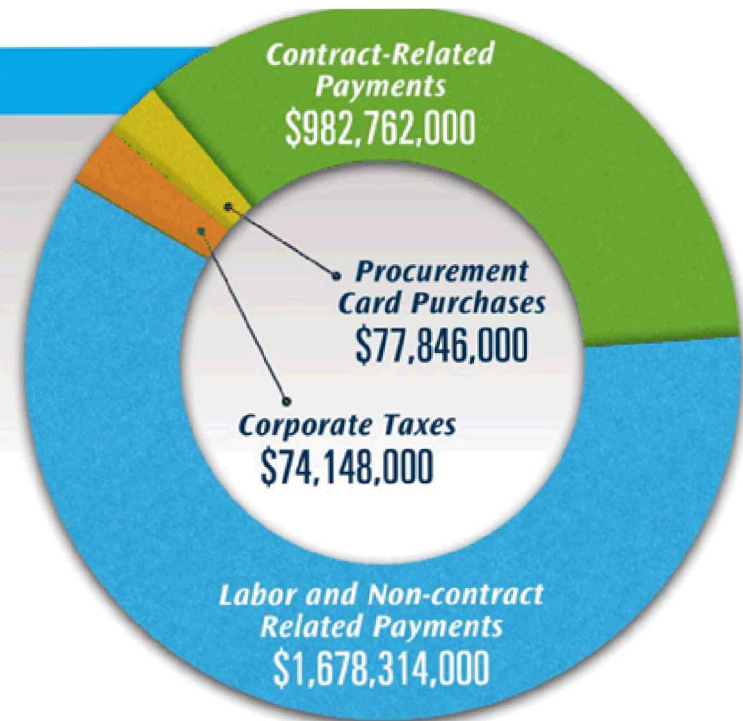
- Total Sandia workforce: 12,611
- Regular employees: 10,643
- Advanced degrees: 5,898 (55%)

*Data as of
December 14, 2015*

Total Laboratory Expenditures

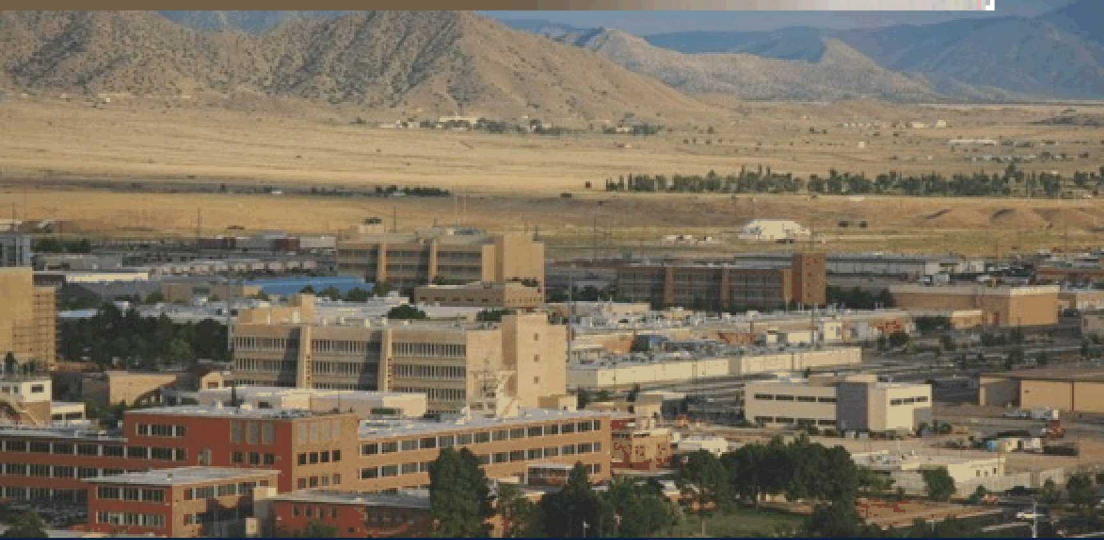
\$2,813,070,000

(in FY2015)



Sandia Sites

Albuquerque, New Mexico



Livermore, California



Kauai, Hawaii



*Waste Isolation Pilot Plant,
Carlsbad, New Mexico*

*Pantex Plant,
Amarillo, Texas*



*Tonopah,
Nevada*

Sandia Addresses National Security Challenges

1950s

Nuclear weapons

Production and manufacturing engineering



1960s

Development engineering

Vietnam conflict



1970s

Multiprogram laboratory

Energy crisis



1980s

Missile defense work

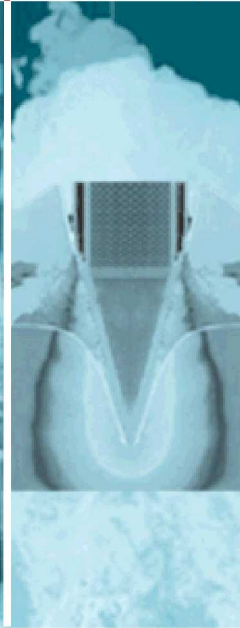
Cold War



1990s

Post-Cold War transition

Stockpile stewardship



2000s

START
Post 9/11

National security



2010s

LEPs
Cyber, biosecurity proliferation

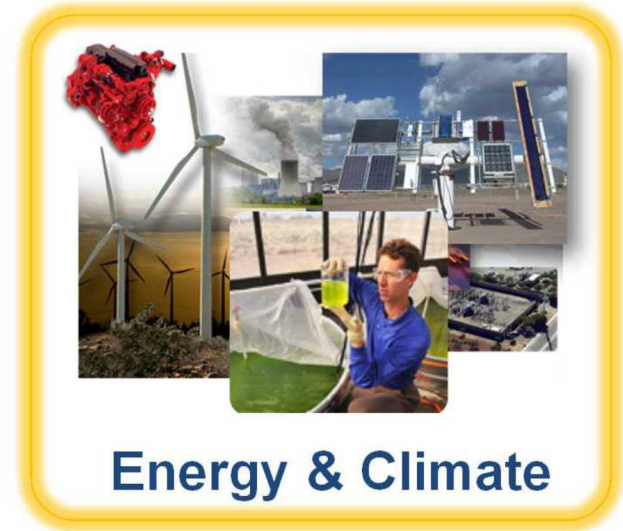
Evolving national security challenges



Sandia National Laboratories Program Management Units (PMUs)



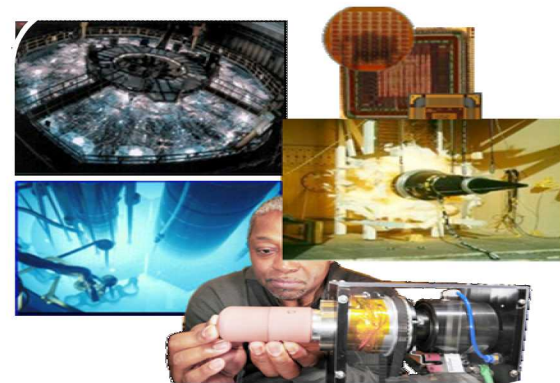
Defense Systems & Assessments



Energy & Climate

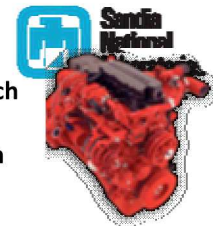


International, Homeland, & Nuclear Security



Nuclear Weapons

History of Sandia Energy Programs

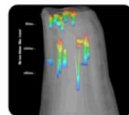


a nuclear weapons engineering laboratory with deep science and engineering competencies



Energy crisis of the 1970s spawned the beginning of significant energy work

Strategic Petroleum Reserve – geological characterization of salt domes to host oil storage caverns



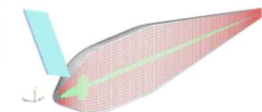
DOE's Tech Transfer Initiative was established by Congress in 1991



Advent Solar
Energy Policy Act of 2005



Joint BioEnergy Institute



Water Power Program

1950

1960

1970

1980

1990

2000

2007

2009

2010

Vertical axis wind turbine

NRC cask certification studies & core melt studies



Solar Tower opens



CRF opens to researchers



SunCatcher™ partnership with Stirling Energy Systems

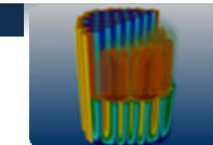
Distributed Energy Technology Laboratory (DETL) to integrate emerging energy technologies into new and existing electricity infrastructures

Power grid reliability study



Sunshine to Petrol Pilot Test

Large-scale pool fire tests of liquefied natural gas (LNG) on water



Consortium for Advanced Simulation of Light Water Reactors (CASL)

Climate uncertainties & economies



Combustion Research Computation and Visualization (CRCV) opens

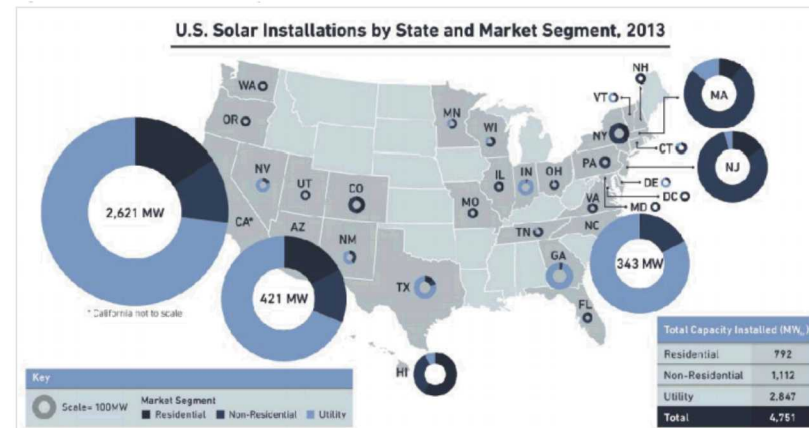
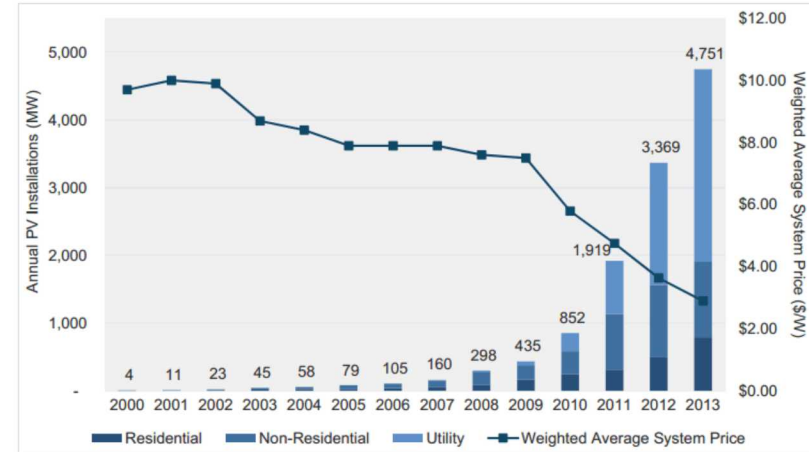
Our core NW competencies enabled us to take on additional large national security challenges

PV capacity is growing fast!

- ~30 GW installed today
 - Installed capacity is projected to double every 2 years!
 - Highest growth rate expected in distribution-connected PV

■ Dealing with high amounts of PV

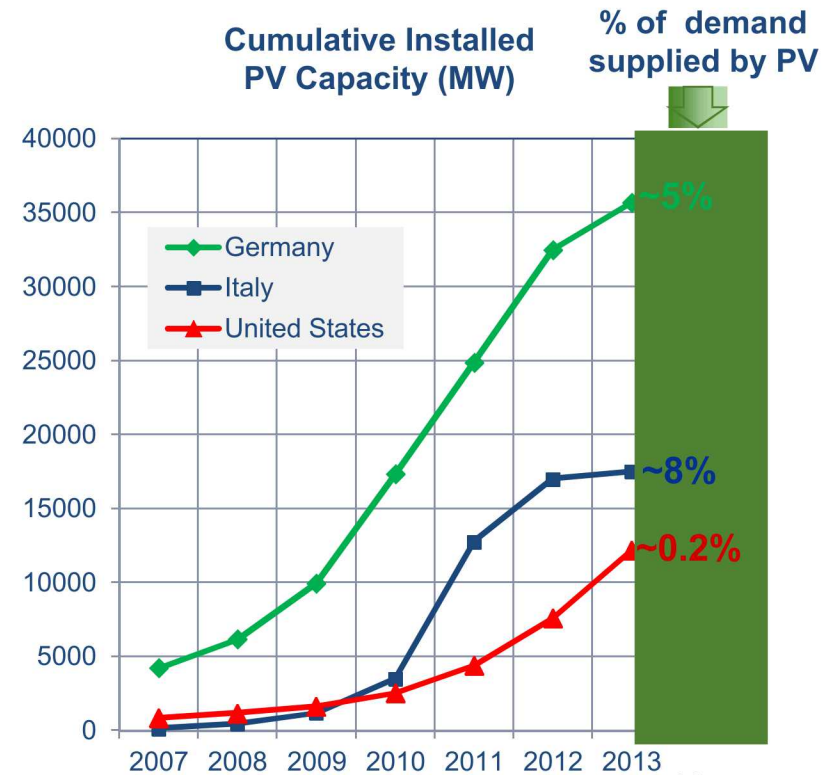
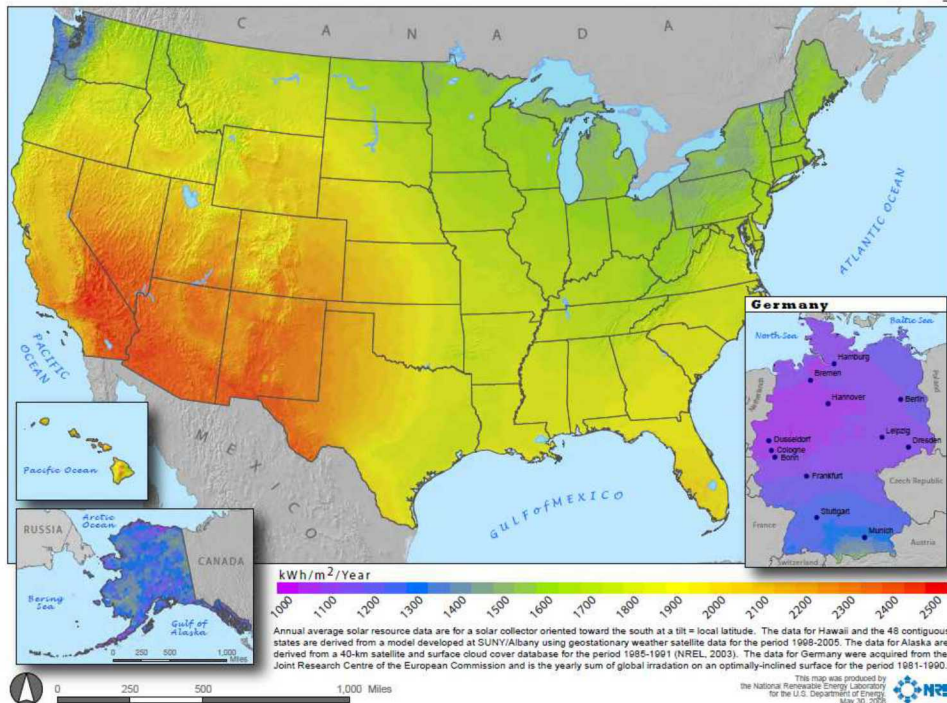
- California
- Hawaii



Source: GTM Research, US Solar Market Insight 2013 Year in Review

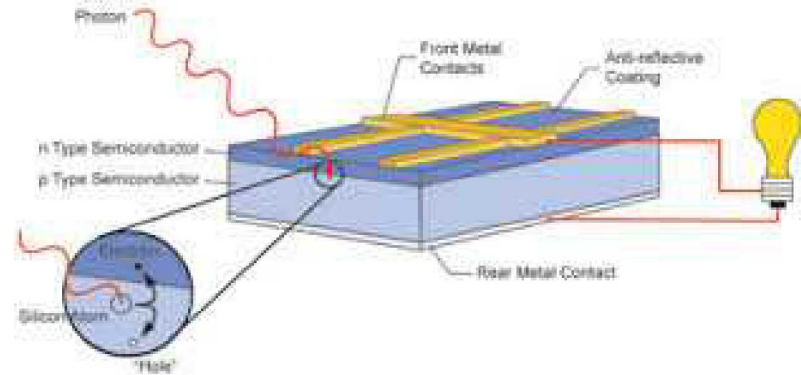
Huge potential for further growth!

- US lags other countries in terms of installed capacity, but the future potential is much greater
 - How much of this potential can be tapped while maintaining high grid reliability and performance?

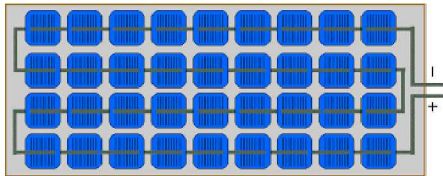


What is a PV?

PV Cells



A typical module has 36 cells in series



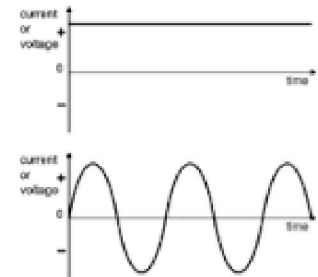
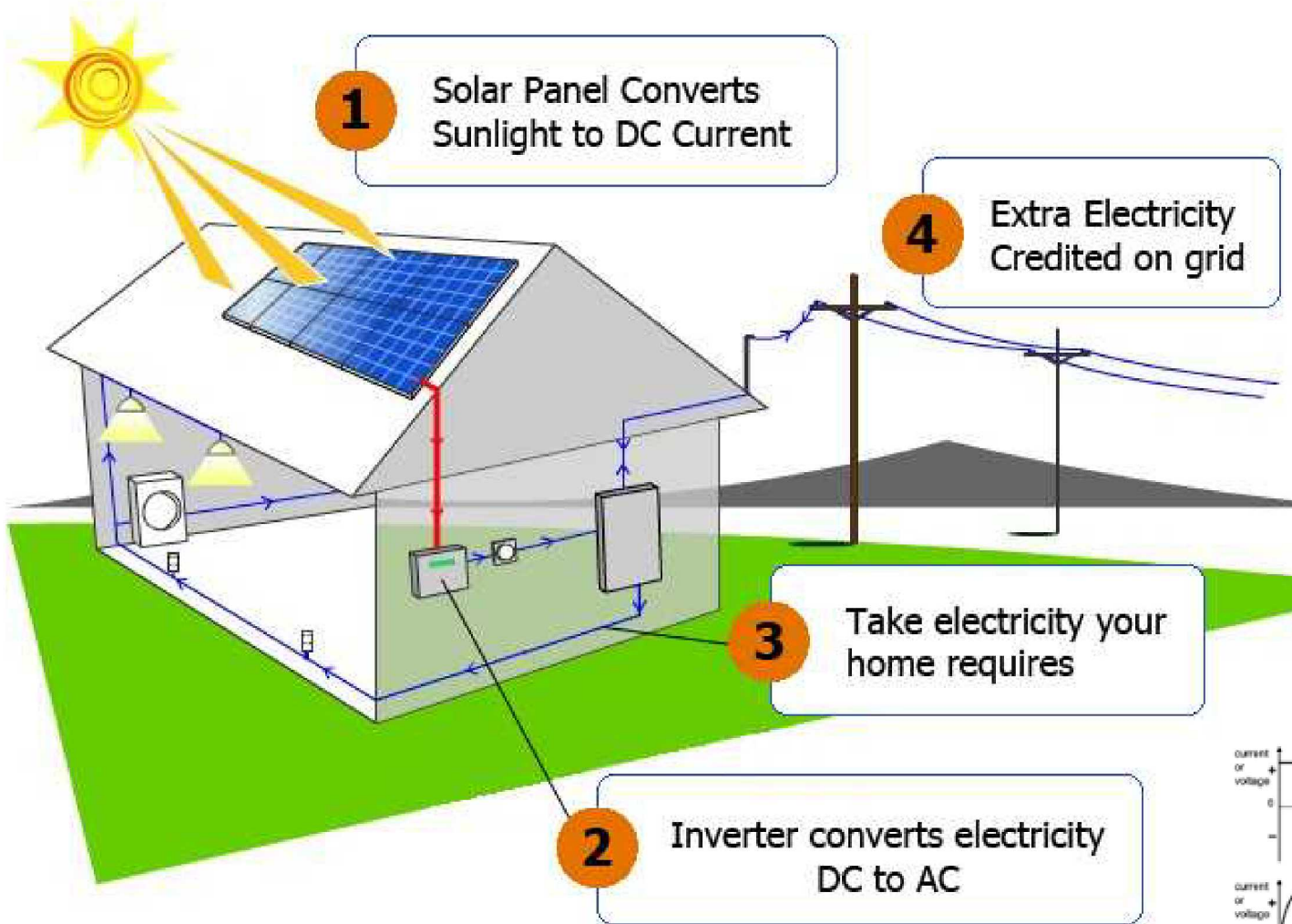
PV Modules



PV System



How does it work?



PV System Size



PV Research at Sandia



Solar Resource

PV System

Power Electronics

Grid Integration

Reliability and Safety

Testing, Modeling, Simulation

Standards for Performance and Safety

Soft Costs (Financing, Permitting, Installation)

PV System Performance and Reliability

PV Performance Modeling Steps

1. Irradiance and Weather – Available sunlight, temperature, and wind speed all affect PV performance. Data sources include typical years (TMY), satellite and ground measurements.

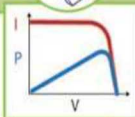
2. Incidence Irradiance – Translation of irradiance to the plane of array. Includes effects of orientation and tracking, beam and diffuse irradiance, and ground surface reflections.

3. Shading and Soiling – Accounts for reductions in the light reaching the PV cell material.



4. Cell Temperature – Cell temperature is influenced by module materials, array mounting, incident irradiance, ambient air temperature, and wind speed and direction.

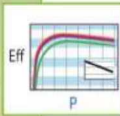
5. Module Output – Module output is described by the IV curve, which varies as a function of irradiance, temperature, and cell material.



10. System Performance Over Time – Monitoring of plant output can help to identify system problems (e.g., failures, degradation).



9. AC Losses – For large plants, there may be significant losses between the AC side of the inverter and the point of interconnection (e.g., transformer).



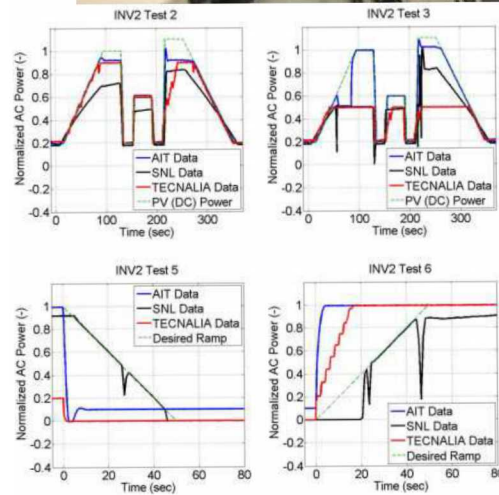
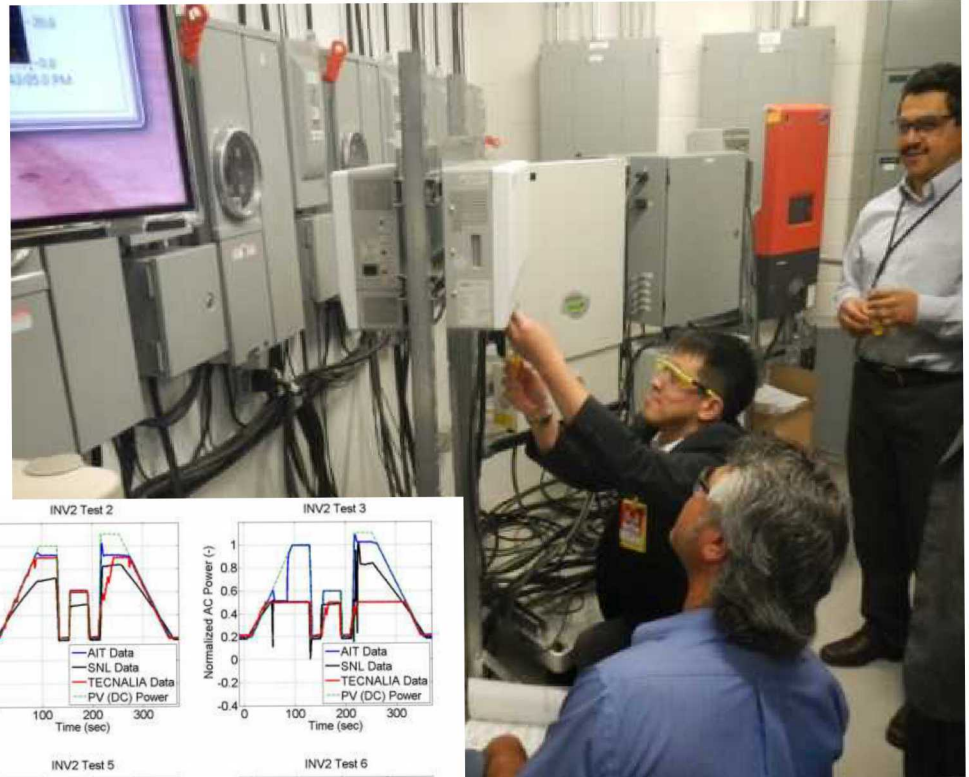
8. DC to AC Conversion – The conversion efficiency of the inverter can vary with power level and environmental conditions.

7. DC to DC Max Power Point Tracking – A portion of the available DC power from the array is lost due to inexact tracking of the maximum power point.

6. DC and Mismatch Losses – DC string and array IV curves are affected by wiring losses and mismatch between series connected modules and parallel strings.

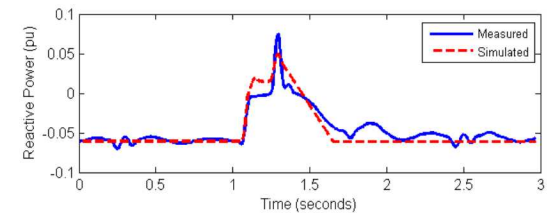
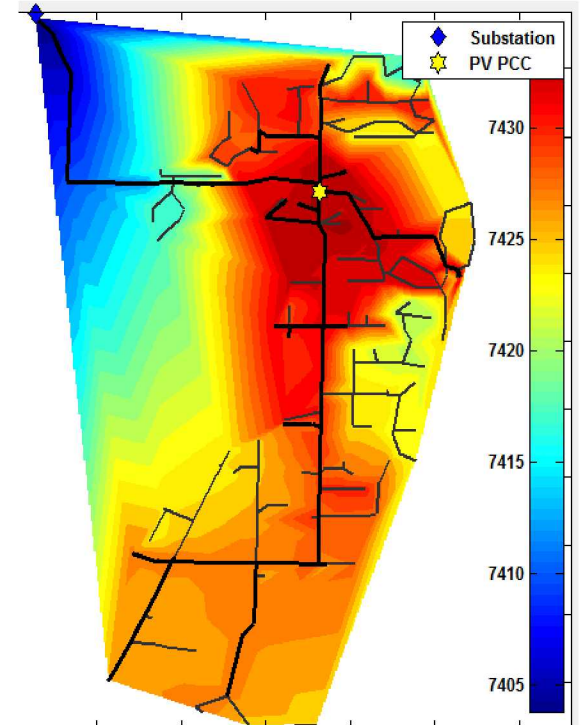
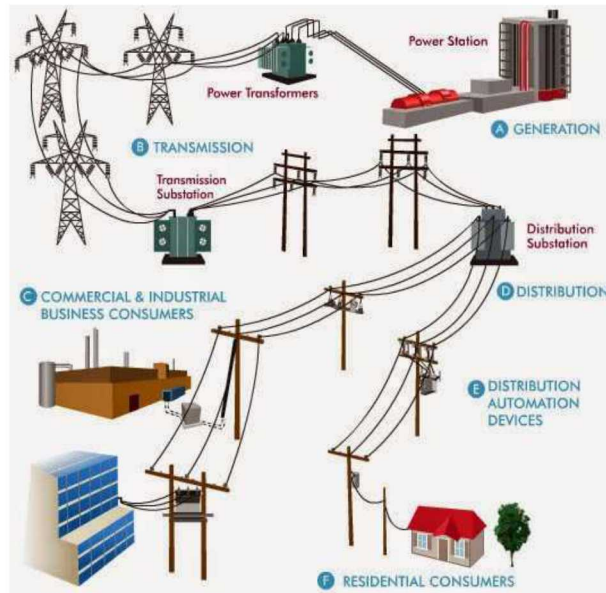
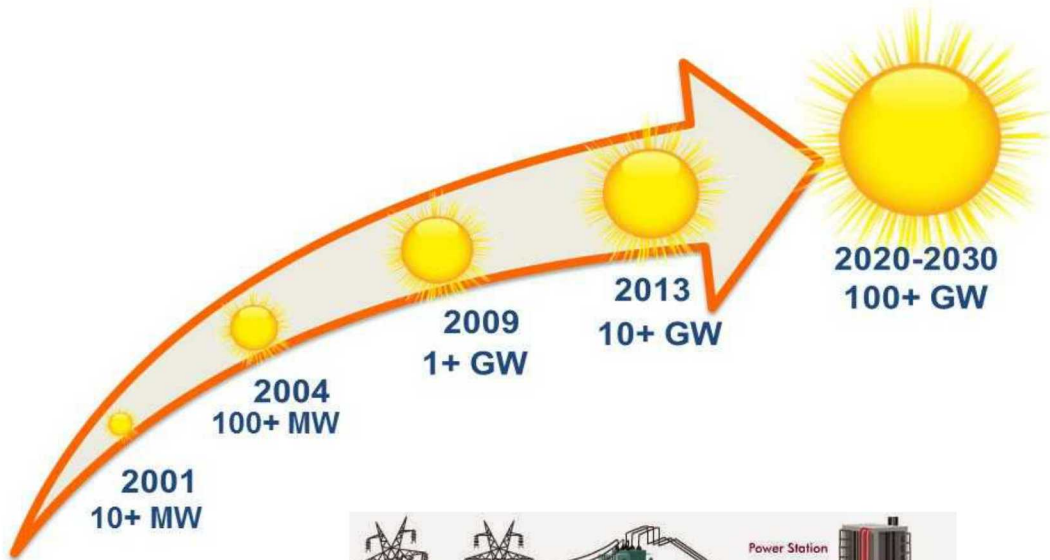


Power Electronics (PV Inverters)



PV Inverters

Systems Integration



Soft Costs and Balance of Systems

PV Value* Photovoltaic Energy Valuation Model v. 1.1

Category	Parameter	Value
Solar Resource Calculations	Site Code	48007
	System Size in Watts	5000
	System Losses	0.05
	System Efficiency	0.20
Electricity Rate Inputs	Electricity Rate	0.10
	Electricity Rate	0.10
	Electricity Rate	0.10
	Electricity Rate	0.10
Operations & Maintenance Inputs	Operation & Maintenance Cost	0.02
	Operation & Maintenance Cost	0.02
	Operation & Maintenance Cost	0.02
	Operation & Maintenance Cost	0.02
System Age and Remaining Lifetime	System Age	0
	Remaining Energy Years	20
	Remaining Energy Years	20

Estimate Type	Value
Approximate Range of Value Estimate	
Low	\$ 8,585.84
Average	\$ 10,585.10
High	\$ 12,790.36

Energy Value, PV (\$/kW)	Accumulated Energy, Present Value (\$/kW)	Energy Value, PV (\$/kW)	Accumulated Energy, Present Value (\$/kW)	Energy Value, PV (\$/kW)	Accumulated Energy, Present Value (\$/kW)
100	1,000.00	100	1,000.00	100	1,000.00
200	2,000.00	200	2,000.00	200	2,000.00
300	3,000.00	300	3,000.00	300	3,000.00
400	4,000.00	400	4,000.00	400	4,000.00
500	5,000.00	500	5,000.00	500	5,000.00
600	6,000.00	600	6,000.00	600	6,000.00
700	7,000.00	700	7,000.00	700	7,000.00
800	8,000.00	800	8,000.00	800	8,000.00
900	9,000.00	900	9,000.00	900	9,000.00
1000	10,000.00	1000	10,000.00	1000	10,000.00

PV & Real Estate Value



Glint and Glare

Mapping **Results**

Summary: **OP ATCI**

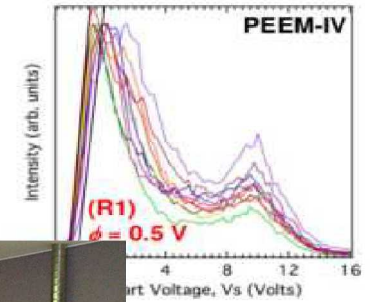
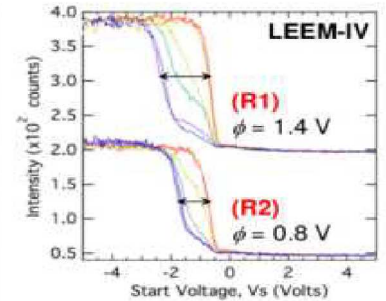
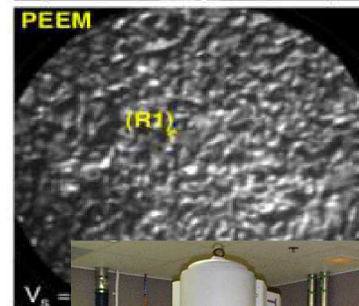
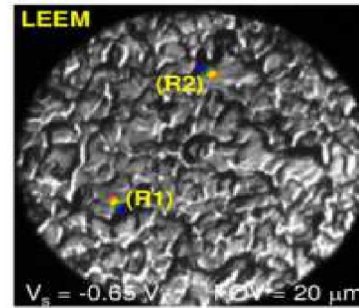
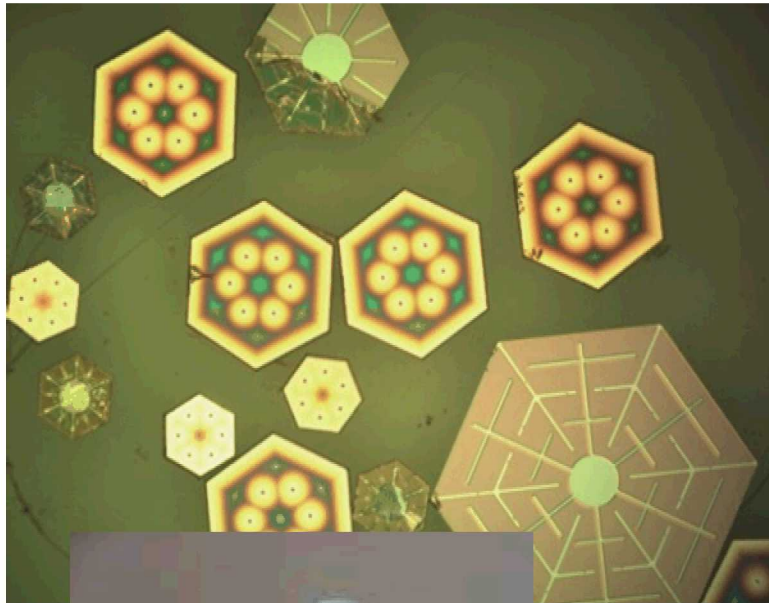
Glare found

Legend:
 - Low potential for temporary after-image
 - Possible for temporary after-image
 - Possible for permanent eye damage

Graph showing glare levels over time (Date).

Download occurrence plot
 Download glare data (csv)
 Printable Report

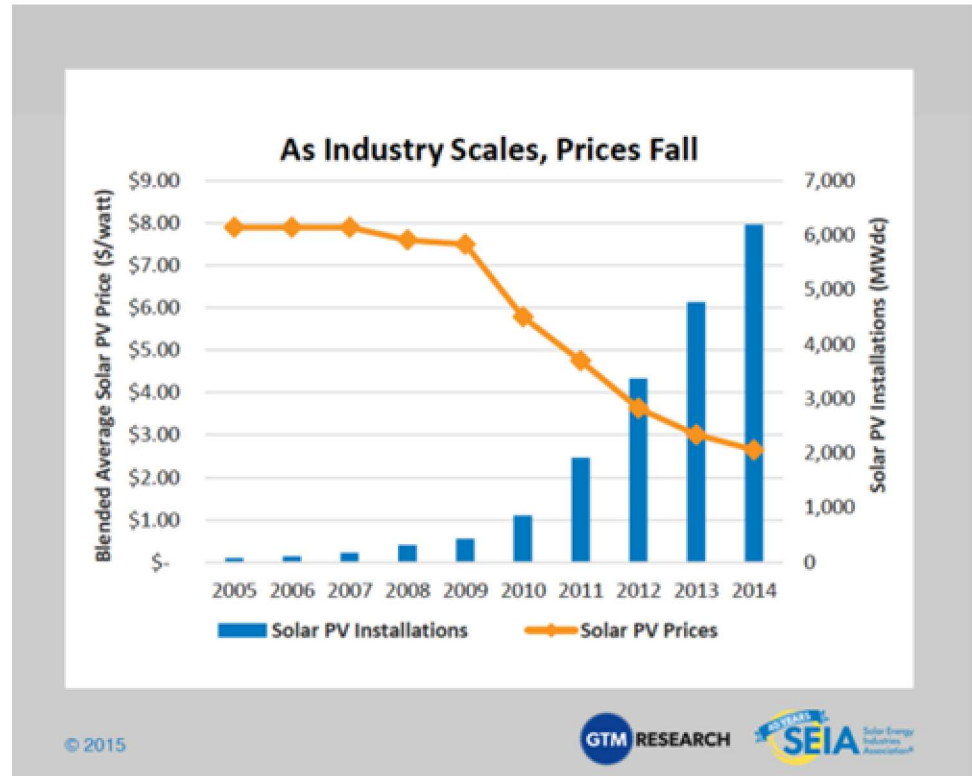
PV Cells and Materials R&D



DOE Solar Energy Technology Office SunShot Initiative

SunShot 2020 Goals

- PV cost is competitive with conventional electricity cost
- The grid is able to accommodate 10X more solar than today



Distributed Energy Technologies Laboratory



- Focus on PV inverters, energy storage, microgrids and other distributed energy technologies
- Efficiency, grid compatibility, interoperability, reliability and safety
- In operation since early 1980's, currently pace-constrained
- Constantly reconfiguring and adding new capabilities to support new industry needs

PV Systems Evaluation Laboratory

- Fully configurable test platforms for indoor, outdoor and long-term testing
- Full-scale cell and module performance characterization laboratory
- Controlled side-by-side PV system and component characterization
 - PV Systems, PV modules
 - Components such as cables, connectors, etc.



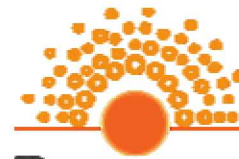
PV Systems Evaluation Laboratory

- PSEL – Hosts small systems, up to ~50 kW ea.
- NSTTF Site – Interconnection infrastructure for large systems, up to ~1 MW

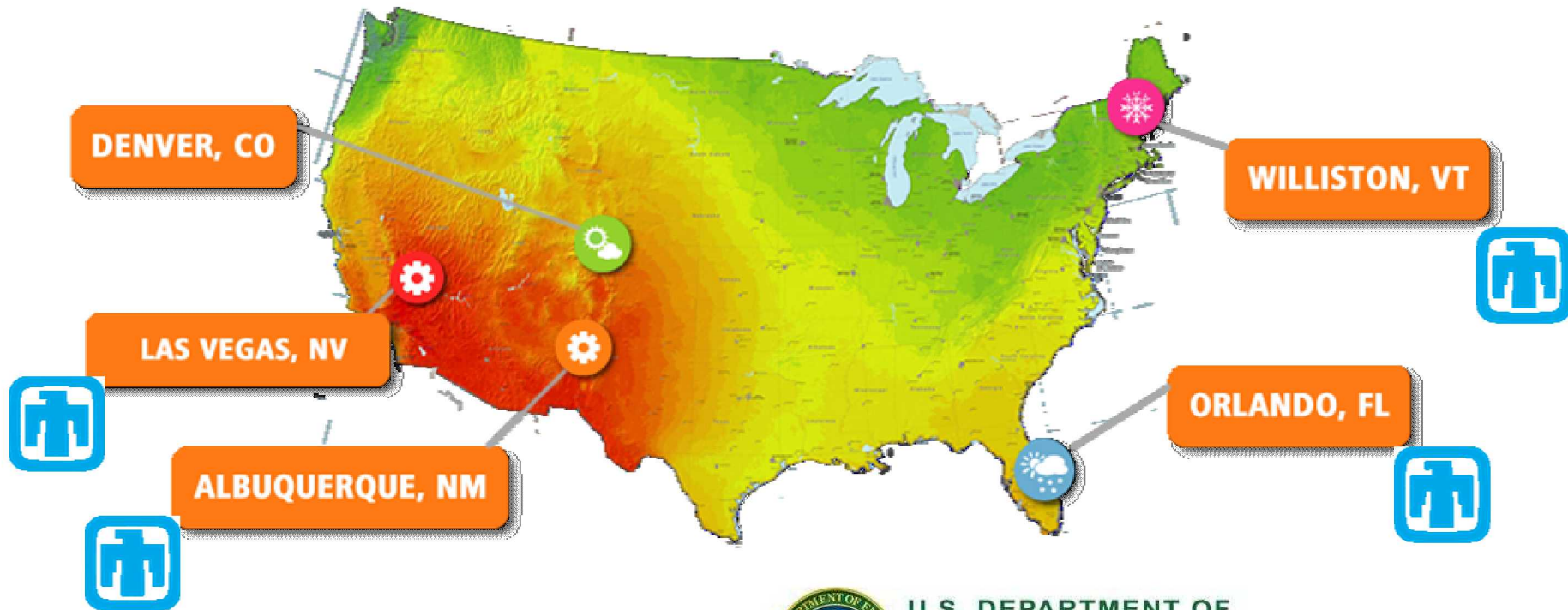


Regional Test Centers (RTCs)

- Public-Private Partnership
- Independent, rigorous PV technology validation in diverse climates
- Supports R&D and bankability



Regional Test Centers
Differentiating PV Quality



U.S. DEPARTMENT OF
ENERGY

Questions?
Comments?