Solar Siting Opportunities for Rhode Island

Performed on behalf of
Rhode Island Office of Energy Resources

August 18, 2020

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Logistics

Logistics

- This webinar is being recorded
- Everyone has been muted by default
- Webinar timing:
  - 1:30 to 1:40 – Logistics and background
  - 1:40 to 3:00 – Presentation of methodology and results
  - 3:00 to 3:30 – Q&A

If you have questions, please submit them using the "Chat" feature. We will pause at least once mid-presentation to answer submitted questions.

Agenda

- Webinar logistics and introduction
- Background
- Methodology
- Solar potential results
- Caveats to solar potential analysis
- Solar integration topics
- Incentives for non-conventional solar in neighboring states
- Questions

Background

Synapse Energy Economics

- Founded in 1996 by CEO Bruce Biewald
- Leader for public interest and government clients in providing rigorous analysis of the electric power sector
- Staff of 30 includes experts in energy and environmental economics and environmental compliance

Recent relevant work

- Getting SMART (2019)
  - Evaluated impacts of recent distributed solar policies in MA, on behalf of Cape Light Compact
  - Analyzed and described regulations aimed at incentives for non-greenfield solar
- Avoided Emissions and Generation Tool, aka "AVERT" (2014-2019)
  - Conducted GIS analysis on behalf of U.S. EPA
  - Developed hourly solar and wind profiles that can be used to quickly estimate marginal emissions impacts on the electricity grid
- Future of Solar PV in the District of Columbia (2019)
  - Evaluated feasibility, projections, and rate impacts of the District's expanded RPS on behalf of DC OPC
  - Geospatial analysis of rooftop and parking lot solar; looked at community and private solar and solar potentials by Ward

Project Purpose

- Estimate total, technical, and economic potentials (in MW) for PV systems on the following areas:
  1. Rooftops – residential single family, residential multifamily, commercial, industrial, municipal, and other
  2. Landfills
  3. Gravel pits
  4. Brownfields
  5. Undeveloped and developed commercial and industrial parcels
  6. Parking lots / carports
- Provide estimates of solar costs and GHG reduction impacts
- Provide summary of what other neighboring states have done to promote solar PV development and balance other land use interests
- Provide background summary on current PV policies in RI

Note: We did not evaluate any potential for ground-mounted solar on residential or agricultural parcels

Project Approach and Data Sources

- Identify suitable areas for solar development using geospatial analysis in GIS software
- Convert areas into capacity potential (MW), energy potential (MWh), and avoided greenhouse gases (GHGs, measured in million metric tons or MMT) using spreadsheet post-processing

Source	Dataset(s)
RIGIS clearinghouse	Building footprints
RI Town/City Governments	Parcel and zoning data
RI Commerce Corporation	REF program existing solar installations and costs
National Grid	Net metering projects by town; REG, VNM, and distributed generation contracts; limited hosting capacity data
Local solar developers	Incremental cost data and siting considerations for non-traditional sites
U.S. EPA's AVERT Tool	Avoided emissions factors
University of Rhode Island	Prior landfill analysis data
RI Housing	U.S. Census data
RI OER	Solar policy data
RI DEM	Brownfield and landfill locations
U.S. Geological Survey	Gravel pit locations
NREL	Packing factors; capacity factors

Project Outreach

- Conducted a kickoff meeting to frame the analysis and solicit feedback and data; issued project update to stakeholders to elicit more feedback
- Communicated with town planners and state agencies
- Discussed existing solar data with OER, National Grid, and RI Commerce Corporation
- Surveyed solar developers on Rhode Island-centric data relevant to siting solar at the categories of interest
- Compared analysis relative to other recent or ongoing studies in Rhode Island (e.g., Dunksy RI Market Potential Study for OER, studies at University of Rhode Island)

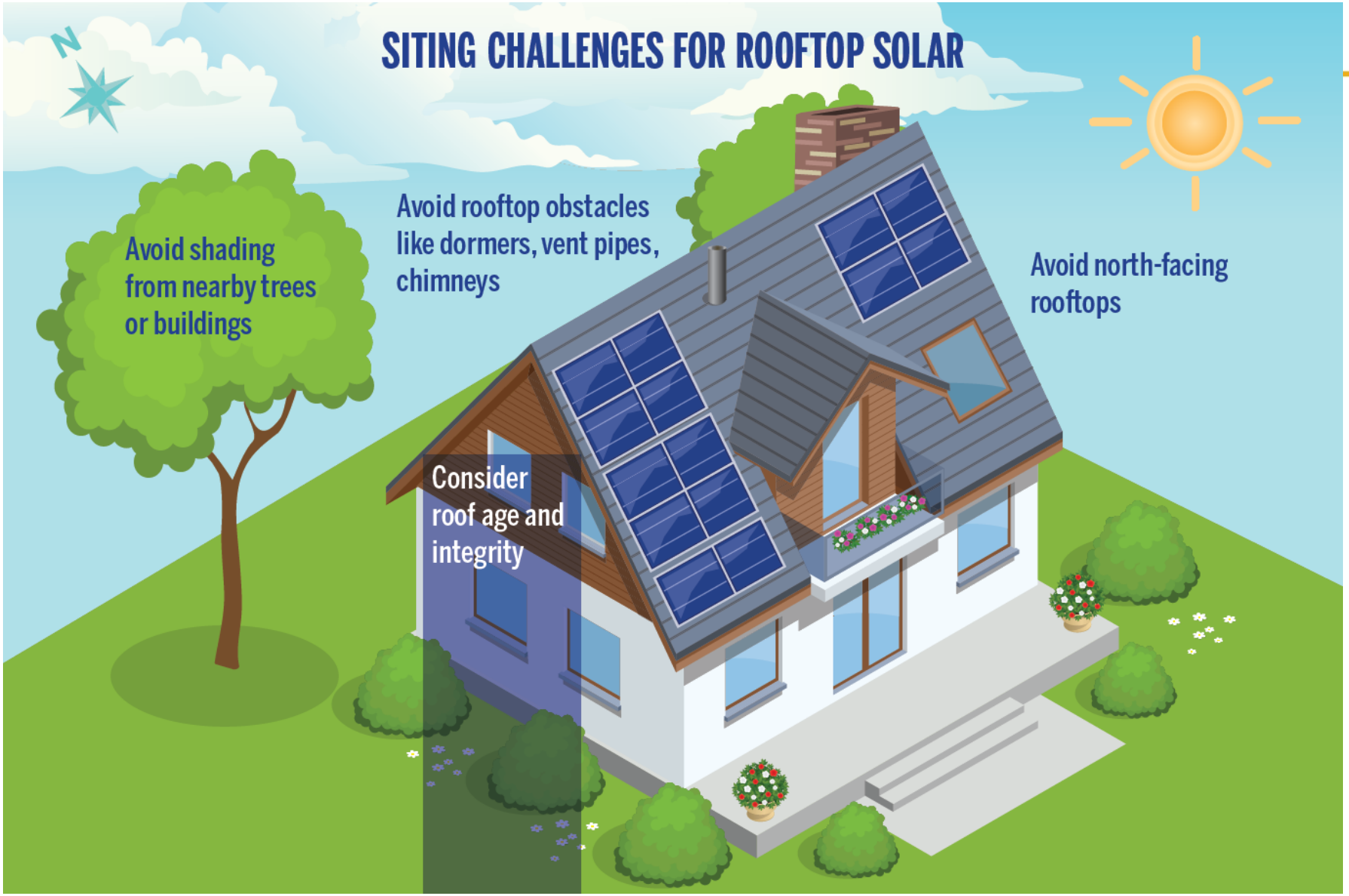
What is solar "potential"?

- We evaluate three different types of potentials in this analysis:

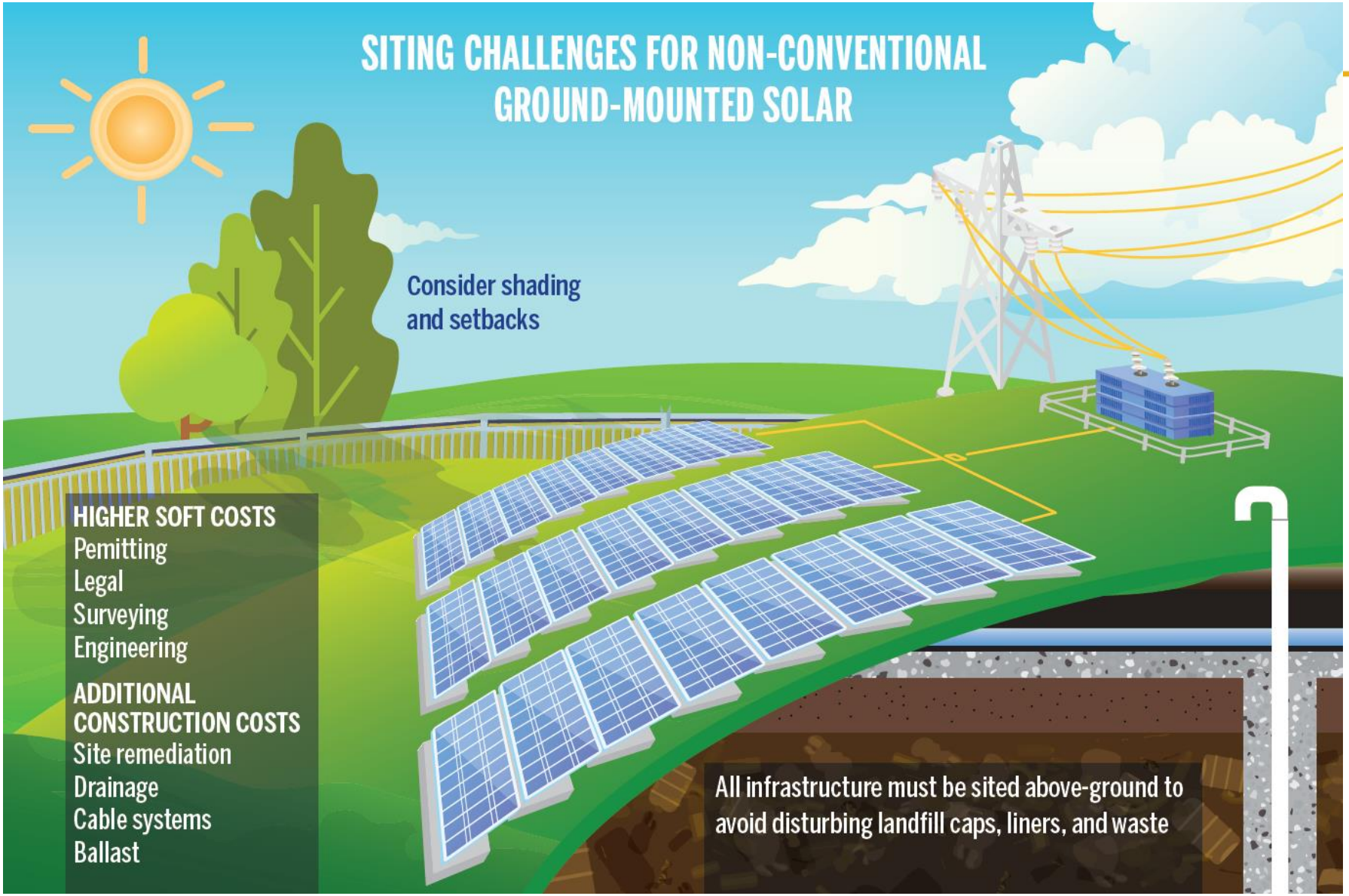
Potential Type	Description
Total	The entire area under consideration for solar PV, excluding areas with existing solar installations through Fall 2019. We evaluate total potential for every solar category.
Technical	A subset of total potential, evaluated after removing areas not technically suitable for solar development. We evaluate technical potential for every solar category. *Examples of "unsuitable" areas include those that are too close to adjacent parcels, roof areas that are shaded or have obstructions, land areas currently occupied by wetlands, or steeply-sloping land.*
Economic	A subset of technical potential that evaluates the amount of solar that is likely to be installed. We evaluate economic potential only for residential rooftops. *This accounts for the current cost of the technology, the current financial incentives available, and the household economics specific to a municipality.*

What is solar “potential”? (cont.)

- Importantly, there are not “bright-line” distinctions between each category. Instead, there is a spectrum.
  - For example, many installations could be technically achievable with enough money (e.g., you can build new feeders, get a new roof, or move HVAC systems).
  - Likewise, economic potential depends on the current state of technology and policies. With different technology prices and policies, our estimate of economic potential could be different.
- Wherever possible, we have strived to present potentials for all categories on an apples-to-apples basis, so that technical potential for landfills (for example) is comparable to technical potential for gravel pits.
- For most categories, we present ranges of results. The purpose of these ranges are to reflect the uncertainty in some of the key drivers of our potential calculations.



These challenges may reduce the "technical potential," relative to the "total potential."



These challenges may reduce the "technical potential," relative to the "total potential."

Solar Installations to-date in RI

Program	Subprogram	Total installations	Total MW-DC
Rooftop	Residential	7,341	51
Rooftop	Commercial	208	24
Ground	All	163	74
Other (carports, brownfields)		10	13
Total		**7,722**	**162**

- All data is up-to-date through Fall 2019. Data shown only includes installed projects, not planned or cancelled projects.
- Data covers all projects in the following programs: REF, REG (Small), REG (Medium, Large, and Commercial), VNM, Distributed Generation Contracts Program, 30 MW pilot, and earlier non-programmatic net metering.

Methodology

Rooftop Solar Approach

- **Total Potential:** Used building footprint data to estimate rooftop area. Used parcel and zoning data (provided by towns and cities) to assign each building footprint to one of seven different building subcategories and one of three building sizes (small, medium, and large).

Rooftop Subcategories

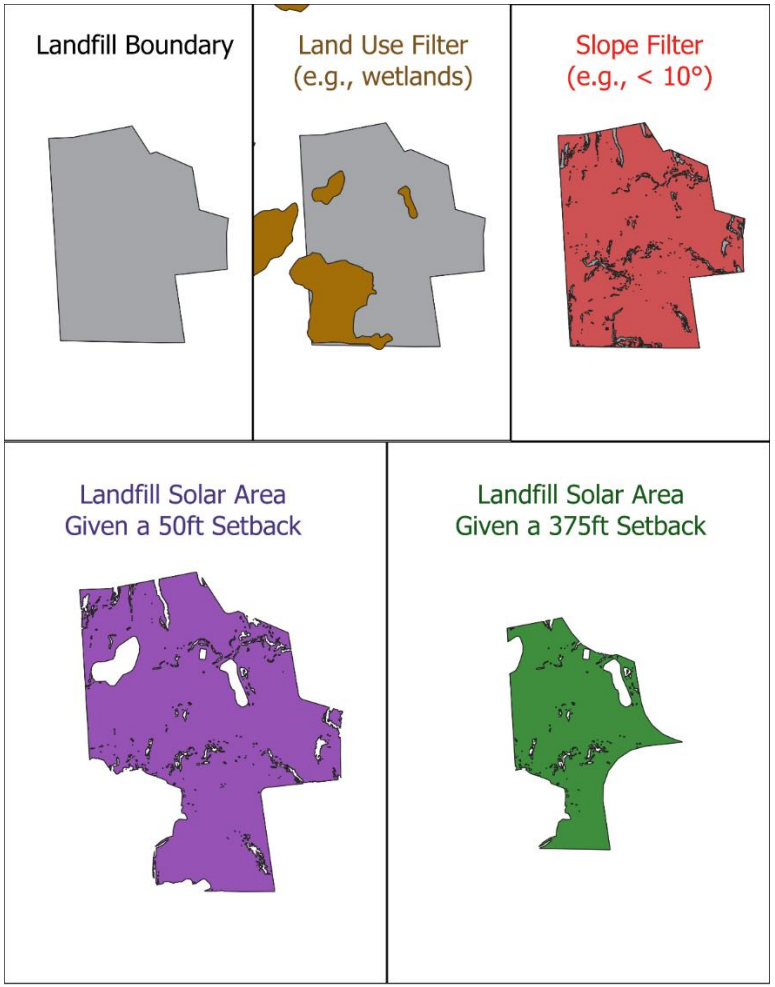
Residential single family	Municipal
Residential multi-family	Mixed use
Commercial	Other
Industrial	

- **Technical Potential:** Scaled total potential values based on share of rooftop space that is suitable for solar, relative to total rooftop area (NREL 2016) to estimate MW.
- **Economic Potential:** For residential rooftop solar only, we developed low and high estimates for economic solar potential. The low and high estimates are bounded by three different variables: (1) Range of $/Watt solar costs, (2) REF or REG incentives, and (2) range of median household income according to US Census data. The solar cost and incentive data are used to estimate a range of paybacks, which are used to estimate market penetration. Income level for each town (relative to statewide average) is used to scale potential adoption for each municipality.

Ground-Mount: Landfill Solar Approach

- **Total Potential:** Relied on geospatial data of landfills from URI (compiled for previous 2011 solar potential study).
- **Technical Potential:** Removed all building footprints. Removed areas identified as non-buildable land types (e.g., wetlands, water, recreational areas, roads) and land with gradients larger than 10°. Removed all land within 50 feet of all building footprints to account for shading and maintenance. Analyzed two different setbacks from parcel edges (50 and 375 feet) to account for shading from neighboring trees, and to approximate zoning setback requirements.

Example of total potential to technical potential screening



Ground-Mount: Gravel Pit Solar Approach

- **Total Potential:** We utilized USGS point data for the 13 sand/stone/gravel pits in RI to identify gravel pit locations, then used municipal parcel data to assign parcels to each of the gravel pit locations. For towns without GIS parcel data, we created an estimated polygon for the gravel pit parcel using satellite data.
- **Technical Potential:** Applied same GIS filter approach as for landfills (wetlands, slope, building and property line setbacks).

Ground-Mount: Brownfield Solar Approach

What is a Brownfield?

According to RI DEM, brownfields are property where expansion, redevelopment, or reuse of the property might of which may be complicated by the presence or potential presence of a hazardous substance, pollutant, or contaminant. Brownfields can be any type of property, including commercial, industrial, or residential properties.

- **Total Potential:** RI DEM provided a dataset detailing over 700 remediated brownfields throughout the state, including data with addresses and brownfield size. We cleaned this address data and successfully matched about one-third of all brownfields to parcels in the town/city geospatial data. For those that didn't match to an address in GIS, we manually added the 14 largest brownfields. After converting to MW, we subtracted capacity from existing brownfield installations.
- **Technical Potential:** Same GIS filter approach as for landfills and gravel pits (wetlands, building and property line setbacks), except for slope.

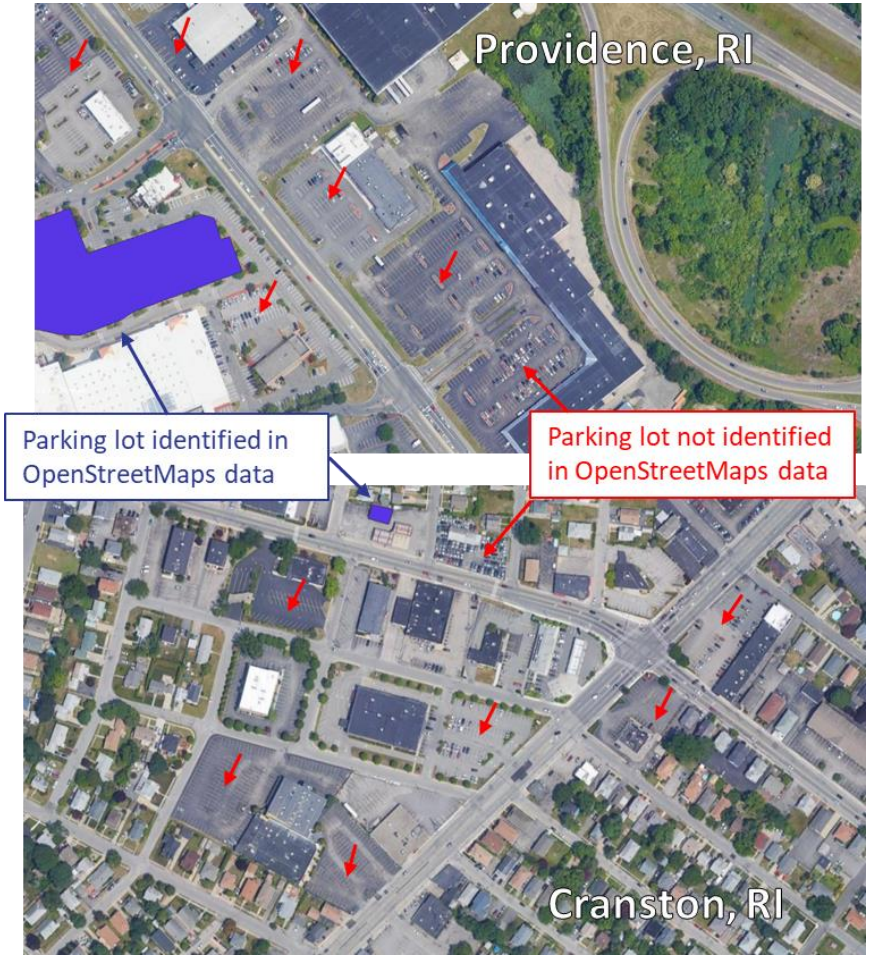
Ground-Mount: Commercial and Industrial Approach

- **Total Potential:** Used parcel and zoning data provided by towns and cities to identify parcels as being used for industrial or commercial purposes. After converting to MW, we subtracted capacity from existing C&I ground-mounted solar installations.
- **Technical Potential:** Removed areas identified as non-buildable land types (e.g., wetlands, water, recreational areas, roads). Removed all buildings and land within 50 feet of all building footprints to account for shading and maintenance. Analyzed two different setbacks from parcel edges (50 and 375 feet) to account for shading from neighboring trees, and to approximate zoning setback requirements.

Note: Rooftop solar on existing commercial and industrial buildings were separately examined under the "rooftop" category.

Parking Lot Carport Solar Approach

- **Total potential:** We use a crowdsource-generated shapefile obtained from OpenStreetMaps.com (OSM) to identify a subset of the parking lots throughout Rhode Island. We performed a series of spot checks for different-sized municipalities to estimate the parking lot area not included in the OSM dataset. After converting to MW, we subtracted capacity from the few existing carport solar installations.
- **Technical potential:** We screened out all building footprints and screened out any areas within 50 feet of a building.
  - Existing data on carport solar is currently very limited. For this analysis, we had access to detailed data at two installations that existed as of Fall 2019. By Summer 2020, there were roughly half-dozen installations in Rhode Island.
  - Because of the limited number of in-state installations, assumptions on capacity factor and kilowatts-per-square-kilometer were instead based on conventional ground-mounted solar installations solar data. Actual values for parking lot solar installations may be different.



Converting Solar Areas to MW / MWh Potentials

- **MW Potential:** We converted each category's area values into MW potential using appropriate capacity density values using rooftop and ground-mounted data from NREL (NREL 2016a and NREL 2016b).
- **MWh Potential:** We converted each category's MW capacity potential into generation values using capacity factors appropriate for each category of solar. For ground-mount and carport solar we apply a 20% capacity factor (NREL 2016b). For rooftop solar, capacity factors are applied depending on the size and location (city/suburb) of the buildings, ranging from 13.7% to 16% (NREL 2016a).

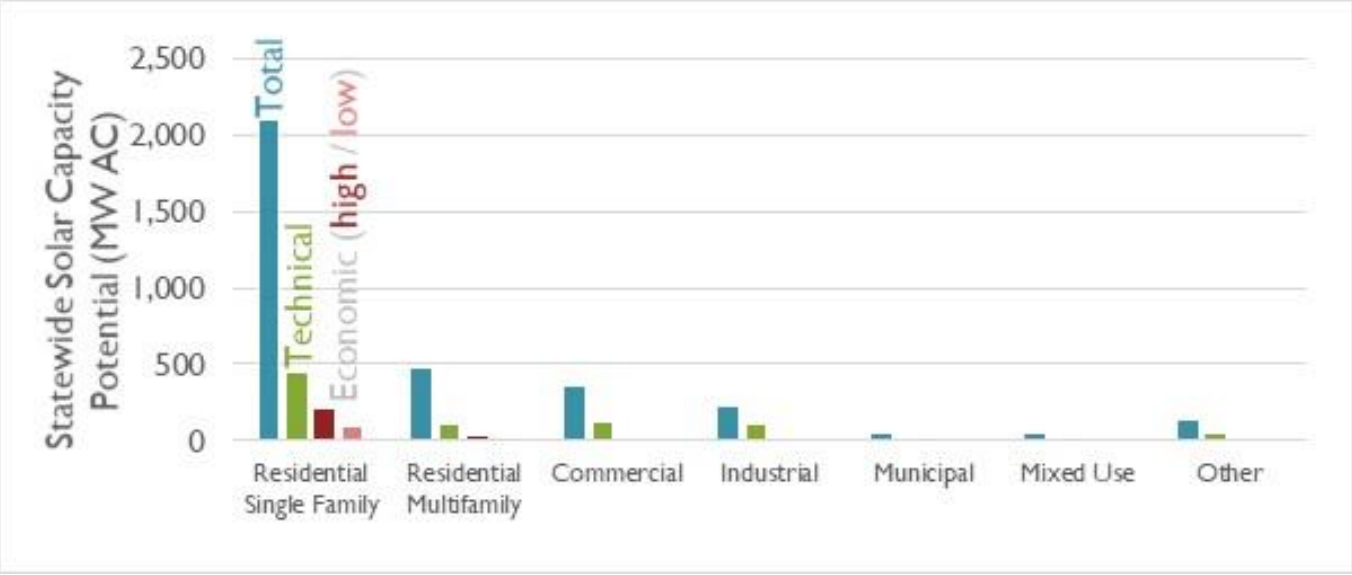
Sources:
NREL 2016a: "Rooftop Solar Photovoltaic Technical Potential in the United States"
NREL 2016b: "Estimating Renewable Energy Economic Potential in the United States: Methodology and Initial Results"

Pause for questions

Solar Potential Results

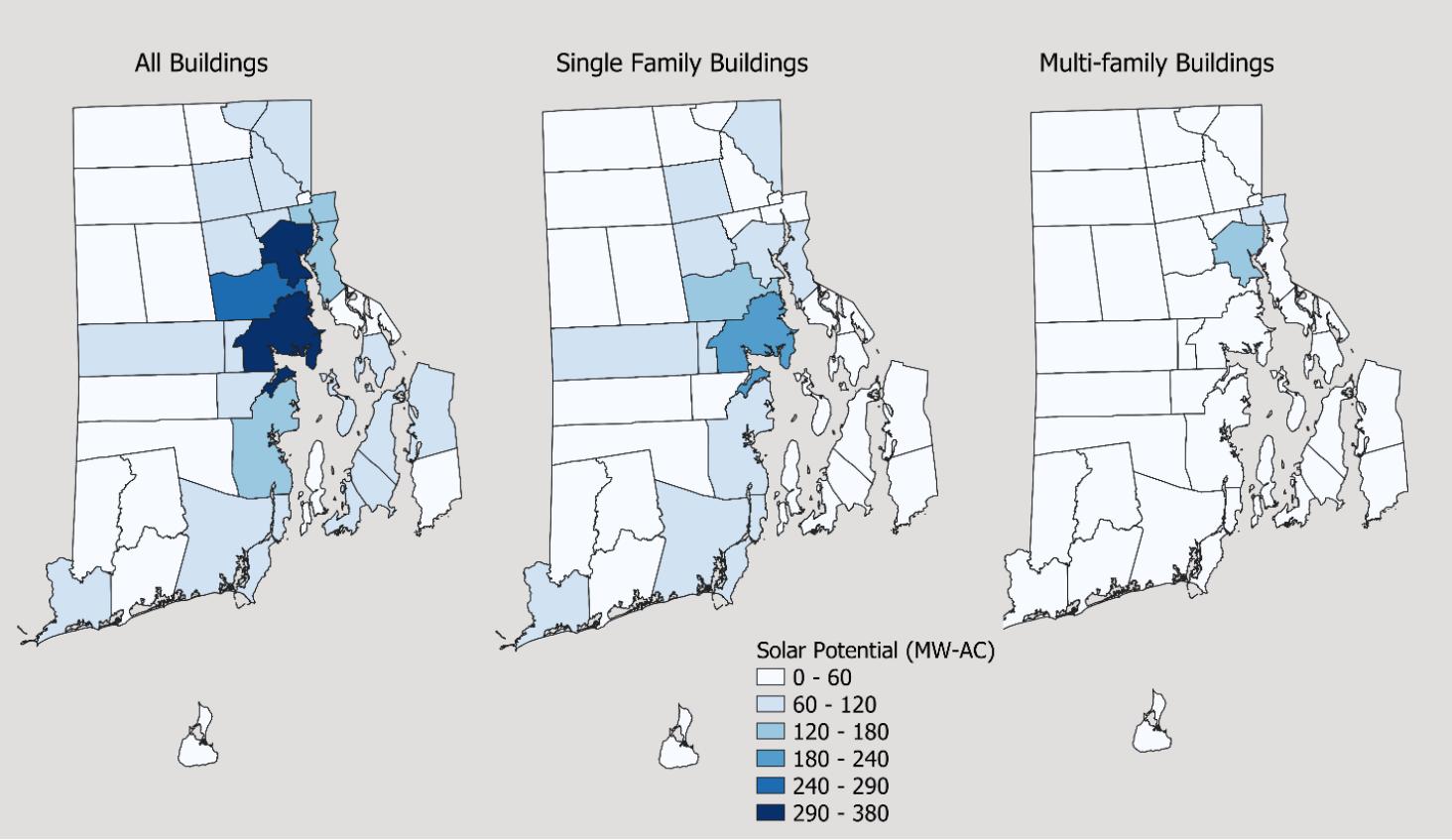
Rooftop Solar Results

- Statewide, there is a total potential of about 3,400 MW AC, with nearly half of that in the Residential Single-Family category.
- Statewide totals are in line with analysis from NREL 2016
- Technical screening reduces total potential to 25% of original estimate, 850 MW
- We analyzed a total of 367,000 rooftops statewide.
- Based on the application of screening values from NREL (2016):
  - 3-5% of residences are not suitable for any solar (around 12,900 households)
  - Screening takes into account rooftop geometry, shading, rooftop obstacles (e.g., HVAC), and other factors



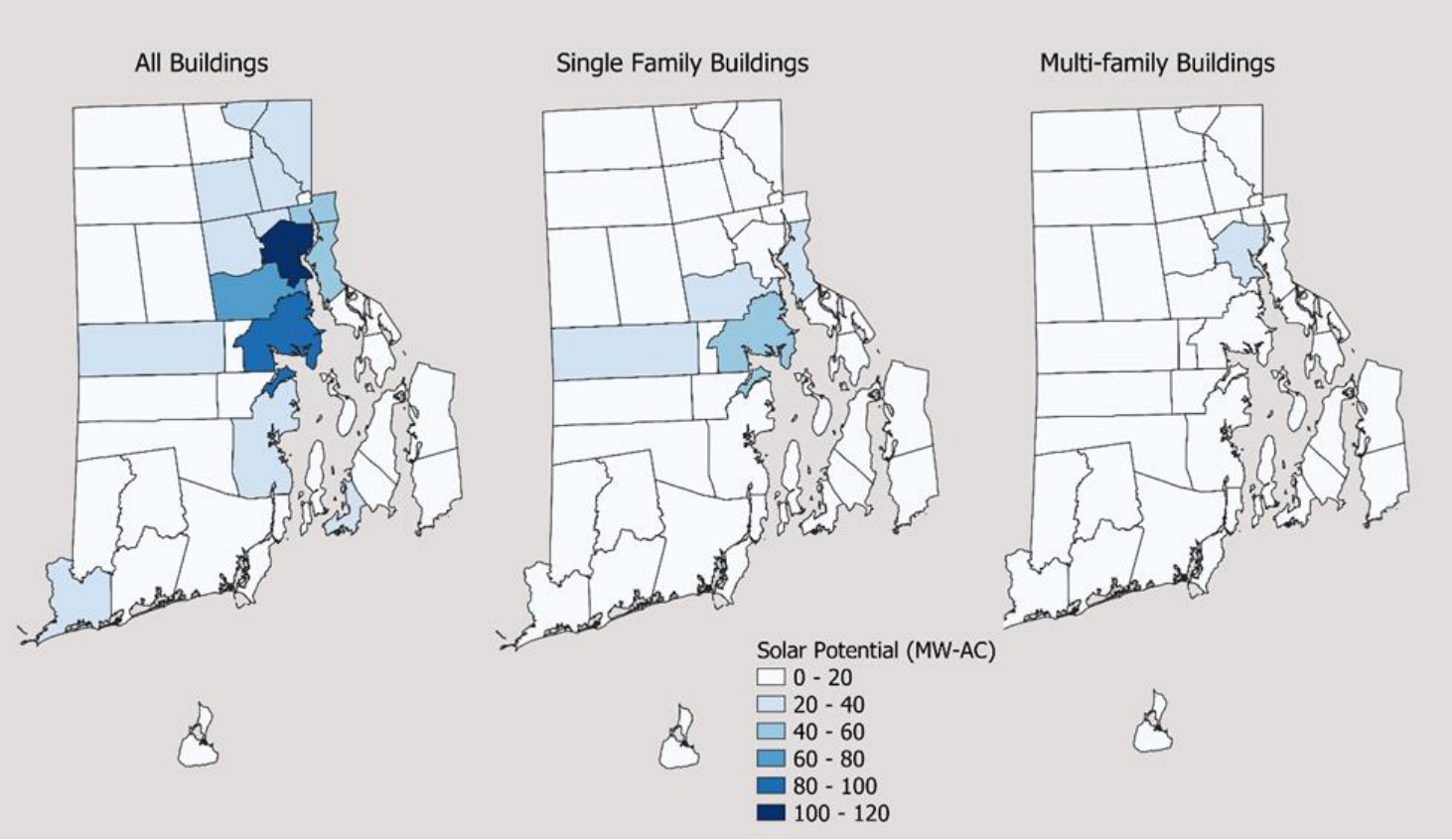
Rooftop Solar Results: Total potential for residential buildings

- All towns have at least 13 MW (total potential) for rooftop solar. The average town has about 90 MW (total potential) of rooftop solar.
- Generally, if a town has more buildings, it has more rooftop solar potential.
- The largest potential rooftop category is residential single-family.



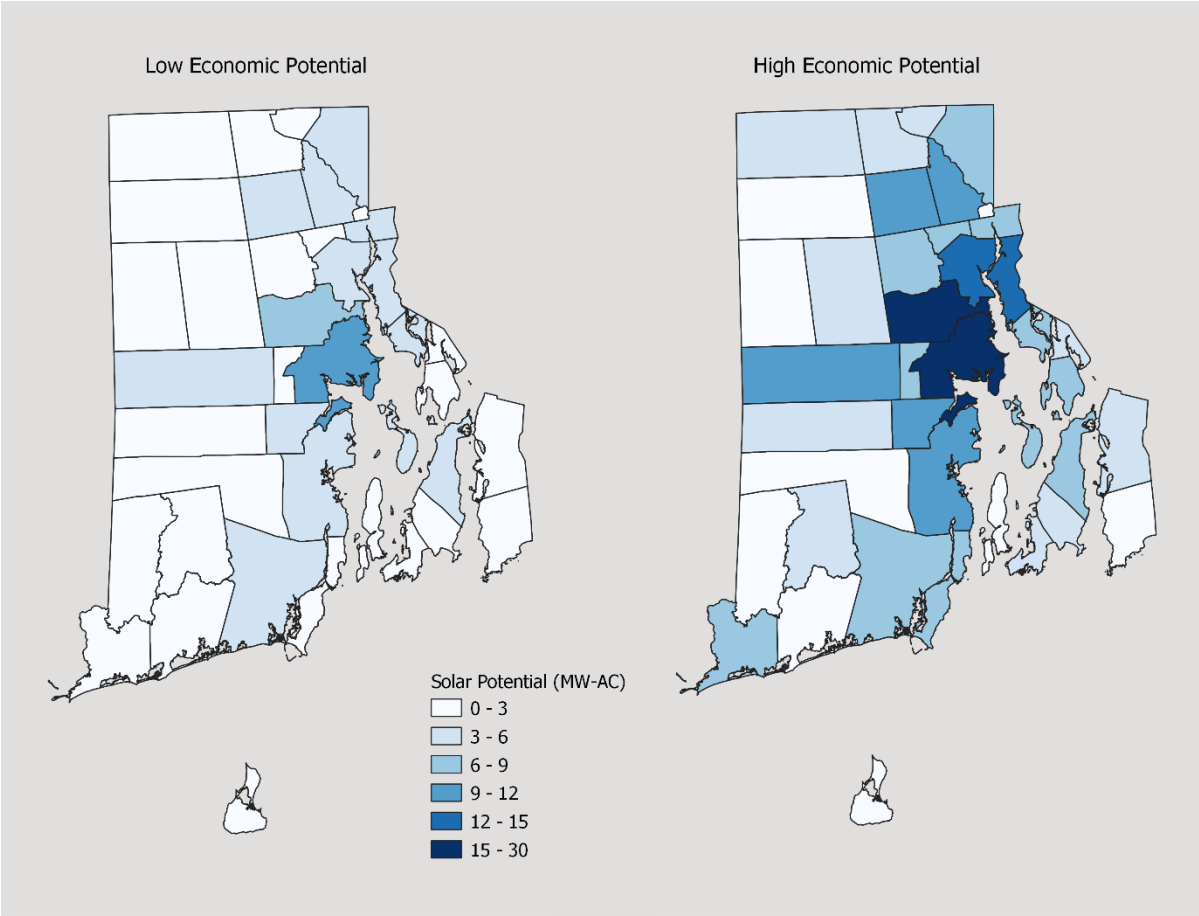
Rooftop Solar Results: Technical potential for residential buildings

- All municipalities have at least 3 MW of technical rooftop solar potential.
- The average municipality has about 22 MW of rooftop solar technical potential.
- The technical screening reduces the total rooftop solar potential to about 25 percent of the original estimate—about 850 MW.



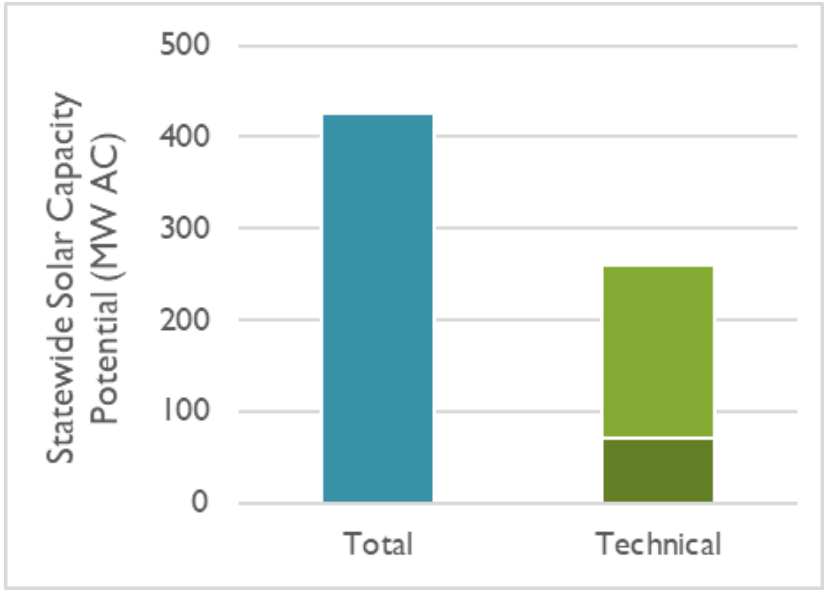
Rooftop Solar Results: Economic potential for residential buildings

- Statewide, our economic potential analysis reduces residential rooftop potential from 2,580 MW (total) to 550 MW (technical) to 110-250 MW (economic).
- Even at lowest end of economic analysis, all 39 municipalities have at least some economical potential for residential rooftop solar.
- Aggregate economic potential for single family homes ranges from 90 to 210 MW.
- Aggregate economic potential for multi-family homes ranges from 20 to 40 MW.



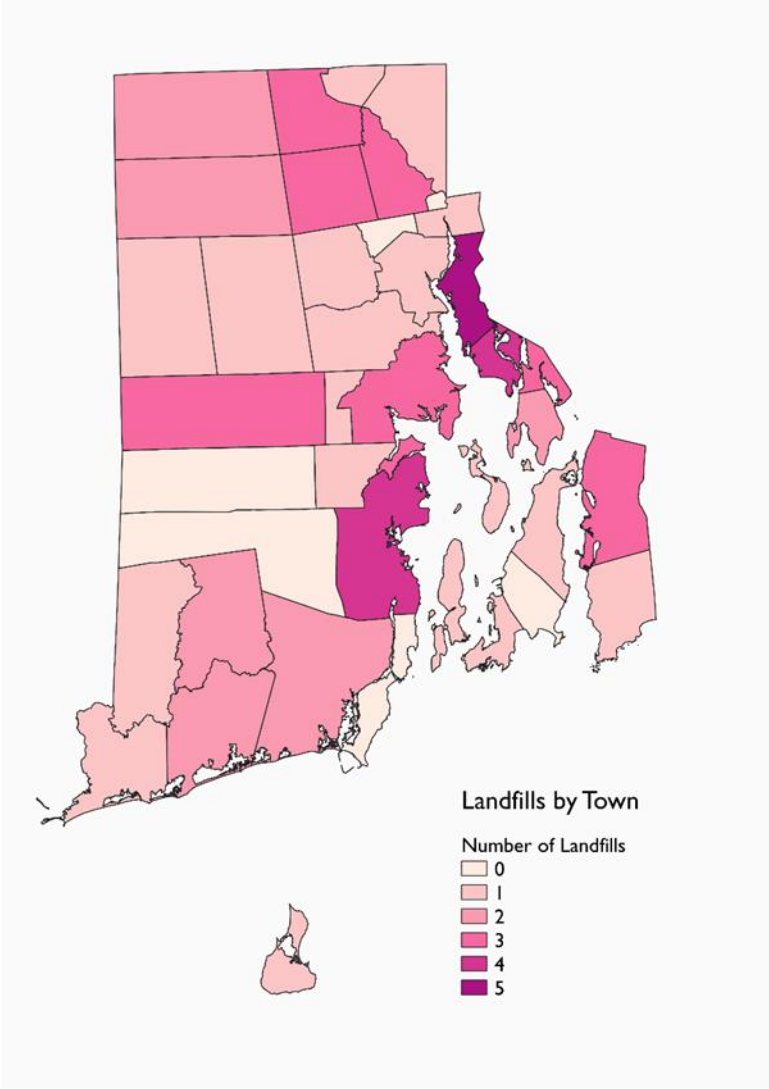
Landfill Solar Results

- Statewide, there is a total landfill solar potential of 430 MW.
- Technical screening reduces total potential to between 70 and 260 MW, depending on the setback assumed.
- Capping status was not included in the technical potential filter; some landfills in technical potential category may require a cap prior to solar installation.
  - Of the 63 landfills in our dataset, 19 are known to be capped.
  - 17 do not appear to have a current re-use, and 12 appear to have a partial re-use.

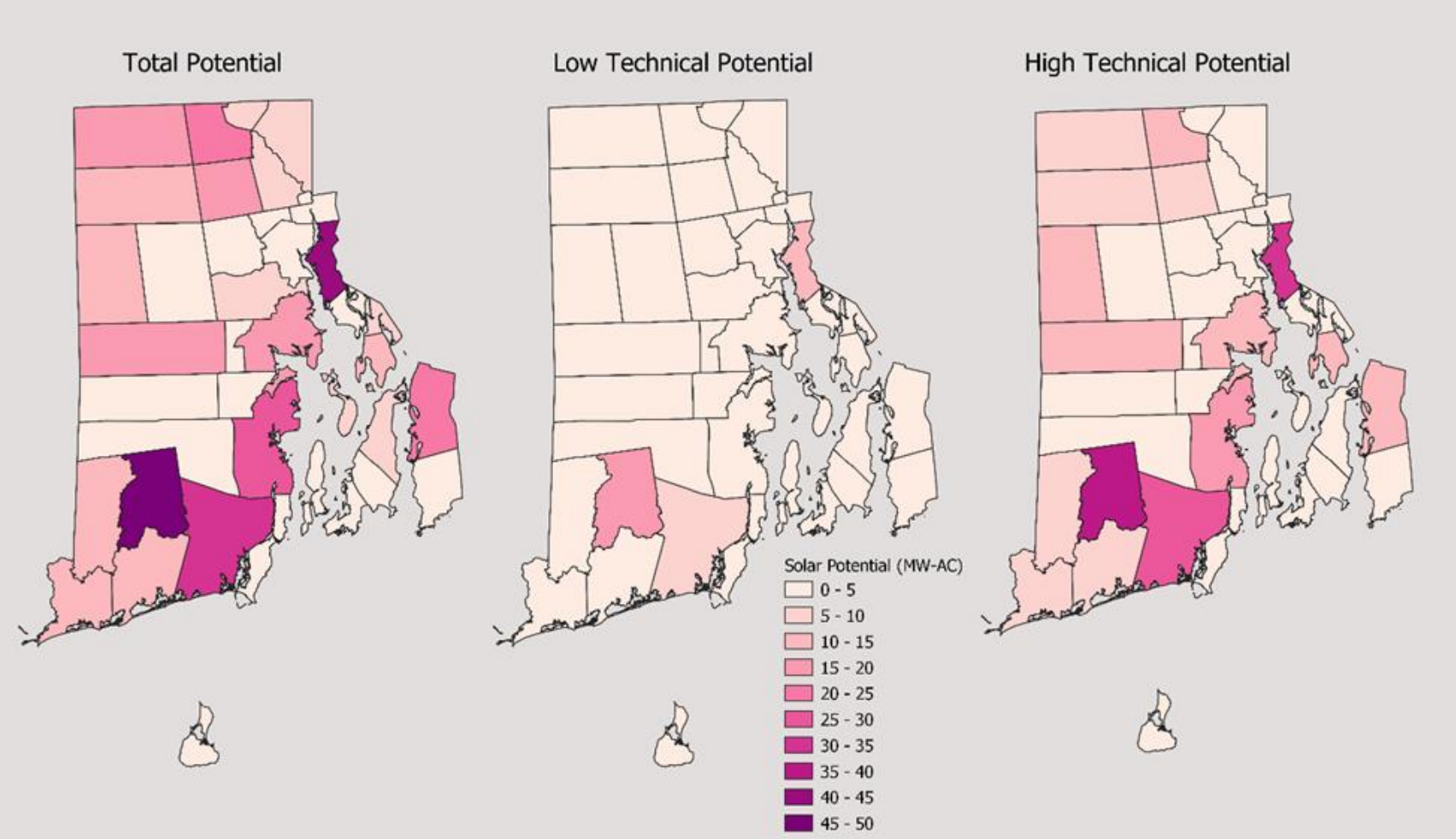


Landfill Solar Results

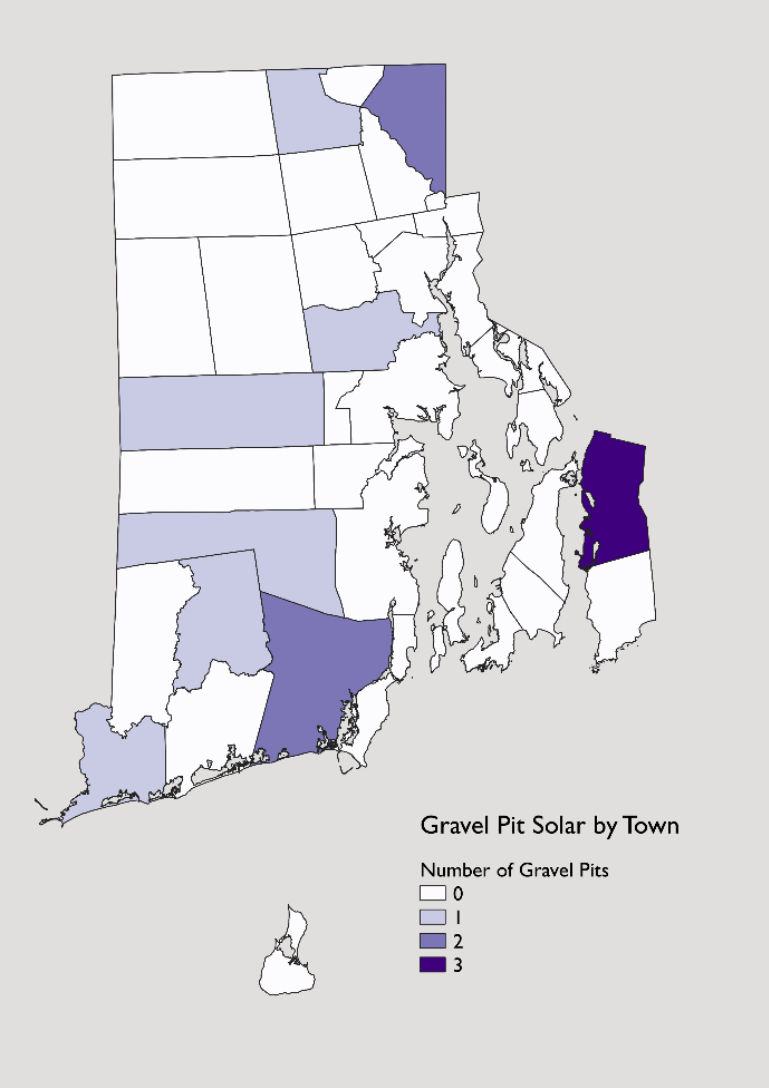
- There are 63 landfills across 34 towns.
- Some landfills are small; after applying the large setback, only 33 landfills remain for technical potential.



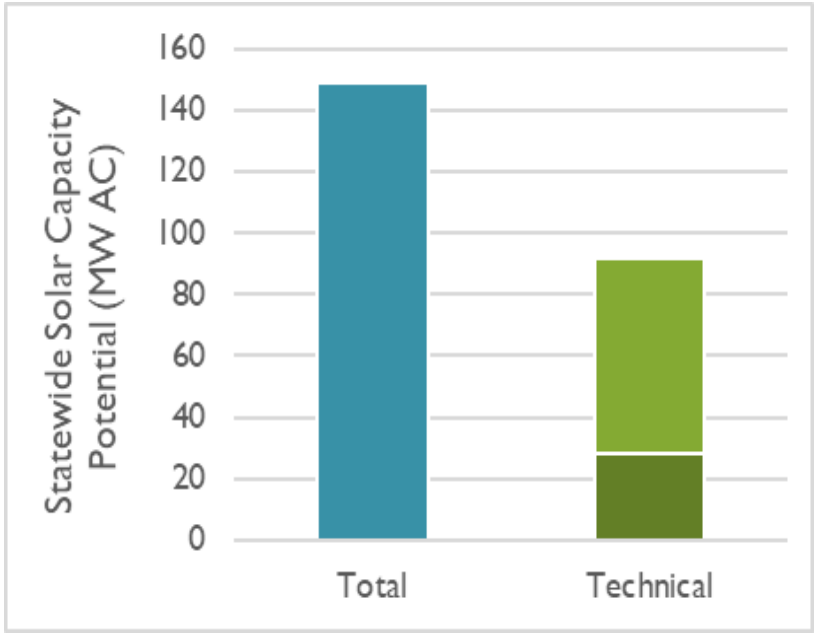
Landfill Solar Results



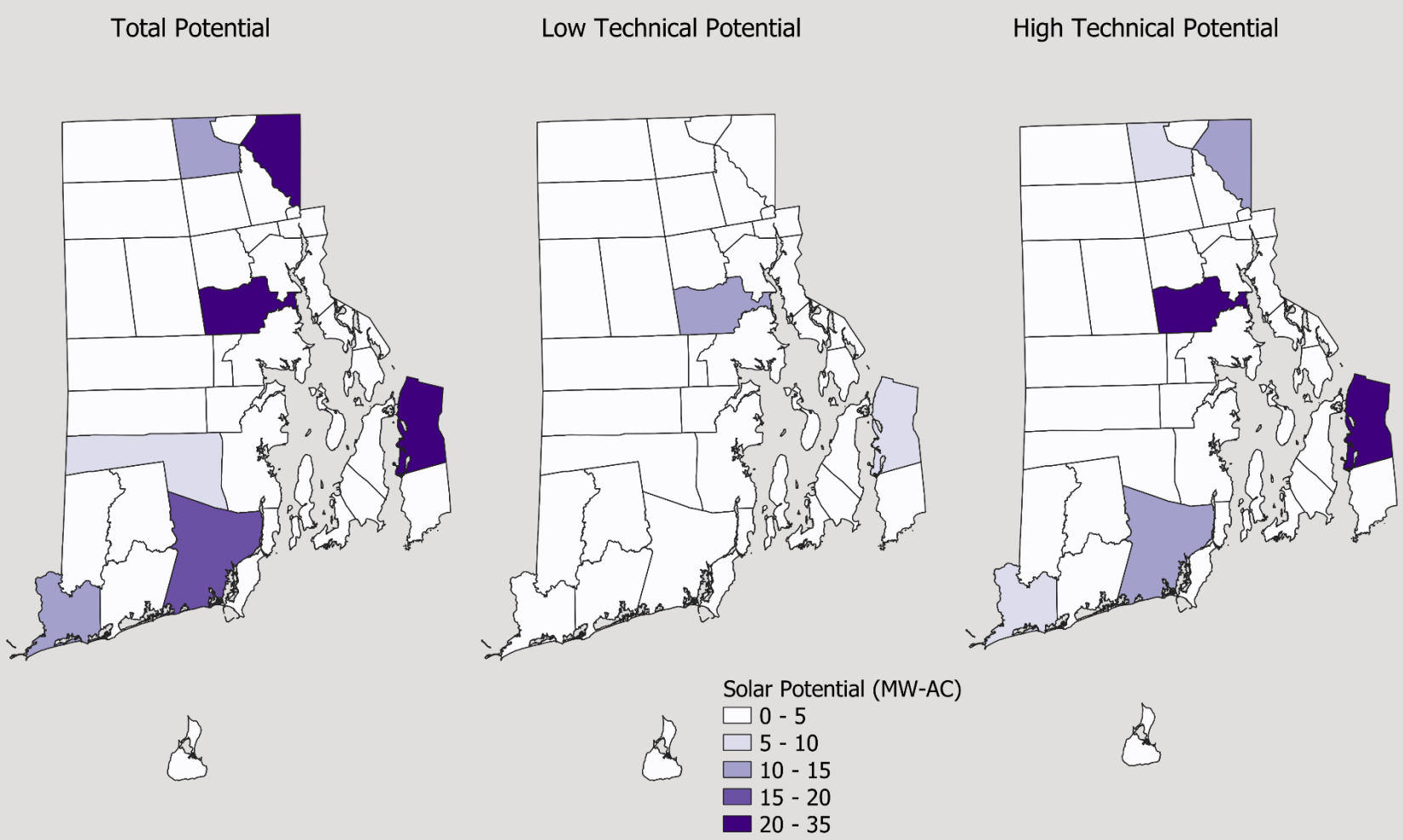
Gravel Pit Solar Results



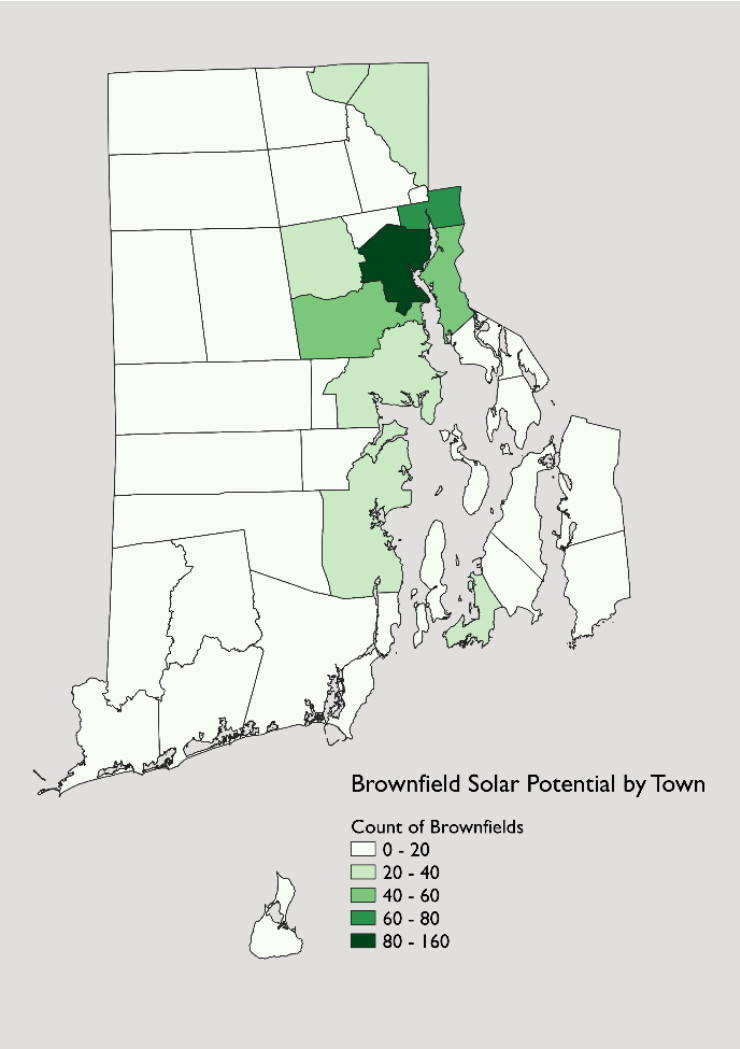
- Statewide, there is a total potential of 150 MW.
- Technical screening reduces potential to between 30 and 90 MW, depending on the setback assumed
- Several municipalities are home to multiple gravel pits
  - 13 gravel pits, but only 9 towns with a gravel pit
- Only 12 gravel pits have technical potential for solar.



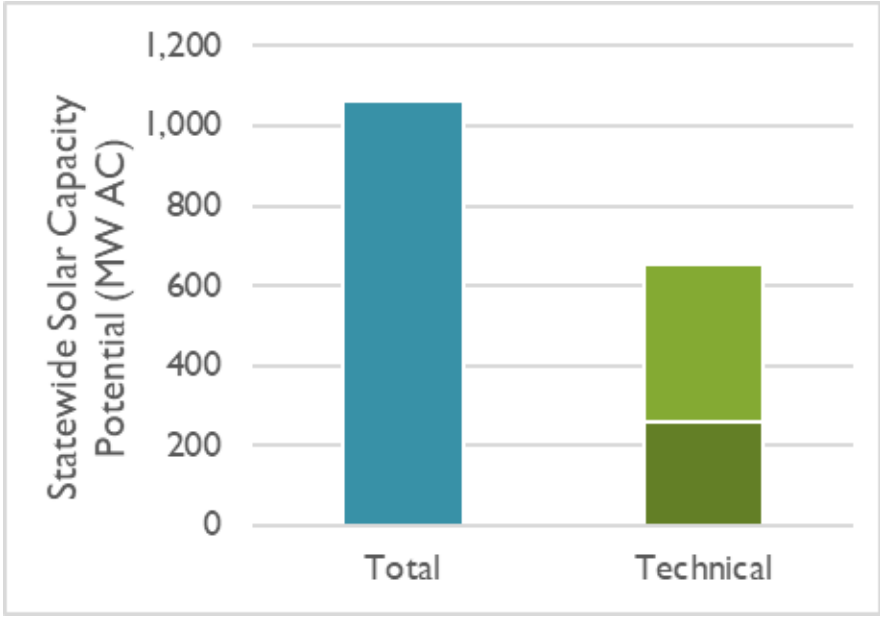
Gravel Pit Solar Results



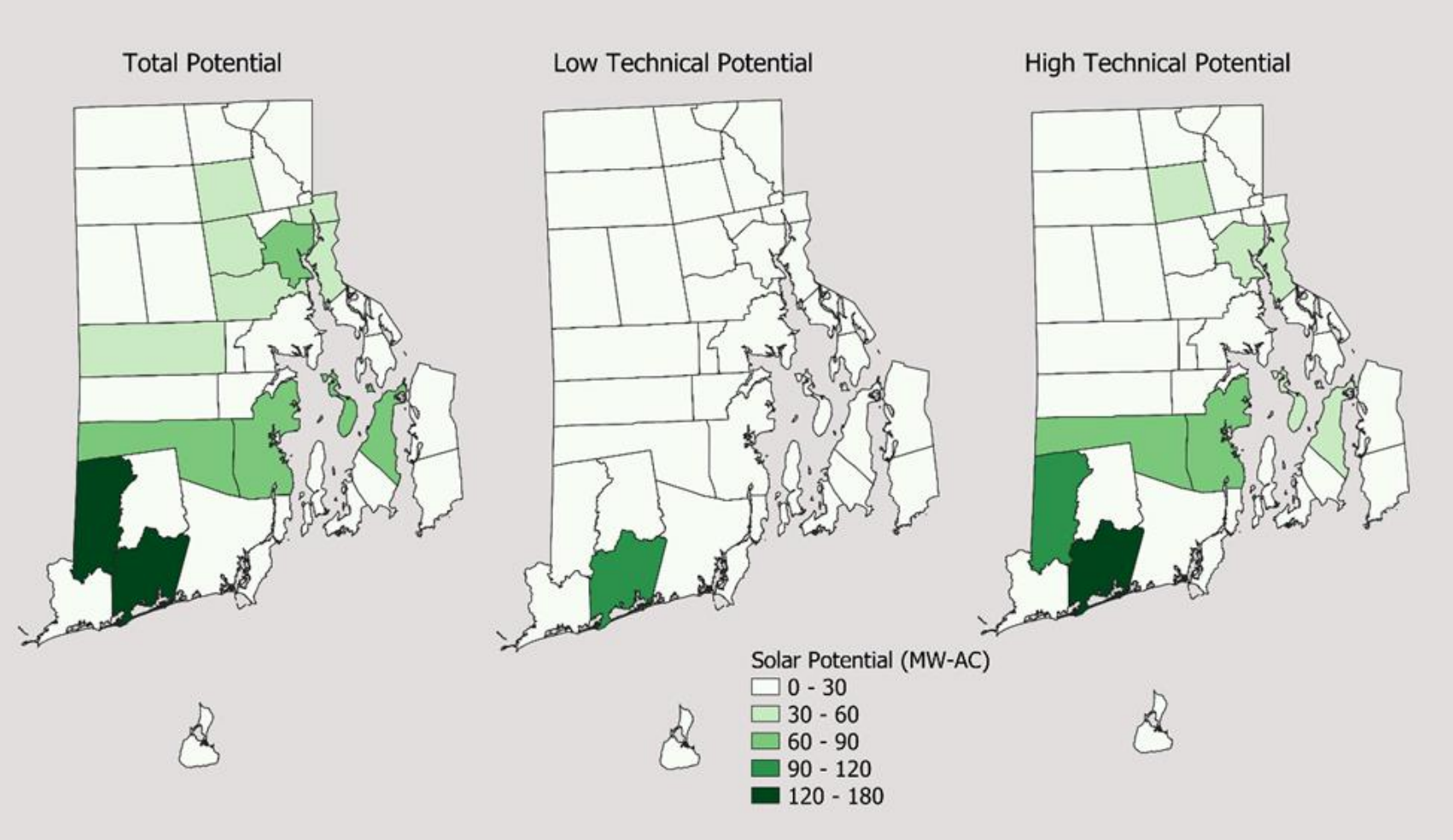
Brownfield Solar Results



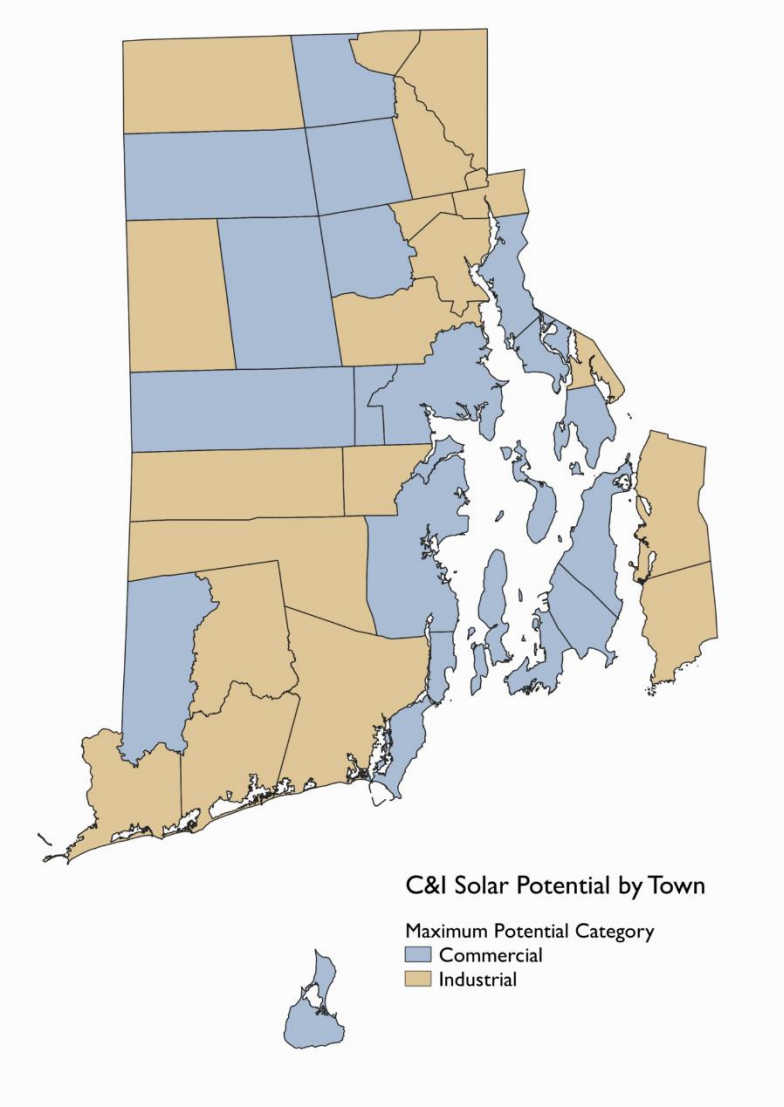
- Statewide, there is a total potential of 1,060 MW
- Technical screening reduces potential to between 260 and 650 MW, depending on the setback assumed
- Most brownfields are found in Metro Providence.



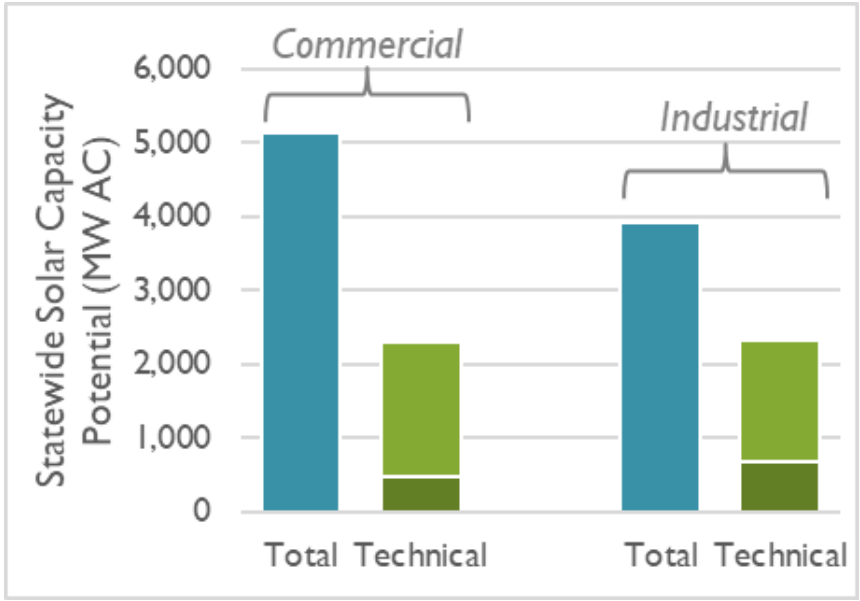
Brownfield Solar Results



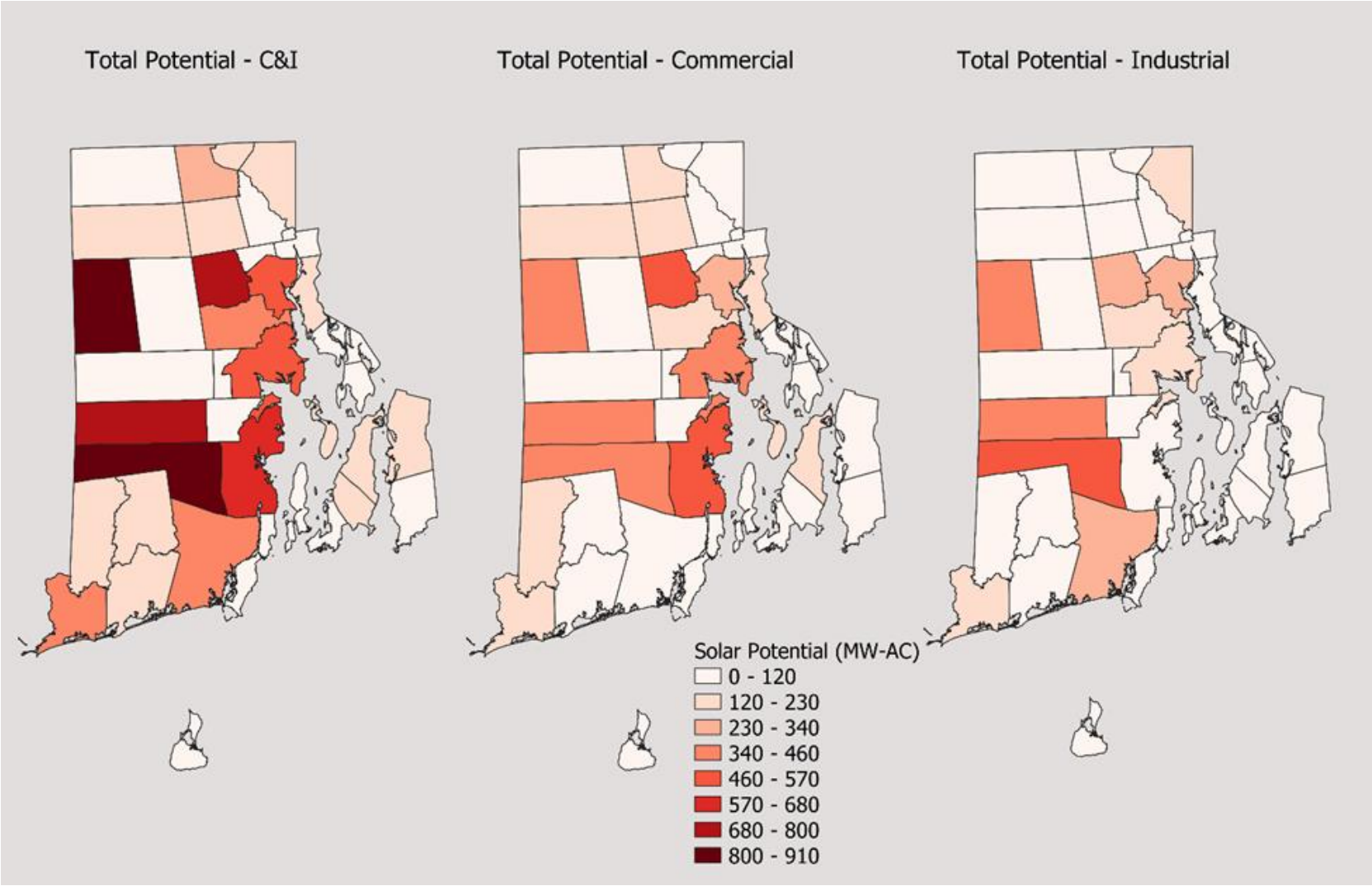
Commercial and Industrial (C&I) Developed and Undeveloped Parcels Results



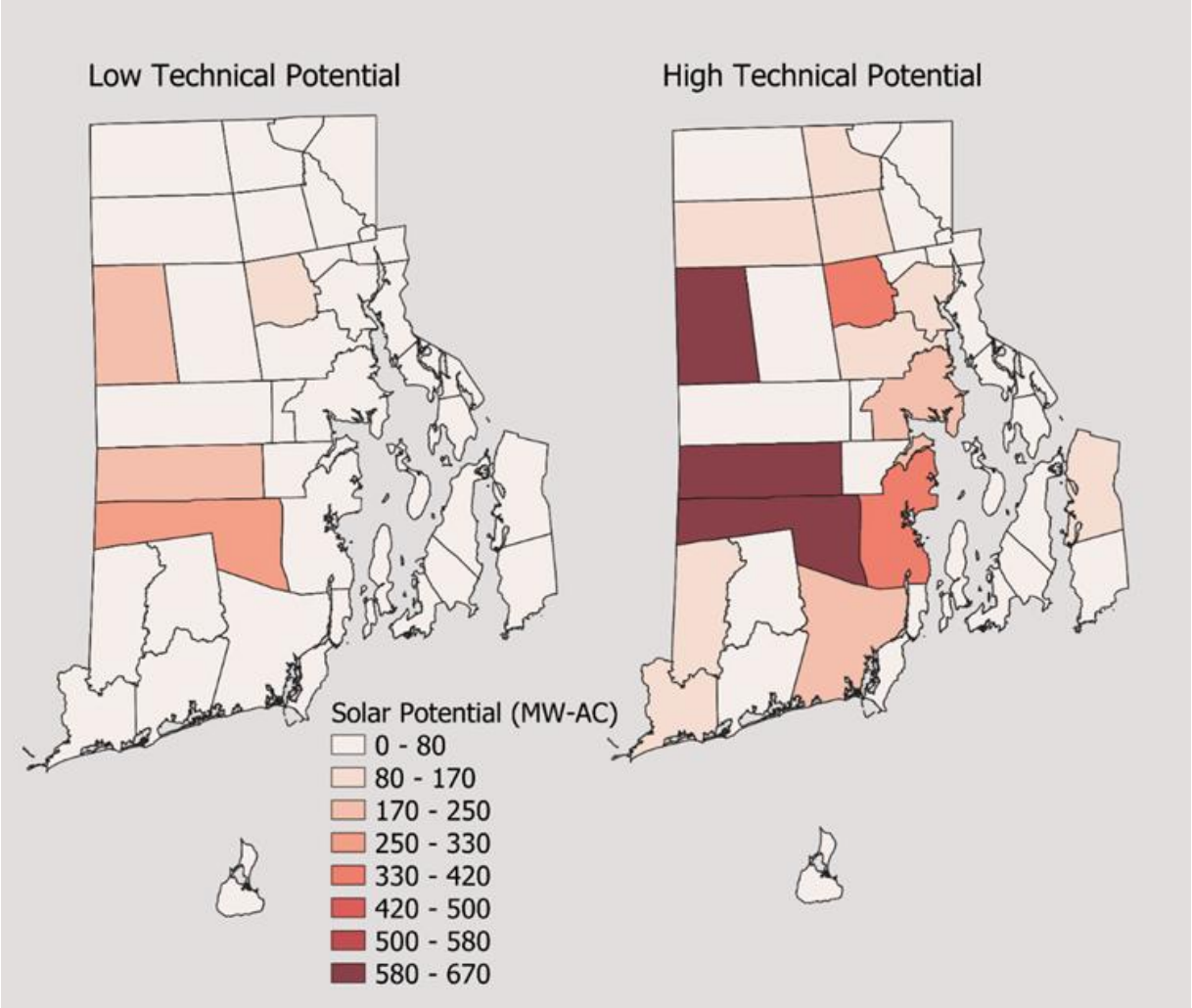
- Statewide, there is a total potential of 9,000 MW, split 55/45 between commercial and industrial sites
- Technical screening reduces potential to between 1,200 and 4,600 MW, depending on the setback
- C&I potential is linked to a municipality's land area, but is also driven by the number and size of parcels that are classed as commercial or industrial



C&I Solar Total Potential

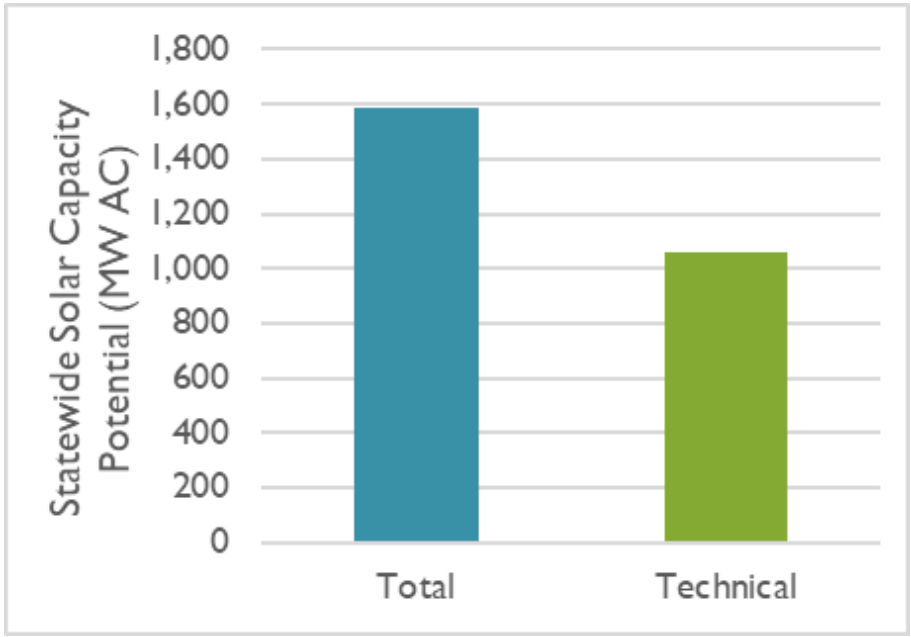


C&I Solar Technical Potential

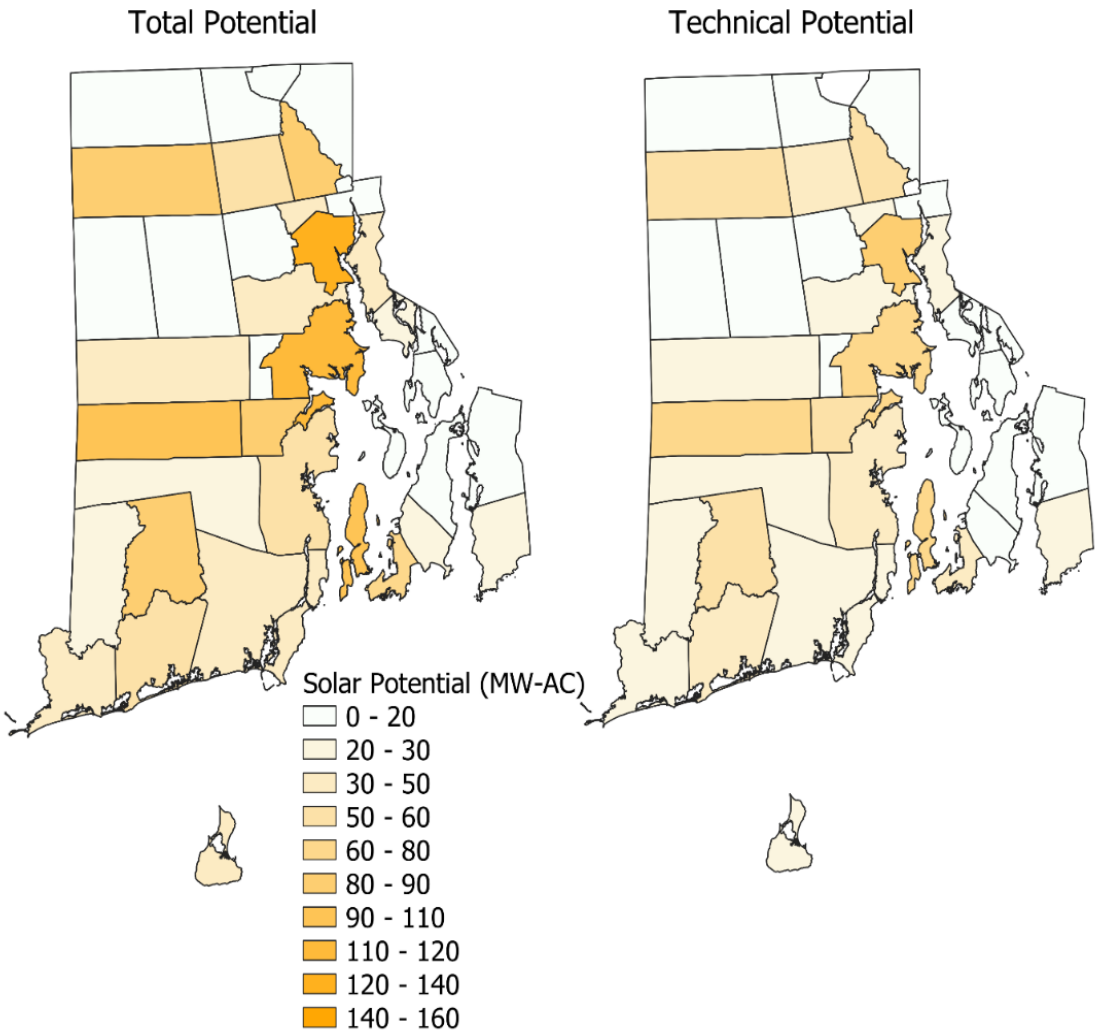


Parking Lot Solar Results

- Statewide, there is a total parking lot solar potential of 1,590 MW
- Technical screening reduces potential to about 1,060 MW



Parking Lot Solar Results



Annual Avoided Emissions and Costs

Category	Technical potential avoided GHG emissions per year (MMTCO2)
Rooftop	0.74
Landfills	0.07 – 0.27
Brownfields	0.27 – 0.69
Gravel pits	0.03 – 0.10
Commercial and industrial parcels	1.21 – 4.83
Parking lots	1.19
Total	**3.47 – 7.65**

Category	Estimated cost ($/Watt-DC)	Estimated cost ($/MWh-AC)
Rooftop	$3.07 – $4.15	$153 – $208
Landfills	$3.21	$122
Brownfields	$3.21	$122
Gravel pits	$3.21	$122
Commercial and industrial parcels	$3.21	$122
Parking lots	$5.09	$188

- Avoided GHG emissions estimated using U.S. EPA's AVERT model (avoided emissions rate for solar of about 0.57 short tons per MWh)
- All costs are derived from historical solar installation data provided by RI Commerce Corporation and National Grid
- For several categories (landfills, gravel pits, brownfields) data is limited—cost information shown in this table is for generic ground-mounted solar installations.
- Parking lot costs are based on a very small number of data points. Costs may change as the technology matures.

Case Study: Estimating incremental costs at non-conventional sites

- Synapse received information on incremental solar costs for non-conventional sites from one developer in Rhode Island (Revity)
- Costs in the table presented are for a single 6.3 MW installation in Warwick at a landfill/brownfield site.
- Incremental costs at non-conventional sites may be caused by the need for additional permitting and site remediation prior to installing solar panels.
- Incremental costs provided by Revity indicate an increase of about 4% above median costs.
- This is the experience of a single installer; more data is needed to better quantify incremental costs.

Incremental solar siting costs for example installation at a landfill / brownfield site

Cost Category	Incremental Costs ($/$W_{DC}$)
Permitting/ Professional Fees	**$0.03**
Legal	$0.01
Civil engineering	$0.01
Environmental engineering	$0.01
Survey	<$0.01
Miscellaneous permits	<$0.01
Site Remediation	**$0.03**
Removal of electrical debris	$0.01
Solid waste excavation	$0.02
Landfill cap repair	$0.01
Construction	**$0.05**
Drainage work	$0.02
Ballasted block for cap	$0.02
Cable tray system for cap	$0.01
Developer Burden	**$0.01**
Oversight/ coordination	$0.01
Total	**$0.13**

Caveats to Solar Potential Analysis

Solar Potential Caveats

- Rooftop: Used building footprint as proxy for rooftop area, which slightly overestimates rooftop space. Structural integrity of roofs not considered due data availability, so our estimates likely include roofs that are not structurally suitable for solar.
- Rooftop and C&I: Out of the 39 towns in Rhode Island, Synapse received zoning and parcel data from 34 of the towns. For the towns we did not receive data for, we used available data from comparable towns and scaled based on population size and density.
- Carports: Our analysis does not take into account parking lots that are adjacent to tall buildings, which would increase the necessary setback due to shading. Analysis does not include parking garages, which could increase our estimates.

Solar Potential Caveats (cont.)

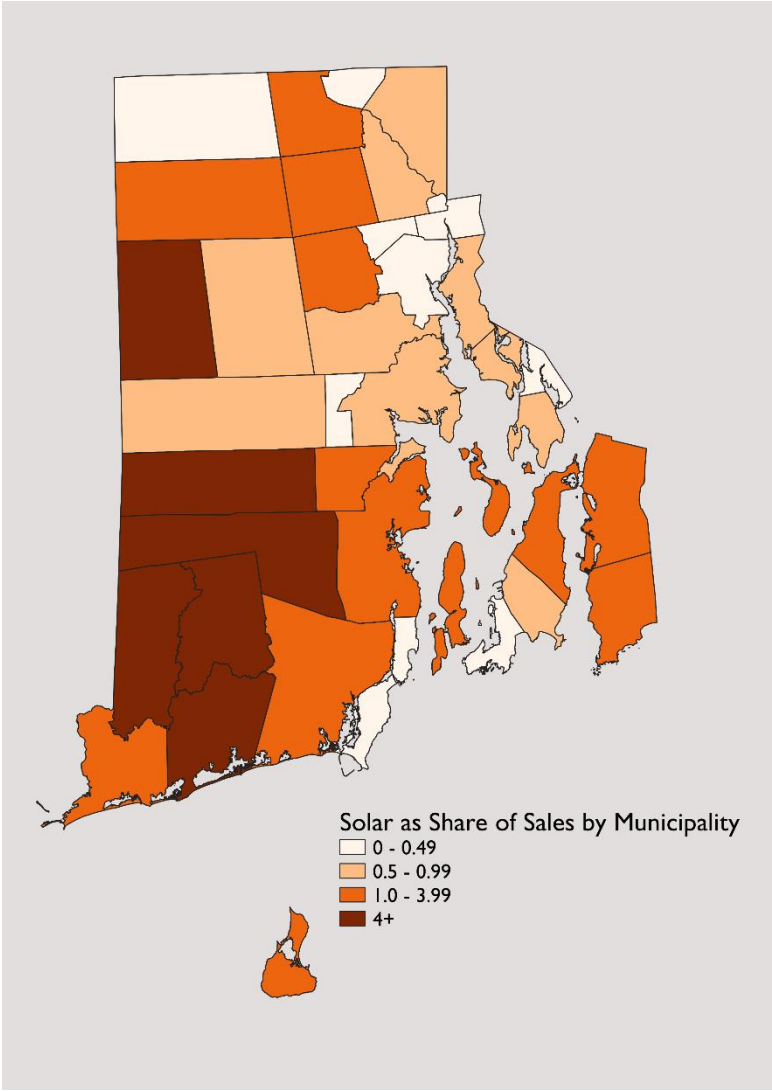
- Ground-mounted solar:
  - Setbacks were determined using input provided by town planners and solar developers. Using input from solar developers, we assume the need for a 50ft setback from buildings and a property setback of 50 to 375 feet.
  - Slope limitation of 10° was assumed based on feedback from solar developers
  - Gravel pits: Original USGS dataset is from 2003 and may exclude newer pits.
  - Landfills: Original URI dataset is from 2005 and may exclude newer landfills. Did not consider capping status in technical suitability. Due to the large number of landfills, we were not able to manually check the accuracy of the shapefile areas relative to satellite imagery for every landfill.
  - Brownfields: Dataset only includes remediated brownfields, rather than all brownfields. Because of the large number of brownfield sites, each parcel was not manually analyzed. As a result, our analysis likely includes some sites that have already been repurposed or are planned for redevelopment for some other purpose. Not all brownfields were mappable to real addresses.
  - C&I: There is likely still some overlap between this category and brownfields due to the unmappability of all brownfields in the dataset.

See this document's appendix and the full report for more detail on study caveats.

Solar Integration Topics

Solar as a Share of Electricity Sales

- For purposes of comparison, 19 of 39 municipalities have technical potentials that roughly match or exceed electricity sales.
- This analysis compares annual solar generation to annual retail electricity sales; these values are not necessarily comparable on a daily or hour-by-hour basis, as solar generation does not perfectly match electricity consumption.
  - For example, in summer months, solar output often peaks around noon, whereas the demand for electricity may not peak until later in the evening.
- Other technologies and practices, such as demand response and energy storage, may be able to better match electricity supply with electricity demand and more easily allow solar to provide a larger share of Rhode Island's electricity.



Hosting Capacity

Data Provided

- In November 2019, Synapse received data from National Grid on feeder hosting capacity. This dataset lists the hosting capacity for 3-Phase lines throughout Rhode Island.
- For each line, we have several datapoints. These include the amount of DG capacity currently connected to the line and the amount of DG capacity that is pending. This data also includes two limited datasets about available hosting capacity.

Data Challenges

- Shapefiles were provided for 1- and 2-phase lines, but these lines do not have any numerical data about hosting capacity.
- We have no information about where the limiting subsegments are within each 3-phase line, or what the specific hosting capacities are over the entire lines.
- These 3-phase lines are often very large. They frequently span across towns and are impossible to assign to a single town.

Hosting Capacity (cont.)

Other caveats

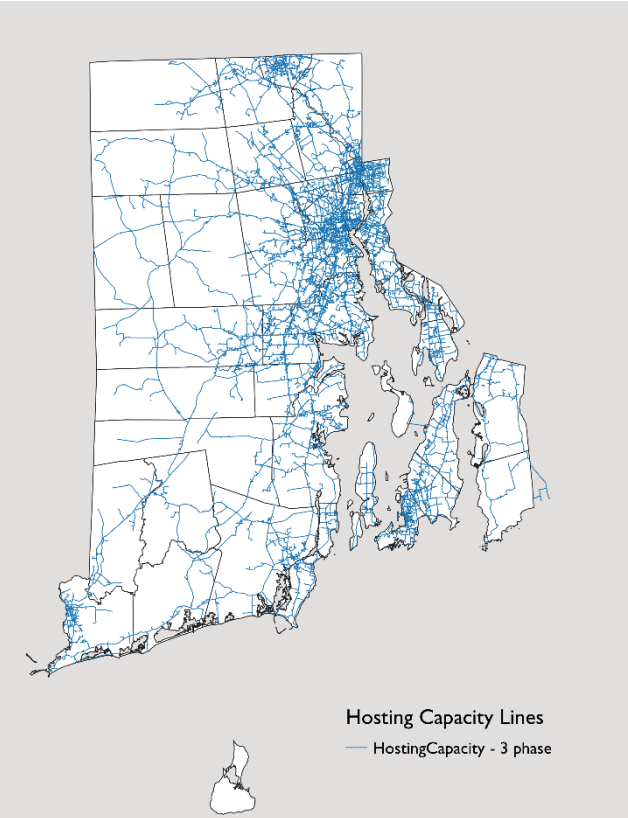
- Data received from National Grid represents the hosting capacity at a certain point in time; this hosting capacity can evolve as the distribution grid changes.
- Hosting capacity should not necessarily be seen as a physical barrier to solar (for example, like setbacks or slope). In many situations, feeder upgrades can be performed. These cost money, but can expand hosting capacity.

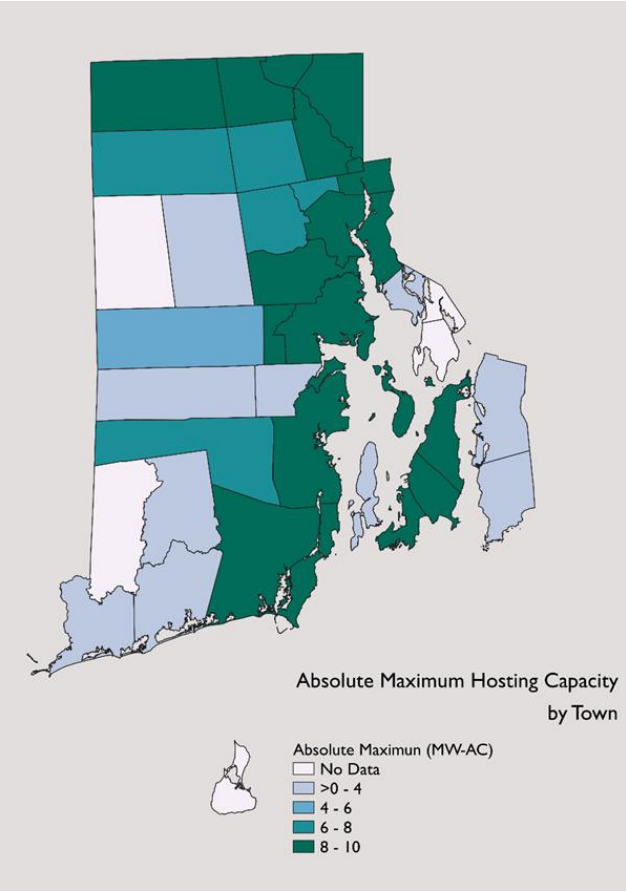
Takeaways

- Because we cannot discern what the hosting capacities are at a smaller resolution than the lines as a whole, and because we cannot assign lines to specific towns, it is impossible to identify the actual hosting capacity with certainty.
- Given this limitation, we have performed a series of analyses that help to compare certain hosting capacity datapoints to aggregate technical capacity (see following slides).

Hosting capacity – Project Perspective

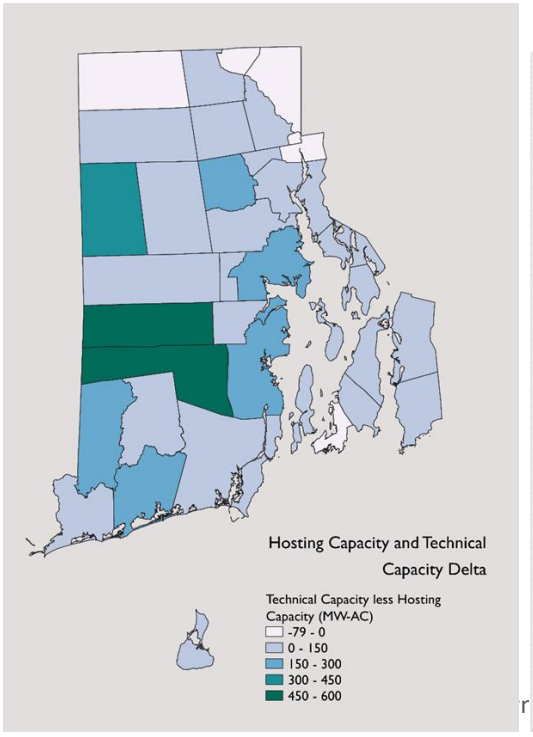
- First, we identified each of the feeder lines that go through each of the 39 municipalities.
- For each municipality, we examined the maximum incremental hosting capacity for any one of the lines in that area.
- The map to the right identifies the maximum hosting capacity currently allowable for each town on any one line.
- Because lines cross municipal boundaries, and because we do not have data on where the maximum capacity is located, it is possible that some of the maximum quantities are appropriate for certain municipalities, but not others.

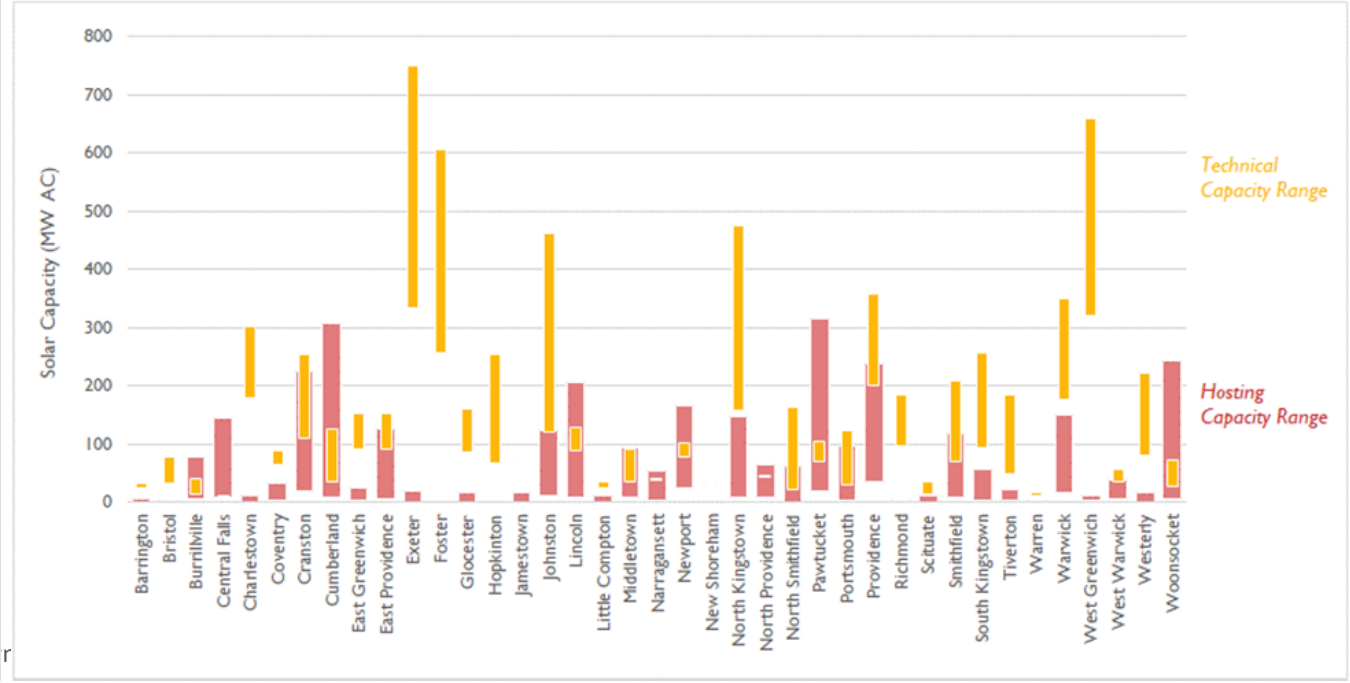




Hosting capacity – Policy Perspective

- Second, we compare the range of aggregate technical capacities with the range of hosting capacities.
- The “low” end of each hosting capacity is calculated by summing the minimum hosting capacities for each of the lines within each municipality.
- The “high” end of each hosting capacity is calculated by summing the maximum hosting capacities for each of the lines within each municipality.
- Because lines cross municipal boundaries, and because we do not have data on where the specific maximums or minimums are located, it is possible that some of the stated quantities are appropriate for certain municipalities, but not others.





Incentives for non-conventional solar in neighboring states

Summary of incentives for non-conventional solar in neighboring states

- Massachusetts:
  - SMART program is a tariff-based program that offers incentives for 10 or 20 years depending on system size
  - For example, the base compensation rates for National Grid's Massachusetts territory are $0.31126 per kWh for units that are less than or equal to 25 kW AC and $0.15563 per kWh for units greater than 1 MW
  - There are adders and subtractors that modify this compensation rate: solar that is sited on brownfields and eligible landfills are at $0.03 per kWh and $0.04 per kWh respectively. In addition, any solar generating units that are located on a greenfield are subject to a greenfield subtractor between $0.0005 per kWh to $0.001 per kWh per acre occupied by the solar development depending on the land use type.
- New York
  - Incentives are available of a dollar-per-watt basis
  - Projects sited on brownfields and landfills are eligible for an additional incentive of $0.10 per Watt in addition to the standard nonresidential incentives.

Summary of incentives for non-conventional solar in neighboring states (cont.)

- Vermont
  - Has set specific incentives for net metering projects on preferred sites, including brownfields and certain types of landfills.
  - Incentives vary by size of installation (for example, the 2019 incentive was $0.174/kWh for preferred sites versus $0.134/kWh for non-preferred sites for projects 15-150 kW in size)
- Additional federal and state-level funding:
  - EPA's RE-Powering America's Land Initiative provides funding through a number of federal programs offering financing in site planning, preparation, construction, or capital equipment purchases in support of brownfield redevelopment. Not specific to renewable development.
  - Other states (including CT) offer funding for clean energy and energy efficiency projects developed on contaminated sites.

Questions?

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Appendices

Installations to-date, by program

Program	Subprogram	Type	Total Installations	Total MW_{AC}	Range MW_{AC}
REF	Brownfield Solar PV Program	Roof	-	-	-
REF	Brownfield Solar PV Program	Ground	-	-	-
REF	Commercial Scale Program	Roof	108	14	0.009 - 5.692
REF	Commercial Scale Program	Ground	18	21	0.009 - 4.630
REF	Commercial Scale Program	Carport	2	0.4	0.048 - 0.174
REF	Commercial Scale Program	Unknown	1	0.2	0.217 - 0.217
REF	Commercial Scale Program	Roof/Ground Combination	2	0.4	-
REF	Commercial Scale Program	Roof/Ground/Carport Combination	-	-	0.118 - 0.169
REF	Small Scale Program	Roof	1,123	8	0.000 - 0.000
REF	Small Scale Program	Ground	60	0.5	0.001 - 0.022
REF	Small Scale Program	Roof/Ground Combination	1	0.01	0.001 - 0.024
REG, Small Scale	Commercial	-	13	0.1	0.006 - 0.015
REG, Small Scale	Individual	-	3,375	20	0.002 - 0.016
REG, Small Scale	Third-party owned	-	98	0.5	0.002 - 0.022
REG, Large Scale	Commercial-Scale Solar	Ground	9	7.1	0.434 - 0.868
REG, Large Scale	Commercial-Scale Solar	Rooftop	2	1.7	0.868 - 0.868
REG, Large Scale	Large-Scale Solar	Ground	4	9.3	1.364 - 3.520
REG, Large Scale	Medium-Scale Solar	Unknown	27	5.5	0.036 - 0.217
REG, Large Scale	Medium-Scale Solar	Rooftop	9	0.9	0.036 - 0.216
REG, Large Scale	Medium-Scale Solar	Ground	1	0.2	0.217 - 0.217
VNM	Unknown	-	20	52	0.060 - 7.387
DG Contracts		-	27	18	0.039 - 2.607
Community Solar Virtual Net Metering Pilot Program		-	1	2.5	2.5
Total			**7,711**	**186**	**-**
All Net Metering	Residential	-	7,341	44	-
All Net Metering	Commercial	-	208	21	-

- All data is up-to-date through Fall 2019. Data shown only includes installed projects, not planned or cancelled projects.
- Data covers all projects in the following programs: REF, REG (Small), REG (Medium, Large, and Commercial), VNM, Distributed Generation Contracts Program, 30 MW pilot, and earlier non-programmatic net metering.

Rooftop Solar Results by Municipality

	Statewide	Barrington	Bristol	Burrillville	Central Falls	Charlestown	Coventry	Cranston	Cumberland	East Greenwich	East Providence	Exeter	Foster	Glocester	Hopkinton	Jamestown	Johnston	Lincoln	Little Compton	Middletown
Total number of rooftops (thousands)	367	7	8	6	3	6	14	27	12	5	16	3	3	5	4	3	11	7	3	7
Total capacity (MW)	3,401	58	72	52	31	43	116	260	111	61	149	28	21	39	33	27	106	87	26	71
Technical Capacity (MW)	852	13	18	10	9	7	23	69	28	16	41	5	3	7	6	5	26	26	4	19
Economic Capacity, Low (MW)	107	3	3	2	0.4	1	4	8	4	3	6	1	1	1	1	1	2.8	4	1	3
Economic Capacity, High (MW)	253	8	6	5	1	3	10	17	8	9	14	2	1	3	2	3	6	9	2	6

Notes:

- *Values of "-" indicate a zero.*
- *All data is subject to quality control and may change.*
- *The "Economic Capacity" category only includes residential multi-family and residential single-family buildings.*
- *"Low" category assumes REF payback and low end of median income for each town; "High" category assumes REG payback and high end of median income for each town.*
- *All potential numbers are calculated independent from a municipality's eligibility to participate in current state programs.*
- *All potential numbers are calculated independent from requirements under current net metering that limits generation to 125% of onsite usage for non-VNM projects.*

Rooftop Solar Results by Municipality (cont.)

	Narragansett	Newport	New Shoreham	North Kingstown	North Providence	North Smithfield	Pawtucket	Portsmouth	Providence	Richmond	Scituate	Smithfield	South Kingstown	Tiverton	Warren	Warwick	West Greenwich	West Warwick	Westerly	Woonsocket
Total number of rooftops (thousands)	9	8	2	11	10	5	19	8	36	4	5	7	13	8	4	32	3	9	12	10
Total capacity (MW)	72	82	13	124	95	49	172	76	356	26	43	81	110	62	38	300	27	77	108	97
Technical Capacity (MW)	16	22	3	37	22	13	49	17	103	5	8	24	18	10	10	86	7	20	21	27
Economic Capacity, Low (MW)	3	2	0.6	4	3	2	3	3	6	1	1	5	3	2	1	10	1	3	3	1
Economic Capacity, High (MW)	8	5	2	10	6	4	8	8	12	3	3	11	7	4	3	23	4	6	6	3

Notes:

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- *The "Economic Capacity" category only includes residential multi-family and residential single-family buildings.*
- *"Low" category assumes REF payback and low end of median income for each town; "High" category assumes REG payback and high end of median income for each town.*
- *All potential numbers are calculated independent from a municipality's eligibility to participate in current state programs.*
- *All potential numbers are calculated independent from requirements under current net metering that limits generation to 125% of onsite usage for non-VNM projects.*

Number of houses that can't get solar

	Statewide	Barrington	Bristol	Burrillville	Central Falls	Charlestown	Coventry	Cranston	Cumberland	East Greenwich	East Providence	Exeter	Foster	Glocester	Hopkinton	Jamestown	Johnston	Lincoln	Little Compton	Middletown
Total number of residential rooftops (thousands)	326	6	7	6	3	5	14	25	10	5	14	2	2	4	4	3	9	7	3	6
Fraction of small buildings with no buildable area	-	3%	3%	5%	3%	5%	5%	3%	3%	3%	3%	5%	5%	5%	5%	3%	3%	3%	5%	3%
Number of residential buildings with no buildable area	11,965	222	243	300	95	250	654	862	340	161	496	112	102	175	170	93	314	243	141	195
Estimated potential (MW AC)	72	1	1	2	1	1	4	5	2	1	3	1	1	1	1	1	1.9	1	1	1

Notes:

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- *All data is subject to quality control and may change.*
- *All potential numbers are calculated independent from a municipality's eligibility to participate in current state programs.*
- *Fraction of small buildings with no buildable data is based on 2016 NREL analysis of metro areas in southern New England, and varies based on type of town (suburban, urban, rural, etc.).*
- *Estimated potential is calculated by multiplying the number of buildings for each town by the statewide average of MW AC per residential household based on REG and REF data (about 6 kW per household). Note that because these buildings are deemed as wholly unsuitable for solar, this MW number should not be interpreted as the solar that cannot be installed; instead, it is the solar that could be installed were these buildings to be suitable for solar.*

Number of houses that can't get solar (cont.)

	Narragansett	Newport	New Shoreham	North Kingstown	North Providence	North Smithfield	Pawtucket	Portsmouth	Providence	Richmond	Scituate	Smithfield	South Kingstown	Tiverton	Warren	Warwick	West Greenwich	West Warwick	Westerly	Woonsocket
Total number of residential rooftops (thousands)	9	7	2	10	9	4	18	8	31	3	4	7	12	7	4	29	2	8	11	9
Fraction of small buildings with no buildable area	3%	3%	3%	3%	3%	3%	3%	3%	3%	5%	5%	3%	5%	5%	3%	3%	5%	3%	5%	3%
Number of residential buildings with no buildable area	307	251	46	345	320	148	608	267	926	163	213	231	586	323	133	741	95	277	522	296
Estimated potential (MW AC)	2	2	0.3	2	2	1	4	2	6	1	1	1	4	2	1	4	1	2	3	2

Notes:

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- *All data is subject to quality control and may change.*
- *All potential numbers are calculated independent from a municipality's eligibility to participate in current state programs.*
- *Fraction of small buildings with no buildable data is based on 2016 NREL analysis of metro areas in southern New England, and varies based on type of town (suburban, urban, rural, etc.).*
- *Estimated potential is calculated by multiplying the number of buildings for each town by the statewide average of MW AC per residential household based on REG and REF data (about 6 kW per household). Note that because these buildings are deemed as wholly unsuitable for solar, this MW number should not be interpreted as the solar that cannot be installed; instead, it is the solar that could be installed were these buildings to be suitable for solar.*

Landfill Solar Results by Municipality

	Statewide	Barrington	Bristol	Burrillville	Central Falls	Charlestown	Coventry	Cranston	Cumberland	East Greenwich	East Providence	Exeter	Foster	Glocester	Hopkinton	Jamestown	Johnston	Lincoln	Little Compton	Middletown
Total number of landfills	63	4	2	2	-	2	3	1	1	1	5	-	1	2	1	1	1	3	1	-
Total capacity (MW)	425	4	14	16	-	12	17	7	5	2	43	-	14	13	13	3	3	9	3	-
Technical Capacity, Low (MW)	71	0	3	0	0	2	4	1	0	0	12	0	3	1	3	0	0	0	0	0
Technical Capacity, High (MW)	260	2	10	8	0	7	12	4	3	0	33	0	12	8	9	2	2	2	2	0

Notes:

- *Values of "-" indicate a zero.*
- *All data is subject to quality control and may change.*
- *We have not yet incorporated the slope screen step (e.g., remove areas with slopes > 10% grades). Final values for technical capacity will be lower.*
- *"Low" category assumes a 50-ft setback from buildings and a 50-ft setback from adjacent properties. "High" category assumes a 50-ft setback from buildings and a 375-ft setback from adjacent properties.*
- *All potential numbers are calculated independent from a municipality's eligibility to participate in current state programs.*
- *All potential numbers are calculated independent from requirements under current net metering that limits generation to 125% of onsite usage for non-VNM projects.*

Landfill Solar Results by Municipality (cont.)

	Narragansett	Newport	New Shoreham	North Kingstown	North Providence	North Smithfield	Pawtucket	Portsmouth	Providence	Richmond	Scituate	Smithfield	South Kingstown	Tiverton	Warren	Warwick	West Greenwich	West Warwick	Westerly	Woonsocket
Total number of landfills	-	1	1	4	-	3	1	1	1	2	1	3	2	3	3	3	-	1	1	1
Total capacity (MW)	-	3	1	27	-	20	3	7	4	56	5	16	35	23	6	19	-	4	10	7
Technical Capacity, Low (MW)	0	0	0	4	0	3	0	0	0	19	0	0	8	3	0	2	0	0	0	0
Technical Capacity, High (MW)	0	2	1	17	0	12	2	3	2	36	2	10	27	14	1	10	0	0	7	1

Notes:

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- *"Low" category assumes a 50-ft setback from buildings and a 50-ft setback from adjacent properties. "High" category assumes a 50-ft setback from buildings and a 375-ft setback from adjacent properties.*
- *All potential numbers are calculated independent from a municipality's eligibility to participate in current state programs.*
- *All potential numbers are calculated independent from requirements under current net metering that limits generation to 125% of onsite usage for non-VNM projects.*

Gravel Pit Solar Results by Municipality

	Statewide	Barrington	Bristol	Burrillville	Central Falls	Charlestown	Coventry	Cranston	Cumberland	East Greenwich	East Providence	Exeter	Foster	Glocester	Hopkinton	Jamestown	Johnston	Lincoln	Little Compton	Middletown
Total number of gravel pits	13	-	-	-	-	-	1	1	2	-	-	1	-	-	-	-	-	-	-	-
Total capacity (MW)	149	-	-	-	-	-	0.4	35	26	-	-	7	-	-	-	-	-	-	-	-
Technical Capacity, Low (MW)	28	-	-	-	-	-	-	11	3	-	-	1	-	-	-	-	-	-	-	-
Technical Capacity, High (MW)	92	-	-	-	-	-	0.1	22	13	-	-	5	-	-	-	-	-	-	-	-

Notes:

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- *We have not yet incorporated the slope screen step (e.g., remove areas with slopes > 10% grades). Final values for technical capacity will be lower.*
- *"Low" category assumes a 50-ft setback from buildings and a 50-ft setback from adjacent properties. "High" category assumes a 50-ft setback from buildings and a 375-ft setback from adjacent properties.*
- *All potential numbers are calculated independent from a municipality's eligibility to participate in current state programs.*
- *All potential numbers are calculated independent from requirements under current net metering that limits generation to 125% of onsite usage for non-VNM projects.*

Gravel Pit Solar Results by Municipality (cont.)

	Narragansett	Newport	New Shoreham	North Kingstown	North Providence	North Smithfield	Pawtucket	Portsmouth	Providence	Richmond	Scituate	Smithfield	South Kingstown	Tiverton	Warren	Warwick	West Greenwich	West Warwick	Westerly	Woonsocket
Total number of gravel pits	-	-	-	-	-	1	-	-	-	1	-	-	2	3	-	-	-	-	1	-
Total capacity (MW)	-	-	-	-	-	11	-	-	-	5	-	-	19	31	-	-	-	-	15	-
Technical Capacity, Low (MW)	-	-	-	-	-	2	-	-	-	1	-	-	3	6	-	-	-	-	1.6	-
Technical Capacity, High (MW)	-	-	-	-	-	8	-	-	-	3	-	-	12	21	-	-	-	-	8	-

Notes:

- *Values of "-" indicate a zero.*
- *All data is subject to quality control and may change.*
- *We have not yet incorporated the slope screen step (e.g., remove areas with slopes > 10% grades). Final values for technical capacity will be lower.*
- *"Low" category assumes a 50-ft setback from buildings and a 50-ft setback from adjacent properties. "High" category assumes a 50-ft setback from buildings and a 375-ft setback from adjacent properties.*
- *All potential numbers are calculated independent from a municipality's eligibility to participate in current state programs.*
- *All potential numbers are calculated independent from requirements under current net metering that limits generation to 125% of onsite usage for non-VNM projects.*

Brownfield Solar Results by Municipality

	Statewide	Barrington	Bristol	Burrillville	Central Falls	Charlestown	Coventry	Cranston	Cumberland	East Greenwich	East Providence	Exeter	Foster	Glocester	Hopkinton	Jamestown	Johnston	Lincoln	Little Compton	Middletown
Total number of brownfields	738	4	17	8	11	5	16	48	25	7	50	3	-	2	4	7	22	12	2	12
Total capacity (MW)	1,061	1	7	2	3	182	30	38	13	27	40	75	-	4	122	3	33	22	1	15
Technical Capacity, Low (MW)	260	-	-	-	-	119	12	-	5	10	16	29	-	2	13	-	1	-	0.3	-
Technical Capacity, High (MW)	653	0.1	0.9	0.05	0.5	169	22	8	9	19	29	55	-	3	87	0	22	8	0.6	3

Notes:

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- *All data is subject to quality control and may change.*
- *"Low" category assumes a 50-ft setback from buildings and a 50-ft setback from adjacent properties. "High" category assumes a 50-ft setback from buildings and a 375-ft setback from adjacent properties.*
- *All potential numbers are calculated independent from a municipality's eligibility to participate in current state programs.*
- *All potential numbers are calculated independent from requirements under current net metering that limits generation to 125% of onsite usage for non-VNM projects.*
- *The single brownfield in West Greenwich was unable to be coded in GIS and does not have an associated area from the DEM dataset.*

Brownfield Solar Results by Municipality (cont.)

	Narragansett	Newport	New Shoreham	North Kingstown	North Providence	North Smithfield	Pawtucket	Portsmouth	Providence	Richmond	Scituate	Smithfield	South Kingstown	Tiverton	Warren	Warwick	West Greenwich	West Warwick	Westerly	Woonsocket
Total number of brownfields	8	27	-	22	13	6	70	16	164	3	4	19	15	6	12	35	1	19	11	32
Total capacity (MW)	2	22	-	68	3	30	32	67	80	0.4	1	56	0.5	20	9	26	-	11	3	13
Technical Capacity, Low (MW)	0.6	9	-	26	1	-	12	-	-	0.1	-	0	-	-	-	-	-	4	-	-
Technical Capacity, High (MW)	1	16	-	49	2	9	23	29	23	0.3	0	33	-	9	2	6	-	8	0.18	5

Notes:

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- *"Low" category assumes a 50-ft setback from buildings and a 50-ft setback from adjacent properties. "High" category assumes a 50-ft setback from buildings and a 375-ft setback from adjacent properties.*
- *All potential numbers are calculated independent from a municipality's eligibility to participate in current state programs.*
- *All potential numbers are calculated independent from requirements under current net metering that limits generation to 125% of onsite usage for non-VNM projects.*
- *The single brownfield in West Greenwich was unable to be coded in GIS and does not have an associated area from the DEM dataset.*

Parking Lot Solar Results by Municipality

	Statewide	Barrington	Bristol	Burrillville	Central Falls	Charlestown	Coventry	Cranston	Cumberland	East Greenwich	East Providence	Exeter	Foster	Glocester	Hopkinton	Jamestown	Johnston	Lincoln	Little Compton	Middletown
Est. number of parking lots	10,872	120	87	27	13	400	267	307	20	567	253	200	40	600	200	720	107	640	216	120
Total capacity (MW)	1,588	18	13	4	2	58	39	45	3	83	37	29	6	88	29	105	16	94	32	18
Technical Capacity (MW)	1,058	12	8	3	1	39	26	30	2	55	24	19	4	58	19	70	10	62	21	12

Notes:

- *Values of "-" indicate a zero.*
- *All data is subject to quality control and may change.*
- *Technical category assumes a 50-ft setback from buildings.*
- *All potential numbers are calculated independent from a municipality's eligibility to participate in current state programs.*
- *All potential numbers are calculated independent from requirements under current net metering that limits generation to 125% of onsite usage for non-VNM projects.*

Parking Lot Solar Results by Municipality (cont.)

	Narragansett	Newport	New Shoreham	North Kingstown	North Providence	North Smithfield	Pawtucket	Portsmouth	Providence	Richmond	Scituate	Smithfield	South Kingstown	Tiverton	Warren	Warwick	West Greenwich	West Warwick	Westerly	Woonsocket
Est. number of parking lots	227	453	280	393	227	40	107	47	870	640	67	420	287	20	20	760	720	107	273	13
Total capacity (MW)	33	66	41	57	33	6	16	7	127	94	10	61	42	3	3	111	105	16	40	2
Technical Capacity (MW)	22	44	27	38	22	4	10	5	85	62	6	41	28	2	2	74	70	10	27	1

Notes:

- *Values of "-" indicate a zero.*
- *All data is subject to quality control and may change.*
- *Technical category assumes a 50-ft setback from buildings.*
- *All potential numbers are calculated independent from a municipality's eligibility to participate in current state programs.*
- *All potential numbers are calculated independent from requirements under current net metering that limits generation to 125% of onsite usage for non-VNM projects.*

C&I Solar Results by Municipality

	Statewide	Barrington	Bristol	Burrillville	Central Falls	Charlestown	Coventry	Cranston	Cumberland	East Greenwich	East Providence	Exeter	Foster	Glocester	Hopkinton	Jamestown	Johnston	Lincoln	Little Compton	Middletown
Total number of parcels	19,075	143	533	59	216	124	236	1,448	564	251	579	188	166	104	128	61	1,521	74	22	410
Total capacity (MW)	9,045	42	87	42	14	157	53	373	185	119	123	910	804	144	227	4	780	92	17	157
Technical Capacity, Low (MW)	1,162	1	5	1	-	12	-	1	0	10	-	280	248	18	27	-	84	-	1	7
Technical Capacity, High (MW)	4,611	8	41	22	1	80	8	122	73	63	27	665	588	84	132	1	403	31	9	57

Notes:

- *Values of "-" indicate a zero.*
- *All data is subject to quality control and may change.*
- *"Low" category assumes a 50-ft setback from buildings and a 50-ft setback from adjacent properties. "High" category assumes a 50-ft setback from buildings and a 375-ft setback from adjacent properties.*
- *All potential numbers are calculated independent from a municipality's eligibility to participate in current state programs.*
- *All potential numbers are calculated independent from requirements under current net metering that limits generation to 125% of onsite usage for non-VNM projects.*

C&I Solar Results by Municipality (cont.)

	Narragansett	Newport	New Shoreham	North Kingstown	North Providence	North Smithfield	Pawtucket	Portsmouth	Providence	Richmond	Scituate	Smithfield	South Kingstown	Tiverton	Warren	Warwick	West Greenwich	West Warwick	Westerly	Woonsocket
Total number of parcels	99	335	102	636	617	407	531	327	4,701	81	121	193	352	216	377	1,881	164	339	434	334
Total capacity (MW)	11	75	5	595	33	294	90	201	553	131	45	184	360	213	18	540	795	76	342	155
Technical Capacity, Low (MW)	-	3	-	54	-	2	0.4	10	14	17	-	6	36	29	-	16	244	3	32	0.1
Technical Capacity, High (MW)	1	19	0.2	332	1	119	21	69	145	88	19	100	172	131	2	174	581	19	159	41

Notes:

- *Values of "-" indicate a zero.*
- *All data is subject to quality control and may change.*
- *"Low" category assumes a 50-ft setback from buildings and a 50-ft setback from adjacent properties. "High" category assumes a 50-ft setback from buildings and a 375-ft setback from adjacent properties.*
- *All potential numbers are calculated independent from a municipality's eligibility to participate in current state programs.*
- *All potential numbers are calculated independent from requirements under current net metering that limits generation to 125% of onsite usage for non-VNM projects.*

Aggregated non-Rooftop Solar by Municipality

	Statewide	Barrington	Bristol	Burrillville	Central Falls	Charlestown	Coventry	Cranston	Cumberland	East Greenwich	East Providence	Exeter	Foster	Glocester	Hopkinton	Jamestown	Johnston	Lincoln	Little Compton	Middletown
Total capacity (MW)	12,267	65	121	64	19	409	140	497	232	231	243	1,022	823	248	391	115	832	216	52	189
Technical Capacity, Low (MW)	2,579	13	17	4	1	172	42	43	10	76	52	329	255	79	62	70	95	62	22	19
Technical Capacity, High (MW)	6,675	22	61	32	3	295	68	187	100	138	113	744	603	153	248	73	437	103	33	72

Notes:

- *Values of "-" indicate a zero.*
- *All data is subject to quality control and may change.*
- *"Low" category assumes a 50-ft setback from buildings and a 50-ft setback from adjacent properties. "High" category assumes a 50-ft setback from buildings and a 375-ft setback from adjacent properties.*
- *All potential numbers are calculated independent from a municipality's eligibility to participate in current state programs.*
- *All potential numbers are calculated independent from requirements under current net metering that limits generation to 125% of onsite usage for non-VNM projects.*

Aggregated non-Rooftop Solar by Municipality (cont.)

	Narragansett	Newport	New Shoreham	North Kingstown	North Providence	North Smithfield	Pawtucket	Portsmouth	Providence	Richmond	Scituate	Smithfield	South Kingstown	Tiverton	Warren	Warwick	West Greenwich	West Warwick	Westerly	Woonsocket
Total capacity (MW)	46	166	47	747	69	361	141	282	764	285	61	318	456	289	36	696	901	106	410	176
Technical Capacity, Low (MW)	23	56	27	123	23	11	23	15	99	99	7	47	76	39	2	91	314	18	60	1
Technical Capacity, High (MW)	25	82	28	437	26	152	56	106	255	189	28	184	238	176	7	264	651	38	201	48

Notes:

- *Values of "-" indicate a zero.*
- *All data is subject to quality control and may change.*
- *"Low" category assumes a 50-ft setback from buildings and a 50-ft setback from adjacent properties. "High" category assumes a 50-ft setback from buildings and a 375-ft setback from adjacent properties.*
- *All potential numbers are calculated independent from a municipality's eligibility to participate in current state programs.*
- *All potential numbers are calculated independent from requirements under current net metering that limits generation to 125% of onsite usage for non-VNM projects.*

Additional Rooftop Solar Caveats

- The building categories were determined based on the zoning data each town provided. Because each town's zoning codes are different, the extrapolation of the zoning data into broader categories is imperfect and therefore the building categories are only as good as the zoning data provided.
- Zoning and parcel data is of different vintages, and in some cases information on vintage does not exist
- We assume the same capacity factors to convert both total potential and technical capacity (MW) into potential energy (MWh). However, these capacity factors assume that solar is sited on the feasible parts of roofs, rather than the parts deemed infeasible by NREL (e.g., parts of roofs that contain HVAC equipment, are shaded, or have complex rooftop geometry). As a result, it is likely that the total potential energy is lower than what is estimated here.

Additional Landfill Solar Caveats

- Setbacks were determined using input provided by solar developers. From this input, we make some assumptions about property surroundings and building height to provide a set back range from 50 feet to 375 feet from property lines and a 50 feet set back from buildings.
  - For the building setback, we assumed the average building was 20 feet in height (equivalent to a 2-story house with 10 feet tall stories). According to input from solar developers, solar facilities are typically sited at a distance of at least 3X the height of a nearby building when sited at a North-South relative to the building. When located East or West of a building, this metric is 2X. We assumed that half of solar installations will be built North-South, and half will be built East-West (in reality, solar installations will be built North, South, Northwest, East-by-Northeast, and many other directions relative to buildings). This assumption translates into a height multiplier of 2.5X. Finally, we multiplied 2.5 by 20 feet to get a 50 feet building setback.
  - For the low estimate setback from property lines, we used input from solar developers indicating that properties located next to commercial or industrial parcels may only need to be setback 50 feet to arrive at our low estimate of a 50-foot setback.
  - For the high estimate setback from property lines, we used input from solar developers indicating that properties located next to residential parcels must be set back 200 feet. We additionally assume the existence of 70 feet tall trees around the edge of the property that require an additional setback. Using the same 2.5 ratio from the building setback, we add another 175 feet to the total required set back, adding to a total 375-foot setback.
  - The setbacks from buildings and parcel lines are estimates based on existing literature and input from solar developers. However, the geography and tree locations vary, and towns may have individual setback requirements that are different from the ones we have defined here.

Additional Landfill Solar Caveats (cont.)

- Data available on re-use of land is out of date. Using google satellite data, we screened out land that was obviously no longer suitable for solar (e.g., baseball fields, existing solar, and more), but this satellite data was last updated 2018 and may not be completely accurate.
- Surveys of solar developers suggested that their projects were unlikely to see cost increases or changes to feasibility as long as land slopes were lower than 10 percent; however, construction on steeper land may be possible at higher costs.
- In the current analysis, we have not screened for solar potential based on reuse (yes, no, partial, unknown), although we have manually removed areas from parcels that appear to be currently used for solar, ballfields, etc.

Additional Gravel Pit Solar Caveats

- Data available on re-use of land may be out of date. Using google satellite data, we screened out land that was obviously no longer suitable for solar (e.g., baseball fields, existing solar, and more), but this satellite data was last updated 2018 and may not be completely accurate.
- For caveats for setbacks, see slide titled “Landfill Solar Caveats”.
- For caveats for slopes, see slide titled “Landfill Solar Caveats”.

Additional Brownfield Solar Caveats

- Data available on re-use of land is likely not completely up to date. Because of the high volume of brownfield sites, this category was not manually screened. As a result, there are likely some number of the sites we are counting here that have already been reused or committed to reuse in the future.
- For the top 15 brownfields in area listed in the DEM database that we were not able to match, we were able to manually code 4 of them and add them to the GIS analysis.
- For caveats for setbacks, see slide titled “Landfill Solar Caveats”.
- For total area of all brownfields (mapped and unmapped), we rely on data gathered by DEM to estimate total area.
  - We then reduce these total areas proportional to the resulting areas calculated after account for setbacks and inappropriate land uses.
  - However, it is possible that these numbers are inaccurate. For the brownfields that were mappable, we estimate that DEM areas are 1.4 times larger than they “should” be, when going by the mapped parcel areas.

Additional C&I Solar Caveats

- Commercial and industrial parcels were identified using zoning and parcel data provided by the towns. Each towns' individual zoning data is of different vintages and has different characteristics influencing the results for this category.
- Out of the 39 towns in Rhode Island, Synapse received zoning and parcel data from 34 of the towns. For the towns we did not received zoning and parcel data from, we used census data to find a similar town and used that towns C&I parcels per square mile and applied this ratio to the town without data using that towns square mile data.
  - For example, we did not receive data for West Warwick. Based on census data, West Warwick is similar to Newport. We then used Newport's C&I parcels per square mile ratio to determine number and area of C&I parcels in West Warwick based on .
- Because we were only able to correctly include one third of existing brownfield sites in the state, we could only remove the brownfields from the C&I category that were correctly coded. This means that there will still be some overlap between the C&I parcels we have identified here and other existing brownfields.
- We are likely overcounting some amount of existing solar in this category that is actually built on brownfields.
- We have received data for programs awarded incentives in the Large, Medium, and Commercial REG program.
  - While we are currently accounting for the installed MW from these programs, we have not yet been able to integrate the cost data into our REF program database.
  - As a result, estimated $/Watt for landfills, gravel pits, brownfields, and undeveloped C&I parcels may change in a later version of this analysis.

Additional Parking Lot Solar Caveats

Open Street Maps (OSM)

- Synapse used Open Street Map (OSM) to estimate the number of parking lots in Rhode Island.
- OpenStreetMap is a tool for creating and sharing map information.
- Utilizes local knowledge. Anyone can contribute to OSM
- But, the quality of the data relies on the input of the contributors.

Caveats

- Existing data on carport solar is limited; there are currently only 4-5 installations in Rhode Island
- Based on spot checks, carport data in Rhode Island appears to be underestimated in OSM.
- More data in specific urban areas (especially downtown Providence) as opposed to rural areas.
- Appears to be more data where there were more active mappers/mapping communities, so not entirely correlated with population size.
- Limited literature available on land use dedicated to parking lots in Rhode island which makes validation of OSM data challenging.
- Because of limited installations, capacity factor and packing factor assumptions are based on ground-mounted solar data; actual values for these sites may be different.
- Our analysis does not take into account that some municipalities may have taller or shorter buildings, which could impact the necessary setback.