SAND2017-7979PE

The US Regional Test Center Program

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The US DOE Regional Test Center Program

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24 July 2017

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The Regional Test Center Program

Objectives Are To:

Create a robust, impartial and technically exacting R&D program that supports US technological leadership in solar energy

Develop an extensible platform of multiple R&D sites, with equivalent infrastructure and instrumentation, to measure and understand the performance of new solar technologies in different climates

Assist manufacturers in demonstrating the bankability of their products (manufacturers gain high-fidelity, multi-climate performance data and analysis reports authored by the national labs)

Give companies access to the expertise and engineering capabilities of the national labs to support product development

Support local, regional and national education and research needs

PV technology must be predictable to be "bankable" – investors need to know how systems will function in across environments and climates.

Achieving the Vision: Equal but Different

Four-Pronged Success Strategy

Site Design

- Secure sites
- Identical Infrastructures
- World-class meteorological instrumentation

High-fidelity data collection

- High-fidelity data monitoring
- Daily data review
- O&M protocols
- Data-protection protocols
- Exacting calibration

Stream-lined installation approach

- Boilerplate data-acquisition systems
- Fast-track installation racking
- Publicly available, non-proprietary R&D data

Publicly-available R&D data

- National resource for PV performance data

The RTCs Have World-Class Infrastructure…

1. RTC Meteorological Station	
Irradiance: DHI	Eppley 8-48
Irradiance: GHI	Kipp & Zonen CMP 22
Irradiance: DNI normal	Kipp & Zonen CHP 1
Spectral sensor*	Black photon BPI-IT1
GPS solar tracker w/ shading ball	Kipp & Zonen SOLYS 2
Barometric pressure	Vaisala CS106
Wind speed and direction	RM Young 03002-L
Relative humidity and temp	Vaisala HMP60-L
Rain gauge**	Met One Instruments 375

* NV RTC only
** Heated in VT, NM, FL

2. Baseline, or Reference, PV Array

6kW c-si mono
270W Suniva modules

POA irradiance:
- EETS reference cells
- CMP-11 pyranometer

Thermocouples
DC current shunts
DC voltage dividers

2. RTC Soiling Station

10 mini-modules
Tilt angles: 0 – 45 degrees
Half of each is cleaned 2X/week

4. Vermont Snow Station

3 modules:
- 45, 30, 15 degrees

4 modules:
- 0, 15, 30, 45 degrees

Camera
Short-circuit current

…And an Exacting Approach to Validation

1. Validation Plan and System Design

- Technical objectives, length of study, roles & responsibilities

2. Module Characterization

- Flash testing for Voc, Isc, FF, Pmax, Vmax, efficiency
- Imaging: IR, EL, optical
- Performance coefficients

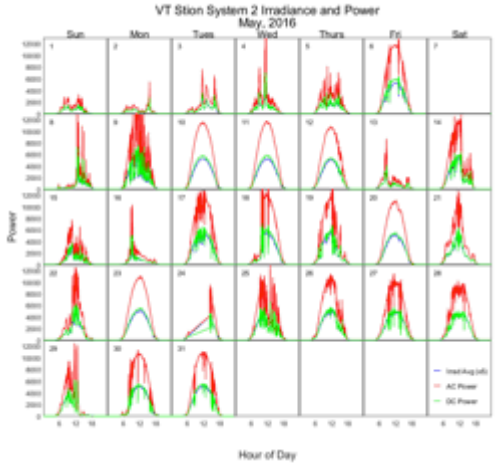
3. High-Fidelity Performance Data

- DC voltage: resistive voltage divider with accuracy of 0.1%.
- DC current: Empro current shunts, with accuracy of 0.1%.
- Solar cell temperatures – Omega Type-T thermocouples

- POA irradiance – Kipp & Zonen CMP-11
- PV reference cell -- EETS
- Custom data: tracking monitors, albedometers, AC data
- Data collected at ~ 5 seconds; averaged at one-minute intervals

4. Performance Analysis

- MATLAB scripts automate performance analyses
- Daily data review
- Twice yearly performance reports to partners



5. O&M Protocols

- Sensor cleaning and calibration (2x/wk)
- Annual IV curves

The RTCs Support Diverse Technologies

Photovoltaic Cell Types

- Mono-Si, Poly-Si
  - PERC, IBC, HIT
- "Shingled" mono and multi Si
- CIGS (discrete and monolithic)
- CPV (HighX)

Module Types

- Bifacial
- Multiple back-sheet types
- Framed and frameless modules

Other Products

- Thermocouples
- Meteorological stations
- Installation studies

Mounting Types

- Fixed-tilt
- Single-axis tracker
- Dual-axis tracker

Tilt Angles

- 10˚, 15˚, 30˚, 35˚, 90˚

Module Orientations

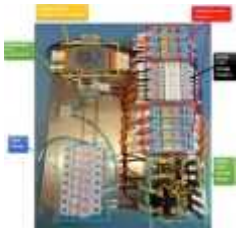
- South
- West
- Vertical– EW and NS

~21 technology companies
~42 distinct technologies
>50 PV systems
>550 kW capacity

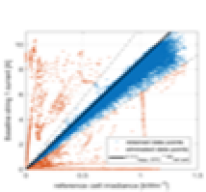
The RTCs Meet Industry Needs

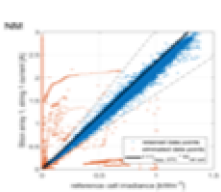
- Multi-climate field studies

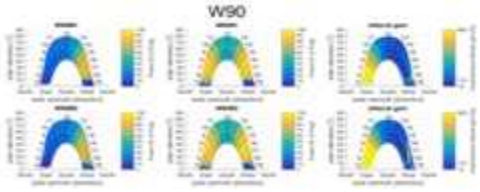
- High-fidelity performance and meteorological data



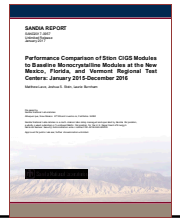
- Performance analysis by the national labs

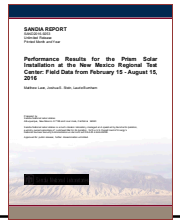


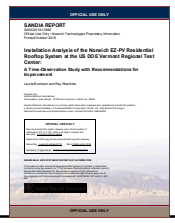




- Bankability/technological validation in the form of Sandia-published reports







- Product development: access to lab capabilities and expertise

The RTCs Provide Other Benefits to the US

- **R&D Data**
  The RTCs support a national data repository, making near-real-time and high-quality data from the weather stations and non-proprietary PV arrays available to the public

- **Technical Assistance**
  States, towns and electric utilities seeking to better understand PV have sought data and technical advice from the RTC program

- **Workforce Training and Education**
  Sandia's technical experts work closely with installers and students at the RTCs, teaching them about performance monitoring, new module technologies and stateof-the-art O&M




Partners and Technologies at One or More RTC Sites

- 4 soiling stations
- 1 snow station -- VT

Project	Company/partner	Tech Types	NM	CO	FL	NV	VT
RTC	Heliovolt (out of business)	1	D	D	O		
RTC	Stion	2	O	O	O		O
RTC	Suniva	1	O	O	O	O	O
RTC	Maxim	3	O	D	O		
RTC	SunPower (Bifi)	4	O	O			
RTC	SunPower (P-Series)	1	O		I		I
RTC	Solar City	4	O	O	I	I	O
RTC	SolarWorld	4	O	O	I	I	O
RTC	Soitec (not in CPV anymore)	1		O		O	
RTC	Prism Solar	2	O	O		O	O
RTC	ENKI	3	O		O		
RTC	All Earth Renewables	3					O
RTC	Renewable NRG	1					O
RTC	Norwich/Chilicon/SolarWorld	3					O
RTC	Ten K Solar	1		O			
PVMC	Miasole	1					O
PVMC	Solar Frontier	1					O
PVMC	Global Solar	1					O
PVMC	Solopower	2					O
	Totals	42					

O = Operational
I = Installation in progress
D = Decommissioned
Green = VT RTC installations

The Vermont RTC: Showcase for VT and US Innovation

Site selected in 2012

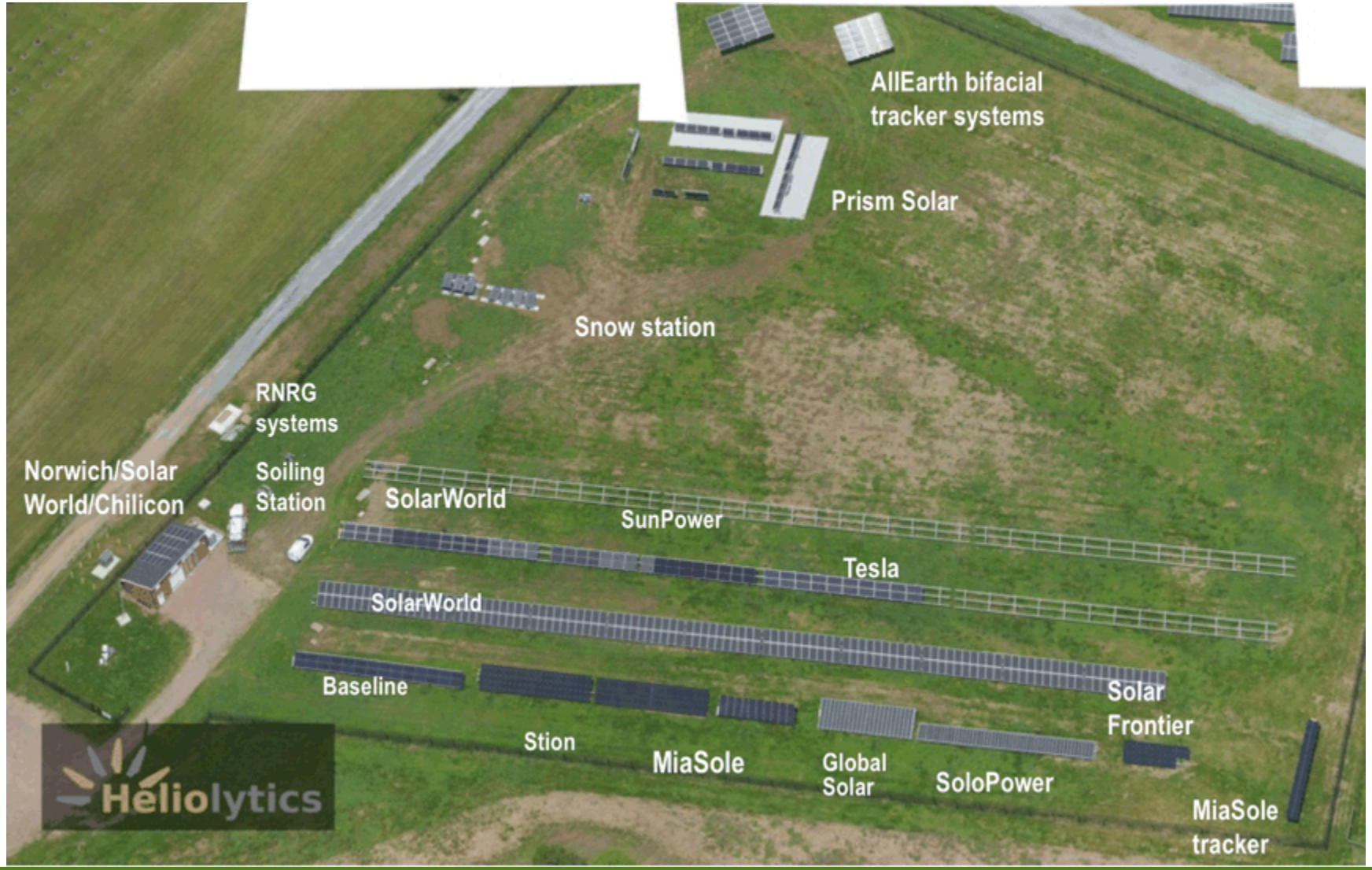
Construction starts and site launched in 2013

National solar testing site being launched in Vt.

WILSON RING, Associated Press · Published: November 4, 2013 2:14 PM CDT · *Updated: November 4, 2013 2:15 PM CDT*

First systems installed in 2014

Aerial View of the VT RTC in 2017



Technological Diversity at the VT RTC

Prism Solar

SolarWorld

RNRG

AllEarth Renewables

SunPower P-series

Norwich Technologies

Climate Data from the VT RTC:

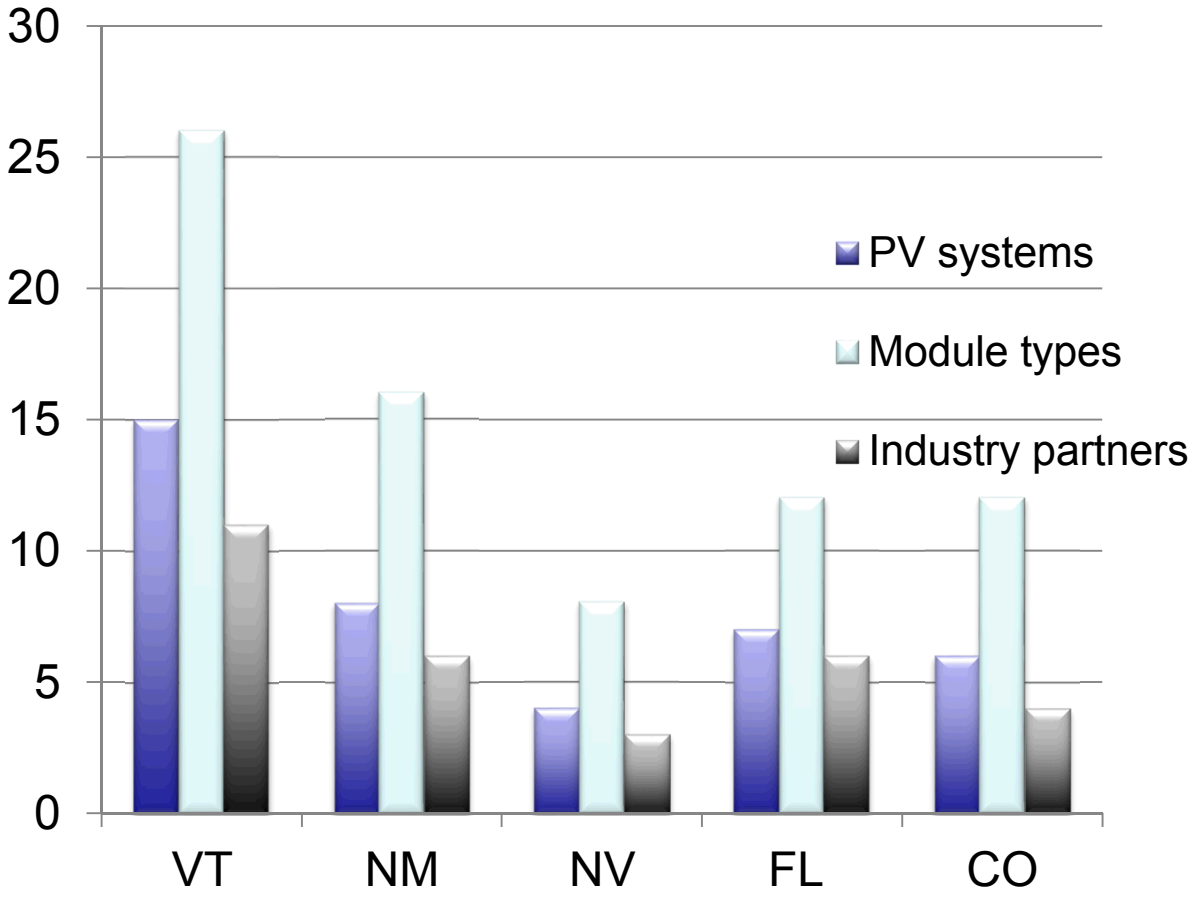
Advancing Our Understanding of the Impact of Climate on Performance

Wet Spring

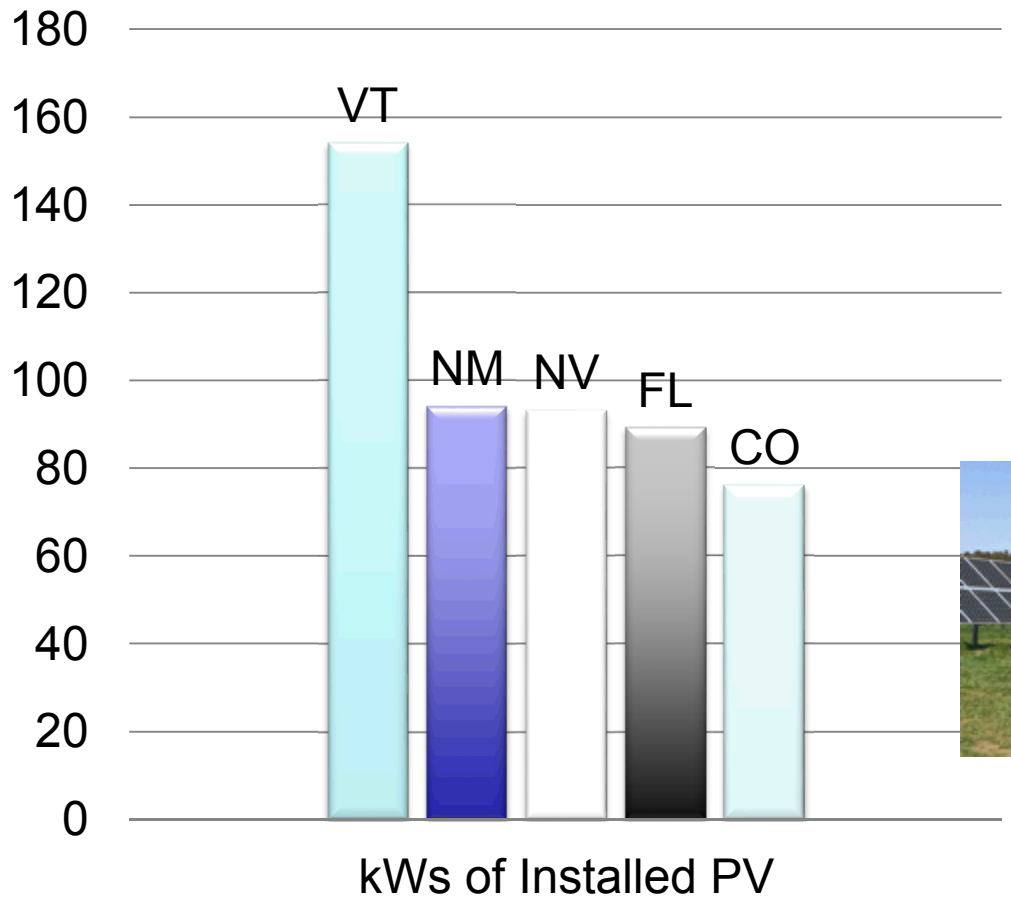
Snow in Winter

Soiling in Summer

VT RTC Leads in Installation Metrics…

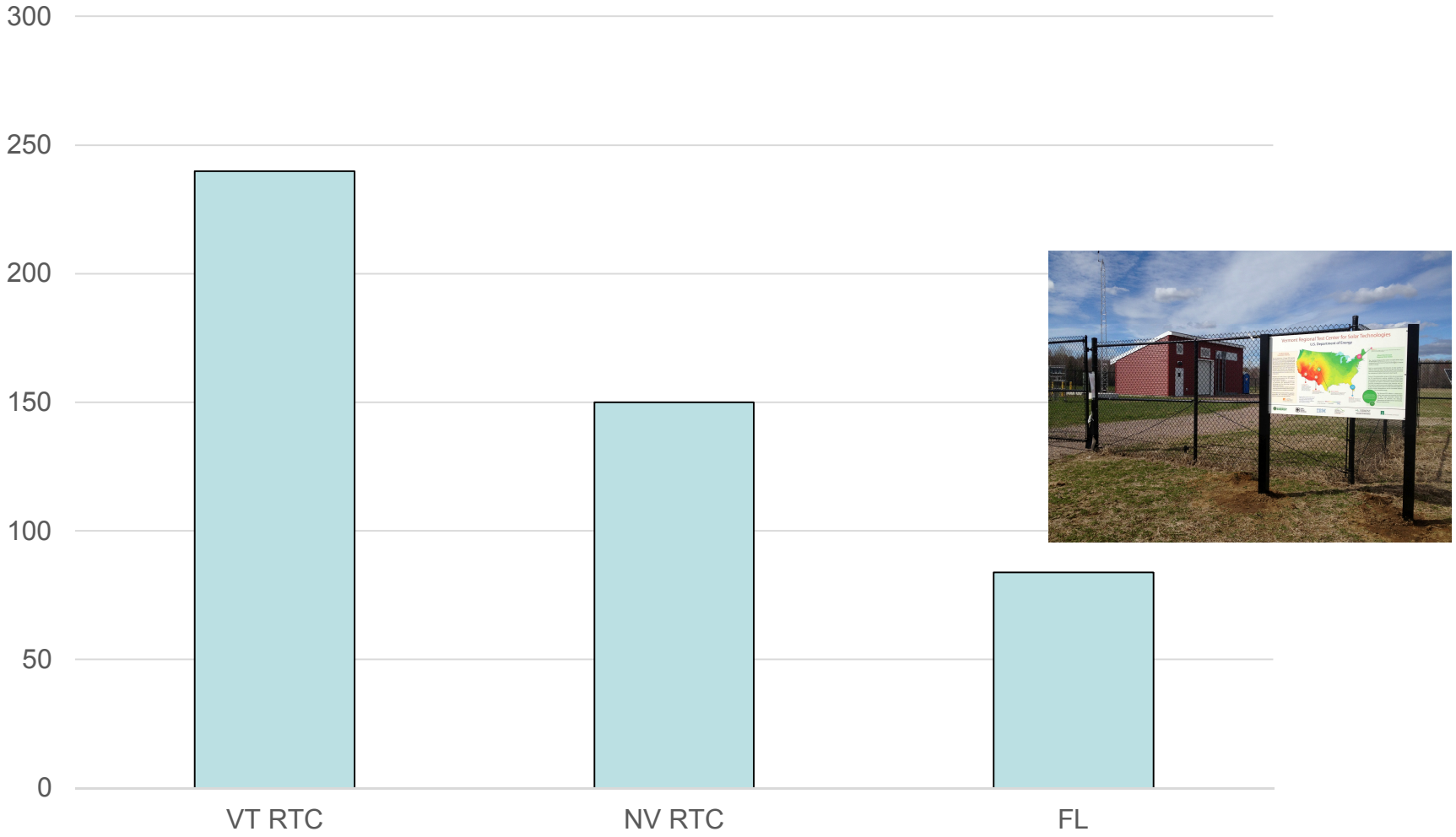


… Including Kilowatts (kWs) per Site



But Also in O&M Costs per RTC Site *

(in thousands)



*** Non-national lab sites**

Challenges Ahead: Trump's Budget to Congress (May 2017)

"The PV subprogram…funds the Regional Test Centers (RTCs), which are located in Denver, Colorado; Albuquerque, New Mexico; Orlando, Florida; Las Vegas, Nevada, and Williston, Vermont.

The RTCs provide facilities to study and validate the performance of PV technology pathways, including semiconductor materials, packaging and power electronics. These data elements deliver essential feedback to early stage R&D.

During FY 2018, the Nevada, Vermont and Florida sites will begin a transition to **a self sustainable business model** that is not reliant on federal funding, and the Colorado site will be decommissioned and folded into an existing, smaller, outdoor test facility on the NREL campus, which is also used to maintain reference standards necessary for benchmark tests. "

Opportunities for Self-Sustainability

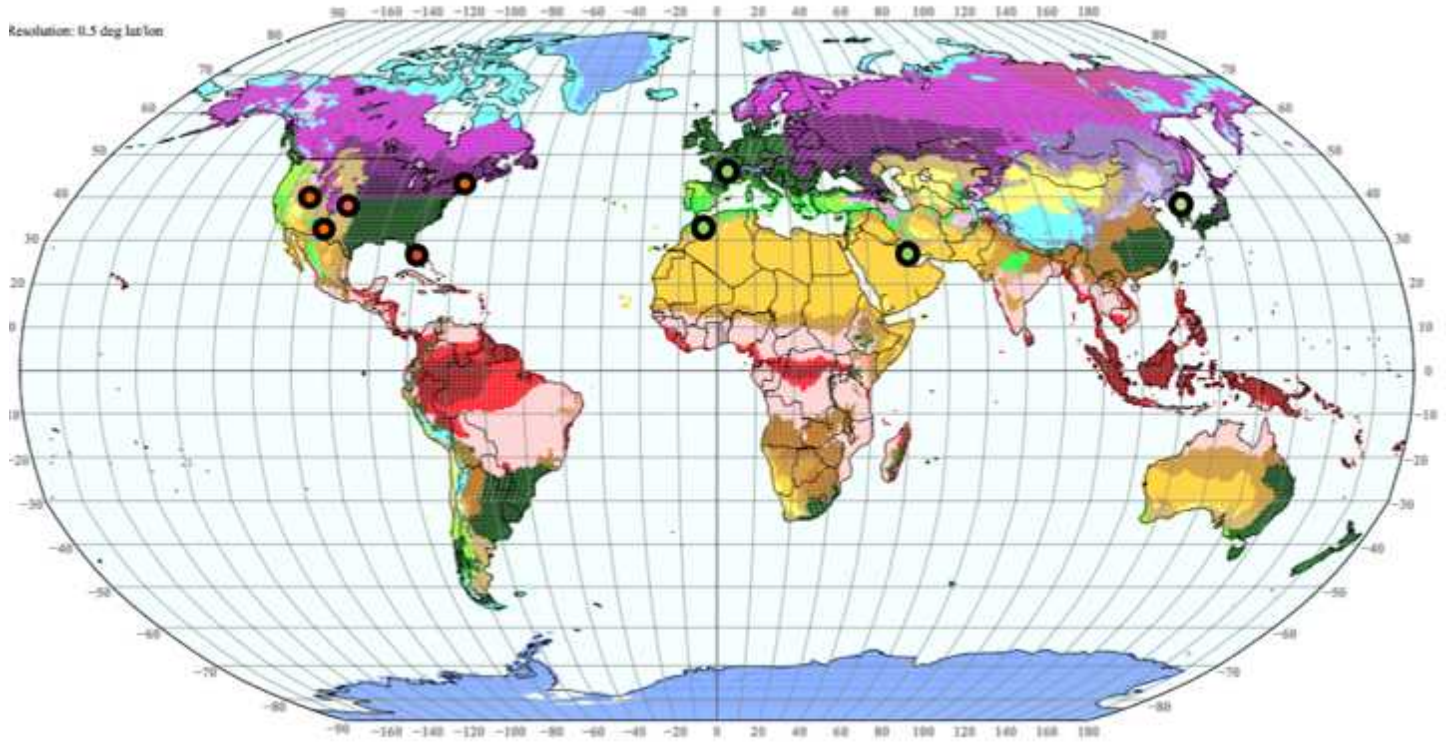
Challenges

DOE funding cuts; shrinking US solar industry; limited budget and time to develop

Opportunities

- Identify customers who would pay full cost of validation study (including installation, O&M, etc.) Prospective candidates include large-scale insurance companies, national homebuilders, solar developers, industrial manufacturers, foreign companies with interest in US markets
- Create ties with other DOE-funded R&D projects to leverage the resources and infrastructure at the RTCs more broadly for research
- Seek funding from the DOD to support performance and reliability assessments of solar technologies of interest to the military
- Develop international collaborative based on the RTC program, with members paying to support the organization
- Leverage the RTCs for solar-training--emphasizing performance and reliability, hands-on O&M, exposure to new technologies, etc.--in partnership with site partners
- Solicit regional and site-owner support for ongoing operations, with emphasis on local and community value

International RTC Collaborative



Founding Members by Location: U.S. (DOE RTC sites); Germany; Morocco, Qatar, South Korea. Oher regions and countries are actively being recruited.

Next Steps?

TBD

Regional Test Centers

Differentiating PV Quality

pvrtc.org

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