CESA Webinar

Using Solar to Reduce Peak Loads: Evaluating Rhode Island's Distributed Solar Pilot

Hosted by
Nate Hausman, Project Director, CESA

July 12, 2018

Clean Energy States Alliance

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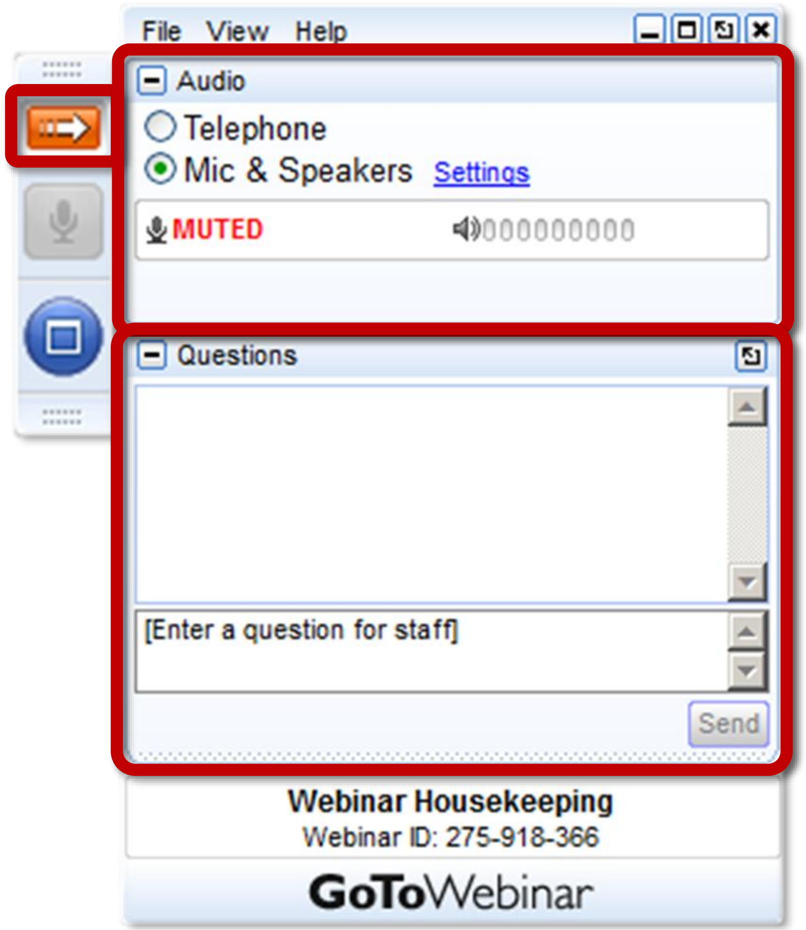

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SMUD Powering forward. Together.

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Department of Commerce Innovation is in our nature. (State of Washington)

DOER Massachusetts Department of Energy Resources

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OEI Wisconsin Office of Energy Innovation

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CESA's Multistate Initiative to Develop Solar in Locations that Provide Benefits to the Grid

CESA is working with five states and the District of Columbia to identify locations where solar and other DERs could increase the reliability and resilience of the electric grid.

This project is part of the **Solar Energy Innovation Network**, a collaborative research effort to explore new ways solar energy can improve the affordability, reliability, and resiliency of the nation's electric grid. NREL is operating the Solar Energy Innovation Network with funding from the U.S. Department of Energy Solar Energy Technologies Office.

www.cesa.org/projects/states-advancing-solar/multistate-initiative

Using Solar to Reduce Peak Loads: Evaluating Rhode Island's Distributed Solar Pilot

Webinar Speakers

- **Danny Musher**, Chief of Program Development, Rhode Island Office of Energy Resources
- **Shawn Shaw**, Principal, The Cadmus Group
- **Nate Hausman**, Project Director, Clean Energy States Alliance (moderator)

Overview of Rhode Island System Reliability Procurement Distributed Generation Pilot

Danny Musher, RI Office of Energy Resources

July 12, 2018

Rhode Island Office of Energy Resources

- OER is the lead state agency on energy policy and programs
- OER works closely with diverse partners to advance Rhode Island as a national leader in the clean energy economy

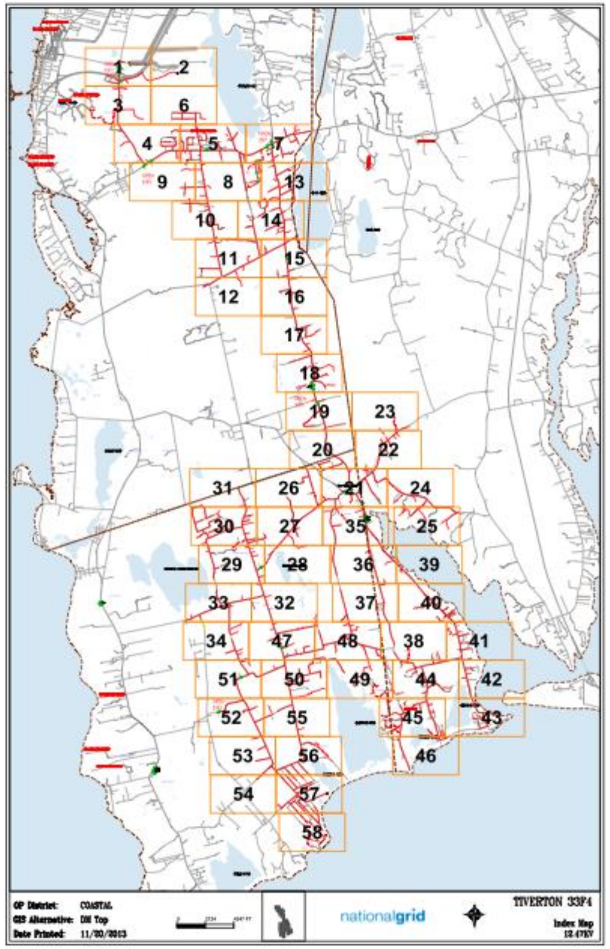
RI System Reliability Procurement (SRP) Pilot

Exploring whether reducing peak load can defer utility infrastructure investment

- Between 2012 and 2017, National Grid conducted an SRP "non-wires alternative" pilot in the towns of Tiverton and Little Compton

- The pilot targeted summer afternoon distribution system peak loads with energy efficiency and demand response programs

- Aimed at deferring a $2.93 million substation feeder



OER SRP Distributed Generation (DG) Pilot

Can solar be part of the peak reduction solution package?

- Starting in 2015, OER provided funds to support integration of solar PV into the SRP pilot

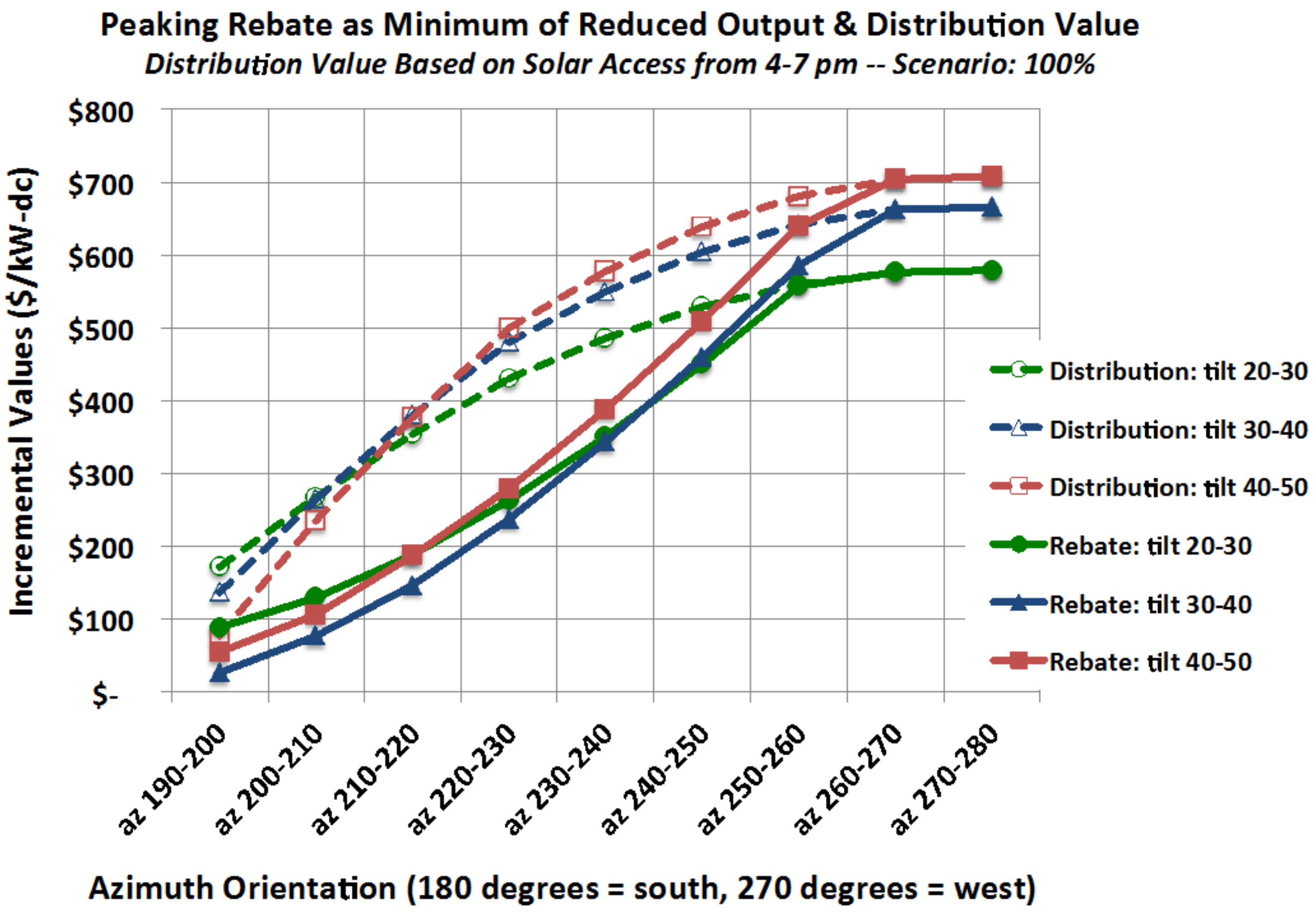
- Two implementation strategies:
  - Solarize initiative with incentives for west-facing solar
  - RFP for larger solar project

- **Goal: 520 kW nameplate to achieve 250 kW coincident peak reduction**

Solarize Initiative Approach

- Solarize incentives designed to enroll west-facing projects to meet late-afternoon peak

- Sliding-scale incentives offered for west-facing projects based on the minimum of:
    1. incremental value to distribution system or
    2. lost revenue as compared to a south-facing system



RFP Approach

- RFP eligible to projects bidding into the state's feed-in tariff program (Renewable Energy Growth Program)

- Competitively-awarded grants based solely on incremental costs to maximize projects' net benefit to distribution system
  - I.e., selected based on: (incremental $/kW deferral benefit) – ($/kW incremental cost bid)

Azimuth Orientation (degrees)	Pre-Calculated Incremental Distribution Value ($/kW-AC)
180-189	$ -
190-199	$ 195
200-209	$ 360
210-219	$ 519
220-229	$ 652
230-239	$ 752
240-249	$ 826
250-259	$ 881
260-269	$ 923
270	$ 953
1-axis	$ 1030
2-axis	$ 1140

Figure 3. Incremental distribution values for each solar configuration

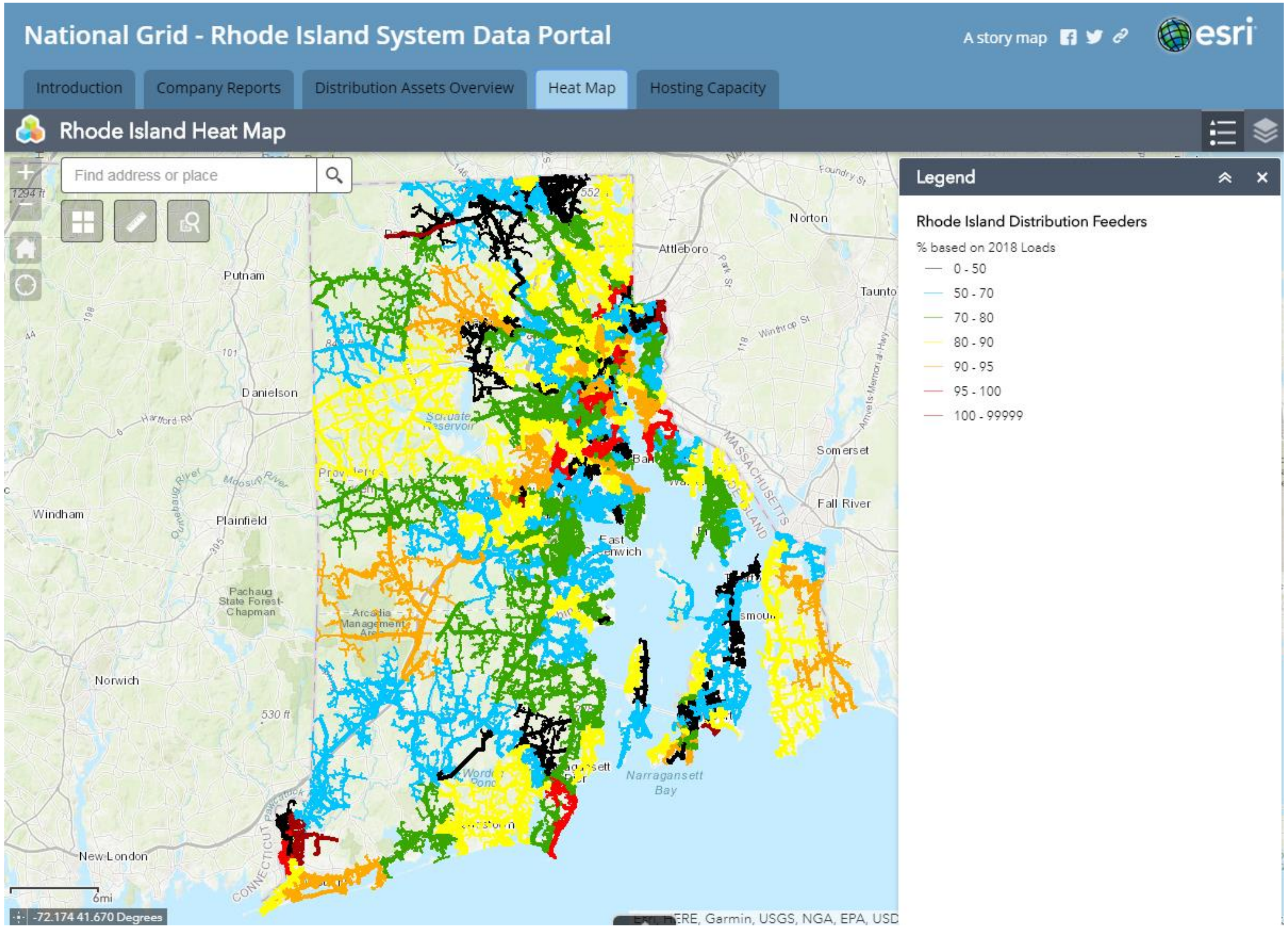
Results of Pilot

- Pilot enrolled 735 kW of solar DG, exceeding original goal of 520 kW
  - Solicitation: 250 kW single-axis tracking system awarded grant
  - Solarize: 67 customers signed contracts for 485 kW of capacity
- After attrition, final numbers were:

System Type	Number of Sites	Capacity (kW DC)
Little Compton Solarize	32	211.92
Tiverton Solarize	25	187.81
Grid Support Solar Field – single-axis tracking system	1	249.9
Total Installed	**58**	**649.63**

Future of non-wires and SRP in Rhode Island

- National Grid will make distribution system data accessible to third parties online
- National Grid will issue RFPs for load reduction on highly loaded feeders, shown on the System Data Portal



Thank You!

Danny Musher

Chief, Program Development

RI Office of Energy Resources

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State of Rhode Island Office of Energy Resources

Evaluation Results:

System Reliability Procurement DG Pilot

July 12, 2018

Shawn Shaw, P.E.

Your Presenter for Today

Distributed Energy Resources Team Lead at Cadmus

- Electric power systems engineer
- Joined Cadmus in **2004**
- **Specialties** include solar PV, solar thermal, and energy storage, with **focus** on technology design/installation practices, EM&V, and program support

About Cadmus

Since 1983

Energy and environmental consulting firm with 550 employees

35 years of experience consulting in energy industry

Leaders in solar, energy storage, and microgrid technologies

Experts on DER policies and planning, program design, and evaluation

Extensive Regional Expertise

Understand Regulatory Environment

Numerous public and private clients

Cadmus Markets & Services

- **Distributed Energy Resources**
- **Climate/Sustainability**
- **International Development**
- **Evaluation, Measurement, & Verification**
- **Planning & Market Analysis**
- **Energy Policy & Regulatory Support**
- **Strategic Communications**
- **High Performance Building Consulting**
- **Business Resilience**

Special Acknowledgements

Thanks to the following individuals and organizations

- Rhode Island Office of Energy Resources (OER) and Danny Musher for study funding and leadership
- Ryan Constable, Lindsay Foley, and Caleb George of National Grid for working closely with the study team to provide necessary feeder-level data and feedback on study findings
- Stephen Treat and James Kennedy of Cadmus - the project manager and lead data analyst, respectively, for the project

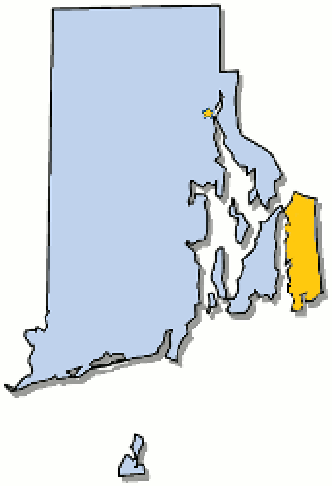
System Reliability Procurement

What Is It?

- In 2006, National Grid mandated to pursue “all cost-effective” energy efficiency resources before acquisition of additional electrical supply.
- Mandate required National Grid to develop a System Reliability Procurement (SRP) plan annually that considers a wide range of customer- and utility-sited energy resources.
- These resources may help to reduce peak loads on the electrical grid.
- National Grid must assess whether they can be deployed to avoid the use of expensive utility power plants and defer the investment of capital on infrastructure upgrades.

Measures in the SRP include:

- Smart thermostats and controls
- High efficiency lighting and HVAC
- Demand response



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System Reliability Procurement

Suite of Programs

Goal: Defer estimated $2.9M infrastructure upgrade

Programs include:

- EnergyWise
- Small Business Direct Install
- Demand Link (thermostats and plug devices)
- Demand Link (Central AC)
- Demand Link (Window AC)
- Window AC Rebate
- Window AC Recycling

The initial program did not include a DG component...which is where **OER** comes in

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OER DG Pilot

Adding Solar PV to the SRP

The Rhode Island OER partnered with National Grid to develop and offer a DG pilot program that addressed system capacity constraints in concert with demand response and energy efficiency measures already implemented.

Goal: Demonstrate 250kW demand reduction

Includes Two Elements:

Solarize Program: Targeted bulk purchasing program with marketing and logistical support, and targeted incentives for west-facing PV systems

250 kW Tracking PV: Tracking PV system that orients arrays towards the sun throughout the day

Who Is Involved?

Key Parties and Stakeholders in the DG Pilot

- Rhode Island OER – Program Administrator
- NGRID – Utility Partner
- Cadmus – Program Evaluator
- SolPower – Solarize Installer
- Local Residents – Program Participants
- Town Officials – Solarize Partners
- SmartPower – Solarize Marketing Support

Study Scope and Methods

In completing this two-year study, Cadmus was tasked with:

- **Data collection:** coordinate meter troubleshooting, dashboard development, and combining weather, utility SCADA, and PV generation data sources
- **Analysis:** PV system generation, feeder loading, and weather data for two summer seasons (2016 and 2017)
- **Process evaluation:** interview and survey program participants, Sol Power, OER, and other stakeholders to document program processes and outcomes

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Timeline

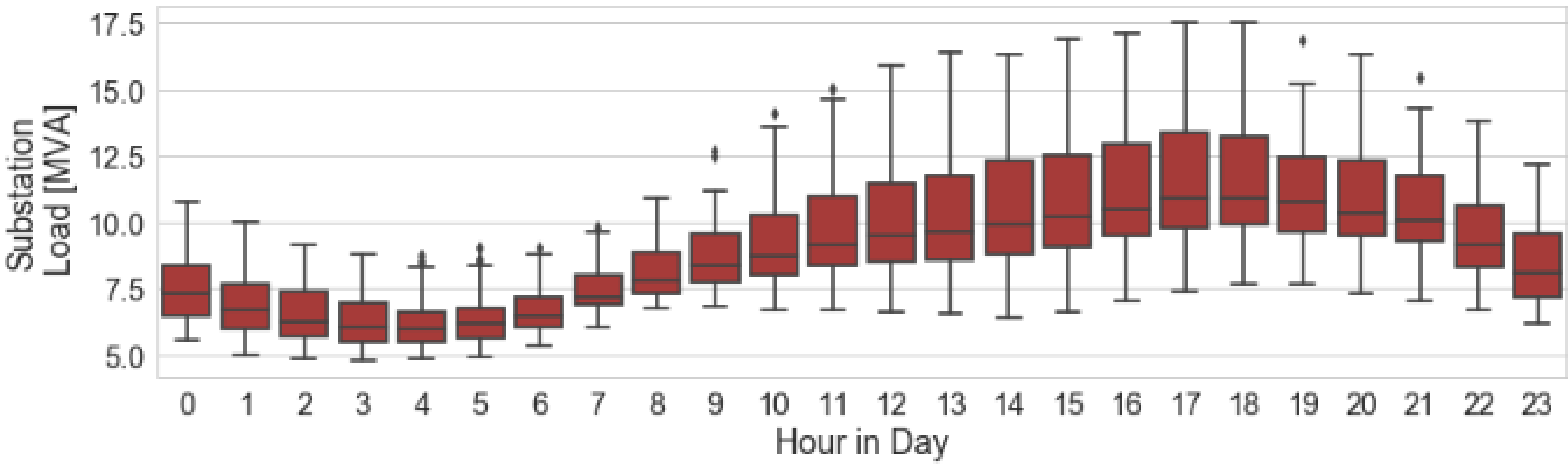
January 2015	Solarize Tiverton and Solarize Little Compton campaigns launch
February 2015	OER issues RFP for "Solar PV for Distribution Grid Support" for larger-scale PV system(s) in SRP pilot area
April 2015	"Solar PV for Distribution Grid Support" RFP awarded for single-axis tracking system
June 2015	Solarize Tiverton and Little Compton conclude
October 2015	Evaluation for the SRP DG pilot begins
Summer 2016	First full summer of PV production data (only Solarize installations)
July 2017	Single-axis tracker system begins operation
Summer 2017	Second full summer of PV production (Solarize installations and single-axis tracker)
May 2018	Evaluation for SRP DG pilot concludes

Definitions

- **Capacity Factor**: The ratio of actual energy produced by an energy generating unit or system in a given period, to the hypothetical maximum possible.
- **Coincident Hours**: Highest decile of hourly demands (i.e., top 10% of load hours)
- **Peak Hour:** The single highest energy consumption over an hourly interval during the summer
- **Peak Load:** Measure of total energy consumption during the Peak Hour

Loading on Constrained Feeders

Primarily Residential Circuits with Summer Afternoon and Evening Peaks



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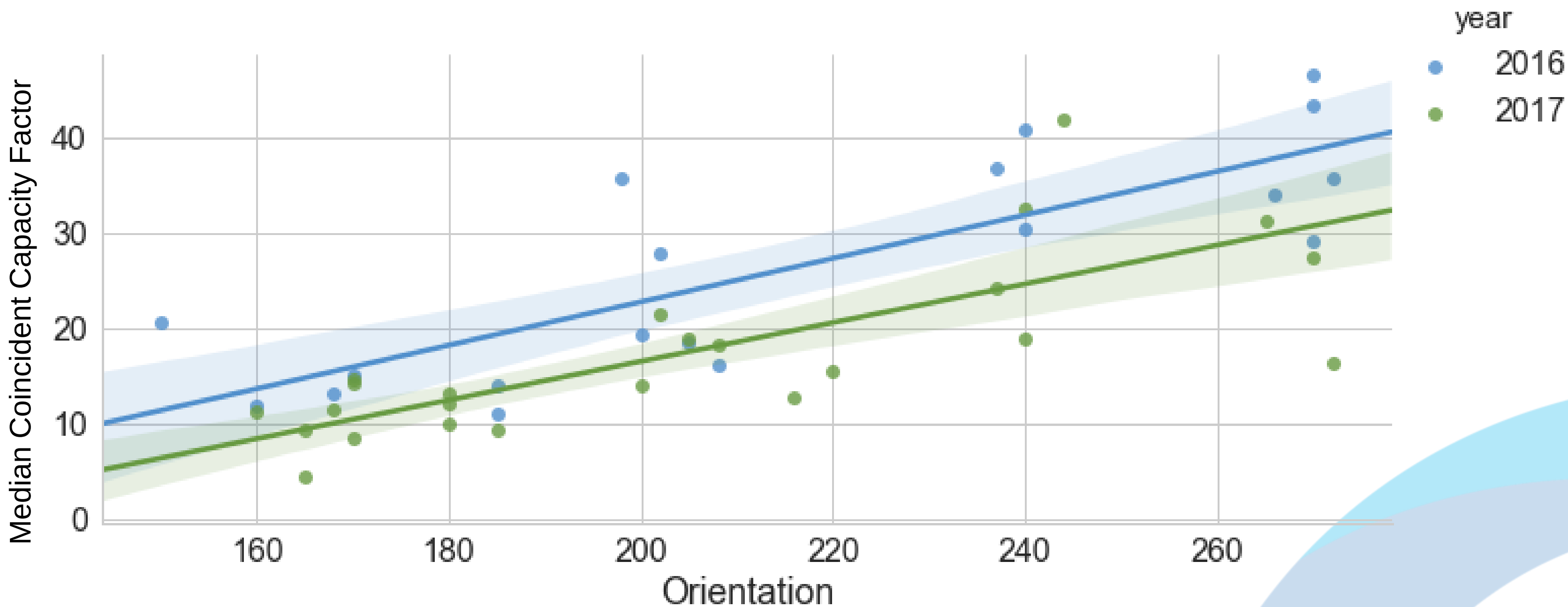
PV Orientation and Output

Orienting PV Arrays Westward Improved Coincident Peak Output

- As expected, array orientation made a significant difference in output during peak periods (17:00 - 19:00)
- Note that 2016 irradiance was higher than 2017 and unusually high in general
- As expected, west-facing PV arrays had ~10% less annual output



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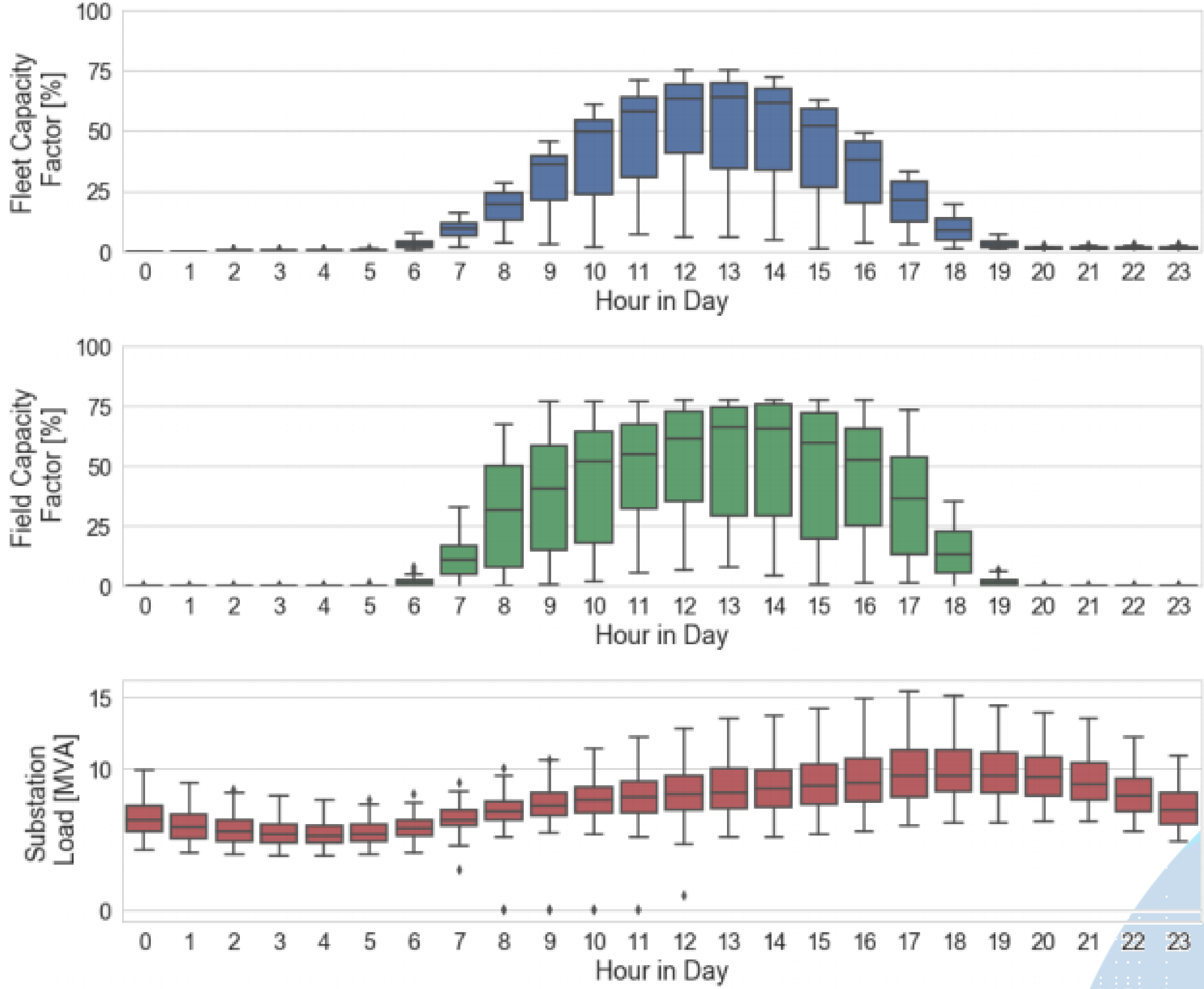
PV Generation and Feeder Loads

Hourly Profile-Summer 2017



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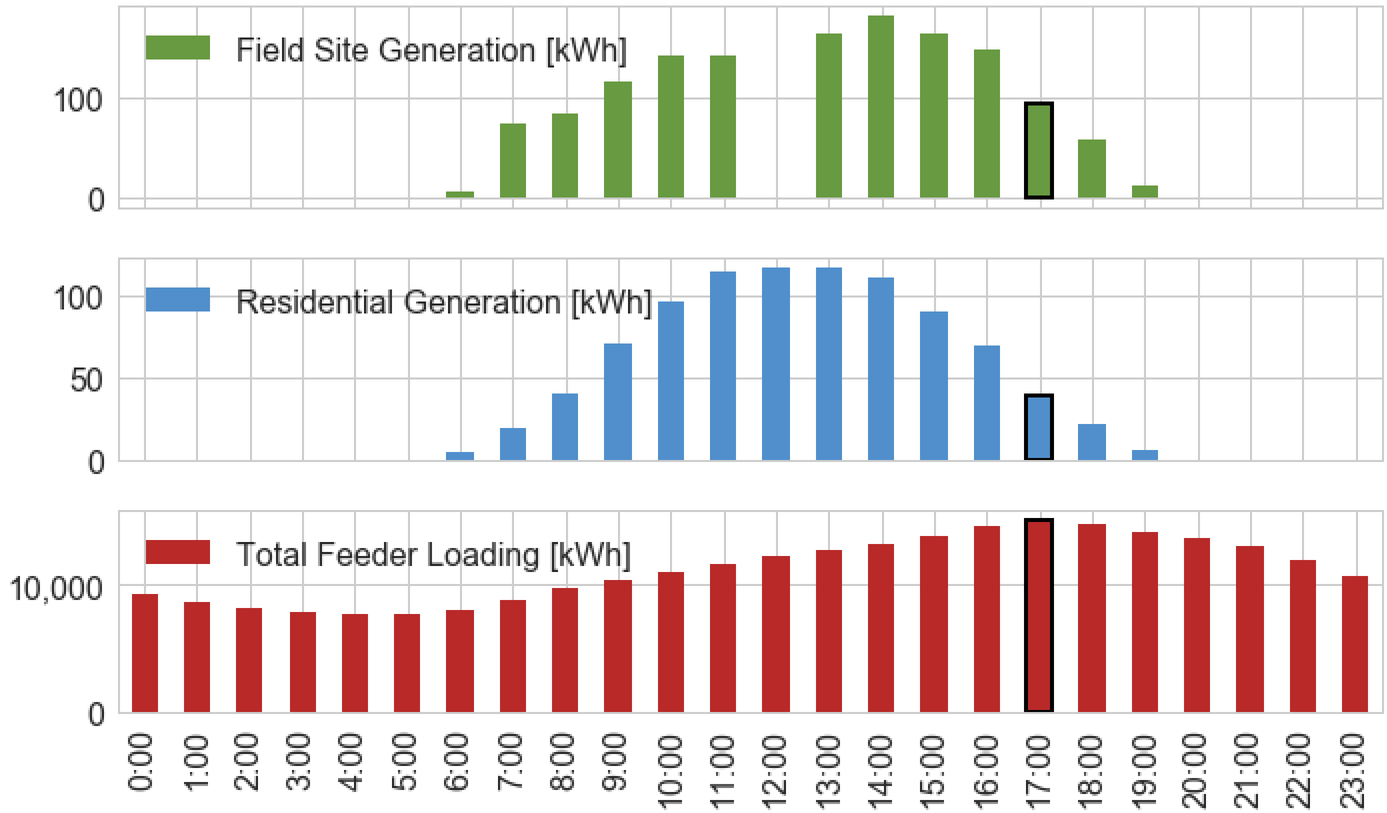
Coincidence of PV Generation and Load

Peak Hour Aligns Poorly with PV but Better Alignment Over Broader Range of High Loading Hours



- Peak hour 17:00 - 18:00 on June 21, 2017
- PV fleet generating < 50% peak output during this time
- However, over half of the highest load hours occurred between 15:00 - 20:00

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PV Systems Reduce Peak Demand

Results Depend on Orientation

- Average demand reduction based on orientation and system capacity
  - **0.21 kW** demand reduction per kWdc **south-facing PV**
  - **0.28 kW** demand reduction per kWdc **west-facing PV**
  - **0.32 kW** demand reduction per kWdc **single-axis tracking PV**

System Type	Orientation	Summer 2016				Summer 2017			
		Monitored Installed Capacity, kW-DC	Coincident Capacity Factor, kW-AC/ kW-DC	Mean Coincident Power Output, kW-AC	Coefficient of Variance for Coincident Power Output	Monitored Installed Capacity, kW-DC	Coincident Capacity Factor, kW-AC/ kW-DC	Mean Coincident Power Output, kW-AC	Coefficient of Variance for Coincident Power Output
Roof-Mounted	South	58.7	27%	16.1	94%	87.5	21%	18.1	122%
	South-west	39.2	31%	12.1	85%	60.1	26%	15.8	96%
	West	31.8	33%	10.6	80%	30.1	28%	8.6	90%
Ground-Mounted	Single Axis	n/a	n/a	n/a	n/a	249.9	32%	80.1	93%
Total Measured		129.7	30%	38.8	87%	427.6	28%	121.3	95%
Extrapolated to Program*		395.2	30%	117.0	n/a	645.0	27%	174.4	n/a

Concerning Variability

Are PV Savings “Reliable”?

- Measured by coefficient of variability (CV)

$$CV = \frac{Standard\ Deviation\ (\sigma)}{Sample\ Mean}$$

- Understanding Results
  - Lower values = more certainty/less dispersion
- Findings
  - South facing fleet least variable for annual savings (CV=122%)
  - West facing fleet least variable for peak savings (CV=90%)
  - Solar field CV relatively low but higher than west facing systems’ (CV=93%)
  - Timing of peak also has a major impact on coincident savings but CV was lower in 2016, when mean was also lower
    - Overall CV (2016): 87%
    - Overall CV (2017): 95%

Demand Reduction Costs with Solar PV

Cost-Effectiveness in the Eye of the Beholder

- South-facing systems already seen as cost-effective and are low-hanging fruit
- Expanding to include west-facing systems comes at a premium, with incentives out-pacing better coincident performance
- Renewable Energy Fund loosened requirements to allow west-facing systems to qualify, likely driving participation at least as much as SRP incentive

System Type	Orientation	Number of Systems Received SRP	SRP Incentive Only		Total Incentive (SRP + REF)	
			Given to System Owners per PV Capacity Installed [$/kW-DC]	Cost to Reduce Coincident Load [$/kW-AC]	Given to System Owners per PV Capacity Installed [$/kW-DC]**	Cost to Reduce Coincident Load [$/kW-AC]
Roof-Mounted	South	3	$70	$337	$1120	$5400
	Southwest	12	$278	$1055	$1360	$5160
	West	16	$480	$1683	$1490	$5224
Ground-Mounted*	Single Axis	1	$740	$2310	$740	$2310

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Getting to 5% Demand Reduction

Scaling Up Solar and Storage

- Extrapolating performance of DG Pilot, achieving a 5% demand reduction (0.6MW) would require:
  - $3 to $3.1M in total incentives (SRP + REF) for residential systems
  - $1.3M in incentives for 1-axis tracking PV system(s)
- Modeled generic Li-Ion centralized energy storage system as alternative to provide load relief (768 kW and 1.54 MWh), equivalent to:
  - Approximately 150 to 200 residential systems
  - 3x 250kW four-hour bulk energy storage systems

Process Worked Well but Some Lessons Learned

- Communications around tilt, orientation, and shading incentive impacts should be kept simple and clear
- Potential Solarize customers were more responsive to simple pitches that did not have too many details about the pilot
- Project developer (Econox) had difficulty financing the single-axis tracking PV system
- Solarize programs in Tiverton/Little Compton were successful, with good conversion rates (19%-22%) and helping Sol Power expand their presence and build business
  - Campaigns occurred in the fall, after many summer residents had left, or results may have been even better
- The tools provided to Sol Power for calculating incentives were ultimately useful, but there were initial challenges in understanding and completing the incentive calculations correctly

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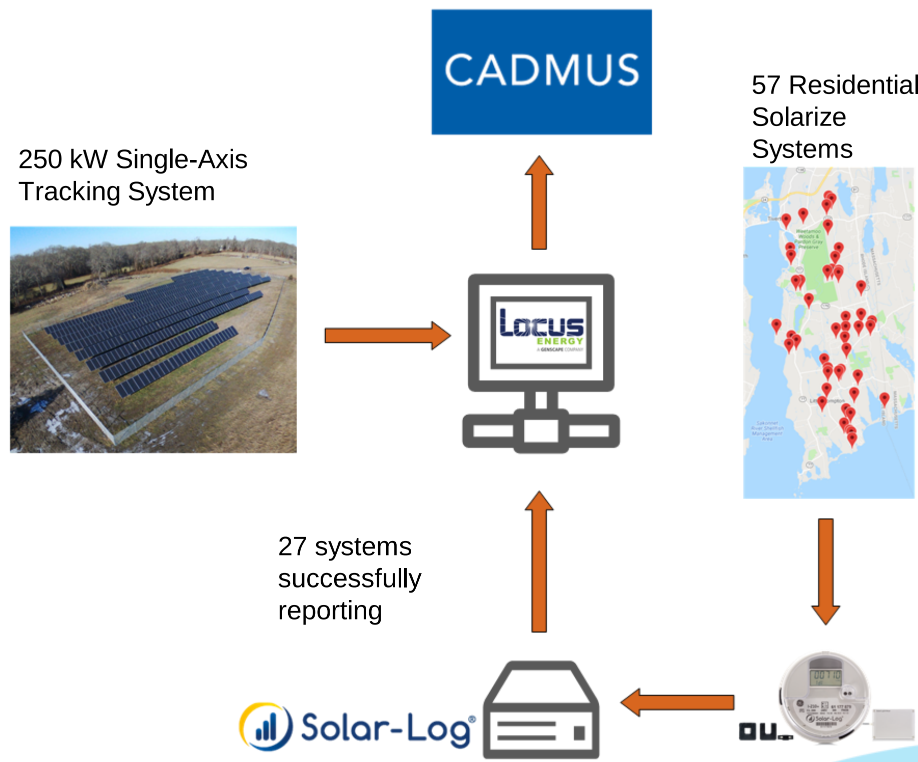
Evaluation Challenges

Metering: A Major challenge that Reduced Sample Size/Caused Significant Delays

- Of the 57 systems installed as part of the DG Pilot, 19 were consistently reporting in 2016, and 27 in 2017
  - All residential Solarize systems used Solar-Log production meters and DAS equipment.
  - The data was aggregated on Solar-Log servers and pushed to OER’s Locus database daily
- 250 kW single-axis tracking system encountered development challenges that delayed interconnection until early July 2017
  - The 250 kW single-axis tracking system used a Locus DAS system and reported directly to the Locus server



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Conclusions

- Though it fell short of reducing peak demand (highest load hour) by 250kW, the pilot did reduce demand by 182.1 kW for the 2017 peak.
- Demand reduction benefits are variable and highly dependent on timing of peaks. Late afternoon/early evening peaks are non-coincident with even west-facing PV generation.
- Solarize program was successful, even during low occupancy period in a region with many summer residents.
- West-facing systems produced approximately 50% more electricity than south-facing systems during 17:00 - 19:00 peak hours, but about 10% less on an annual basis.
- Achieving demand reduction with solar PV can be cost-effective compared to some large infrastructure improvements.

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Considerations for Future Programs

- Coordinate demand reduction program with other available incentives
  - Carefully review program requirements (e.g., TSRF)
  - Solarize, or similar, recruitment efforts make the most of those participants by increasing conversion rates and lowering overall costs
- Optimize incentive levels for their purpose
  - Targeted incentives (e.g., for west-facing systems) can expand the pool of potential participants to include those that would not normally be cost-effective for residential PV
  - Avoid free-riders (i.e., paying for systems that would be installed anyway)
  - PV customers may also be ripe for other demand response or energy efficiency measures
- Metering cannot be taken for granted
  - PV installers are not metering technicians
  - Add training, support, and/or incentives for good metering data to make it a priority
- Diversity of resources can support grid reliability
  - Energy storage presents a promising opportunity
  - DG can potentially reduce need for infrastructure and demand response calls

Thank You

Shawn Shaw, P.E.

PRINCIPAL

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“System Reliability Procurement Distributed Generation Pilot Evaluation Report” is available at: http://www.energy.ri.gov/electric-gas/future-grid/oer-system-reliability-solar.php

Thank you for attending our webinar

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