U.S. DEPARTMENT OF
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Office of
ENERGY EFFICIENCY &
RENEWABLE ENERGY

Sustainability Plan for the Solar Regional Test Centers

December 2018

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Executive Summary

The U.S. Department of Energy (DOE) Regional Test Center (RTC) Program for Solar Technologies is a network of five outdoor testing facilities located in different climate regions across the country. The sites include Willison, Vermont; Cocoa, Florida; Henderson, Nevada along with co-location at the National Renewable Energy Laboratory (NREL) in Golden, Colorado and Sandia National Laboratory (Sandia) in Albuquerque, New Mexico. The RTC program, which was established by the DOE Solar Energy Technologies Office (SETO) in 2011, is led by Sandia. These sites serve as a complete representation of the range of outdoor conditions for which accurate long-term performance prediction creates value for the domestic photovoltaics (PV) industry. These values may be captured through insights leading to greater reliability or lower cost at the bill-of-material level or monetized through more accurate energy harvest prediction. Several of the installations have been utilized as part of vocational education programs and curricula at a number of universities. To date, 15 domestic companies have partnered with the RTCs to evaluate new solar technologies, including new cell materials, power electronics, and performance prediction tools.

In order to efficiently conduct the required research and optimize the use of federal resources, SETO has encouraged Sandia to consider pathways to make the RTC sites that are not located at DOE National Laboratories self-sufficient over the past three years. These efforts were documented in the President's FY2016 Budget Request, which referenced increasing cost share for new PV systems at the RTCs, and in the President's FY2018 Budget Request, which referenced a transition to a self-sustainable business model for non-lab sites that is not reliant on federal funding.

SETO has prepared this report in reference to Conference Report 115-929, which accompanies H.R. 5895: The Energy and Water, Legislative Branch, and Military Construction and Veterans Affairs Appropriations Act, 2019. The instructions are that: "Within available funds, $4,050,000 is provided for the five photovoltaic Regional Test Centers (RTCs). Further, not later than 90 days after the enactment of this Act, the Department shall submit to the Committees on Appropriations of both Houses of Congress a plan for transitioning the RTCs to a self-sustaining business model as originally envisioned."

The plan is:

- The three RTCs not located at DOE National Laboratories will transition away from federal support by the end of Fiscal Year 2021, subject to appropriations;
- If independent ownership is not identified for any RTC not located at a DOE National Laboratory by September 2020, DOE will initiate decommissioning of the site(s) in order to reach closure by the end of Fiscal Year 2021.

The transition to non-federal support will require considerable changes to convert the Vermont, Florida, and Nevada regional test centers into standalone facilities, each with the leadership and financial strength needed for independent operations. Organizations positioned to benefit from taking ownership of an RTC are those that could leverage the field testing and product validation infrastructure that is already in place. Such organizations may operate locally within the geographic region of a specific RTC site, or could have interests spanning multiple sites such as large engineering firms that provide product testing and reliability services for project financiers across the country. Existing industrial partners, universities, research institutes or utilities also represent examples of potential owners.

The Florida and Nevada RTC facilities have existing management structures that are broadly compatible with the transition toward self-sufficiency. The Florida RTC is operated by the University of Central Florida (UCF), which has a strong presence within the photovoltaics research community and may be positioned to operate the site independently as part of their research infrastructure. The Nevada site is operated by the Southern Nevada

Water Authority (SNWA), which in partnership with the University of Nevada, Las Vegas (UNLV) may also have the necessary resources and expertise to enable the site to function without federal support.

The Vermont RTC currently lacks an onsite research partner that could manage the site without direct support from the larger RTC program. Discussions with faculty at the University of Vermont (UVM) are ongoing. Adding to the challenges is the fact that the current site owner, GlobalFoundries Inc., recently announced that it is putting ownership of its Williston, Vermont property, where the Vermont RTC site is located, up for sale, which may require the site to be decommissioned by as early as May 2019.

During the course of their operations to date, the five RTC sites have assisted domestic manufacturers in bringing new and unproven products to market by providing access to accurate and unbiased field testing in a range of climate regimes. Due to the dramatic growth of the US PV deployment base during the past 8 years and the corresponding expansion of domestic PV system performance data, SETO believes that determining the climate-specific behavior of new PV products is a role that can be effectively managed by the private sector. The types of new products and designs that will still require small-scale, high resolution field testing are generally the most disruptive and least predictable. In these cases, the successful detection and interpretation of anomalies during outdoor testing generally requires detailed on site characterization and analysis capabilities, which exist at the DOE National Laboratories. As a result, SETO anticipates continuing to support outdoor testing capabilities in Colorado and New Mexico after transitioning the Vermont, Florida, and Nevada RTC sites to independent operations. Developing such capabilities at the Vermont, Florida, and Nevada RTC sites would not effectively utilize the capabilities already supported at the DOE National Laboratories and would require duplication of equipment and research staff.

Estimates of the current costs of the RTC program and an outline of future plans are provided in Section III of this document, with a more detailed description of sustainability activities and challenges at each site provided in Section IV. Section IV also contains tables of milestones and decision points that are specific to the Vermont, Florida, and Nevada sites. The following table provides a summary of the common milestones that are shared by these sites:

<table>
<tr><th>Date</th><th colspan="3">Milestone or Decision Point</th></tr>
<tr><td>February 2019 through June 2020</td><td colspan="3">Complete discussions with any relevant stakeholders to finalize an ownership model for each RTC site</td></tr>
<tr><td>March 2019 (VT) or September 2020 (FL, NV)</td><td colspan="3">Decision Point: Finalize transition plan and transfer ownership or begin executing decommissioning plan(s).</td></tr>
<tr><th colspan="2">New Ownership</th><th colspan="2">Decommissioning</th></tr>
<tr><td rowspan="2">June 2021</td><td rowspan="2">Complete any modifications to the RTC site that are needed for independent operations under new ownership. Confirm that the site will have appropriate financial independence</td><td>April 2019 (VT) or March 2021 (FL, NV)</td><td>Decommissioning plan approved All external parties, contractors and relevant agencies necessary for decommissioning have been assigned to a task-driven work schedule.</td></tr>
<tr><td>June 2019 (VT) or September 2021 (FL, NV)</td><td>Site decommissioning complete.</td></tr>
<tr><td>October 2021</td><td colspan="3">Transition complete for the Vermont, Florida, and Nevada RTCs</td></tr>
</table>

Summary table of milestones and decision points that are shared by the Vermont, Florida, and Nevada RTC sites. Milestone tables that are specific to each of these sites can be found in the Ongoing Activities and Challenges entry for that site in Section V of this document.

1 Overview of the Regional Test Center Program

Launched in 2011, The RTC Program consists of a national network of five field sites dedicated to solar photovoltaic (PV) energy research that directly supports the DOE Solar Energy Technology Office's mission to further the affordability, reliability, and performance of PV technologies in the United States. The RTC sites are located in Vermont, Florida, Nevada, Colorado, and New Mexico. The program makes this network of field laboratories accessible to U.S. companies engaged in the PV industry across the supply chain, from PV technology manufacturers to PV system installers and operators. The RTC sites, which span the major climate zones within the U.S., provide a platform for product validation across the full range of environmental conditions that are of interest to domestic PV companies.

The program, which is managed by Sandia in partnership with the NREL, has created a technically rigorous platform for the cross-site comparison of different solar technologies. Each RTC has a common infrastructure, including world-class meteorological instrumentation, high-resolution energy-production monitoring equipment, and operating protocols to ensure data quality. The sites in New Mexico and Colorado, located at Sandia and NREL respectively, directly benefit from the extensive technical capabilities and photovoltaic expertise of the national laboratories. In contrast, the three sites located in Florida, Vermont, and Nevada are locally owned and operated. While lacking the in-house technical expertise of the national laboratory sites, these sites are positioned to adapt in accordance with local interests and to customize their operations to support state and local needs.

Distribution of the RTCs across the United States. Sandia manages four of the five sites (New Mexico, Vermont, Florida, and Nevada). NREL manages the Colorado RTC.

2 Foundational Work for Long Term Sustainability

Within three years, the Vermont, Florida, and Nevada RTCs are expected to transition to independent operations and no longer be dependent on federal support. It is anticipated that while federal funding will not be used to maintain any local infrastructure, the sites could still be used for research projects funded through competitively awarded programs sponsored by the DOE or another federal agency.

The RTC program was originally conceived as a network of research facilities that could support the needs of U.S. manufacturers and other domestic companies looking for independent field testing and performance validation of their products. As a result of being developed as a research program, most aspects of the RTC network were optimized for data quality and accuracy rather than independent financial viability. However, during the past three years, the DOE has begun emphasizing and supporting efforts by the RTC leadership at Sandia to reduce the federal funds needed to operate the Vermont, Florida, and Nevada sites in order to begin transitioning these sites to self-sustaining operations as originally envisioned. The following strategies are being used by the Sandia leadership team to reduce the dependence of these sites on federal funding:

Improving Operational Efficiency: Site operations include activities such as the design, installation, and monitoring of each PV system, as well as the analysis and reporting of data to industry partners. The RTC leadership team at Sandia has continuously worked to standardize and automate data monitoring, analysis, and report generation while streamlining installation processes and increasing the quality of acquired data sets. Strategies developed by Sandia for this purpose include prebuilding grid-tied racking for multiple projects at once and designing a data acquisition and monitoring system that can be purchased directly by industry partners.

Increased Local and Private Partnership: Partnerships with local institutions are important to both supporting the costs of site operation and expanding the value that each site provides to local stakeholders. The national laboratories have therefore worked closely with site owners and local universities who are interested in supporting the research activities that are conducted at each site. Examples include the partnerships formed with the Southern Nevada Water Authority and the UNLV, who together provide the bulk of system design, system installation, and site maintenance for the Nevada RTC. Partnerships with local utilities, educational institutions, and nearby companies are continually developed and implemented whenever possible.

Increased Cost-Recovery from Project Partners: Increasing cost-recovery from project partners allows greater leverage for federal funding, and also ensures that industry partners are sufficiently invested in any new product validation studies conducted at the RTCs. Industrial partners now cover almost all system installation costs compared with the early years of the RTC program when industry partners often contributed less than 20 percent of installation expenses.

To date, cost share from RTC partners has been collected almost exclusively based on system installation costs, which means that costs not directly associated with individual projects, such as program management, data analysis, and site maintenance are currently not being recovered from partners. As a result, each new validation study conducted at an RTC site requires an influx of federal funding beyond the minimum funds needed to maintain the site. During the past year, both Sandia and NREL have created cost matrices that enable them to better predict the full lifecycle costs of a full product-validation study, including site operation and maintenance (O&M) and national laboratory technical support. These tools open the door for larger amounts of cost-sharing that includes program costs that previously were not attributable to any individual validation project. The RTC leadership team continues to work to begin requiring project partners to pay for a substantial share of total lifecycle project costs, rather than only those associated with system construction.

3 Anticipated Trajectory Towards Sustainability

FY19 Budget Guidance: In accordance with Conference Report 115-929, which accompanies the Energy and Water, Legislative Branch, and Military Construction and Veterans Affairs Appropriations Act, 2019, SETO will dedicate $4.05 million of FY19 funding to Sandia and NREL in order to maintain operations at all five RTC sites in FY19 and implement the self-sufficiency plan described herein. This funding will provide the $2.88 million needed to meet expected FY19 operating costs across the RTC sites, including the expected launch of several new validation projects. The remaining $1.17 million of FY19 funds will be dedicated to (1) Making any infrastructure or site improvements that may be necessary to facilitate the transition of the Vermont, Florida, and Nevada sites towards independent operations, and (2) Launching and maintaining additional field validation experiments that leverage RTC infrastructure, and (3) Establishing a decommissioning reserve fund for the Vermont, Florida, and New Mexico sites.

The following table summarizes the FY16-18 federal expenditures (excluding transitioning costs not determined at this time) at each of the RTC sites. The FY19 level is anticipated and is subject to change. If independent ownership is not identified for any RTC not located at a DOE National Laboratory by September 2020, DOE will initiate decommissioning of the site(s) in order to reach closure by the end of Fiscal Year 2021. The three RTCs not located at DOE National Laboratories will transition away from federal support by the end of Fiscal Year 2021, subject to appropriations.

Annual Federal RTC Program Expenditures by Site[1]	FY16 Federal Expenditures ($k)	FY17 Federal Expenditures ($k)	FY18 Federal Expenditures (Est. $k)[2]	FY19 Anticipated Federal Funds (Est. $k)[3]
Vermont	508	736	579	300
Florida	307	192	127	100
Nevada	261	328	234	200
Colorado	422	234	928	400
New Mexico	2534	2185	2361	1880
Total	**4032**	**3675**	**4229**	**2880**

Summary of actual and planned expenditures for the RTC program between FY16 and FY19. FY19 levels in this table include funding dedicated to launching and maintaining additional technology validation projects and pursuing site improvements, and therefore are generally larger than the minimum FY19 operations budget estimates.

As each site moves closer to self-sufficiency, substantial one-time investments ($100,000 or higher) beyond the expenditure estimates provided in the table above may be required to make permanent changes to site infrastructure, location, or ownership. For example, the large increase in federal expenditures sent to the

[1] The numbers provided in this table are revised from previous estimates of RTC expenditures in order to more accurately capture program management expenses for Sandia staff. For example, some staff costs associated with Vermont in prior estimates that were used for overall RTC program management are now included in the New Mexico row.
[2] Florida and Nevada FY18 expenditures have not yet been fully invoiced, and so are estimated based on anticipated spending at those two sites.
[3] Decreased system installation activities and infrastructure modifications at each site as well as increases in operational efficiency are expected to significantly reduce program costs from FY18 to FY19.

Colorado site in FY18 allowed for that site to transition from a large third-party owned location to a smaller plot of land on NREL's campus. This transition is expected to considerably reduce costs in all years moving forward. Similar transitions, expenditures, or investments may be necessary in the next three years for the Vermont, Florida, and Nevada sites in order to maximize the efficiency and sustainability of the sites.

4 Ongoing Activities and Challenges by Site

Each RTC site currently faces a unique set of challenges on the path to sustainability. The following sections provide a more detailed description of the current operating environments at each site, and identifies site-specific issues associated with moving towards self-sufficient operations.

4.1 Vermont Regional Test Center

Williston, Vermont

Aerial view of the Vermont RTC, depicting existing installations. Available racking for new installations can be seen to the north of the SolarWorld, SunPower, and Tesla systems. The site has can support an additional 150 kW of PV systems. Image credit: Heliolytics and Sandia.

Site Description

The Vermont RTC is located in Williston, Vermont on land currently owned and operated by GlobalFoundries Inc. The fenced four-acre site can support 300 kilowatt (kW) of PV systems, and is connected to the Green Mountain Power grid. In addition, the Vermont RTC supports a nearby 60 kW PV array that can be leveraged for research purposes, such as measuring the field performance of inverter and battery systems and other grid-integration challenges.

First System Installed	2014
Number of PV Technologies	27
Number of Industry Partners	14
Number of Installed kWs	148
Remaining Capacity (kWs)	152[4]
Site Acreage	4

Unique Site Attributes

The Vermont RTC receives substantial attention from industry partners due to its harsh, winter climate and location in New England, which has seen a 70-fold increase in installed solar capacity since 2010.

Abundant snow in the winter makes the Vermont RTC an attractive site for research on PV performance under harsh conditions. Image Credit: Sandia.

Special Features

- Snow-measurement-station
- Underground electrical and communication conduit accessible via junction boxes to facilitate new installations
- Onsite office to support student and faculty research
- Showcase for local companies; public tours are often requested
- Secure, fenced-in four-acre site in a dedicated location
- 400 linear feet of fast-track racking available for new installations

[4] The capacity of the Vermont RTC could be expanded, provided an electrical upgrade is possible.

Key Stakeholders

GlobalFoundries is a semiconductor manufacturing company that acquired the site from IBM in 2014. As owners of the RTC site, GlobalFoundries charges the RTC program for basic building and grounds maintenance and for overseeing the final design, permitting, and commissioning of each new installation. To date, for various reasons, GlobalFoundries has been unwilling to allow other entities to provide these services in their place.

RAK Solar, a subsidiary of local electric company E&S Electric, provides installation and monitoring services to the Vermont RTC, including routine maintenance of the meteorological instrumentation, construction of new systems, and oversight of onsite monitoring and communications systems. Although RAK Solar has no direct research interests in the Vermont RTC, they have benefitted from working with and being trained by Sandia staff and have provided technically excellent and highly responsive service.

Current Sustainability Activities and Plans

GlobalFoundries recently informed Sandia that it intends to sell the company's Williston property, a 500-acre piece that includes the land on which the RTC sits. They have also informed Sandia that as of May 30, 2019, they will no longer supply O&M services at the site. These two announcements have created an urgent need to finalize plans for more stable ownership of the Vermont RTC, preferably by entities with a synergistic research, educational, or business interest in the site. As a result, Sandia and GlobalFoundries have engaged with multiple local stakeholders to identify viable options for the long-term sustainability of the Vermont RTC. Discussions are currently underway with two local institutions, both of which would offer significant advantages to the RTC site if they to take over site ownership and/or operations:

The University of Vermont (UVM)

Preliminary discussions regarding the future of the Vermont RTC have taken place with UVM administrators and faculty. The university has expressed interest in assuming ownership of the Vermont RTC, predicated on (1) Sufficient faculty interest in leveraging the site for research, (2) Willingness of GlobalFoundries or the new site owner to donate the site to UVM, and (3) Confidence that the site would attract enough research funding and other support to be self-sustaining over the long term, including the possibility of state support and also local philanthropic support.

The Burlington Electric Department (BED)

In a meeting with Sandia, the leadership of BED expressed support for the RTC and alluded to the company's willingness to participate in and help convene meetings with local stakeholders to raise awareness, money, etc. BED would also consider assisting in a transition of ownership or management to UVM. BED's role in the latter could include (1) Brokering a conversation with GlobalFoundries regarding their willingness to sell or donate the site to UVM, (2) Partnering with UVM on the construction of a new RTC, or (3) Making a donation in support of the site. If the new site were in BED's service territory,[5] BED would provide the electrical infrastructure and offer net-metering for the site, with the revenue going to UVM to support the site.

An additional note regarding local support for the Vermont RTC is that Vermont Technical College has expressed an interest in contributing to the operational costs of the RTC in return for leveraging the site to further its workforce development program but does not intend to provide funds until 2022. With four years of

[5] Most of the UVM campus is in Green Mountain Power service territory, though UVM also owns some property that is serviced by BED.

lead time to build up its workforce activities, the college believes it would then be well positioned to apply for additional grants and approach foundations for continued support of activities at the Vermont RTC.

Remaining Challenges

The Vermont RTC faces an immediate challenge in GlobalFoundries' recent decision to sell the site. Overall, there are two viable paths forward. GlobalFoundries or the new site owner would agree to sell or donate the RTC to a new site partner, or Sandia would work with local stakeholders to identify a new site of comparable quality and capacity. The potential costs associated with finding and developing a new site for the RTC would likely be substantial.

The Vermont RTC does not currently have a direct partnership with an educational or research institution with a strong interest in solar energy, grid integration of distributed energy resources, or vocational training. Such an institution would be able to benefit from the research capabilities present at the RTC, and would likely be very helpful in allowing the RTC site to continue with its mission to support the development of the domestic PV industry in the absence of continued federal support.

Expected Timeline of Key Milestones

The decision horizon for the Vermont RTC site is rapidly approaching due to the leasing agreement with the current site owner ending in the next few months. It is unclear whether it will be possible to extend the leasing agreement due to the current site owner's intent to sell the land currently occupied by the RTC site.

<table>
<tr><th colspan="4">Vermont Regional Test Center</th></tr>
<tr><th>Date</th><th colspan="3">Milestone or Decision Point</th></tr>
<tr><td>February 2019</td><td colspan="3">Identify a new RTC site location or extend the current RTC's leasing agreement before the current contract with GlobalFoundries expires in May 2019.</td></tr>
<tr><td>March 2019</td><td colspan="3">Decision Point: Unless a new site and site owner have been identified by March 2019, failure to extend the current leasing agreement with GlobalFoundries will require the rapid decommissioning of the Vermont RTC site by May 2019.</td></tr>
<tr><th colspan="2">Transition Plan Identified</th><th colspan="2">DOE Initiates Site Decommissioning</th></tr>
<tr><td>June 2020</td><td>Finalize future technical leadership and financial support for the Vermont RTC. Identify any new partnerships or site modifications that will be necessary to support future operations.</td><td>April 2019</td><td>Decommissioning cost estimate provided to DOE. All external parties and contractors necessary for decommissioning have been identified.</td></tr>
<tr><td>June 2021</td><td>Complete any modifications to the RTC site that are needed for independent operations under its new leadership. Confirm that the site will have access to adequate financial resources to support future activities and operations.</td><td>June 2019</td><td>Site decommissioning complete.</td></tr>
<tr><td>October 2021</td><td colspan="3">Transition complete for the site.</td></tr>
</table>

4.2 Florida Regional Test Center

The University of Central Florida, Cocoa, Florida

The Florida RTC, looking to the east. Image Credit: Florida Solar Energy Center.

Site Description

The Florida RTC is located in Cocoa, Florida, on property owned by the University of Central Florida (UCF) and managed by the Florida Solar Energy Center (FSEC). The site has an overall capacity of 100-200 kW. FSEC has an imaging and diagnostic laboratory that provides technical services to the RTC. The latter includes a flash tester and electroluminescence and infrared imaging equipment. In addition, FSEC can perform current-voltage curve traces at the module- and string-level.

First System Installed	2013
Number of PV Technologies	15
Number of Industry Partners	6
Number of Installed kWs	89
Remaining Capacity (kWs)	200[6]
Site Acreage	5

[6] The capacity of the Florida RTC could be expanded by another 200 kW if additional tree clearing takes place.

Unique Site Attributes

The Florida RTC receives substantial attention from industry partners who want performance data from a tropical climate that tests modules' ability to withstand long-term exposure to heat and moisture simultaneously. Florida is also attractive to industry because it is one of the fastest growing states for solar in the country and in the top ten for total solar installations.

Special Features

- Secure, unshaded site, with room for expansion
- Location is off-campus and in a secluded area with no traffic so anthropogenic soiling is minimal
- Committed technical and support staff at FSEC
- Onsite flash-tester and office space for faculty, staff and students
- Installations are performed by FSEC on pre-built, standardized racking systems, reducing costs to industry partners

Key Stakeholders

The FSEC is a dedicated solar energy research institute within UCF. As such, the center conducts research, tests and certifies solar systems, and develops educational programs, all of which are activities that align with the goals of the RTC program. FSEC's responsibilities for maintaining the RTC site range from sensor cleaning to new system installation to ensuring data quality and availability. UCF and FSEC currently have multiple solar energy research projects, and are therefore, well positioned to leverage the RTC site for future research purposes and bring in funds that could maintain sustainable operations without federal support.

Current Sustainability Activities and Plans

Sandia is currently attempting to build a coalition of Florida stakeholders who understand the value of the RTC and who are committed to ensuring its long-term sustainability. Sandia will work with FSEC on convening a series of meetings and conversations with multiple stakeholders, including FSEC, the FSEC Advisory Board, the Florida Solar Industries Association, electric utilities, the City of Orlando, and state government officials. In addition, a stakeholder tour will be conducted of the Florida RTC to highlight the benefits of the RTC program, including its research contributions, educational and training opportunities, and role as a showcase for solar innovation.

In 2017, FSEC invited Sandia to present an overview of the RTC program at the annual meeting of the 32-member FSEC Advisory Board. Among the members present were representatives from Duke Energy, Tampa Electric, the City of Orlando, Universal Studios, and the Smart Electric Power Alliance. As a result of follow-on discussions, participants agreed that the Florida RTC could help Florida, generally, and Orlando, specifically, meet their renewable energy goals[7] in the following ways: (1) Generation of performance data to support the design of climate-optimized systems and validate the reliability and performance of modules and other technologies being considered for installation in Florida, (2) Design and deployment of monitoring

[7] The city of Orlando's has committed to 100 percent renewable energy for all municipal buildings by 2030 and 100 percent renewable energy for the entire city by 2050.

systems for innovative technologies (e.g., floating PV) to track their performance and reliability, (3) Training of next-generation installers and O&M/PV performance technicians, (4) Deployment of a satellite RTC co-located with an existing demonstration site in Orlando that would validate new technologies and be a technical showcase for grid modernization and solar power, and (5) Partnership with Orlando Utilities Commission (OUC), the benefits of which for OUC would include collaboration with the national labs and its hometown university (UCF).

Remaining Challenges

During the transition to independent operations, the Florida RTC is likely to remain within UCF and FSEC management. Conversations during the upcoming year are needed with UCF and FSEC to determine whether research funding or partner cost-recovery funds will be sufficient to maintain the site and retain the necessary staff who are vital to ensuring quality operations over the long term. Additional effort is needed to identify new partners or site opportunities that will allow the Florida RTC to have the highest impact for the largest number of partners and stakeholders throughout the region and throughout the renewable energy sector as a whole.

The final operational structure of the Florida RTC will play a significant role in determining the ability of the DOE to maintain several long term module degradation experiments. Depending on the outcome of this transition, the DOE may have an interest in providing limited support to this site in order to maintain current long-term, multi-year experiments at the site and reduce any future risks to its ability to support solar energy research activities in this climate zone.

Expected Timeline of Key Milestones

<table>
<tr><th colspan="4">Florida Regional Test Center</th></tr>
<tr><th>Date</th><th colspan="3">Milestone or Decision Point</th></tr>
<tr><td>June 2019</td><td colspan="3">Complete discussions with UCF and any other relevant stakeholders to finalize the expected future ownership model for the Florida RTC site.</td></tr>
<tr><td>January 2020</td><td colspan="3">Determine whether RTC operations are likely to be sustainable under the chosen management model and identify financial support to maintain site. Identify any new partnerships or site modifications that will be necessary to support future site operations.</td></tr>
<tr><td>September 2020</td><td colspan="3">Decision Point: Finalize transition plan and transfer leadership of RTC site or begin developing and executing decommissioning plans.</td></tr>
<tr><th colspan="2">Transition Plan Identified</th><th colspan="2">DOE Initiates Site Decommissioning</th></tr>
<tr><td rowspan="2">June 2021</td><td rowspan="2">Complete any modifications to the RTC site that are needed for independent operations under its new leadership. Confirm that the site will have access to adequate financial resources to support future activities and operations.</td><td>March 2021</td><td>Decommissioning cost estimate provided to DOE. All external parties and contractors necessary for decommissioning have been identified.</td></tr>
<tr><td>September 2021</td><td>Site decommissioning complete.</td></tr>
<tr><td>October 2021</td><td colspan="3">Transition complete for the site.</td></tr>
</table>

4.3 Nevada Regional Test Center

River Mountains Water Treatment Facility, Henderson, Nevada

Wide-angle view of the Nevada RTC from an adjacent roof. The site has 122 kW of installed PV and can support at least another 100 kW. Image Credit: UNLV.

Site Description

The Nevada RTC is located on land occupied by the River Mountains Water Treatment Facility, which is operated by the Southern Nevada Water Authority (SNWA). The RTC is guarded and has restricted access, although visits from partners and stakeholders can be readily arranged.

First System Installed	2014
Number of PV Technologies	8[8]
Number of Industry Partners	5
Number of Installed kWs	122
Remaining Capacity (kWs)	200
Site Acreage	3

Unique Site Attributes

The Nevada RTC shows the most extremes in terms of high temperature, high irradiance and low precipitation. These climatic characteristics provide a research platform for assessing the heat sensitivity of solar cells and designing module coatings that repel particulate buildup.

[8] An experimental system installed by WattGlass is expected to increase the number of technologies on site by six.

Special Features

- Isotype cell sensor for solar spectral measurements
- Technical support is provided by the Center for Energy Research at the UNLV
- Installation labor and other technical assistance is provided at no charge by SNWA
- Onsite office is available for student education and research
- Nevada RTC "Operations Manual" serves as how-to guide for work-study students
- High-security site (guards on duty 24/7; access to the RTC requires a badge)

UNLV students routinely receive training and help support the Nevada RTC. Image Credit: UNLV

Key Stakeholders

TSNWA has been a valued supporter of activities at the Nevada RTC. Since 2012, when SNWA agreed to set aside land on which the Nevada RTC would be built, the company has provided abundant in-kind contributions, including design and installation support.

TUNLV has also been a key stakeholder for the Nevada RTC since 2012, providing technical and O&M support for the site. In addition to overseeing daily operations to ensure data quality and availability, UNLV supports the design and deployment of new installations. UNLV has been the leader in directing and supporting student research at the Nevada RTC and has also been the first author on several RTC-related publications. UNLV has multiple active solar research projects and may be able to leverage the capabilities of the RTC site to pursue future funding and maintain activities there without federal support.

Current Sustainability Activities and Plans

In August 2018, Sandia representatives met with the Nevada Governor's Office of Energy. The Governor's office expressed an interest in providing funding to UNLV to allow for their continued technical management of the Nevada RTC, predicated on the university's willingness to expand educational and training opportunities at the site. Sandia and Nevada representatives are currently planning a full tour of the RTC after the Governor's office staff changes are completed following the results of the 2018 elections.

In April 2018, Sandia met with the director and staff of the Nevada Clean Energy Project in Las Vegas. The intent of the meeting was to introduce the Nevada RTC to those in attendance and to have a discussion

regarding stakeholder interest and sustainability of the site. Those present felt the Nevada RTC would be of interest to certain constituents, such as the casinos and Nevada Energy, especially if there is an educational component. Sandia intends to reconvene these stakeholders as a larger group in 2019.

Remaining Challenges

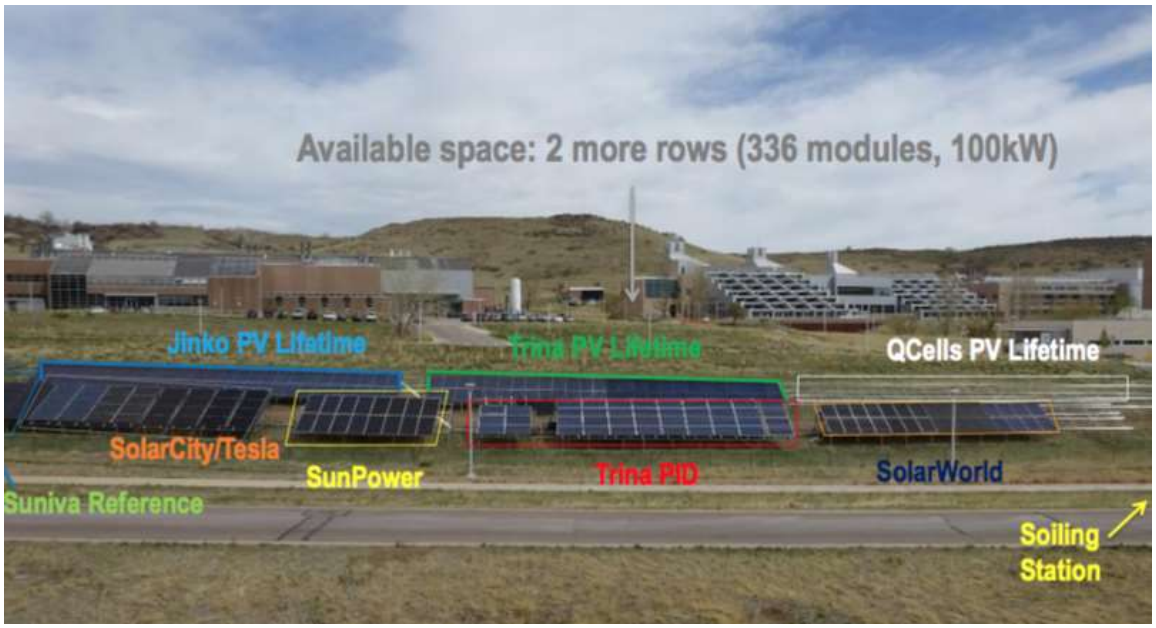
TSNWA has demonstrated its capability to support site logistics and construction activities during the site's lifespan to date. UNLV has additionally demonstrated the capacity to handle the design of new PV systems and has actively participated in student training and education activities at the site. The primary remaining challenge for the Nevada site is likely to be working with SNWA and UNLV to determine whether there will be sufficiently widespread interest in conducting research and educational activities at the RTC to make maintaining the site viable for the long term.

Expected Timeline of Key Milestones

<table>
<tr><th colspan="4">Nevada Regional Test Center</th></tr>
<tr><th>Date</th><th colspan="3">Milestone or Decision Point</th></tr>
<tr><td>June 2019</td><td colspan="3">Complete discussions with SNWA, UNLV, and any other relevant stakeholders to finalize the expected future ownership model for the Nevada RTC site.</td></tr>
<tr><td>January 2020</td><td colspan="3">Determine whether RTC operations are likely to be sustainable under the chosen management model and identify financial support to maintain site. Identify any new partnerships or site modifications that will be necessary to support future site operations.</td></tr>
<tr><td>September 2020</td><td colspan="3">Decision Point: Finalize transition plan and transfer leadership of RTC site or begin developing and executing decommissioning plans.</td></tr>
<tr><th colspan="2">Transition Plan Identified</th><th colspan="2">DOE Initiating Site Decommissioning</th></tr>
<tr><td rowspan="2">June 2021</td><td rowspan="2">Complete any modifications to the RTC site that are needed for independent operations under its new leadership. Confirm that the site will have access to adequate financial resources to support future activities and operations.</td><td>March 2021</td><td>Decommissioning cost estimate provided to DOE. All external parties and contractors necessary for decommissioning have been identified.</td></tr>
<tr><td>September 2021</td><td>Site decommissioning complete.</td></tr>
<tr><td>October 2021</td><td colspan="3">Transition complete for the site.</td></tr>
</table>

4.4 Colorado Regional Test Center

National Renewable Energy Laboratory, Golden, Colorado



The Colorado RTC on the NREL campus in Golden, Colorado. Image Credit: NREL.

Site Description

The Colorado RTC is currently located at NREL main campus (South Table Mountain) in Golden, Colorado, near Denver. This site has access to the nation's leading module and system characterization expertise and equipment located at NREL. The Colorado RTC was previously located at the Colorado SolarTAC facility near the Denver International Airport, with 20 acres under lease and 1 MW of electrical interconnection capacity installed. Due to the changing needs of the RTC program and the desire to eliminate the $200,000 annual fees for use of the SolarTAC site, NREL halted their membership in 2018, and will focus future deployments on the NREL main campus.

First RTC system installed	2013
Number PV technologies	26
Number industry partners	12
Number of installed kWs	175
Remaining capacity (kWs)	100
Site acreage	2

Unique Site Attributes

The Colorado RTC leverages best-in-class PV research expertise and capabilities at NREL. Close proximity to optical and electrical characterization adds value to field tests. These capabilities include electroluminescence, ISO17025 measurement of IV characteristics, failure analysis, high accuracy field measurement, accelerated

test capability, world radiometric resource assessment, and access to leading NREL scientific staff. Climate conditions are also favorable for solar PV with high annual irradiance and moderate temperature.

Special Features

The NREL site includes approximately 20 kW of legacy PV module deployment space at the Outdoor Test Facility for studying small systems. There is also a new PV field deployment with 200 kW of total capacity at 30-degree fixed tilt over natural ground cover. 125 kW capacity is currently in use with existing systems, leaving 75 kW of capacity for new fixed-tilt systems.

A brand-new single-axis tracking field recently added 75 kW of capacity for validation testing on single-axis trackers, which is already fully allocated between the multiple programs that have funded it. There is 7 kW reserved for long term degradation studies, 15 kW for a new RTC partner study and the remainder for other PV research programs. In addition to its PV hosting capacity, the site has the ability to interconnect 1 MWh of grid-interactive energy storage. At the moment, 21 kWh of lithium-ion and 60 kWh of vanadium redox flow-battery energy storage projects are deployed.

Key Stakeholders

NREL staff, including scientists working within the Outdoor Test Facility, the PV reliability and performance group, the Energy Systems Integration Facility have been important partners, as well as the PV Device Characterization Group, and the Energy Storage joint taskforce, which are PV reliability, vehicles electrification, grid integration groups.

Current Sustainability Activities and Plans

The Colorado RTC site is a valuable research and development resource to scientists at NREL, and SETO funding is currently planned to continue at the present level for the next three years pending appropriations. Current RTC-dedicated funding levels of $200,000 per year for the Colorado site allow current partners to receive performance reports and allows timely responses to DOE requests for feedback. A focus on new partners with 100 percent cost share or domestic manufacturers with > 50 percent cost share ensures that additional projects will not significantly increase the financial burden of the RTC program.

Remaining Challenges

No significant challenges with the continued operation of the Colorado RTC site in its current capacity are expected.

4.5 New Mexico Regional Test Center

Sandia National Laboratories, Albuquerque, New Mexico

Aerial view of the New Mexico RTC. Image Credit: Sandia

Site Description

The New Mexico RTC is located within the Photovoltaic Systems Evaluation Laboratory (PSEL) research facility at Sandia National Laboratories in Albuquerque, New Mexico. PSEL is an integrated testing facility that uniquely combines indoor and outdoor PV module characterization capabilities with the ability to perform outdoor operational and reliability evaluations of PV systems and components. In operation since the energy crisis of the 1970's, PSEL has been reconfigured many times to address the evolving energy needs of the nation. Recent electrical upgrades bring the total capacity of the site up to 750 kW, the equivalent of 150 residential sized systems and enough capacity to support 50 or more research systems.

First RTC system installed	2013
Number PV technologies	45
Number of industry partners	8
Number of installed kWs	275
Remaining capacity (kWs)	475
Site acreage	7

Unique Site Attributes

Sandia's field validation facility is a state-of-the-art, adaptable, and technically rigorous photovoltaic testing facility. In addition, the site is located in a dry climate at high altitude that sees dramatic night-day temperature swings and also has high annual solar energy potential. Among the five sites, the New Mexico RTC has the most severe ultraviolet exposure.

Special Features

- Seven-acre fenced site located on Kirtland Air Force Base. High-level of site security attractive for proprietary or sensitive research.
- Co-located with unique outdoor module characterization lab and comprehensive indoor lab.
- Most of the site is graded and prepared to accept standardized fixed-tilt racking.
- 750 kW grid tie capacity, three transformers (one dedicated to PV)
- Possible expansion to the East to develop single-axis tracker field

Key Stakeholders

Sandia currently hosts multiple research and development programs of the Sandia Photovoltaics and Materials Technologies Department funded by SETO. The PSEL research facility that hosts the New Mexico RTC site also supports partnerships with local manufacturers and test labs. Each of the Sandia Facilities and High-Performance Computing organizations have invested directly in the New Mexico RTC site infrastructure to increase the amount of renewable energy installed on site in order to offset usage and reduce demand from the local utility. Sandia's Facilities Department additionally leverages the site to conduct Net Zero building research in order to evaluate potential future national laboratory infrastructure upgrades.

Current Sustainability Activities and Plans

The New Mexico RTC is sustainable at current DOE funding levels, with minimal year over year growth in the number of RTC partners. Despite ample availability of electrical interconnect capacity, PSEL will have exhausted most of its pre-built racking by the end of FY19. A plan to repurpose racking from recently concluded system validation studies will meet anticipated needs for FY20, but investment in additional racking will be required for FY21 and beyond.

For new validation projects, the partner provides test devices and purchased hardware such as inverters and power monitoring systems, while the RTC Program provides design, installation, inspection and on-going analysis. Limited direct partner installations are allowed, within Sandia's facility guidelines. During FY19-21, partners will provide increased cost share to achieve a partial to full funding model. A standardized costing tool is under development to better calculate future cost share requirements for new partners.

Remaining Challenges

No significant challenges with the continued operation of the New Mexico RTC in its current capacity are expected.

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