SAND2014-19635C

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Regional Test Centers

Supporting the U.S. PV Industry with Outdoor Technology Validation in a Wide Range of Climates

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U.S. DEPARTMENT OF ENERGY

NNSA National Nuclear Security Administration

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Need for Field Validation of PV Technologies

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- Almost all PV investments are all made prior to revenue generation.
  - Building new production lines
  - Choosing certain PV components for a large project
- Therefore investors require high level of confidence in selected technology performance and reliability.
- Current product certifications do not provide enough assurance.
- Field data from different climates that demonstrates predictable energy production and a good reliability record is essential.
- The US DOE funded the creation of the Regional Test Centers to provide a model for how such technology validation can be accomplished.

Regional Test Centers

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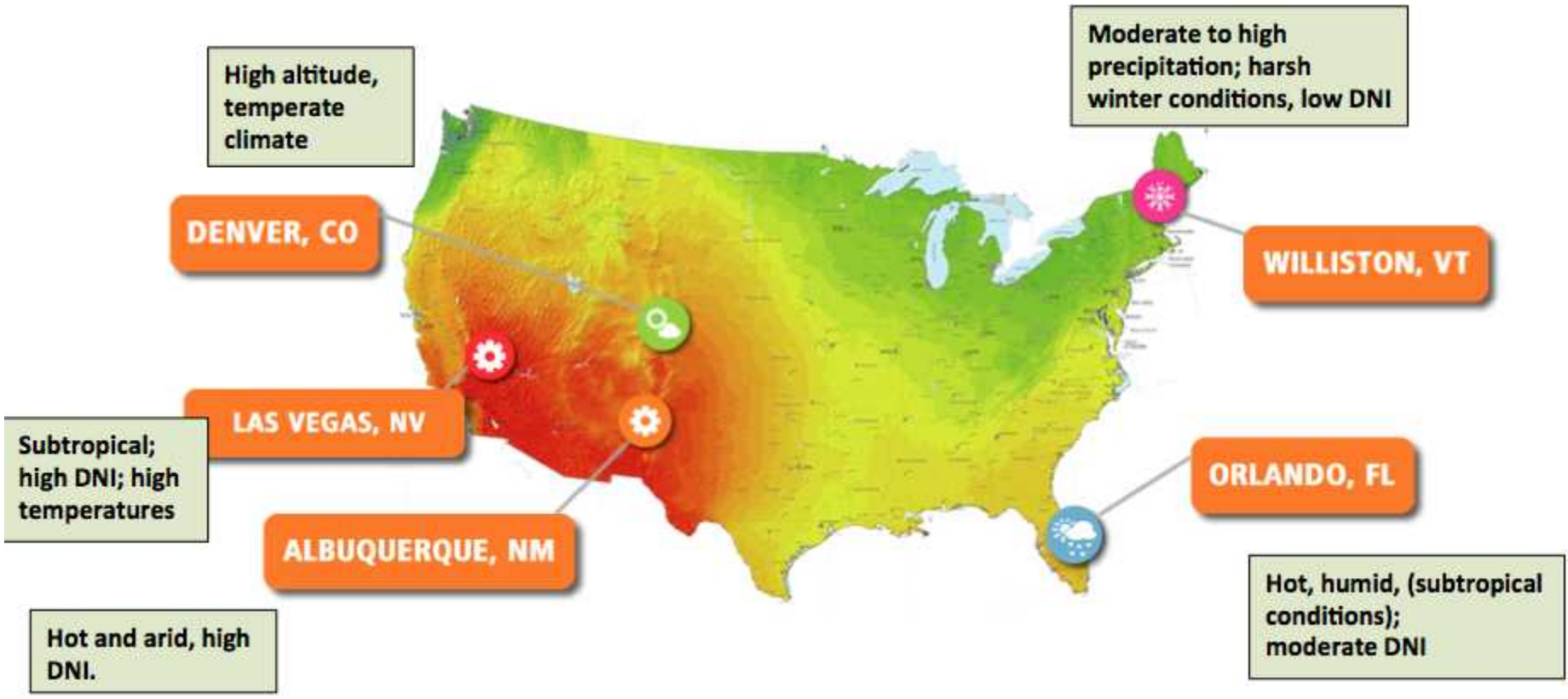
- Five locations representing a range of climates and environmental conditions



Land and Grid-tie

- Each site has open space and field access to grid ties.
- New Mexico: 2 sites at Sandia National Laboratories
  - South site: 1 MW capacity
  - North site: 250 kW capacity
- Colorado: 2 sites at National Renewable Energy Laboratories
  - Solar TAC
  - NREL
- Florida: Florida Solar Energy Center
  - 300 kW capacity, room for expansion
- Vermont: IBM in Wiliston, VT
  - 300 kW capacity
- Nevada: River Mountains site in Henderson, NV
  - ~150 kW capacity

Identical Solar Weather Stations

- Identical weather stations at each site
  - Tracked pyroheliometer
  - Thermopile pyranometers (Global and diffuse horizontal)
  - 10 m weather tower (wind speed and direction)
  - Barometric pressure
  - Ambient temperature
  - Relative humidity
  - Precipitation
- Features to be added soon
  - Soiling rate stations
  - Snow sensors (when appropriate)

Soiling station being built at ASU

Standard PV Monitoring Approach

- Standardizing the monitoring approach allows for performance comparisons between sites.
- Campbell Scientific– Modbus communications, 1 minute data frequency.
  - Plane of array irradiance (pyranometer, ref cell, ref module)
  - AC Power Monitoring – Shark power analyzer
  - DC system current and voltage (0.1% shunts)
  - String current (0.1% shunts)
  - Module temperatures
- Data management system collects data
  - Daily data quality checks are performed
- Baseline c-Si systems at each site
  - 6 kW systems at each site
  - 60 kW additional system in VT

Performance and Reliability Analysis

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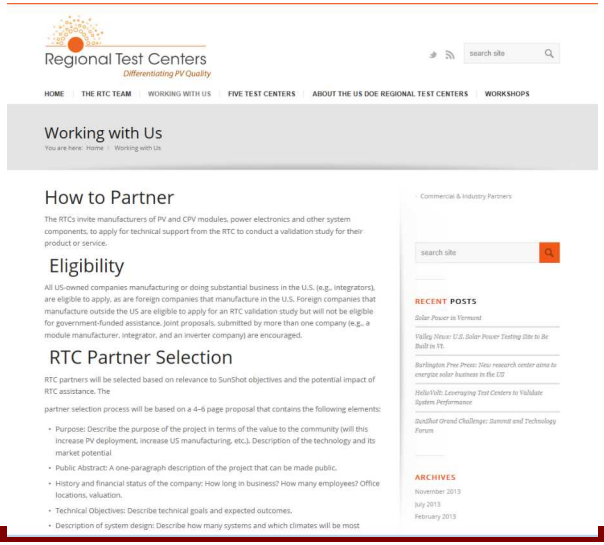
- Baseline characterization of modules
  - Calibrate module performance model(s)
- Analysis scripts are run monthly
  - Data plotted on “Calendar” plots and annotated.
  - Anomalous data is identified and filtered (shading, snow, grid outages)
  - Performance model is run to predict output
  - Measured and predicted output is compared
- Summary performance reports delivered to partners quarterly or semiannually
- System degradation analysis run annually
  - Filter data by irradiance
  - Correct for temperature

Partnering Process

- Webpage (https://rtc.sandia.gov) provides information for potential partners.
- Preliminary proposal submitted following guidance on website.
- Technical discussions between company and RTC screens and refines the proposal. Cost share is negotiated.
  - RTC reviews final proposal against published criteria and reports to DOE for concurrence.
- Work and legal agreements are finalized.
- Project begins.



Current Partners

Partner	Technology	Sites	Total kW	Innovations/opportunities
Heliovolt	Module	**NM, FL, CO**	**15 kW**	CIGS performance validation. Looking for new investor.
Soitec	HCPV	**NV**	**84 kW**	Detailed CPV model development and validation
Maxim	Module PE	**CO**, NM, FL	120 kW	Validating module integrated PE to allow closer row spacing (shade tolerant)
Stion	Module	NM, FL, VT	36 kW	Validating frameless, glass-glass modules in different climates
Cogenra	LCPV	NM	50 kW	Hybrid thermal-electric low-x CPV. Develop and validate performance model. Waiting for completion of product redesign cycle.
ENKI-Yingli	Coatings	**NM, FL**	**16 kW**	Comparison of performance between different coatings
Prism Solar	Bifacial module	NM, VT, NV	15 kW	Detailed performance model development and validation (affect of tilt, azimuth, and albedo on performance gains for bifacial modules.

- Proposals from 8 additional partners are in process

340 kW Installed and/or Under Construction

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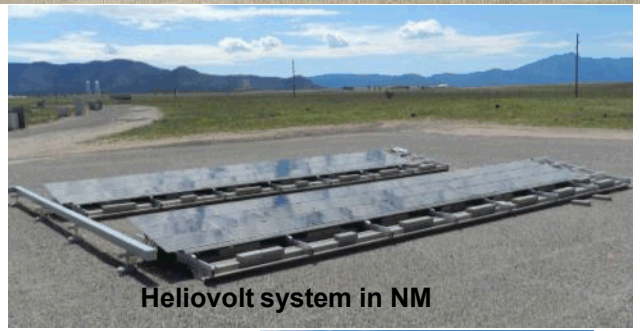
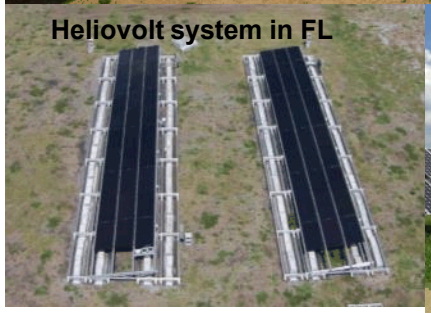
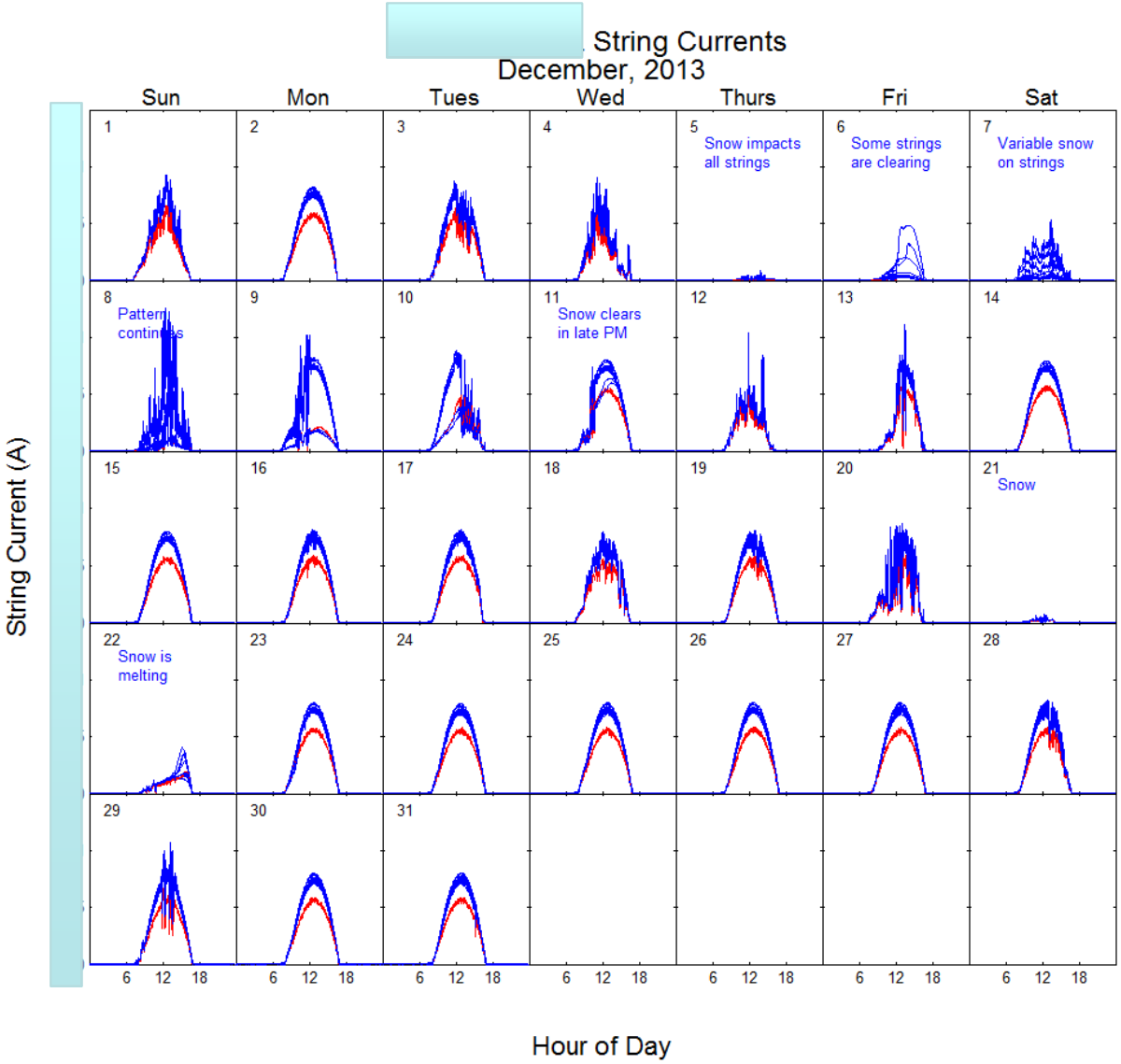




Results and Accomplishments

- Phase 1 infrastructure in place at all five RTC locations
- Validation plans developed for current active partners
- Data management system designed and deployed (PVDMS)
- Outreach materials developed
  - New website: https://rtc.sandia.gov
  - Fact sheets developed
- New recruitment process was developed
  - >8 new partner proposals have been received using new process.
- Automated analysis scripts have been developed.

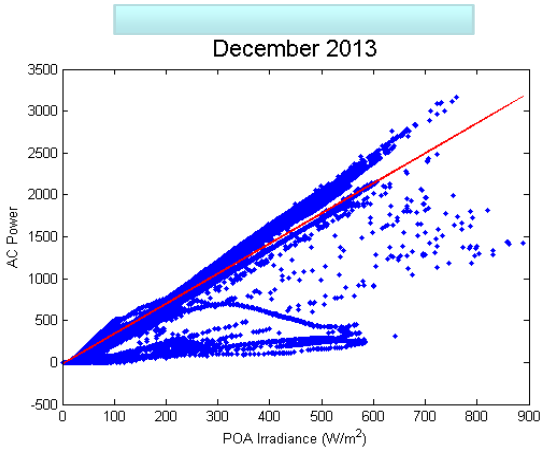
Detailed Performance Analysis



Matlab scripts developed to automate performance analyses.

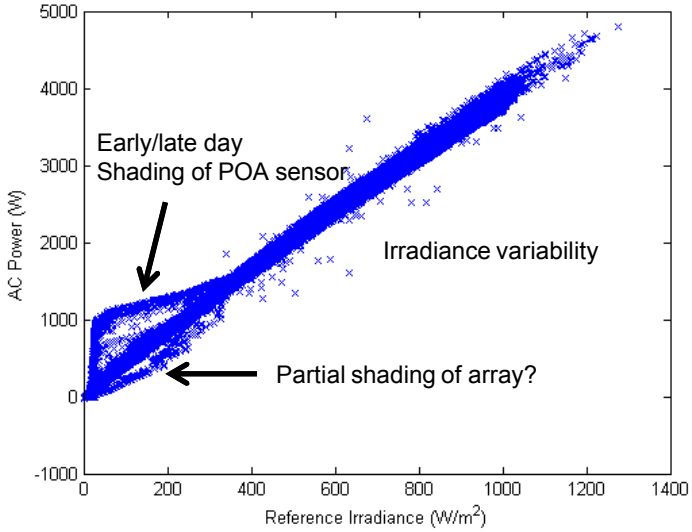
Monthly analysis process similar for all partners

Quarterly or semiannual reports to partners.



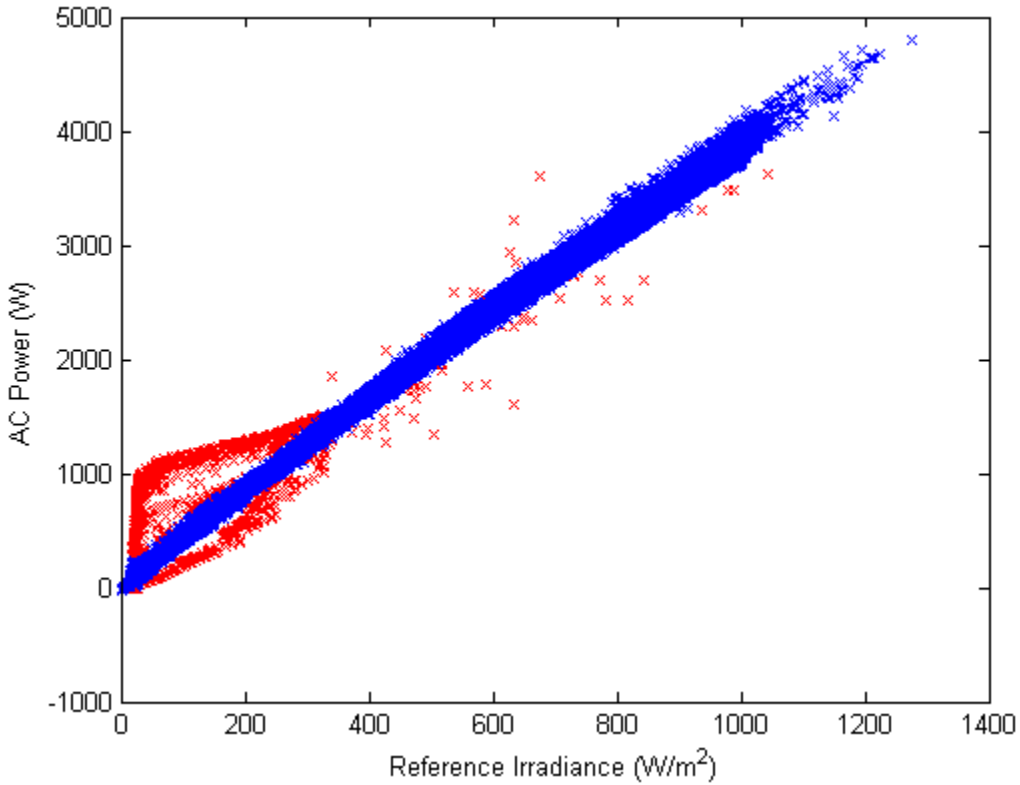
Data Filtering

- Field data is messy – Filtering is important.



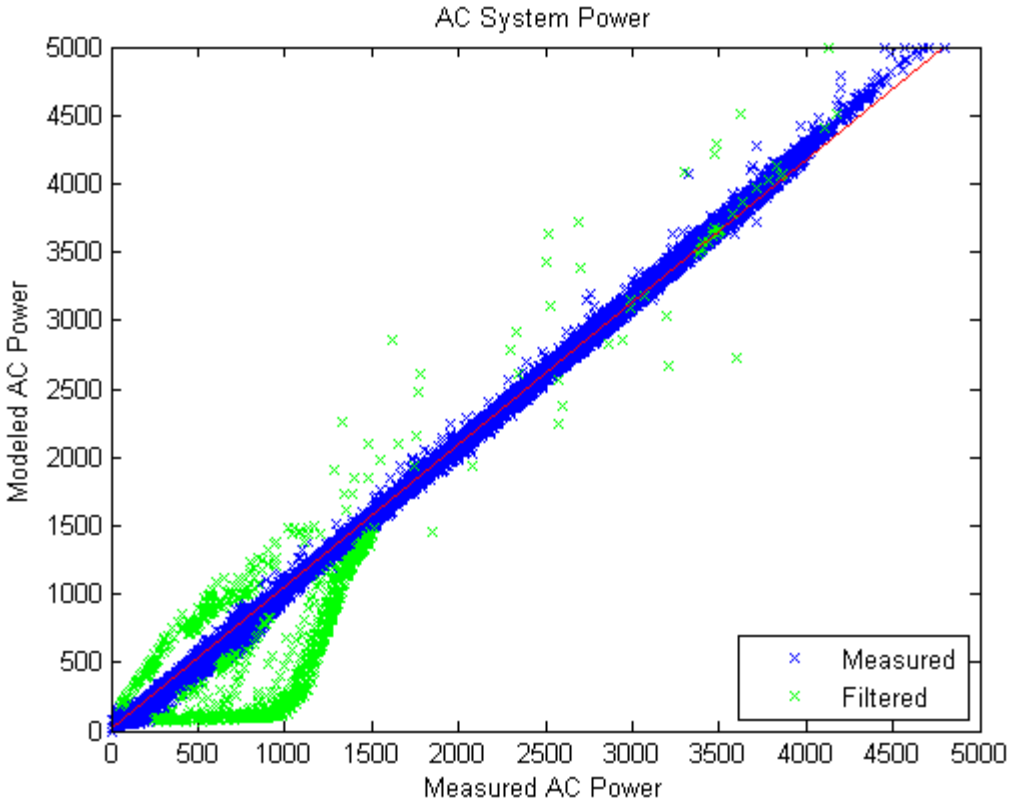
Filtering removes data that can't be modeled adequately

- Partial shading
- Fast changing irradiance



Included data represents technology performance (e.g., modules)

Performance Modeling



Value Proposition

- The RTCs provide a proving ground for PV technologies
  - Fielded systems in range of climate helps to validate performance and reliability.
- The RTCs are considering adding new capabilities to enhance our ability to test and validate
  - Module test beds for rapid deployment of new module technologies.
    - Generic, configurable racking and BOS for module tests
    - Continuous module IV scans track performance over time and under a range of conditions.
  - Power Electronics test beds
    - Generic, configurable PV arrays to test and validate new PE hardware solutions in the field. (e.g., 60 kW c-Si system in VT)
- The challenge is developing a sustainable business model supported by combined government and industry funding.

Results and Accomplishments

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Thank You!

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http://solar.sandia.gov

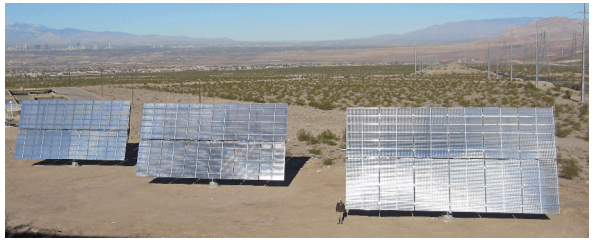
http://PV.sandia.gov

http://pvpmc.org

PROJECT OBJECTIVES

Goal: Operate four RTCs in NM, FL, VT, and NV. Work with U.S. industry partners to validate their PV technologies in a range of climates.

Task 1 – Develop Regional Test Center infrastructure
Task 2 – Install and commission all planned partner systems
Task 3 - Technical Assistance and Analysis
Task 4 - Oversee and Manage US DOE RTCs and their Partners



84 kW Soitec System in NV

FY14 - APPROACH

Task 1 – Infrastructure
- Upgrade PSEL site to host smaller RTC systems in NM (250kW capacity)
- Install RTC-owned reference systems and soiling station at sites

Task 2 – Install partner systems (Soitec and Stion)
Task 3 – Baseline characterization of modules from Soitec and Stion
Task 4 – Manage project, scheduling, budget, etc.
- Develop business processes to add new industry partners

KEY RESULTS AND OUTCOMES

- 84 kW Soitec system installed in NV, Stion (12 kW) systems to be installed in NM, FL, and VT by end of FY14 or shortly thereafter.
- PSEL site upgrades, complete, 6 kW reference systems installed at most sites by end of FY14. 60 kW+6 kW systems in VT.
- ENKI added as new partner (systems installed in NM and FL) (16kW).
- Prism Solar approved as new partner.
- New RTC partners are being recruited.
  - Chilicon (proposal received)
  - Renewable NRG Systems (proposal received)
  - PVMC (proposal received)
  - TenKSolar
  - Solaflect
  - Norwich Technologies
  - SELF
- New Website and 8 Factsheets available

Soiling station being built at ASU

FY14 Major Go-No Go (Complete or INCOMPLETE)

- 60 kW installed in VT by end of FY14 **(COMPLETE)**
- PSEL site ready for up to 250 kW by end of FY14 (**COMPLETE)**
- 6 kW reference systems installed at each site by end of FY14 **(NM, FL, and VT are complete. NV is delayed)**
- New partner application process is deployed **(COMPLETE)**

6 kW Reference System in NM

60&6 kW Systems in VT