Residential Solar Investment Program (RSIP)

2012 – 2022 Program Impact Evaluation and Future Recommendations

slipstream

Project Manager: Dan Streit

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1.0 EXECUTIVE SUMMARY

The Connecticut Green Bank (Green Bank) implemented the Residential Solar Investment Program (RSIP) from 2012 until the program achieved its statutory objective of facilitating the deployment of 350 MW-DC of residential solar generating capacity in Connecticut in 2022. This evaluation assesses RSIP's effectiveness in using ratepayer funds (as program incentives paid to residential customers) to accelerate residential solar adoption and offers recommendations for how the Green Bank may support the ongoing orderly and sustainable development of the state's residential solar market.

To evaluate the success of RSIP, we consider metrics that demonstrate the impact of the program on energy production in Connecticut, on the state's economy and environment, and on Connecticut residential electric customers, with a particular focus on low and moderate income (LMI) households. We also compare performance metrics for RSIP and for the Connecticut residential solar market to residential solar programs and markets in other states in the Northeast and to national averages.

1.1 RESULTS

1.1.1 Deployed Generating Capacity

Based on a review of robust data for all projects funded through the program, the evaluation confirms that the Green Bank successfully implemented RSIP, deploying 350 MW-DC of residential solar generating capacity in the state. The evaluation finds that the Green Bank also achieved at least two additional key measures of success (described below) by effectively adapting and innovating the RSIP structure and implementation strategy during the program.

Figure 1 reflects the Green Bank's effective use of RSIP to mature and transform Connecticut's residential solar market, as Connecticut achieved the highest rate of residential PV capacity deployment in the Northeast, at a rate that was nearly twice the national average.

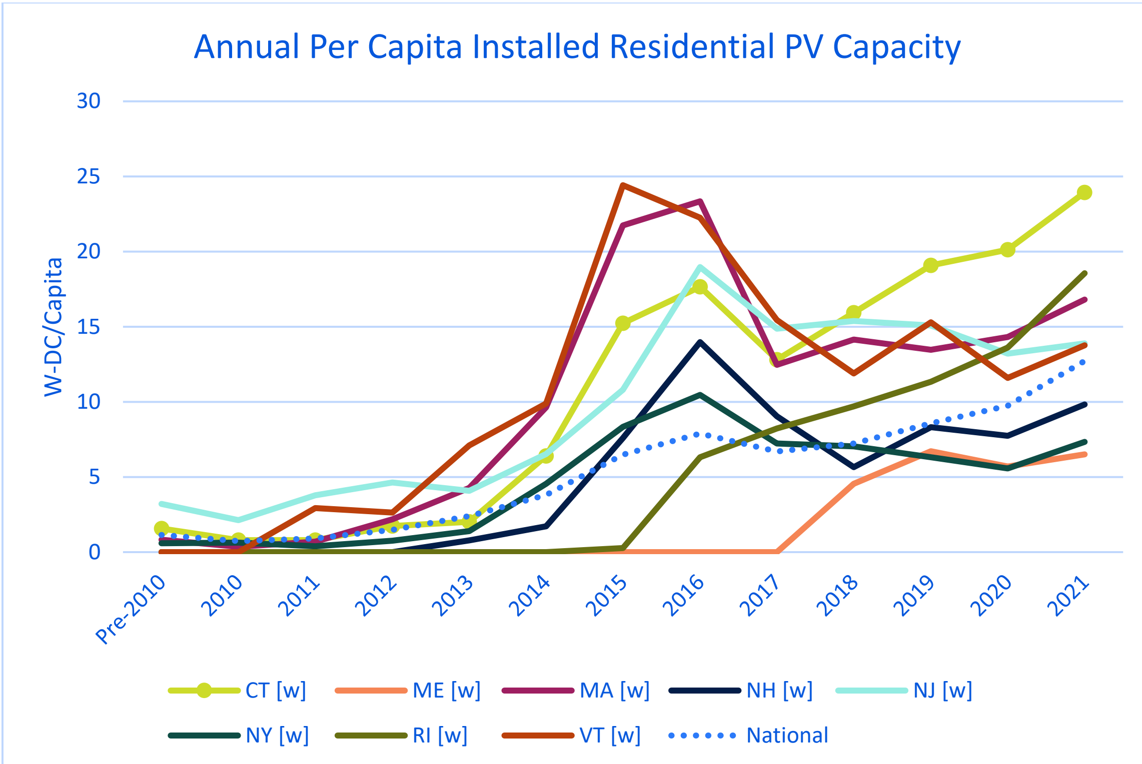


Figure 1 Annual Per Capita Installed Residential PV Capacity

1.1.2 Cost-Effective Program Implementation

The Green Bank used a declining incentive step structure to decrease incentive levels over the lifetime of the program and leveraged private investment. The strategy involved timing the reductions in incentive levels with market development and declines in the installed cost of residential solar. This resulted in RSIP leveraging $8.15 in private investment for every publicly funded program incentive dollar. When compared with other states in the Northeast, the evaluation found that RSIP cost-effectively achieved its residential solar generating capacity goal; the overall incentive cost for RSIP per installed watt and per MWh of solar energy generated through the program was similar to, or less than parallel metrics for other states.

1.1.3 Equitable Program Participation

The Green Bank's program offerings and partnerships resulted in Connecticut LMI households installing solar at a rate 10 percentage points higher than the national average. While LMI households experience higher rates of energy burden than more affluent households, they also face greater barriers in accessing the benefits of residential solar energy. Nationally, due to these barriers, only 31.9 percent of residential solar arrays have been installed in census tracts where the median income is less than the area median income (AMI), while 56.7 percent were installed by households living in census tracts for which the median income was 120 percent or more of the AMI. In contrast to national trends, the Green Bank used the enhanced LMI Performance Based Incentive (LMI PBI) offering, as well as program implementation partnerships, such as the Solar for All program and Solarize campaigns, to increase participation by LMI households and by households living in low and moderate income census tracts. As a result of these efforts, 43.4 percent of residential solar installations in Connecticut took place in LMI census tracts.

1.2 RECOMMENDATIONS

When the Connecticut Assembly tasked the Green Bank with developing and implementing RSIP, it also directed the Green Bank to facilitate the orderly and sustainable development of the Connecticut residential solar industry. As RSIP expired, residential solar program support has shifted to the Residential Renewable Energy Solutions (RRES) tariffed solar structure. RRES is offered through the state's electric utilities and the Green Bank does not have an explicit role in implementing RRES.

1.2.1 Market Monitoring

Interviews, conducted for this evaluation, with Connecticut stakeholders, including representatives from the electric utilities, solar developers, and program partners revealed that the development and multi-year implementation of RSIP by the Green Bank played an essential role in supporting the growth of the state's solar industry. The Green Bank remains committed to supporting the orderly and sustainable development of the industry post-RSIP. This evaluation recommends that the Green Bank monitor compliance filings by the state's electric utilities to track the rate of residential solar adoption in the state. In parallel, we encourage the Green Bank to leverage insights gained from its invaluable RSIP project dataset to guide its future support of Connecticut's residential solar market and its facilitation of the development of other clean energy markets in the state in the future. We also encourage the Green Bank to maintain its role as a trusted convener of residential solar industry stakeholders and leverage that role to investigate and resolve any challenges that may emerge to the ongoing orderly and sustainable development of the industry.

1.2.2 Low-Moderate Income Market Support

This evaluation finds that Connecticut has a robust solar industry and that the pace of residential solar installations remains strong in the new RRES structure. However, we also find that the rate of solar deployment in LMI communities may decrease significantly post-RSIP. We recommend that the Green Bank pursue new strategies, partnerships, and engagement mechanisms to support residential solar adoption in LMI communities.

1.2.3 Adjacent Industry Development

The evaluation recommends that the Green Bank maintain its role as a key convener and facilitator in Connecticut's solar industry post-RSIP. While Connecticut's residential solar industry has developed significantly during RSIP, adjacent and synergistic industries, such as solar + storage is less well-developed. We recommend that the Green Bank maintain its central role among residential solar developers and program partners by pursuing opportunities to support the development of intersecting early-stage industries.

2.0 PROJECT BACKGROUND

The Connecticut Green Bank (Green Bank) engaged Slipstream to evaluate the performance of the Green Bank's Residential Solar Investment Program (RSIP) from its inception in 2012 to the achievement in 2022 of its mandate to support the installation of 350 MW of residential solar capacity in Connecticut. In this report, we evaluate the Green Bank's success in achieving its legislatively mandated objective for RSIP, as well as related energy, environmental, and economic impacts of the program throughout the lifetime of the program.

Section 3 of the report describes the methodology used for the evaluation, then Sections 4 and 5 present our findings on RSIP's impact on the state and current conditions in the Connecticut solar market. To assess the relative effectiveness of RSIP in facilitating the development of the Connecticut solar market, Section 6 compares metrics for RSIP and for the Connecticut market to equivalent data points for other states in the region. To advise the Green Bank on how it may continue to support the orderly and sustainable development of the Connecticut solar industry, Section 7 offers three sets of recommendations by which the Green Bank could continue to pursue this objective.

Recognizing that the Green Bank deployed over $148 million of public funds (as incentives paid to residential customers) to implement RSIP, it is important to assess how cost-effectively these funds were spent to achieve the program objectives. To inform the cost-effectiveness evaluation of RSIP, this report evaluates the development of the Connecticut residential solar market. Our analysis reviews RSIP's internal performance metrics and compares RSIP, and the development of the Connecticut market, to parallel metrics for residential solar programs and markets in other states in the Northeast and nationally.

The Green Bank developed and implemented RSIP in pursuit of its statutory directive to support the "sustained, orderly development of a state-based solar industry"[1] in Connecticut. In 2022, the Green Bank achieved RSIP's 350 MW capacity objective and the state transitioned from offering RSIP to support residential solar installations to utilizing the Residential Renewable Energy Solutions (RRES) offering, a tariffed PV structure, for this purpose. Through RRES, Eversource and United Illuminating customers may select either a "Buy-All" tariff or a "Netting" tariff. Customers who select the "Buy All" tariff may sell solar electricity to the utility at a rate that exceeds the current retail rate for a 20 year term. Customers who select the "Netting" tariff enter into a net metering agreement with the utility, and may also be able to receive certain "adders." Eversource customers may receive payment for RECs produced, while United Illuminating customers may qualify for a "Low-Income Adder" or for a "Distressed Municipality Adder."

To smooth the transition from RSIP to RRES, with the support of PURA in October of 2020, the Green Bank offered an extended RSIP incentive structure (RSIP-E), which the Green Bank made available for projects seeking approval after RSIP had reached the 350 MW statutory

[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."

threshold and during COVID, but prior to the full implementation of RRES. The Green Bank leveraged an alternative source of financing (i.e. ability to aggregate and sell RECs into the Class I RPS) to fund RSIP-E incentives.

While no longer implementing RSIP, the Green Bank remains committed to supporting the orderly and sustainable development of the market. This report includes recommendations for how the Green Bank may most effectively continue to support residential solar installations in Connecticut without the benefit of RSIP.

3.0 METHODOLOGY

Slipstream completed five tasks to evaluate the performance of RSIP and to provide recommendations to the Green Bank:

1. Program Context Definition. We completed a detailed review of relevant program and institutional documents and data. In this task, we reviewed all components of the Green Bank Evaluation Framework[2]; past published analyses of RSIP's performance and/or potential (e.g., assessment of total addressable market for residential solar in Connecticut[3]); and past published reports on RSIP's achievements of key metrics (e.g., bi-annual reports to the Connecticut Assembly[4].) The background information collected under this task informed all sections of this report.
2. Program Data Analysis. The Green Bank provided comprehensive data for all projects that were funded through RSIP and RSIP-E. The dataset includes 46,651 records and 205 data fields and reflects all 46,226 projects completed through December 2022. Included in the dataset were records for 425 projects that were approved for RSIP or RSIP-E, but which were not completed. In addition to project-level data, Slipstream analyzed detailed information about incentive levels offered for each step in RSIP's declining incentive block structure[5]; program participation by residents who live in LMI and Vulnerable Communities; and factors used over time to estimate the non-energy impacts of the program. Impact factors included:
    a. State emissions avoided due to increased deployment of residential PV production
    b. Job years created by investments in residential solar projects
    c. Tax revenue generated by investments in residential solar projects.
    d. Energy cost savings realized by low and moderate income (LMI) households who participated in RSIP.

[2] Connecticut Green Bank. "Evaluation Framework: Assessing, Monitoring, and Reporting of Program Impacts and Processes." 2016.
[3] Geostellar. "The Addressable Solar Market in Connecticut." 2013.
[4] Connecticut Green Bank. "Progress Report on the Residential Solar Investment Program." 2020.
[5] Certain tables and figures in this report distinguish between projects funded by RSIP and projects funded through RSIP-E. Tables and figures that do not provide separate data for RSIP-E group both project sub-sets in the analyzed data.

The results of this analysis are described in Section 4 of this evaluation and were used in Section 6 to compare the Connecticut market to other states in the region.

3. Regional Analysis. Slipstream identified and analyzed data available on residential solar installations and residential solar programs in the Northeast. States reviewed included Maine, Massachusetts, New Hampshire, New Jersey, New York, Rhode Island, and Vermont. Slipstream's search started with a detailed review of entries for residential solar programs in each state in the Database of State Incentives for Renewables & Efficiency (DSIRE)[6], from which we established an inventory of potentially relevant programs. For each program, we pursued primary data, program reports, and regulatory or legislative filings that offered data on program impacts and performance metrics. To supplement findings in DSIRE, we searched for relevant programs on the websites of electric utilities in states in the region, as well as the websites of state energy offices and public utilities commissions. In addition to internet research, we conducted limited and targeted outreach to utility and government representatives to request relevant data and program information. The findings from this task are described in Section 6.
4. Stakeholder Interviews. Slipstream conducted remote interviews with key external stakeholders in the Connecticut residential solar market. From the interviews, we documented views on the impacts of RSIP and the Green Bank on the market, and solicited input on the most effective ways for the Green Bank to support the residential solar market post-RSIP. We interviewed representatives from Eversource, United Illuminating, the Connecticut Solar and Storage Association, and SmartPower. Information from the stakeholder interviews informed Sections 5 and 7 of this report.
5. Data Analysis. Slipstream analyzed RSIP data and data on residential solar adoption in other states in the Northeast. We calculated the annual and cumulative impacts of RSIP on multiple metrics describing energy production, energy costs, emissions reductions, economic benefits, distribution of socioeconomic benefits, and program cost-effectiveness. For metrics for which there was sufficient data to analyze markets and program performance in other states, Slipstream calculated relevant metrics for those states and assessed the relative impact of RSIP in comparison to programs in other states. The results of this task are described in sections 4, 5, and 6 of this report.

4.0 RSIP IMPACTS: 2012 - 2022

Slipstream's evaluation confirmed that the Green Bank successfully implemented RSIP to facilitate the deployment of 350 MW-DC of residential solar capacity in Connecticut. We also confirmed that the Green Bank used the RSIP-E funding mechanism to supplement the PV capacity produced under RSIP to enable deployment of an additional 26.88 MW-DC of residential solar capacity, for combined capacity of 376.90[7] MW-DC. Table 1 indicates the

[6] www.dsireuse.org
[7] The actual installed capacity through RSIP was 350.02 MW-DC.

number of projects completed each year from 2012 through 2022, as well as the generating capacity that those projects produced and

Table 2 displays annual production and incentive payment by the type of REC associated with the project.

Table 1. Annual Capacity and Funding

		Installed Capacity (MW-DC)		Incentive Funds Issued	
Calendar Year	Completed Installations	RSIP	RSIP-E	RSIP	RSIP-E
2012	242	1.63	0.00	$2,784,788	$-
2013	1,037	7.33	0.00	$11,145,112	$1,569 [8]
2014	1,475	10.46	0.15	$12,405,920	$156,518
2015	8,159	60.62	1.15	$39,648,831	$650,559
2016	7,062	55.52	0.24	$23,107,805	$113,090
2017	4,160	32.45	0.01	$10,364,723	$9,697
2018	5,411	44.28	0.01	$13,106,951	$1,748
2019	7,137	60.63	0.25	$16,760,039	$91,293
2020	6,437	54.11	0.79	$13,582,222	$254,726
2021	4,480	22.96	18.59	$5,804,000	$4,887,034
2022	626	0.02	5.69	$4,146	$1,417,714
Total	**46,226**	**350.02**	**26.88**	**$148,714,535**	**$7,583,947**

Table 2 Annual Production and Incentive Payments by SHREC Phase

		Installed Capacity (MW-DC)			Incentive Funds Issued		
CY	Count	Pre-SHREC	SHREC	SHREC-E	Pre-SHREC	SHREC	SHREC-E
2012	242	1.63	-	-	$2,784,788.40	$0.00	$0.00
2013	1,037	7.33	-	-	$11,145,111.57	$0.00	$1,569.00
2014	1,475	10.46	-	0.15	$12,405,920.07	$0.00	$156,517.83
2015	8,159	22.45	38.17	1.15	$22,146,940.76	$17,501,889.87	$650,559.38
2016	7,062	6.90	48.62	0.24	$6,446,758.14	$16,661,046.46	$113,090.00
2017	4,160	-	32.45	0.01	$0.00	$10,364,722.52	$9,696.75
2018	5,411	-	44.28	0.01	$0.00	$13,106,951.29	$1,747.70
2019	7,137	-	60.63	0.25	$0.00	$16,760,038.98	$91,292.61

[9] Connecticut Green Bank. “Progress Report on the Residential Solar Investment Program.” 2020.

2020	6,437	-	54.11	0.79	$0.00	$13,582,221.72	$254,725.63
2021	4,480	-	22.96	18.59	$0.00	$5,803,999.68	$4,887,033.86
2022	626	-	0.02	5.69	$0.00	$4,145.91	$1,417,714.17
Total	**46,226**	**48.78**	**301.24**	**26.88**	**$54,929,518.94**	**$93,785,016.43**	**$7,583,946.93**

The expected useful life (EUL) of photovoltaic (PV) systems is commonly estimated to be 20-30 years. In previous reports[9], the Green Bank calculated anticipated impacts of the projects supported by RSIP to be realized during a 25-year equipment lifetime. We find that assuming a 25-year project lifetime aligns with industry best practices[10,11,12]. Table 3 shows the estimated annual amount of electricity generated by projects completed in each year of RSIP. If 430,000 MWh of electricity is produced a year from residential solar PV through projects supported by the RSIP, and Connecticut's net energy load in 2021 is 28,300 GWh,[13] then the RSIP has helped reduce load by 1.5%. The table also shows the annual emissions avoidance benefits enabled by the additional residential solar generating capacity of RSIP projects funded in that year. If 230,000 tCO2 are being avoided as a result of the RSIP, and in 2018 Connecticut emitted 42.2 MMTCO2e,[14] then the RSIP has helped avoid GHG emissions by 0.5%. Slipstream calculated emissions avoidance by using the current and historical emissions reduction factors published through the U.S. EPA's industry-accepted AVERT framework.

Table 3. Estimated Annual Generation and Emissions Avoidance

CY	Annual MWh generated	tCO_2	Lbs. PM 2.5	Lbs. Nox	Lbs. SO_2
2012	1,862	1,038	93	1,283	1,696
2013	8,352	4,779	419	7,173	9,246
2014	12,086	6,658	607	9,548	11,560
2015	70,340	40,430	3,531	49,023	49,123
2016	63,509	35,700	3,136	36,543	26,085
2017	36,975	19,921	1,706	17,106	11,190
2018	50,433	27,876	2,373	26,957	23,208
2019	69,326	36,053	2,047	14,606	7,573
2020	62,521	31,688	1,751	10,733	2,636
2021	47,317	23,982	1,325	8,123	1,995
2022	6,501	3,295	182	1,116	274
Total	**429,221**	**231,419**	**17,169**	**182,210**	**144,586**

Figure 2 applies an assumed 25-year system life to show the annual energy generation and cumulative GHG emissions reduction benefits resulting from RSIP projects throughout the

[9] Connecticut Green Bank. "Progress Report on the Residential Solar Investment Program." 2020.
[10] NREL. "Energy Analysis | Useful Life." Viewed December, 2022. (https://www.nrel.gov/analysis/tech-footprint.html.)
[11] U.S. Department of Energy. "Federal Energy Management Program | Optimizing Solar Photovoltaic Performance for Longevity." Viewed December, 2022. (https://www.energy.gov/eere/femp/optimizing-solar-photovoltaic-performance-longevity).
[12] Huang, S. "Solar Energy Technologies Office Photovoltaics End-of-Life Action Plan." U.S. Department of Energy Office of Energy Efficiency & Renewable Energy. 2022. (https://www.energy.gov/sites/default/files/2022-03/Solar-Energy-Technologies-Office-PV-End-of-Life-Action-Plan.pdf).
[13] "2022 Clean & Renewable Energy Report" by PURA (February 6, 2023)
[14] 2018 Connecticut Greenhouse Gas Emissions Inventory" by DEEP (2021)

lifetimes of all funded projects (from 2012 – 2047). Figure 3 shows the parallel impacts of the RSIP on reductions in PM 2.5, NOx, and SO_2 emissions.

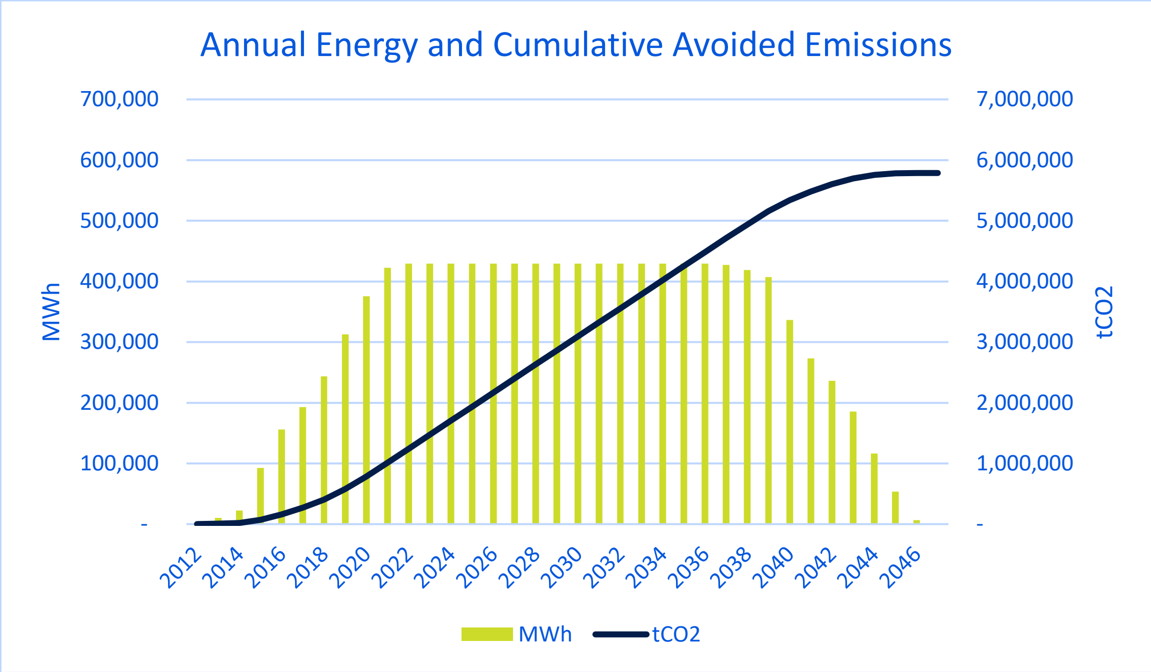


Figure 2. Estimated Energy Generation and Avoided GHG Emissions: 2012 - 2047

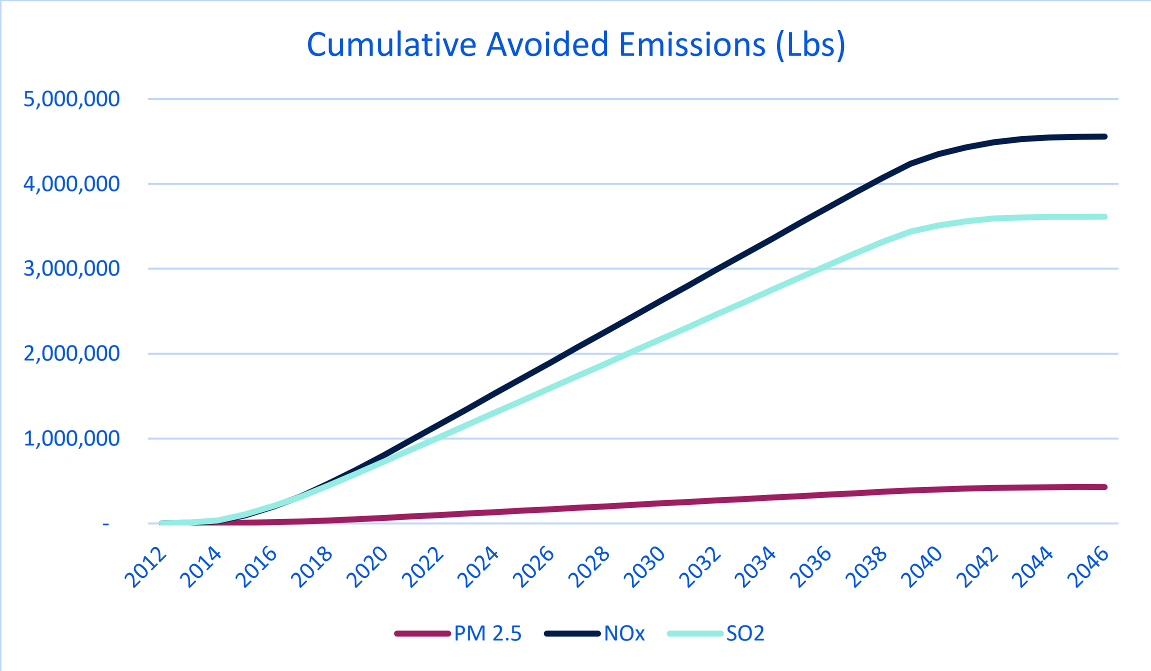


Figure 3. Estimated Avoided Particulate Emissions: 2012 - 2047

In addition to generating energy and environmental benefits, projects funded through RSIP created economic value for the State of Connecticut. From 2012 – 2022, RSIP issued total incentives of $148,714,535 and the Green Bank issued additional incentives of $7,583,947 through RSIP-E. The RSIP incentives achieved a leverage ratio[15] of 8.15 to catalyze total investment of $1,429,942,769 in Connecticut's economy. The combination of public and private investment created positive economic ripples in the State's economy, including job creation and generation of state tax revenue. The Green Bank previously engaged outside expertise to investigate the number of job years created[16] and the amount of state tax revenue generated, for each $1,000,000 of total investment in residential solar projects[17]. The Green Bank updated these analyses periodically during the lifetime of RSIP to reflect changes in the state's residential solar industry and in its tax structure. Slipstream applied the job year creation and tax revenue generation factors developed by third parties, that were effective as of the completion date of each project to estimate the annual and cumulative economic impacts of RSIP.

Slipstream's analysis showed that RSIP projects created 6,494 direct job years[18], 9,239 indirect and induced job years[19], and $44,967,956 in state tax revenue. Table 4 describes RSIP's annual and cumulative economic impacts.

Table 4. RSIP Economic Impacts

				Job Years		
CY	**RSIP Amount**	**Installed Cost**	**Leverage Ratio**	**Direct**	**Indirect and Induced**	**Tax Revenue**
2012	$2,784,788	$8,401,052	2.0	49.6	79.3	$295,021
2013	$11,146,681	$32,735,501	1.9	193.1	309.0	$1,149,576
2014	$12,562,438	$45,184,351	2.6	266.6	426.5	$1,586,743
2015	$40,299,390	$270,845,102	5.7	1596.8	2554.2	$9,511,295
2016	$23,220,895	$221,104,968	8.5	1050.8	1531.1	$7,764,565
2017	$10,374,419	$112,023,431	9.8	440.0	573.2	$3,243,617
2018	$13,108,699	$156,510,605	10.9	613.0	797.1	$4,531,735
2019	$16,851,332	$216,971,831	11.9	849.7	1104.6	$6,282,378
2020	$13,836,947	$194,542,509	13.1	761.8	990.4	$5,632,941

[15] The leverage ratio is calculated as the total private investment in funded projects divided by the total RSIP incentive amount.

[16] Navigant Consulting Inc., Connecticut Department of Economic and Community Development, and Connecticut Green Bank. June 2016. "Clean Energy Jobs In Connecticut."

[17] Navigant Consulting, Inc. and Connecticut Green Bank. January 19, 2018. "Tax Revenue Calculator Final Report."

[18] Direct Job-Years are the "total number of installer, electrician, and PM [Project Manager]/engineering jobs created for 1 year." [Navigant Consulting Inc., Connecticut Department of Economic and Community Development, and Connecticut Green Bank. June 2016. "Clean Energy Jobs in Connecticut."]

[19] Indirect jobs years are created by, "the response as supplying industries increase output in order to accommodate the initial change in final demand. These indirect beneficiaries will then spend money for supplies and services, which results in another round of indirect spending." Induced jobs are, "generated by the spending of households who benefit from the additional wages and business income they earn through direct and indirect activity." [Navigant Consulting Inc., Connecticut Department of Economic and Community Development, and Connecticut Green Bank. June 2016. "Clean Energy Jobs in Connecticut."]

2021	$10,691,034	$149,506,466	13.0	585.5	761.1	$4,328,931
2022	$1,421,860	$22,143,236	14.6	86.7	112.7	$641,153
Total	**$156,298,482**	**$1,429,969,053**	**8.15**	**6,494**	**9,239**	**$44,967,956**

5.0 CONNECTICUT RESIDENTIAL SOLAR MARKET

Slipstream's evaluation assessed the effect of RSIP on the development of Connecticut's solar market since 2012, as well as current market conditions in the state. To evaluate how RSIP supported the market, we reviewed changes in RSIP incentive rates and concurrent changes in the cost of installed residential solar over time. This analysis showed how the program progressed, starting from a high initial cost for RSIP incentives and low generation capacity, and ending with low incentive rates leveraging large amounts of private capital to support new projects.

5.1 THE GREEN BANK'S ROLE IN THE MARKET

Program incentives for residential solar installations may serve two primary purposes. First, a financial incentive can sufficiently reduce a resident's project costs and/or ongoing financing or electricity costs, making installation of a PV system more cost-effective for that resident. Two measures of cost-effectiveness are length of payback period, and positive cash flow. In the former, program incentives may shorten the payback period over which the financial value of the electricity generated by the system repays the customer's up-front costs. For PV systems installed in conjunction with a PPA, or those financed with a loan or lease, cash-flow analysis is a more applicable measure of cost-effectiveness. A second purpose of a financial incentive is to motivate a customer to take action to install PV, even if poor cost-effectiveness of a project would not otherwise be an obstacle to the customer's participation.

The Green Bank offered three types of RSIP incentives, which improved project cost-effectiveness for customers and served to motivate customers to install PV arrays at their homes. The Expected Performance Based Buydown (EPBB) offered a one-time up-front payment to customers based on the generating capacity of their system and benefited customers who purchased their systems. The Performance Based Incentive (PBI) provided ongoing payments on a quarterly basis for 6 years to customers based on the amount of electricity produced by their array. The PBI served customers who hosted third-party owned projects. The Low and Moderate Income Performance Based Incentive (LMI PBI) offered a higher PBI incentive level for income-qualified customers.

Nationally, the installed cost of residential photovoltaic systems has decreased significantly during RSIP's lifetime. NREL states that the installed cost of residential solar arrays decreased 42 percent from 2012 to 2020[20]. At RSIP's inception, unsubsidized residential PV systems were

[20] 2020 is the most recent year for which NREL published data on the installed cost of residential solar arrays. [NREL. "Solar Market Research & Analysis | Solar Installed System Cost Analysis." Viewed

unlikely to offer opportunities to customers for either positive cash flow or for reasonably attractive returns on investment. As the installed cost of residential solar decreased and electricity rates increased, the Green Bank used the incentive step structure to progressively reduce the amount of the RSIP incentive so that RSIP funding filled the gap between the market rate cost of solar and the lower project cost, at which solar is a financially attractive energy source for customers. When establishing incentives steps, the Green Bank timed reductions so as to maintain levels that would incentivize adoption, while reducing levels so as to optimize cost effectiveness and minimize levels of program free ridership. Figure 4, Figure 5, and Figure 6 show the reductions in RSIP incentive levels by step along with the decreasing installed cost of solar. The relationship between the rapid decline in costs during the early years of the program followed by slower rates of change in the later years of the program aligns with parallel changes in the EPBB and PBI incentive levels. Reductions in the LMI PBI incentives lagged reductions in installed cost and in the EPBB and PBI levels. The Green Bank's decision to maintain higher LMI PBI incentives for a longer period of time was an effective response to the Green Bank's recognition that LMI communities and vulnerable communities were underserved in RSIP's early years. As described below, the Green Bank's strategy to increase participation in RSIP by LMI communities resulted in rates of solar adoption in LMI communities in Connecticut that exceeded regional and national averages.

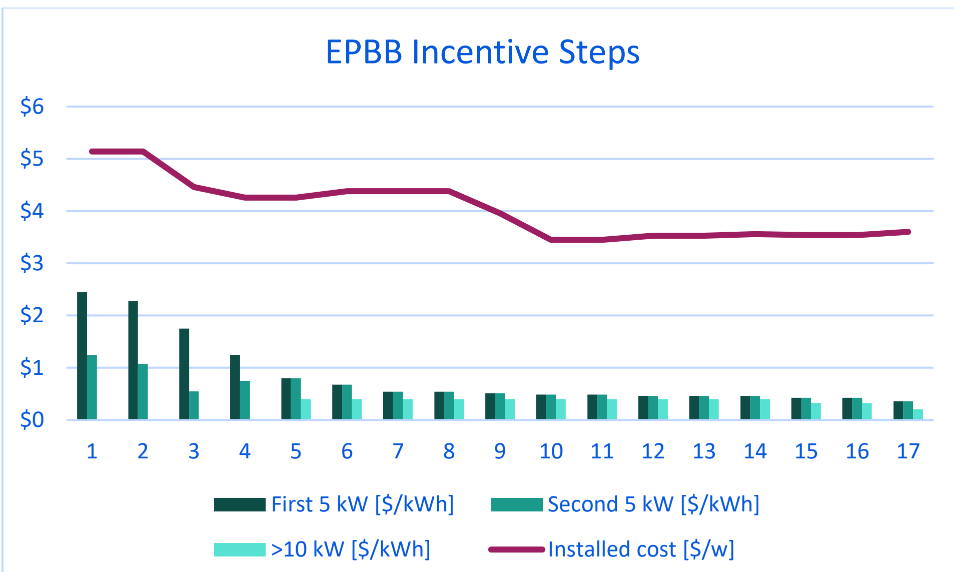
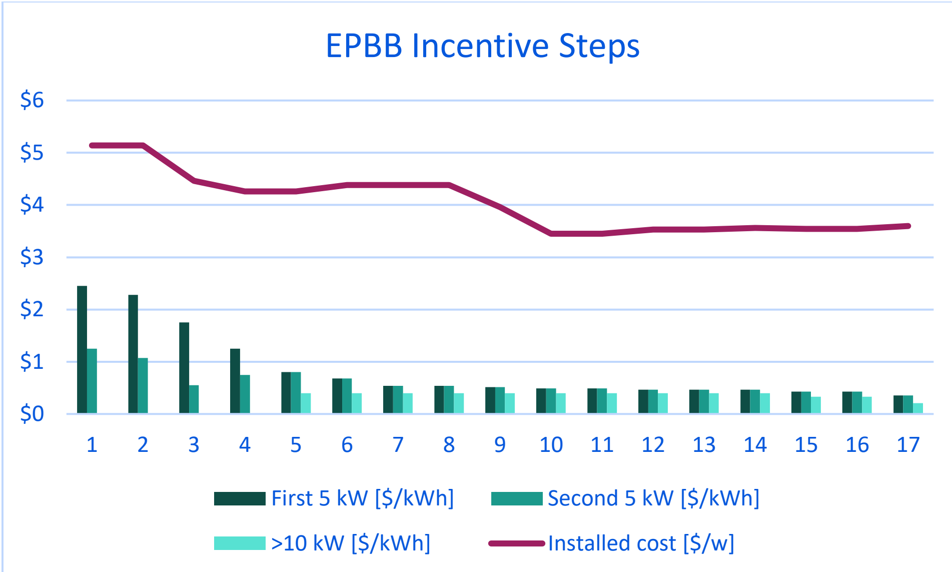


Figure 4. EPBB Steps and Changes in Installed Cost

November, 2022. https://www.nrel.gov/solar/market-research-analysis/solar-installed-system-cost.html]



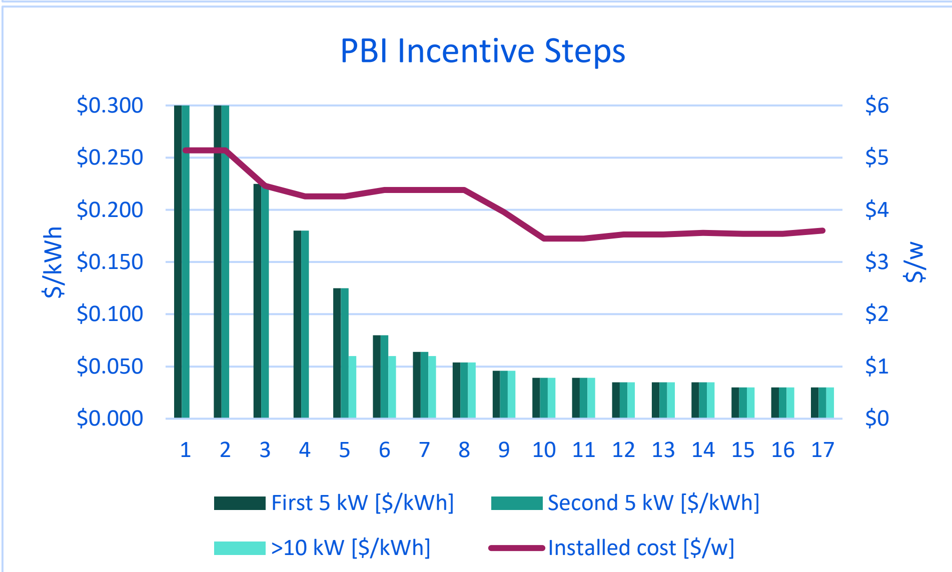


Figure 5. PBI Steps and Changes in Installed Cost

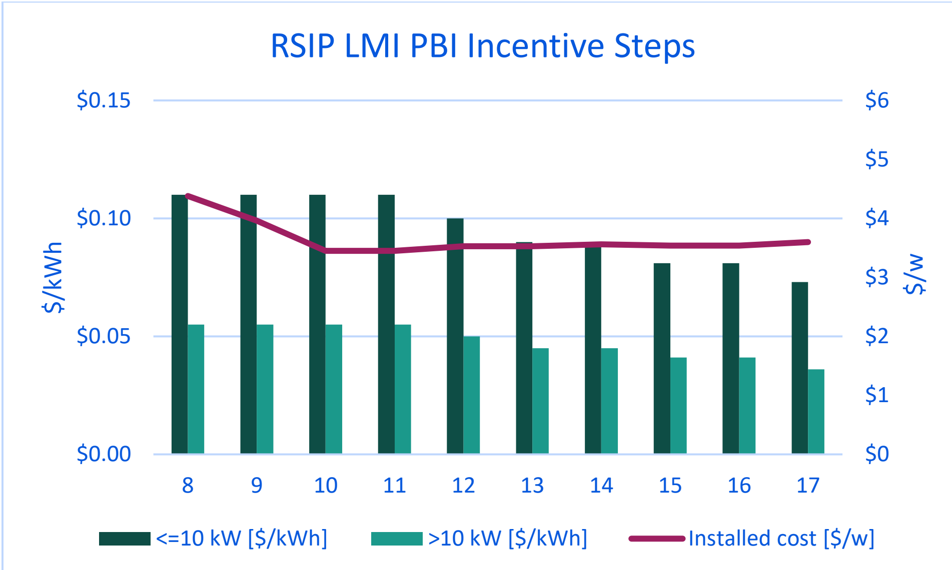


Figure 6. LMI PBI Steps and Changes in Installed Cost

Table 5 shows the average installed cost and incentive amount for each year of the program, as well as the ZREC[21] equivalent cost. Figure 7 compares the annual weighted average costs of LRECs, as well as small, medium, and large ZRECs with the ZREC equivalent cost of RSIP incentives.

Table 5. RSIP Leverage and ZREC Cost

CY	Installed Cost ($/W)	Incentive ($/W)	Leverage Ratio	ZREC Equivalent ($/MWh)
2012	$5.14	$1.70	2.02	$99.72
2013	$4.46	$1.52	1.94	$88.97
2014	$4.26	$1.18	2.60	$69.29
2015	$4.38	$0.65	5.72	$38.19
2016	$3.96	$0.42	8.52	$24.38
2017	$3.45	$0.32	9.80	$18.71
2018	$3.53	$0.30	10.94	$17.33
2019	$3.56	$0.28	11.87	$16.20
2020	$3.54	$0.25	13.06	$14.75

[21] Separately from RSIP, Connecticut customers were able to engage in 15-year ZREC contracts with the state's electric utilities. A ZREC is equivalent to 1 MWh of electricity generated by a solar project owner. (Connecticut Green Bank. October, 2019. "What You Need to Know about Solar for Your Facility." https://portal.ct.gov/-/media/DEEP/p2/institution/WhatYouNeedtoKnowAboutSolarFAQshandoutpdf.pdf) This evaluation applied the amount of the RSIP incentive and the estimated electricity to be produced over a 15 year period by each RSIP project to determine the equivalent cost of ZRECs as an alternative financing incentive for the project.

2021	$3.60	$0.26	12.98	$15.06
2022	$3.88	$0.25	14.57	$14.58

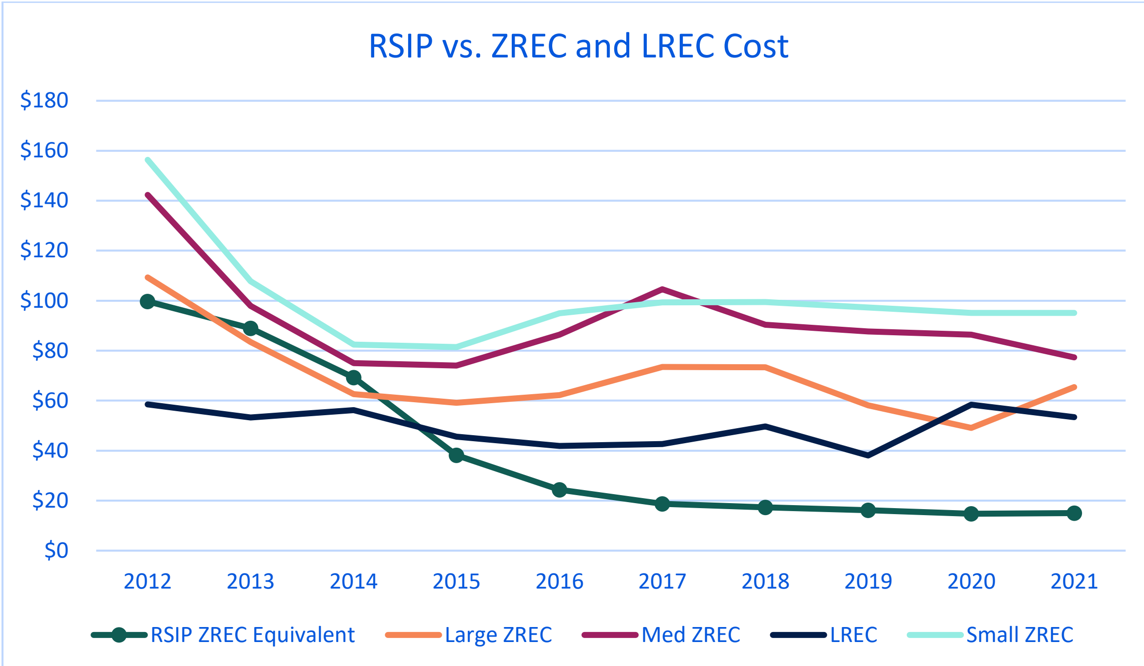


Figure 7 Comparative costs of LREC, ZREC, and RSIP incentives

As shown in the table, the Green Bank reduced incentive levels more rapidly than the rate of decrease in installed cost. While reducing incentive costs ahead of the market, the Green Bank continued to support the orderly and sustainable development of the Connecticut residential solar market, as shown by the accelerating rate of RSIP participation over time.

Interviews with key stakeholders in the Connecticut residential solar market revealed consistent themes in the Green Bank's role in establishing and growing the state's solar industry. Several key observations emerged from the stakeholder interviews:

- In the early development of the Connecticut solar market, the Green Bank (and its predecessor) were essential conveners of diverse stakeholders, including electric utilities, solar developers, ratepayers, and community-based organizations. The Green Bank led conversations among representatives of these stakeholders that produced common objectives and shared understandings. Throughout its implementation of RSIP, the Green Bank maintained its role as an independent third-party convener and earned the trust of all stakeholders.
- Prior to the launch of RSIP, there was not a coherent residential solar market in Connecticut. RSIP was essential in developing a functional market for the state.
- As a program and as a financing tool, RSIP operated smoothly. The Green Bank anticipated challenges to RSIP before the challenges created problems for the market

and the Green Bank innovated to find solutions. The availability and predictability of RSIP incentives enabled the orderly and sustainable development of the state's solar industry.

- Solar developers and installers trust the Green Bank and, based on this trust, companies have chosen to invest in growing their businesses in the state.
- During its operational life, RSIP supported the creation of a self-sustaining market.
- The Green Bank was essential in adapting RSIP to create ways for low-and-moderate income households and communities to access affordable solar power.

5.2 ADDITIONAL MARKET INFLUENCES

The research confirmed that residential solar projects are installed in the context of a complex market in Connecticut. As of the release of this report, Connecticut residents, solar installers, and electric utilities continue to pivot the market from RSIP to the RRES tariffed solar structure. However, the transition from RSIP to RRES is one of multiple influences on the market.

Current influences on the market beyond the control of the Green Bank and the electric utilities include:

Inflation. Rapidly increasing prices and potential consumer expectations of ongoing cost increases may affect cost-effectiveness of projects for customers, as well as customer decisions on if/when to install PV arrays at their residences.

Interest Rates. Rising borrowing costs for customers may affect customer willingness to use a loan to fund the first costs of a solar project. High interest rates have also contributed to slower residential real estate markets, which customers may view as potentially negatively affecting the equity in their homes. Home equity can be an important input that enables customers to finance high-cost home improvements, such as the purchase of a PV system. Reduced home equity could contribute to lesser ability and/or willingness for homeowners to finance solar projects.

Supply Chain. Lack of product availability due to disruptions in manufacturing and distribution supply chains, along with labor shortages, may force delayed installations for customers.

Federal Funding. The Inflation Reduction Act (IRA) and Infrastructure Investment and Jobs Act (IIJA) increased federal funding for an array of climate change mitigation, renewable energy, and energy efficiency projects and programs. Increased federal funding may attract additional actors to renewable energy markets and may contribute to technological and/or market delivery innovations that could influence the Connecticut residential solar market. Also, federal funding like the Greenhouse Gas Reduction Fund within IRA, specifically for zero emission technologies and low-income and disadvantaged communities (i.e., Sec. 134(a)(1)) could help Connecticut restore its LMI deployment success in LMI communities, which achieved high rates of solar adoption during RSIP, but have lost ground under RRES.

Tax Credits. Recent legislation returned the amount of the federal Investment Tax Credit to 30% and signaled continuation at this rate through at least 2032. Federal tax credits are a key source of residential solar financing for many homeowners. Increasing and stabilizing the tax credit may accelerate residential solar installations and support market stability due to the elimination of year-end deadlines to access specified tax credit levels.

Assessing the relative magnitude of the influence exerted by each of these factors on the residential solar market and the comparative importance of the past RSIP framework and the current RRES tariff on the industry is outside of the scope of this analysis. While the Green Bank may be unable to influence the preceding market factors, Slipstream recommends that the Green Bank consider potential short-term and long-term impacts of these influences on the trajectory of the residential solar industry and that the Green Bank discern its intended future role in the market in the context of these factors.

5.3 RESIDENTIAL SOLAR ADOPTION IN LOW AND MODERATE INCOME COMMUNITIES

In 2020, the median income for households throughout the country that installed solar was 158 percent of the median income of the county in which the home was located.[22] Conversely, in the United States, as of 2020, only 30 percent of solar adopter households had income that was less than the applicable area median income and only 20 percent of solar adopters had incomes that were less than 80 percent of the area median income.[23]

The Green Bank recognized that, while on-site solar power may be effective in reducing energy burden among low-and-moderate income (LMI) households, financial barriers may deter or prevent households in this market segment from accessing the benefits of solar energy. The Green Bank implemented multiple strategies in RSIP to improve access to solar for LMI households. These initiatives included:

- Introduction of the LMI Performance Based Incentive (LMI PBI), which offered a higher PBI rate for residential customers whose documented[24] household income was less than the applicable Area Median Income (AMI).
- Development and implementation of the Solar for All[25] program, in which the Green Bank provided subordinate capital and program support that enabled PosiGen (a solar developer) to use inclusive underwriting standards when offering lease financing for solar installations for LMI households. The program support also enabled targeted and

[22] Barbose, G. Forrester, S. O'Shaughnessy, E. Dargouth, N. "Residential Solar-Adopter Income and Demographic Trends: 2022 Update." Lawrence Berkeley National Laboratory. March, 2022.
[23] Ibid.
[24] Residential customers demonstrated income-eligibility for the LMI PBI by either providing copies of relevant tax forms or documenting participation in certain other income-qualified programs, such as the Low Income Home Energy Assistance Program (LIHEAP) or the Supplemental Nutrition Assistance Program (SNAP).
[25] More information about Solar for All can be found at: https://www.ctgreenbank.com/strategy-impact/societal-impact/successful-legacy-programs/solar-for-all/

coordinated market engagement of LMI communities, where market-rate solar developers may be less likely to market their services.

- Support for community-based Solarize[26] campaigns increased participation across income segments. However, the Solarize campaigns have been especially effective in engaging residents in LMI communities.
- Instituted data collection and analysis practices that allowed the Green Bank to track and report on its progress in catalyzing participation by LMI households and by residents in LMI communities.

Through the Solar for All program and the Solarize campaigns, the Green Bank also developed ongoing relationships with community-based organizations (CBOs) that serve LMI communities.

Figure 8[27] shows residential solar adoption in Connecticut by the AMI band of the census tract in which each project is located and by year of installation[28]. The line on the chart shows the national average for that year for the percentage of all new installations for residences in census tracts with median income less than the applicable AMI. Figure 8 suggests that the Green Bank's design and implementation of RSIP contributed to higher participation in RSIP by households located in LMI census tracts than would have been expected based on national averages. As shown in the figure, solar adoption in LMI census tracts tracked or slightly lagged the national average through 2014. In 2015, the Green Bank introduced the LMI PBI program and launched the Solar for All initiative and the rate of adoption in LMI census tracts quickly increased. The rate of participation in LMI census track has remained above the national average since the introduction of these program elements.

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[26] SmartPower implemented Solarize campaigns that leveraged RSIP. Information about Solarize Connecticut can be found at: https://www.smartpower.org/solarize-connecticut.html

[27] The project-level data provided by the Green Bank included data points that characterized the census tract in which the property is located, including the AMI band, classification as a Vulnerable Community, Distressed Community, and/or EJ Community, as well as the majority race in the census tract. Data reported in this evaluation is based on census tract data provided by the Green Bank. Slipstream did not separately confirm the census tract characteristics indicated for each project.

[28] Data adapted from the Lawrence Berkeley National Laboratory's *Residential Solar-Adopted Income and Demographic Trends*." Viewed November, 2022 data set. (https://emp.lbl.gov/projects/solar-demographics-trends-and-analysis/)

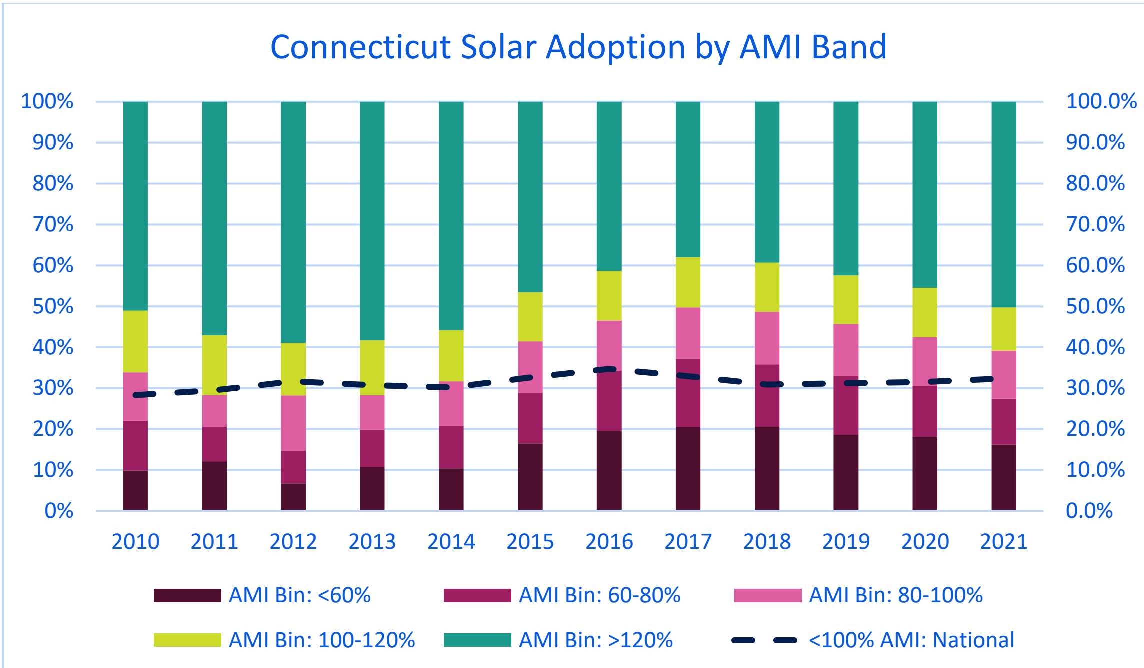

Figure 8. Connecticut Solar Adoption by AMI Band

RSIP was designed to increase adoption of residential solar in single family owner-occupied homes. Homeownership rates in Connecticut vary based on a household's income, with homeownership rates generally higher among households with higher incomes. Due to differences in homeownership rates based on income, potential for RSIP participation also varies by income level. Table 6 compares RSIP participation by the AMI band in which the residence is located to homeownership rates for the same income levels.

Table 6. RSIP Participation vs. Owner-Occupancy Rate

AMI Band	RSIP Projects		Percent of all owner-occupied homes in band	Difference (RSIP rate vs. owner occupied rate)
	Number	Percentage		
<60%	4,120	8.91%	7.19%	1.73%
60-80%	6,268	13.56%	12.60%	0.96%
80-100%	8,707	18.84%	16.85%	1.98%
100-120%	10,931	23.65%	23.65%	0.00%
>120%	16,189	35.02%	39.71%	-4.69%
Unknown	12	0.0%	0.0%	0.0%

The data show that the rate of participation in RSIP by households in census tracts with median income that is less than the area median exceeds the distribution of owner-occupied homes in the same areas. In turn, the rate of participation in RSIP by households living in the most affluent census tracts deviates most greatly of any of the income bands and is substantially lower than the corresponding distribution of all owner-occupied homes. Thus, Green Bank effectively implemented RSIP to make residential solar accessible for LMI households, as demonstrated by the fact that homeowners in lower AMI bands participated in RSIP at a rate exceeding the homeownershp rate within their respective AMI band.

The Green Bank recognized that socioeconomic and societal factors other than income may also contribute to differences between communities and households in their ability to access the benefits of residential solar installations. To measure RSIP's effectiveness in reaching potentially underserved communities, the Green Bank collects six data points about the socioeconomic characteristics of the census tract and community where each project is completed. [Note: A census tract or community may meet the requirements of more than one community designation. Projects are included in the counts of all community designations for which the site address qualifies.]

- Census tract median income as a percentage of the area median income
- Majority race within the census tract
- Designation of the location as a "Distressed Community"[29]
- Designation of the location as an "Environmental Justice Community"[30]
- Designation of the location as a "Vulnerable Community"[31]
- Designation of the location as a "Justice 40 Community"[32]

Figure 9 shows that higher shares of total owner-occupied residences in Majority Black and Majority Hispanic census tracts participated in RSIP than participated in Majority White census tracts. Figure 10 expands upon this analysis and shows that residents in low-income census tracts across all racial categories participated in RSIP at rates that exceeded the parallel homeownership rates for the same combination of income band and majority race.

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[29] The Connecticut Department of Economic and Community Development identifies "Distressed Communities as directed by C.G.S. Section 32-0p, "based on "high unemployment and poverty, aging housing stock and low or declining rates of growth in job creation, population, and per capita income."

[30] Environmental Justice Communities are, "A) a United States census block group, as determined in accordance with the most recent United States census, for which thirty per cent or more of the population consists of low income persons who are not institutionalized and have an income below two hundred per cent of the federal poverty level; or (B) a distressed municipality, as defined in subsection (b) of section 32-9p;"

[31] Public Act 20-5 of the Connecticut General Assembly defines "Vulnerable Communities" as populations that may be disproportionately impacted by the effects of climate change, including, but not limited to, low and moderate income communities, environmental justice communities pursuant to section 22a-20a, communities eligible for community reinvestment pursuant to section 36a-30 and the Community Reinvestment Act of 1977, 12 USC 2901 et seq., as amended from time to time, populations with increased risk and limited means to adapt to the effects of climate change, or as further defined by the Department of Energy and Environmental Protection (DEEP) in consultation with community representatives".

[32] Justice 40 Communities are "Disadvantaged Communities" identified by the U.S. Department of Energy by levels of fossil fuel dependence, energy burden, environmental and climate hazards, and socio-economic vulnerabilities in that tract. (Source: Department of Energy *General Guidance for Justice40 Implementation.)*

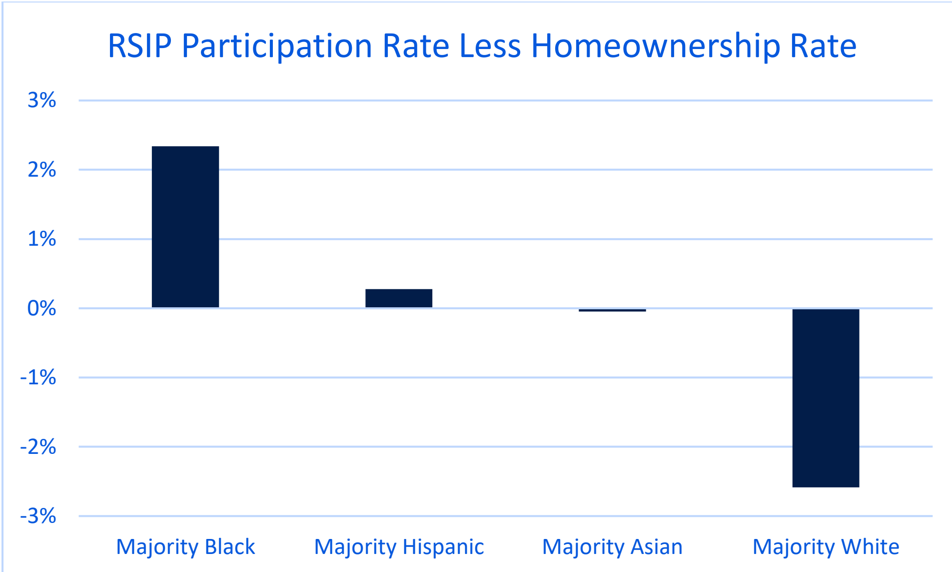

Figure 9 Rates of owner-occupied housing unit participation in RSIP, by majority race.

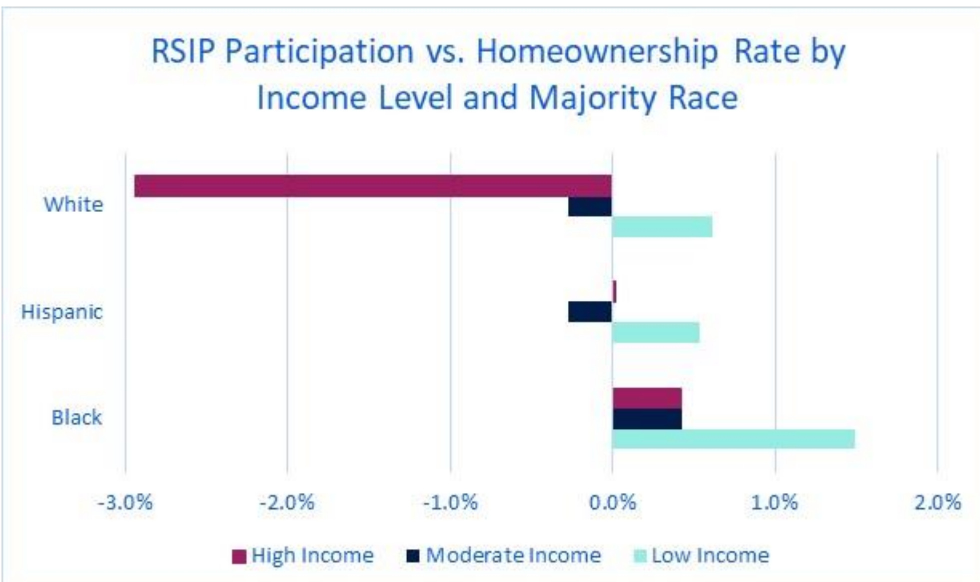

Figure 10 RSIP Participation vs. Homeownership Rate by Income Level and Majority Race

Figure 11 shows the increasing rate of RSIP participation in Majority Black and Majority Hispanic census tracts from 2012 – 2022. Figure 12 and Figure 13 show increasing rates of RSIP participation over time by residents in designated Vulnerable communities, Justice 40 communities, Community Reinvestment Act (CRA) eligible areas, Distressed communities, Environmental Justice (EJ) Communities, and census tracts in which the median income is less than the area median income. Table 7 shows the share of RSIP projects that benefited households who lived within each of these community designations[33].

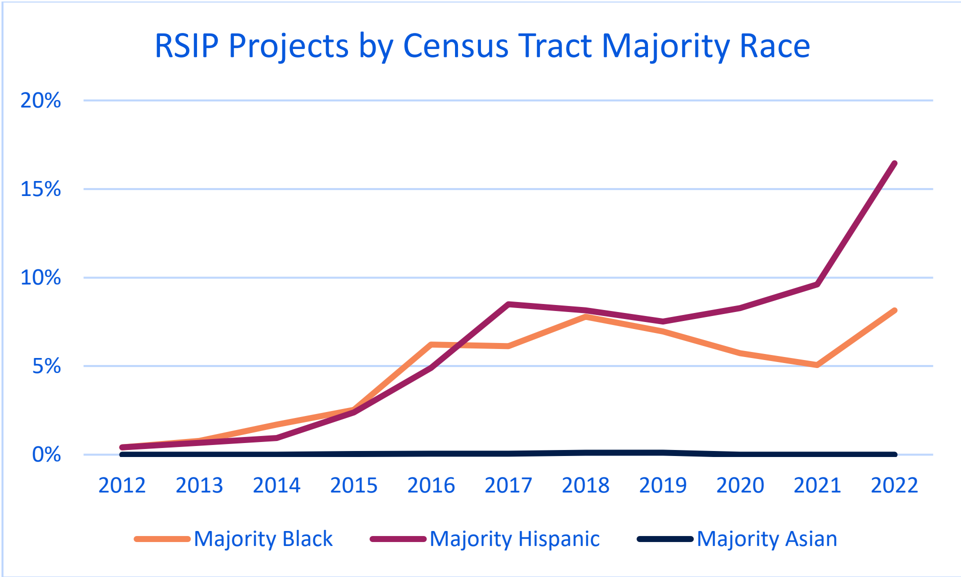

Figure 11 Change in RSIP Participation by Census Tract Race

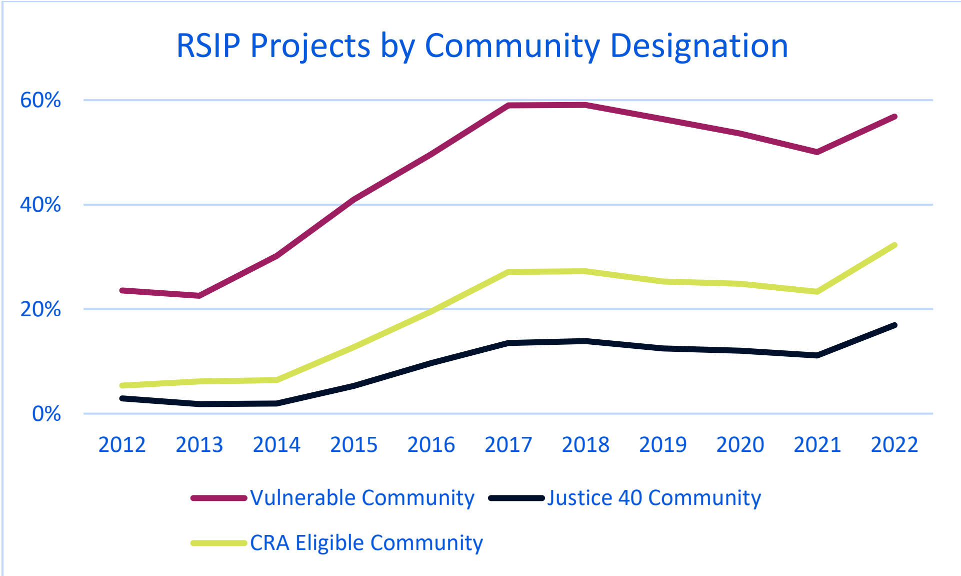

Figure 12 Change in RSIP Participation by Community Designation - Part 1

[33] A census tract or community may meet the qualifications for more than one designation.

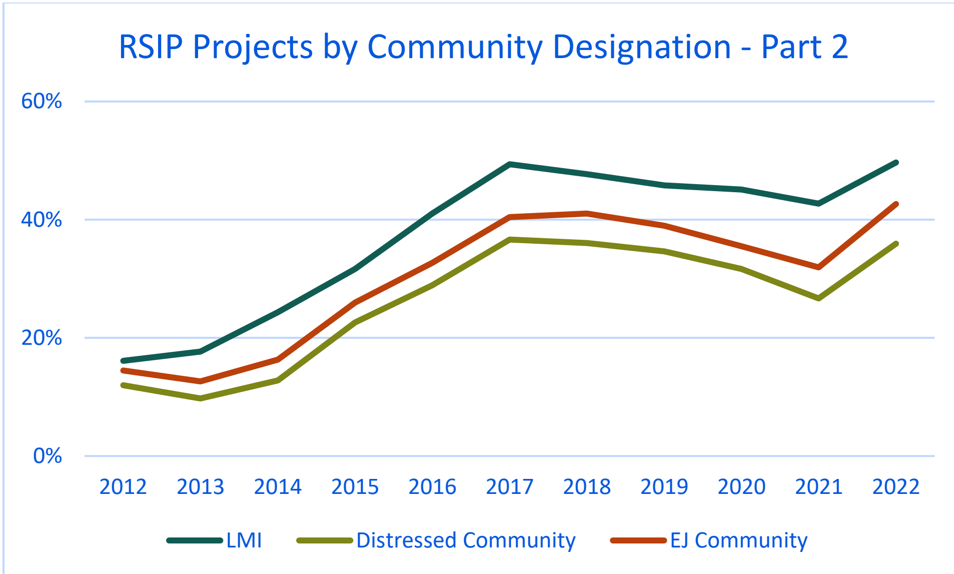

Figure 13 Change in RSIP Participation by Community Designation - Part 2

Table 7. Detailed RSIP Participation in Community Categories

CY	Majority Black	Majority Hispanic	Majority Asian	LMI	Distressed Community	EJ Community	Vulnerable Community	Justice 40 Community	Meet at least one Criteria
2012	0.4%	0.4%	0.0%	16.1%	12.0%	14.5%	23.6%	2.9%	23.6%
2013	0.8%	0.7%	0.0%	17.6%	9.7%	12.6%	22.6%	1.8%	22.9%
2014	1.7%	0.9%	0.0%	24.3%	12.8%	16.3%	30.2%	2.0%	30.6%
2015	2.5%	2.4%	0.0%	31.6%	22.6%	26.0%	41.0%	5.3%	41.4%
2016	6.2%	4.9%	0.1%	41.0%	28.9%	32.7%	49.6%	9.7%	50.6%
2017	6.1%	8.5%	0.0%	49.4%	36.6%	40.5%	59.0%	13.5%	59.8%
2018	7.8%	8.2%	0.1%	47.7%	36.0%	41.0%	59.1%	13.9%	60.2%
2019	7.0%	7.5%	0.1%	45.8%	34.6%	39.0%	56.4%	12.5%	57.2%
2020	5.7%	8.3%	0.0%	45.1%	31.7%	35.5%	53.6%	12.0%	54.4%
2021	5.1%	9.6%	0.0%	42.7%	26.7%	31.9%	50.0%	11.1%	50.6%
2022	8.1%	16.5%	0.0%	49.7%	35.9%	42.7%	56.9%	16.9%	57.7%
Total	**5.4%**	**6.4%**	**0.0%**	**41.3%**	**29.4%**	**33.5%**	**50.4%**	**10.3%**	**51.1%**

In 2014, the Green Bank recognized that Connecticut residents with low and moderate incomes, as well as residents who lived in vulnerable communities faced increased barriers to installing PV arrays on their homes and that additional support may be necessary to ensure equitable levels of participation by Connecticut residents. To support equitable participation in RSIP, in 2015, the Green Bank launched the enhanced LMI PBI offering, engaged residents in vulnerable communities through collaboration with Posigen, and leveraged Solarize campaigns to reduce barriers to participation by LMI residents and residents in vulnerable communities. With the exception of census tracts that are majority Asian or for which there is not a majority race, from 2012 through 2022, RSIP participation by residents in each of the tracked community categories increased.

As shown in Table 8, rates of cumulative participation by residents in all identified categories of communities increased significantly following the program adaptations that the Green Bank introduced in 2015.

Table 8. Change in Participation in Categorized Communities

Census Tract Category	2012 - 2014 Participation Rate	2015 - 2022 Participation Rate	Increase in Participation Rate
Majority Black	1.2%	5.7%	+359%
Majority Hispanic	0.8%	6.8%	+746%
Majority Asian	0.0%	0.1%	N/A
LMI	21.1%	42.6%	+102%
Distressed Community	11.6%	30.6%	+164%
CRA Eligible Community	6.2%	22.3%	+256%
EJ Community	14.8%	34.7%	+135%
Vulnerable Community	26.7%	51.9%	+94%
Justice 40 Community	2.0%	10.8%	+442%
At least one designation	**27.1%**	**52.7%**	**+95%**

The most direct means through which an on-site residential solar installation benefits a household is by reducing energy expenses through generation of electricity that offsets consumption or is sold to the electric utility (both at the same $/kWh rate). RSIP funded projects that customers financed through leases, power purchase agreements, loans, and cash payments. Customer cost savings are the difference between the value of the generated electricity (realized either through reduced purchases of electricity or by selling the energy) and the customer's periodic financing expenses.

The Green Bank sought to adapt RSIP so that it could most effectively reduce energy burden for LMI households. Figure 14 shows the annual cost reduction realized by RSIP customers in census tracts with median income below 100 percent of AMI, and for participants who received the LMI PBI incentive (introduced by Green Bank in 2015). Figure 14 shows the combined impacts of the reduced energy costs offset by the financing costs of leases or power purchase agreements. It does not account for costs of payments on loans used to finance customer-owned solar arrays.

[Note: The left axis in the chart applies to the vertical bars, which show energy cost savings for each customer group. The right axis applies to the lines, which show for each customer group, the percentage of household electricity use that would be offset by the project.]

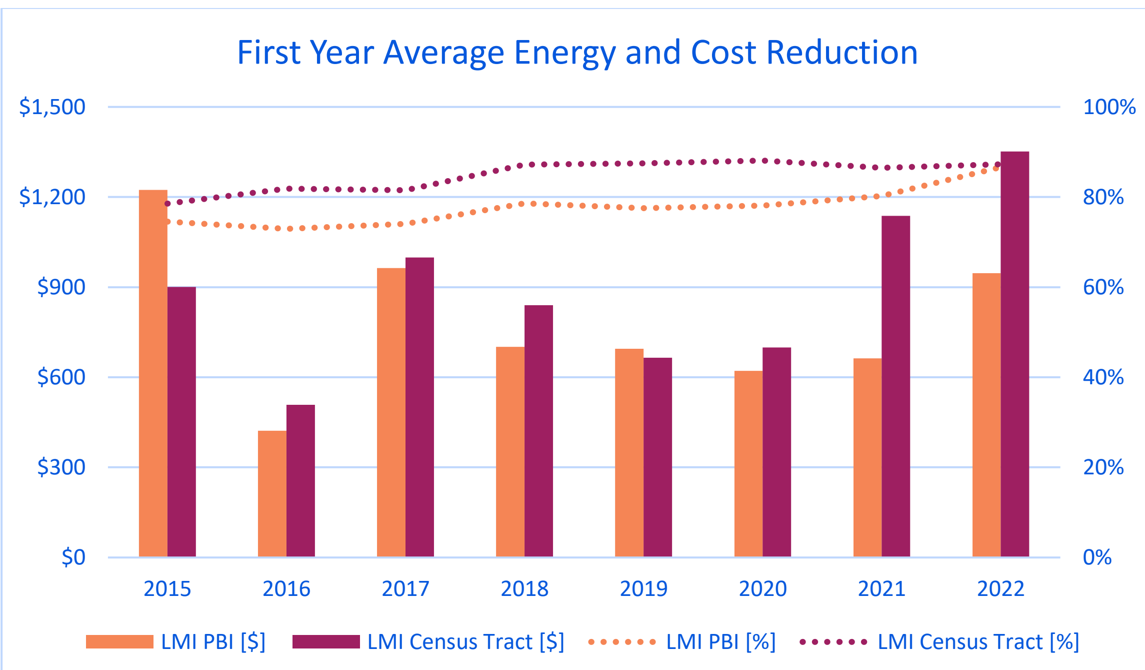

Figure 14. LMI Energy Cost Savings

As shown in Figure 14, following the Green Bank's introduction of the LMI PBI in 2015 and its concurrent intentional engagement in LMI communities, RSIP enabled significant benefits for income-qualified households and households in low- and moderate-income census tracts. RSIP participants in these groups realized average electricity consumption offsets of 75 percent or more in each of the remaining years of the program. These groups of participants also achieved meaningful reductions in overall energy cost, even after accounting for ongoing solar financing expenses.

6.0 COMPARATIVE EFFECTIVENESS OF RSIP

According to the U.S. National Renewable Energy Lab (NREL), the average installed cost of a 22-panel residential PV array fell from $7.53/watt in 2010 to $2.71/watt in 2022[34]. The Federal Investment Tax Credit; state and utility-based incentive programs; the rapid development of PV technology; and the maturation of the solar industry, among other factors, all contributed to cost reductions and increased solar adoption nationally.

An analysis of over 400 residential solar incentive structures[35] found significant variation among the estimated impact and cost-effectiveness of various incentive types. In the context of an evolving solar market, multiple potential program frameworks, and a mandate to be an effective steward of public funds, the Green Bank is interested in understanding the relative cost-effectiveness and impact of RSIP compared to other states in the region and to national averages. This section compares the results produced by RSIP to several national metrics. Acknowledging that residential solar markets, energy costs, and insolation may vary regionally, this section also provides a detailed comparison of solar deployment in Connecticut with the results achieved by other states in the region.

6.1 NATIONAL COMPARISON

Electricity costs, the local installed cost of solar, and location-based solar energy potential may all influence rates of solar deployment. Figure 15 compares Connecticut to national averages for these key influences on rates of solar installations and Figure 16 compares the growth of solar installations in Connecticut to national averages.

[34] NREL. "Solar Market Research & Analysis | Solar Installed System Cost Analysis." Viewed November, 2022. https://www.nrel.gov/solar/market-research-analysis/solar-installed-system-cost.html

[35] Matisoff, D. Johnson, E. "The comparative effectiveness of residential solar incentives." Energy Policy 108 (2017) 44-54.

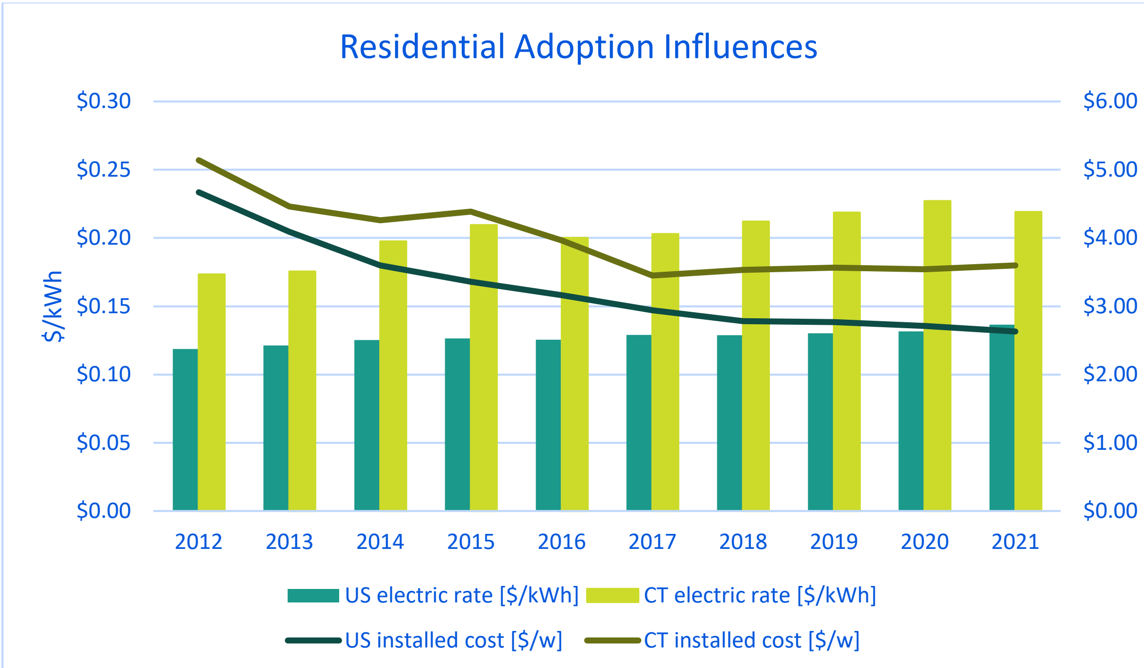

Figure 15. Changes in Electricity Prices and Installed Cost of Solar

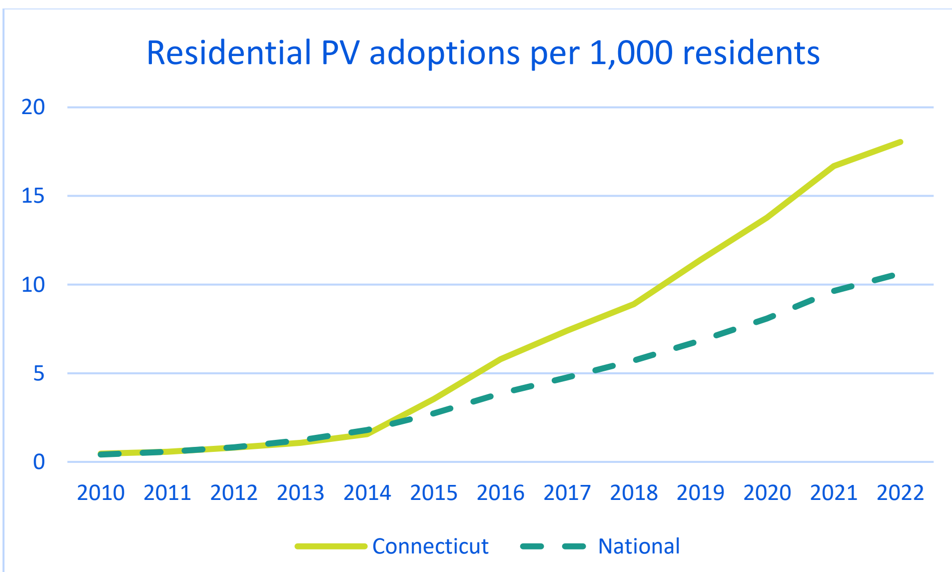

Figure 16. Trends in Rate of Residential Solar Adoption

As described above, nationally, solar adoption has skewed greatly toward higher income households. The Green Bank designed and adapted RSIP to increase access and participation by LMI households. Table 9 compares rates of solar adoption by AMI band in Connecticut to national averages.

Table 9. Residential Solar Adoption by AMI Band

Census tract AMI Band	Connecticut	National Average
Less than 60%	17.8%	12.0%
60% - 80%	13.4%	9.1%
80% - 100%	12.2%	10.8%
100% - 120%	12.0%	11.3%
Greater than 120%	44.6%	56.7%

6.2 REGIONAL COMPARISON

Slipstream compared RSIP to strategies that other states in the region have implemented to support residential solar adoption. We investigated the following:

1. State-level program and market context
2. Total residential solar adoption
3. Residential solar adoption in LMI communities
4. Cost of emissions reductions
5. Cost-effectiveness of state and utility-based incentives

Each state in the region has taken a different approach to supporting residential solar installations. Additionally, during the past 20 years, states and electric utilities have implemented new programs, terminated programs, and revised rules and structures for other programs. Program changes and differences in program sponsors contribute to diverse residential solar markets in the Northeast and to challenges in obtaining comprehensive and consistent data on program participation throughout the region. In addition to programs sponsored by states and investor-owned electric utilities (IOUs), some municipal utilities and municipal governments have also sponsored residential solar programs.

For this analysis, Slipstream focused on data for statewide residential solar programs, as well as for programs and tariffs offered by IOUs in the region. The analysis excluded Federal, state, and local tax credits and tax exemptions, as well as programs offered by municipal utilities and electric cooperatives. While we attempted to obtain data for all state and IOU-sponsored programs in the region, we recommend that the data used to analyze programs outside of Connecticut not be viewed as comprehensive data that describes all residential solar installations in each state. Table 10 identifies the programs what were considered for the comparison:

Table 10. Residential Solar Programs Reviewed

State	Program(s)	Program Years
Connecticut	RSIP + net metering	2012 – 2022
Maine	Net Energy Billing	2009 – 2022
Massachusetts	Solar Massachusetts Renewable Target (SMART)	2018 – 2022
New Hampshire	Renewable Energy Fund (REF)	2011 – 2022

New Jersey	• SREC Registration Program (SRP) • Transitional Incentive (TI) • Administratively Determined Incentive (ADI)	• 2000 – 2022 • 2016 – 2022 • 2020 - 2022
New York	NY-SUN	2000 – 2022
Rhode Island	• Renewable Energy Fund (REF) • Renewable Energy Growth Program (REG)	• 2014 – 2021 • 2015 - 2022
Vermont	Net metering	2017 - 2022

Programs may be categorized by the type of incentive structure that they offer. Table 11 compares the types of residential solar programs that were reviewed, according to the following definitions:

- *Capacity based buy downs* pay an incentive to customers, typically at the time of installation. The incentive amount is based on the rated capacity (kW-DC or kW-AC) of the system.
- *Performance based incentives (PBIs)* offer ongoing payments to customers. The amount of the payment depends on actual electricity generated. The incentive rate may be fixed for the lifetime of the PBI payments, or it may be adjustable.
- *Solar Renewable Energy Credit (SREC)* programs are a sub-type of PBI in which customers have the ability to sell the environmental attributes of each MWh of electricity that their solar installation generates. SREC programs may establish an SREC purchase price or may allow customers to sell the SREC at a floating market rate.
- *Tariffed solar programs* are a third type of PBI, which allows customers to sell all electricity produced by their solar panels at a designated advantageous (greater than or equal to the retail rate) purchase price.

To help fund RSIP, the Green Bank developed a Solar Home Renewable Energy Credit (SHREC) instrument. The Green Bank retained ownership of the environmental attributes of the energy generated by RSIP projects. It then aggregated the environmental attributes of groups of RSIP projects to create renewable energy credits, which it sold to Connecticut's electric utilities through long-term contracts. Revenue generated from these sales was used to recover previously sunk costs in the RSIP, as well as future RSIP projects. Table 11 does not list SHRECs as a separate program type because the SHREC is not the incentive provided to the end-user.

Table 11. Categorization of Northeast Solar Programs

State	Buy Down	PBI	SREC	Tariffed Solar
Connecticut	RSIP EPBB	• RSIP PBI • RSIP LMI PBI		[Post-RSIP]
Maine	*No incentives offered*			
Massachusetts		SMART		
New Hampshire	REF			
New Jersey			• SRP	

			• TI • ADI	
New York	NY-SUN			
Rhode Island	REF			REG
Vermont	*No incentives offered*			

The diverse strategies implemented by Northeast states and differences in demographic factors and homeownership rates, among other factors, have contributed to different levels and patterns of solar adoptions in each state. Figure 17 shows the growth in the residential PV adoption rate as a share of estimated owner-occupied households, while Figure 18 compares the increases in average residential PV capacity (W-DC) per residential electric customer and Figure 19 shows the estimated percentage of all residential sales that were generated by residential PV. These charts build on the findings shown in Figure 1 (see Executive Summary), which showed that, in each year since 2017, the rate of residential PV capacity growth (W-DC/capita) in Connecticut has exceeded the national average, as well as the comparable rates for all states in the Northeast.

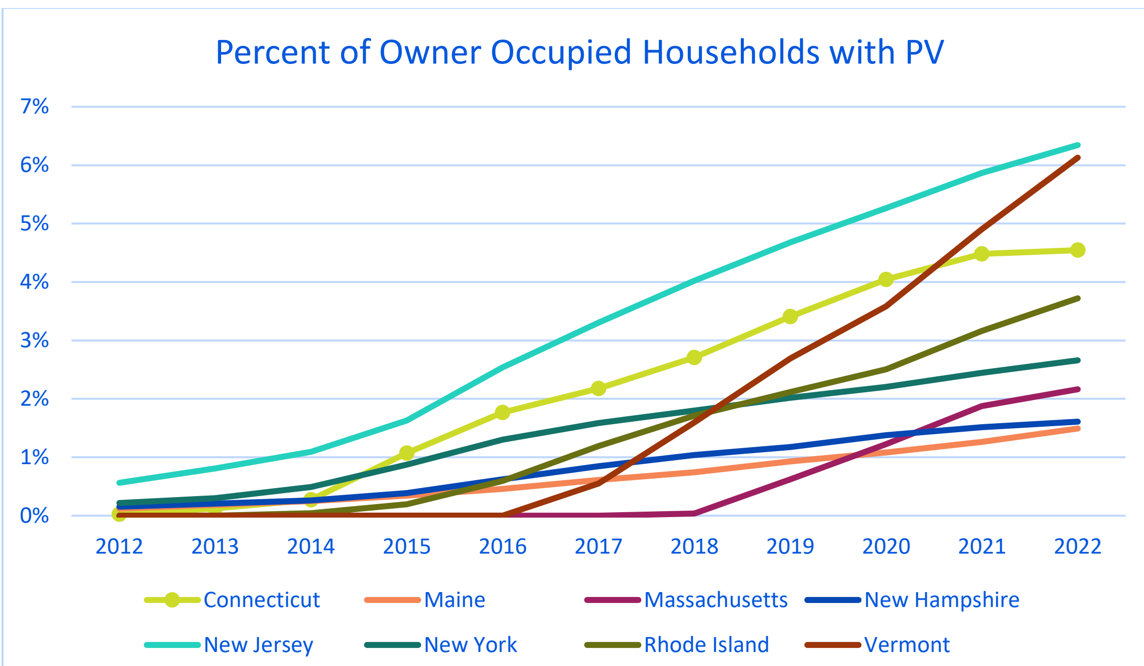

Figure 17. Comparative Rates of Solar Adoption in the Northeast

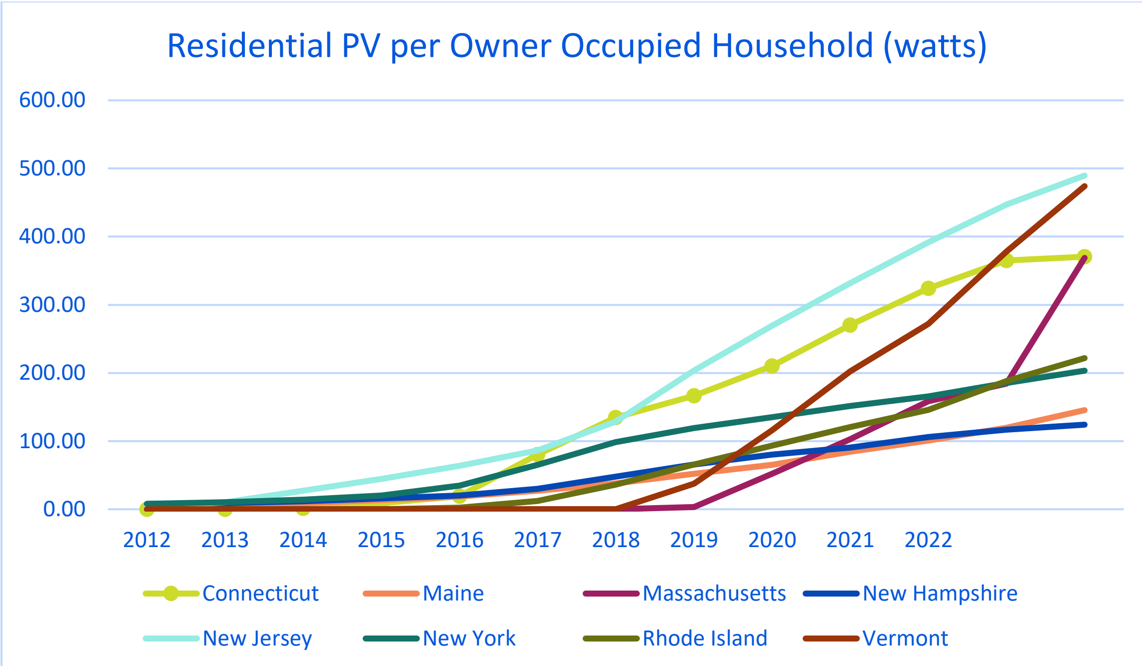

Figure 18. Residential PV Capacity per Owner-Occupied Household

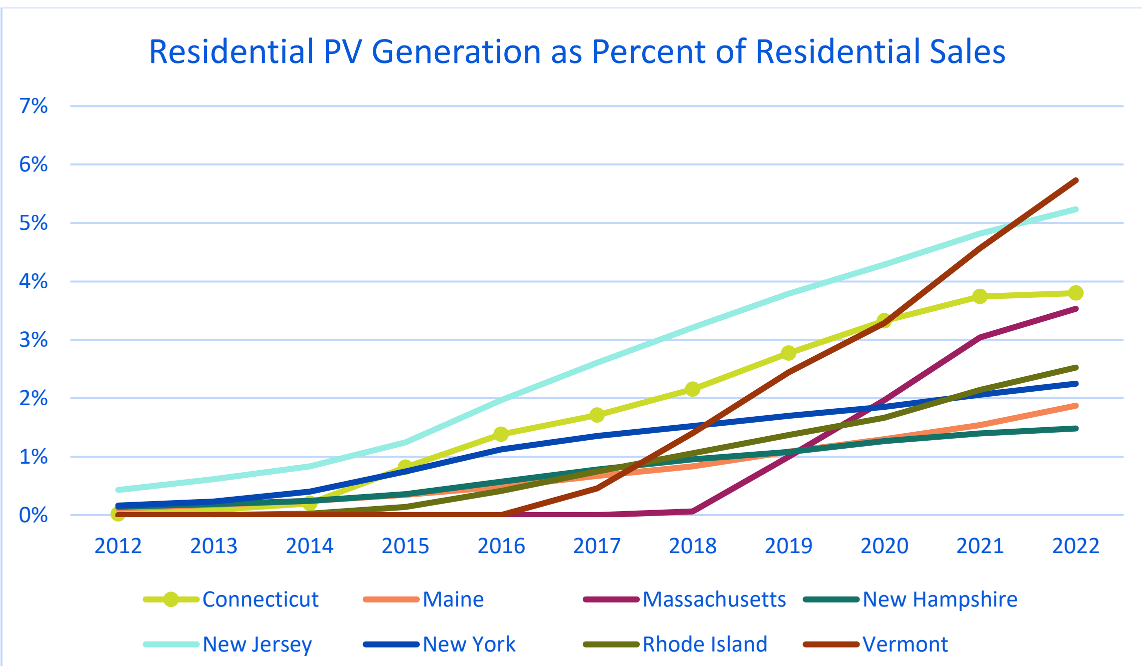

Figure 19. Residential PV Generation vs. Total Residential Electric Sales

6.3 PROGRAM COST EFFECTIVENESS

Differences in the categories of programs used in the region create challenges in comparing incentive costs and program cost-effectiveness. Differences between programs funded by taxpayers, ratepayers, and public-private partnerships present additional obstacles to conducting meaningful comparisons.

While we acknowledge the challenge of comparing the impact and cost-effectiveness of different program types, we sought to analyze common metrics across multiple states in order to offer a meaningful cost-benefit assessment of RSIP in comparison to parallel approaches in other states in the region. We applied national or regional averages to address informational gaps. All assumptions and calculation methodologies are described in Appendix 1.

To compare the cost of one-time capacity-based incentives with the costs of programs offering periodic incentive payments over multiple years (such as PBI, SREC, and tariffed solar programs), we converted all incentive rates to the amount of the incentive paid per REC[36] generated by the installed project. All states in the region have established renewable portfolio standards (or equivalent frameworks), under which utilities must procure and retire renewable energy credits (RECs) that are equal to a given percentage of the utility's total electricity sales. While not all states have solar carve outs within their RPS and not all programs generate RECs for utilities, an SREC offers a common production-based factor through which we may compare diverse structures.

Most tariffed solar, REC, and PBI programs establish the period during which the customer will receive the incentive. After the expiration of this period, customers no longer receive performance-based credits; most revert to a default electric rate; or are no longer eligible to sell the RECs that their system produces. For programs that define a maximum participation term, we calculated total RECs that the installed generating capacity would be expected to produce within that period of time. If a program does not set an endpoint for eligibility to receive incentives, we assume that the system will continue to produce qualifying electricity throughout a standard 25-year useful equipment life.

After calculating the total incentive cost for each program, we normalized the total cost based on the amount of generating capacity that the incentive payments funded (Figure 20) and by the amount of the incentive paid per REC generated by participating projects (Figure 21).

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36 In this context, "REC" is used to mean one megawatt hour (MWh) of electricity generated by a residential solar installation.

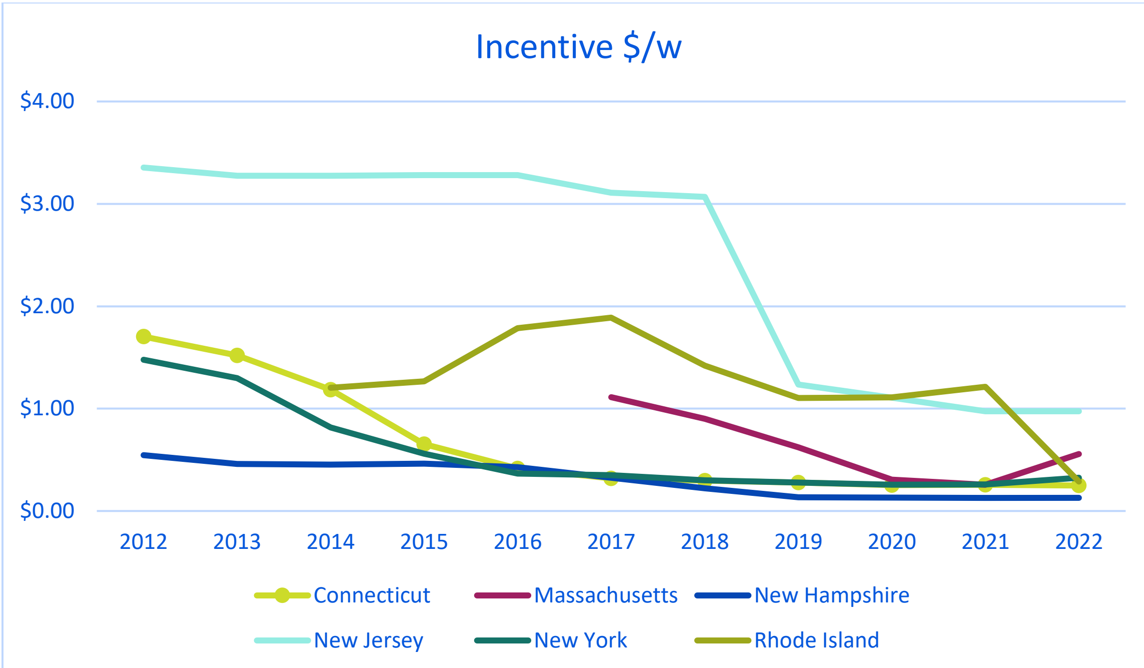
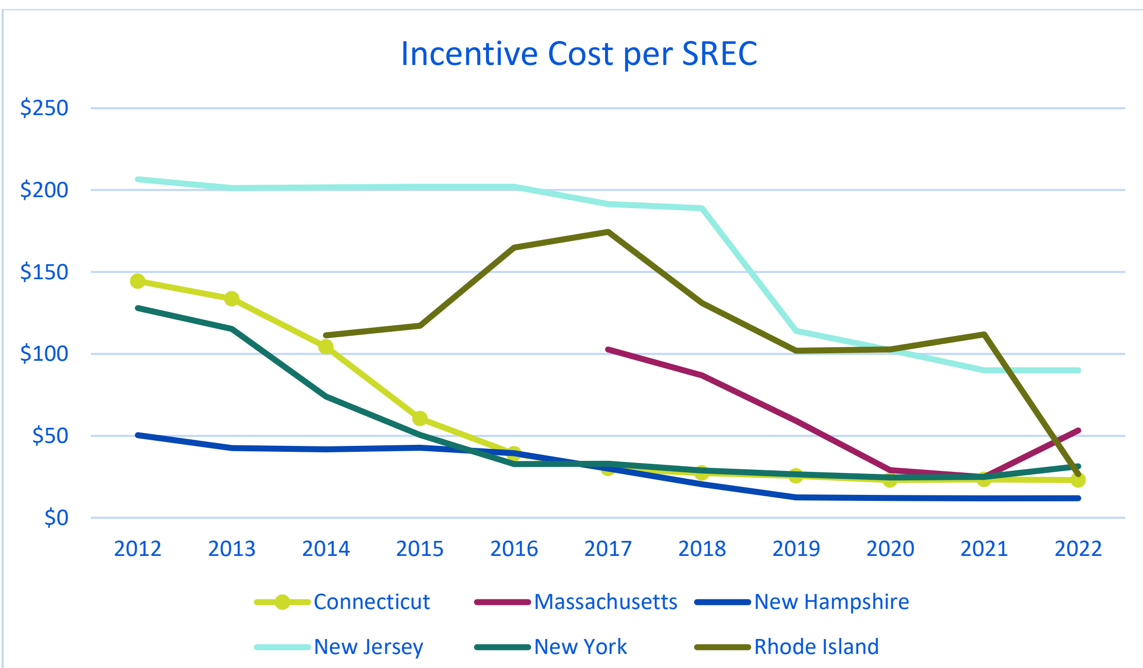


Figure 20. Trends in Comparative Incentive Cost ($/w)



[37]

Figure 21. Trends in Comparative Incentive Cost per SREC

Figure 22 shows that the Green Bank successfully and cost-efficiently used RSIP incentives, in combination with support for financing tools and technical assistance, to support the

[37] SREC costs shown assume that customers may sell SRECs for 10 years following installation.

development of the Connecticut residential solar market. As shown in the figure, by 2017, Connecticut had achieved the highest annual per capita addition of residential PV capacity, while applying one of the lowest incentive rates in the region.

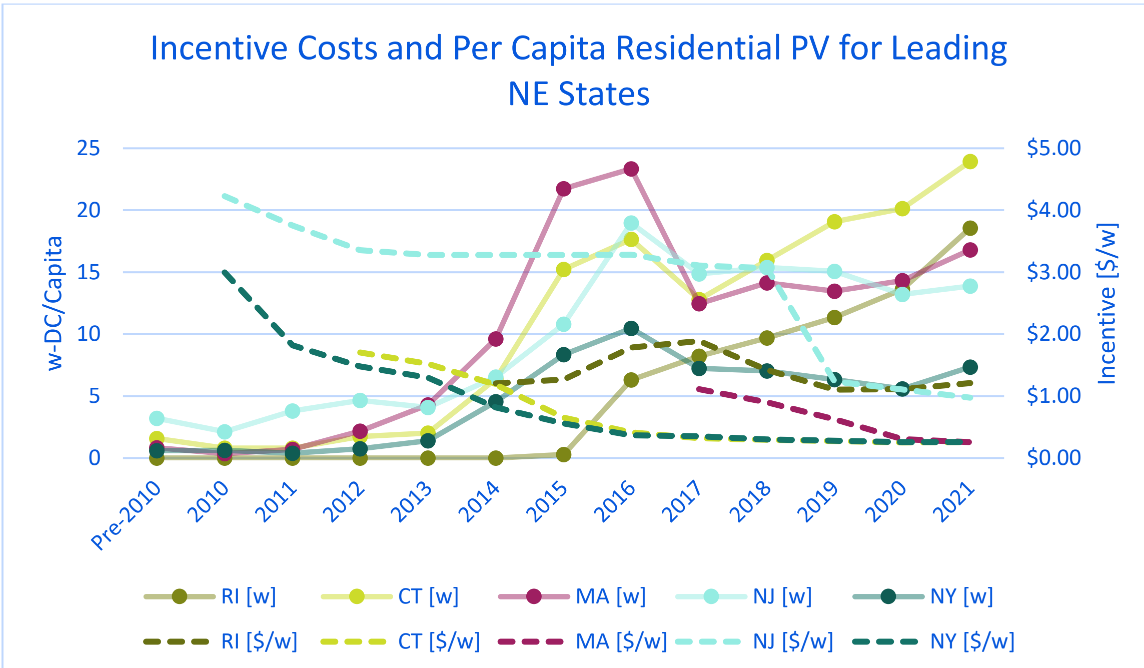


Figure 22 Comparative capacity growth and Incentive Rates

6.4 LEVERAGE

Many solar programs are designed to create incentives and/or fill cost-effectiveness gaps in order to facilitate private investment in residential solar installations. The most direct way of evaluating effectiveness in facilitating entry of private investment is to compare the amount of the program incentive to the private funds invested in projects.

Calculating the leverage ratio that a program achieves requires information about both the total installed cost of the project and the cost of the incentive that the program paid to the customer. Data was available to calculate incentive costs for all of the programs that were reviewed. Project cost information was also available for programs in Massachusetts, New Hampshire, New York, and Rhode Island. For states that did not publish project cost data, we used data published by NREL on the average installed cost per watt for residential solar arrays for the applicable year[38].

Figure 23 shows that annual leverage ratios generally increased for all programs from 2012 – 2022. Falling installation and equipment costs and maturation of the solar industry allowed for

[38] NREL. “Solar Market Research & Analysis | Solar Installed System Cost Analysis.” Viewed November, 2022. https://www.nrel.gov/solar/market-research-analysis/solar-installed-system-cost.html

progressively reducing incentive levels over time. While several states observed moderate decreases in leverage ratios for some years, RSIP's leverage ratio increased in each year of the program and, with Massachusetts, achieved the highest leverage ratio of any state in the region in 2021.

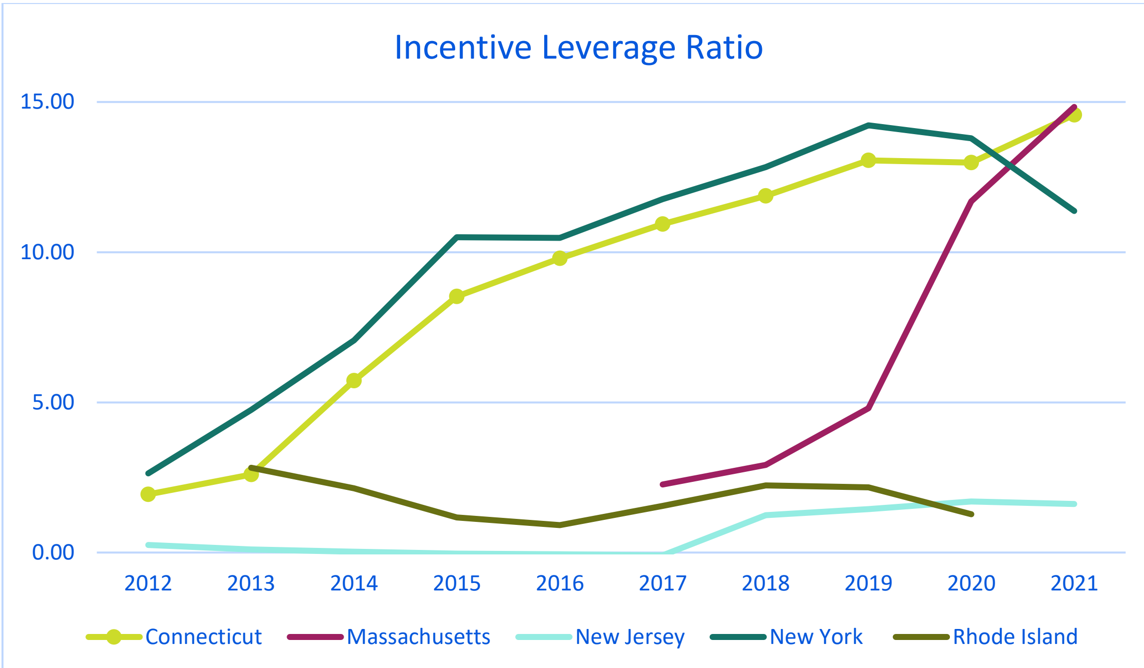


Figure 23. Trends in Comparative Incentive Leverage Ratios

Figure 24 shows that RSIP's cumulative leverage ratio of 8.15 was the second highest of all states that were evaluated. While New Hampshire achieved greater leverage than Connecticut, RSIP has supported a statewide rate of solar adoption per owner-occupied home (4.55%) that is nearly three times the parallel rate achieved by New Hampshire (1.61%). The figure does not include values for Maine and Vermont because no programs were identified for these states that provided direct incentives for residential solar installations.

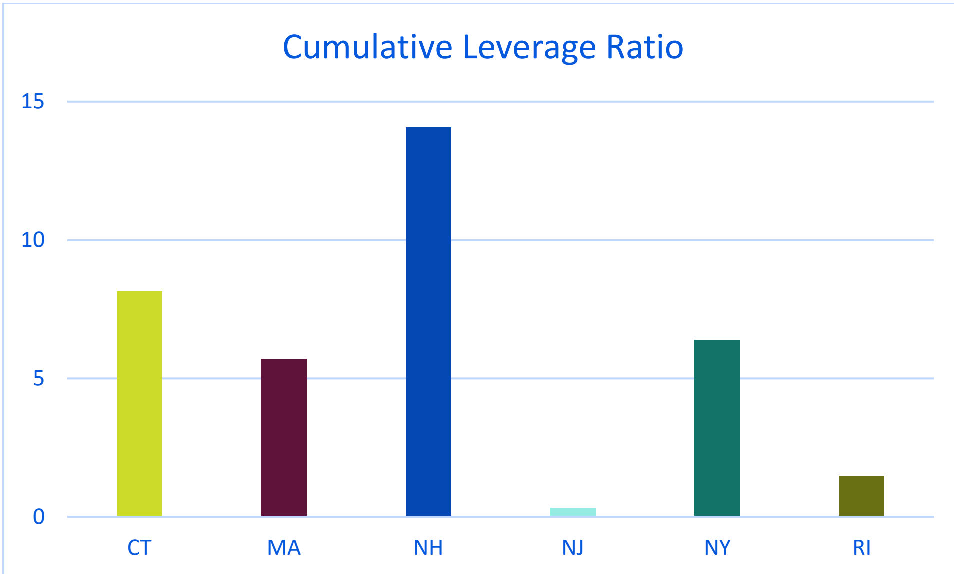


Figure 24. Comparative Cumulative Leverage Ratios

A residential solar program may create a spillover effect if the market effects created by the program lead to non-participants installing solar. A complete spillover analysis is outside the scope of this evaluation; however, insights on potential spillover effects may be extracted from information on the comparative cost of installed residential solar in each state. National data shows that residential PV capacity has increased as the installed cost of solar has decreased. Therefore, if a program stimulates that state's solar market, causing the installed cost of solar to decrease, that decrease may prompt additional residential installations that occur outside of the program. Figure 25 shows changes over time in the installed cost of solar in each state, as well as the national average installed cost.

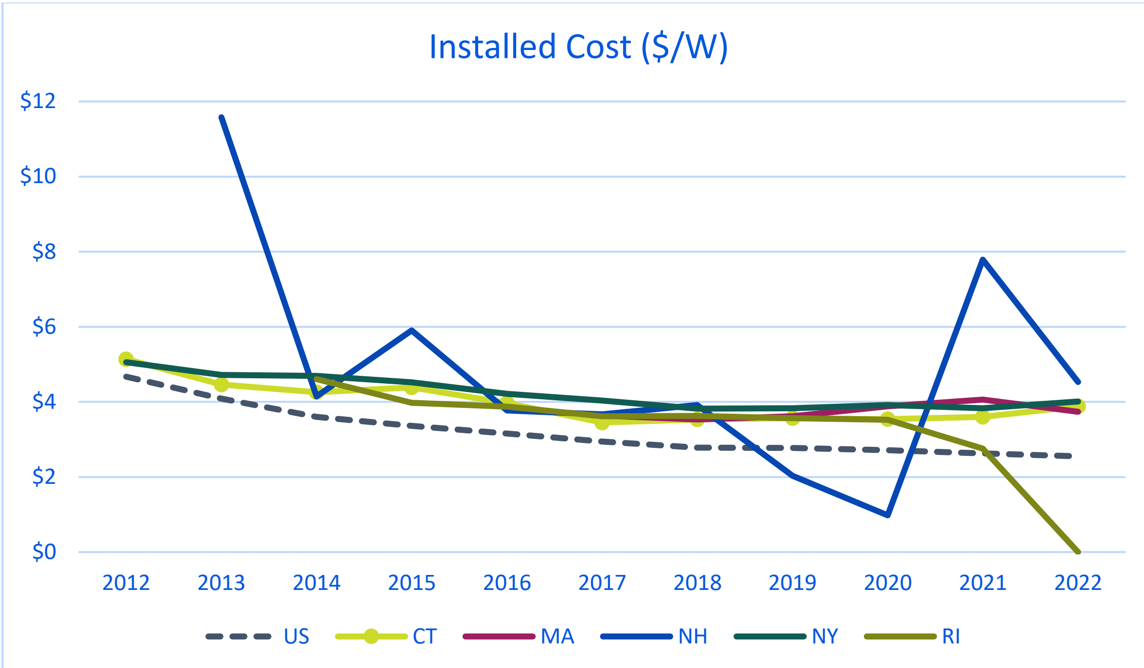


Figure 25. Comparative Trends in Installed Cost ($/W). No state-specific data available for ME, NJ, or VT.

6.5 LMI PARTICIPATION

As discussed above, the Green Bank recognized that LMI households and households living in high-burden areas may face greater challenges in accessing the benefits of solar energy and created the LMI PBI incentive, as well as the Solar for All initiative to increase participation by LMI and households with high energy burdens. The barriers to solar adoption by LMI households have been identified as an obstacle nationally, and some states have deployed targeted strategies to address these barriers. In the Northeast these states include Massachusetts, Rhode Island, and New York, in addition to Connecticut. However, since LMI households may install a solar array through a non-LMI program, or outside of a utility or state supported program, LMI program participation may not provide a comprehensive view of LMI adoption.

For the four states that offer dedicated LMI programs, Figure 26 shows the share of total participation in each state's residential solar program that was in the state's LMI sub-program. The 3.67 percent of RSIP participants who have benefited from the enhanced LMI PBI incentive is similar to participation rates in Massachusetts and Rhode Island.

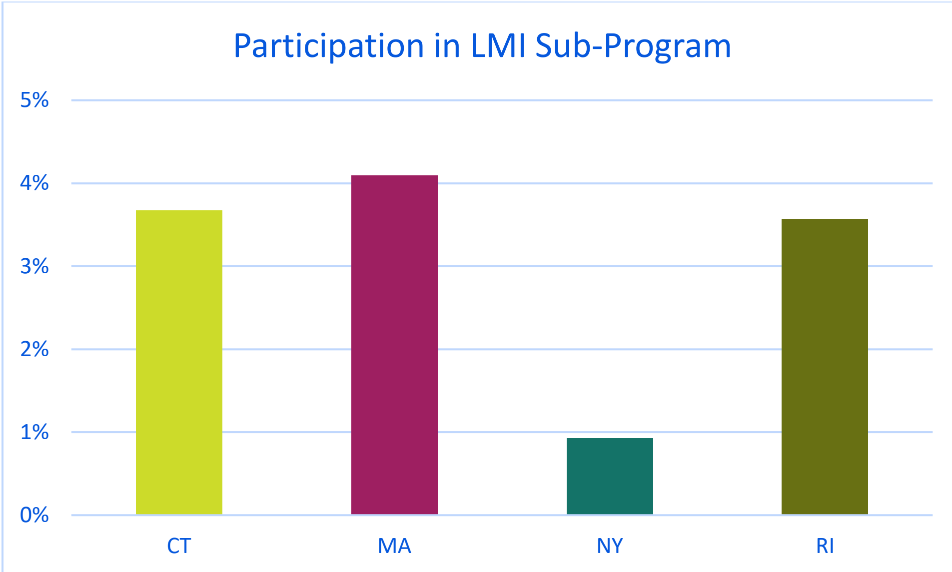


Figure 26. Comparative LMI Program Participation

In Tracking the Sun: Pricing and Design Trends for Distributed Photovoltaic Systems in the United States, Lawrence Berkeley National Lab (LBL) collected data from electric utilities, public utilities commissions, and state energy offices across the country about the locations of interconnected solar installations[39]. LBL's Solar Demographics Trends and Analysis research group used this data to map the location of each installation to a census tract and then cross-referenced the locations with median income characteristics of the tract collected through census data. Slipstream used the LBL dataset to assess levels of LMI solar adoption for each state in the region.

Figure 27 shows the share of each state's solar adoption that took place in census tracts with median incomes that are in each AMI band.

[39] LBL estimates that the *Tracking the Sun* dataset includes 77% of total installations in the U.S. through 2021.

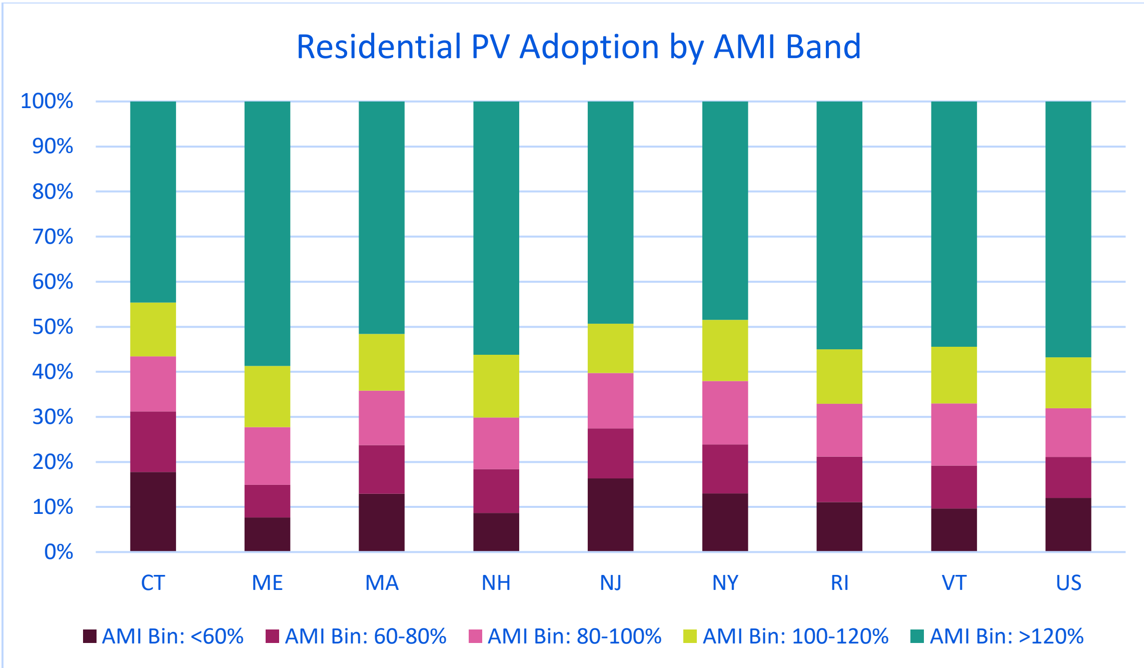


Figure 27. Comparative PV Adoption by AMI Band

The chart shows that the portion of installations taking place in the most affluent areas is lower in Connecticut than in any other state in the region. Additionally, Connecticut had a higher rate of solar adoption in low-income (< 80% AMI) census tracts than any other state in the region.

6.6 ENVIRONMENTAL IMPACT

States may enact residential solar programs to achieve environmental objectives, as well as to support residents in reducing energy costs. Shifting generation from fossil fuel powered facilities to distributed renewable resources reduces greenhouse gas (GHG) emissions, including CO_2, as well as particulate emissions, including PM2.5, NOx, and SO_2, that can cause and aggravate health conditions, such as asthma. Table 12 translates the reduced annual electricity generation needed, due to program-supported residential solar installations, to corresponding reductions in GHG and particulate emissions.

Table 12. Annual Emissions Avoidance by State

	Annual emissions avoidance			
	Mt CO_2e	Lbs. PM2.5	Lbs. NOx	Lbs. SO_2
Connecticut	130,327	63,409	36,888	9,096
Maine	24,883	12,248	7,285	1,743
Massachusetts	162,032	66,905	29,561	10,895
New Hampshire	17,804	9,284	5,876	1,257
New Jersey	562,156	628,207	904,630	80,012
New York	224,839	115,897	73,234	15,932

Rhode Island	25,546	12,809	7,864	1,804
Vermont	50,790	24,388	14,189	3,570

Figure 28[40] shows changes over time in the cost per unit of reduced CO_2 emissions.

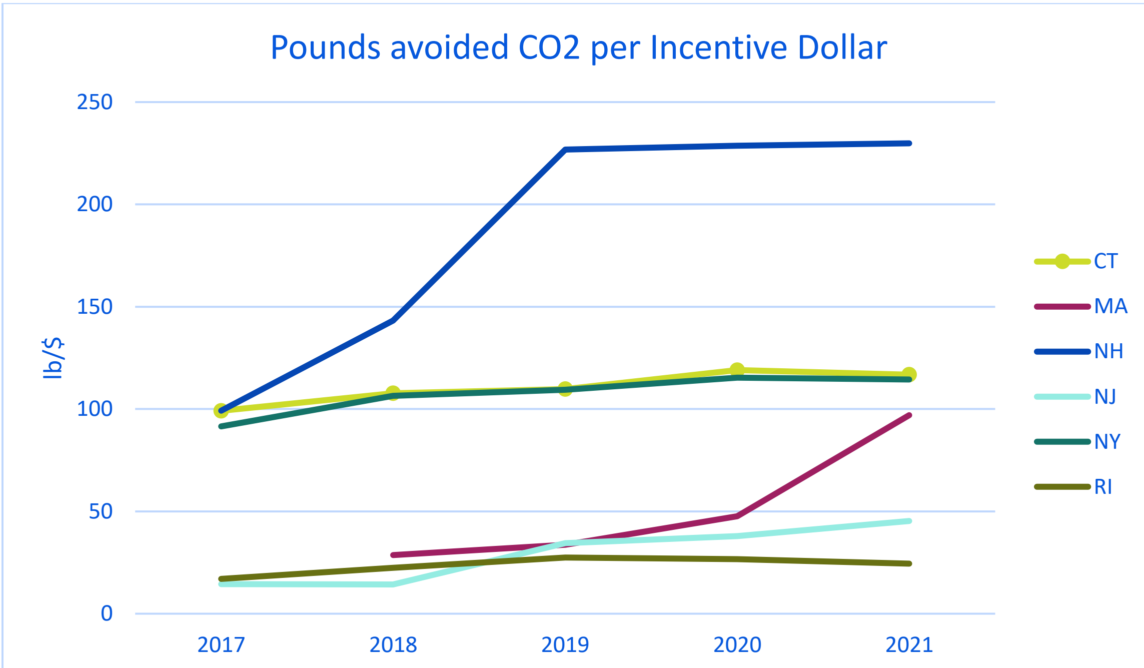


Figure 28. Trend in Comparative Cost of GHG Emissions Reductions

As a part of the ISO New England (ISO-NE) wholesale energy market, marginal emissions in Connecticut are roughly equivalent to that of the neighboring states which are also members of ISO-NE: Maine,

[40] The figure assumes that installed projects will have a 25-year useful life and that the full incentive cost of lifetime emissions reductions is paid at the time the project is installed.

Massachusetts, New Hampshire, Rhode Island, and Vermont.

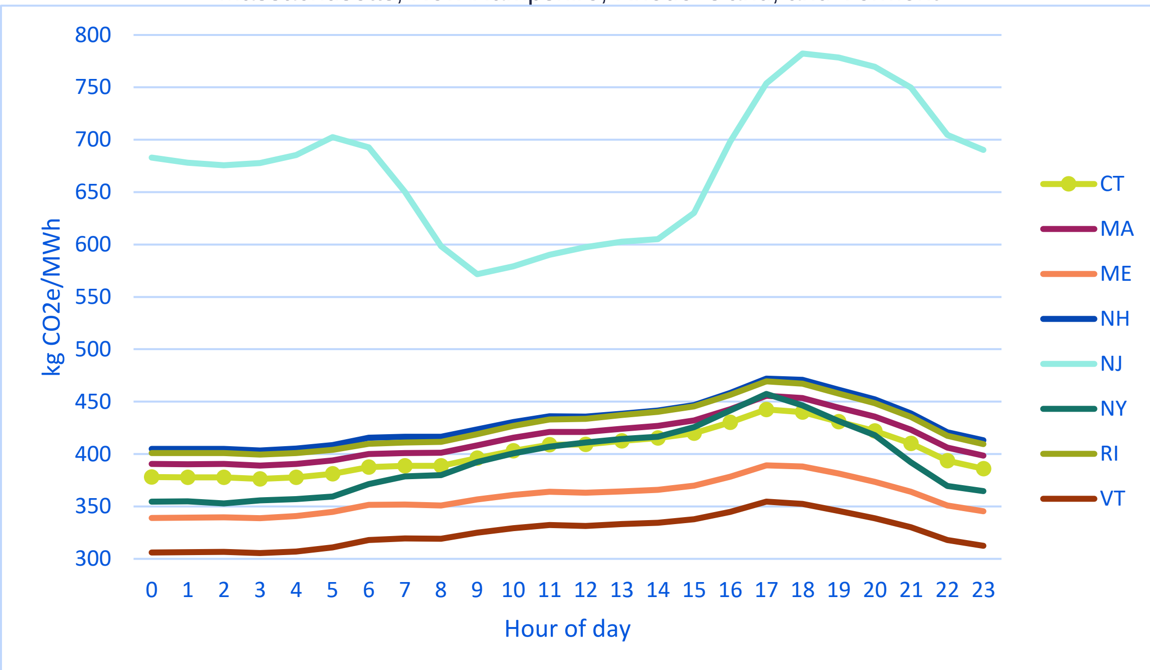


Figure 29[41] shows the modeled 2022 annual average of hourly long-run marginal emissions rates (LRMER, in kg CO_2e/MWh) for all ISO-NE states as well as New York and New Jersey. LRMER is the emissions rate of the change in generation (increase or decrease) that would result from a marginal change in electric load, calculated using a model that allows for structural changes (such as new or retired capacity, changes in transmission constraints, etc). Because rooftop solar PV is a permanent capacity change which results in time-varying generation and is small relative to other generation sources, LRMER is a useful metric to quantify the effect of PV on emissions rates.

[41] Source: Gagnon, Pieter; Frazier, Will; Cole, Wesley; Schwarz, Marty; Hale, Elaine (2021): Cambium data for 2021 Standard Scenarios. National Renewable Energy Laboratory. https://cambium.nrel.gov/

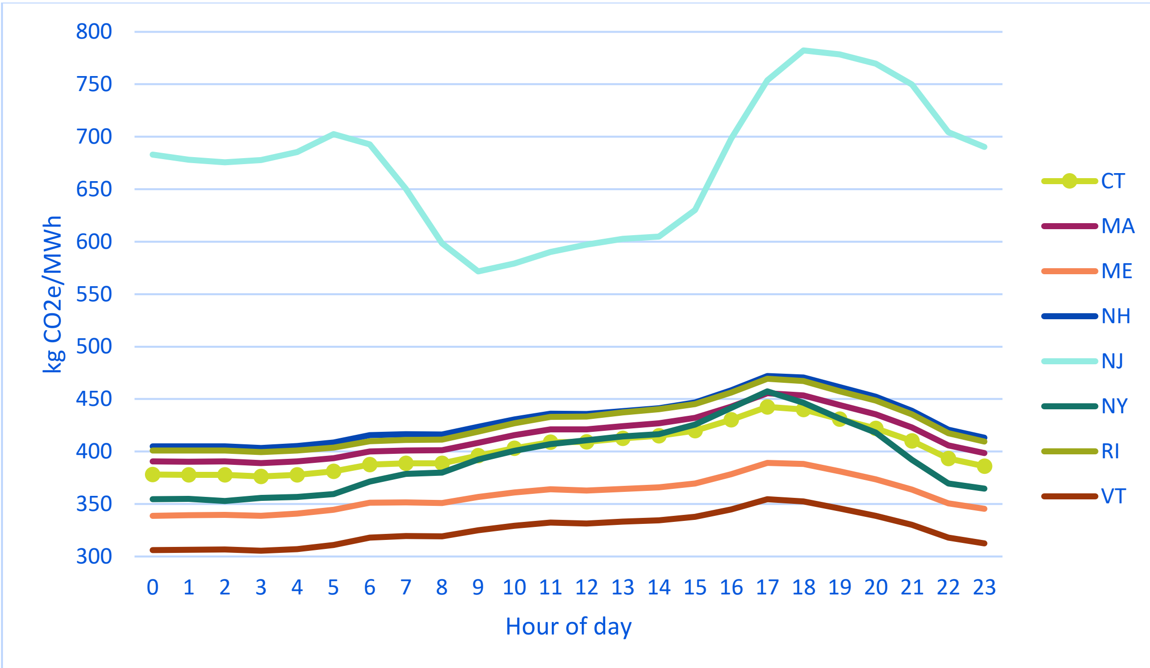


Figure 29. Long Run Emissions Rates for Northeast States

The LRMER profile for New York is similar to ISO-NE because, although New York is its own ISO (NYISO), it is similar in size to ISO-NE, and ISO-NE is its most significant interchange. By contrast, New Jersey is part of the PJM ISO, which is the largest ISO in the U.S., with roughly 10 times the capacity of either ISO-NE or NYISO.

Thus, while a comparison between New York or the ISO-NE states would be similar in terms of emissions impact per kW of solar installed, a comparison to New Jersey is instructive.

To compare the emissions impact per dollar invested, we used AVERT emissions factors from 2017 through 2021 (earlier data does not include an avoided emissions rate for distributed solar PV). NJ is in the Mid-Atlantic region with an average avoided CO_2 rate of 1607 lb/MWh across the five years; all other states are in the New England region with an average avoided CO_2 rate of 1135 lb/MWh. The emissions rates were then combined with the solar PV capacity and generation data available for each neighboring state, along with the total program dollars for those states with incentive programs active in the analysis years. The data is summarized in Table 12.

The total solar PV capacity and generation are for the five years of analysis (2017 – 2021), while lifetime emissions reductions assume a lifetime of 25 years for each solar array. Because avoided CO_2 rates are expected to decline over time, this will tend to over-estimate the total reduction. Total incentive dollars includes all program times, and for states with a REC or SREC program, includes the lifetime of the REC (typically 15 years). Figure 30 shows a graphical comparison of the effectiveness and per capita emissions reduction impact of program dollars in reducing CO_2 emissions for those states with solar incentive programs. As seen in the figure, despite having an electrical grid with lower rates of GHG emissions per MWh of generation than some other states in the region, Connecticut supported avoided GHG emissions at a comparable incentive cost per unit of avoided carbon dioxide emissions.

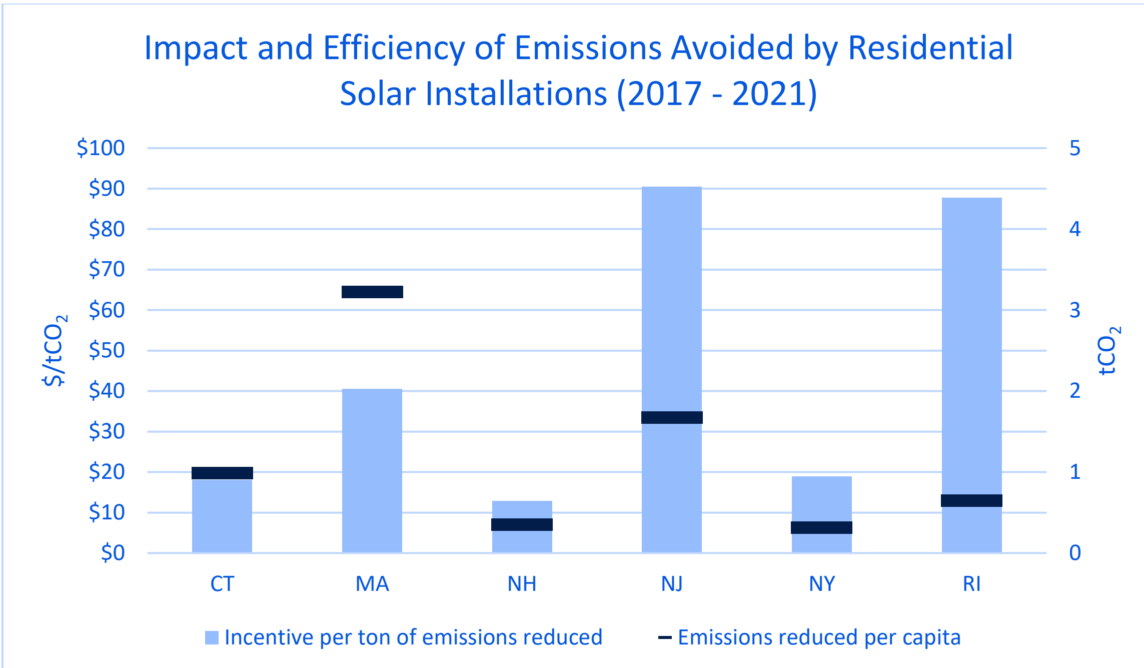


Figure 30. Comparative Average Emissions Reduction Cost

7.0 RECOMMENDATIONS

In 2022, the Green Bank achieved its statutory requirement for RSIP of deploying 350 MW of residential solar generation capacity. The Green Bank used supplementary financing to fund the deployment of an additional 26.88 MW of capacity through the RSIP-E incentive blocks. RSIP-E served as an effective bridge between the achievement of the 350 MW RSIP objective and the launch of the RRES tariffed solar offering in early 2022. Data on installed residential solar in Connecticut, in combination with feedback from stakeholders who were interviewed for this evaluation confirms that the Green Bank also achieved its parallel mandate of supporting the "orderly and sustainable development" of the Connecticut residential solar industry.

The Green Bank remains committed to supporting the orderly and sustainable development of the Connecticut residential solar industry, but is no longer able to implement RSIP to support the industry. The Green Bank is working internally and with stakeholders, including the Connecticut Public Utilities Regulatory Authority (PURA), to discern how it can most effectively support the industry post-RSIP and in the context of the RRES tariffed solar framework.

RSIP program data, comparisons between the Connecticut market and other residential solar markets in the region, stakeholder feedback, and lessons learned from other states that have transitioned from incentive programs to tariffed solar structures can all offer guidance to the Green Bank in determining how to support the market moving forward. The following sections describe the current status of the transition to tariffed solar in Connecticut; market segments that may benefit from ongoing Green Bank support; and recommendations for how the Green Bank can continue to support sustainable and orderly development of the Connecticut solar industry.

7.1 TRANSITION TO RRES

In 2020, the last full year in which RSIP was active, RSIP supported the deployment of 54.9 MW of residential solar generating capacity. The Green Bank has determined that ongoing orderly and sustainable development of the market would be represented by the addition of 50MW – 60 MW of residential solar generation per year without RSIP. Multiple stakeholders confirmed that this target range of deployment would demonstrate orderly and sustainable development of the market.

Per the design of RSIP's declining incentive block structure, at RSIP's conclusion the incentive rates of $0.358/WPTC (for systems <10 kW) and $0.207/WPTC (for systems 10KW – 20KW) had fallen over 92 percent from the rates offered for the RSIP Step 1 incentive in 2012. Reduced incentives, in combination with dramatically reduced installed costs and a robust private market led to some projects being cost-effective for residents, even in the absence of RSIP support. Anecdotal feedback from stakeholders confirmed that reductions in incentives were effective in enabling a smooth transition at the conclusion of RSIP. Stakeholders offered further anecdotal support by noting that, as RSIP reached the 350 MW threshold, more customers were able to install solar without applying for an incentive.

In early 2022, Eversource and United Illuminating (UI) launched tariffs in compliance with the Residential Renewable Energy Solutions (RRES) Program. Under the RRES authorization, both utilities are required to file periodic reports[42] with the Connecticut Public Utilities Regulatory Authority (PURA), which indicate the number of RRES participants and the capacity installed under each utility's tariff.

Interviews with representatives from Connecticut's electric utilities and reviews of compliance filings indicate that the utilities approved over 75 MW-DC of residential capacity in 2022 and it is likely that the actual capacity installed will meet or exceed the Green Bank's capacity objective for orderly and sustainable development of the market. These initial levels of participation in the RRES tariff suggest that the Green Bank effectively implemented RSIP's declining incentive structure so that the sunsetting of the program did not create significant disruptions in annual production. Initial filings also suggest that total production in Connecticut's residential solar market remains robust post-RSIP. We recommend that the Green Bank regularly review the

[42] See compliance filings under order number nine of PURA docket 21-08-02

RRES regulatory filings and monitor participation rates and the rate at which new generation is added.

7.1.1 Market Monitoring

During its implementation of RSIP, the Green Bank developed a robust dataset, including over 200 unique data points for all 46,226 completed projects, as well data from customer applications that did not result in an installation. The dataset reflects how RSIP's financial value proposition to customers developed over time and characteristics of the customers who participated in the program. The Green Bank can leverage insights from the RSIP project data set to both provide baseline information against which it may compare data that it will collect on future RRES participation and residential solar adoption in Connecticut.The Green Bank can use the RSIP dataset to inform its strategy for how it will support the orderly and sustained development of Connecticut's residential solar market in the future.

One of the Green Bank's central roles is to facilitate financing for emerging clean energy industries and markets in Connecticut. While each clean energy market is unique, there may be common characteristics in what interventions are effective in supporting the growth of early-stage residential clean energy markets, such as the solar + storage market that is discussed in more detail below. The Green Bank can leverage insights from its RSIP dataset to guide its strategy for facilitating the growth of other clean energy industries in the state.

7.1.2 Trusted Convener

The Green Bank has been recognized nationally as an innovator and RSIP's success has also received recognition. As described in Section 5.1, interviews with stakeholders confirmed that the Green Bank is viewed by solar installers, industry representatives, and the electric utilities as a trusted convener of parties with diverse interests. This function contributed to the success of RSIP. Post-RSIP, Industry stakeholders continue to look to the Green Bank as a leader in supporting the residential solar industry. We recommend that the Green Bank maintain its partnerships with residential solar developers, community organizations, and the electric utilities and that it seek out opportunities to convene these stakeholders to address emerging challenges to the industry.

7.2 SUPPORT FOR LMI ADOPTION

While initial indicators show that the rate of residential solar adoption post-RSIP remains strong, participation in RRES may not occur equitably across income strata and demographic groupings. While the RRES tariffs offered by both utilities include enhanced rates available to customers who meet certain income-eligibility or environmental justice community standards, initial data and insights from stakeholders suggests that there have been low rates of participation in the LMI-focused tariffs.

Interviews highlighted that residential solar projects are "sold, not bought." This statement asserted that most installations result from an effective sales engagement by a solar developer with a homeowner, rather than as a result of a homeowner proactively reaching out to a contractor to initiate a project. Solar developers are typically private businesses which must earn a profit to remain solvent. In addition to having fewer financial resources than more affluent customers, LMI households and residents in EJ communities may face additional barriers to residential solar, such as older homes that require pre-installation repairs, along with other barriers. Recognizing that LMI communities may present more barriers to developing projects and less potential revenue, solar developers may be expected to engage less in these communities and more on affluent communities that offer greater potential profits.

The Green Bank used the Solar for All program and Solarize campaigns to facilitate intentional market development in LMI communities. The impact of these strategies is demonstrated in Figure 27 above, which shows higher rates of participation in LMI census tracts in Connecticut than in other states in the region. While RRES offers enhanced terms for LMI customers, RRES is a utility tariff offering, while RSIP was a market development and transformation program. As a market development program, RSIP supported engagement between stakeholders and guided the growth of the industry. RRES offers attractive financial terms to customers who adopt solar, but is not structured to facilitate stakeholder engagement or promote participation by underserved market segments.

The Green Bank has developed relationships with CBOs that serve LMI communities and has successfully deployed program features to increase participation by LMI households. We recommend that the Green Bank continue to develop its relationships with CBOs and works with them to monitor participation in LMI communities that the CBOs serve. To support market development in LMI areas, the Green Bank may facilitate additional Solarize campaigns to support participation in LMI communities.

Since the completion of RSIP limits the financial resources available to the Green Bank to support solar development in LMI communities, the Green Bank may need to pursue alternative financing mechanisms for this work. Funds available to states through the Federal Inflation Reduction Act (IRA) may offer resources that the Green Bank could use to support solar adoption in LMI communities. For example, the Rhode Island Office of Energy Resources and the Rhode Island Commerce Corporation's Renewable Energy Fund recently released an "Affordable Solar Access Pathways RFP." The program developed from this RFP will leverage the higher Investment Tax Credits for EJ Focus Areas that the IRA enabled to support intentional market development in EJ communities, which may have greater numbers of LMI households.

The Green Bank developed key partnerships with SmartPower and PosiGen, among other organizations, which were instrumental in supporting RSIP participation by LMI households and by residents in vulnerable communities. Both SmartPower and PosiGen have created innovative business models that contributed to their effectiveness in reaching LMI communities. The Green Bank may support ongoing solar adoption in vulnerable communities by seeking out additional innovative organizations that are well-positioned to work in vulnerable communities and using funding through the Green Bank Capital Solutions program to catalyze the growth and success of these organizations.

In addition to supporting market development in LMI communities, the Green Bank may consider how to provide credit enhancements to address gaps left by the primary financing mechanisms used in the solar industry. Stakeholder interviews indicated that there are well established solar loans and leases that provide attractive financing options for customers with strong credit and sufficient income. However, the same stakeholders noted that customers with lower income levels and/or poor credit may not be able to access these industry-standard financing options. To increase access to solar for LMI households, the Green Bank may follow on the success of the credit enhancement that it created to offer the Solar for All program and assess options to create another credit enhancement tool that would minimize default risk for private firms that finance residential solar in LMI communities. Offering a credit enhancement could greatly reduce or eliminate, financing decline rates in LMI communities. Since lack of financing typically leads to a lost sales opportunity for a developer, developers may avoid working in areas where they anticipate customers are less likely to be approved for financing. A credit enhancement could both enable more LMI households to finance solar installations and encourage more developers to work in LMI communities.

7.3 SOLAR + STORAGE ADJACENCY

When RSIP was introduced, participants in the program were early adopters of PV technology, while customers who participated at the conclusion of the program may have been early majority adopters who installed solar on their homes in a more well-developed market. As described above, the Green Bank's role as a convener and facilitator of diverse industry stakeholders helped to establish the Green Bank as a valued and trusted resource for the Connecticut solar industry. The electric utilities do not have a parallel market development role related to the RRES tariff as the Green Bank established for RSIP. We recommend that the Green Bank maintain its role as a trusted partner in the industry as focus evolves from residential solar to growing "Solar Plus" industries.

As the solar industry members with which the Green Bank has developed partnerships through RSIP evolve their businesses to offer battery storage, EV charging, and other electrification technologies alongside residential solar installations, the Green Bank may use funding that is available to grow battery storage and electrification industries to apply the market development expertise it applied to residential solar to ensure the orderly and sustainable development of that market, while simultaneously supporting the growth of adjacent and complementary "solar plus" industries in Connecticut. Maintaining the role of trusted partner and facilitator will enable the Green Bank to both better monitor the residential solar market and build on RSIP's success to increase adoption of related technologies.

The Green Bank currently supports the SEEDS 3 project, which is investigating opportunities to support adoption of battery storage and electrification technologies by households who have already installed residential solar. We recommend that the Green Bank use the findings from the SEEDS 3 research, as well as new funding available through the IRA and other sources to leverage its standing in the Connecticut solar industry to advance adoption of adjacent residential clean energy technologies. In particular, given the variety of incentives available, lack of clarity around who and what qualifies, and ability to combine incentives, we see an important role for the Green Bank in working with homeowners to combine and maximize incentives across federal, state, and utility offerings. Because rules for many of the IRA incentives are still in active development by the IRS, it will be important to begin planning soon to prepare for late 2023 when more clarity is expected.

8.0 CONCLUSION

This evaluation find that the Green Bank successfully achieved its legislative objective of using RSIP to facilitate the addition of 350 MW-DC of residential solar electricity generating capacity in Connecticut. The Green Bank surpassed the 350 MW goal by cost-effectively managing the RSIP declining incentive step structure so that the funding offered customers and solar developers incentives to install new capacity while reducing rebate levels as market-based project costs fell. This strategy maintained the value of RSIP incentives to customers and solar developers while avoiding free ridership or poor cost-effectiveness that could result from offering overly generous incentive rates.

In addition to adding generating capacity, RSIP leveraged $8.15 of private investment for every incentive dollar, fostered the creation of 15,733 direct, indirect, and induced job years, and created economic activity that generated nearly $45 million in state tax revenue. The renewable energy generated by RSIP-funded solar arrays will result in an estimated annual avoidance of 231,419 tons of carbon dioxide, 17,169 lbs of PM 2.5, 182,210 lbs of NOx, and 144,586 lbs of SO_2 each year for the next 25 years.

The Green Bank demonstrated leadership in the Northeast and nationally in using program innovations, like the LMI PBI and Solar for All, to address higher barriers to residential solar adoption faced by households in LMI communities. Throughout its work, the Green Bank established itself as an essential convener and facilitator of stakeholders in Connecticut's residential solar industry.

Post-RSIP, we find that the Green Bank successfully implemented RSIP to grow the state's residential solar industry in an orderly and sustainable fashion. Success is demonstrated by the continued growth of the market during the first year of RRES. We recommend that the Green Bank maintain its role as a trusted industry partner and identify new resources that it may apply to grow adjacent and synergistic markets and to ensure continued high rates of adoption among LMI communities.

APPENDIX 1. SUPPLEMENT TO METHODOLOGY

Incentive Cost Calculations

To compare RSIP's cost-effectiveness with residential solar programs offered in other states, this evaluation calculated the current and expected future cost of three categories of financial incentives. While net-metering tariffs offer customers a higher rate for solar electricity than the utility's wholesale costs, this evaluation did not calculate a financial value to customers for participating in net-metering tariffs.

1. Installation incentives are paid to the customer at the time of the installation. Our calculations used the face value of the incentive at the time it was issued.
2. Performance based incentives are paid to the customer over a specified period of time as a higher credit rate for solar energy production or as an ongoing "adder" for solar energy. The cost of performance based incentives is calculated as the difference between the standard residential electricity rate and the higher rate or adder value paid to the customer for solar energy produced. The analysis uses current or documented historical (where available) electricity rates and does not assume a given escalation factor. The incremental rate is applied to the expected annual energy produced by the system and extended over the number of years allowed by the applicable tariff or agreement.
3. Solar Renewable Energy Credits (SRECs) may be sold by a customer based on the solar energy produced by the customer's residential solar array. The number of SRECs generated was calculated based on total estimated electricity produced by the installed capacity during the time period allowed by the state's SREC regulations. The cost of the SRECs was calculated based on the average market price for SRECs in the applicable state for each year of a program. If a state specified the price at which a customer may sell SRECs the calculation applied the specified price.

ZREC Equivalency

A ZREC is a 15-year agreement between a customer and either Eversource or United Illuminating under which the utility will purchase renewable energy produced by a customer's solar array.

Program Data Availability

Residential solar program participation data availability varied significantly among the eight states in the region. Table 13 summarizes the information that was reviewed for each state.

Table 13. Data Availability by State

	CT	MA	ME	NH	NJ	NY	RI	VT
Years	2012-2022	2018-2022	2009-2022	2009-2022	2009-2022	2000-2022	2014-2022	2017-2022
# Projects	X	X	X	X	X	X	X	X
Capacity	X	X	X	X	X	X	X	X
Incentive cost	X	X	N/A	X	Partial	X	X	N/A
Installation cost	X	X		X		X	Partial	
Electricity Production	X					X		
LMI Participation	X	X				X	Partial	
Project-level data?	X	X			X	X		X

Production data was used for the analysis for all programs for which this data is available. To include programs that do not publish production data, we estimated production based on the capacity (kW-DC) of the installed solar arrays. We used the average annual production efficiency rate[43] found in programs for which production data is available, in combination with the generating capacity data for those programs lacking production data to estimate annual production for these programs.

[43] The average production efficiency rate for programs with published production data was 1,082.50 kWh/kW/Year.