845 Brook Street, Rocky Hill, CT 06067
T 860.563.0015
ctgreenbank.com

CONNECTICUT GREEN BANK

Memo

To: Connecticut General Assembly – Energy & Technology Committee

From: Bryan Garcia (President & CEO)

Cc Board of Directors of the Connecticut Green Bank, Brian Farnen (General Counsel and CLO), Matt Macunas (Associate Director and Legislative Liaison), Sergio Carrillo (Director of Incentive Programs), Eric Shrago (Managing Director of Operations), and Selya Price (Senior Advisor to President & CEO)

Date: December 31, 2020

Re: Progress Report on the Residential Solar Investment Program (RSIP)

Overview

This memo provides an update on progress toward the public policy goals of the Residential Solar Investment Program (RSIP) and recommendations on how to support the sustained orderly development of CT's residential solar PV industry and related policy goals, in particular in the context of the COVID-19 pandemic and associated economic impacts.

RSIP was legislatively enabled through Section 106 of Public Act (PA) 11-80[1], updated by PA 15-194[2], PA 16-212[3] and most recently by PA 19-35[4], amending Connecticut General Statute (CGS) at Section 16-245ff[5]. The Green Bank is providing progress updates on the following provisions of Section 16-245ff:

> (4)(b) The Connecticut Green Bank, established pursuant to section 16-245n, shall structure and implement a residential solar investment program established pursuant to this section that shall support the deployment of not more than three hundred fifty megawatts[6] of new residential solar photovoltaic installations located in this state on or before (1) December 31, 2022, or (2) the deployment of three hundred fifty megawatts of residential solar photovoltaic

[1] PA 11-80: https://www.cga.ct.gov/2011/ACT/Pa/pdf/2011PA-00080-R00SB-01243-PA.pdf, "An Act Concerning the Establishment of the Department of Energy and Environmental Protection and Planning for Connecticut's Energy Future."
[2] PA 15-194: https://www.cga.ct.gov/2015/act/pa/pdf/2015PA-00194-R00HB-06838-PA.pdf, "An Act Concerning the Encouragement of Local Economic Development and Access to Residential Renewable Energy."
[3] PA 16-212: https://www.cga.ct.gov/2016/act/pa/pdf/2016PA-00212-R00SB-00366-PA.pdf, "An Act Concerning Administration of the Connecticut Green Bank, the Priority of the Benefit Assessments Lien under the Green Bank's Commercial Sustainable Energy Program and the Green Bank's Solar Home Renewable Energy Credit Program."
[4] PA 19-35: https://www.cga.ct.gov/2019/ACT/pa/pdf/2019PA-00035-R00HB-05002-PA.pdf, "An Act Concerning a Green Economy and Environmental Protection."
[5] https://www.cga.ct.gov/current/pub/chap_283.htm#sec_16-245ff (Residential Solar Investment Program)
[6] All solar PV capacity units in this progress report are provided in direct current (DC). The performance of PV modules and arrays are generally rated according to their maximum DC power output (watts).

installation, in the aggregate, whichever occurs sooner. The procurement and cost of such program shall be determined by the bank in accordance with this section.

(4)(d)(3) provide incentives that decline over time and will foster the sustained, orderly development of a state-based solar industry;[7]

(4)(j) On or before January 1, 2017, and every two years thereafter [(e.g., January 1, 2021)] for the duration of the program, the Connecticut Green Bank shall report to the joint standing committee of the General Assembly having cognizance of matters relating to energy on progress toward the goals identified in subsection (b) of this section.

RSIP Progress toward 350 MW

Through November 30, 2020, 43,276 projects totaling 348.7 MW (DC) of residential solar PV have been approved through the RSIP, or 99.6% of the 350 MW (DC) public policy goal under Section 16-245ff. Of the 348.7 MW approved, 91% or 317.5 MW have been completed.

As the Green Bank supports the market in meeting the installed capacity goal of the public policy through declining incentives offered through the RSIP, it now turns its focus to achieving the public policy objective of fostering the sustained, orderly development of a state-based solar industry in light of COVID-19 impacts and in the transition from net metering plus RSIP to a tariff compensation structure for residential solar PV customers.

In addition to reporting on CT General Statute (CGS) Section 16-245ff, the Green Bank is providing updates on:

- The impacts of the COVID-19 pandemic on the residential solar market and industry.
- Benefits and trends in deploying residential solar PV, including societal impact, as well as deployment in vulnerable communities.
- Regulatory implementation of the policy transition from net metering to a tariff compensation structure, as put forth in PA 18-50 and updated by PA 19-35.

[7] Section 16-245ff (4)(d): The Connecticut Green Bank shall develop and publish on its Internet web site a proposed schedule for the offering of performance-based incentives or expected performance-based buydowns over the duration of any such solar incentive program. Any such direct financial incentives shall only apply to the first twenty kilowatts of direct current of the qualifying residential solar photovoltaic system. Such schedule shall: (1) Provide for a series of solar capacity blocks the combined total of which shall be a maximum of three hundred-fifty megawatts and projected incentive levels for each such block; (2) provide incentives that are sufficient to meet reasonable payback expectations of the residential consumer and provide such consumer with a competitive electricity price, taking into consideration the estimated cost of residential solar installations, the value of the energy offset by the system, the cost of financing the system, and the availability and estimated value of other incentives, including, but not limited to, federal and state tax incentives and revenues from the sale of solar home renewable energy credits; **(3) provide incentives that decline over time and will foster the sustained, orderly development of a state-based solar industry;** (4) automatically adjust to the next block once the board has issued reservations for financial incentives provided pursuant to this section from the board fully committing the target solar capacity and available incentives in that block; and (5) provide comparable economic incentives for the purchase or lease of qualifying residential solar photovoltaic systems or power purchase agreements from such systems. The Connecticut Green Bank may retain the services of a third-party entity with expertise in the area of solar energy program design to assist in the development of the incentive schedule or schedules. The Department of Energy and Environmental Protection shall review and approve such schedule. Nothing in this subsection shall restrict the Connecticut Green Bank from modifying the approved incentive schedule to account for changes in federal or state law or regulation or developments in the solar market when such changes would affect the expected return on investment for a typical residential solar photovoltaic system by ten per cent or more. Any such modification shall be subject to review and approval by the department.

- Progress in support of battery storage for resilience in CT, in particular for residential battery storage deployed with solar PV.

Progress toward RSIP Policy Goals

As of November 30, 2020, a total of 43,276 or 348.7 MW of RSIP projects had been approved for incentives, representing 99.6% of the **statutory target of 350 MW**. Of the 348.7 MW approved, 91% or 317.5 MW had completed as of November 30, 2020. With RSIP approaching 350 MW of approved capacity, and just over 30 MW yet to complete, RSIP is expected to reach its statutory target of 350 MW of deployed (i.e., installed) capacity in 2021.

The RSIP statute specifies 350 MW of "deployed" (i.e., installed and energized) capacity, and because a portion of RSIP projects approved for incentives will not complete and will end up being cancelled[8], the Green Bank will approve projects beyond 350 MW to ensure achieving the statutory target. At the Green Bank's Board of Directors Meeting on September 23, 2020[9], the Board approved incentive approvals past the 350 MW target, including up to 10 MW to account for RSIP cancellations, and an additional 22 MW to support the residential solar PV industry toward achieving sustained orderly development in the context of COVID-19 impacts. The Green Bank will therefore approve up to 32 MW of additional capacity beyond the 350 MW statutory target, for a total of 382 MW. Because RSIP was not legislatively extended in 2020, the Green Bank assumed cost-recovery risk for this additional 32 MW to bridge the time period from now until the 2021 legislative session, when the CT General Assembly can consider a statutory extension of RSIP.

CGS section 16-245ff (4)(d)(3) provides that incentives are to decline over time and will foster the **sustained, orderly development of a state-based solar industry.** The goal of sustained orderly development ensures a long-term marketplace for solar PV contractors supporting residential end-use customers in Connecticut, supports the state's goal of reducing greenhouse gas emissions to 80% below 2001 levels by 2050 and supports the state's economic development goals. Public Act 15-194, An Act Concerning the Local Encouragement of Local Economic Development and Access to Residential Renewable Energy, which expanded RSIP from 30 to 300 MW, is written as a local economic development and clean energy policy, leveraging the Class I Renewable Portfolio Standard to support local job creation and state revenues through corporate, individual, and sales taxes. The Green Bank interprets achieving sustained orderly development to mean that adoption of residential solar PV will continue at a rate similar to recent RSIP approval volume of 50-60 MW per year.

Recommendations

The Green Bank offers the following three recommendations to help ensure the sustained orderly development of the Connecticut residential solar PV market within the context of the ongoing COVID-19 epidemic and economic impacts, and the state's broader energy and environmental policies and climate change mitigation goals.

1. **Consideration of RSIP Extension through Industry Justification** – in light of COVID-19 pandemic impacts on the solar industry, the Green Bank recommends that the local solar industry justify to the Connecticut General Assembly (CGA) an increase in RSIP's capacity

[8] On average, 15-20% of RSIP projects are cancelled due to expiration of incentives for projects not completed or projects cancelled due to customers changing their mind or other reasons.
[9] https://ctgreenbank.com/about-us/governance/connecticut-grboard-meetings/

target by 100 MW from 350 MW to 450 MW for projects approved before 2022. If justified, an extension would provide time for the industry to re-stabilize and transition from a net metering plus RSIP policy to a tariff-based compensation structure. For additional perspective, the ZREC program was extended to a 10th year to provide incentive support to non-RSIP projects in 2021, and the energy efficiency market was provided with increased incentives to support industry stabilization due to COVID-19 in 2020 and through some of 2021. Similarly, the residential solar industry is in need of incentives during this uncertain economic time to recover from COVID-19 and the policy transition period. See the section of this report titled "COVID Impacts on the Residential Solar Industry" starting on page 4 for further discussion.

Draft updates to statute provided by the Green Bank - see Attachment 1. The proposed statutory updates would also: (a) extend net metering from December 31, 2021 up until the tariff is available to customers to ensure a seamless compensation transition even if tariffs are not ready for implementation by January 1, 2022, and (b) applies the SHREC cost recovery policy to match the timeframe of an RSIP extension - this provides utilities with cost-efficient REC purchase options to meet Class I Renewable Portfolio Standard obligations (i.e., with a price of $5 less than the Alternative Compliance Payment, which is $40 in 2021) while allowing for cost recovery of RSIP incentive expenditures.

2. **Continue Priority to Reduce Energy Burden on Vulnerable Communities** – while the state of Connecticut continues to face economic hardship due to COVID-19, the Green Bank encourages the CGA to continue to prioritize solutions that meet both short and long-term objectives and solve multiple problems. A priority of the Green Bank is support for vulnerable communities who bear the highest energy burdens in a state with one of the highest energy costs in the nation. Providing low-and-moderate-income (LMI) families with easy and affordable access to solar PV in combination with energy audits and impactful energy efficiency measures would provide cost savings that eliminate the energy affordability gap, helping them with other critical needs such as food and housing, while supporting the state progress toward its climate change mitigation goals. The section of this report "Addressing Higher Energy Burdens among LMI Households," starting on page 15 describes studies commissioned by the Green Bank (one of which is provided as Attachment 2), in collaboration with Operation Fuel, that further quantify LMI household energy burdens and offer clean energy solutions.

3. **Ensure Increased Resilience through Battery Storage** – encourage development of a Connecticut battery storage industry, in particular to deploy battery storage in combination with residential solar PV to socialize peak demand reduction and other benefits of these technologies among all ratepayers while creating more local jobs and contributing to modernization of the state's electric grid. The CGA should revisit HB 5351, "An Act Concerning Certain Programs and to Incentivize and Implement Electric Energy Storage Resources,"[10] which encouraged deployment of 1,000 MW of storage by December 31, 2030, including for behind-the-meter residential end-use customers.

   The CGA could support efforts by PURA put forth in docket 17-12-03, PURA Investigation into Distribution System Planning of the Electric Distribution Companies[11], providing the Authority's framework for investigating methods for realizing an equitable modern electric grid in Connecticut. Within this docket, specifically 17-12-03RE03 on Electric Storage, the Green Bank submitted a proposal for incentivizing residential battery storage deployed with solar PV, "Solarize Storage[12] – A Proposal of the Connecticut Green Bank Under Docket No. 17-12-03(RE03) – Electric Storage," submitted to PURA on July 31, 2020. More discussion on battery

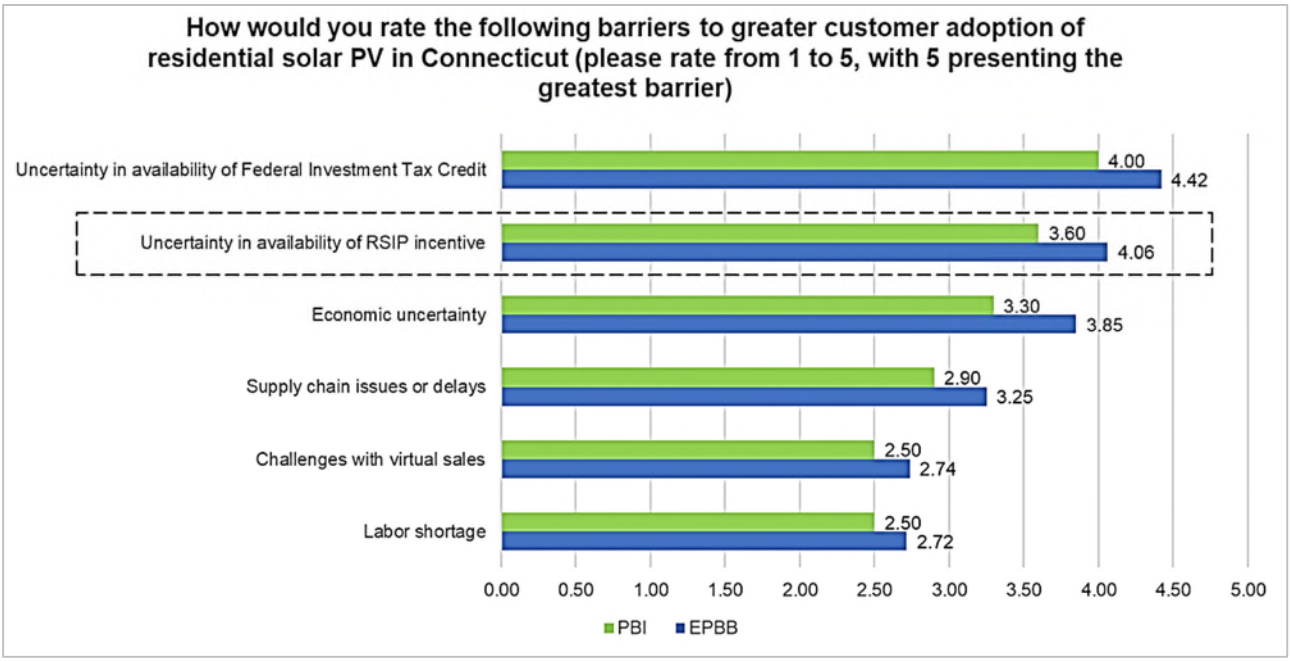
[10] https://www.cga.ct.gov/2020/TOB/h/pdf/2020HB-05351-R00-HB.PDF
[11] https://portal.ct.gov/PURA/Electric/Grid-Modernization/Grid-Modernization
[12] https://www.ctgreenbank.com/wp-content/uploads/2020/08/PURA-Docket-No.-17-12-03RE03-%E2%80%93-Solarize-Storage-Proposal-from-the-Green-Bank.pdf

storage including the benefits of deploying storage with solar PV is provided in the report section "Battery Storage and other Technologies," starting on page 18.

COVID Impacts on the Residential Solar Industry

The Green Bank's first recommendation to the CGA, for the local solar industry to justify an extension of the RSIP, reflects the economic impacts of the COVID-19 epidemic on the residential solar industry, made evident across all indicators – unemployment claims, industry surveys, Green Bank program data, and recent polling data. Figure 1 provides an example of survey results of residential solar PV contractors indicating that uncertainty in the availability of the RSIP incentive is and will be a barrier to the ability of customers to adopt residential solar, along with two other key factors – uncertainty in the availability of the recently-extended federal Investment Tax Credit ("ITC") and economic uncertainty (resulting from COVID-19).

Figure 1. Survey Results on Barriers to Customer Adoption of Residential Solar PV



"PBI" and "EPBB" are defined on page 9 of this report

In addition, contractors are contending with project delays and cancellations and most recently, are seeing increases in COVID cases among their staff. RSIP data indicates that volume has been down this year (during the pandemic) versus last year for 5 out of 8 months for incentive applications and 6 out of 8 months for project completion submissions, with positive months just above the zero mark in all months except September 2020 (for incentive applications) when it was announced that RSIP was running out of capacity, and in November 2020 (for project completion submissions) as contractors worked to meet the current year's federal ITC deadline. Further information about COVID-19 impacts on the clean energy industry is provided in the Connecticut Clean Energy Industry Report, published in November 2020.[13]

While program volume has improved toward the end of calendar year 2020 due to the time pressure of multiple program and policy change impacts, residential solar industry processes will

[13] https://www.ctgreenbank.com/wp-content/uploads/2020/11/2020-Connecticut-Clean-Energy-Industry-Report.pdf

continue to be slowed down by COVID and businesses will need support to stabilize their businesses over the coming year. Customer demand remains strong but customer affordability and confidence to sign long term contracts will suffer without sufficient incentives to make the economics of solar PV viable during challenging economic times. Now more than ever, it is important to support CT businesses and provide solutions for homeowners to reduce their energy costs. This is reflected in continuity of the ZREC program to incentivize non-RSIP solar PV projects into 2021 and in increased incentive levels for state of CT energy efficiency programs (including full subsidization of Home Energy Solutions energy audits). Residential solar PV should be treated similarly via an industry-justified legislative extension of RSIP incentives to bridge the policy gap to the tariff compensation structure scheduled to be implemented by 2022.

RSIP Benefits and Various Market Trends – Including Vulnerable Communities

As previously noted, as of November 30, 2020, a total of 43,276 or 348.7 MW of RSIP projects had been approved for incentives, representing 99.6% of the statutory target of 350 MW. Of the 348.7 MW approved, 91% or 317.5 MW had completed as of November 30, 2020. With RSIP approaching 350 MW of approved capacity, and just over 30 MW yet to complete, RSIP is expected to reach its statutory target of 350 MW of deployed (i.e., installed) capacity in 2021. RSIP project volume in 2020 began to recover due to the time pressure of RSIP running out of program capacity and the perception of an upcoming decrease in the ITC, though project cancellations are typically 15-20% of yearly volume and have yet to be reflected in 2020 data.

Table 1 below summarizes RSIP benefits since program inception, including projects approved from March 2012 through November 30, 2020. The fleet of almost 349 MW of approved RSIP projects is anticipated to produce over 397 million kWh of electricity annually or over 9.9 million MWh over the 25-year project lifetimes. Total job-years created are 15,404, of which 6,276 are direct and 9,128 are indirect and induced jobs.[14] Over 5.5 million tons of carbon dioxide emissions will be avoided over the project lifetimes.[15]

---

[14] Jobs methodology was developed by Navigant Consulting (now Guidehouse) for the Connecticut Green Bank in consultation with the Department of Economic and Community Development – https://www.ctgreenbank.com/wp-content/uploads/2018/03/CGB_DECD_Jobs-Study_Fact-Sheet.pdf. It should be noted that a tax revenue methodology was also developed by Navigant Consulting for the Connecticut Green Bank in consultation with the Department of Revenue Services – https://www.ctgreenbank.com/wp-content/uploads/2018/09/CGB-Eval-Tax-Methodology-7-24-18.pdf

[15] Air emissions methodology developed by the Connecticut Green Bank in consultation with the US Environmental Protection Agency and the Department of Energy and Environmental Protection – https://www.ctgreenbank.com/wp-content/uploads/2018/01/CGB-Eval-IMPACT-091917-Bv2.pdf. It should be noted that a public health methodology was also developed by the Connecticut Green Bank in consultation with the U.S. Environmental Protection Agency (EPA), Department of Public Health, and Department of Energy and Environmental Protection – https://www.ctgreenbank.com/wp-content/uploads/2018/03/CGB-Eval-PUBLICHEALTH-1-25-18-new.pdf. The Green Bank's benefit estimation methodology is also referenced in the Green Bank Comprehensive Annual Financial Report for fiscal year ended June 30, 2020, available at: https://www.ctgreenbank.com/wp-content/uploads/2020/10/FY20-CT-Green-Bank-CAFR-FINAL-10.28.20.pdf (PDF pages 142-149 and Appendix 7 starting on PDF page 287). While public health benefits are not provided in Table 1, the Green Bank submitted additional information into PURA docket 20-07-01 on 12/18/20 to detail methodology for valuing these benefits (http://www.dpuc.state.ct.us/dockcurr.nsf/8e6fc37a54110e3e852576190052b64d/557bd2e06ebfbebd852586450057b242?OpenDocument), including reference to another EPA resource, "Estimating the Public Health Benefits of Energy Efficiency and Renewable Energy with EPA's Benefits per kWh Values," https://www.epa.gov/sites/production/files/2020-01/documents/usepa_bpk_flyer_2019_10.21.19.pdf.

Table 1. RSIP Benefits for Projects Approved CY 2012-2020

Calendar Year Approved	Number of Projects	Capacity Approved (MW)	Expected Generation Annual (MWh)	Expected Generation Lifetime (MWh)	Annual CO2 Tons Avoided	Lifetime CO2 Tons Avoided	Total Jobs Created	State Tax Revenues Generated
2012	771	5.4	6,138	153,460	3,478	86,940	395	$906,414
2013	1,464	10.4	11,850	296,261	6,665	166,618	705	$1,618,179
2014	4,480	33.3	37,878	946,940	21,530	538,248	2,213	$5,080,266
2015	7,024	54.0	61,532	1,538,294	35,145	878,632	3,579	$8,215,530
2016	5,620	44.6	50,803	1,270,078	28,276	706,889	2,127	$5,428,075
2017	4,430	35.2	40,134	1,003,355	21,844	546,093	1,101	$3,545,827
2018	5,979	49.4	56,237	1,405,922	31,083	777,082	1,571	$5,058,521
2019	6,845	58.5	66,605	1,665,115	36,814	920,353	1,870	$6,017,423
2020	6,663	57.9	65,890	1,647,259	36,420	910,488	1,843	$5,933,286
Total	**43,276**	**348.7**	**397,067**	**9,926,684**	**221,254**	**5,531,343**	**15,404**	**$41,803,522**

In addition to the above benefits of over 397 million kWh of solar energy expected to be produced annually by nearly 349 MW of solar PV projects approved through RSIP, this solar PV capacity can help meet the broader electric sector's peak demand. Though solar PV does not coincide exactly with the system peak, solar PV provides significant load reduction during the hours the sun is shining and provides savings during the system peak. For example, an analysis conducted by Guidehouse for the Green Bank analyzed the peak demand contribution of 230 MW of RSIP projects during the summer heat wave in July 2019. The analysis results indicated that "if not for RSIP-supplied solar, an additional 1 GWh of energy would have been needed from non-renewable sources like natural gas, oil, and coal, and that the benefits amounted to over $3 million in system benefits, nearly 500 tons of avoided CO2 emissions, and about 175 pounds of NOx on the single peak day (which occurred on July 21, 2019). An additional $10 million in peak reduction benefits would have resulted from pairing 100 MW of battery storage with the RSIP solar PV projects. See Attachments 3 and 4 for a fact sheet and presentation document with analysis details.

The benefits of solar PV can be measured more broadly such as is done through benefit-cost analyses and value of distributed energy resource (DER) studies. For example, a report and study by Synapse Energy Economics, "Solar Savings in New England,"[16] produced in December 2020, quantifies wholesale energy market benefits of small-scale solar PV in New England from 2014 to 2019 to be $1.1 billion, associated with more than 8,600 GWh of electricity from behind-the-meter (BTM) solar PV. The report explains that the energy benefits result from both load reduction and price impacts:

> *"When BTM solar produces electricity, electric utilities—and ultimately electric ratepayers—will purchase fewer kWh of electricity from other sources (e.g., fossil fuel fired power plants). As BTM solar output increases, consumers pay less for electricity because the quantity of electricity purchased from other sources decreases. In addition, BTM solar has a second effect on electricity costs: because it reduces the demand for electricity to be purchased from other sources, it avoids the need to buy power from the most expensive power plant.* ***This leads to a lower 'market clearing price' that is paid to all electric***

[16] https://www.solarpowerworldonline.com/wp-content/uploads/2020/12/new-england-clean-energy.pdf

generators on the grid… As a result, more BTM solar not only decreases the quantity of electricity purchased, it also reduces the price paid for purchased electricity—which benefits all New England ratepayers."

In addition to energy benefits, the Synapse report quantifies capacity benefits, avoided costs of carbon dioxide emissions, and the public health benefits of avoided criteria pollutants, summarized in Figure 2. The benefits are provided for a low to high range of 20.5 to 37.1 cents/kWh, not including additional benefits not quantified.

Figure 2. Summary of Behind-the-meter Solar PV Benefits (Synapse Energy Economics)

Table 3. Summary of historical BTM solar benefits (2019 cents per kWh)

Benefit category	High	Medium	Low
Energy	11.9 ¢	11.9 ¢	11.9 ¢
Capacity	1.6 ¢	1.6 ¢	1.6 ¢
Criteria pollutants (SO_2, NO_x, $PM_{2.5}$)	1.0 ¢	1.0 ¢	1.0 ¢
CO_2 @ $425/MT	22.6 ¢	-	-
CO_2 @ $200/MT	-	10.7 ¢	-
CO_2 @ $112/MT	-	-	6.0 ¢
Energy, capacity, and pollution reduction benefits of BTM solar	**37.1 ¢**	**25.2 ¢**	**20.5 ¢**

Additional benefits not calculated:

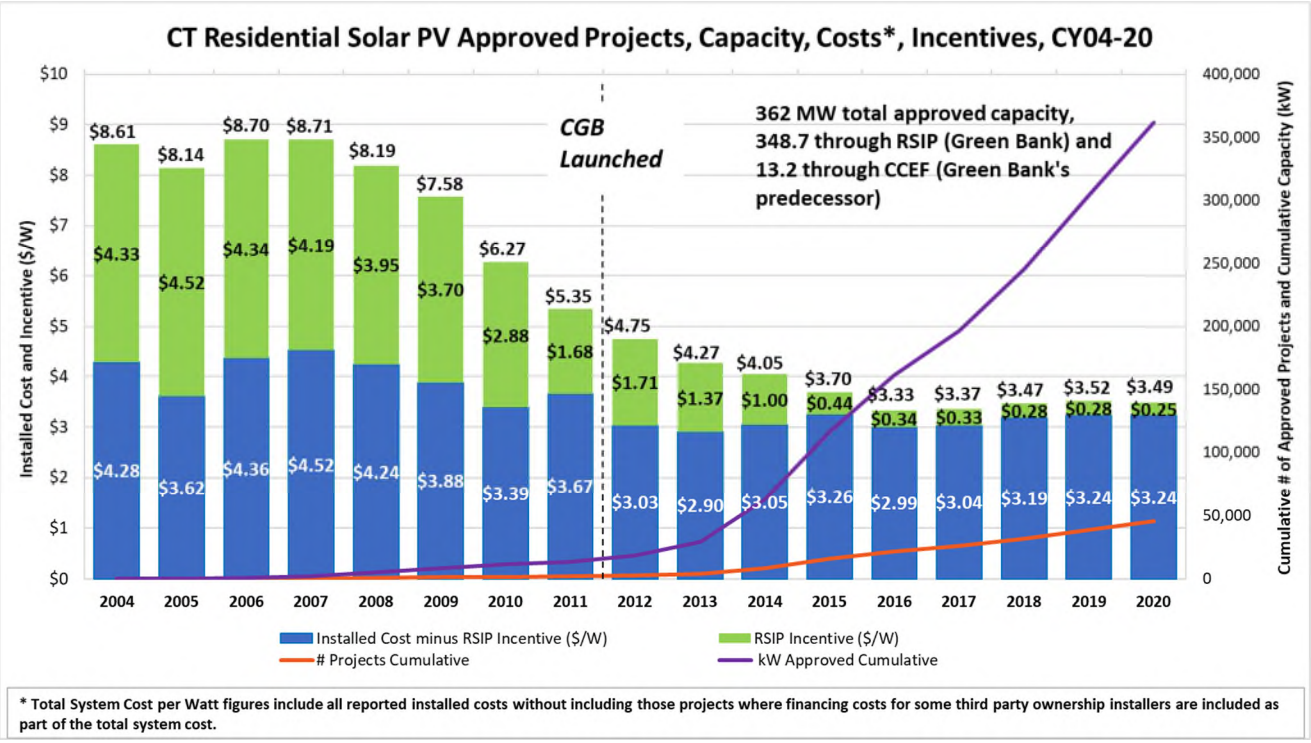
- Capacity price impacts
- Local economic benefits
- Reliability benefits
- Retail margin
- Transmission and distribution capacity
- Local tax support
- Participant savings

RSIP and Market Trends

Figure 3 provides historical perspective on Connecticut's residential solar PV market from 2004 through 2020, based on projects incentivized through RSIP from 2012-2020 and before that through the Connecticut Clean Energy Fund (CCEF), the Green Bank's predecessor organization.

The average residential PV incentive has been dramatically reduced as shown by the upper/green portion of the bars in the chart, while the average installed cost minus the RSIP incentive shown in the lower/blue portion of the bars have stayed roughly stable. Comparing 2004 to 2020, the average installed cost decreased 59% from $8.61/W to $3.49/W and the average RSIP incentive decreased 94% from $4.33/W to $0.25/W, while approved capacity increased over 450,000% from 12.7 kW in 2004 to 57.9 MW in 2020 (through November 2020). With the inception of the Green Bank in 2011, and the launch of RSIP in 2012, incentives were reduced more steeply, by 85% from $1.71/W in 2012 to $0.25/W in 2020 (as compared to the 60% reduction from 2004 to 2012). At the same time, installed costs decreased 26% from $4.75/W to $3.49/W and approved capacity grew almost 1000% from 5.4 MW in 2012 to 57.9 MW in 2020 (through November 2020).

Figure 3. RSIP Approved Projects, Capacity, Installed Costs, and Incentives, CY 2004-2020



* Total System Cost per Watt figures include all reported installed costs without including those projects where financing costs for some third party ownership installers are included as part of the total system cost.

Of the total approved RSIP projects to date, 26% are homeowner owned projects, incentivized with Expected Performance Based Buydowns (EPBBs) (i.e., one-time, upfront rebates), and 74% are third party owned projects (i.e., leases and power purchase agreements), incentivized with Performance Based Incentives (PBIs) (i.e., incentives provided on a per kWh basis, quarterly over six years for electricity produced through leases and power purchase agreements). While the EPBB and PBI are administered differently and over different time periods, they are, as required by statute, economically comparable on a net present value basis.

Table 2 provides RSIP cost and incentive data by calendar year and incentive type. The incentive for an RSIP project has decreased from an average of 36% of project cost in 2012 to an average of just over 7% in 2020 (9.6% for an EPBB project and 6.2% for a PBI). Associated with the incentive reduction, Table 2 shows that the ratio of the installed cost minus RSIP incentive to the RSIP incentive increased from a ratio of nearly 2-1 in 2012 to nearly 13-1 in 2020, reflecting increasingly efficient leveraging of RSIP funds to deploy higher levels of solar PV. The right-most column of Table 2 provides RSIP incentives in terms of their ZREC-equivalent, which average $19/MWh in 2020 as compared to roughly $100/MWh under the small ZREC Program. The Green Bank has cost-effectively deployed residential solar PV in Connecticut through RSIP.

Table 2 reflects trends in installed costs which decreased from 2012 to 2016, then increased slightly in recent years from 2016 to 2019, and looks to have slightly decreased in 2020 (including data through November 2020). Drivers that have contributed to costs staying relatively flat or increasing in recent years are:

- Federal import tariffs on modules/cells, inverters, and steel (used in system racking). Related to import tariffs have been challenges around uncertainty in availability of equipment.
- Increased customer acquisition and other soft costs.
- Increased labor, insurance, and financing costs.

- Solar PV companies absorbing cost increases for some time before having to pass some costs onto customers in order to stay in business. (That said, contractors indicate that they still absorb to various degrees the unexpected costs of installation, such as distribution system infrastructure upgrades, to help projects move forward).

Installed costs for residential solar PV in Connecticut are slightly less than that occurring across the country (i.e., $3.52/W in CT vs. $3.80/W nationally in 2019 – see Figure 4.[17]

Other factors that are affecting the net cost or economics of solar PV projects are:

- The federal Investment Tax Credit decreasing from 30% to 26% in 2020, an upcoming decrease to 22% in 2023, then to 0% in 2024 for homeowner-owned projects and 10% for third party owned projects.
- Property tax exemptions are being disputed by a handful of CT municipalities, in particular for solar PV projects that are third-party owned.

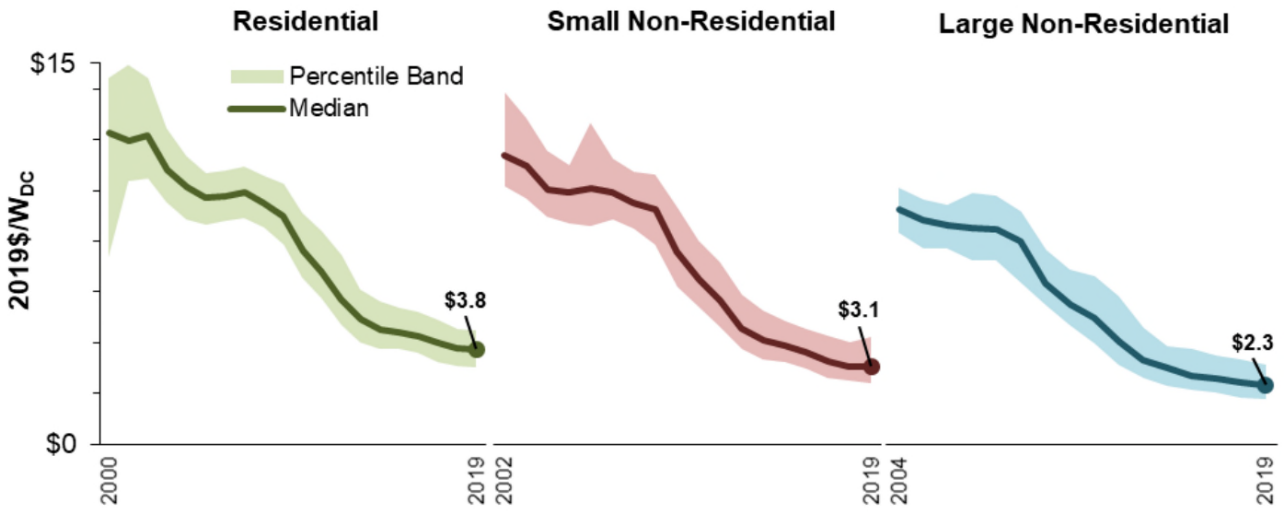
Table 2. RSIP Cost and Incentive Data for Projects Approved CY 2012-2020[18]

Calendar Year Approved	Average Installed Cost ($/W)	Average RSIP Incentive ($/W)	Average Installed Cost minus RSIP Incentive	RSIP Incentive as % of Installed Cost	Installed Cost minus RSIP Incentive/ RSIP Incentive Leverage Ratio	ZREC Equivalent Incentive ($/MWh)
2012	**$4.75**	**$1.71**	**$3.03**	**36.1%**	**1.8**	**$130**
2013	**$4.27**	**$1.37**	**$2.90**	**32.0%**	**2.1**	**$104**
2014	**$4.05**	**$1.00**	**$3.05**	**24.6%**	**3.1**	**$76**
2015	**$3.70**	**$0.44**	**$3.26**	**11.9%**	**7.4**	**$33**
2016	**$3.33**	**$0.34**	**$2.99**	**10.2%**	**8.8**	**$26**
2017	**$3.37**	**$0.33**	**$3.04**	**9.9%**	**9.2**	**$25**
2018	**$3.47**	**$0.28**	**$3.19**	**8.1%**	**11.3**	**$21**
EPBB	$3.65	$0.38	$3.27	10.5%	8.5	$29
PBI	$3.43	$0.26	$3.17	7.5%	12.3	$20
2019	**$3.52**	**$0.28**	**$3.24**	**7.8%**	**11.8**	**$21**
EPBB	$3.67	$0.38	$3.30	10.3%	8.7	$29
PBI	$3.47	$0.24	$3.22	7.1%	13.2	$19
2020	**$3.49**	**$0.25**	**$3.24**	**7.2%**	**12.9**	**$19**
EPBB	$3.61	$0.35	$3.26	9.6%	9.4	$26
PBI	$3.44	$0.21	$3.23	6.2%	15.2	$16
Total	**$3.58**	**$0.45**	**$3.13**	**12.6%**	**6.9**	**$34**

[17] "Distributed Solar 2020 Data Update" by LBNL (December 2020) - https://emp.lbl.gov/sites/default/files/distributed_solar_2020_data_update.pdf

[18] Average system cost per Watt figures include all reported installed costs without including those projects where financing costs for some third-party ownership installers are included as part of the system cost.

Figure 4. National Installed Price Trends (2000-2019)



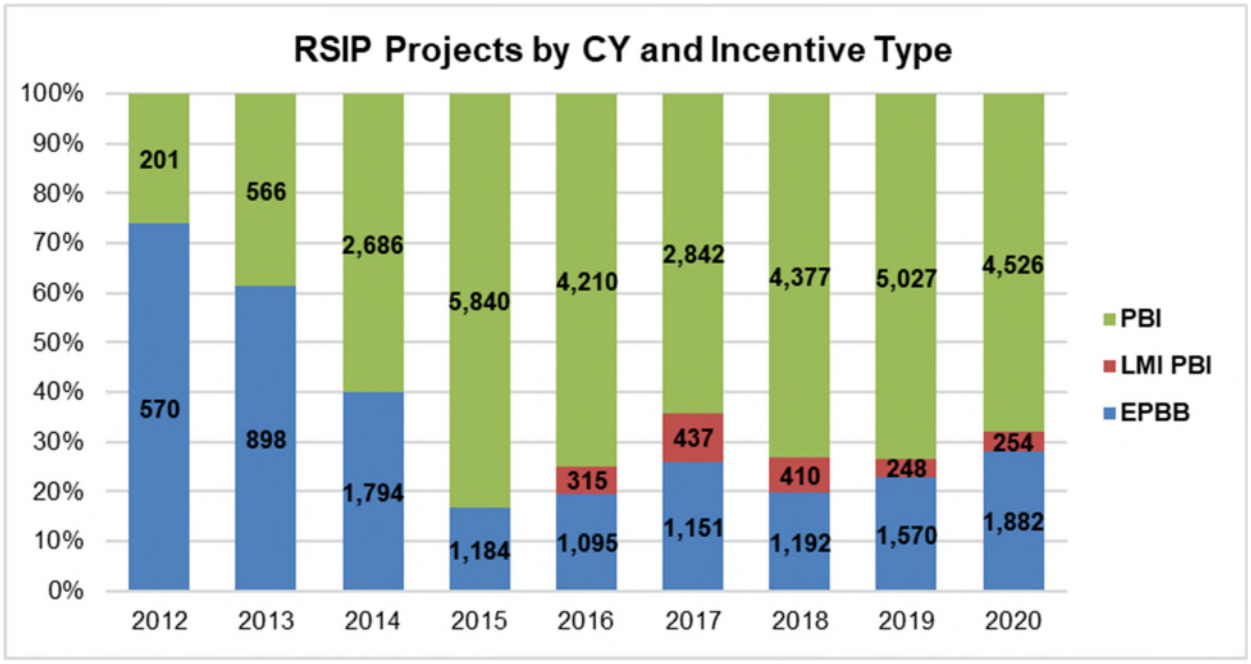
Expanding Solar PV Adoption in Low-to-Moderate Income and Underserved Communities

While solar PV adoption was strong among residential households through 2015, to ensure that the benefits of solar were being shared equally among all income classes and to correct for natural market failures, the Green Bank devised and successfully implemented a strategy to increase adoption among low-to-moderate income (LMI) households from 2016 onward. Through a public-private partnership with PosiGen Solar, the Green Bank established a "Solar for All" initiative to expand deployment of residential solar PV among LMI households. The Green Bank supported the partnership through an investment in PosiGen's Connecticut solar lease fund, a higher RSIP incentive[19] for projects serving LMI-verified customers, and collaboration on Solarize-style marketing campaigns.

Figure 5 presents the number of RSIP projects that received the higher LMI PBI, as well as PBI (non-LMI) and EPBB incentives, with the stacked bars reflecting the percentage of each project type in each year. From 2012 to 2018, third-party owned projects, including PBI and LMI PBI, have grown in market share from 26% in 2012 to 83% in 2015, remaining between 70-80% from 2016 through 2020, and cumulatively almost 74% of RSIP projects since 2012. LMI PBI projects made up 5.6% of projects in 2016, increased to higher levels of 9.9% in 2017 and 6.9% in 2018, decreased to lower levels of 3.6% in 2019 and 3.8% in 2020, and cumulatively represent 3.9% of RSIP projects. While interest in rooftop solar PV has remained robust among LMI customers, ongoing challenges in securing income verification documentation for accessing the higher incentive level remains a challenge for providers.

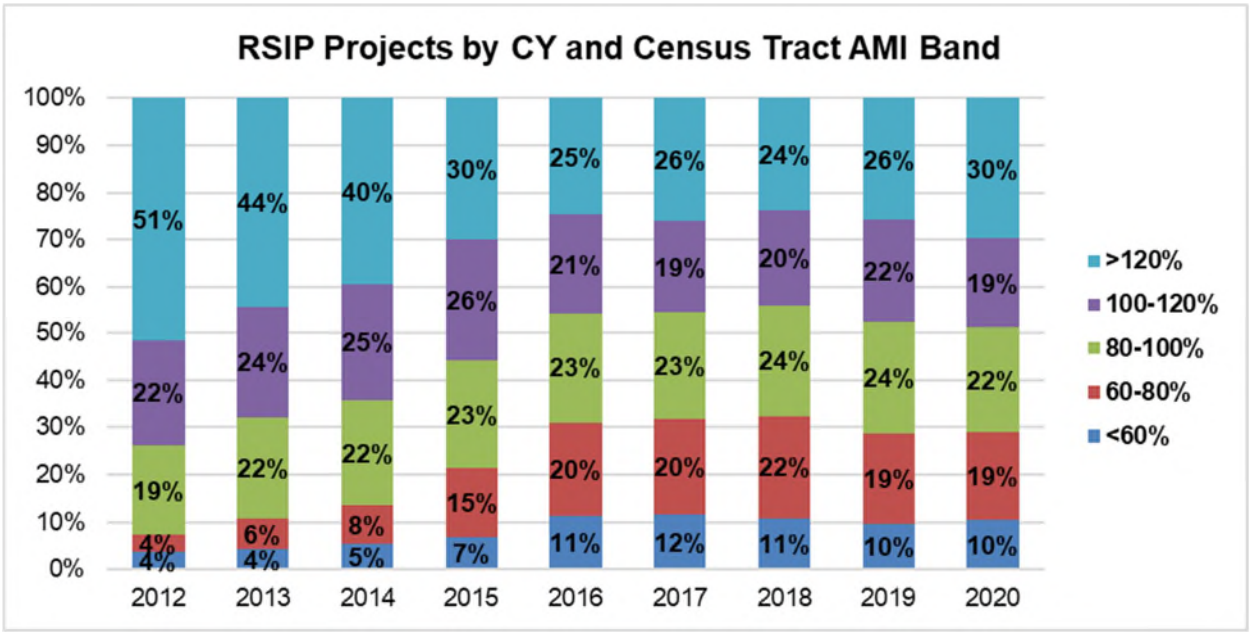
[19] The LMI incentive is only offered as a PBI incentive based on research indicating that LMI customers are less able to fully utilize the ITC based on lower tax liability. For example, the current LMI PBI is 2.7 times higher than the PBI.

Figure 5. RSIP Projects by Calendar Year and Incentive Type



While only a small percentage of RSIP projects utilized the higher LMI PBI incentive, broader adoption of residential solar PV in LMI communities has increased significantly since the Solar for All initiative launched. From 2016-2020, approximately half of all RSIP customers lived in census tracts with average median income (AMI) of 100% or less, as shown in Figure 6.[20]

Figure 6. RSIP Projects by Calendar Year and Census Tract AMI Band



[20] The Green Bank defines LMI as 100% or less of the Area Median Income (AMI) of a Metropolitan Statistical Area (MSA) and groups projects by the average AMI of their census tract from the American Community Survey (ACS) 5-Year Estimate data. The ACS data reflected in this report is from the 2018 ACS.

Table 3 below compares approved RSIP project volume by census tract income bands as a percentage of the number of owner-occupied households in the respective income bands.[21] The highest market penetrations are in the lowest three income bands with 6.3% in the <60% income band, and 6.8% in both the 60-80% and 80-100% income bands. The lowest market penetration is 3.3% in the >120% (highest income band), followed by 4.6% in the 100-120% income band.

Table 3. RSIP Projects by Income Band as % of Owner-Occupied Households

Census Tract Income Band (AMI)	# Projects (cumulative)	Total Owner Occupied 1-4 Unit Households	% of Households
<60%	3,946	62,247	6.3%
60-80%	7,382	109,142	6.8%
80-100%	9,936	145,988	6.8%
100-120%	9,464	204,880	4.6%
>120%	12,676	343,989	3.7%
Total	**43,404**	**866,246**	**5.0%**

Table 4 provides another, similar perspective on LMI market penetration based on the distribution of RSIP projects among income bands as compared to the distribution of owner-occupied housing units among income bands. While only 7.2% of owner-occupied housing units belong to homeowners in the <60% income band, a higher percentage, namely 9.1% of all RSIP projects were adopted by homeowners in this lowest income band (i.e., the lowest income band group was responsible for more than their share of solar PV adoption). By comparison, 39.7% of owner-occupied housing units belonged to homeowners in the >120% income band, but these homeowners accounted for only 29.2% of RSIP projects. These numbers illustrate that LMI market penetration is beyond parity with respect to income bands, that LMI customers will go solar if they have the means, and that the LMI market is a key growth market for the long-term sustainability of the residential solar industry.

Table 4. Distribution of RSIP Projects by Income Band versus Distribution of Owner-Occupied Households by Income Band

Census Tract Income Band (AMI)	# Projects (cumulative)	% Project Distribution (cumulative)	Total Owner Occupied 1-4 Unit Households	% Distribution Owner Occupied 1-4 Unit Households
<60%	3,946	9.1%	62,247	7.2%
60-80%	7,382	17.0%	109,142	12.6%
80-100%	9,936	22.9%	145,988	16.9%
100-120%	9,464	21.8%	204,880	23.7%
>120%	12,676	29.2%	343,989	39.7%
Total	**43,404**	**100.0%**	**866,246**	**100.0%**

[21] Data on the number of owner-occupied households by AMI band was derived from 2018 ACS data.

While the RSIP has been effective in reaching LMI households, Green Bank has also investigated whether the RSIP has been successful in reaching communities of color (i.e., Black and Hispanic households). When examining solar deployment by the racial and ethnic makeup of the census tract, an analysis conducted in 2019 demonstrated that RSIP has been very successful in reaching communities of color. On an Owner-Occupied Housing (OOH) basis, there were 86% more RSIP installations in majority Black neighborhoods, 18% more in majority Hispanic neighborhoods, and 20% more in No Majority race neighborhoods as compared to majority White neighborhoods – see Table 5 to compare % OOH vs % of RSIP for AMI Bands of less than 100%. A report on this analysis titled "Sharing Solar Benefits" was published in May 2019.[22]

Table 5. Owner-Occupied Housing and RSIP Distribution by Race/Ethnicity and Income

Census Tract Income Level (AMI Band)	Majority Hispanic		Majority Black		Majority White		No Majority Race	
	% of OO Homes	% of RSIP	% of OO Homes	% of RSIP	% of OO Homes	% of RSIP	% of OO Homes	% of RSIP
<60%	30.3%	24.91%	12.8%	22.41%	18.8%	14.58%	38.0%	38.09%
60%-80%	10.8%	13.04%	5.7%	7.68%	62.7%	56.04%	20.7%	23.24%
80%-100%	1.2%	1.57%	2.9%	4.48%	89.7%	87.94%	6.3%	6.01%
100%-120%	--	--	--	--	95.0%	95.04%	5.0%	4.96%
>120%	--	--	--	--	96.1%	95.14%	3.9%	4.86%
Grand Total	3.6%	4.11%	2.1%	3.77%	85.3%	81.81%	9.0%	10.31%

Federal Grants Supporting Adoption of Solar PV in the LMI Market

Under two U.S. Department of Energy (DOE) grants, the Green Bank has been working to increase the state's low-and-moderate (LMI) solar market and scale up strategies that increase affordability for LMI households. The first grant, "State Strategies for Solar Adoption in Low-and-Moderate Income Communities," led by the Clean Energy States Alliance (CESA), awarded in FY18 for three years, has continued to support Green Bank efforts to encourage adoption of solar PV among LMI households and communities of color. The grant received a no-cost extension through December 2020. As part of the efforts under this grant, the Green Bank developed a model to integrate housing, health, and energy service delivery to address in-home health threats and reduce energy burdens through solar plus energy efficiency. In addition, the Green Bank has actively participated in PURA docket 19-07-01, "Statewide Share Clean Energy Facility Program", to develop a strong, statewide shared solar program, and has collaborated with developers on the financing aspects of proposals submitted into the 2020 program solicitation.

The goal of a second DOE-funded grant, "Bringing LMI Solar Financing Models to Scale", also led by CESA, began in FY20 and provides funding for three years to help accelerate widespread adoption of a residential rooftop solar PV deployment model among LMI single-family homes throughout the country. The Green Bank in partnership with Inclusive Prosperity Capital (IPC), is providing advisory support on this project and is supporting a public-sector learning network in replicating the Solar for All program (a PosiGen/Green Bank partnership). The model will accelerate

[22] ctgreenbank.com/wp-content/uploads/2019/05/Sharing-Solar-Benefits-May2019.pdf

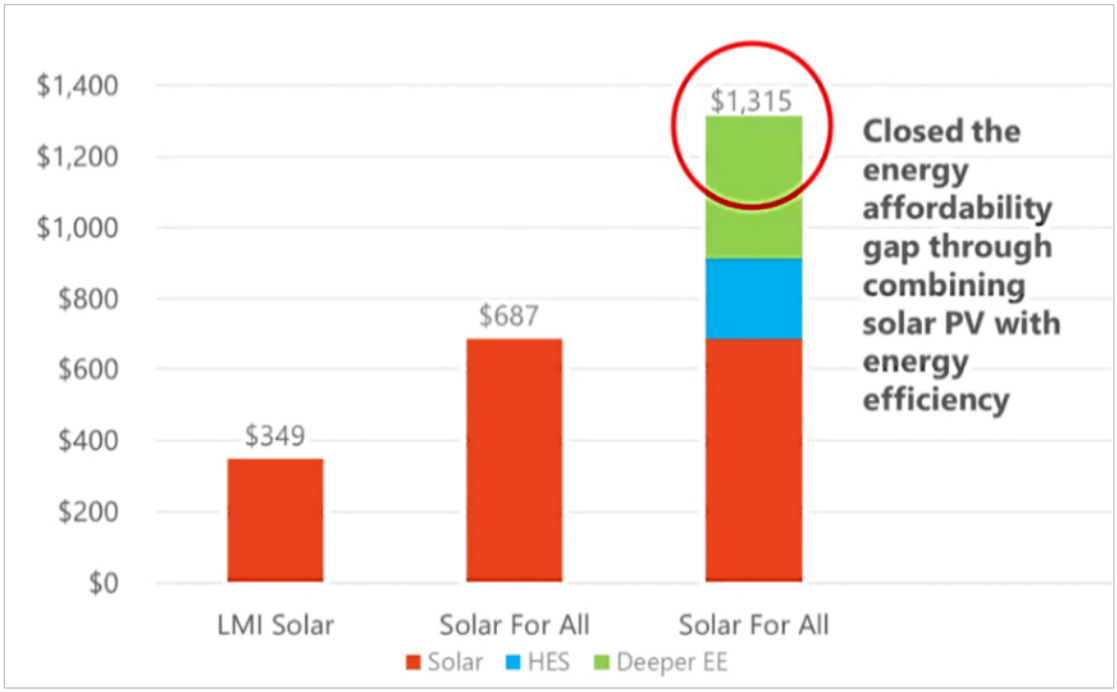
the adoption of solar and energy efficiency solutions for single-family LMI homes by providing financing templates, market insights, and development guidance.

Addressing Higher Energy Burdens among LMI Households

LMI households have higher energy burdens (percentage of income spent on household energy costs) than upper-income households, so solar PV and energy efficiency projects can help significantly alleviate this burden and provide greater energy security for these families. The Green Bank commissioned VEIC to conduct a study "Mapping Household Energy & Transportation Affordability in Connecticut"[23], in collaboration with and to build on earlier analysis by Operation Fuel. The report shows that combined spending on energy, transportation, and housing in Connecticut households exceeds affordable levels in areas throughout the state. On average, these costs are 49% statewide, which is above the 45% threshold for affordability. Low- and moderate-income households are burdened at a higher rate – 68% – than wealthier residents because these costs consume a larger portion of their household income.

A related study conducted by VEIC, "Connecticut Green Bank Low and Moderate Income Solar Program Savings Analysis,"[24] found that programs that combine energy efficiency and solar can close the energy affordability gap for LMI homeowners. Figure 7 provides an example illustrating how the PosiGen/Green Bank Solar for All Program (which requires an energy audit and follow-on energy efficiency measures in addition to adoption of solar PV) can close the energy affordability gap of between $600-$1,400 per year for low-income families. This report is provided as Attachment 2.

Figure 7. Closing the LMI Household Energy Affordability Gap with Residential Solar PV plus Energy Efficiency



[23] https://ctgreenbank.com/wp-content/uploads/2020/11/Mapping-Household-Energy-and-Transportation-Affordability-Report-Oct-2020.pdf
[24] https://www.ctgreenbank.com/wp-content/uploads/2020/11/CGB-LMI-Solar-Program-Savings-Analysis-Oct-2020.pdf

Solar PV Cost Reduction Efforts

An area of ongoing importance for the long-term sustainability of the solar PV industry is reduction of costs, in particular non-hardware or soft costs. Recognizing that hardware costs were steadily decreasing but soft costs were remaining high, the Green Bank participated in multiple U.S. Department of Energy (DOE) funding opportunities over the past 9 years, as the lead organization as well as in collaboration with other organizations on projects led by the Clean Energy States Alliance (CESA). These efforts have included:

- Two rounds of the DOE Rooftop Solar Challenge focused on improvement of municipal solar PV permitting and removal of barriers to solar PV adoption resulting from zoning regulations or interconnection rules and processes, in collaboration with municipalities, the Office of the State Building Inspector, contractors, the state's two investor-owned utilities, university partners, CESA (who led the second round), and other stakeholders. Resources developed through these efforts can be found at www.energizect.com/sunrisene.
- Participation in the DOE SunShot Prize: Race to 7-day Solar, a national competition intended to reduce the time it takes to "go solar" across the country. This project enabled the team to create resources including a video that explains the process of going solar from permit to plug-in[25]. Connecticut won a $100,000 prize from the DOE for its success.[26]
- The Green Bank was a DOE-funded SolSmart technical advisor contract winner – funding from this award provided resources for further consulting support to municipalities on solar PV permitting and zoning improvements to earn SolSmart certifications for solar-friendliness. These resources have also enabled greater safety for firefighters through training sessions coordinated by the Green Bank team on fire safety considerations where solar PV is present.

Currently, the Green Bank continues to work with municipalities on solar PV permitting and other municipal clean energy efforts through Sustainable CT[27], "a voluntary certification program to recognize thriving and resilient Connecticut municipalities. An independently funded, grassroots, municipal effort, Sustainable CT provides a wide-ranging menu of best practices. Municipalities choose Sustainable CT actions, implement them, and earn points toward certification." Sustainable CT provides a platform for achieving sustainability across a broad range of needs and connects municipalities to resources to help them achieve sustainability goals. The Green Bank provides technical and financial assistance for Sustainable CT[28] actions or action areas pertaining to: (1) C-PACE, (2) municipal permitting, (3) electric vehicle deployment, (4) use of clean energy in municipal buildings, (5) community energy campaigns targeting single-family households, with a focus on vulnerable communities and (6) benchmarking and providing financing for projects in multifamily buildings.

Future State Policy Support - Transition from Net Metering plus RSIP to a Tariff Compensation Structure for Residential Solar PV

PA 18-50, "An Act Concerning Connecticut's Energy Future," prescribed sweeping changes to the state's clean energy programs, including Section 7 of the Act which specified that the current net metering policy would end when RSIP ended and would be replaced by a tariff structure. PA 19-35 decoupled the end of net metering from RSIP, extending net metering to December 31, 2021, and

[25] http://www.gosolarct.com/1-Get-Into-Solar/Whats-Involved-From-Paperwork-to-Panels
[26] https://www.ctgreenbank.com/sunshot-prize-competition-ends/
[27] https://sustainablect.org/
[28] https://ctgreenbank.com/SUSTAINABLECT/

expanding RSIP from 300 MW to 350 MW to provide additional time for policy implementation – stakeholder comments into PURA dockets aimed at tariff implementation in 2018 and early 2019 made evident the need for more time to establish and implement residential solar tariffs. In addition, the netting interval for the netting (or Use-Buy-Sell) option under the tariff was changed to allow for a monthly interval (in addition to smaller intervals such as daily, sub-daily and instantaneous). Tariff elements put forth in PA 18-50 that remained unchanged were that customers would have two options, a Buy-All Sell-All option (which would likely be implemented as a fixed rate over 20 years) and a netting option (for which the metering configuration will allow for self-consumption), with a compensation level determined via competitive solicitations or based on average installed cost and a reasonable rate of return that is just, reasonable, and adequate.

In 2020, PURA resumed tariff development through Docket No. 20-07-01, "PURA Implementation of Section 3 of PA 19-35 – Renewable Energy Tariffs and Procurement Plans," focused on the residential tariff, and with its initial objectives stated as: (1) Economic Development – the sustained, orderly development of the state's solar industry; (2) Environmental Compliance – achieving a 100% zero carbon electric grid by 2040; and (3) Ratepayer Costs – balancing ratepayer costs. The Green Bank, along with the utilities, the solar industry, environmental groups, the Office of Consumer Counsel, and other stakeholders, have participated in multiple hearings and responded to notices and interrogatories to provide input into the objectives of the docket, the structure of the tariff and associated program, and suggestion of compensation rates and calculation methodologies.

The Green Bank's priorities in providing input into the docket have focused on whether the future tariff structure and compensation level (i.e., tariff rates assuring a reasonable rate of return) will support the sustained, orderly development of the state's solar industry, provide for a smooth transition to a post-RSIP compensation structure and program, and adequately support deployment among LMI households. A few points are highlighted here:

- With 350 MW of residential solar PV deployed through RSIP, the state will have reached about 45,000 households. However, there are an estimated 500,000 residential rooftops (i.e., more than 40% of CT households) for which solar is likely viable, and possibly as many as 650,000 at an installed cost of $3.50/W (roughly the current average in RSIP) and with ITC support.[29] An effective tariff will be needed to reach the rest of the addressable residential solar market in Connecticut and achieve the state's climate change mitigation goals.
- One of the Green Bank's primary objectives is "To strengthen Connecticut's communities by making the benefits of the green economy inclusive and accessible to all individuals, families, and businesses." Therefore, the Green Bank has highlighted the importance of implementing a tariff adder for LMI projects that will provide a higher incentive for these projects – we know from RSIP experience that the higher LMI PBI has supported greater deployment of solar PV among LMI households.
- Because the tariff compensation structure is anticipated to be administered by CT's utilities (possibly with support from other entities), there is the opportunity to leverage the utility billing process to offer innovative financing (e.g., direct payment to third parties, splitting tariff revenue streams among homeowners, third-party owners, and lenders) that will allow homeowners, in particular LMI households, to affordably access both solar PV and energy efficiency measures to more comprehensively meet energy needs and lower energy burdens.

[29] The Addressable Solar Market in Connecticut by Geostellar (December 6, 2013). https://www.ctgreenbank.com/wp-content/uploads/2016/03/Total_Addressable_Market_CT_Final.pdf

- Finally, the Green Bank has recommended that the tariff compensation structures and compensation levels encourage the deployment of battery storage, the importance of which is discussed in the next section.

PURA has indicated that a draft decision on the tariff is expected in December 2020.

Battery Storage and other Technologies

As more solar PV is deployed throughout Connecticut, the Green Bank, PURA, DEEP, the industry, the state's utilities, and other stakeholders are viewing clean energy deployment more holistically, in the context of grid modernization, electrification of heating, cooling and transportation, and commercialization and deployment of complementary technologies such as energy storage and energy efficiency to enable the state to meet its climate change mitigation and broader policy goals.

Since the beginning of RSIP in 2012, it has been a requirement to have an energy assessment performed in a home in order to access the solar PV incentive, preferably using the utility-administered Home Energy Solutions (HES).[30] These energy assessments encourage customers to adopt energy efficiency measures such as insulation, heat pump hot water heaters, and air and ground source heat pumps that enable electrification of space heating and cooling, technologies which are complementary to solar PV. Deployment of complementary technology combinations will maximize economic, energy and environmental benefits to all stakeholders.

An emerging market is residential battery storage installed in combination with solar PV. Battery storage provides backup power benefits for customers who are increasingly concerned about resiliency and increased energy independence, while also providing peak demand reduction benefits to the grid by storing and making available solar energy when it is most needed. Commercially available battery storage systems based on lithium ion chemistry are already providing demand reduction benefits throughout New England and the United States and enabling significant cost savings. Technologies such as battery storage are also critical to integration of solar PV into the grid as market penetration increases, mitigating the need for infrastructure upgrades on local circuits while providing an alternative to large infrastructure investments such as substations upgrades. As of December 2020, an estimated 400 battery storage projects have been installed with residential solar PV without incentives (i.e., less than 1 in 100 systems). Incentives for battery storage would accelerate the pace of technology adoption, cost reductions and further technology and market development, including increasing ratepayer and societal benefits.

For the past two years, the Green Bank has been seeking funding to administer a battery storage incentive program. The Green Bank contracted with Guidehouse (formerly Navigant Consulting) to conduct cost-effectiveness analysis for the Green Bank's application submission to PURA's Electric Efficiency Partners Program (EEPP) in 2018 (i.e., Docket No. 18-12-35), proposing an incentive program for residential battery storage installed with solar PV. The program was designed so that a customer would be required to charge the battery with solar PV during the day and discharge the battery to meet on-site load during ISO New England summer peak hours using a "Set it and Forget it" strategy. The analysis showed that battery storage utilized in this way provides peak reduction benefits to the grid as well as being available to the customer for backup power during outage events. Although determined by PURA to be a certified EEPP partner, and while the application for the project was not approved, as decision makers wanted more time to consider battery storage policy more broadly and holistically, the results show that residential battery storage provides peak

[30] The HES assessment includes an energy audit with a blower door test as well as several on-site improvements like air and duct sealing, weather-stripping and water saving measures.

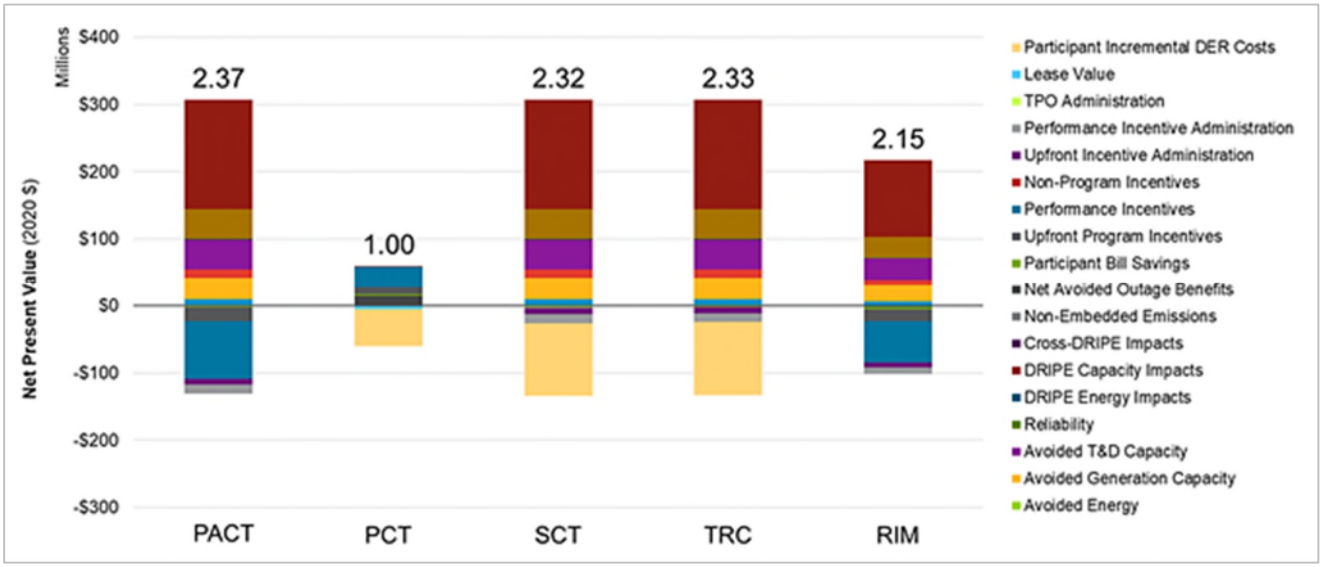
demand reduction value to the grid.

As provided earlier in the Recommendations section of this report, the CGA could revisit HB 5351, "An Act Concerning Certain Programs and to Incentivize and Implement Electric Energy Storage Resources," which encouraged deployment of 1,000 MW of storage by December 31, 2030.

The CGA could also support efforts by PURA put forth in docket 17-12-03, PURA Investigation into Distribution System Planning of the Electric Distribution Companies, providing the Authority's framework for investigating methods for realizing an equitable modern electric grid in Connecticut. Within this docket, specifically 17-12-03RE03 on Electric Storage, the Green Bank submitted a proposal for incentivizing residential battery storage deployed with solar PV, "Solarize Storage – A Proposal of the Connecticut Green Bank Under Docket No. 17-12- 03(RE03) – Electric Storage," submitted to PURA on July 31, 2020.[31] The Green Bank understands that PURA will be issuing a "straw proposal" imminently in Docket No. 17-12-03RE03 based on the proposals submitted by the Green Bank and other stakeholders.

The Green Bank's battery storage program design proposed to deploy 50 MW of battery storage paired with new or existing solar PV by 2025, reaching an estimated 10,000 households. The program design includes: (1) a declining upfront incentive block structure administered by the Green Bank, in exchange for passive dispatch to meet on-site load during specified hours (e.g., ISO-NE summer peak hours), and (2) a performance-based incentive administered by the utility companies modelled on the Eversource Connected Solutions demand response program, whereby customers allow their batteries to dispatch to meet on-site load and export to the grid during scheduled peak events. Program-wide, the design delivers benefit to cost ratios greater than one for all cost-effectiveness tests, as shown in Figure 8, from program (PACT), participant (PCT), societal (SCT), total resource (TRC) and ratepayer (RIM) perspectives.

Figure 8. Cost-effectiveness of Residential Battery Storage plus Solar PV[32]



[31] https://www.ctgreenbank.com/wp-content/uploads/2020/08/PURA-Docket-No.-17-12-03RE03-%E2%80%93-Solarize-Storage-Proposal-from-the-Green-Bank.pdf
[32] https://www.ctgreenbank.com/wp-content/uploads/2020/08/PURA-Docket-No.-17-12-03RE03-%E2%80%93-Solarize-Storage-Proposal-from-the-Green-Bank.pdf

In summary, cost-effectiveness analyses show that deploying solar PV plus battery storage provides benefits to the grid while providing resiliency benefits to customers and supporting higher levels of solar PV deployment.

Other Green Bank Initiatives and Partnerships in Support of Clean Energy

In addition to supporting adequate and sustainable compensation policy for solar energy, battery storage and energy efficiency, and deployment of clean energy in underserved communities, the Green Bank has continued to support the development of the residential solar PV and other clean energy markets through financing, marketing and educational initiatives, and strategic partnerships, for example by:

- Continuing to offer the Smart-E loan[33] through local community banks and credit unions that finance installation of residential solar PV, renewable thermal technologies such as air and ground source heat pumps, energy efficiency, alternative fuel vehicles, energy storage and other measures, including health and safety (e.g., asbestos, lead, mold). In 2020, the Green Bank has provided a 2.99% special offer for technologies most impactful for climate change mitigation.[34]
- Continuing to support solar PV contractors and third-party system owners, ranging from large, national companies to regional players and small, local businesses that provide for a strong, diverse state industry.
- Continuing to collaborate with stakeholders such as Solar Connecticut (the state's solar PV industry association) and the Renewable Energy and Efficiency Business Association (REEBA).
- Addressing consumer protection by collaborating with the Connecticut Department of Consumer Protection, the Office of Consumer Counsel, and the Office of the Attorney General to address consumer complaints and contractor issues. The Green Bank meets with the Department of Consumer Protection on a quarterly basis to address current issues and complaints.
- Providing GoSolarCT.com to support consumers of solar PV with a trusted source of information.
- Collaborating with the Clean Energy States Alliance (CESA)[35] to develop resources on solar PV consumer protection and related topics, in addition to participating as an active member in CESA's clean energy market transformation programs and projects.
- Participating in the ISO New England Distributed Generation Forecast Working Group[36].

[33] https://ctgreenbank.com/programs/smart-e-loans/
[34] https://www.ctgreenbank.com/programs/smart-e-loans/
[35] https://www.cesa.org/
[36] https://www.iso-ne.com/committees/planning/distributed-generation/

APPENDIX I

2021 Legislative Proposal

Residential Solar

Purpose: COVID-19 has impacted year-on-year project activity for residential rooftop solar PV system installers. To stabilize economic activity in the state's project market, and support Connecticut's climate and energy goals, this proposal sustains state incentives for the Residential Solar Investment Program ("RSIP") so as to not remove this support during recession, and while successor systems are still being assembled through stakeholder input at PURA.

Key Points:

- Increases the RSIP capacity cap from 350 MW to 450 MW for projects that can be approved before 2022.
- For the residential sector, extends the existing net metering compensation method for solar PV projects until PURA directs electric distribution companies to offer successor tariff compensation. Clarifies eligibility of projects for certain incentives during the transition between compensation methods (i.e., from net metering plus RSIP transitioning to the tariff structure anticipated to begin in 2022).
- Extends the Green Bank's cost recovery policy to match the RSIP extension. Functionally this provides utilities with cost-efficient REC purchase options to meet Class I Renewable Portfolio Standard obligations.

Previous Adjustments to these Statutes:

- PA 19-35, PA 18-50

AN ACT CONCERNING THE SUSTAINED, ORDERLY DEVELOPMENT OF THE STATE SOLAR INDUSTRY.

Be it enacted by the Senate and House of Representatives in General Assembly convened:

Section 1. Section 16-243h of the general statutes is repealed and the following is substituted in lieu thereof (*Effective from passage*):

On and after January 1, 2000, and until December 31, 2021 or, for residential customers, the date the electric distribution companies begin offering the renewable energy tariffs pursuant to subsection (b) of section 16-244z of the general statutes, each electric supplier or any electric distribution company providing standard offer, transitional standard offer, standard service or back-up electric generation service, pursuant to section 16-244c, shall give a credit for any electricity generated by a customer from a Class I renewable energy source or a hydropower facility that has a nameplate capacity rating of two megawatts or less for a term ending on December 31, 2041, provided any customer that has a contract approved by the Public Utilities Regulatory Authority pursuant to section 16-244r, as amended by this act, on or before December 31, 2021, shall be eligible for such credit. The electric distribution company providing electric distribution services to such a customer shall make such interconnections necessary to accomplish such purpose. An electric distribution company, at the request of any residential customer served by such company and if necessary to implement the provisions of this section, shall provide for the installation of metering equipment that (1) measures electricity consumed by such customer from the facilities of the electric distribution company, (2) deducts from the measurement the amount of electricity produced by the customer and not consumed by the customer, and (3) registers, for each billing period, the net amount of electricity either (A) consumed and produced by the customer, or (B)

the net amount of electricity produced by the customer. If, in a given monthly billing period, a customer-generator supplies more electricity to the electric distribution system than the electric distribution company or electric supplier delivers to the customer-generator, the electric distribution company or electric supplier shall credit the customer-generator for the excess by reducing the customer-generator's bill for the next monthly billing period to compensate for the excess electricity from the customer-generator in the previous billing period at a rate of one kilowatt-hour for one kilowatt-hour produced. The electric distribution company or electric supplier shall carry over the credits earned from monthly billing period to monthly billing period, and the credits shall accumulate until the end of the annualized period. At the end of each annualized period, the electric distribution company or electric supplier shall compensate the customer-generator for any excess kilowatt-hours generated, at the avoided cost of wholesale power. A customer who generates electricity from a generating unit with a nameplate capacity of more than ten kilowatts of electricity pursuant to the provisions of this section shall be assessed for the competitive transition assessment, pursuant to section 16-245g and the systems benefits charge, pursuant to section 16-245l, based on the amount of electricity consumed by the customer from the facilities of the electric distribution company without netting any electricity produced by the customer. For purposes of this section, "residential customer" means a customer of a single-family dwelling or multifamily dwelling consisting of two to four units. The Public Utilities Regulatory Authority shall establish a rate on a cents-per-kilowatt-hour basis for the electric distribution company to purchase the electricity generated by a customer pursuant to this section after December 31, 2041. Notwithstanding this section, qualifying residential solar photovoltaic systems approved under the residential solar investment program pursuant to section 16-245ff of the general statutes before the date the electric distribution companies begin offering the renewable energy tariffs pursuant to subsection (b) of section 16-244z of the general statutes shall be eligible for the credit established in this section.

Sec. 2. Subsections (b), (c), and (d) of section 16-245ff of the general statutes is repealed and the following is substituted in lieu thereof (*Effective from passage*):

(b) The Connecticut Green Bank, established pursuant to section 16-245n, shall structure and implement a residential solar investment program established pursuant to this section that shall support the deployment of not more than **[**three**]** four hundred fifty megawatts of new residential solar photovoltaic installations located in this state **[**on or**]** approved before **[**(1) December 31, 2022, or (2) the deployment of three hundred fifty megawatts of residential solar photovoltaic installation, in the aggregate, whichever occurs sooner**]** the date the electric distribution companies begin offering the renewable energy tariffs pursuant to subsection (b) of section 16-244z of the general statutes, provided the bank shall not approve direct financial incentives under this section for more than one hundred megawatts of new qualifying residential solar photovoltaic systems, in the aggregate, between July 2, 2015, and April 1, 2016. The procurement and cost of such program shall be determined by the bank in accordance with this section.

(c) The Connecticut Green Bank shall offer direct financial incentives, in the form of performance-based incentives or expected performance-based buydowns, for the purchase or lease of qualifying residential solar photovoltaic systems or power purchase agreement from such systems until the **[**earlier of the following: (1) December 31, 2020, or (2) the deployment of three hundred megawatts, in the aggregate, of residential solar photovoltaic installation**]** date the electric distribution companies begin offering the renewable energy tariffs pursuant to subsection (b) of section 16-244z of the general statutes. The bank shall consider willingness to pay studies and verified solar photovoltaic system characteristics, such as operational efficiency, size, location, shading, and orientation, when determining the type and amount of incentive. Notwithstanding the provisions of subdivision (1) of subsection (h) of section 16-244c, the amount of renewable energy

produced from Class I renewable energy sources receiving tariff payments or included in utility rates under this section shall be applied to reduce the electric distribution company's Class I renewable energy source portfolio standard until the Public Utilities Regulatory Authority approves the master purchase agreement pursuant to subsection (e) of section 16-245gg.

(d) The Connecticut Green Bank shall develop and publish on its Internet web site a proposed schedule for the offering of performance-based incentives or expected performance-based buydowns over the duration of any such solar incentive program. Any such direct financial incentives shall only apply to the first twenty kilowatts of direct current of the qualifying residential solar photovoltaic system. Such schedule shall: (1) Provide for a series of solar capacity blocks the combined total of which shall be a maximum of **[**three**]** four hundred fifty megawatts and projected incentive levels for each such block; (2) provide incentives that are sufficient to meet reasonable payback expectations of the residential consumer and provide such consumer with a competitive electricity price, taking into consideration the estimated cost of residential solar installations, the value of the energy offset by the system, the cost of financing the system, and the availability and estimated value of other incentives, including, but not limited to, federal and state tax incentives and revenues from the sale of solar home renewable energy credits; (3) provide incentives that decline over time and will foster the sustained, orderly development of a state-based solar industry; (4) automatically adjust to the next block once the board has issued reservations for financial incentives provided pursuant to this section from the board fully committing the target solar capacity and available incentives in that block; and (5) provide comparable economic incentives for the purchase or lease of qualifying residential solar photovoltaic systems or power purchase agreements from such systems. The Connecticut Green Bank may retain the services of a third-party entity with expertise in the area of solar energy program design to assist in the development of the incentive schedule or schedules. The Department of Energy and Environmental Protection shall review and

approve such schedule. Nothing in this subsection shall restrict the Connecticut Green Bank from modifying the approved incentive schedule to account for changes in federal or state law or regulation or developments in the solar market when such changes would affect the expected return on investment for a typical residential solar photovoltaic system by ten per cent or more. Any such modification shall be subject to review and approval by the department.

Sec. 3. Subsection (b) (2) of section 16-244z of the general statutes is repealed and the following is substituted in lieu thereof (*Effective from passage*):

(2) On and after the later of (1) a date determined by the Public Utilities Regulatory Authority or (2) January 1, 2022, each electric distribution company shall offer the following options to residential customers for the purchase of products generated from a Class I renewable energy source that is located on a customer's own premises and has a nameplate capacity rating of twenty-five kilowatts or less for a term not to exceed twenty years: (A) A tariff for the purchase of all energy and renewable energy certificates on a cents-per-kilowatt-hour basis; and (B) a tariff for the purchase of any energy produced and not consumed in the period of time established by the authority pursuant to subparagraph (C) of subdivision (1) of this subsection and all renewable energy certificates generated by such facility on a cents-per-kilowatt-hour basis. A residential customer shall select either option authorized pursuant to subparagraph (A) or (B) of this subdivision, consistent with the requirements of this section. Such generation projects shall be sized so as not to exceed the load at the customer's individual electric meter from the electric distribution company providing service to such customer, as determined by such electric distribution company. For purposes of this section, "residential customer" means a customer of a single-family dwelling or a multifamily dwelling consisting of two to four units.

Sec. 4. Subsection (a) of section 16-245gg of the general statutes is repealed and the following is substituted in lieu thereof (*Effective from*

passage):

(a) Not later than July 1, 2016, the Connecticut Green Bank shall negotiate and develop master purchase agreements with each electric distribution company. Each such agreement shall require the electric distribution company to purchase, annually, fifteen-year tranches of solar home renewable energy credits produced by qualifying residential solar photovoltaic systems under the residential solar investment program. Each electric distribution company's annual obligation to purchase fifteen-year tranches of solar home renewable energy credits produced by qualifying residential solar photovoltaic systems begins on the date that the Public Utilities Regulatory Authority approves the master purchase agreement pursuant to subsection (e) of this section and the obligation to purchase additional fifteen-year tranches expires on December 31, **[**2022**]** 2025. **[**, or after the deployment of three hundred fifty megawatts of residential solar photovoltaic installation, in the aggregate, whichever occurs earlier.**]**

Connecticut Green Bank Low and Moderate Income Solar Program Savings Analysis

Research for and support from:

CONNECTICUT GREEN BANK SM

October 2020

Acknowledgements

This work is funded in part or whole by Clean Energy States Alliance (CESA) under U.S. Department of Energy Solar Energy (DOE) Technologies Office Award Number DE-EE-0007667.

Executive Summary

This report quantifies realized and estimated solar and energy efficiency savings in 2019 for 252 customers that participated in the Connecticut Green Bank's low and moderate income (LMI) solar programs. These programs include an incentive available to solar projects installed for low- or moderate-income households, as well as a public-private partnership that supports a solar lease paired with energy efficiency services targeted at low and moderate income households (the Solar for All program). While all customers that participate in these programs receive basic weatherization and efficiency improvements through the utility-run Home Energy Solutions ("HES")[1] program, customers that participate in the Solar of All program also receive deeper energy efficiency services. Based on this analysis, customers that participated in the Green Bank's LMI incentive program but not the Solar for All program achieved average measured savings of $349 in 2019 from their solar PV installation. These customers are also estimated to have saved an additional $200-$250 from their participation in the HES program, bringing their total estimated 2019 savings to $549-$599. Customers that participated in the Solar for All program achieved average measured savings of $687 from solar in 2019, and an estimated average savings of $403 from deeper energy efficiency improvements recommended through the HES program. The combined solar lease, HES program measures and recommended energy efficiency improvement offered in the Solar for All program are estimated to have delivered average annual savings of $1290-$1340 per customer in 2019.

Introduction

In 2015 the Connecticut Green Bank (CGB) developed a new initiative focused on delivering behind the meter solar savings for low- and moderate-income households in Connecticut. The program, which provides an elevated incentive to income-qualifying households through the Green Bank's Residential Solar Investment Program, and features a public private partnership that created a solar and energy efficiency lease targeted at LMI households, has increased annual solar deployment in LMI communities from 44% to 54% since 2015.

[1] https://www.energizect.com/your-home/solutions-list/home-energy-solutions-core-services

The first component in the Green Bank's LMI solar program is an elevated incentive offered through the organization's long-running Residential Solar Investment Program (RSIP). The RSIP was established in 2012, but the Green Bank's LMI incentive did not launch until August 2015. The incentive was created to correct market inequities in the distribution of behind the meter solar projects in the RSIP. The LMI incentive is a performance-based incentive ("LMI PBI") that is approximately three times higher than the non-LMI incentive. The incentive is only available to qualifying third-party owned solar providers that have responded to an open RFP and had their product approved by the Green Bank, to ensure the value of the elevated incentive is passed through to customers. To receive the LMI incentive for a given project the solar provider must confirm the household meets the program's income requirements.[2] As of July 1, 2020, two (2) third-party owned solar providers and their solar products have been approved to access the LMI incentive.[3]

Recognizing the unique challenges of serving the LMI market, and that a concerted effort and specialized product would be needed to properly serve this market, Green Bank opened a Request for Proposals from financing providers to establish a public-private partnership to better serve the LMI market segment. PosiGen Solar Solutions, a Louisiana based solar provider, was selected under the open RFP and together with the Green Bank established Connecticut's "Solar for All" program. PosiGen offers a solar lease paired with energy efficiency improvements that leverage and build on efficiency services provided by through the state's Home Energy Solutions program.[4] Any homeowner can qualify for PosiGen's product, but the company specifically targets LMI households and simplifies the approval process by using an alternative underwriting process rather a traditional credit check. Green Bank supported PosiGen's foray into the Connecticut market by investing an initial $5 million in PosiGen's Connecticut solar lease fund and has since provided additional subordinated investments to enable the company to continue to offer an affordable LMI solar product in the Connecticut market. Since the program launched, nearly 3,300 households have participated and almost 22MW of solar has been installed as of August 2020. For more information on Connecticut's Solar for All program visit: https://www.cesa.org/resource-library/resource/building-a-state-solar-program-for-low-and-moderate-income-homeowners-replicating-connecticuts-success/

In July 2020, five years since the LMI program launched, the Green Bank and the Vermont Energy Investment Corporation (VEIC) conducted an analysis of realized solar savings for customers who participated in the Solar for All program, or whose project received the LMI PBI. The analysis

[2] To receive the LMI incentive the solar provider must confirm that the household earns below 100% of Area Median Income (AMI), based on the applicable Metropolitan Statistical Area

[3] In order to access the LMI incentive the solar provider's product pricing must be approved by Green Bank. Green Bank does not allow lease escalators to be applied to LMI products.

[4] https://www.energizect.com/your-home/solutions-list/home-energy-solutions-core-services

considers both measured solar savings as well as estimated energy efficiency savings for participants.

Methodology

Solar Savings

To measure customer solar savings, a sample set of 252 residential solar projects was established. The dataset included 242 randomly selected PosiGen customers whose solar PV systems were energized prior to December 31, 2018, and for whom a full year's worth of production data was available for 2019. This sample size represents approximately 15% of PosiGen's installed portfolio as of 12/31/2018.[5] 61% of these projects were verified as income-eligible households and received the LMI PBI, which is representative of PosiGen's larger portfolio ratio of LMI PBI to PBI projects.[6] The analysis also included 10 out of 15 customers whose solar PV project qualified for the LMI PBI, but whose systems were not installed by PosiGen. Only 10 out of these 15 total projects were included because a full year's worth of data for 2019 was not available for the remaining 5 projects.

Table 1. Solar Savings Analysis Data set

Program	Number of Projects	Capacity (kW)	Average System Size (kW)	Average Lease or PPA Price
Solar for All				
LMI PBI	148	917	6.2	$78/month
PBI	94	629	6.7	$84/month
LMI PBI Only	10	68	7.6	$0.17/kWh

For LMI PBI Only projects, system sizes ranged from 3.3kW to 12.87kW and customer power purchase agreement (PPA) pricing ranged from $0.163/kWh in Eversource territory to $0.192/kWh in United Illuminating territory. Customers that participated in the Solar for All program installed systems ranging from 4.5kW to 8.7kW and their lease prices ranged from $54.99 to $119.99 based on the solar PV system size.

[5] As of 12/31/2018 PosiGen had 1,513 customers whose systems were installed and energized. As of April 30, 2020, PosiGen had 2,513 customers whose systems are installed and energized.

[6] While only approximately 60% of PosiGen's projects are verified as income-eligible (earning <100% AMI), 73% of projects are in census tracts with a median income <100% of AMI. This is due, in part, to the fact that not all customers are able to provide the information required to verify their income.

The Green Bank monitors system production for each solar installation that receives an incentive through the RSIP (regardless of whether the project receives an LMI or non-LMI incentive). The Green Bank also collects information on each customer's annual electric load through the incentive application process. To calculate customer savings, each customer's pre-solar annual electric load was compared to their system's solar production from January 1, 2019 – December 31, 2019 to determine how much of their electric load was offset by their solar production, and the total value of net metering credits the customer received in 2019.[7] The cost of the customer's solar PPA or lease was then subtracted from these savings to determine each customer's net savings for the year.

Solar Savings Calculations

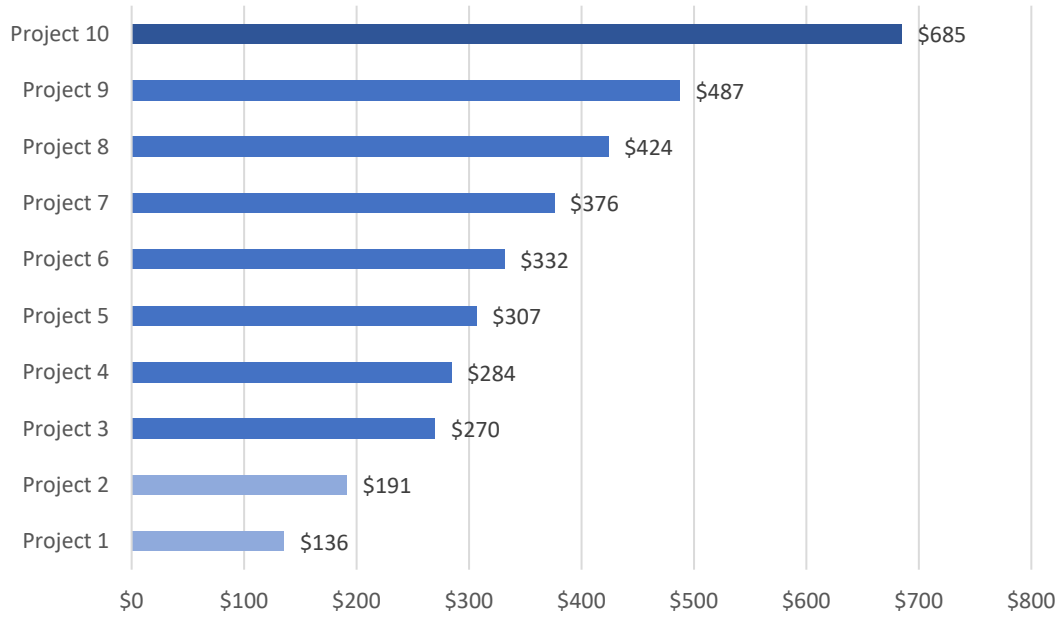
Net Solar PPA Savings = *(Pre-Solar annual electric load * applicable utility rate) – (((Pre-Solar annual electric load – measured solar PV production) * applicable utility rate) + (Measured solar PV production * PPA rate))*

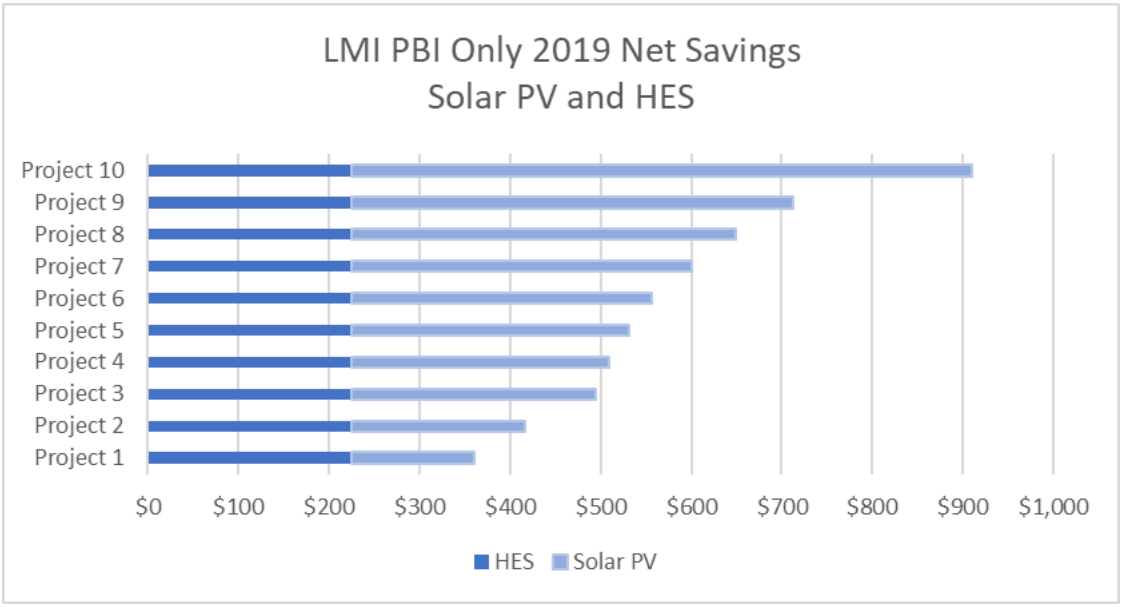
Net Solar Lease Savings = *(Pre-Solar annual electric load * applicable utility rate) – (((Pre-Solar annual electric load - measured solar PV production) * applicable utility rate) + (Monthly Lease Price * 12))*

LMI-PBI Only customers saw average savings of $349, which equates to an average of 18% of their annual utility bill. 2019 annual customer savings ranged from $136 to $685, with larger savings realized by customers who had a larger percent of electric load offset by solar PV, and customers with larger loads and related offset seeing greater savings. LMI-PBI Only customers were able to offset their electric load with solar by 79% on average.

[7] ***Net metering*** is a billing mechanism that credits solar energy system owners for the electricity they export to the grid at the retail purchase rate.

Figure 1: 2019 LMI-PBI Only Net Customer Solar Savings





Customers that participated in the Solar for All program saw average savings of $687, which equates to an average of 34% of their pre-solar utility bill by offsetting their electric load with solar by 83% on average. 2019 annual customer savings ranged from $46 to $1,585, with customers who had a larger percent of electric load offset by solar PV seeing greater savings. 98% of customers saw annual solar savings greater than $100, with the highest percentage of customers (27%) realizing savings of $500-$750 annually.

Figure 2. 2019 Solar for All Customer Net Savings by Dollar Amount ($)

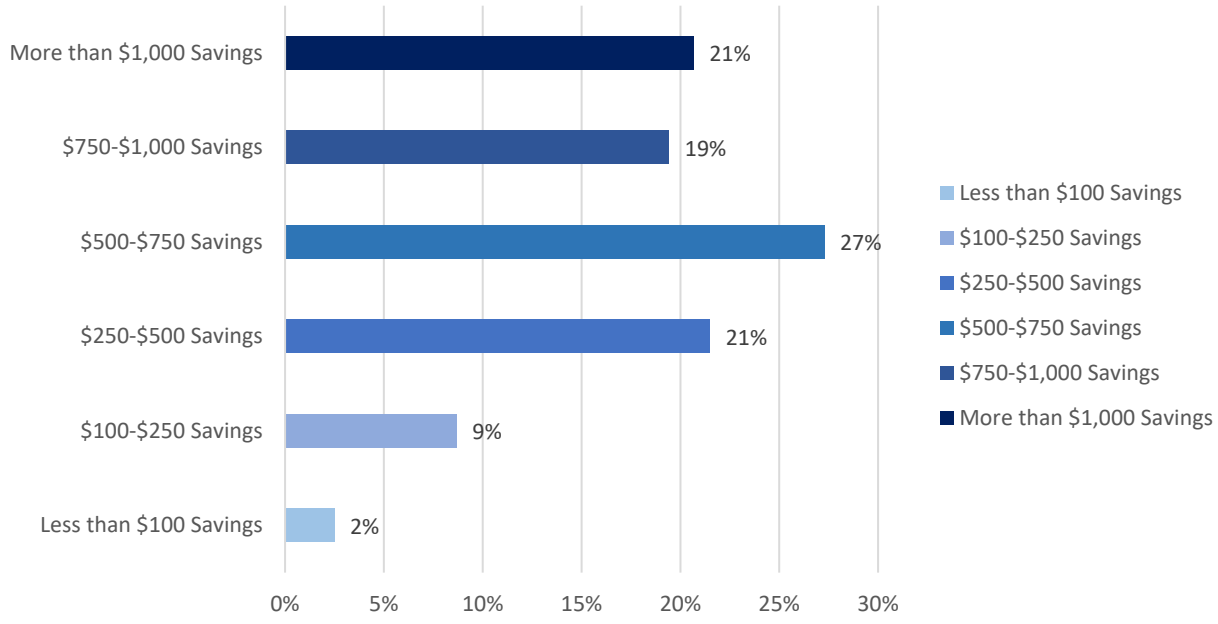
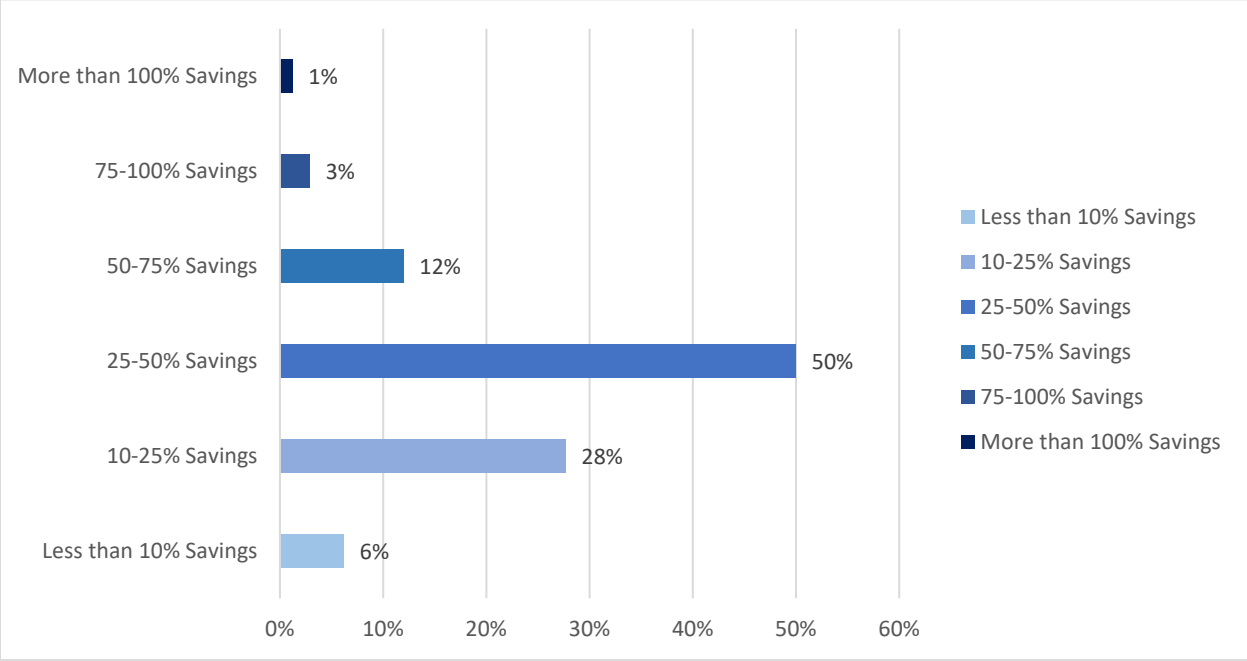


Figure 3. 2019 Solar for All Customer Net Savings by Percent (%) of Pre-Solar Electric Bill



Within the Solar for All sample, 61% of customers income-qualified for the LMI PBI, which is consistent with the broader portfolio's ratio of LMI-PBI to PBI customers. When comparing LMI PBI to PBI customers, the sample revealed that the distribution of savings was roughly the same between the two groups, with most customers saving between $500 and $750 (27% and 28% respectively).

Table 2. 2019 Solar for All Customer Net Savings by Incentive Type

Net Savings	LMI PBI Customers	PBI Customers	Grand Total
Less than $100 Savings	3%	2%	2%
$100-$250 Savings	9%	7%	9%
$250-$500 Savings	22%	21%	21%
$500-$750 Savings	27%	28%	27%
$750-$1,000 Savings	20%	19%	19%
More than $1,000 Savings	20%	22%	21%
Grand Total	**100%**	**100%**	**100%**

On average LMI PBI customers in the Solar For All Program, saved $679 through their solar lease and PBI customers saved an average of $699, with both groups saving nearly 34% of their pre-solar electric bill, on average.

Table 3. 2019 Solar for All Average Customer Savings by Incentive Type

Incentive Type	Average Net Dollar ($) Savings	Average Net Savings Percent (%)
LMI PBI	$679	34%
PBI	$699	33%
Grand Total	**$687**	**34%**

Table 4: 2019 Net Savings for LMI PBI Only and Solar for All Customers

Program	Average Net Dollar ($) Savings	Average Net Savings Percent (%)
LMI PBI Only	$349	18%
Solar for All	$687	34%

When comparing solar savings attained by the LMI PBI Only program and the Solar for All program, it is important to note that the LMI PBI Only dataset is very small, including only 10 projects, and the majority (90%) of those were completed in Eversource service territory which has a lower $/kWh electric rate. By contrast, the majority (67%) of Solar for All projects were completed in UI service territory which has a higher $/kWh electric rate. Additionally, the annualized average lease rate through the Solar for All program is approximately $260 less that the annualized average PPA rate for the LMI PBI program.

Energy Efficiency Savings

All customers that participate in the RSIP are required to complete a home energy audit through the utility-run Home Energy Solutions ("HES") program. A HES visit consists of an assessment of

the home's energy performance as well as the installation of basic weatherization and energy saving measures. It is estimated that a HES audit saves customers $200-$250 annually.[8] Customers that went solar through the RSIP and were eligible for the LMI PBI all completed a HES audit and are estimated to be saving an additional $200-$250 per year in addition to their solar savings. As a result, customers whose project received the LMI PBI but did not install solar with PosiGen are estimated to have saved an average of $549-$599 in 2019 as a result of their participation in the RSIP and HES programs.

Customers that participate in the Solar for All program, receive a package of "deeper" energy efficiency measures on top of their HES services. The services each customer receives are in addition to the services they receive as part of the HES program and provide increased energy savings. The deeper measures include recommended measures resulting from the HES program. Through this portion of Solar for All product, each customer receives $2,400 worth of efficiency measures and the cost of the service is rolled into their monthly price for the 20-year term of the lease. Estimates of savings achieved through these efficiency measures are calculated based on the deemed savings for each individual measure, as stated in the Connecticut Program Savings Document[9].

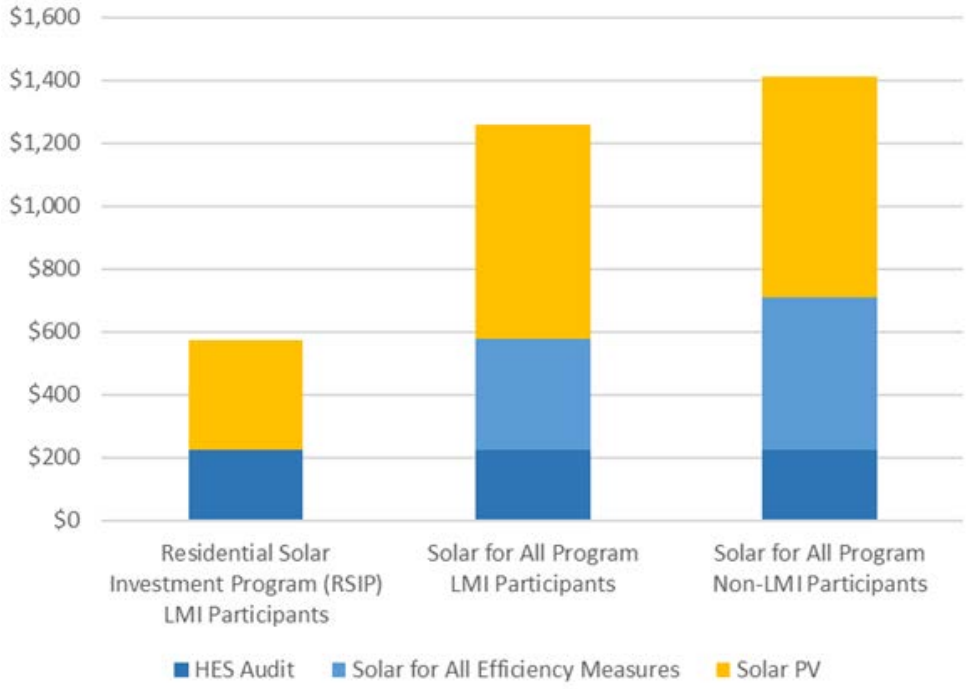
Estimated savings from the additional energy efficiency improvements made in the home are calculated for each customer. Based on these calculations, PosiGen customers in the sample saved an average of $403 from energy efficiency in addition to their solar savings and savings from the HES program. The range of savings from additional recommended EE measures estimated for customers in the dataset was $19 -$1343. Based on these estimates of energy efficiency savings, customers that participated in the Solar of All program are estimated to have saved an average of $1,315 in 2019.

Table 5. 2019 Estimated Average Total Customer Savings

Program	Average Net Solar Savings	Average Estimated Energy Efficiency Savings	Average Estimated Total Customer Savings
LMI PBI Only	$349	$200-$250	$549-$599
Solar for All	$687	$603-$653	$1290-$1340

[8] https://www.energizect.com/your-home/solutions-list/home-energy-solutions-core-services
[9] https://www.puc.nh.gov/EESE%20Board/EERS_WG/ct_trm.pdf

Figure 4. Average Annual Customer Savings: Energy Efficiency and Solar PV.



APPENDIX III

Solar Battles the New England Heatwave

Contribution of the Green Bank's Residential Solar Program to the 2019 Summer Peak

Rising Temperatures Lead to Rising Load and Increased Public Health Risks

Hartford Courant

July 31, 2019

July on Track to become Hottest on Record with another Hartford Heat Wave

By Christine Dempsey and Zach Murdock

July is expected to end as the hottest on record in the Hartford area as meteorologists forecast a heat wave to continue into the final day of the month.

July 2019 was the hottest month on record for many New England cities, including Hartford, CT, with temperatures reaching 90°F on an average day that month at Bradley International Airport.[1, 2]

The biggest heatwave of 2019 came on the weekend of July 20-21:[2]

Date	Max Temp	Humidity	Heat Index
July 20	98°F	44%	108°F
July 21	100°F	34%	105°F

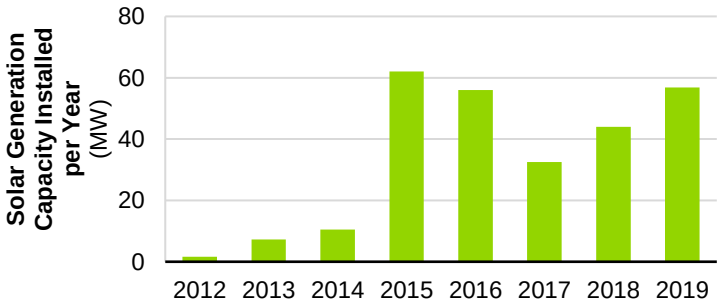
"Tuesday was so hot and humid, authorities warned people about two problems: The excessive heat and bad air." [1]

Sunny, humid days lead to higher temperatures and consequently higher air conditioning usage. This stresses the electric grid, resulting in increased power coming from coal plants. Pollutants emitted by such plants include nitrogen oxides (NOx) and volatile organic compounds, which react in sunlight to create ground level ozone (the main ingredient in smog), which is harmful to public health.

"Saturday and Sunday, July 20-21, saw the highest average temperature and heat index readings in New England for any weekend in the past 20 years. And both Saturday and Sunday's peak grid demand were among the ten highest weekend loads in recent history… Had the July 20-21 weekend heat had occurred on a weekday, ISO New England Forecasters estimate that demands could have fallen within the top ten highest demand days." [3]

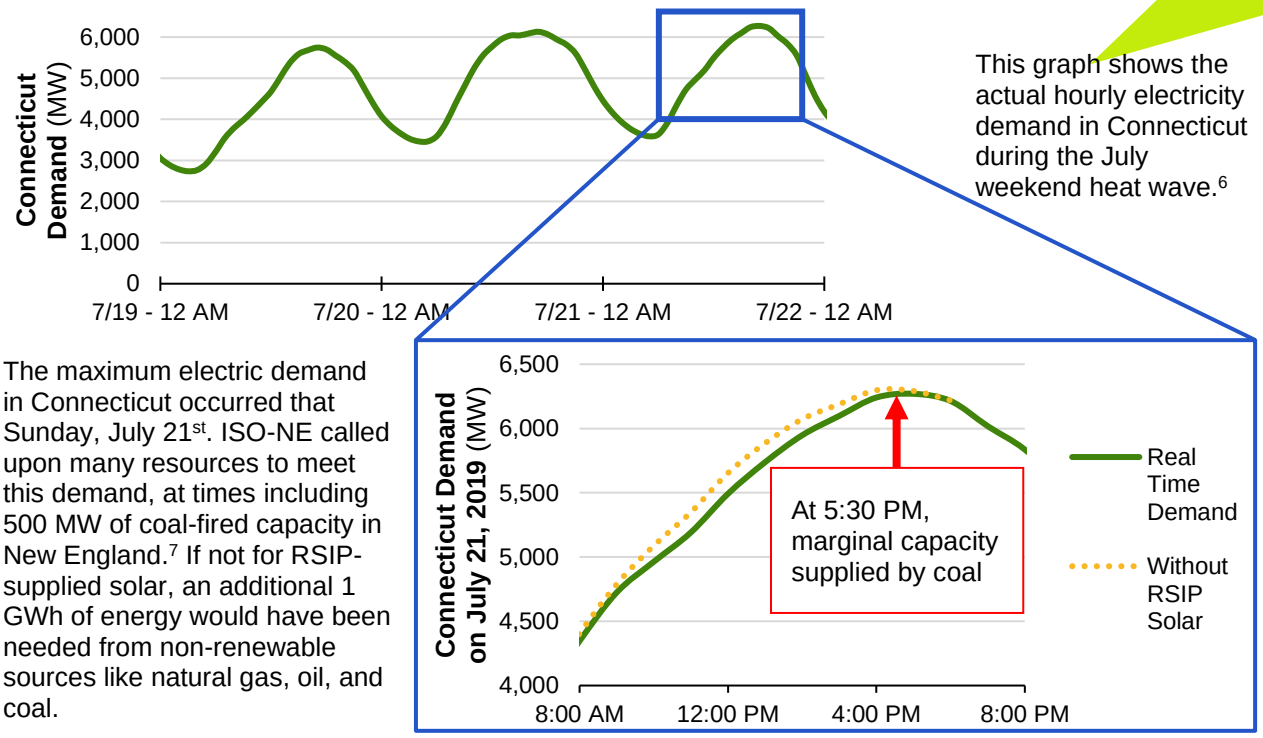
Connecticut's Distributed Solar Power Plant

RSIP has reached every corner of Connecticut, with nearly 28,000 solar PV projects reporting on July 21, 2019. In total, this fleet had a maximum power output of about 230 MW on July 21st.[4]



This is over half the size of the coal-fired plant at Bridgeport Harbor Generating Station in Bridgeport, CT, one of three coal power plants operating in New England on July 21st.[5]

Peak Load Reduction Benefit to Ratepayers from Homes that Installed Solar PV

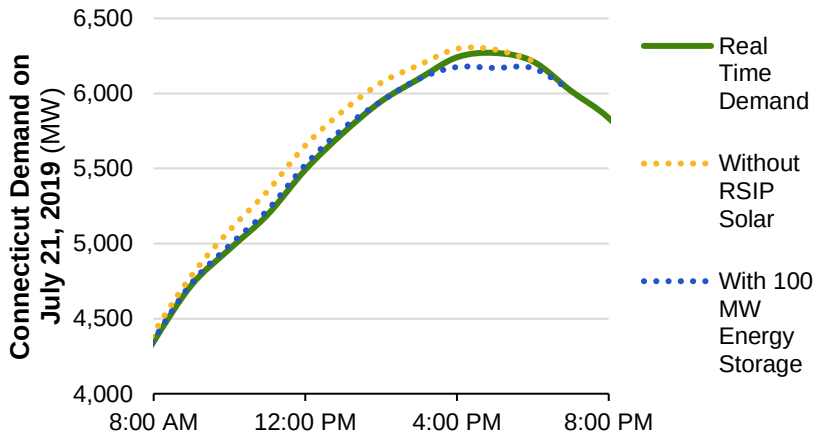


This graph shows the actual hourly electricity demand in Connecticut during the July weekend heat wave.[6]

The maximum electric demand in Connecticut occurred that Sunday, July 21st. ISO-NE called upon many resources to meet this demand, at times including 500 MW of coal-fired capacity in New England.[7] If not for RSIP-supplied solar, an additional 1 GWh of energy would have been needed from non-renewable sources like natural gas, oil, and coal.

This equates to a savings of over $3 million in system benefits, nearly 500 tons of CO2e, and around 175 pounds of NOx on the single peak day.[8]

Additional Benefit of Combining Residential Solar with Energy Storage



If 100 MW of energy storage capacity was added to the residential solar installations, this could shift stored solar energy from earlier in the day to be dispatched to reduce peak load later in the day.

This level of storage capacity would have been enough to bump the demand in all of New England on July 21st out of the top 5 highest weekend demand days in ISO-NE history.[3]

Sources:

1. *Dempsey, Christine; Murdock, Zack. "July on track to become hottest on record with another Hartford heat wave." Hartford Courant, 31 Jul. 2019*
2. *Weather Underground, Bradley International Airport Station, Heat Index calculated from https://www.wpc.ncep.noaa.gov/html/heatindex.shtml*
3. *"Summer 2019: Lowest regional grid electricity use in at least 16 years." ISO Newswire, 2 Oct. 2019*
4. *RSIP Data as of February 25, 2020*
5. *Brunelli, Peter. "Weekend Energy Use Neared N.E. Megawatt Record." ecoRI News, 22 Jul. 2019*
6. *"2019 SMD Hourly Data" from ISO-NE*
7. *"Dispatch Fuel Mix" for July 21, 2019 from ISO-NE*
8. *Based on effective peak demand savings of 28 MW and peak energy savings of 1,000 MWh. System benefits monetized with capacity, transmission, and distribution from Table 3-1 of 2019 C&LM Plan. Emissions rates from Table 150 of 2018 AESC study.*

Guidehouse

APPENDIX IV

Solar Battles the New England Heatwave

An Analysis of the Contribution of the Connecticut Green Bank's Residential Solar Incentive Program to the 2019 Summer Peak

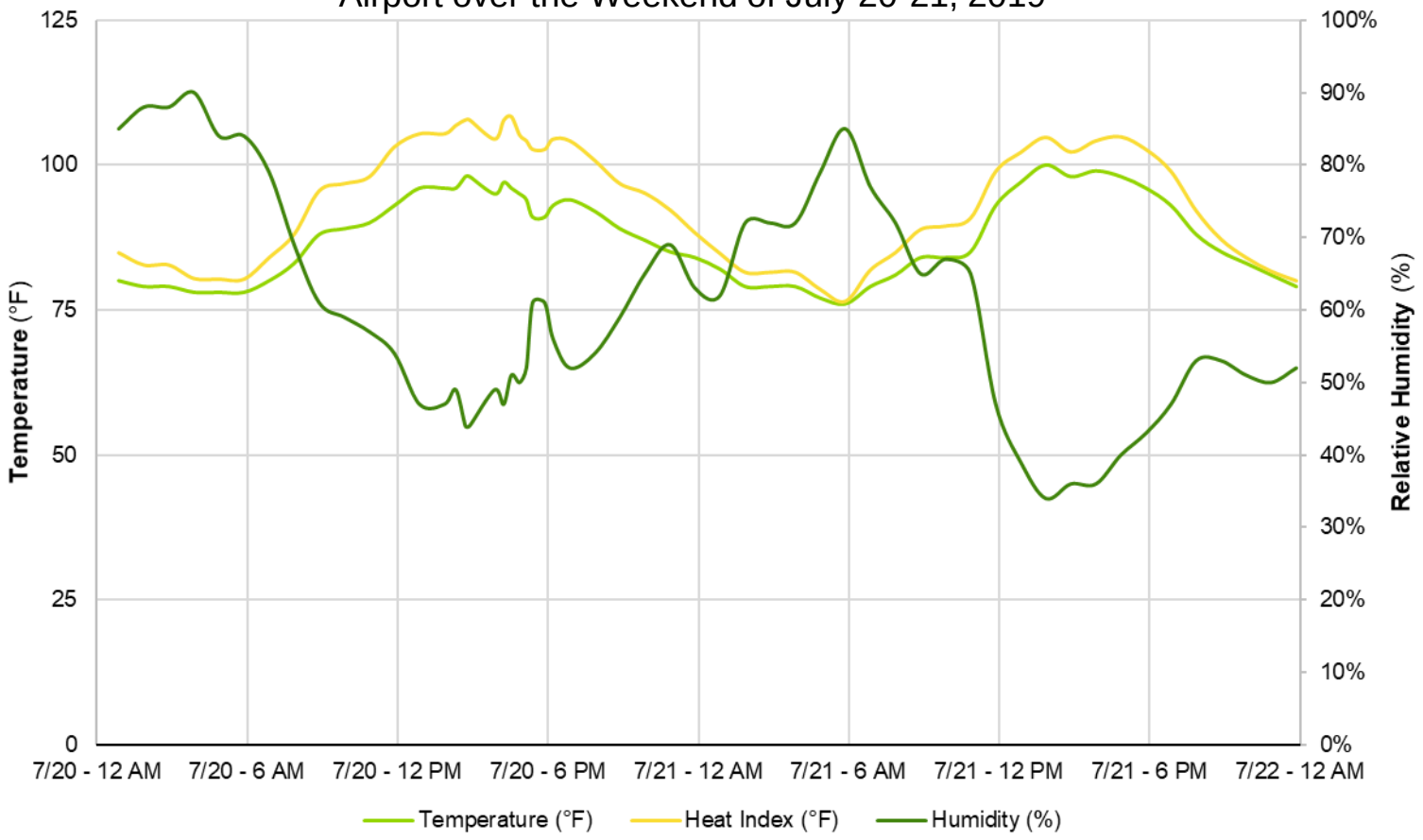
Appendix IV
June 12, 2020

2019 Summer Heatwave

July 2019 was the hottest month on record in Hartford, Connecticut

- During one especially brutal heatwave over the weekend of July 20-21, the heat index regularly exceeded 100°F in Connecticut[1]
- These high temperatures lead to public health concerns not only due to the excessive heat, but also due to poor air quality[2]

Temperature and Humidity at Bradley International Airport over the Weekend of July 20-21, 2019[1]



Sources:

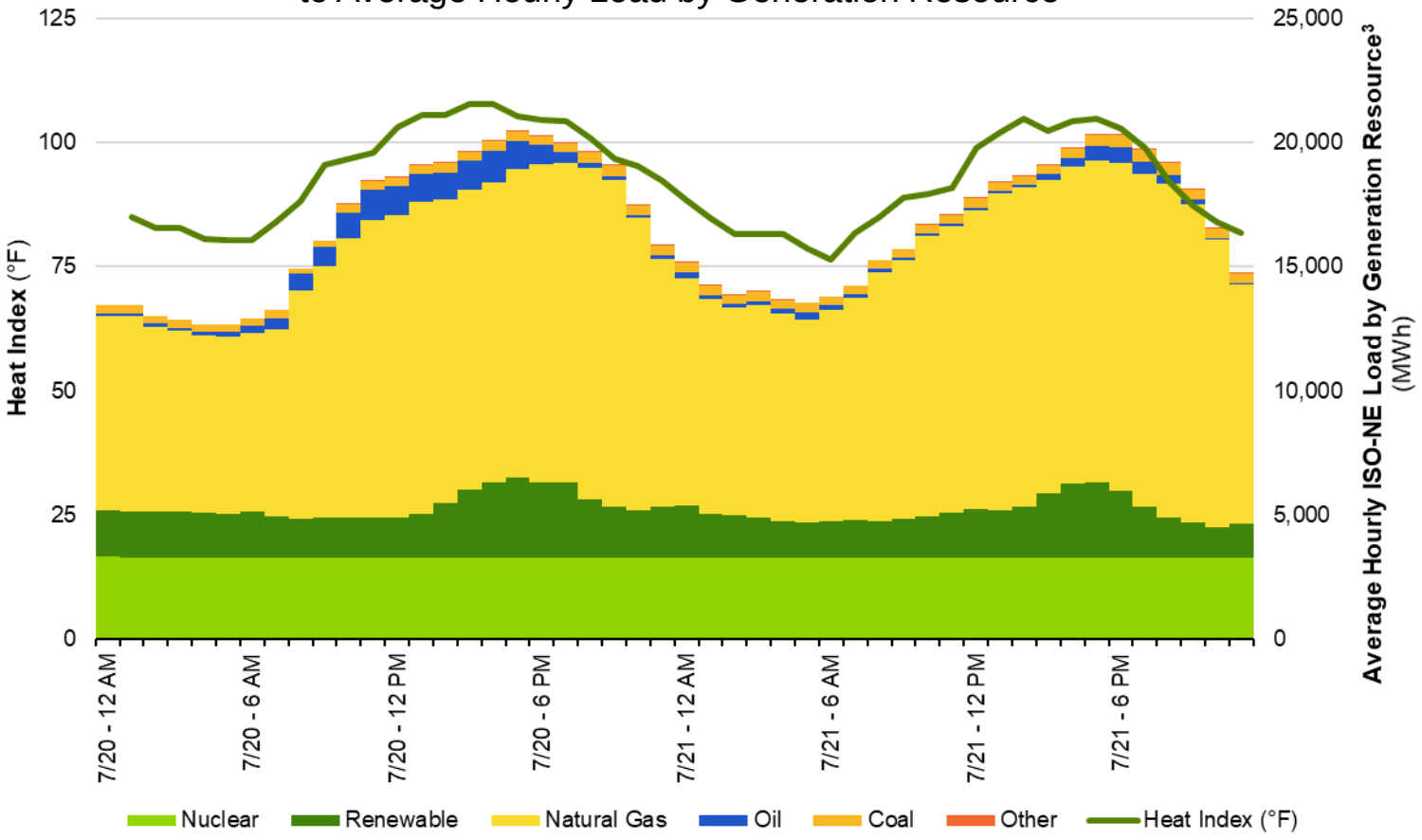
1. Weather Underground, Bradley International Airport Station. Heat Index calculated using https://www.wpc.ncep.noaa.gov/html/heatindex_equation.shtml
2. Dempsey, Christine; Murdock, Zack. "*July on track to become hottest on record with another Hartford heat wave.*" Hartford Courant, 31 Jul. 2019

Guidehouse

Electric Grid's Response to the Heatwave

Higher temperatures lead to higher AC usage, which strains the grid

Heat Index at Bradley International Airport compared to Average Hourly Load by Generation Resource [1,3]



- This weekend heatwave led to high demand for electricity throughout New England; July 20th and 21st had the 2nd and 3rd highest peak weekend day demand ever in New England[4]
- To meet high demand, ISO-NE has to call upon higher-cost and higher-polluting resources that contribute to poor air quality such as oil and coal

Sources:

3. "Dispatch Fuel Mix" for July 20-21, 2019 from ISO-NE, averaged over hour of day, available at https://www.iso-ne.com/isoexpress/web/reports/operations/-/tree/gen-fuel-mix
4. "*Summer 2019: Lowest regional grid electricity use in at least 16 years.*" ISO Newswire, 2 Oct. 2019

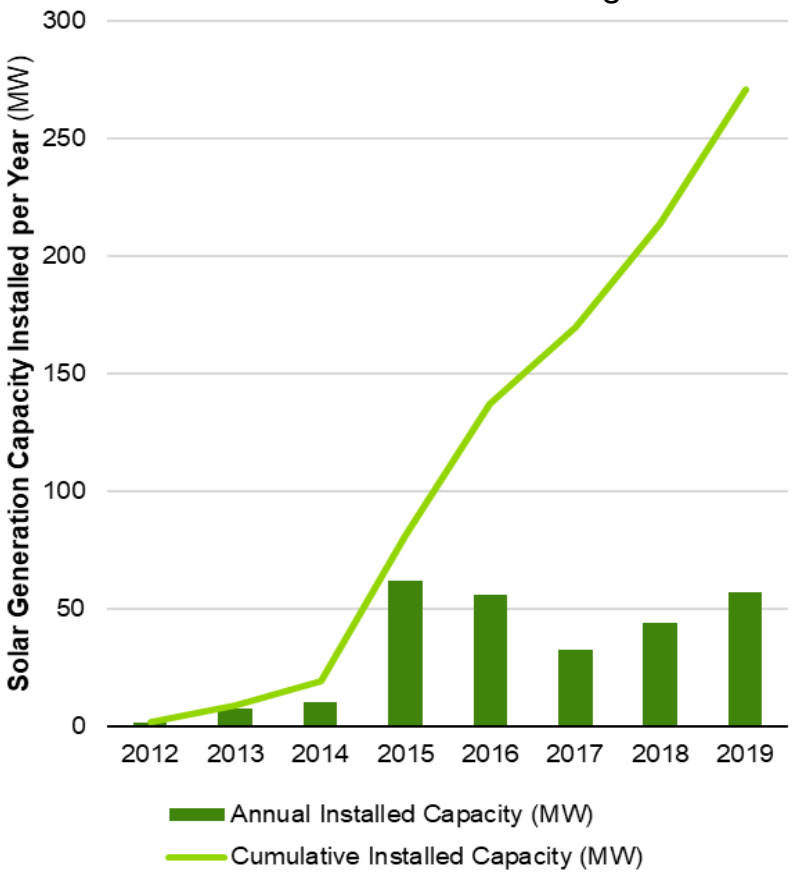
Guidehouse

Connecticut's Distributed Solar Power Plant

RSIP increased CT's solar capacity to widespread adoption by 2019

- On July 21, 2019 nearly 28,000 RSIP solar PV projects were operational[5]
- Altogether, this fleet had a maximum power output of about 230 MW[5]

Annual and Cumulative Solar PV Capacity Installed in Connecticut through RSIP [5]



- One of the three coal-fired power plants in New England that could have been called upon that day was the 384-megawatt Bridgeport Harbor Generating Station in Bridgeport, Connecticut[6]
- **On this day, the RSIP solar PV projects' capacity amounts to over half of the capacity of the Bridgeport coal-fired plant**

Sources:

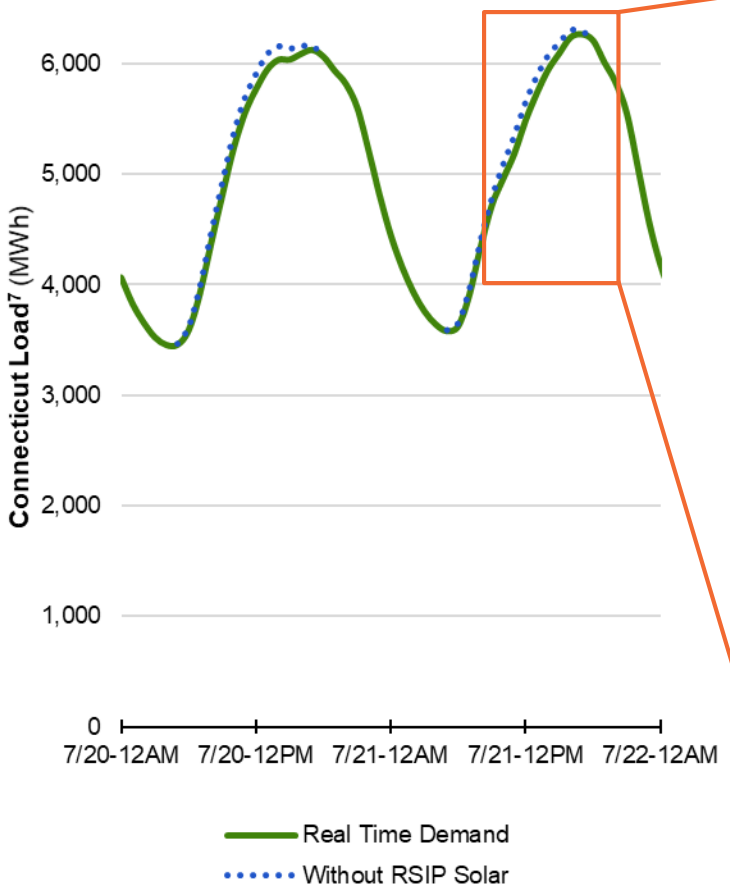
5. RSIP Data as of February 25, 2020
6. Brunelli, Peter. *"Weekend Energy Use Neared N.E. Megawatt Record."* ecoRI News, 22 Jul. 2019

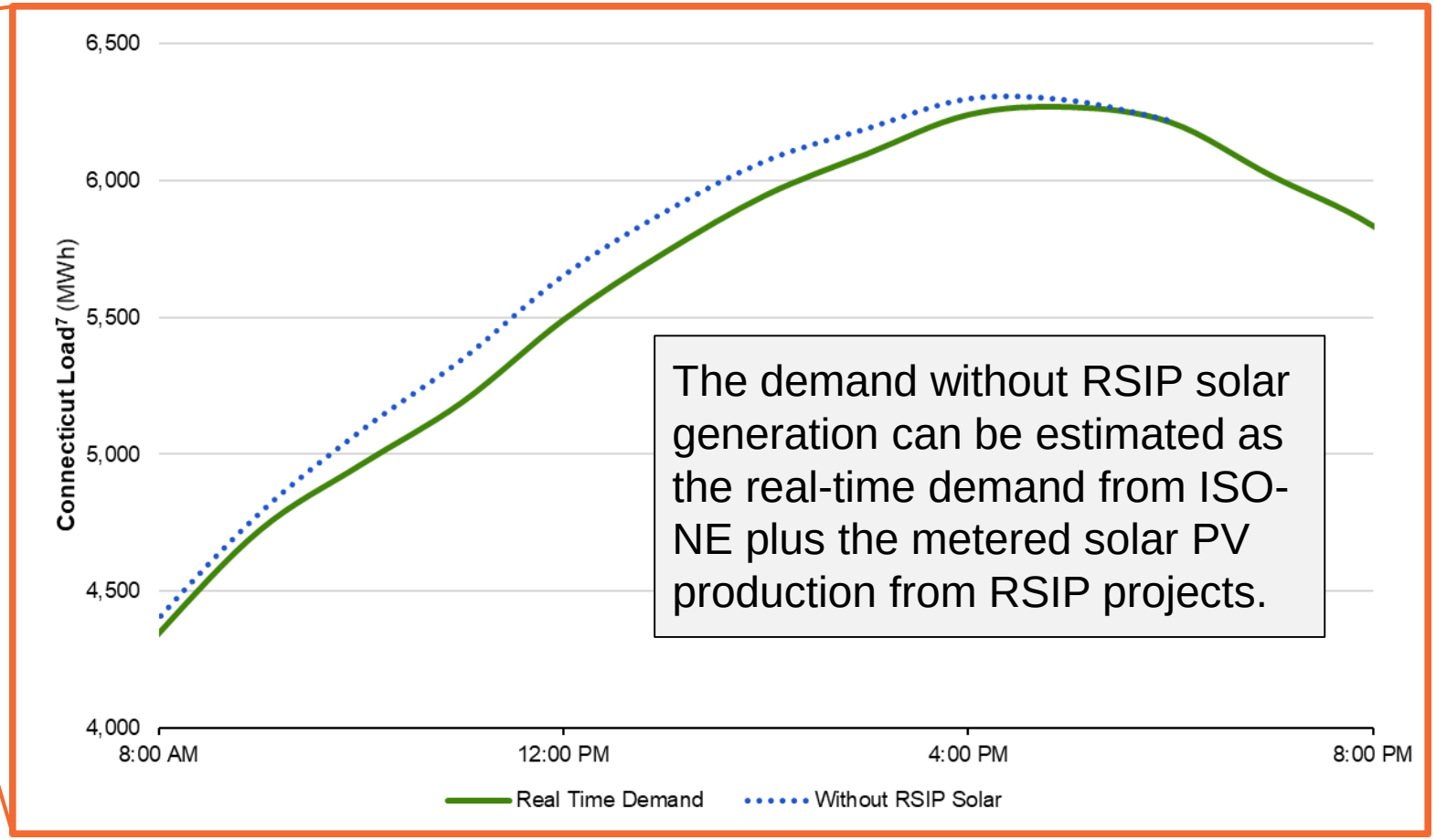
Guidehouse

Peak Load Reduction Attributable to RSIP

Removing RSIP generation from actual demand illustrates its effect

Real Time Hourly Electricity Demand in Connecticut [7]





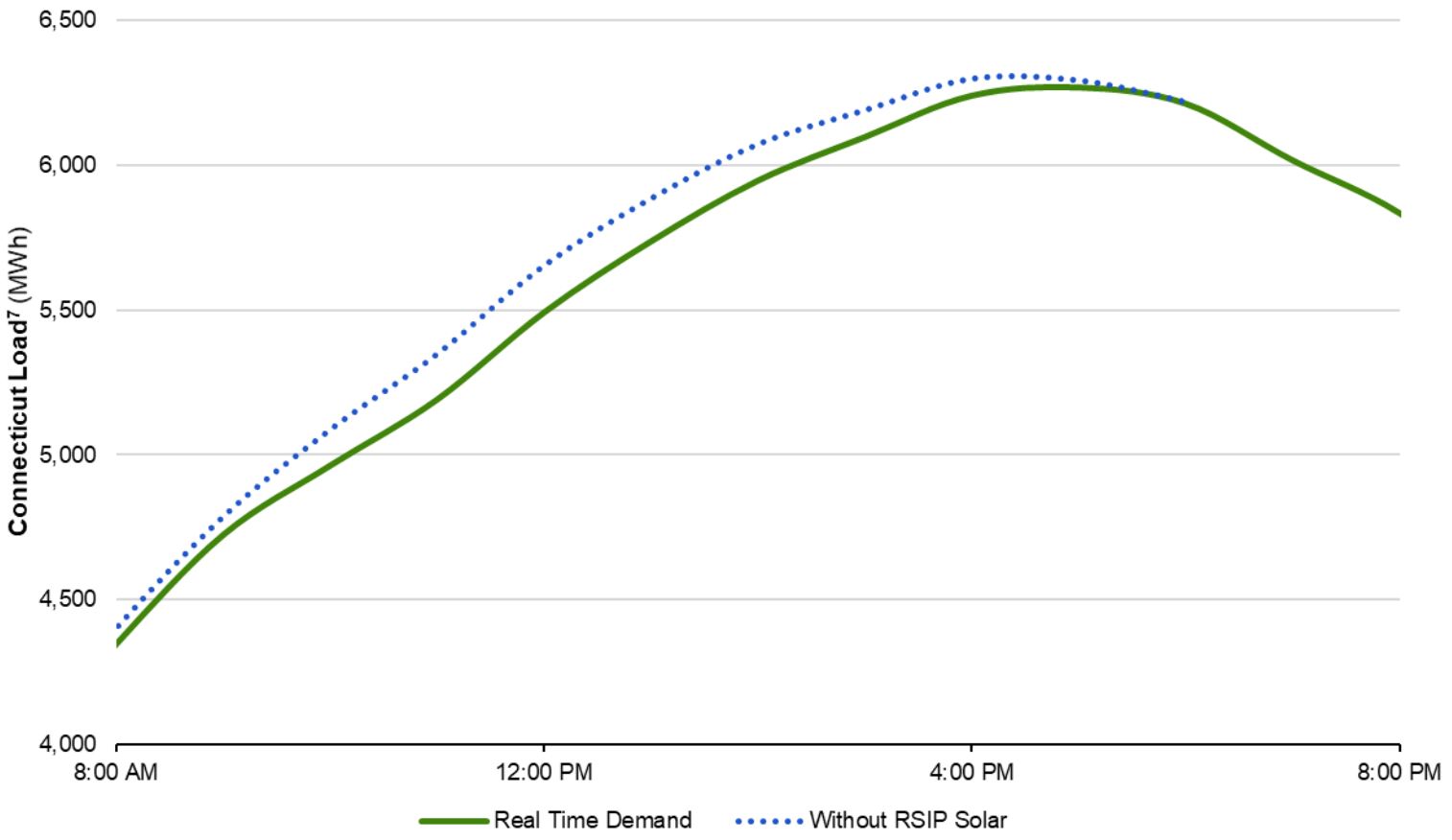
The demand without RSIP solar generation can be estimated as the real-time demand from ISO-NE plus the metered solar PV production from RSIP projects.

Guidehouse

Peak Load Reduction Attributable to RSIP

The difference in demand with and without RSIP presents its benefit

- The difference in peaks between these two curves represents the peak reduction from RSIP, which equates to roughly **28 MW**
- The area between these two curves represents the energy savings from RSIP for the day, which equates to roughly **1 GWh**



Sources:

7. RSIP Data as of February 25, 2020. Real time demand in Connecticut from "2019 SMD Hourly Data" from ISO-NE, available at https://www.iso-ne.com/isoexpress/web/reports/load-and-demand/-/tree/zone-info

Guidehouse

Monetary Benefit of Peak Load Reduction from RSIP

Peak reduction provides direct monetary benefits to ratepayers

- The 28 MW of peak reduction relieves the need for additional peaking capacity and infrastructure upgrades. The 2020 C&LM states that these are worth $104.90 per kW of peak load reduction.[8] That means that RSIP saved roughly **$3 million of peaking investments in 2019.**
- The 1 GWh of energy savings is electricity that would have otherwise been purchased at the real time locational marginal price, shown on the right.[9] By multiplying the hourly RSIP generation by the hourly LMP and then summing over the hours in the day, we find that RSIP saved roughly **$33,000 worth of energy on July 21, 2019**.
- Assuming electricity emission rates of 954 lb CO2/MWh and 0.174 lb NOx/MWh,[10] that 1 GWh of energy savings also saved roughly **500 tons of CO2 and 175 lbs of NOx on the peak day.**

Hour-Starting	RT LMP ($/MWh)	RT Demand (MWh)	RSIP Solar Generation (MWh)	RT Demand net of RSIP Solar (MWh)
7/21/19 12:00 AM	$90.02	4,452	0.00	4,452
7/21/19 1:00 AM	$53.93	4,167	0.00	4,167
7/21/19 2:00 AM	$41.25	3,938	0.00	3,938
7/21/19 3:00 AM	$51.06	3,764	0.00	3,764
7/21/19 4:00 AM	$41.00	3,646	0.97	3,647
7/21/19 5:00 AM	$50.11	3,585	7.20	3,593
7/21/19 6:00 AM	$36.96	3,631	26.77	3,657
7/21/19 7:00 AM	$28.19	3,918	48.75	3,967
7/21/19 8:00 AM	$33.67	4,347	57.10	4,404
7/21/19 9:00 AM	$31.70	4,724	63.87	4,788
7/21/19 10:00 AM	$25.72	4,963	124.39	5,088
7/21/19 11:00 AM	$24.63	5,191	157.15	5,348
7/21/19 12:00 PM	$26.88	5,492	161.33	5,654
7/21/19 1:00 PM	$31.66	5,738	147.37	5,885
7/21/19 2:00 PM	$33.67	5,947	124.48	6,072
7/21/19 3:00 PM	$33.43	6,098	91.11	6,189
7/21/19 4:00 PM	$35.15	6,241	56.78	6,298
7/21/19 5:00 PM	$41.00	6,270	22.67	6,292
7/21/19 6:00 PM	$44.92	6,214	4.47	6,218
7/21/19 7:00 PM	$45.46	6,018	0.34	6,018
7/21/19 8:00 PM	$43.51	5,836	0.00	5,836
7/21/19 9:00 PM	$37.59	5,557	0.00	5,557
7/21/19 10:00 PM	$40.66	5,061	0.00	5,061
7/21/19 11:00 PM	$44.63	4,567	0.00	4,567

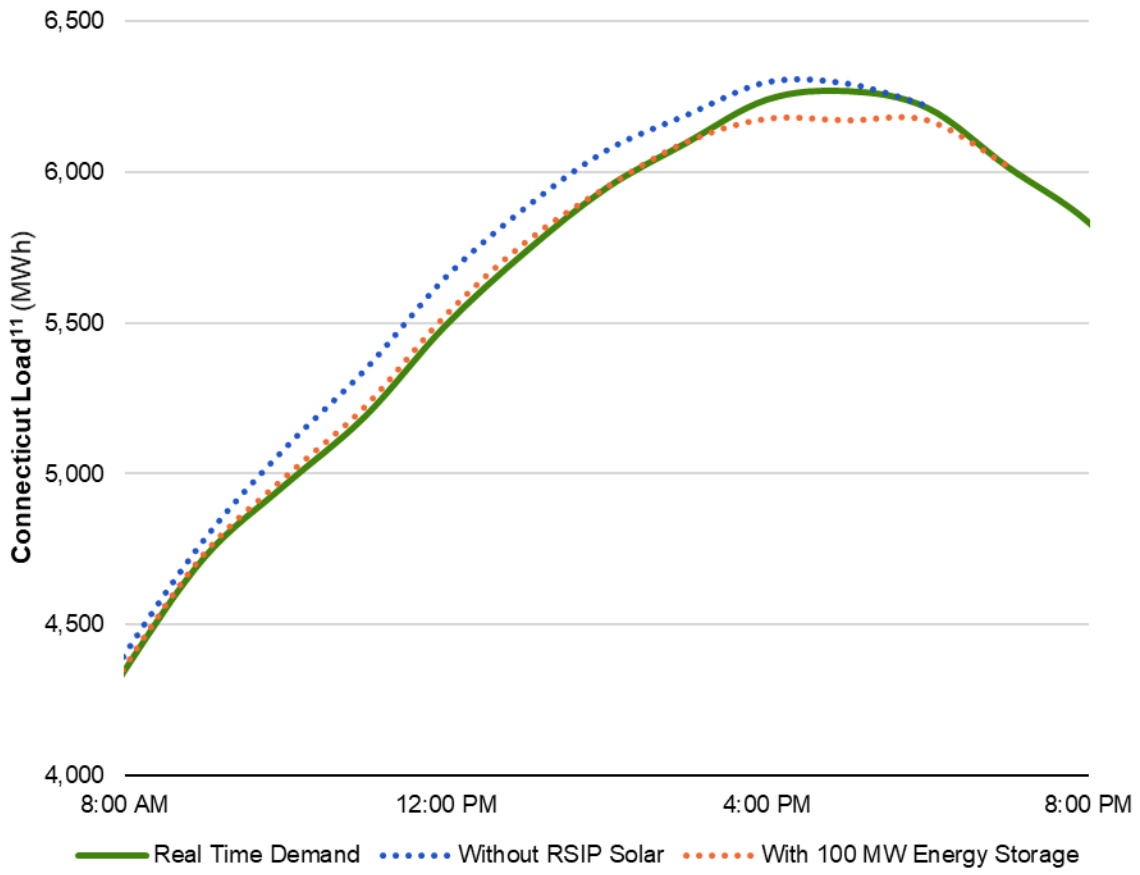
Sources:

8. "*2020 Plan Update to the 2019-2021 Conservation & Load Management*", Table 3-1, pg. 37, 1 Mar. 2020, available at https://www.energizect.com/sites/default/files/2020%20Plan%20Update_3.1.20%20Filing.pdf
9. RSIP Data as of February 25, 2020. Real time demand in Connecticut from "2019 SMD Hourly Data" from ISO-NE, available at https://www.iso-ne.com/isoexpress/web/reports/load-and-demand/-/tree/zone-info
10. Synapse, et. al. "*Avoided Energy Supply Components in New England: 2018 Report*", Table 30, pg. 80, 30 Mar. 2018, available at https://www.synapse-energy.com/sites/default/files/AESC-2018-17-080.pdf

Combining Solar with Energy Storage

Energy storage can shift solar power to more directly address the peak

- If 100 MW of energy storage capacity (assuming a 2 hour capacity on average) had been paired with existing RSIP solar by July 21, 2019, the peak could have been reduced by nearly 100 MW more than RSIP alone, with a minor impact on energy savings for the day due to energy storage efficiency losses
  - This storage capacity would create over **$10 million in additional peak reduction benefits**
  - Adding 100 MW of storage capacity would have been enough to move July 21, 2019 out of the top 5 highest weekend demand days in ISO-NE history[12]



Sources:

11. RSIP Data as of February 25, 2020. Assumes 100 MW x 200 MWh of energy storage with 90% round-trip efficiency charged throughout the day via RSIP solar and discharged optimally over a three hour event

12. ISO-NE, https://www.iso-ne.com/about/key-stats/electricity-use/

Appendix – Methodology Notes

- Peak load reduction benefits were calculated using AC output of RSIP solar PV
- Peak capacity savings were monetized using 15-year levelized value of capacity, transmission, and distribution in 2019 $ (i.e., [$71.09/kW + $0.86/kW + $30.89/kW] * 102%), where “15-year levelized value” refers to the average value of savings for a given year. This value does not include savings from avoided Pooled Transmission Facilities, Reliability, or Capacity DRIPE.
- Emissions rate of electricity assumes average marginal generating unit over the course of July 21, 2019 was 45% natural gas-fired combined cycle plant and 55% natural gas-fired combustion turbine plant.
- Energy storage assumed to dispatch 50 MWh from 4 – 5 pm, 100 MWh from 5 – 6 pm, and 50 MWh from 6 – 7 pm on July 21, 2019, which could be accomplished in practice by calling upon half of the available energy storage systems at 4 PM for two hours and the other half at 5 PM for two hours.