July 31, 2020

Mr. Jeffrey R. Gaudiosi, Esquire
Executive Secretary
Public Utilities Regulatory Authority
10 Franklin Square
New Britain, CT 06051

RE: Solarize Storage – A Proposal of the Connecticut Green Bank Under Docket No. 17-12-03(RE03) – Electric Storage

Dear Mr. Gaudiosi:

The Connecticut Green Bank, along with its local clean energy association partners (see Appendices 9 through 10), third-party owner partners (see Appendices 11 through 14), battery storage technology partners (see Appendices 15-17), and academic partner (see Appendix 18), submits the Solarize Storage program ("the Program") to the Public Utilities Regulatory Authority ("PURA") in response to the "Request for Program Designs" ("RFPD") under Docket No. 17-12-03(RE03) ("the Docket").

The Program leverages the knowledge, experience, and innovation of the Green Bank in enabling the deployment of behind the meter residential solar PV systems,[1] through its administration of incentive programs and financing solutions that have led to efficient and effective deployment, by fostering the sustained orderly development of a local solar industry. The Green Bank believes that the achievement of the Program as outlined in the attached proposal, would build on success by combining distributed energy resources ("DER") – such as behind-the-meter residential solar PV with battery storage – and exceed the objectives outlined by PURA in the RFPD.

The Program will seek to deploy 50-megawatts of battery storage, in combination with residential solar PV systems, by the end of 2025. Starting January 1, 2021, through a combination of declining upfront incentives and easy and affordable access to financing,[2] and ongoing performance-based incentives,[3] the Program "cost effectively" increases benefits to participants, ratepayers and society by deploying battery storage systems in combination with behind the meter solar PV.

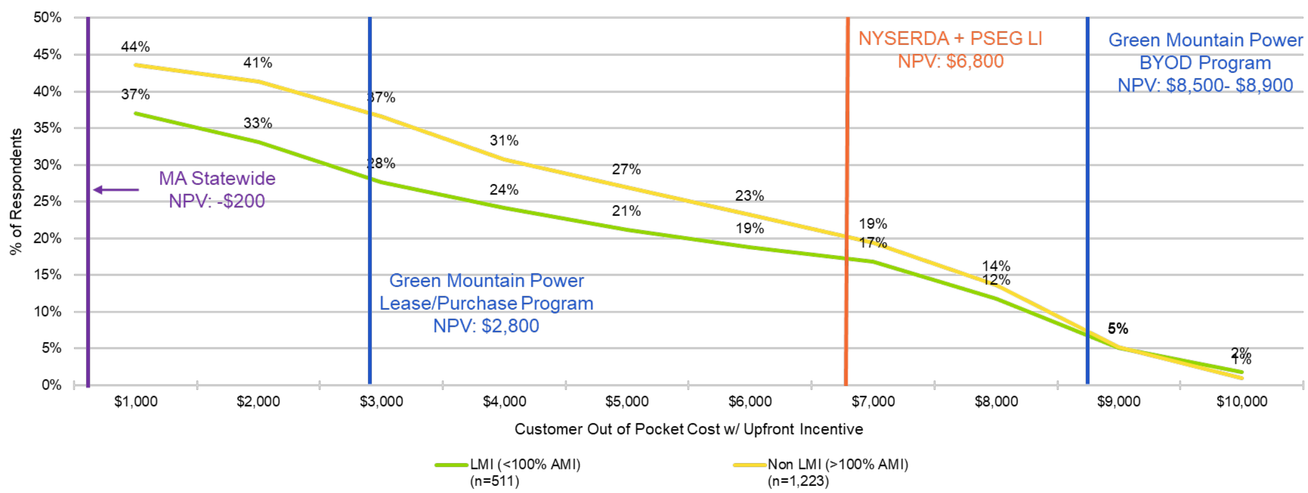
The Program was developed using an innovative, comprehensive, and well-conceived design approach, including:

- **<u>Market Research</u>** – through a survey administered by Guidehouse, customer sentiment towards solar PV and battery storage, and various "best practice" funding mechanisms from Northeastern states were assessed – see Figure 1. From this research, useful insights and strategies were uncovered to discern willingness to pay, which helped inform the program design in terms of

[1] CGS 16-245ff – Residential Solar Investment Program (RSIP)
[2] Administered by the Green Bank as outlined it its Comprehensive Plan
[3] Administered by the EDCs as outlined in the Conservation and Load Management Plan

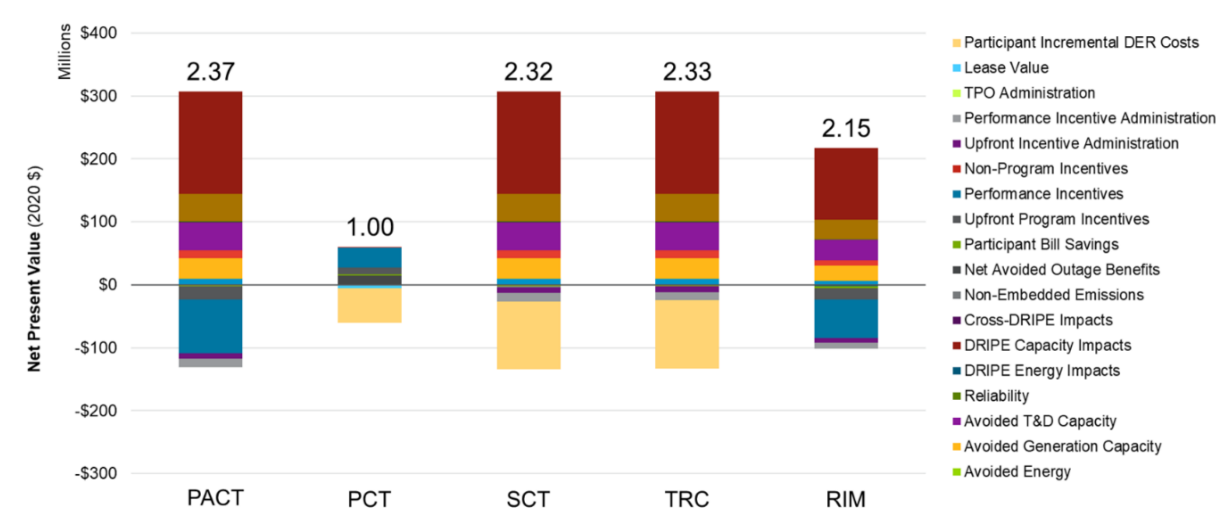
incentive levels and program targets, and it will support efforts later in targeting specific customer demographics, segments, and locations.

Figure 1. Connecticut Willingness to Pay for Battery Storage by Income Compared to the Net Present Value of "Best Practice" Incentive Programs in the Northeast (i.e., Massachusetts, New York, and Vermont)



- **<u>Comprehensive Cost-Effectiveness Testing</u>** – through a spreadsheet tool developed by Guidehouse (see Appendix 8 – [CONFIDENTIAL]), unique strategies for comprehensive benefit-to-cost analyses of various program designs can be performed to calculate benefits to participants (i.e., Participant Cost Test – PCT), ratepayers (i.e., Total Resource Cost Test – TRC; Ratepayer Impact Measure – RIM), and society (i.e., Societal Cost Test – SCT), as well as the Green Bank as a program administrator for the declining upfront incentive (i.e., Program Administrator Cost Test – PACT), and the utilities as program administrators for the ongoing performance-based incentive (i.e., Utility Cost Test – UCT) – see Figure 2.

Figure 2. Cost-Effectiveness of Solarize Storage for Program Administrators, Participants, Ratepayers and Society



The market research and cost-effectiveness modelling, along with other industry research on effective incentive programs,[4] informed the incentive design for the Program – see Table 1.

[4] "Energy Storage Incentive Programs," Energy Storage Association, February 2019, https://energystorage.org/wp/wp-content/uploads/2019/09/Incentive-Report_v7.pdf

Table 1. Solarize Storage Incentive Block Structure for Upfront and Ongoing Performance-Based Incentives

Incentive Step	**Effective Non-LMI Upfront Incentive** ($/kWh)	**Effective LMI Upfront Incentive** ($/kWh)	**Estimated Average Upfront Battery Storage Incentive per System**	**Ongoing Performance Based Incentive** ($/kW)[5]	**Nominal Value of Ongoing Performance Based Incentive per System**	**Nominal Value of Upfront and Performance Based Incentives per System**
1	$280	$560	$3,950	$225	$11,250	$15,200
2	$240	$480	$3,400	$225	$11,250	$14,650
3	$200	$410	$2,900	$225	$11,250	$14,150
4	$170	$330	$2,350	$225	$11,250	$13,600
5	$130	$260	$1,850	$225	$11,250	$13,100
Total			**$2,300**		**$11,250**	**$13,550**

- **Community-Based Social Marketing Strategies** – in partnership with the Yale Center for Business and the Environment, the Green Bank will utilize their applied research experience with Solarize and Energize campaigns to reduce "soft costs" (including customer acquisition and financing), accelerate customer demand in targeted locations, and ensure that the benefits of solar PV in combination with battery storage reach vulnerable communities (i.e., low-to-moderate income families and communities of color) to increase their resilience during times of need through emergency back-up power.

- **Innovative Financing Mechanisms** – beyond financing available from third-party owners, through the use of financing solutions, including on-bill financing mechanisms,[6] the Green Bank will provide easy and affordable access to capital to program participants for loan and/or lease financing to help them get over the barrier of the upfront costs of battery storage in combination with residential solar PV.

In designing the Program, the Green Bank sought and received the support from the local solar PV and battery storage industries in terms of the overall design of the program – its targets, incentive types and levels, and administration. The Green Bank also sought feedback from the EDCs, including the importance of providing an upfront declining incentive in combination with an ongoing performance-based incentive. The Green Bank looks forward to working with the industry, EDCs, and capital providers to implement the Program.

The Green Bank, guided by PURA, working in collaboration with the industry and the EDCs, wants to "put Connecticut on the map" when it comes to innovation in grid modernization!

Attached you will find the proposal from the Green Bank to bring Solarize Storage to our state.

Sincerely,

Lonnie Reed
Chair
Former Representative of the 102nd District
Former Co-Chair of E&T Committee

Bryan T. Garcia
President and CEO

[5] The program design used the Connected Solutions Demand Response Program performance-based incentive of $225/kW for the summer season in Massachusetts (over a 10-year period) as a starter for the EDC active dispatch program. The Green Bank would suggest that a lower performance-based incentive level or shorter period for the incentive be considered.
[6] CGS 16a-40m – Residential Clean Energy On-Bill Repayment Program

Proposal from the Connecticut Green Bank

Docket No. 17-12-03(RE03)
Equitable Modern Grid – Electric Storage

Table of Contents

I. PROGRAM DESIGN CATEGORIES

A. Program Length

A.1.	Provide a recommended program length and, if applicable, annual, interim and/or cumulative deployment target including justification for such recommendation(s).

The Connecticut Green Bank, along with its partners, including residential solar PV contractors in Connecticut (including third-party owners) and battery storage technology companies, propose Solarize Storage, a five-year electric storage incentive program ("the Program") with a 50-megawatt target ("the Target") – 50 MW of electric storage by the end of 2025 – for additional detail, see Appendix 1 "Battery Storage Program Design". The electric storage systems installed through the Program are to be in combination with behind the meter residential solar PV ("the System").

The successful implementation of the Program will reach approximately 10,000 homes[1] that have installed or plan to install solar PV on their properties together with battery storage across both Avangrid and Eversource service territories – see Table 1.

Table 1. Incentive Step Block Structure for the Program

Incentive Step	**Estimated # of Participants**	**Capacity Block** (MW)
1	400	2.0
2	700	3.5
3	1,300	6.5
4	2,600	13.0
5	5,000	25.5
Total	**10,000**	**50.0**

Based on a survey ("the Survey") conducted by Guidehouse,[2] specifically to support the Green Bank's design of the Program, 76% of households that have participated in the Residential Solar Investment Program ("RSIP") are interested in adding electric storage to their PV systems[3] – see Appendix 1 for the findings of the Survey and Appendix 2 for the "Residential Solar Survey Instrument". Some survey respondents have previously considered battery storage and most frequently indicate they haven't purchased electric storage because it is too expensive or they are waiting to see if incentives will be offered to

[1] The Program modelling assumes an average battery storage capacity of 5 kW and 13.5 kWh, installed cost of $11,000 per system, Eversource vs. UI at 80% and 20% respectively, new solar PV and battery storage vs. retrofit solar PV and battery storage at 30% and 70%, respectively, and LMI to non-LMI participants at 5% to 95% respectively.

[2] Guidehouse administered a survey to gather data from previous RSIP and Smart-E residential program participants on customer interest in and willingness to pay for battery storage. The survey also identified the most valuable aspects of battery storage to customers and key customer demographics. This data informed the Green Bank's program design strategy and the cost effectiveness analysis. More detail on the survey objectives and analysis approach can be found in Appendix 1.

[3] See Appendix 1 response to Question 7; n=68

reduce costs.[4] The Green Bank's program design will address the interest and concerns noted by survey respondents and increase the adoption of battery storage.

The Systems installed through the Program, and the achievement of the Target, will increase benefits to participants, ratepayers, and society.

A.2.	Discuss whether there is any requested flexibility or scalability trigger associated with an interim deployment target(s), if applicable.

The Green Bank requests that the Program have both flexibility and scalability triggers associated with interim deployment targets for the following reasons:

- **Flexibility** – the Program uses an upfront declining incentive block structure from the Green Bank through its Comprehensive Plan to combine residential solar PV with battery storage to provide emergency back-up and support passive demand response, in combination with a performance-based incentive from the Electric Distribution Companies ("EDCs") through the Conservation and Load Management Plan ("C&LMP") for ongoing active demand response. The incentives are determined using conventional "cost effectiveness" testing in combination with "best practice" programs benchmarked in the Northeast region and a Connecticut willingness to pay survey. Based on progress being achieved with respect to the Target, incentive levels within the Program should be able to be adjusted to support the achievement of interim deployment targets, ensuring an adequate Participant Cost Test ("PCT") and an appropriate Program Administrator Cost Test ("PACT") and/or Utility Cost Test ("UCT").

- **Scalability** – the Program, if successful at delivering positive benefits for participants (i.e., as measured by the PCT), ratepayers (i.e., as measured by the Ratepayer Impact Test or "RIM" and the Total Resource Cost Test or "TRC") and society (i.e., as measured by the Societal Cost Test or "SCT"), should be allowed to scale-up (i.e., increase the Target), so long as measurable results are being delivered as evidenced by "cost effectiveness" testing, subsequent evaluation, measurement and verification ("EM&V"), and the existence of additional areas of the grid where high demand can be alleviated through the Program. If interim targets are being achieved faster than anticipated, and an increase in benefits are inuring to participants, ratepayers, and society, then the Target within the Program should be able to be increased with the review and approval of the Public Utilities Regulatory Authority ("PURA").

By being more flexible and scalable with interim deployment targets, the Program will further meet the three objectives for electric storage programs outlined in the RFPD by PURA.

[4] See Appendix 1 response to Question 15 – with too expensive (67%), waiting for incentives (48%), do not believe benefits worth the cost (25%), unclear about technology requirements (20%), and more; n=1,505.

B. Program Eligibility

B.1.	Provide the program eligibility requirements, including the customer class(es) (e.g. residential, commercial, and/or industrial) and/or customer type eligible to participate in the program, and provide the rationale for such requirements and any restrictions on eligibility;

In order to be eligible for the Program, the customer must pair battery storage with residential solar PV that has previously been installed (i.e., battery storage retrofit to existing solar PV) or is newly installed in combination with the battery storage.[5]

Combining electric storage with behind the meter residential solar PV:

- Enables the customer to receive additional federal tax credits (i.e., Investment Tax Credit, and Modified Accelerated Cost Recovery System where appropriate) and emergency back-up power, thereby improving the participant's benefits;

- Enables ratepayers and society to receive additional benefits (e.g., reduced peak demand, avoided air emissions) from the investment already made by participants in behind the meter solar PV, while supporting better grid integration with battery storage; and

- Enables low-to-moderate income ("LMI") households to benefit as well (e.g., Solar with Justice) since the Green Bank prioritizes vulnerable communities in its approach to clean energy investment and deployment.

It should be noted that the Green Bank, in collaboration with the EDCs, requires participants in the RSIP to conduct an energy assessment through the Home Energy Solutions ("HES") and Home Energy Solutions – Income Eligible ("HES-IE") programs[6]. Similarly, Program participants would be required to participate in HES or HES-IE if they had not previously done so.

If PURA were interested in the Green Bank administering other storage program incentive structures, then the Green Bank would consider it, including:

- **Small Commercial Solar PV and Battery Storage with and without the ZREC** – through the ZREC program with net metering or looking ahead at the tariff-based compensation structure, battery storage can also be combined with solar PV for small businesses, including those participating in the Small Business Energy Advantage ("SBEA") financing program of the EDCs or the Commercial Property Assessed Clean Energy ("C-PACE") financing program of the Green Bank.

[5] It should be noted that previously installed battery storage systems with residential solar PV would be eligible for the active demand response component of the Program.

[6] See Appendix 1 response to Question 5 for the upgrades survey respondents made following the energy assessment.

- **Battery Storage Only** – without solar PV, battery storage in combination with other Distributed Energy Resources ("DER"), including renewable heating and cooling, electric vehicles, and other clean energy and demand response measures, could be incentivized through a specific program.

If PURA would like to request that the Green Bank develop additional program designs beyond the Program proposed, then the Green Bank would consider it.

B.2.	Discuss whether the program design envisions a standalone electric storage system and/or whether it contemplates an energy storage system coupled or co-located with other energy resources, providing rationale for such a requirement.

The Program not only envisions but would require an electric storage system in combination with a behind the meter residential solar PV system to maximize participant, ratepayer, and societal benefits.

Beyond the rationale provided in B.1., as of July 1, 2020 there are over 41,000 households that have installed (or been approved for) residential solar PV through 15 incentive steps offered through the RSIP for a total of nearly 330 MW of approved installed capacity – see Table 2.[7]

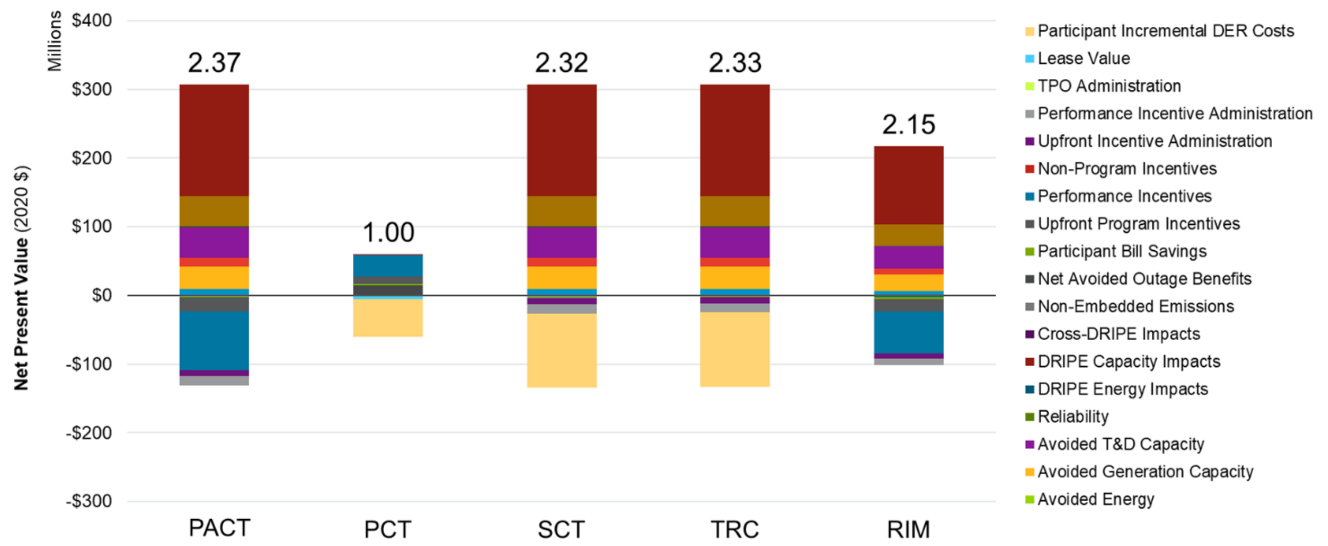
Table 2. RSIP Incentive Steps, Projects, Installed Capacity, Installed Costs, and Incentives

RSIP Incentive Step	**# of Projects**	**Installed Capacity** (kW_{STC})	**Average Installed Cost** ($/W)	**Average RSIP Incentive** ($/W)
1	206	1,381	$5.23	$1.79
2	842	5,993	$4.50	$1.63
3	1,838	13,101	$4.27	$1.23
4	2,591	19,284	$4.40	$1.03
5	1,743	13,365	$4.46	$0,75
6	1,572	12,221	$4.43	$0.51
7	2,559	19,079	$4.35	$0.40
8	3,425	27,131	$4.13	$0.36
9	3,276	26,117	$3.79	$0.33
10	3,897	30,033	$3.45	$0.33
11	2,212	18,187	$3.51	$0.32
12	2,019	16,332	$3.56	$0.28
13	2,301	19,237	$3.51	$0.27
14	9,966	84,777	$3.55	$0.27
15	2,842	23,380	$3.61	$0.23
Total	**41,290**	**329,623**	**$3.83**	**$0.44**

By combining battery storage (i.e., energy storage system or "ESS") with residential solar PV, additional benefits for participants, ratepayers, and society can be achieved – see Figure 1.

[7] Power BI for the Connecticut Green Bank as of July 1, 2020

Figure 1. Benefits to Program Administrators (PACT)[8], Participants (PCT), Society (SCT) and Ratepayers (TRC and RIM) for Solarize Storage



By combining DERs – or "enhanced demand side management technologies" – such as behind the meter residential solar PV with battery storage, the total participant, ratepayer, and societal benefits are increased.

The locations of the residential solar PV systems installed in the EDC service territories also presents an opportunity for the Green Bank to target battery storage deployment. By combining electric storage with behind the meter residential solar PV, Connecticut has the potential to reduce not only peak demand from 350 MW of residential solar PV installed through the RSIP, but to also reduce peak demand by 50 MW for targeted periods of time (e.g., ISO-NE summer peak) and specific events through the passive and active demand response from the deployment of battery storage. Through the combination of electric storage with behind the meter residential solar PV, the reliability of the electric grid is improved for all ratepayers (e.g., through summer peak demand reductions) and the air pollution resulting from fossil fuel power plants can be reduced for society – see Appendix 3 and Appendix 4 on the Summer Heat Wave of 2019 fact sheet and analyses.

C. Compensation Structure

The Program involves three (3) components – ownership of the electric storage system for emergency back-up, and incentives for passive and active dispatch – see Figure 2.

[8] The PACT shown is the combined costs and benefits for the program administrators of both the upfront incentive and the performance-based incentives programs.

Figure 2. Components of Solarize Storage

Battery Ownership (Emergency Back-Up) | **Passive Dispatch** (Default Settings) | **Active Dispatch** (Call Events)

As will be explained further on in the proposal, there are several options for ownership of the electric storage system, including:

- Participant purchases and owns the system;
- Participant leases the system from a TPO; or
- Participant leases the system from an EDC.

To stimulate demand for electric storage systems, the Green Bank will provide an upfront incentive with the allowance for emergency back-up and requiring passive dispatch default settings to address the ISO-NE summer peak period, and the EDCs will provide an ongoing performance-based incentive for active dispatch, modeled on Eversource's Connected Solutions Demand Response program, which calls for between 30-60 events during the summer season (June 1-September 30) and 5 events during the winter season (December 1-March 31) – however, the Program does not include a winter peak performance-based incentive in Connecticut as is done in Massachusetts.[9]

C.1.	Provide details of the specific recommended compensation structure (e.g., upfront payments, payments for performance, rate design(s), low- to no-cost financing, or a combination thereof) or any other recommendations for incentivizing electric storage deployment;

Developing a compensation structure for the Program requires careful consideration of customer preferences on a number of factors that translate to benefits and costs. For example, the Survey indicates that the primary motivation for respondent interest in installing a battery storage system is the ability to have back-up power in the event of a power outage (i.e., 53% of respondents).[10] These potential customers expect that battery storage would be able to power a refrigerator, lights, computer, freezer, electronics, television, and other devices.[11] On the other hand, in terms of costs, many potential customers are unaware of the federal tax credit for battery storage (i.e., 78% are unaware),[12] the majority of respondents prefer an upfront incentive (i.e., 53% of respondents who have a preference) versus a performance-based incentive (if given the

[9] https://www.eversource.com/content/ct-c/residential/save-money-energy/manage-energy-costs-usage/demand-response/battery-storage-demand-response

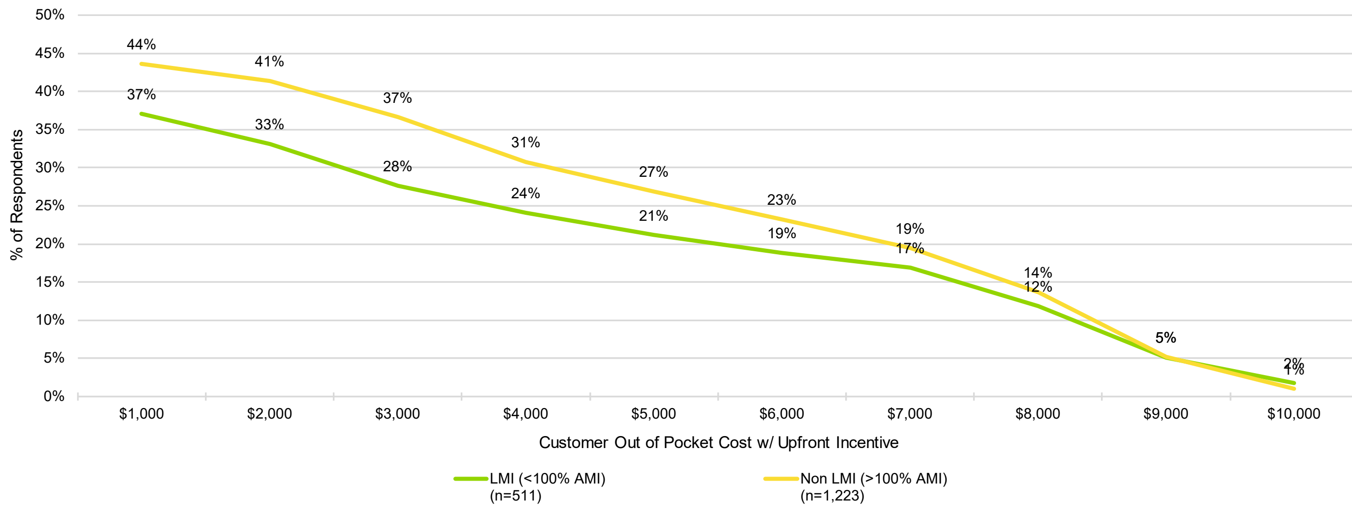
[10] See Appendix 1 response to Question 20 – with (#2) energy independence at 23%, and (#3) save money on energy bills at 10%; n=1,857

[11] See Appendix 1 response to Question 18; n=736

[12] See Appendix 1 response to Question 22 – with 22% aware of the ITC; n=1,789

choice of only one type of incentive),[13] and depending upon income, the willingness to pay for battery storage varies – see Figure 3.

Figure 3. Willingness to Pay for Battery Storage by Area Median Income of Survey Respondents



Note: Respondents who reported needing more information before deciding how much they are willing to pay are counted as not willing to pay at any price. The willingness to pay curves presented assume a customer is willing to pay at any price up to their maximum willing to pay ("maximum WTP") value.

Figure 3 shows the survey respondent willingness to pay for a typical battery storage system based on the income of the respondent – low-to-moderate income ("LMI") households with less than 100 percent area median income ("AMI") or non-LMI households with greater than 100 percent AMI. Survey respondents were shown a hypothetical starting purchase price for the storage system including a randomly selected upfront incentive amount and asked if they would be interested in purchasing a battery storage system at that price. Based on the willingness to pay at the starting price, customers were asked about a second, and potentially third, scenario, as further described in the Appendix 1 "Key Survey Results" Section.

The findings indicate that various levels of incentives are needed (e.g., higher incentive for LMI households) in order to get potential customers to want to install battery storage in combination with their residential solar PV systems.

Based on the findings of the Survey, "best practice" program design on battery storage from neighboring states in the Northeast, and industry research on effective incentive program design,[14] the Green Bank proposes the following compensation structure:

- **Upfront Incentive** – 55% of the Survey respondents who were former RSIP participants were very interested in receiving an upfront incentive for battery

[13] See Appendix 1 response to Question 32a – with 21% moderately preferring upfront incentive, 31% with no preference, and 15% either moderately or strongly preferring a performance-based incentive of equivalent value; n=1,727.
[14] "Energy Storage Incentive Programs," Energy Storage Association, February 2019, https://energystorage.org/wp/wp-content/uploads/2019/09/Incentive-Report_v7.pdf

storage similar to the incentive they received through the RSIP.[15] In order to increase demand for homeowners to pursue the installation of electric storage in combination with their behind-the-meter residential solar PV systems, the Green Bank proposes a declining incentive block structure for an upfront incentive to the homeowner or third-party owner ("TPO") ("the Participants") (see Table 3).

Table 3. Solarize Storage Declining Upfront Incentive Block Structure

Incentive Step	**Estimated # of Participants**	**Capacity Block** (MW)	**Effective[16] Upfront Incentive for Non-LMI Participants** ($/kWh)[17]	**Effective Upfront Incentive for LMI Participants** ($/kWh)	**Average Upfront Battery Storage Incentive per System**
1	400	2.0	$280	$560	$3,950
2	700	3.5	$240	$480	$3,400
3	1,300	6.5	$200	$410	$2,900
4	2,600	13.0	$170	$330	$2,350
5	5,000	25.5	$130	$260	$1,850
Total	**10,000**	**50.0**			**$2,300**

It should be noted that there will be a cap of $7,500 of upfront incentive per Participant within the Program.[18] Providing a cap on the level of upfront incentive that can be received per Participant will increase ratepayer benefits by reducing the amount of upfront incentives per Participant that installs a battery storage system above the cap.[19]

In order for the Participants to receive the upfront incentive, they would be required to:

1. **<u>Passive Dispatch Default Settings</u>** – set the electric storage system to automatically store and dispatch solar energy through the battery to reduce demand during ISO-NE summer peak periods which currently includes June through August weekdays from 1:00 to 5:00 p.m. using no more than 80% of the battery storage capability (i.e., at least 20% will be reserved for back-up power). In this case, 1.2 kW of benefits are attributed to the passive dispatch Program administered by the Green Bank dispatched to meet the customer load – see Figure 4 and Appendix 1 "Cost Effectiveness Analysis" Section.

[15] See Appendix 1 response to Question 23 – 40% moderately interested and 5% not interested; n=1,172

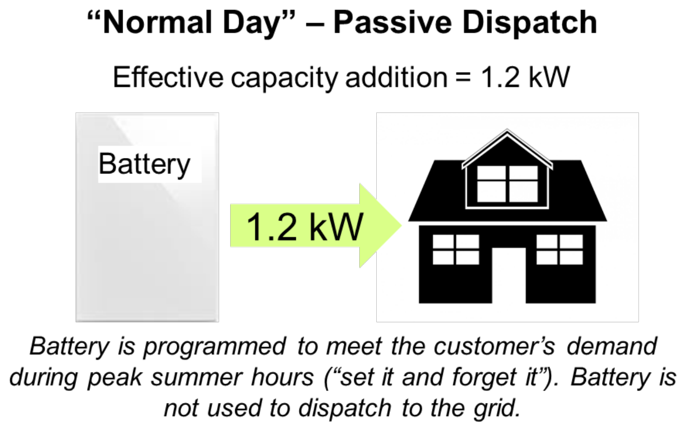
[16] The effective incentive level factors in the usable energy capacity (kWh) and the maximum power output rating (kW) of the energy storage system, the nameplate rating of the solar PV system, and includes an incentive cap of $7,500.

[17] Incentive is adjusted based on kWh and kW capacity – in this case (for Tesla Powerwall) the incentive is limited by the kW power

[18] This equates to the value of the incentive for two Tesla Powerwall installations for the non-LMI incentive (i.e., Step 1 – $3,750 for one Powerwall) and one Tesla Powerwall installation for the LMI incentive (i.e., Step 1 – $7,500).

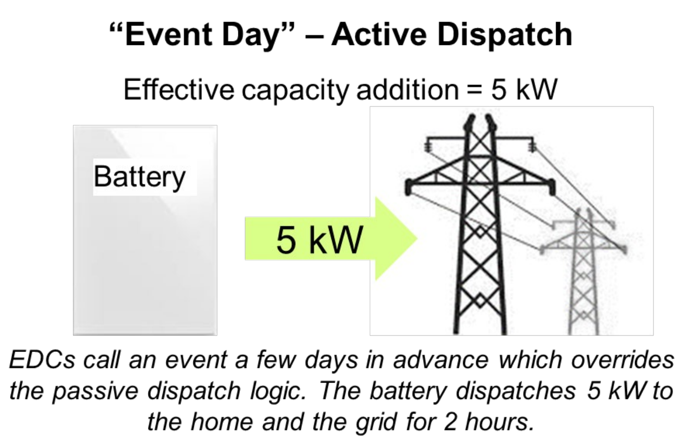
[19] The RSIP has tiered incentives based the type of incentive (i.e., EPBB) and on the size of the solar PV system – (1) up to 10 kW at one level of incentives per step (e.g., Step 15 EPBB – $0.426/W), and (2) greater than 10 kW, but no more than 20 kW at another lower level of incentive per step (e.g., Step 15 EPBB – $0.328/W).

Figure 4. Passive Dispatch Default Settings – "Set It and Forget It" Administered by the Green Bank



2. **Active Dispatch Settings for Demand Response Events** – allow the EDCs, and participating TPO's (in collaboration with the EDCs), to actively dispatch the System during demand response events during the summer season to improve systemwide benefits.[20] In this case, 3.8 kW of benefits are attributed to the active dispatch program administered by the EDCs because in the absence of an event, the battery storage system would have been able to dispatch 1.2 kW of benefits. However, during an event day, 5.0 kW is actively dispatched over a period of time – see Figure 5 and Appendix 1 "Cost Effectiveness Analysis" Section.

Figure 5. Active Dispatch Program – Demand Response Events Administered by the EDCs and TPOs



Physically, the battery is discharging 5 kW – 1.2 kW from passive dispatch through the Green Bank, and an additional 3.8 kW for active dispatch through the EDCs and TPOs. In other words, on peak days when an active dispatch event is

[20] It should be noted that the Connecticut Solutions Program in Massachusetts includes a summer season incentive (i.e., $225/kW) and a winter season incentive (i.e., $50/kW). Solarize Storage only includes the summer season performance-based incentive in its modeling.

called, the battery discharges 5 kW; of the peak reduction benefit accrued by that dispatch, roughly 30 percent is allocated to the Green Bank due to the passive dispatch baseline, while the rest is allocated to the EDCs and TPOs managing the active dispatch of the battery.

In order for the Green Bank to recover the cost of providing Participants with this upfront incentive, it would have to demonstrate to PURA the effectiveness of this passive dispatch approach – or "set it and forget it" (i.e., that the electric storage system is set to appropriately and automatically store and dispatch energy to meet customer load during the ISO-NE summer peak demand periods). For demonstrating this performance, the Green Bank would then receive performance-based cost recovery each year over a three-year period for successfully demonstrating the effectiveness of this approach.[21]

- **Performance-Based Incentive** – 37% of the Survey respondents were very interested in receiving a performance-based incentive in addition to the upfront incentive for battery storage in exchange for allowing the battery to be discharged during peak times.[22] And 29% of Survey respondents are much more likely to buy a battery storage system with an additional performance-based incentive.[23] In order to maximize ratepayer benefits beyond reducing ISO-NE summer peak through passive dispatch or "set it and forget it," the EDCs (as administrators of the C&LMP), as well as TPOs, would dispatch the electric storage system over the course of a year during appropriate events (i.e., likely 30-60 times a year) to maximize the benefits to the transmission and distribution system (e.g., through active demand response).

  In order for the Participants to receive the performance-based incentive from the EDCs, the entity dispatching the electric storage system would need to demonstrate the electric grid benefits resulting from such active dispatch of the system. The Participants can be compensated through an appropriate mechanism, including a check in the mail or credit on their utility bill – and the TPO receiving the incentive directly on behalf of the homeowner for a reduced-rate battery storage lease.[24]

The incentive structure design of the upfront incentive plus ongoing performance-based incentive, if successful, will demonstrate a total PCT of 1.00, and PACT of 2.37 for the Program, while achieving the Target.

[21] Cost recovery would be similar to the RSIP, where the Green Bank's cost recovery for administering the RSIP is based on actual performance of the solar PV systems installed through the incentive program based on the production of RECs from revenue grade meters, which are then purchased by the EDCs through a 15-year Master Purchase Agreement at a REC price sufficient to cover the costs of the incentives and program administration.
[22] See Appendix 1 response to Question 29 – with 53% moderately interested and 10% not interested; n=1,727
[23] See Appendix 1 response to Question 31 – with 57% not sure and 14% no more likely; n=1,727
[24] See Appendix 1 response to Question 32 for customer preference on performance-based incentive delivery method; n=1,551

- **Financing** – beyond available financing products that may already exist in the market, to support the implementation of the Program, the Green Bank, working in partnership with the EDCs through the Joint Committee (i.e., Energy Efficiency Board and the Connecticut Green Bank Board of Directors),[25] and private sector financial institutions, would (could) offer:

  ☑ **Smart-E Loan** – would offer through local community banks and credit unions, to provide customers with easy access to affordable (i.e., unsecured and low interest) and long-term (i.e., up to 20 years) loans.

  On July 1, 2020, the Green Bank launched a Smart-E Loan Special Offer, including for battery storage, that would provide loans at 2.99% for 5, 7, and 10-year terms. Funding for the interest rate buydowns comes from the American Recovery and Reinvestment Act – between $1.0 to $1.5 million outstanding – see Appendix 5 (i.e., Smart-E Loan battery storage promotional advertisement) and Appendix 6 (i.e., Smart-E Loan battery storage program guidelines).

  ☑ **On-Bill Loan Financing** – could offer an on-bill loan financing option to provide Participants with the necessary low-cost and long-term capital upfront to finance the System. Through CGS 16a-40m (i.e., Residential Clean Energy On-Bill Repayment Program), PURA could review and approve guidelines for such a financing program which would make the Program easier to implement, including supporting the implementation of CGS 16-244z. The policy includes "shut-off" (i.e., disconnection) for non-repayment of the loan and "staying with the meter" (i.e., assignment of repayment obligations to subsequent owners of the property) provisions – that in the case of solar PV and battery storage could be applied to the System, as opposed to electricity to the home. In other words, if a customer fails to repay an on-bill loan for their solar PV and/or battery storage system, then that system, as opposed to their electricity, could be "shut-off" thereby eliminating the benefits the borrower would have received from the System. The objectives of an on-bill repayment program would be to increase access to and affordability of the System for Participants, increase demand by Participants, and increase the use of private capital sources to finance the System.[26]

  It should be noted that the Green Bank is in the process of filing an

[25] CGS §16-245m(d)(2)

[26] "Financing Energy Improvements on Utility Bills: Market Updates and Key Program Design Considerations for Policymakers and Administrators" by the SEEAction Network (May 2014).

application with the USDA under its Rural Energy Savings Program ("RESP"), to borrow $10 million of federal funds at 0% interest rates, a portion of which could be used to provide low-cost and long-term financing for on-bill repayment of battery storage in the rural communities (i.e., towns with populations less than 50,000 people) of Connecticut. After the Green Bank submission of a Letter of Interest with the USDA on May 14, 2020, including an on-bill repayment program for battery storage, the USDA subsequently invited the Green Bank on July 1, 2020 to submit a loan application.

☑ **On-Bill Lease Financing** – the Green Bank, working with the EDCs, could help develop an on-bill lease financing program option that could be provided to Participants whereby the EDCs would own and then lease the battery storage system to the Participant – or the EDC could partner with a TPO through a competitive process, to support an on-bill lease financing program.

The Green Bank has experience with residential and commercial solar lease and PPA financing, which makes expensive technology more affordable and accessible to participating end-use customers.[27] The Green Bank and EDCs (i.e., Eversource) also have experience working together on sourcing capital into the SBEA program, which has resulted in lowering the cost of capital for the program, and thereby reducing the amount of ratepayer subsidy needed to support the on-bill conservation and load management financing program for small businesses.

Based on the Survey respondents who report a preference for battery ownership structure, 43% of respondents would prefer to own the battery storage system, while 19% prefer to lease the battery storage system[28] – and, of those who would prefer to own, 36% would prefer to finance the system versus 35% who would prefer to pay with cash.[29] Those respondents who would prefer to own the system felt that low interest rates were important to help finance battery storage systems.[30]

Through a combination of upfront incentives, performance-based incentives over time, and easy and affordable access to financing, the Green Bank believes that the Program would be in a position to achieve the Target, while delivering on PURA's objectives.

[27] Comprehensive Annual Financial Report of the Green Bank for FY19 (pp. 158-174)
[28] See Appendix 1 response to Question 33 – with 38% not sure; n=1,727
[29] See Appendix 1 response to Question 34 – with 29% not sure; n=741
[30] See Appendix 1 response to Question 35; n=266

C.2.	Provide justification for any recommended compensation structure, including but not limited to, how the compensation structure will ensure that the articulated benefits are realized;

The recommended compensation structure is justified through its "cost effectiveness," which is summarized in Table 4 and Figure 6 below. The Program benefits and overall cost effectiveness will be verified through annual EM&V of the active and passive dispatch of the Systems.

Table 4. Cost Effectiveness of Solarize Storage

Incentive Step	Capacity Block (MW)	PACT[31]	PCT	SCT	TRC	RIM
1	2.0	1.23	1.13	1.22	1.22	1.07
2	3.5	1.68	1.00	1.66	1.67	1.50
3	6.5	2.03	0.99	2.00	2.01	1.83
4	13.0	2.44	0.99	2.39	2.40	2.24
5	25.0	2.75	0.98	2.66	2.67	2.55
Total	**50.0**	**2.37**	**1.00**	**2.32**	**2.33**	**2.15**

Figure 6. Benefits and Costs of Solarize Storage[32]

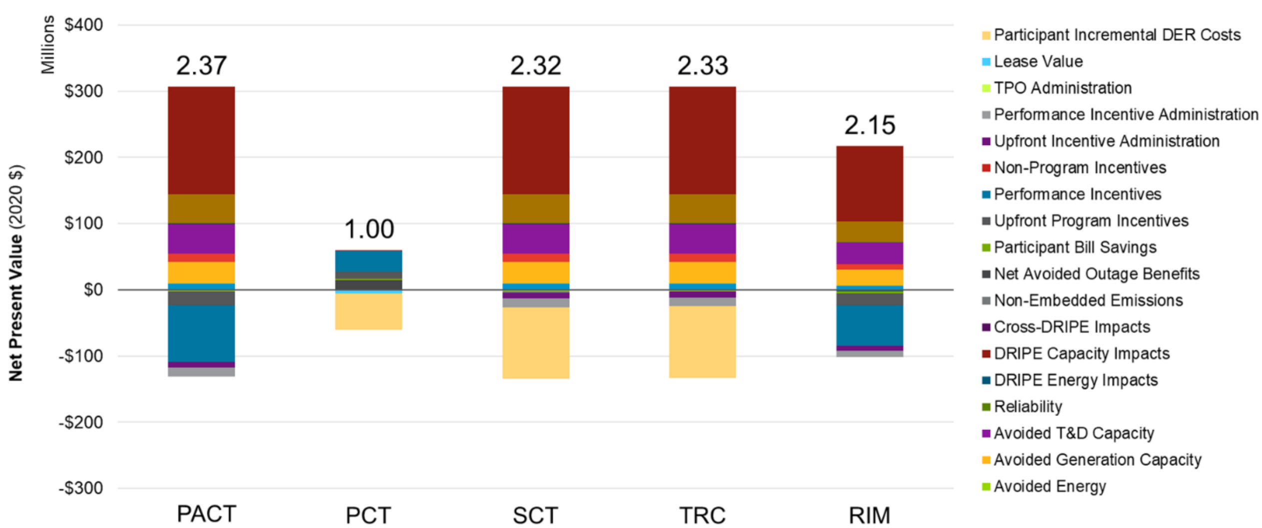


Figure 7 shows that by combining battery storage with residential solar PV, the PACT of the upfront incentive program greatly improves, while the PCT stays about the same in the scenario in which the ITC remains after 2021.[33] The middle graphic provides a perspective on what happens to the PCT when the federal ITC is no longer available over the course of the Program. Therefore, it is important that the Program begin as quickly as possible, otherwise there could be limited demand for battery storage, or said another

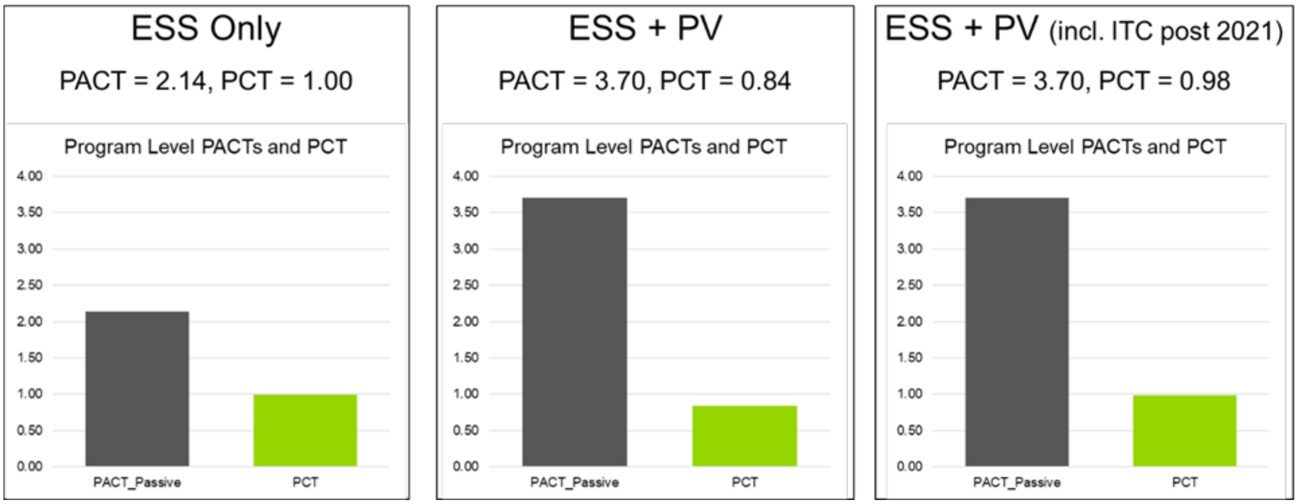
[31] The PACT shown is for the Combined Program: Upfront Incentive Program run by Connecticut Green Bank and Performance-Based Incentive Program run by the EDCs

[32] Ibid.

[33] Assume the value of the ITC is 22% in years 2021-2025

way, the incentive would have to be increased in order to compensate the Participant for the loss of the ITC. This 'gap' could be addressed by increasing the performance-based incentive, or, once CGS 16-244z is in effect, then the "…reasonable rate of return that is just, reasonable, and adequate…" presumes that the Participant is compensated for the loss of the ITC. There is also the possibility that the federal ITC gets extended, including a separate ITC for battery storage only.[34][35]

Figure 7. Comparison of PACT and PCT for Battery Storage Only vs. Battery Storage with Residential Solar PV



By combining battery storage with solar PV systems, total benefits to participants, ratepayers, and society are maximized. For example, participant benefits are nearly $100 million for storage + solar PV vs. $50 million in PCT benefits without including solar PV in the analysis. Furthermore, the RIM and TRC benefits are nearly $275 and $400 million for storage + solar PV vs. $200 and $300 million in RIM and TRC benefits without solar PV included.

These benefits will be realized by demonstrating real-time performance of the electric storage systems being managed in the aggregate through passive and active dispatch and monitoring.

The Green Bank has demonstrated strong experience delivering real-time performance of behind the meter systems, including:

- **<u>kWh Production</u>** – performance-based incentives and cost recovery through the sale of Solar Home Renewable Energy Credits ("SHRECs") for behind the meter solar PV systems installed through the RSIP; and

- **<u>kW Forward Capacity</u>** – earning revenues in the form of capacity payments through ISO-NE's Forward Capacity Markets ("FCMs"), which uses real-time data collection of DER performance as proof of benefits being realized over

[34] https://www.pv-tech.org/news/itc-extension-to-2025-added-to-us1.5trn-infrastructure-bill
[35] https://pv-magazine-usa.com/2020/06/24/houses-1-5-trillion-infrastructure-bill-packed-with-pro-solar-pro-storage-provisions/

certain periods of time.

The Green Bank is committed to demonstrating how DERs like solar PV and battery storage, together, can increase the total value of economic benefits to participants, ratepayers, and society.

C.3.	Provide details on how the proposal will support participation by low- to moderate-income (LMI) customers and/or underserved communities, including enhanced compensation and/or enhanced marketing to such customers, as appropriate. Provide justification for any proposed enhanced compensation or marketing;

Prioritizing 1) the focus on existing RSIP customers and 2) the need for resilience of our most vulnerable citizens (e.g., LMI and underserve communities), the Program proposes to add battery storage as emergency back-up onto behind-the-meter residential solar PV.

Within the Green Bank's administration of the RSIP, the "Solar for All" model has become a national award-winning model for enabling participation by LMI customers to install residential solar PV on their homes.[36] As a "parity state" when it comes to income and a "beyond parity state" when it comes to deployment of solar PV in communities of color, a goal of the Green Bank is "to strengthen Connecticut's communities by making the benefits of the green economy inclusive and accessible to <u>all</u> individuals, families and businesses".[37] Through the deployment of residential solar PV in LMI communities, the Green Bank is helping families reduce the burden of energy costs, while creating jobs in their communities and reducing air pollution that adversely impacts local public health and causes global climate change.

In FY 2019, the Green Bank enabled 6,321 projects (i.e., 62% of FY19 projects), 32.1 MW of clean energy deployment (i.e., 49% of deployment), and $153.7 million of investment (i.e., 56% of investment) in 100% or below state median income.[38]

The Green Bank, working with the solar PV industry, EDCs, and TPO's, will support increased participation by LMI customers installing battery storage on residential solar PV by:

- **<u>Offering an Additional Incentive</u>** – providing an additional upfront incentive to encourage the adoption of more electric storage by LMI families by improving the economic payback of the system (i.e., increasing the PCT) – see Table 5. The Program proposes an average upfront incentive of $7,500 per LMI participant in Step 1, which is reduced to $3,500 in Step 5 while keeping the PCT well over 1.00;

[36] For its "Solar for All" partnership with PosiGen, the Green Bank won the State Leadership in Clean Energy Award in 2018. The Green Bank's approach has also been featured as a best practice in Solar with Justice: Strategies for Powering Up Under-Resourced Communities and Growing an Inclusive Solar Market.
[37] "Sharing Solar Benefits: reaching Households in Underserved Communities of Color in Connecticut" (May 2019)
[38] Comprehensive Annual Financial Report of the Green Bank for FY19 (p. 132)

Table 5. Upfront Incentive and PCT for Non-LMI vs. LMI Participants

Incentive Step	**Capacity Block** (MW)	**Non-LMI Participants**		**LMI Participants**	
		Effective Upfront Incentive ($/kWh)	PCT	Effective Upfront Incentive ($/kWh)	PCT
1	2.0	$280	1.12	$560	1.77
2	3.5	$240	0.99	$480	1.67
3	6.5	$200	0.99	$410	1.58
4	13.0	$170	0.98	$330	1.50
5	25.0	$130	0.98	$260	1.44
Total	**50.0**		**0.99**		**1.51**

- **Enhanced Marketing** – providing additional on the ground and neighbor-to-neighbor research and marketing support to reduce the costs of customer acquisition by contractors (e.g., Solarize, Solar for All)[39]; and

- **Improved Locational Targeting**– undertaking additional analyses, in collaboration with academic institutions like Yale University, to identify target locations where (1) the grid is experiencing high demand, and (2) locations that include vulnerable communities.[40]

These additional considerations are justified in order to ensure energy affordability and helping LMI families become more resilient in the face of grid outages and natural disasters, while balancing against the overall cost-effectiveness of the Program.

C.4.	Discuss incremental existing and proposed sources of funding for projects that would be eligible pursuant to this proposed program design, including ratepayer funding, revenues from wholesale market participation, and other sources, such as federal tax incentives. Discuss how program and other eligibility requirements impact the availability of such sources of funding; and

Beyond the upfront incentives, performance-based incentives, and access to financing proposed under the Program, other incremental sources of funding that would be eligible, include:

- **Investment Tax Credit** – when paired with solar PV, battery storage can receive a federal investment tax credit of 26% in 2020 and 22% in 2021 of the capital cost of the system.[41] Based on responses to the Survey, 45% would purchase a battery storage system by the end of 2021 to ensure they could receive the tax credit[42]. This source of funding would help improve the PCT. As

[39] Solar Energy Evolution and Diffusion Among Low- and Middle-Income Households (SEEDS II) - https://cbey.yale.edu/programs/solar-energy-evolution-and-diffusion-among-low-and-middle-income-households-seeds-ii
[40] https://cbey.yale.edu/our-stories/circuits-of-sunlight-marketing-solar-where-it-is-most-needed
[41] This tax credit drops to 0% for homeowner-owned systems and 10% for TPO's starting in 2022
[42] See Appendix 1 response to Question 28a – with 43% unsure and 12% unavailability of the tax credit wouldn't influence decision; n=1,727

noted above, there is the possibility that the ITC is extended, and potentially inclusive of battery storage only provisions.

- **Modified Accelerated Cost Recovery Systems (MACRS)** – with or without solar PV, battery storage is eligible for a 5-year MACRS depreciation schedule with solar (if battery is charged by solar more than 75% of the time) – an equivalent reduction in capital cost of about 21%; and a 7-year MACRS depreciation schedule without solar – an equivalent reduction in capital cost of about 20%.[43] This source of funding would help improve the PCT for TPO or utility-owned projects only.

- **ISO-NE Wholesale Capacity Market** – the Green Bank participates in the ISO-NE On-Peak Hours Resource Program for behind-the-meter residential solar PV. ISO-NE makes capacity payments to owners of demand resources based on the demand reduction value of the resource as measured by the hourly kWh reduction over defined performance hours. The Green Bank, through its partner C-Power, commits a defined capacity to the resource program as measured in kWac. C-Power then acquires Capacity Supply Obligations ("CSO") through the Forward Capacity Market ("FCM") auction process. The revenues received by the Green Bank through this ISO-NE program are quite variable and cannot be used as a reliable resource to improve the PCT, nor the PACT.

  For the Program proposed by the Green Bank, to be consistent with practices undertaken in other regional markets (e.g., Massachusetts),[44] the Green Bank would reallocate the demand resources (i.e., capacity rights) it owns from the solar PV installations, if feasible and if needed, to solar plus battery storage installations with its EDC and TPO partners. The usage of these resources could improve the PCT, depending upon how these resources are valued and allocated.

These are a few of the existing sources of funding for projects that would be supported by the Program, in combination with the upfront and performance-based incentives.

C.5.	Provide examples of the success of the recommended compensation structures in other jurisdictions, if applicable.

To validate the appropriateness of the proposed program design and incentive levels, the Green Bank reviewed "best practice" battery storage incentive programs from other Northeastern states. This review included a net present value ("NPV") analysis to compare the cash flows from battery storage purchase and peer program participation to the incentive design for the proposed program. This analysis uses standardized assumptions

[43] https://www.nrel.gov/docs/fy18osti/70384.pdf

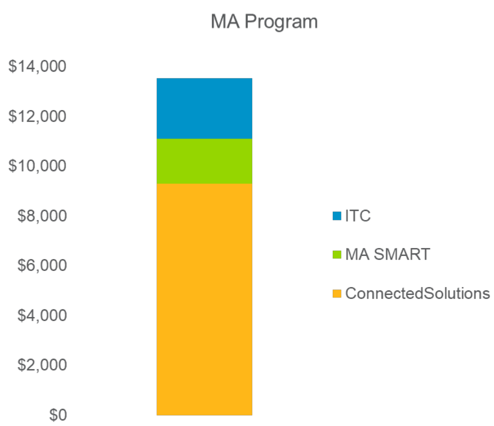
[44] It should be noted that within the Terms and Conditions of Eversource's Connected Solutions program in Massachusetts is the following with respect to "Energy and Demand Reduction Benefits" – The program administrator is entitled to 100% benefits & rights associated with the DRM. However, for the Connected Solutions Program, the program administrator agrees to waive or transfer ownership rights to the customer or their designated vendor for the ISO New England forward capacity market (FCM) annual and monthly capacity supply obligation (CSO).

for numerous factors including purchase and install cost, operations and maintenance, and discount rates, to provide a sound comparison, as detailed further in Appendix 1 "Battery Storage Benchmark Programs" Section.

There are a number of other jurisdictions in the Northeastern Region that provide similar compensation structures as are being proposed by the Green Bank, including:

- **Massachusetts** – through the Massachusetts SMART program of the Department of Energy Resources ("DOER") and Connected Solutions Program of Eversource, there are combinations of battery storage incentives, including those paired with solar PV – see Figures 8 and 9.
    - **Massachusetts DOER Solar MA Renewable Target (SMART) Program** – $0.0505/kWh performance incentive; and
    - **Eversource's Connected Solutions Demand Response Program** – $225/kW summer performance incentive.[45] A typical home battery could contribute an average of 5 kW per event. This would earn $1,125 for the summer season.[46]

Figure 8. Present Value of Massachusetts's Battery Storage Incentive Programs

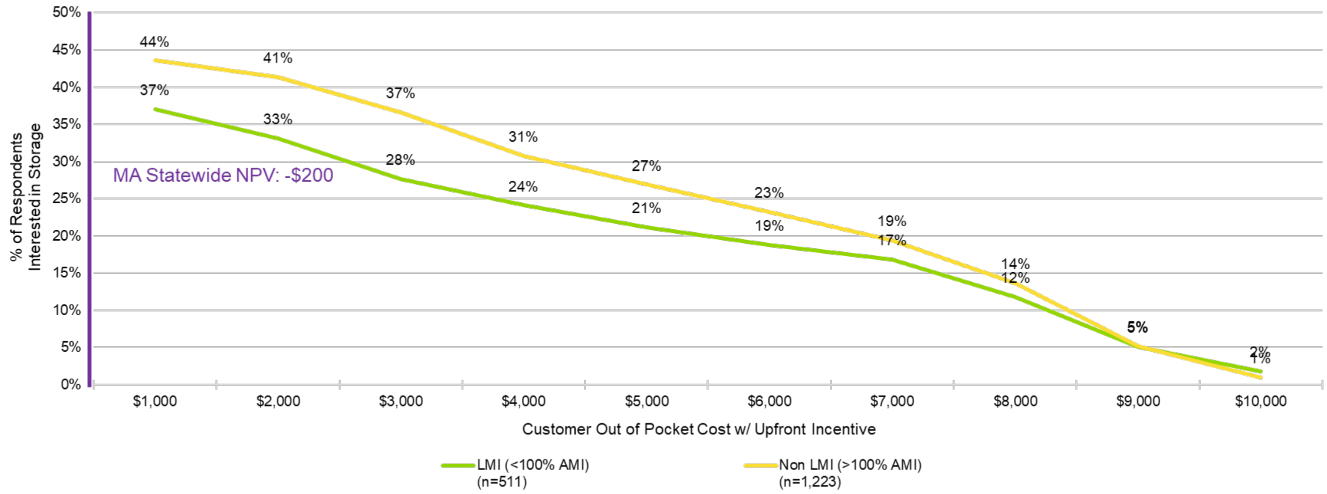


The present value of these incentives in Massachusetts is equal to $13,500 per system, leaving no installed cost to the Participant to finance.

The net present value for Massachusetts's incentive program participants compared to the willingness to pay for both LMI and non-LMI survey respondents is shown in Figure 9.

[45] As noted above, there is a $50/kW winter season performance-based incentive through the Connected Solutions Program, however, Solarize Storage did not include this incentive.
[46] For a period of 5-years at this level of incentive with an option to extend for an additional 5 years

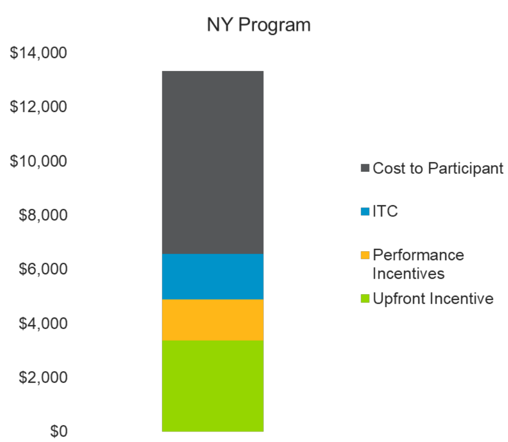
Figure 9. Connecticut Willingness to Pay for Battery Storage in Comparison to the Net Present Value to Customer after Massachusetts's Incentives



Note: Respondents who reported needing more information before deciding how much they are willing to pay are counted as not willing to pay at any price. The WTP curves presented assume a customer is willing to pay at any price up to their maximum WTP value.

- **New York** – through the New York Sun program of the New York State and Energy Research Development Authority ("NYSERDA") and the Public Service Enterprise Group's ("PSEG") Energy Storage Rewards programs, there are combinations of battery storage incentives, including those paired with solar PV – see Figures 10 and 11.
  - **NY Sun of NYSERDA** – upfront incentive of $250 per kWh of installed capacity; and
  - **PSEG's Energy Storage Rewards Program** – a Long Island, New York program provides $8/kW-month for May through September, and $0.25/kWh dispatch during events.

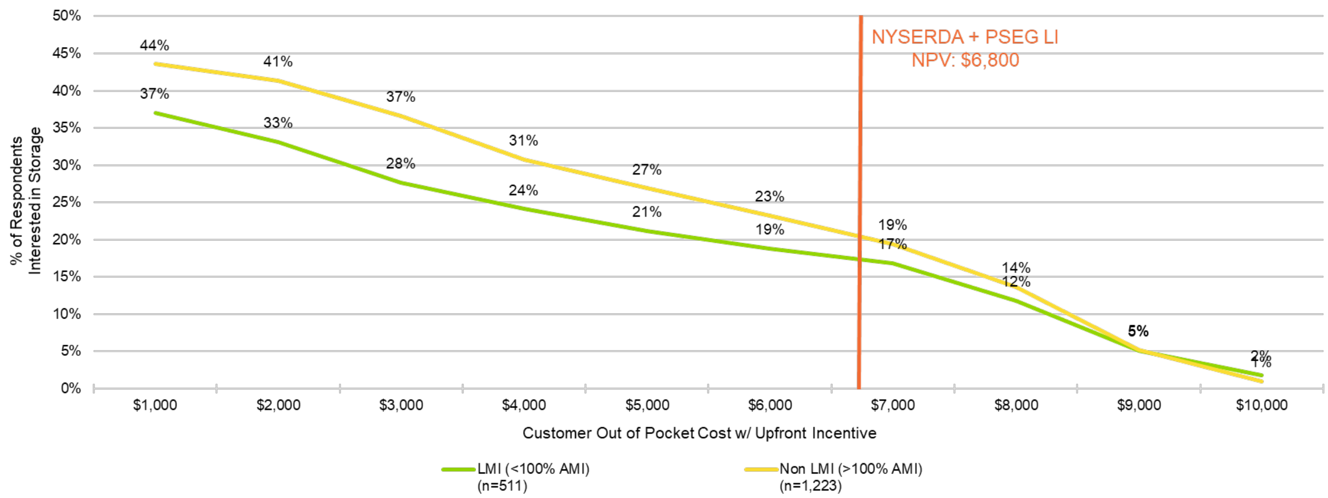
Figure 10. Present Value of New York's Battery Storage Incentive Programs



The present value of these incentives in New York is equal to $6,600 per system, leaving $6,800 of the installed cost to the Participant to finance.

The net present value for New York's incentive program participants compared to the willingness to pay for both LMI and non-LMI survey respondents is shown in Figure 11.

Figure 11. Connecticut Willingness to Pay for Battery in Comparison to the Net Present Value to Customer after New York's Incentives



Note: Respondents who reported needing more information before deciding how much they are willing to pay are counted as not willing to pay at any price. The WTP curves presented assume a customer is willing to pay at any price up to their maximum WTP value.

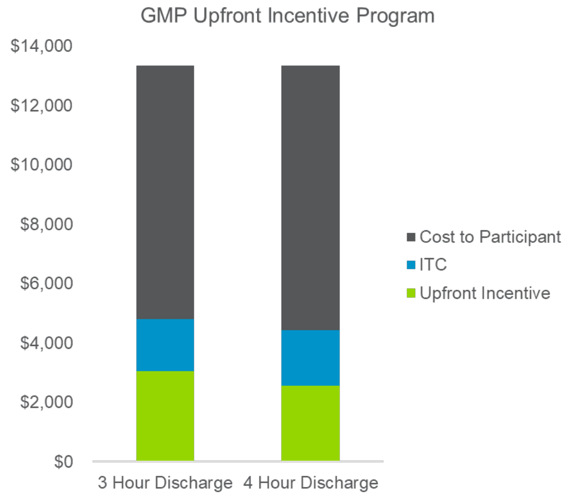
- **Vermont** – through the various Green Mountain Power battery storage incentive programs in Vermont, there are combinations of battery storage incentives, including various ownership options – see Figures 12, 13, and 14.

  - **Green Mountain Power programs**

    - **Tesla Powerwall** – a 10-year $55 per month lease program or $5,500 upfront for two Tesla Powerwall systems with utility administered demand response; and

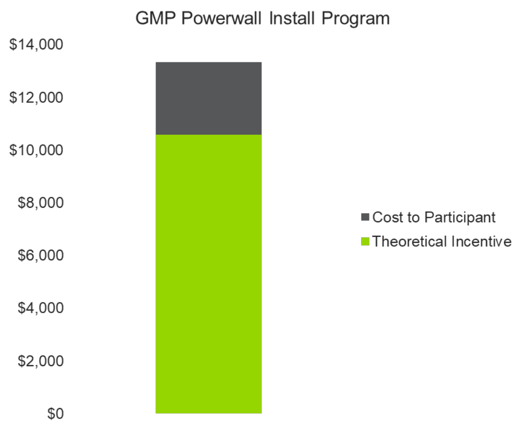
    - **Bring Your Own Device Program** – bring your own device ownership options with utility administered demand response.

Figure 12. Present Value of Vermont's Upfront Battery Storage Incentive Programs



The present value of these incentives in Vermont is equal to $4,400-$4,800 per system, leaving $8,500-$8,900 of the installed cost to the Participant to finance.

Figure 13. Present Value of Vermont's Power Wall Lease Programs

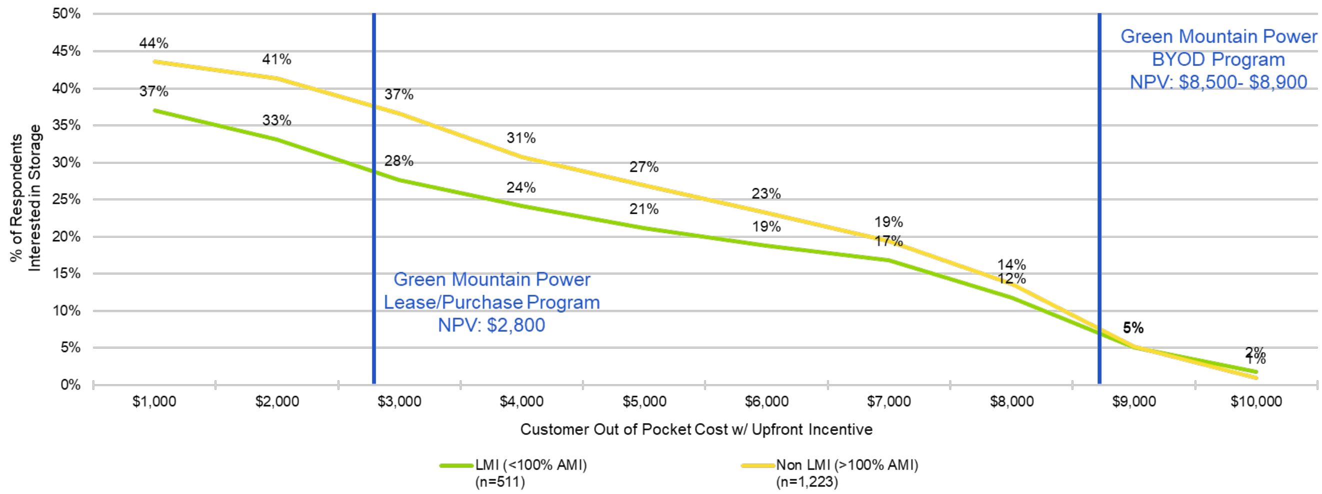


The present value of these incentives in Vermont is equal to $10,600 per system, leaving $2,800 of the installed cost to the Participant to finance.

The net present value for Vermont's incentive program participants compared to the willingness to pay for both LMI and non-LMI survey respondents is shown in Figure 14.

Figure 14. Connecticut Willingness to Pay for Battery Storage in Comparison to the Net Present Value to

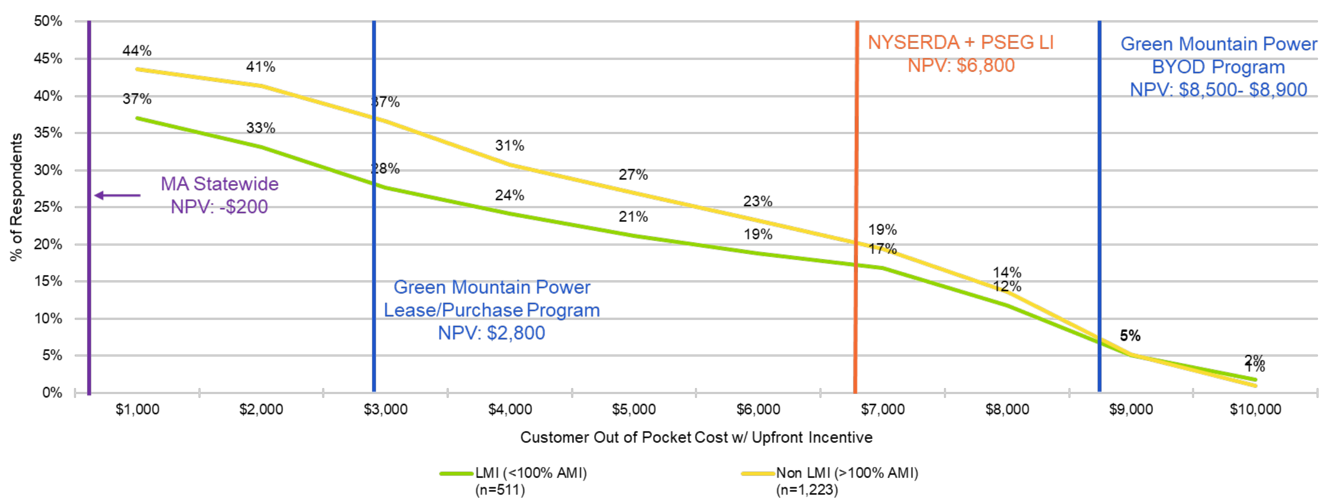
Customer after Vermont's Incentives



Note: Respondents who reported needing more information before deciding how much they are willing to pay are counted as not willing to pay at any price. The WTP curves presented assume a customer is willing to pay at any price up to their maximum WTP value.

The Green Bank, based on the findings of the Survey with respect to customer willingness to pay for battery storage based on income, in conjunction with "best practice" battery storage incentive programs from other Northeastern states, is identifying appropriate incentive levels for the Program – see Figure 15.

Figure 15. Willingness to Pay for Storage by Income Class in Connecticut vs. Best Practice Battery Storage Incentive Programs in the Northeast (i.e., Massachusetts, New York, and Vermont)



Note: Respondents who reported needing more information before deciding how much they are willing to pay are counted as not willing to pay at any price. The WTP curves presented assume a customer is willing to pay at any price up to their maximum WTP value.

D. Compensation Level

D.1.	Provide a methodology for calculating the compensation level, including the

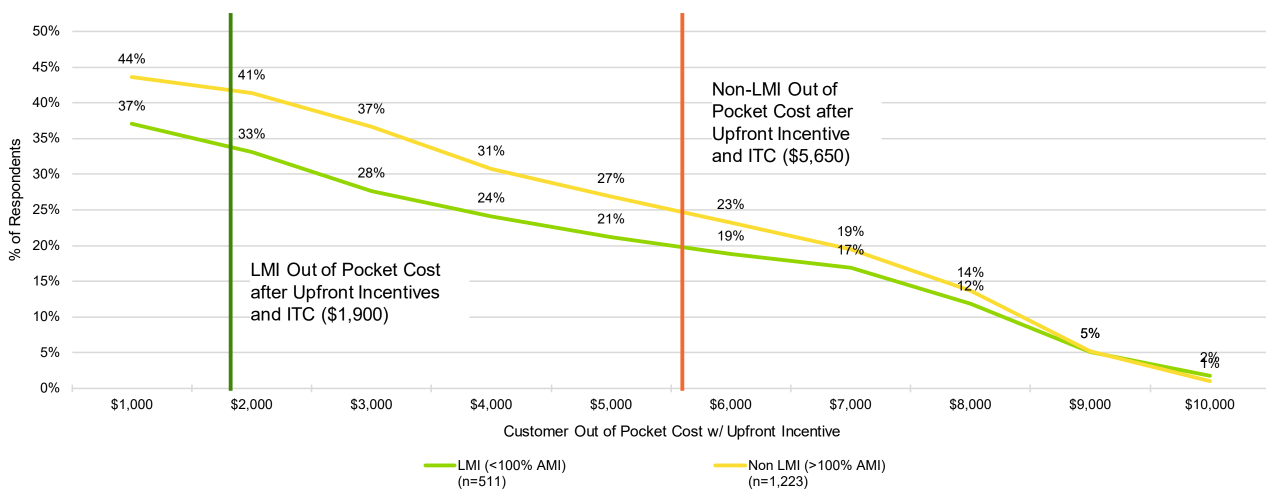
> units used to calculate such compensation (e.g., compensation based on energy, kWh, or power, kW);

The compensation level was calculated by utilizing both the Survey, as well as the results from the cost-benefit analysis, specifically the Participant Cost Test ("PCT").

The findings of the Survey indicated the following information with respect to the compensation type (i.e., upfront or performance-based incentive) and level (i.e., amount):

- Respondents are interested in multiple types of compensation. Of the former RSIP participant Survey respondents, 95% are interested in receiving an upfront incentive[47]. Respondents are also interested in the performance-based incentive (i.e., 83% of respondents), and 29% of respondents indicated they would be much more likely to buy a battery storage system if the performance-based incentive were available in addition to an upfront incentive.[48]
- Of respondents who have a preference for receiving either an upfront or performance-based incentive, 78% would prefer to receive only an upfront incentive as opposed to only a performance-based incentive[49].
- 25% of Non-LMI respondents report that they are willing to pay at the starting customer out of pocket cost of $5,650 in the proposed program design, which includes an upfront incentive and the ITC, see Figure 16.
- 34% of LMI respondents report being willing to pay at the starting customer out of pocket cost of $1,900 in the proposed program design, which includes an upfront incentive and the ITC, see Figure 16.

Figure 16: Willingness to Pay for Storage by Income Class in Connecticut Compared to Starting Customer Out of Pocket Cost with Upfront Incentive and ITC



Note: Respondents who reported needing more information before deciding how much they are willing to pay are counted as not willing to pay at any price. The WTP curves presented assume a customer is willing to pay at any price up to their maximum WTP value.

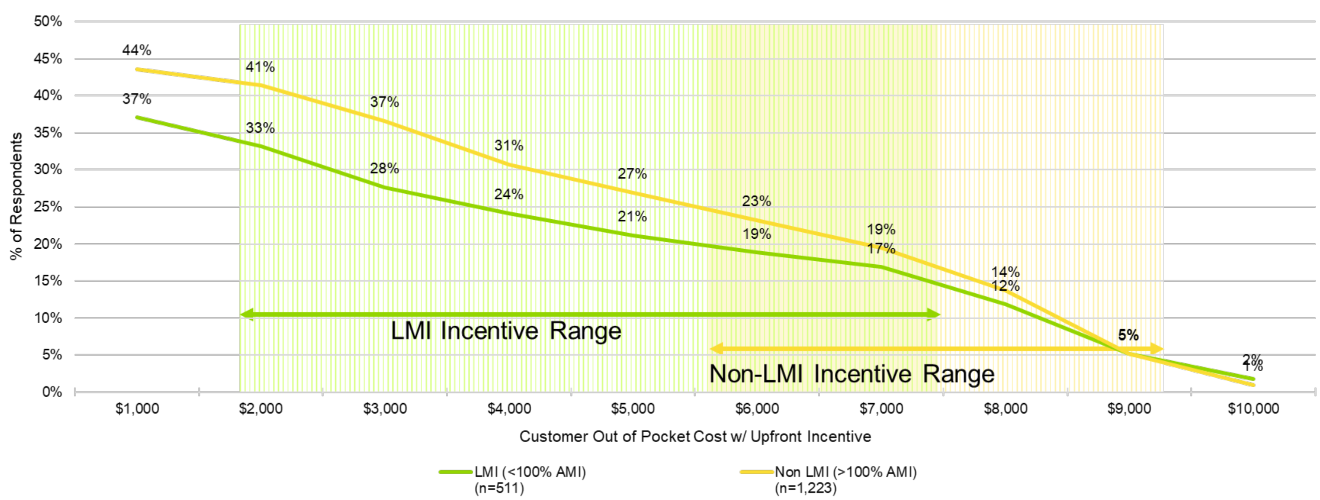
[47] See Appendix 1 response to Question 23; n=1,172
[48] See Appendix 1 response to Question 29, Question 30 and Question 31; n=1,727
[49] See Appendix 1 response to Question 32a; n=1,727

The Survey findings informed the calculations of the compensation levels for the upfront and performance-based incentives in order to get the Participants to deploy battery storage in combination with their solar PV system. The compensation level for the upfront incentive is calculated based primarily on the usable energy capacity (kWh) of the battery, adjusted to account for the battery's maximum power output rating (kW) and the size of the associated PV system (kW). For the compensation level in $/kWh for each capacity block for the upfront declining incentive structure – see Table 6 and Figure 17.

Table 6. Declining Compensation Levels for Upfront Incentive for Non-LMI and LMI Participants and Total Incentives

Incentive Step	**Non-LMI Compensation** ($/kWh)	**Estimate of Non-LMI Compensation per System**	**LMI Compensation** ($/kWh)	**Estimate of LMI Compensation per System**	**Estimate of Total Upfront Battery Storage Incentives**[50]
1	$280	$3,750	$560	$7,500	$1,575,000
2	$240	$3,250	$480	$6,500	$2,388,750
3	$200	$2,750	$410	$5,500	$3,753,750
4	$170	$2,250	$330	$4,500	$6,142,500
5	$130	$1,750	$260	$3,500	$9,187,500
Total					**$23,047,500**

Figure 17. Willingness to Pay for Storage by Income Class in Connecticut with Proposed Upfront Declining Incentive Levels for the Program



Note: Respondents who reported needing more information before deciding how much they are willing to pay are counted as not willing to pay at any price. The WTP curves presented assume a customer is willing to pay at any price up to their maximum WTP value.

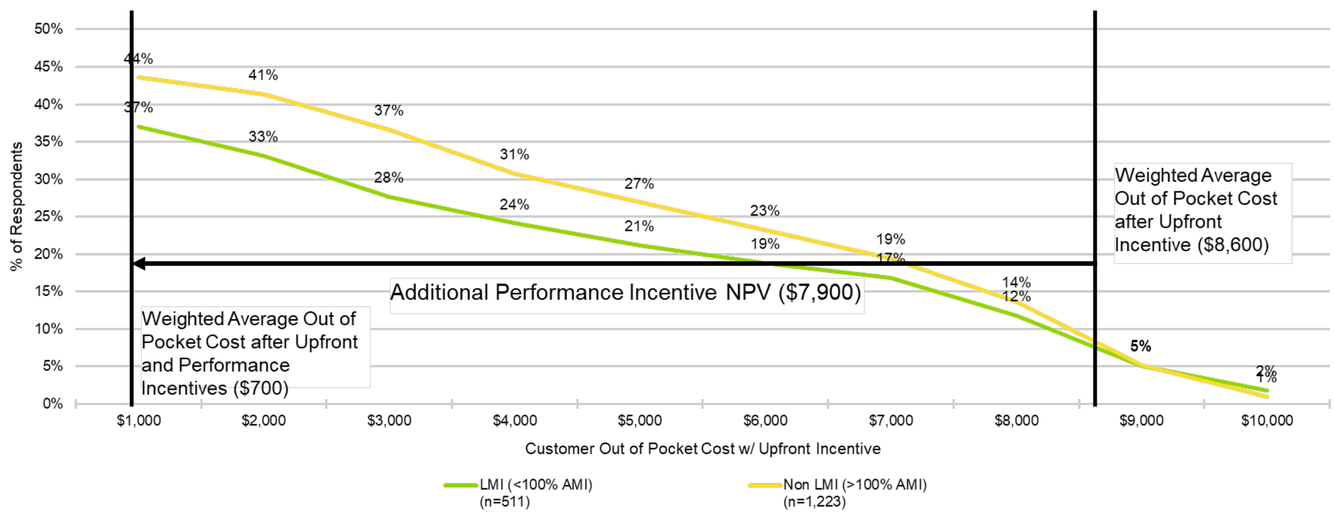
The compensation level for the performance-based incentive is based on the average kilowatt (kW) used per demand response event, averaged over the season. There are two seasons customers can enroll in, the summer and the winter. This proposal assumes the same compensation level as in Eversource's Connected Solutions Demand Response program, where the incentive per average kW used is $225/kW in the summer, however

[50] Assumes the battery storage systems are 95% from non-LMI and 5% are from LMI

the Program didn't assume the winter season incentive of $50/kW.

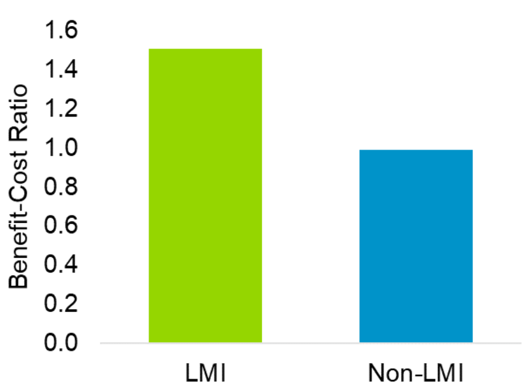
The compensation levels for the upfront incentive from the Green Bank, in combination with the performance-based incentive from the EDCs, are key factors in not only ensuring that customer demand is created for the System through the Program (see Figure 18), but also to evaluate and optimize the Benefit-Cost ratio for the Program's non-LMI and LMI participants (see Figure 19). The PCT benefit-cost ratio is at approximately 1.0 for the non-LMI participants, while about 1.5 for the LMI participants which ensures that the compensation levels will create benefit for program participants and encourage adoption.

Figure 18. Willingness to Pay for Storage by Income Class in Connecticut with Proposed Upfront and Performance-Based Incentive Levels for the Program



Note: Respondents who reported needing more information before deciding how much they are willing to pay are counted as not willing to pay at any price. The WTP curves presented assume a customer is willing to pay at any price up to their maximum WTP value.

Figure 19. Participant Cost Test for the Program - LMI vs. Non-LMI Households



See Section J for further information about the Cost-Benefit Analysis.

D.2.	Provide rationale for such calculation methodology;

The PCT considers the costs and benefits specific to the program participant, so is the best mechanism to determine if the compensation level for the upfront incentive is sufficient enough to create demand for battery storage.

The Survey also informs that the calculated compensation levels are in the range of what potential participants would expect based on their responses,[51] and "best practice" programs in the Northeast were also considered in the program design.

D.3.	Explain how the compensation level will change based on storage performance, over time, MW deployed, or with changes to technology costs (i.e., incentive / compensation "blocks" or "steps");

The compensation level will decline in each upfront incentive capacity block, while remaining the same for the ongoing performance-based incentive over a 10-year period. The upfront incentive will be the highest in the first step of the Program, when the costs of energy storage systems are expected to be the highest. It is expected that the Program will increase market deployment of battery storage, improving the maturation of the industry (i.e., fostering the sustained orderly development of a local battery storage industry), which will result in a decrease in the installed costs of the Systems over time.

Thus, the upfront incentive compensation will decrease over the course of the program with the benefits to the Participant continuing to outweigh the costs, while the performance-based incentive will remain the same. See Table 7 for the compensation level for each capacity block at a declining rate from $280/kWh to $130/kWh for non-LMI and $560/kWh to $$260/kWh for LMI over the 5 incentive steps and a fixed $225/kW for the summer season for 10 years for the performance-based incentive.

Table 7. Proposed Compensation Level for Non-LMI and LMI Participants for the Upfront and Performance-Based Incentives

Incentive Step	**Effective Non-LMI Upfront Incentive** ($/kWh)	**Effective LMI Upfront Incentive** ($/kWh)	**Average Upfront Battery Storage Incentive per System**	**Performance Based Incentive Over Time Summer Season** ($/kW)	**Nominal Value of Ongoing Performance Based Incentive**	**Nominal Value of Upfront and Performance Based Incentives per Participant**
1	$280	$560	$3,950	$225	$11,250	$15,200
2	$240	$480	$3,400	$225	$11,250	$14,650
3	$200	$410	$2,900	$225	$11,250	$14,150
4	$170	$330	$2,350	$225	$11,250	$13,600
5	$130	$260	$1,850	$225	$11,250	$13,100
Total			**$2,300**		**$11,250**	

As seen through the implementation of the RSIP, this type of orderly declining incentive

[51] See Appendix 1 Willingness to Pay Figures.

block structure for upfront incentives will support the maturation of the local industry, while decreasing the market's overall reliance on the need for incentives to create customer demand for the technology over time.

D.4.	Explain how any changes to the compensation level will be identified and/or implemented and whether those changes should be determined at the beginning of the program or adapted over time through an Authority-led program review;

Passive Dispatch – Upfront Declining Incentive Block Structure
Compensation levels change for the upfront declining incentive block structure when the installed capacity of the step is met – see Table 8.

Table 8. Upfront Declining Incentive Block Structure for the Program

Incentive Step	**Capacity Block** (MW)
1	2.0
2	3.5
3	6.5
4	13.0
5	25.0
Total	**50.0**

Typically, based on experience administering a successful declining incentive block structure, steps are clearly identified in the Program (e.g., 3.5 MW block for Step 2). As the Program receives applications within each step, those applications are tracked and disclosed to market participants on an ongoing basis so that they can see where the step currently stands in terms of obligations for incentives to the cap on the step (e.g., the Program is currently at 2.5 MW of the 3.5 MW block in Step 2). As the incentive obligations approach the cap on the step (e.g., 15% of the Step 2 block is left – approximately 0.5 MW of incentives at these levels are still available), the Green Bank would (1) set a date for the start of the subsequent step (e.g., first day of the next month), and (2) notify the market that the current step will end on a specific date (e.g., last day of the current month) and the subsequent step will begin the day after (e.g., first day of the next month). Applications then received before the end of the month receive the level of incentive in that step (e.g., Step 2), while those applications received after that receive the level of incentive in the subsequent step (e.g., Step 3).

If there is the need to change the level of incentive in a step because demand is low, or there is slower than anticipated progress towards the Target, then the Green Bank would issue a Request for Consideration to PURA for an adjustment to the upfront incentive level. The Green Bank would need to provide all of the relevant information to support its rationale and subsequent recommendation. Through the Green Bank's administration of the RSIP, it asked its Deployment Committee, then Board of Directors, and finally DEEP in 2015 to approve of an increase in incentives within its incentive block structure, but that was the creation of a specific type of incentive (i.e., performance-based incentive for LMI or

LMI-PBI) to enable residential solar PV to be deployed in LMI households. With respect to the Program, the Green Bank would ask the Joint Committee, then Deployment Committee, then Board of Directors, and finally PURA to approve of a change in the upfront declining incentive block structure.

Active Dispatch – Ongoing Performance-Based Incentive

In terms of the compensation level for the ongoing performance-based incentive, this would be set by the EDCs. The incentive would need to clearly state the level, time, and number of events to receive the incentive (e.g., $225/kW for summer season for 30 to 60 events for each of the next 5 to 10 years). Modelled after the Connected Solutions Demand Response Program in Massachusetts, the present value of the performance-based incentive over ten years is quite high, resulting in a limited contribution from the Participant in self-financing the battery storage system.

The Green Bank would envision that the EDCs would have to work through a similar process if they were going to change the ongoing performance-based incentive, including asking the Joint Committee, then the Residential Committee, then the Energy Efficiency Board, and finally PURA.

D.5.	Describe any penalties for non-performance under this proposal and to whom the penalties would accrue;

Passive Dispatch – Upfront Declining Incentive Block Structure

The required passive dispatch settings ensure that the energy storage systems will perform during the ISO-NE summer peak period. There will be ongoing verification to review the savings and update the passive dispatch settings if necessary. The storage system vendor can force an update to customer overrides as well – resetting the battery to the default setting for the Program. The terms and conditions requirement for the default settings will be provided to the Participants. If the default settings are not being adhered to, then the ongoing performance-based incentives may be revoked.

The Green Bank proposes to seek cost recovery so long as the passive dispatch default settings are demonstrating fecundity in following the automatic “set it and forget it” dispatch as was envisioned by the Program. The Green Bank recognizes that the initial conditions in the marketplace for new battery storage systems being installed through upfront incentive programs in Connecticut may not go as smoothly as anticipated. However, the Green Bank will rely on its experience in administering the RSIP to ensure that the Program is delivering its intended design and make data-driven decisions during the Program’s implementation – see response below in I2.

Active Dispatch – Ongoing Performance-Based Incentive

If, during an active dispatch event, the energy storage system cannot discharge (e.g., does not have enough charge to contribute to a particular peak event), then the Participant will not be compensated for the performance-based incentive in support of active demand response from the EDCs. The performance-based incentives are calculated at the end of the season and verified through EM&V.

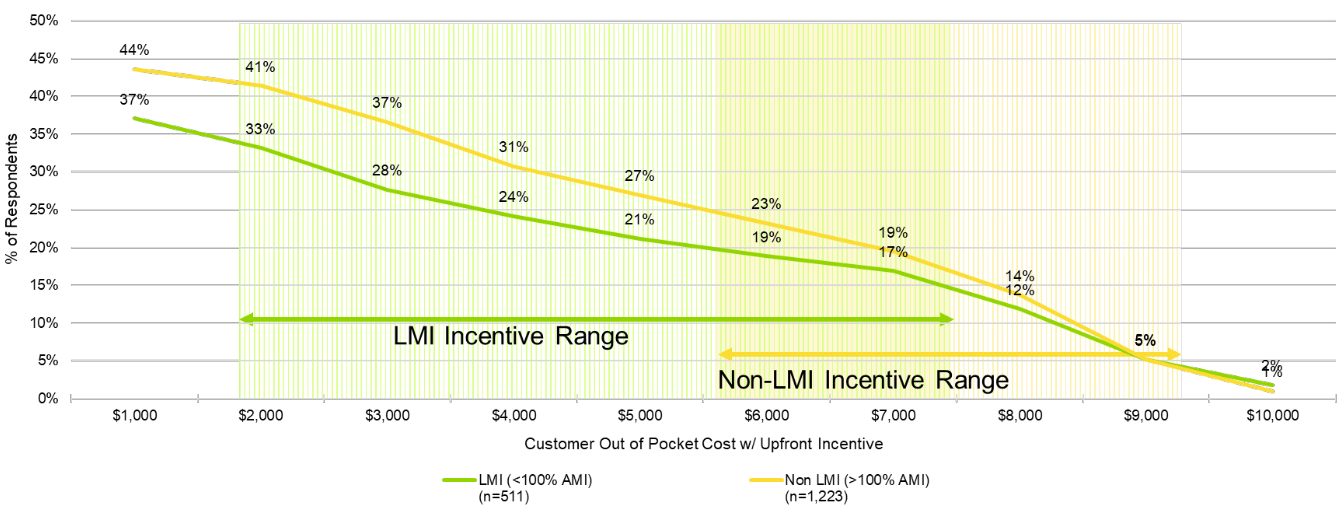
D.6.	Explain why the proposed compensation level will be sufficient to encourage adoption by eligible customers to develop a state-based energy storage market; and

The compensation levels have been determined by a combination of the findings of the Survey, the optimization of incentive levels within the benefit-cost analyses, and are comparable to "best practice" energy storage programs in the Northeast based on a net present value basis of the upfront incentives and the ongoing performance-based incentives over time.

Upfront Declining Incentive Block Structure

The proposed upfront declining incentive block structure for LMI and non-LMI customers will create demand for battery storage in combination with behind-the-meter residential solar PV for customers in various income bands – see Figure 20 and Table 9.

Figure 20. Proposed Upfront Declining Incentive Block Structure for Solarize Storage in Comparison to Willingness to Pay



Note: Respondents who reported needing more information before deciding how much they are willing to pay are counted as not willing to pay at any price. The WTP curves presented assume a customer is willing to pay at any price up to their maximum WTP value.

Table 9. Willingness to Pay per Unit of Incentive and the Associated PCT

Incentive Block	Non-LMI Customers			LMI Customers		
	Effective per Unit Incentive[52]	Percent of Survey Respondents Willing to Pay at Upfront Incentive	PCT[53]	Effective per Unit Incentive	Percent of Survey Respondents Willing to Pay at Upfront Incentive Level	PCT
1	$3,750	25%	1.12	$7,500	34%	1.77
2	$3,250	15%	0.99	$6,500	23%	1.67
3	$2,750	12%	0.99	$5,500	20%	1.58
4	$2,250	7%	0.98	$4,500	18%	1.50
5	$1,750	4%	0.98	$3,500	14%	1.44

Figure 20 and Table 9 show the Survey findings in terms of willingness to pay, in conjunction with the proposed level of incentive and the resulting PCT of the potential non-LMI and LMI participants. Out of pocket costs after the upfront incentive and ITC range from $5,700 to $9,300 for Non-LMI customers and $1,900 to $7,500 for LMI customers.

When applied to the current Green Bank RSIP and Smart-E participant population, and assuming there is untapped market potential for solar plus storage amongst residents who have not previously participated in these Green Bank program, the willingness to pay results suggest the target number of participants and capacity within each incentive block are achievable. This finding is further substantiated by the range of the participant net present value for "best practices" programs within which the Green Bank's participant net present value lies – see Figure 20 above.

The initial upfront incentive blocks serve as a catalyst to get non-LMI customers (i.e., 25 percent willingness to pay at Step 1) and LMI customers (i.e., 34 percent willingness to pay at Step 1) to want to purchase and install battery storage. These small incentive blocks also serve to increase contractor experience with integrating residential solar PV with battery storage at a higher level of incentive. As the market continues to mature, incentives are reduced, making the market less-and-less reliant on the need for upfront incentives.

Performance-Based Incentive

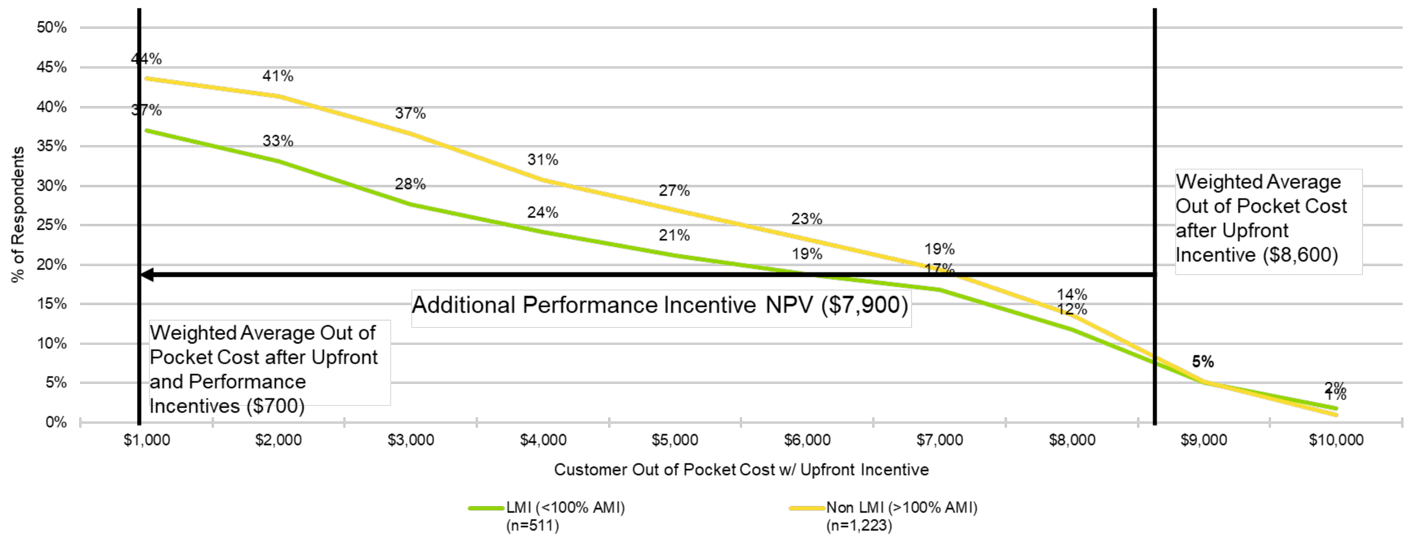
Modelled after the Connected Solutions Demand Response Program in Massachusetts, the present value of the performance-based incentive is quite high, resulting in a limited contribution from the Participant in self-financing the battery storage system – see Figure 21.

Figure 21. Proposed Present Value of the Performance-Based Incentive for Solarize Storage in Comparison to

[52] Assumes first incentive block occurs in 2021 and participants receive ITC value of 22%, equating to $1,705.

[53] Assumes Tesla Powerwall material and install costs.

Willingness to Pay



Note: Respondents who reported needing more information before deciding how much they are willing to pay are counted as not willing to pay at any price. The WTP curves presented assume a customer is willing to pay at any price up to their maximum WTP value.

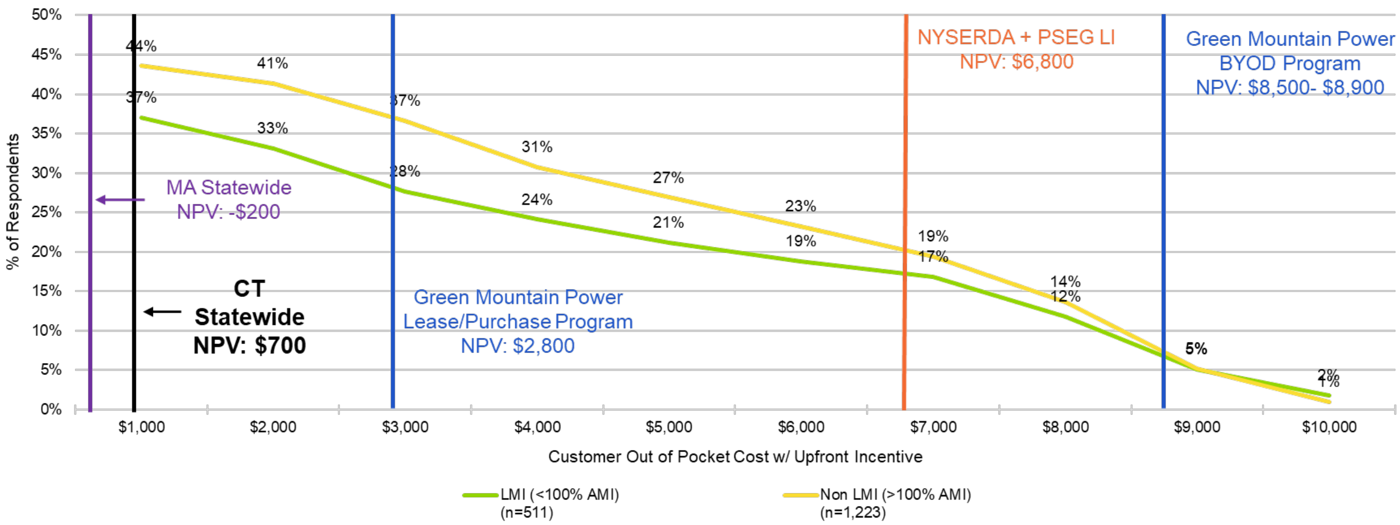
Figure 21 shows the Survey findings in terms of willingness to pay and provides an illustration of the potential perceived value of the performance-based incentive to the customer in their battery storage purchasing decision, assuming a ten-year payment stream. Albeit a significant incentive level on a net present value basis, using the current Connected Solutions Program ongoing performance-based incentive of $225/kW will further bolster customer interest when paired with the upfront incentive.

<u>Combination of Upfront Declining Incentive Block Structure and Performance-Based Incentives Over Time</u>

The combination of these two types of compensation (i.e., present value of the upfront and ongoing performance-based incentive) result in a program that the Green Bank believes will encourage adoption by customers to achieve the Target – see Figure 22.

Figure 22. Solarize Storage Incentive Level Comparison for Northeastern Region Battery Storage Programs to

Willingness to Pay for Battery Storage in Connecticut



Note: Respondents who reported needing more information before deciding how much they are willing to pay are counted as not willing to pay at any price. The WTP curves presented assume a customer is willing to pay at any price up to their maximum WTP value.

Consideration should be given to reducing the level of performance-based incentive by the EDCs using the Connecticut Solutions Demand Response Program levels, which appear to be substantial and more than is necessary to stimulate demand for battery storage. In discussions with the EDCs, they had felt using the Massachusetts performance-based incentive levels was a good place to start, however, the Green Bank would suggest that moving the net present value of incentives for battery storage to the right (i.e., reducing the incentive level towards New York and Vermont), should be considered.

Additionally, the responses from the survey indicate that customers are interested in paying for battery storage at the estimated out of pocket cost after the upfront incentive and ITC are applied.

D.7.	Explain how the proposed support for participation from LMI customers and underserved communities will be sufficient to overcome the additional barriers experienced by these customers and communities.

The Green Bank has successfully implemented programs that support the adoption of high upfront capital cost technologies by LMI customers, including:

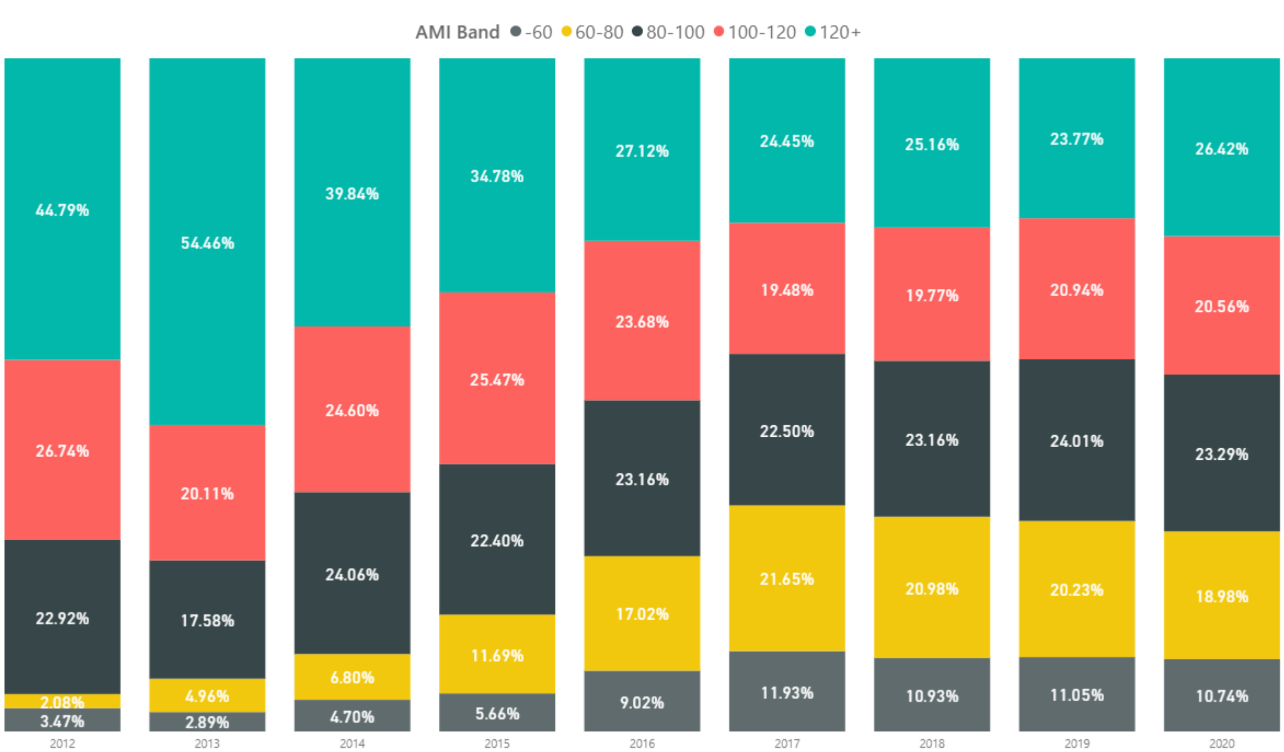
- **<u>LMI-PBI</u>** – developing an additional performance-based incentive under the RSIP for LMI participants to access residential solar PV through a lease or PPA-based financing structure. For example, in Step 15 of the RSIP, there is a $0.030/kWh performance-based incentive for non-LMI (i.e., equivalent to a $13 ZREC price) and $0.081/kWh low-to-moderate-income performance-based incentive (i.e., equivalent to a $36 ZREC price). Eligible TPO's must be qualified by the Green Bank to participate in the LMI-PBI.[54]

- **Solar for All** – an initiative of the Green Bank and PosiGen, this community-based social marketing campaign brings residential solar PV and energy efficiency lease financing to LMI communities. The Green Bank identified PosiGen through an RFP it issued in June of 2015.[55]

  Based on a research study for the Green Bank pending final review,[56] the Green Bank and Vermont Energy Investment Corporation ("VEIC") estimate that on average $1,090 of the $1,400 energy affordability gap for LMI families is eliminated as a result of the Solar for All program and product.

These programs, along with continuous communication to solar PV contractors and local lenders regarding the strong credit quality of LMI families in Connecticut, increased the deployment of residential solar PV in less than 80 percent AMI bands – see Figure 23.[57]

Figure 23. Distribution of Approved RSIP Projects by Metropolitan Statistical Area (MSA) and AMI Bands



The Program will include an additional upfront incentive for LMI families to encourage adoption and reduce financial barriers. The compensation addition was calculated to result

[54] https://www.ctgreenbank.com/wp-content/uploads/2017/10/LMI-Incentive-Contractor-RFQ-101017.pdf
[55] https://ctgreenbank.com/wp-content/uploads/2015/12/Resi-Solar-Financing-RFP_Reissue_FINAL1.pdf
[56] "Mapping Household Energy & Transportation Affordability in Connecticut" by VEIC as research for the Green Bank (forthcoming)
[57] Tentative results reported to the Board of Directors of the Green Bank on July 24, 2020 for FY 2020, but actual for fiscal years prior.

in a benefit-cost ratio for LMI customers about 50% greater than that of non-LMI customers. Additionally, the TPO model with lease payments alleviates the barrier of the upfront cost of the battery storage system.

E. Ownership Model

E.1.	Discuss which parties under this proposal would be allowed to own electric storage devices: the EDCs, customers, or a third-party, or some combination thereof. Provide the rationale for the inclusion or exclusion of any of the three groups listed;

The Program allows homeowners, TPOs, and the EDCs the ability to own electric storage devices that follow both the passive and active dispatch of electric storage for receiving an upfront incentive and ongoing performance-based incentive – see Table 10.

Table 10. Party Ownership and Control of Battery Storage

Parties	Ownership	Control / Coordinate Passive Dispatch		Control / Enable Active Dispatch	
		Green Bank	EDC	EDC	TPO
EDCs	Yes	-	Yes	Yes	-
Customers	Yes	Yes	-	Yes[58]	-
TPOs	Yes	Yes	-	Yes	Yes

Like solar PV, customers and TPO's would be the owners of the incented battery storage systems. In addition to TPO leased systems, the Green Bank also supports EDC ownership and lease of systems to customers under the condition that (1) the EDC is using advanced metering infrastructure ("AMI") to support the transition from net metering to a tariff, (2) installed costs for the systems leased by the EDC is publicly disclosed, and (3) ensuring that fair, transparent, and competitive markets are being enabled. In exchange for receiving the upfront and ongoing performance-based incentives, the customer or TPO must allow for the automatic programming of a passive "set it and forget it" dispatch of the battery (i.e., ISO-NE summer peak hours) and allow the EDCs (or TPOs in coordination with the EDCs) to actively dispatch the system pursuant to a formal active demand response program. For leased systems owned by the EDC(s), the EDC would control the system with respect to passive and active dispatch settings.

E.1.1.	Under the proposed ownership model(s), explain which party or parties would have ownership of the attributes and monetizable benefits associated with the storage system, including but not limited to environmental attributes (e.g., renewable energy credits), energy, capacity, and tax incentives;

If the storage system(s) installed were stand-alone (i.e., does not include solar PV supported through the RSIP), then the ownership of attributes and monetizable benefits associated with the storage system reside through contracts between the respective parties (e.g., TPO and homeowner, EDC and homeowner). However, since the System

[58] With households leasing the battery storage system from the EDC

within the proposed Program includes many residential solar PV systems supported through the RSIP in combination with battery storage, it is important to differentiate the ownership of the attributes and monetizable benefits associated with the storage system.

<u>RSIP Terms and Conditions – Energy and Environmental Attributes</u>
Under the RSIP's Terms and Conditions for sales contracts between Homeowners and Contractors,[59] as well as lease and power purchase agreements between Homeowners and TPO's,[60] the ownership of the System attributes is clearly outlined in the "Guidelines for Renewable Energy Claims, RECs, and Other Tradable Energy or Environmental-Related Commodities."[61] If battery storage is "associated with the PV system" (e.g., the participating RSIP customer receives the value of the federal ITC for battery storage because it is combined with the solar PV system, solar PV system is feeding power into the battery, etc.), then the Green Bank is "entitled to all RECs and any other tradable energy or environmental-related commodity produced by or associated with the PV system during its useful life."[62]

<u>REC Transfer of Ownership from Green Bank to EDCs – Environmental Attributes</u>
Through CGS 16-245gg, the Green Bank sells RECs created through the RSIP to the EDCs through a 15-year Master Purchase Agreement ("MPA") to (1) enable the Green Bank's cost-recovery for administering the RSIP, and (2) support the EDC compliance to the Class I Renewable Portfolio Standard ("RPS") through the purchase of Renewable Energy Credits ("RECs"). Under the MPA, the Green Bank (i.e., the Seller), sells RECs created through the RSIP to the EDCs (i.e., the Buyers). The MPA defines RECs,[63] which includes Environmental Attributes. The MPA defines Environmental Attributes,[64] which

[59] Each sales contract is signed by an Eligible Contractor and the Homeowner, and includes the Green Bank Terms and Conditions.
[60] Each lease and PPA contract is signed by the TPO and the Homeowner, and includes the Green Bank Terms and Conditions.
[61] "The Green Bank shall be entitled to all Renewable Energy Certificates (RECs) and any other tradeable energy or environmental-related commodity produced by or associated with the PV system during its useful life, including but not limited to greenhouse gas credits, emissions credits, tradable carbon credits, and all other types of tradable project-related commodities however named that are presently known or designated or created in the future." (as provided in the RSIP RFQ and Program Guidelines, https://ctgreenbank.com/wp-content/uploads/2019/11/Contractor-RFQ_112019_Final.pdf, and RSIP standalone Terms and Conditions, http://www.ctgreenbank.com/wp-content/uploads/2017/11/RSIP-Combined-TC_110116_Ext.pdf.)
[62] RSIP contracts including terms and conditions were provided to PURA for every 50th project through the SHREC Class 1 certification process.
[63] Connecticut Class I Renewable Energy Credits means certain NEPOOL GIS Certificates and any and all other Environmental Attributes derived from the production of a generation facility that has been qualified by the Authority [PURA] as a Connecticut Class I renewable energy source under CGS 16(a)(20), and shall represent title to an claim over all Environmental Attributes associated with the specified MWh of generation from such Connecticut Class I renewable resource. If the SHREC Project ceases to qualify as a Connecticut Class I renewable resource solely as a result of a change in law and Seller is unable, using commercially reasonable efforts, to continue the SHREC Project's qualification as a Connecticut Class I renewable resource after that change in law, then "Connecticut Class I Renewable Energy Credits" shall mean Environmental Attributes including any certificates or credits related thereto reflecting generation by the SHREC Project, all of which shall be transferred solely to Buyer.
[64] Environmental Attributes excludes electric energy and capacity produced, but means any other emissions, air quality, or other environmental attribute, aspect, characteristic, claim, credit, benefit, reduction, offset or allowance, howsoever entitled or designated, resulting from, attributable to or associated with the generation of energy by a qualifying residential solar photovoltaic system as defined in the Energy Act, whether existing as of the Effective Date or in the future, and whether as a result of any present or future local, state, or federal laws or regulations or local, state, national, or international voluntary program, as well as any and all generation attributes under the Connecticut RPS regulations and under any an all other international, federal, state, or other law, rule, regulation, bylaw, treaty or intergovernmental compact, decision, administrative decision, program (including any voluntary compliance or membership program), competitive market or business method (including all credits, certificates, benefits,

does not include Energy Attributes.

Green Bank Participation in ISO-NE Forward Capacity Markets – Energy and Capacity Attributes

Separate from RECs, the Green Bank has partnered with C-Power through a Master Services Agreement ("MSA"), to aggregate forward capacity resulting from the RSIP, to participate in ISO-NE's On-Peak Hours Resource Program within the Forward Capacity Market.[65] The first residential solar PV system assets were enrolled in the Forward Capacity Market by C-Power for the 2018-2019 electricity year (i.e., commencing June 1, 2018). This enrollment included a maximum monthly total of 12.7 MW of residential solar PV systems in July of 2019. Subsequently, a maximum monthly total of 24.4 MW and 28.5 MW of residential solar PV systems were enrolled for the summers of 2020 and 2021, respectively, by C-Power on behalf of the Green Bank.

These assets are enrolled for a 20-year term and earn capacity payments simply by being online and generating electricity during the Summer performance period (i.e., hours of 1:00 to 5:00 p.m., non-holiday weekdays during the months of June through August).

The On-Peak Hours Resource Program is for passive demand resources, which means that there is no curtailment requirement or indeed any changes required to how the resource operates. Prior to the Green Bank's participation in the ISO-NE program, ISO-NE had never previously allowed the enrollment of residential solar PV only assets,[66] but because the Green Bank was able to demonstrate the strict reporting requirements using AlsoEnergy's LocusNOC data platform it operates for the RSIP, ISO-NE has allowed the enrollment of residential solar PV assets that received approval to energize after June 8, 2018.

Homeowner and Third-Party Owner – Tax Incentives

For a description of the ownership of Federal Tax Incentives for Energy Storage Systems for Homeowners and Third-Party Owners – see NREL fact sheet.[67]

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and emission measurements, reductions, offsets ad allowances related thereto) that are attributable, now or in the future; and further, means: (a) any such credits, certificates, benefits, offsets, and allowances computed on the basis of the SHREC Project's generation using renewable technology or displacement of fossil-fuel derived or other conventional energy generation; (b) any Certificates issued pursuant to the NEPOOL GIS in connection with energy generated by a SHREC project; and (c) any voluntary emission reduction credits obtained or obtainable by the Seller in connection with the generation of energy by a SHREC Project; provided, however, that Environmental Attributes shall not include: (i) any production tax credits, (ii) any investment tax credits or other tax credits associated with the construction or ownership of a SHREC project; or (iii) any state, federal, or private grants relating to the construction or ownership of a SHREC Project or output thereof. If during the Delivery Period, a change in the laws or regulations occurs that creates value in Environmental Attributes, then at Buyer's request, Seller shall cooperate with Buyer to register such Environmental Attributes or take other action necessary to obtain the value of such Environmental Attributes for Buyer.

[65] C-Power takes on the administrative work of enrolling the aggregated residential solar PV assets, bidding for the Capacity Supply Obligations in future Forward Capacity Auctions, monitors and manages the performance of these assets, submits asset performance information to ISO-NE, and remits capacity payments to the Green Bank.

[66] On February 17, 2019, SunRun successfully bid residential solar PV and battery storage in ISO-NE capacity markets - https://www.globenewswire.com/news-release/2019/02/07/1712238/0/en/ISO-New-England-Awards-Sunrun-Landmark-Wholesale-Capacity-Contract.html

[67] https://www.nrel.gov/docs/fy18osti/70384.pdf

Essentially, energy storage systems are ineligible for the Investment Tax Credit ("ITC"), unless the system is installed on, and charged exclusively by, an existing or new solar PV system.

Ownership of Attributes and Monetizable Benefits
The System, proposed by the Program, connects behind-the-meter residential solar PV with battery storage to increase participant, ratepayer, and societal benefits.

In terms of the ownership of environmental attributes associated with the System, the EDCs own Solar Home RECs (SHRECs) through a Master Purchase Agreement (MPA) with the Green Bank for projects that have been included in a SHREC Tranche, whereby the EDCs purchase the SHRECs provided through the RSIP, which contain all Environmental Attributes associated with the residential solar PV systems.

In terms of the ownership of the energy and capacity attributes associated with the System, the Green Bank owns them through the contract it has indirectly between the Contractor and the Homeowner and indirectly with the Third-Party Owners through the RSIP Terms and Conditions, which contain "any other tradeable energy or environmental-related commodity produced by or associated with the PV system during its useful life".

In terms of federal tax credits, as long as battery storage is being combined with residential solar PV (i.e., battery storage is associated with solar PV), then the Homeowner, TPOs, or EDCs own the value of the investment tax credits.

E.1.2.	Explain how co-locating or coupling a storage system under this proposal with other new or existing energy resources impacts the ownership of the associated attributes and monetizable benefits for both the new storage system and the new or existing distributed energy resource;

By combining the residential solar PV system installed through the RSIP, with battery storage through the Program, the Homeowner, TPO, or EDCs will be able to access the federal investment tax credit to offset the cost of the battery storage system improving the PCT. Battery storage alone has not been demonstrated to be eligible for the federal investment tax credit, however battery storage added onto an existing or a new solar PV system is eligible to receive the federal investment tax credit.

As noted above, if battery storage is "associated with the PV system," then the Green Bank is "entitled to all RECs and any other tradable energy or environmental-related commodity produced by or associated with the PV system during its useful life" so long as battery storage is installed on a solar PV system supported through the RSIP.

The Program proposed by the Green Bank would enable 50 MW of battery storage that can be used for emergency back-up, as well as passively and actively dispatched, in combination with at least 350 MW of behind the meter residential solar PV, to increase benefits to participants, ratepayers, and society.

E.1.3.	Explain how the proposed ownership model(s) impacts the value streams the storage system can provide and/or participate under; and

In terms of the three (3) ownership models proposed by the Green Bank through the Program, the following is a breakdown of the value streams the storage systems can provide or participate under – see Table 11.

Table 11. Value Stream Available to Various Owners of Battery Storage Systems in Combination with Solar PV

Value Streams	Customer	EDCs	TPO
Energy Attributes (e.g., ISO-NE)[68]	X	X	X
Environmental Attributes (e.g., RPS)		X	
Investment Tax Credit	X[69]	X[70]	X
Modified Accelerated Cost Recovery System		X[71]	X

It should be noted that the Green Bank would consider transferring ownership of the energy attributes (e.g., capacity rights) from the solar PV system(s) to the customers, EDCs and TPOs, if ownership of the solar PV system attributes is needed to enable participation of the battery storage in retail or wholesale market programs, in exchange for cost recovery for its administration of the upfront declining incentive block portion of the Program.

E.1.4.	Explain how the proposed ownership model(s) may impact the eligibility of new storage systems for current and proposed federal tax incentives, including a potential federal tax incentive for standalone energy storage.

To be eligible for the upfront incentive from the Green Bank for the Program, battery storage would need to be paired with solar PV and would therefore be eligible for federal tax incentives.

EDCs would likely allow standalone energy storage to participate in their active demand response program – under current rules, standalone storage would not be eligible for federal tax incentives.

E.2.	Explain whether the proposed ownership model(s) would affect, positively or negatively, utility operations, including how third-party owners would coordinate with the EDCs, if applicable to this proposal.[72] Provide the accompanying rationale for such explanation; and

[68] Through the Program, the Green Bank would forfeit its rights to any energy benefits resulting from a combined RSIP and battery storage system, and instead receive cost recovery for administering the Program.
[69] Only through 2021
[70] Only if the EDC(s) have their own lease program
[71] Ibid
[72] Respondents need not respond to the specific question of coordinating with the EDCs if the answer is provided later in this proposal. Respondents may simply reference the location of the response later in the proposal.

TPOs could access both an upfront and a performance-based incentive and pass the benefits on to homeowners, for example through only a small increase in a monthly lease payment for solar PV plus battery storage, while recovering their cost through ongoing demand response payments from the EDCs, assuming that the customer has designated the TPO as their "battery partner." Customers may choose how the incentive payment will be provided: (1) split between the customer and battery partner, (2) incentive provided to the customer, (3) incentive provided to the battery partner (and incorporated into pricing offered to customer or yearly incentive provided to customer). TPO assists the customer in program enrollment.

E.3.	Explain whether the proposed ownership model(s) would affect third-party investment or financing models, specifically third-party owners' ability to offer Power Purchase Agreements or lease agreements to end-use customers.

The Program would allow TPOs to offer lease agreements for solar PV plus battery storage, as they do now, and would allow the battery storage leased through these arrangements to participate in both passive and active demand response.

The Program would also allow the EDCs to have their own lease program for battery storage, if they chose to so long as (1) they have an AMI in place to support the net metering to tariff transition, (2) they disclose installed cost information of the leased systems, and (3) ensure that fair, transparent, and competitive markets are being enabled with the TPO's in the marketplace.

F. Operational Control Model

F.1. Provide a proposed operational control model that addresses, at a minimum:

F.1.1.	Which parties would have operational control of the electric storage system, including justification for providing such parties with operational control;

The Program envisions two operational control models, both requirements for the Participants:

1. **Passive Dispatch** – "set it and forget it," (i.e., default mode) which is an automatic dispatch of the System during the ISO-NE summer peak period of June through August from 1:00 to 5:00 p.m. on weekdays administered by the Green Bank, using dispatch software (e.g., Virtual Peaker) as a platform to monitor compliance, update settings, and capture data for EM&V.

2. **Active Dispatch** – demand response, which is an active dispatch of the system by the EDCs or TPO, to remove the automatic dispatch of the system with the goal of maximizing the electric storage system's peak load reduction benefits during 30-60 peaks events throughout the year.

The various modes of control will be subject to battery manufacturer technical requirements and limitations. It should be noted that for the dispatch platforms being used (e.g., Virtual Peaker, Energy Hub, etc.), battery manufacturer and dispatch platform per device fees will need to be incorporated into program costs. TPO's that are deemed eligible by the EDCs to actively manage the dispatch of the electric storage system, are eligible for operational control of the system in order to receive ongoing performance-based incentives. Customers that seek to receive performance-based incentives must allow the EDCs to actively manage the dispatch of the System.

Based on the Survey, 83% of potential customers would be very interested in allowing the utility or a third-party to dispatch 100% of the energy within the battery in return for a performance-based incentive as long as the dispatch did not occur during a potential power outage.[73,74]

F.1.2.	For those proposed operational control models where more than one party has operational control, describe the priority of who has control and describe the protocols or guidelines by which assets will be charged and discharged;

Battery storage systems would typically be onboarded first through the upfront incentive program, enrolled for passive dispatch through a dispatch platform (e.g., Virtual Peaker) and then enrolled through the EDCs in the active dispatch program. Batteries would dispatch to meet the requirements of passive dispatch until a peak event is scheduled in the active dispatch program the night before the event. The active dispatch event would be scheduled by the EDCs and would be implemented through the same platform managing the passive dispatch (e.g., Virtual Peaker), taking priority over the passive dispatch schedule. The day after the peak event, the passive dispatch schedule would be put back in place until the next peak event. Assets will be charged and discharged in accordance with whether the asset is on the passive dispatch or the active dispatch schedule, the implementation of which will be managed by a dispatch platform (e.g., Virtual Peaker).

F.1.3.	The technological capability for executing control of the system of the identified parties, including the method(s) of communication to control and monitor the energy storage asset;

Virtual Peaker connects cloud-to-cloud with the proprietary APIs of battery technology providers – see Figure 24. These connections allow for data to stream back to Virtual Peaker multiple times a minute – typical using customer WiFi, though other communications protocols are supported. In order to do both passive and active demand response, Virtual Peaker normalizes outbound signals to each device type, ensuring consistent battery behaviors that comply with the factory/warranty settings of the battery technology provider.

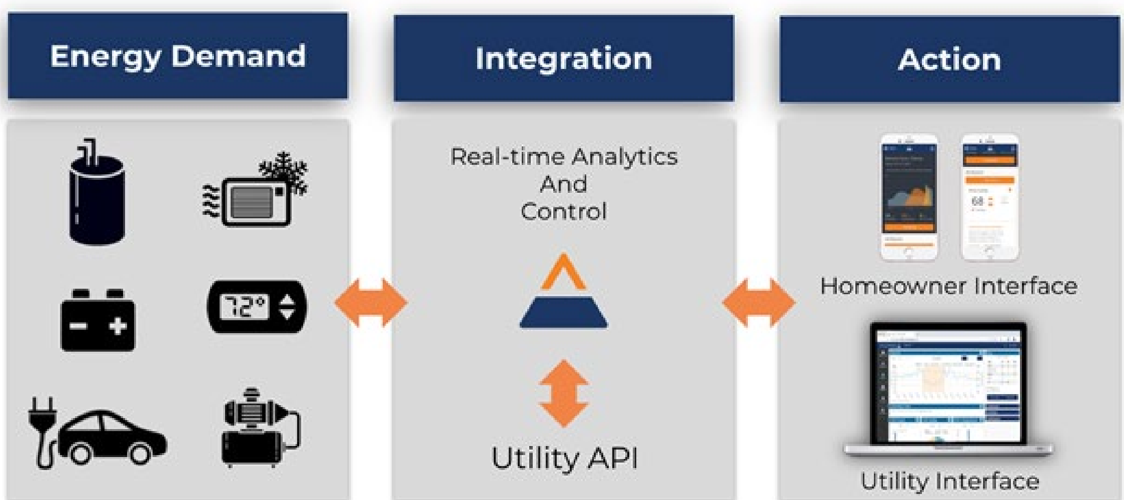
[73] See Appendix 1 response to Question 30 – with 55% moderately interested and 17% not interested' n=1,727

[74] The program envisions a 20% reserve capacity for participant back-up power in the event of an outage.

Virtual Peaker is currently integrated with many battery technologies, including Tesla Powerwall, Generac PWRcell, Sunverge, Sonnen, and SolarEdge StorEdge. These integrations are in use with multiple utilities across the U.S., including Portland General Electric and Green Mountain Power.

Virtual Peaker also supports a number of open standards, including OpenADR 2.0b. While its direct to device use cases are limited at this time, OpenADR would allow for a connection to other DRMS / DERMs systems being utilized by the EDCs.

Figure 24. Virtual Peaker Real-time Analytics and Control

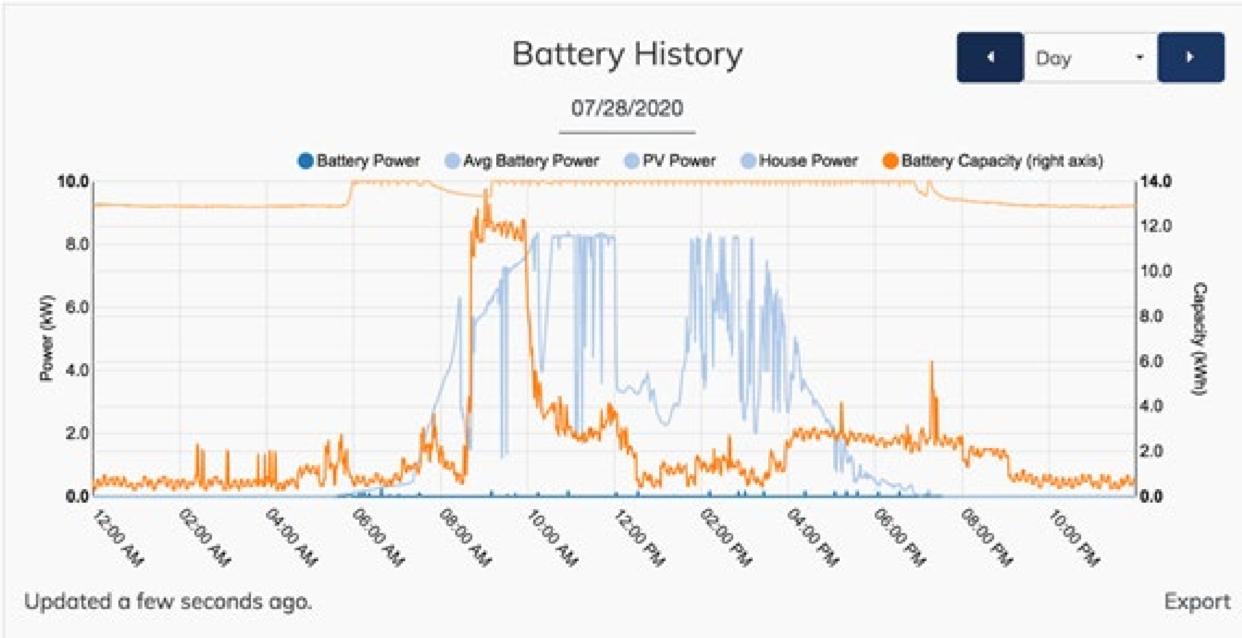


F.1.4.	The data that would be recorded by the party or parties operating the storage system and whether such information would be communicated to program participants;

Battery management systems associated with individual devices will monitor power and energy data and state of charge of the battery system, which will be visible to the Participant. Solar generation, battery usage and home energy usage data may be available to the Participant depending on the solar PV plus battery system configuration and battery management system features.

Data monitored and recorded by the Green Bank's dispatch platform would include real-time power and energy data and state of charge of the battery system, with visibility provided to the Green Bank and EDCs for the purpose of managing battery dispatch – see Figure 25.

Figure 25. Virtual Peaker Platform View



F.1.5.	The planned, controlled, or expected charge and discharge activity over the course of a year for an individual electric storage device, including daily charge and discharge times, the rationale for the proposed charge and discharge activity (e.g., peak load reduction, energy arbitrage, etc.), and how such charge and discharge activity will be achieved, to the extent that this information is not provided in response to the above requirements; and

Passive dispatch would occur during the ISO-NE summer peak period of June through August from 1:00 to 5:00 p.m. on weekdays, and active dispatch is anticipated to take place during 30-60 events (primarily in the summer season) called by the EDCs in anticipation of peak load times, between 2-7 pm for the current ConnectedSolutions Demand Response program.[75] Passive dispatch would be the default and active dispatch events would be scheduled (typically the day before) and would take priority over the passive dispatch schedule, with both types of dispatch enabled by the dispatch platform (e.g., Virtual Peaker).

F.1.6.	Whether the parties with operational control would change with time based on certain factors, such as time (e.g., potential peak times) and the state of the electric grid (e.g., power outage), including a description of how such changes are made, to the extent that this information is not provided in response to the above requirements.

[75] https://www.eversource.com/content/ema-c/residential/save-money-energy/manage-energy-costs-usage/demand-response/battery-storage-demand-response

Passive dispatch would be the default and active dispatch events would be scheduled (typically the day before) and would take priority over the passive dispatch schedule, with both types of dispatch enabled by the dispatch platform (e.g., Virtual Peaker). Power outages would be detected by the battery management system, allowing batteries to go into backup power mode where they would only be available to serve on-site load. Backup power mode during an outage can override the dispatch settings provided by Virtual Peaker. Virtual Peaker would monitor the batteries on an ongoing basis and would send a signal to return the battery to the passive dispatch schedule once the outage was over (e.g., once the battery was out of backup power mode).

F.2.	Provide information on how the parties with operational control under this proposal would coordinate with and provide visibility to the EDCs. Provide a description of the data and/or models that would be used by the parties with operational control and recommendations on how such data/models would be shared with the EDCs;

Participants enrolled in the passive dispatch program would be expected to enroll their batteries in the active dispatch program, providing information to the EDCs about the battery device location, power and energy ratings, and other data collected on the active demand response program participant application. With respect to dispatch coordination, visibility and control of battery devices would be provided to the EDCs through the dispatch platform (e.g., Virtual Peaker). The EDCs would have data on the usable energy capacity of the battery and real-time state of charge in order to determine the potential demand response benefit that could be provided in anticipation of a peak event.

F.3.	Explain whether the proposed ownership model(s) would affect, positively or negatively, utility operations. Provide the rationale for such explanation;

The proposed ownership and operational control models would positively impact EDC operations because the Green Bank would serve as an aggregator to increase customer adoption of battery storage devices, providing greater demand response capabilities to the EDCs. The EDCs would have visibility and control into all battery storage devices onboarded through the Program to enable them to monitor and avoid undesired impacts on the distribution system.

F.4.	Explain whether the proposed ownership model(s) would affect third-party investment or financing models, specifically third-party owners' ability to offer Power Purchase Agreements or lease agreements to end-use customers; and

The Program would allow TPOs to offer lease agreements or PPAs for solar PV plus battery storage, as they do now, and would allow the battery storage leased through these arrangements to participate in both passive and active demand response.

F.5.	Explain how current interconnection standards constrain the charging and discharging capabilities of electric storage systems under this proposal.

	Detail the respondents' understanding of the EDCs' current interconnection standards, if necessary.

For solar PV plus battery storage systems interconnecting to the grid, interconnection standards implemented by the EDCs require that batteries are in non-export modes so that they will not export to the grid unexpectedly and potentially overload the local circuit. Batteries may only export to the grid within an active demand response program, in response to scheduled peak events. Interconnection standards do not prevent batteries from charging from the grid, however, batteries deployed with solar PV are set up to charge only from the PV in order to qualify for the federal ITC.

G. Program Administration

G.1.	Recommend a quasi- or government agency (e.g., the Connecticut Green Bank, the Department of Energy and Environmental Protection, etc.) or company (e.g., the EDCs or a third-party) to administer the day-to-day operation of the program;

The Program proposes a collaboration between the Green Bank and the EDCs: The Green Bank will administer an upfront declining incentive block structure to generate demand for the Systems and increase benefits for Participants; the EDCs will administer an ongoing performance-based demand response incentive to maximize ratepayer and societal benefits.

Green Bank
The Green Bank has demonstrable experience and success in administering declining upfront and performance-based incentive programs for residential solar PV – see Table 12.

Table 12. Deployment and Incentives by Year - RSIP Administered by the Green Bank by Incentive Type (i.e., EPBB, PBI, and LMI-PBI)

Year[76]	**RSIP**					**% Reduction from Start**
	CGB kW	EPBB	PBI	LMI-PBI	CGB ZREC	
2012	1,940	$131	$128	$0	$130	-
2013	7,890	$109	$116	$0	$111	15%
2014	17,125	$83	$86	$0	$85	35%
2015	48,747	$54	$46	$0	$48	63%
2016	53,364	$34	$23	$46	$25	81%
2017	34,783	$31	$18	$47	$24	82%
2018	42,666	$31	$16	$47	$22	83%
2019	65,129	$28	$16	$37	$20	85%
Total	**271,645**	**-**	**-**	**-**	**$33**	

For comparison purposes, the RSIP upfront incentives (i.e., Expected Performance Based

[76] RSIP year is the Green Bank's fiscal year (i.e., July 1 through June 30)

Buydown – "EPBB") and performance-based incentives (i.e., LMI and non-LMI) have been converted to equivalent ZREC prices to show how efficient (i.e., lower incentives) and effective (i.e., deploying more installed capacity) the Green Bank has been administering a REC-based incentive program through the RSIP.

The Green Bank will spend approximately $150 million in REC-based incentives to homeowners and TPOs to achieve 350 MW of behind the meter residential solar PV through the RSIP. The RSIP deploys zero-emission clean energy resources quickly and effectively in its deployment (i.e., which is important in terms of confronting climate change), is efficient in the management of ratepayer resources in terms REC-based policies to support the implementation of in-state resources for the Class I Renewable Portfolio Standard ("RPS"), and transparent in its public disclosure on program participation and system performance.

Connecticut is also the leading residential solar PV deployment program in the Northeast Region of the U.S. in terms of watts per capita over the past three years – see Table 13.

Table 13. Residential Solar PV Deployment in the Northeastern United States (2017-2019)[77]

State	Megawatts Deployed	Watts per Capita
Connecticut	177.5	49.8
Maine	15.9	11.8
Massachusetts	313.5	45.1
New Hampshire	31.9	23.4
New Jersey	423.3	47.7
New York	402.8	20.7
Rhode Island	32.0	30.2
Vermont	27.3	43.8

And, although not calculated here in this proposal, the Green Bank has demonstrated that it is using less ratepayer and taxpayer resources to support residential solar PV deployment than Massachusetts, New Jersey, and New York in terms of installed capacity per state incentives invested (i.e., watts/$1 public or ratepayer incentive).[78]

<u>EDCs</u>

The EDCs have been administering the ZREC and LREC programs for the same period of time as the Green Bank has the RSIP – see Table 14.

Table 14. Deployment and Incentives by Round for the ZREC Program Administered by the EDCs by Incentive Type (i.e., Small, Medium, and Large ZREC)[79][80]

	Small ZREC	Medium ZREC	Large ZREC

[77] Data from the Solar Energy Industry Association on deployment
[78] Comprehensive Plan of the Connecticut Green Bank for FY 2017 through FY 2019 (p. 46)
[79] ZREC year is in Rounds (i.e., Rounds 1 through 8)
[80] https://www.eversource.com/content/docs/default-source/save-money-energy/year-9-lrec-zerc-rfp-bidders-webinar.pdf?sfvrsn=50fd262_2 (Slide 6)

Round[81]	ES kW	ES ZREC	Avan ZREC	ES kW	ES ZREC	Avan ZREC	ES kW	ES ZREC	Avan ZREC
1	4,700	$164	$149	5,260	$149	$135	7,330	$101	$117
2	6,890	$103	$113	7,980	$94	$102	6,330	$77	$90
3	6,080	$81	$84	8,850	$74	$76	12,590	$59	$66
4	5,610	$83	$80	4,210	$75	$73	12,370	$56	$63
5	10,370	$103	$87	6,530	$94	$79	12,780	$71	$58
6	5,330	$99	$99	8,750	$90	$90	14,810	$60	$82
7	1,030	$101	$98	980	$92	$89	3,850	$61	$86
8	-	N/A	N/A	-	$88	$88	-	$54	$63
Total	**40,010**	**$103**	**-**	**42,560**	**$94**	**-**	**70,060**	**$67**	**-**

Although no installed capacity data is available for Avangrid, there is both installed capacity and ZREC prices for Eversource. The installed capacity for Eversource is approximately 152,630 kW through Round 7, and Round 7 ZREC incentive levels are at $101, $92, and $61 for small, medium, and large projects respectively for Eversource.

In total, the ZREC program will spend $1.2 billion in REC-based incentives to support the implementation of the RPS and achieve some level of to be determined installed capacity.

G.1.1.	Discuss whether the program administrator would have operational control of any of the storage systems deployed under this proposal. Provide the rationale for such explanation.

See response to F.1.1. above.

As the administrator of the upfront incentive for the Program, the Green Bank would ensure the automatic passive dispatch of the system for the ISO-NE summer peak period of June through August from 1:00 to 5:00 p.m. on weekdays as a default or “set it and forget it” mode. In exchange for allowing the System to increase ratepayer benefits through the Program, the Participant will receive emergency back-up power through the System (e.g., 20% of electric energy stored at all times, plus up to 100% during times of grid outage or looming weather-related impacts). The Green Bank, working with the battery storage technology company, would set the automatic dispatch as the default mode for the electric storage system and manage through the use of dispatch software (e.g., Virtual Peaker).

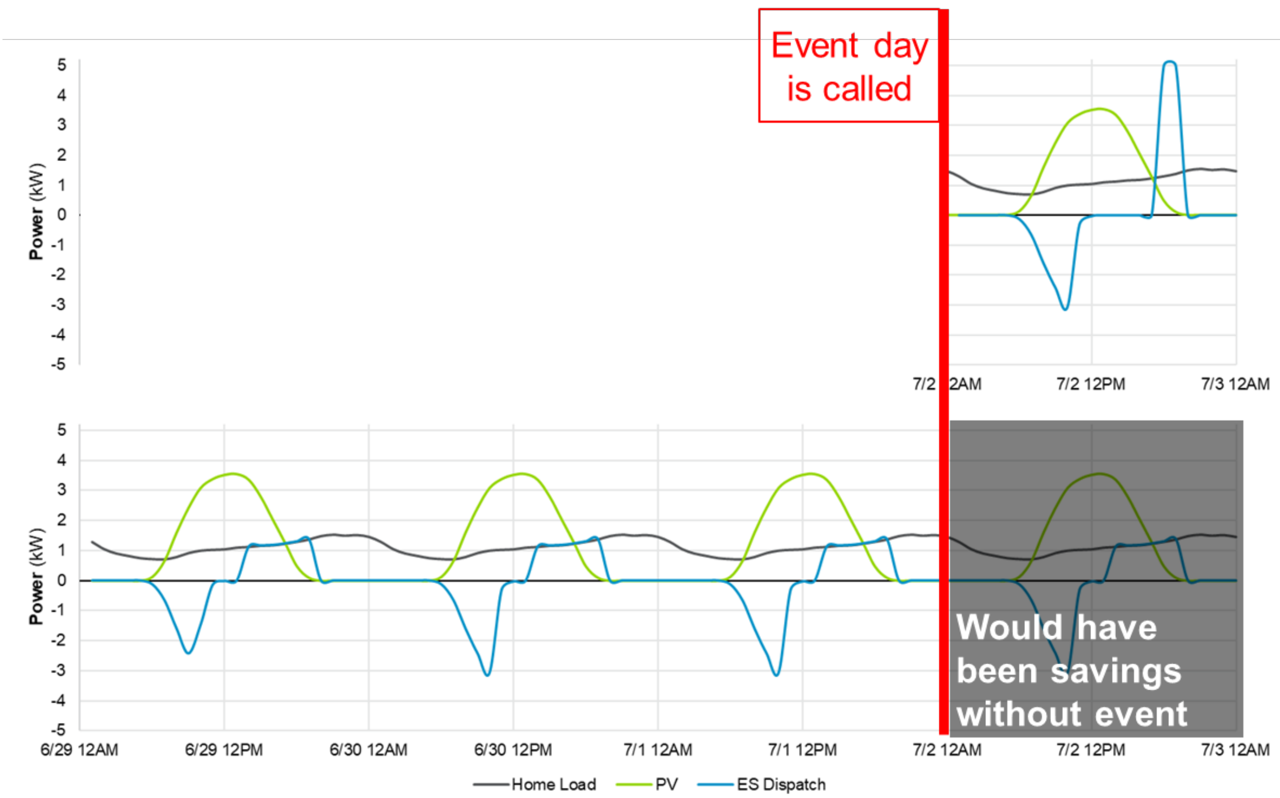
As the administrator of the ongoing performance-based incentive for the Program, the EDCs, working with eligible TPO’s, would manage an active demand response program that dispatches the system during critical events throughout the year (e.g., summer peak periods). The EDCs, working with the battery storage technology companies, in concert with an online dispatch platform (e.g., EnergyHub, Virtual Peaker, etc.), would be able to override the automatic dispatch of the system during specific events.

As a requirement for receiving the upfront incentive, the battery is set to a passive

[81] RSIP year is the Green Bank’s fiscal year (i.e., July 1 through June 30) and ZREC year is Round (i.e., Rounds 1 through 8, with 2020 being Round 9)

dispatch schedule upon installation. The battery would now dispatch daily during peak times during the ISO NE summer period. On a scheduled peak event day, as the dispatch administrator, the EDCs or participating TPOs, would send a signal to the Green Bank dispatch platform (e.g., Virtual Peaker) to assume control of the battery and dispatch during the event. The active dispatch would see 100% of peak reduction potential, depending on the battery's state of charge (excluding the 20% reserve) and assuming the participant does not opt out of that event. Since the battery would have dispatched passively in the case the peak event was not called for active dispatch, the active dispatch can't claim 100% of the benefits but rather the incremental benefits over and above the passive dispatch – see Figure 26.

Figure 26. Passive vs. Active Dispatch of the System during Peak Events



G.2.	Provide justification for such recommendation, including any known experience the recommended organization or company has in administering or operating, if applicable in G.1.1., an energy storage or similar distributed energy resource program and experience with the underlying technology/software necessary to administer such a program;

<u>Passive Demand Response</u>

The Green Bank has experience with passive demand response in terms of similar DERs (i.e., residential and commercial solar PV). Through its partner C-Power, the Green Bank was the first to enroll residential solar PV systems in ISO-NE On-Peak Hours Capacity Market Program. This program makes payments (i.e., capacity payments), to owners of demand resources (i.e., Green Bank), based on the demand reduction value of the resource as measured by the hourly kWh reduction over defined performance hours (i.e., summer peak periods). Owners must commit a defined capacity to the program, as measured in kWac.

Through a Master Services Agreement between the Green Bank and C-Power, C-Power provides the following services for the Green Bank:

- Enrolling assets into the ISO-NE program
- Bidding for Capacity Supply Obligations in future Capacity Market Auctions
- Monitoring and managing the performance of the assets
- Submitting asset performance information to ISO-NE
- Remitting capacity payments to the Green Bank

Prior to the Green Bank, ISO-NE had never previously allowed the enrollment of residential solar PV assets in their program. However, because the RSIP could meet strict reporting requirements using AlsoEnergy's LocusNOC data collection platform, ISO-NE allowed the Green Bank to enroll its fleet of residential solar PV systems.[82]

Active Demand Response
The EDCs, through their administration of the C&LMP, have experience with demand response programs.

G.3.	Discuss whether inverter data is sufficient for program administrative purposes, or if separate metering is required; and

Inverter data alone may be sufficient for program administrative purposes, depending on the battery technology. For example, several battery manufacturers provide revenue-grade metering data via their built-in smart inverter. The project team is open to preferences of the EDCs for the active demand response program and guidance from PURA on its data reporting requirements.

G.4. Any respondent recommending that their own agency or company act as the program administrator must also provide the following:

G.4.1.	A list of administrative activities the program would require of their agency or company, organized by timescale (e.g., separately list daily, monthly, and yearly activities);

Administrative activities in the first year would include:

- Program development and implementation spanning an initial time period of approximately 3 months.
- Set up of EM&V plan and processes.

[82] Systems energized after July 1, 2018

- Establishment of program management processes and activities supporting project development timeframes as detailed in G.4.5.
- Hiring and training of additional staff, if needed, based on program administration budget.
- Establishment or renewal of contractual agreements with technology platforms and EM&V consultant.
- Coordination and collaboration with the EDCs, industry participants including contractors and TPOs, battery storage technology providers, PURA, DEEP and other stakeholders.

Ongoing monthly, quarterly and yearly activities would include:

- Ongoing program administration processes to support project development described in G.4.5.
- Implementation of the EM&V plan, regulatory reporting, and cost recovery assessment for upfront incentive program.
- Performance monitoring and compensation payments for active demand response participants.
- Program management, milestone tracking and reporting.

Daily activities would be performed in the context of the above activities, including those listed in response to G.4.5 to support program goals and targets. Daily activities will need to be flexible to allow for emergent program management questions and needs.[83]

G.4.2.	A description of the program roles and responsibilities (e.g., administrative activities) for all other parties involved with the proposed program design, including the EDCs, PURA, and others;

Beyond the roles and responsibilities of the Green Bank to deliver quality battery storage installations in combination with residential solar PV systems through the local industry of contractors (including TPOs) and lenders to meet PURA's objectives under the Docket, there are other parties that would be involved in the Program with roles and responsibilities, including:

- **<u>EDCs</u>** – through the implementation of the C&LMP, the EDCs would be responsible for implementing the active demand response aspects of the Program. Similar to what Eversource does in Massachusetts through the Connecticut Solutions Program, the EDCs, working with participating households and TPO's, would actively dispatch the battery storage systems (i.e., take the systems off the passive dispatch default settings) for specific events between 30 to 60 times a year. The EDCs would measure the performance of its active dispatch programs and compensate homeowners and TPOs over time accordingly.

[83] For example, in managing RSIP, Green Bank staff provide customer service to contractors and customers, as well as troubleshoot program administrative and technical questions that arise and can vary from day to day.

- **Joint Committee of the EEB and Green Bank** – in its role to examine opportunities to coordinate programs and activities contained in the C&LMP of the EDCs and the Comprehensive Plan of the Green Bank, the Joint Committee would serve a coordination function to "implement state energy policy throughout all sectors and populations of Connecticut with continuous innovation towards leveraging of ratepayer funds and a uniformly positive customer experience". In this role, the Green Bank and the EDCs would report to the Joint Committee on a quarterly basis and make any request for changes to the Program through the Joint Committee, and then on up through their respective governance structures, and then PURA.

- **PURA** – in its capacity as regulator and deliverer of grid modernization in Connecticut, PURA would serve in a rulemaking, review of program performance, and cost-recovery decision-making function. In this role, PURA would receive quarterly and annual program performance report filings, oversee an annual public hearing on the program to assess progress and determine cost-recovery to the Green Bank, and receive any and all Program information (i.e., whether confidential in nature or not) to assess the ongoing performance of the Program in terms of delivering the objectives it has set out in Docket No. 17-12-03(RE03).

These are the other parties, beyond the Green Bank and its participating households, contractors, and TPO's, as well as private capital partners that would be involved in the Program.

G.4.3. An itemized estimate of the agency's or company's administrative costs for marketing and administering the proposed program. Specifically, include the estimated number of employees, by number and full-time equivalents, and provide the estimated annual compensation for each employee as well as the approximate business address to which such employees would primarily report;

Estimate of Administrative, Marketing, and EM&V Costs

The following is a breakdown of the Administrative, Marketing, and EM&V costs by year within the declining incentive block structure for the upfront incentives administered by the Green Bank – see Table 15.[84]

Table 15. Estimate of Average per Year Administrative, Marketing and EM&V Costs for the Program for the Green Bank

	2021-2025	2026-2030	2031-2035	Total
Staff	$500,000	$250,000	$150,000	$4,500,000
Program Development and Administration	$250,000	$150,000	$150,000	$2,750,000
Marketing	$50,000	-	-	$250,000
Evaluation, Measurement, and Verification	$200,000	$100,000	$50,000	$1,750,000

[84] It should be noted that the Board of Directors of the Green Bank approved of a contingency to its FY 2021 battery storage targets and budget should PURA approve the proposal submitted by the Green Bank under the Docket.

Total	**$1,000,000**	**$500,000**	**$350,000**	**$9,250,000**

For details on staffing, see below.

In terms of Program Development and Administrative Costs, the Green Bank would:

- **Inspectors** – hire inspectors to assess the installation and functionality of the projects (i.e., QA-QC) as they reach completion during the first 5-6 years of the program;

- **Distributed Energy Resource Program (DER) Management Platform** – contract with a software platform (e.g., PowerClerk) for managing the incentive application process and collecting equipment and other data for both the solar PV and battery storage components of each project.[85]

- **Battery Storage Dispatch Software Platform** – contract with a software platform (e.g., Virtual Peaker) that manages the System using real-time control and internet-enabled dispatch to administer the passive dispatch response default settings and enable the active dispatch by the EDCs and TPOs.

In terms of Marketing costs, the Green Bank would:

- **Internet Marketing** – continue to support and build on the GoSolarCT website to be an informational resource beyond solar PV to include battery storage; and

- **Community-Based Marketing** – to stimulate the market through the locational targeting of community-based social marketing campaigns to increase and accelerate the deployment of battery storage (e.g., Solarize Storage).

In terms of EM&V costs, the Green Bank would:

- **Evaluation, Measurement and Verification Contractor** – contract with Guidehouse to collect, analyze, and report out the performance of the Systems using the dispatch software platform (e.g., Virtual Peaker) utilized by the Program.

Estimate of the Number of Employees, FTEs, and Compensation

To successfully administer the upfront incentive aspects of the Program – to achieve the Target – the Green Bank estimates three employees will be involved with 300% FTE – see Table 16.

Table 16. Estimate of Annual Compensation of Green Bank Employees Working on the Program

Position Title	# Staff	% FTE	Salary[86]

[85] The cost of the DER Program Management Platform could in part be allocated to the Green Bank Residential Solar Investment Program until that program is closed out with respect to completion of solar PV incentive applications.

[86] Note – does not include employee benefits required by State of Connecticut. For FY 2021, this is budgeted at 85% of salary.

Associate	1	100	$59,513
Manager	1	100	$78,705
Associate Director	1	100	$113,336
Total	**3**	**300**	**$251,554**

Once the Target for the Program is achieved, then the Green Bank will reduce its FTE's and focus its efforts on asset management (i.e., the ongoing passive demand response performance of the electric storage systems) and reporting.

The business address of the employees involved in the upfront incentive portion of the Program is the headquarters of the Green Bank at 845 Brook Street, Rocky Hill, CT 06067.

It should be noted that all of the Green Bank salary information is made publicly available through the Comptroller on Open Quasi.[87]

<u>Performance-Based Incentive Program Administration Costs</u>
The Green Bank's estimate of costs for EDC administration of the performance-based incentive program are provided in Table 17.

Table 17. Estimate of Performance-Based Incentive Program Administration Costs

Annual Cost ($/yr)	Years of Program	Total Cost
$477,000	15	$7,155,000

Over the 15 years that the battery storage performance-based incentive aspects of the Program are operating, the Program Administration costs are estimated to total around $7.2M.[88]

The EDCs can provide a detailed and publicly available breakdown of their administrative costs for their piece of the Program, including the estimated FTE's, compensation levels for those FTE's (including benefits), and other administrative costs to administer the performance-based incentive aspects of the Program.

G.4.4.	An initial marketing and outreach plan for targeting electric storage installations, including any plans for targeted outreach in underserved communities and plans to target storage deployment in beneficial locations on the distribution system;

The Green Bank's primary marketing channel for the Program is through participating contractors in the RSIP. These contractors install nearly 7,500 residential solar PV systems a year totaling over 60 MW of installed capacity through the RSIP. The Green

[87] https://openquasi.ct.gov/
[88] These values were calculated using Eversource's publicly available Administrative Costs for the Massachusetts Active Demand Response (ADR) program. The ADR program encompasses programs beyond battery storage, but it was assumed that 50% of the budget is for battery-related programs. The total 3-year budget was $2.864M, so the battery-specific budget was assumed to be $1.432M over three years, or $477,000 per year.

Bank has worked to foster the sustained orderly development of a local solar industry, and as such, seeks to enable that industry to develop a corresponding local battery storage industry in Connecticut. Supporting residential solar PV contractors by administering an upfront incentive program to stimulate customer demand, is the primary marketing channel for the Program.

Beyond the contractors, the Green Bank expects to support a variety of outreach initiatives targeted at battery storage deployment in combination with residential solar PV, including focus on targeted LMI communities and high demand areas of the grid:

- **GoSolarCT**- expansion of its GoSolarCT website to take potential participants through the journey for installing and managing their electric storage systems;

- **SolarizeCT** – refocusing community-based social marketing campaign to connect competitive market approaches (e.g., issuing RFP's for local contractors) to create demand for battery storage through a Solarize Storage campaign in collaboration with Yale (see Appendix 18 for Letter of Support from Yale);[89]

- **Solar for All** – expanding its low-to-moderate income neighbor-to-neighbor message of residential solar PV to include third-party ownership of electric storage to provide access to affordable resiliency benefits; and

- **Sustainable CT** – as an original co-founder and current co-chair of Sustainable CT, the Green Bank will promote the Program through local sustainability enthusiasts in Connecticut's cities and towns.

Beyond marketing and outreach, the Green Bank will provide potential participants with the access to capital they may need to finance a system on their property – i.e., through loans, leases, and/or on-bill repayment mechanisms.

G.4.5.	An initial plan detailing a program implementation schedule, including the process for submitting a project application and approval, project design review, testing and commissioning requirements, measuring the claimed asset capability, performance verification, demonstration of continued project viability (if required), and quality assurance of the project;

Before the end of the calendar year (e.g., Fall 2020), if PURA selects the Green Bank to administer a battery storage incentive program, the Green Bank would begin final program development steps immediately to refine program details that may have been discussed during the regulatory process, as well as additional feedback from the EDCs, industry and other stakeholders during the program set up process.

Program development and implementation timing and notes:

[89] Green Bank provided a letter of support for a Yale University SEEDS3 grant proposal to the U.S. Department of Energy for the "Patterns and Value of Co-Adoption of Solar and Related Technologies" proposal.

- The program could potentially be implemented in 3 months, depending on applicable platform implementations, where synergies described in G.4.7 could help achieve a shorter timeframe. The first participants in the passive and dispatch platforms could enroll as early as the summer 2021 season.
- Once the program was implemented, contractors could begin applying to become eligible contractors and third-party owners (TPOs) immediately, potentially benefiting from synergies with the RSIP and Smart-E programs and be approved within two weeks.
- Eligible contractors and third-party owners could begin signing contracts with customers and submitting incentive applications to PowerClerk.

Project development timing:

- Similar to RSIP, projects could proceed along the following, average timeline (the program could specify a project completion timeframe such as 270 days before the incentive approval expires):

  1. Incentive application submission to PowerClerk, project review by Green Bank team – approved within 2 weeks
  2. Installation, municipal approval, interconnection approval, testing and commissioning, and project completion submission to PowerClerk – on average within 5 months
  3. Enrollment in dispatch platform (e.g., Virtual Peaker) - in parallel with step 2
  4. Project inspection (for selected projects, a higher percentage at the beginning of the program) - one additional month.
  5. Begin participation in passive and active dispatch protocols, in particular if project completed by summer 2021 (otherwise, could start in winter if a winter season is included, or summer 2022).
  6. Contractor or TPO reimbursed for upfront incentive already provided to customer as discount on sales/lease/PPA agreement.
  7. Performance measurement and reporting would be ongoing in accordance with the plan and schedule for EM&V in section H.
  8. Performance-based incentive payments would be made on schedule set up by EDCs for active demand response program.
  9. Dispatch and performance monitoring would continue for 10 years.

G.4.6.	An initial plan for collecting and making publicly available appropriate program data, such as compensation levels, total compensation provided, installed cost data for standalone energy storage systems and coupled or co-located storage and other energy resource systems, etc.; and

The Green Bank is a leader in collecting and making program data and compensation levels publicly available, especially since it supports incentive and financing programs that use resources provided by Connecticut ratepayers (i.e., through the Clean Energy Fund) and taxpayers (i.e., through the Regional Greenhouse Gas Initiative).

Transparency is a hallmark of the Connecticut Green Bank.

Through its internal data warehouse, and its voluntary payroll and checkbook reporting, the Green Bank makes a lot of information publicly available.

Data Warehouse
Through its data warehouse, the Green Bank collects, analyzes, and disseminates a lot of program data through its separate, yet integrated, data management systems, including:

- **PowerClerk**[90] – collects detailed data on the participant and their system like location, equipment details, installed capacity, installed cost, and more.

- **AlsoEnergy** (who purchased Locus Energy)[91] – collects real-time system performance data of the fleet of Green Bank solar PV assets (i.e., systems that have received incentives and/or financing from the Green Bank).

- **Power BI** – a business analytics service by Microsoft that provides interactive visualizations and business intelligence capabilities with an interface simple enough for end users to create their own reports and dashboards.

The Green Bank reports a lot of information through its "Reporting and Transparency" section of its website.[92]

The Green Bank also makes residential solar PV installed cost data publicly available to potential participants through the Energize CT and GoSolarCT websites.[93] This spreadsheet, updated once a month, provides interested residential solar PV households with detailed information on installed costs by contractor, system locations, and other data making market information transparent to buyers and sellers and enabling market competition.

Through the Application for a Class I Renewable Energy Source Certification, the Green Bank also provides a spreadsheet of every residential solar PV installation it aggregates for the sale of SHRECs through the RSIP. Since participating households are receiving ratepayer incentives through the RSIP, a lot of information is publicly disclosed, including the address of the participant.

Payroll and Checkbook Reporting
The compensation levels of Green Bank staff are publicly available through the Comptroller's Open Connecticut website.[94] The Green Bank was among the first quasi-

[90] PowerClerk enables electric utilities and incentive program administrators to leverage a proven, safe and secure DER workflow and automation software service that is easy to configure, and delivers integration and workflow transparency. PowerClerk has processed over 1 million DER interconnection and incentive applications across more than 100 DER programs.
[91] https://home.alsoenergy.com/assets/pdf/Also_Energy_Residential_Solution_Sheet_070119.pdf
[92] https://ctgreenbank.com/strategy-impact/reporting-transparency/
[93] https://www.energizect.com/your-home/solutions-list/residential-solar-investment-program
[94] https://openquasi.ct.gov/

public agencies to voluntarily work with the Comptroller to not only disclose Payroll data[95] of its employees, but to also disclose every Checkbook level transaction[96] it does.

> *""The Green Bank was an early and active participant in OpenCT," said Bryan Garcia, President and CEO of Connecticut Green Bank, "and this new resource shows exceptional transparency. When you are responsible for managing ratepayer resources in a way that delivers societal benefits to families and businesses, it is critically important to remember that transparency of information on transactions and compensation go hand-in-hand with that mission."*[97]

The Green Bank collects and makes publicly available a lot of information.

G.4.7.	A list of synergies that can be achieved, and approximate quantification, by combining the program administration of any electric storage program(s) with the program administration of other existing programs in the state, if applicable.

The following are possible program administration synergies:

- **Upfront Battery Storage Incentive Program and existing Green Bank Incentive Programs including RSIP and Smart-E** – There could be synergy with (1) the PowerClerk incentive application processing platform, with RSIP potentially covering more than 50% of the cost (e.g., allocated based on project volume), (2) potential staffing overlap that could result in efficiencies with respect to time, knowledge and/or experience, (3) program guidelines development and contractor qualification done for RSIP and the Smart-E loan interest rate buydown for battery storage.

- **Upfront (i.e. Passive Dispatch) Battery Storage Incentive Program and the Ongoing Performance-Based Incentive (i.e., Active Dispatch) Program** – The flat, annual fee for a dispatch platform as well as monthly per device fees for both the dispatch platform and battery technology providers could be shared, based on where benefits are accruing and therefore where additional costs could be allocated while maintaining favorable benefit/cost ratios for both programs. For example, the flat, annual fees could be allocated to the passive dispatch program, while monthly per device fees could be allocated to the active dispatch program. In addition, regardless of the number of platforms and the primary contractual relationship with the dispatch platform provider (and to the extent security considerations allow), both programs could leverage platforms collaboratively for dispatch purposes, and administrators could be given sufficient access to data (e.g., in spreadsheet format)

[95] https://openquasi.ct.gov/payroll/Connecticut%20Green%20Bank
[96] https://openquasi.ct.gov/checkbook/Connecticut%20Green%20Bank
[97] https://www.osc.ct.gov/public/news/releases/20200611.html

needed for EM&V purposes.

- **New and Existing Energy Storage Programs** – New battery storage incentive programs could benefit from software integrations already completed between dispatch platforms and battery technology providers, such as in the Green Mountain Power, Connected Solutions, and Portland General Electric Programs.

These are a few of the program administration synergies that can be pursued or may already exist with other programs in the state as well as programs in other states.

H. Evaluation, Measurement, and Verification (EM&V)

H.1. Provide an EM&V plan that, at a minimum:

See the attached EM&V Plan for the proposed Program – see Appendix 7.

H.1.1.	Recommends an organization or company or type of organization or company that should be used to perform program EM&V and the frequency of EM&V;

In November of 2017, the Green Bank conducted a Request for Qualifications ("RFQ") to identify qualified firms and individuals with expertise in EM&V[98] with expertise in conducting impact, process and/or associated market studies of programs that deliver energy savings through clean energy technology deployment, as well as knowhow in the quantification of non-energy and societal impacts associated with these clean energy technologies.

Through the RFQ, the Green Bank qualified firms to perform program EM&V, including:

- The Cadmus Group
- DNV-GL
- ERS
- Industrial Economics
- Navigant Consulting (now Guidehouse)
- Opinion Dynamics
- Research into Action

Since 2018, the Green Bank has used the services of several of the firms on various projects. For the RFPD, the Green Bank has included examples of the type of comprehensive EM&V work that is relevant to the proposed Program and the EM&V Plan:

- **Technology Review** – Connecticut Green Bank SHREC Securitization by DNV-GL showing an independent technical analysis of residential solar PV systems installed by various contractors using different hardware technologies (e.g., panels, inverters) through the RSIP as part of rating a revenue bond issuance

[98] https://www.ctgreenbank.com/wp-content/uploads/2017/11/RFQ-EMV-2017-CT-Green-Bank-Final.pdf

(i.e., Green Liberty Bond) by Standard & Poor.[99]

- **Peak Demand Reduction Analysis** – contribution of the Green Bank's Residential Solar Program to the 2019 Summer Peak by Guidehouse analyzing 15-minute interval data on the energy production of a fleet of nearly 28,000 residential solar PV systems that reduced peak demand by 230 MW during a heat wave – (see Appendices II and III)

- **LMI Technology Adoption Survey** – PosiGen Solar Lease and Energy Efficiency Program Summary of Participant Survey Results by Opinion Dynamics understanding the motivating factors, attribution, barriers, perception of savings, and satisfaction of residential solar PV and energy efficiency technology adoption by LMI families.[100]

Similar to what the Green Bank provides its Board of Directors in terms of quarterly performance to target memos, the Green Bank will develop and provide a "high-level" progress to targets quarterly memo for PURA, including, but not limited to the number of projects, installed capacity (i.e., kW and kWh), incentives provided (i.e., for LMI and Non-LMI participants), and adherence of participants to the prescribed schedule .

On an annual basis, the Green Bank, working with its EM&V contractor, will provide to PURA a more comprehensive report on the detail of the Program.

H.1.1.1. Provides the relevant and known experience of the recommended organization or company in performance of EM&V activities; and

Guidehouse[101] provides comprehensive and customer-focused energy efficiency, demand response, renewable energy, and energy storage consulting services for public and private entities.

It provides its clients with the following services:

- **Strategy** – helps clients understand when and how customers use energy and what opportunities exist for customer programs via load forecasting, baseline studies, load disaggregation, stakeholder engagement, and expert testimony.

- **Design** – designs programs to meet the client's goals, help find the best implementation partners, and design fluid and innovative customer experiences via design thinking, best practice reviews, listening to customers, program theory design, RFP design, and proposal evaluation.

- **Implementation** – helps clients identify how to best implement programs and

[99] https://bondlink-cdn.com/5721/10169376-OAL-R-01-D_CT_Green_Bank_Securitization_Tech_DD.tyXv7iVK.pdf
[100] Report available upon request
[101] Formerly Navigant Consulting

monitor program performance in near-real time through program implementation support, feedback surveys and dashboards, and customer experience storyboarding and analytics.

- **Evaluation** – measures how effectively programs contribute to client goals and identify areas for improvements to program mechanics and customer experience using program evaluation, process and journey mapping, benchmarking, and listening to customers.

Guidehouse was selected by the Green Bank through both an RFQ, and then an RFP, to support its strategy in designing the Program. Guidehouse provided the strategic tools (i.e., customer willingness to pay survey and "cost-effectiveness" calculator) for the Green Bank staff to then design the Program. Guidehouse has experience providing impact and customer experience evaluation of residential battery storage programs across the country, including evaluation of the Connected Solutions Program in Massachusetts for National Grid and Unitil, the Liberty Utilities Home Battery Storage Pilot, and the Arizona Public Service (APS) Storage Rewards Program.

If approved by PURA, the Green Bank expects to continue working with Guidehouse through the evaluation of the Program that the Green Bank would be implementing.

H.1.1.2. Provides an approximate annual cost estimate for performing EM&V.

The following is a breakdown of the average annual Program Development and Administration and EM&V budget estimates – see Table 18.

Table 18. Program Development and Administration and EM&V Program Budgets for the Program

	2021-2025	2026-2030	2031-2035	Total
Program Development and Administration	$250,000	$150,000	$150,000	$2,750,000
Evaluation, Measurement, and Verification	$200,000	$100,000	$50,000	$1,750,000
Total	**$450,000**	**$250,000**	**$200,000**	**$4,500,000**

The Program Development and Administration budget includes:

- **Inspectors** – hire inspectors to assess the installation and functionality of the projects (i.e., QA-QC) as they reach completion during the first 5-6 years of the program;

- **Distributed Energy Resource Program Management Platform** – contract with a software platform (e.g., PowerClerk) for managing the incentive application process and collecting equipment and other data for both the solar PV and battery storage components of each project.[102]

- **Battery Storage Dispatch Platform** – contract with a software platform (e.g.,

[102] The cost of the DER Program Management Platform could in part be allocated to the Green Bank Residential Solar Investment Program until that program is closed out with respect to completion of solar PV incentive applications.

Virtual Peaker) that manages the System using real-time control and internet-enabled dispatch to administer the passive dispatch response default settings and enable the active dispatch by the EDCs and TPOs.

Within the EM&V budget, is the Guidehouse support which includes:

- **Data Review and Setup** – Guidehouse will provide data management, QA/QC, and support for Green Bank reporting and dashboards related to program- and project-level metrics.

- **Survey Design and Analysis** – Guidehouse will design, implement, and analyze surveys with program participants to explore various research topics including participant satisfaction and experience with program enrollment, ongoing participation in events, program-related communications, and the installed battery storage technologies. Guidehouse will also conduct interviews or surveys with participating program vendors/contractors to assess contractor satisfaction with program administration, barriers and challenges, and to identify opportunities for improvement to increase contractor satisfaction and customer acquisition.

- **Performance Evaluation and Cost Effectiveness Analysis** – Guidehouse will conduct a review and analysis of installation, performance, and financial data in the application database to calculate and report program-level metrics. The team will analyze the project-level telemetry data to estimate and report evaluation performance metrics (e.g., peak demand savings), and will quantify the program cost-effectiveness

- **Reporting** – Guidehouse will produce an annual report of evaluation findings and recommendations. The report will include 1) Description of evaluation objectives and evaluation activities, 2) Summary of key evaluation findings including system performance, 3) Identification of any data collection or performance-related issues, and 4) Recommendations.

The estimated average annual cost of EM&V is $200,000 from 2021 through 2025.

H.1.2. Proposes metrics to determine program success;

The EM&V Plan for the Program (see Appendix 7 for details) identifies several metrics to determine program success, including, but not limited to:

- Program-level metrics, including:
    - Program incentive funds disbursed ($)
    - Program administrative costs ($)
    - Installed capacity (kW and ESS) of ESS and solar PV
    - Average project metrics such as:
        - Incentive per unit ($/unit)

- Battery storage system size (kW)
- Battery storage system size (kWh)
- AC vs. DC coupled

- Evaluation performance metrics, including:
  - Peak demand savings (kW) based on ISO-NE definition – passive demand response (i.e., “Set It and Forget It”)
  - Peak demand savings (kW) based on TPO or EDC dispatch – active demand response (i.e., “Active Dispatch”)
  - Total amount of solar PV produced and ESS charged and discharged by location, anonymized and aggregated for public reporting
  - Cost-effectiveness metrics – estimate to actual

- Operating and reliability performance characteristics, including:

  - Fraction of usable solar energy used for back-up power, as well as passive and active demand response by location, anonymized and aggregated for public reporting
  - Number of back-up power incidents and peak dispatch events, and battery availability for the incident and events by location, anonymized and aggregated for public reporting

- Customer data, anonymized and aggregated for public reporting, including:
  - Customer satisfaction with the Program and the System
  - Customer demographics (e.g., household income, location)

These are a few of the metrics that will be used to determine the Program’s overall success.

H.1.3.	Proposes reporting requirements and reporting frequency to PURA, including timing of such reports (e.g., monthly, quarterly, annually, etc.);

The Green Bank, in collaboration with its EM&V contractor (i.e., Guidehouse), proposes to provide quarterly, biannual, and annual reports on program level metrics, evaluation performance metrics, operating and reliability performance, and customer data on the first day of the month of the start of a quarter (e.g., January 1, April 1, July 1, and October 1) – see Table 19.

Table 19. Green Bank Reporting to PURA on Various Metrics within the EM&V Plan from 2021 through 2028

Reporting Requirements	**2021**				**2022-2027**				**2028-2035**			
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Program Level Metrics			X	X	X	X	X	X	X			
Evaluation Performance Metrics					X				X			
Operating and Reliability Performance					X		X		X			
Customer Data[103]			X	X	X	X	X	X				

[103] Customer satisfaction with the Program and the System will be done annually with a report due on April 1st from the prior year.

Cost Recovery Report						X				X[104]		

Beyond the quarterly program level metric and customer data reports, there will be more detailed evaluation performance report on March 1st and operating and reliability performance report on January 1st and July 1st including how the portfolio of systems performed during the prior year's summer peak season.

The Green Bank would also follow-up the annual report on January 1st with a Cost Recovery Report on April 1st of each year beginning in 2022 and ending in 2028.

H.1.4.	Recommends a process by which changes to the program may be adopted based on such metrics and results;

The success of the upfront declining incentive block portion of the Program that is being administered by the Green Bank, is based on achieving the following five (5) priorities, which derive from the objectives PURA is trying to achieve through the Docket:

1. **Creating Demand** – through local contractors, deploying battery storage systems in combination with residential solar PV, by administering an upfront performance-based incentive program that fosters the growth and development of a local battery storage industry that achieves the 50-MW deployment target no later than the end of 2025;

2. **Achieving Passive and Active Dispatch** – successfully setting and automatically dispatching the systems to achieve the default passive dispatch settings required for the Participants to receive the upfront incentive, while also allowing the EDC or TPOs to actively dispatch the systems between 30 to 60 events a year to further reduce peak demand through ongoing performance-based incentives;

3. **Coordinating with the EDCs** – continuously communicating and coordinating with the EDCs to ensure that the Program is meeting peak event dispatch requests and achieving its maximum potential;

4. **Managing Resources** – efficiently and effectively managing resources, including incentives, and administrative, marketing, and EM&V costs to maintain the PACT and UCT goals of greater than 2 for the Program for the Green Bank and EDCs as administrators; and

5. **Data Collection and Analysis** – developing a data collection and analysis system that transparently communicates the performance of individual projects and the whole portfolio of projects with respect to the cost-effectiveness of the Program in delivering benefits to the participants (i.e., PCT), ratepayers (i.e., TRC and RIM), and society (i.e., SCT), as well as detailed follow-on EM&V

[104] Cost recovery is planned to end with the filing of the last Cost Recovery Report on April 1, 2028, then there would be one report a year filed with PURA on program level metrics, evaluation performance metrics, and operating and reliability performance.

analysis;

The Program is a new approach for Connecticut. So, despite the best efforts and intentions of the Green Bank, EDCs, PURA, and others, there are going to be lessons learned during its implementation. If there is a need to refine the Program in order to ensure that goals and priorities are achieved, then the Green Bank would issue a Request for Consideration to PURA within the approved docket for the Program. A reasonable rationale for a requested change would need to be submitted to PURA, including the provision of appropriate information and justification for such a request.

H.1.5.	Proposes how program performance data will be collected, including installed cost and incentive payment or compensation data, and disclosed to PURA, if a response is not already provided;

PURA is well aware of the Green Bank's data collection expertise, public data transparency, and willingness to provide information when it comes to program performance, installed cost, incentive payments, compensation, and other data.

See response to G.4.6. above.

For the Program, the Green Bank will rely on a provider of a DRMS (e.g., Virtual Peaker) to manage the passive dispatch settings, enable active dispatch of devices in response to peak events and data collection for EM&V purposes.

H.1.6.	Discusses whether inverter data is sufficient for EM&V purposes or if separate metering is required, if the response is different than provided elsewhere in this proposal; and

See response to G.3. above.

Inverter data alone may be sufficient for program administrative purposes, depending on the battery technology. For example, several battery manufacturers provide revenue-grade metering data via their built-in smart inverter. The project team is open to the preferences of the EDCs for the active demand response program and guidance from PURA on its data reporting requirements.

H.1.7.	Provides recommendations on how EM&V costs could be mitigated or how existing EM&V resources could be leveraged.

The evaluation will leverage vendor-provided data aggregated by a third party (e.g., Virtual Peaker). The third-party aggregation will ensure that data is collected and provided in a standardized format for EM&V. This approach eliminates the need for additional metering for evaluation and streamlines data QA/QC activities.

The majority of EM&V costs are front-loaded into Years 1-2 to establish sound processes for data collection, review, analysis, and reporting. Evaluation activities will be streamlined in the subsequent years, leveraging existing processes and automation to the extent possible.

I. Cost Recovery Proposal

I.1.	Where ratepayer funding for compensation is proposed, discuss a funding and/or cost recovery mechanism that the Authority could direct the EDCs to implement (e.g., regulatory asset, reconciling mechanism, etc.). Provide justification;

It should be noted that Docket No. 17-12-03(RE03) RFPD seeks proposals that achieve the goals presently stated in Section 2 of H.B. 5351 "An Act Concerning Certain Programs and to Incentivize and Implement Electric Energy Storage Resources," including:

1) Providing positive net present value to all ratepayers, or a subset of ratepayers paying for the benefits that accrue to that subset of ratepayers;

2) Providing multiple types of benefits to the electric grid, including, but not limited to, customer, local or community resilience, ancillary services, peak shaving or that support the deployment of other distributed energy resources; and

3) Fostering the sustained, orderly development of a state-based electric storage industry.

Despite the Connecticut General Assembly shutting down as a result of the COVID-19 public health crisis, the Green Bank does not believe that the passage of H.B. 5351 is necessary for PURA to act on proposals submitted under this docket through this RFPD. The following is a breakdown of other funding mechanisms the Green Bank believes that PURA can access to support its objectives through proposals submitted under Docket No. 17-12-03(RE03) RFPD's.

Upfront Incentives through the Declining Incentive Block Structure
There are a number of funding and/or cost recovery mechanisms that PURA could access to implement the upfront declining incentive block structure portion of the Program administered by the Green Bank, including:

- **Grid Side System Enhancement Proposals** – per Sections 102 and 103 of PA 15-5, the Grid Side System Enhancement policy's purpose is to demonstrate and investigate how distributed energy resources can be reliably and efficiently integrated into the operation of the electric distribution system in a manner that maximizes the value provided to the electric grid, electric ratepayers, and the public from such resources, while complementing or enhancing the programs products or incentives available through the Green Bank and Connecticut Energy Efficiency Fund. PURA could request that the EDCs submit a proposal to DEEP for evaluation and approval, and subsequently to PURA for review and approval, and then enter into an agreement to carry out these provisions through the Program for the upfront incentives, and the cost incurred can be recovered through a fully reconciling component of electric rates for all customers of Avangrid.

- **Electric Efficiency Partners Program** – per CGS 16-243v, the Electric Efficiency Partners Program's ("EEP Program") purpose is to conserve electricity and reduce demand in Connecticut through the purchase and deployment of energy efficient technologies and enhanced demand-side management technologies (e.g., customer-side emergency dispatchable generation resources, customer-side renewable energy generation). The EEP Program policy notes that "the annual ratepayer contribution for projects approved pursuant to this section shall not exceed sixty million dollars". The funding mechanism would be the same as has been used in the past to support EEP Program projects.

  It should be noted, that through Docket No. 18-09-34, that on March 20, 2019, the Green Bank received a certificate of public convenience from PURA demonstrating its adequate financial resources, managerial ability, and technical competency. In Docket No. 18-12-35, the Green Bank submitted an application into PURA for a combined residential solar PV and electric storage incentive program. With a PACT greater than two, the declining incentive block structure of the upfront incentive, could be funded using the EEP Program given (1) approval by PURA of a certificate of public convenience for the Green Bank, (2) the use of enhanced demand-side management technologies meeting the payback ratio as outlined in the Program, and (3) at least 75% of funding for the Program is supporting technology versus program administration – see Table 20.

Table 20. Budget for the Program in Terms of Administrative vs. Technology Costs

	Total Program Budget	**% of Total Budget**	**% Technology Costs**
Staff	$4,500,000	4.0%	-
Program Development and Administration[105]	$2,750,000	8.5%	7.2%
Marketing	$250,000	0.7%	-
Evaluation, Measurement, and Verification	$1,750,000	5.5%	-
Upfront Declining Incentives	$23,047,500	71.3%	71.3%
Total	**$32,297,500**	**100.0%**	**78.5%**

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- **Zero Emission Renewable Energy Credit Program** – when residential customers are interested in installing solar PV, but are no longer eligible for the RSIP (i.e., 350 MW target is achieved), then they will be eligible for the small

[105] It should be noted that the customer data collection and dispatch software costs within the budget, should be considered a technology cost for the Program. Inspector costs are $438,000 total – the remaining costs are technology costs for data collection and dispatch software.

ZREC until the start of the tariff.[106] Since the small ZREC incentive is fixed, not fully subscribed, and currently around $100/ZREC in Round 7 – approximately 5 times more than the average incentive of $20/ZREC equivalent under the RSIP in Step 15 – then PURA should enable the Green Bank to work with the EDCs to use the small ZREC incentive such that there is (1) no "race to the bottom" (i.e., unnecessary increase in residential solar PV incentives from $20 to $100/ZREC), and (2) a reduction of the small ZREC incentive from $100/ZREC to $35/ZREC equivalent[107] for solar PV only (i.e., including $15/ZREC equivalent to cover administrative costs for the Green Bank),[108] and some determined ZREC equivalent price for solar PV and battery storage for residential customers – see Tables 21 and 22.

Table 21. ZREC Equivalent Price Comparison with RSIP Incentives at Step 15

RSIP Incentive Step	**EPBB** ($/W)	**EPBB ZREC$_{EQ}$** ($/MWh)	**PBI** ($/kWh)	**PBI ZREC$_{EQ}$** ($/MWh)	**LMI-PBI** ($/kWh)	**LMI-PBI ZREC$_{EQ}$** ($/MWh)	**Average Step ZREC$_{EQ}$ Incentive** ($/MWh)[109]
15	$0.426	$49	$0.030	$13	$0.081	$36	$21

Table 22. ZREC Equivalent Price for Upfront Electric Storage Incentive at Various Discount Rates[110]

Electric Storage Incentive Step	**Average Electric Storage Incentive** ($/System)	**ZREC$_{EQ}$ at 0% Discount** ($/MWh)	**ZREC$_{EQ}$ at 3% Discount** ($/MWh)	**ZREC$_{EQ}$ at 7% Discount** ($/MWh)	**ZREC$_{EQ}$ at 10% Discount** ($/MWh)
1	$3,950	$30	$38	$49	$59
2	$3,400	$26	$32	$42	$50
3	$2,900	$22	$28	$36	$43
4	$2,350	$18	$22	$29	$35
5	$1,850	$14	$18	$23	$27

The small ZREC is currently providing two-times, seven-times, and three-times more than the RSIP's EPBB, PBI, and LMI-PBI incentives respectively – or five-times more that the RSIP overall.

At the conclusion of the RSIP, by lowering the small ZREC for residential ratepayers only

[106] CGS 16-245gg(f) – The purchase price of solar home renewable energy credits shall be determined by the Connecticut Green Bank, and such purchase price shall decline over time commensurate with the schedule of declining performance-based incentives and expected performance-based buydowns. Such purchase price shall not exceed the lesser of either (1) the price of small zero-emission renewable energy credit projects for the preceding year, or (2) five dollars less per renewable energy credit than the alternative compliance payment pursuant to subsection (k) of section 16-245. Any customer of an electric distribution company that is eligible for the residential solar investment program shall not be eligible for small zero-emission renewable energy credits pursuant to section 16-244s.

[107] It should be noted that this will be $5 less than the ACP (i.e., $40) on the Class I RPS beginning on January 1, 2021, and consistent with the RSIP lesser of cost recovery mechanism under PA 15-194.

[108] Based on blend of PBI ($15/ZREC), EPBB ($30/ZREC), and LMI-PBI ($40/ZREC) for a $20/ZREC equivalent price including $15/ZREC to cover administrative costs from the Green Bank, including metering, inspection, and staff oversight.

[109] Within Step 15, there 21% of the projects are EPBB, 76% are PBI, and 3% are LMI-PBI

[110] Assumes 8 kW solar PV system, capacity factor of 13%, degradation rate of 0.5%

to not encourage a "race to the bottom," the Green Bank would recommend that PURA consider a $35/ZREC for residential solar PV only (i.e., to cover incentive and administrative costs), and the associated net present value of the upfront declining incentive block structure for residential solar PV with battery storage – using the 3% discount rate – see Table 23.

Table 23. Proposed ZREC Equivalent Price for Battery Storage and Residential Solar PV including Administrative Costs

Electric Storage Incentive Step	**Average Battery Storage Incentive per System**	**ZREC for Residential Solar PV** ($/MWh)	**$ZREC_{EQ}$ for Battery Storage** ($/MWh)	**Total ZREC for Residential Solar PV and Battery Storage** ($/MWh)
1	$3,950	$35	$38	$73
2	$3,400	$35	$32	$67
3	$2,900	$35	$28	$63
4	$2,350	$35	$22	$56
5	$1,850	$35	$18	$53

If the Program were successful in the end, then the small ZREC would be delivering both residential solar PV and battery storage at nearly 50 percent less than the current small ZREC thereby increasing benefits to the participant, ratepayers, and society.

- **<u>Interim Residential Tariff</u>** – CGS 16-244z establishes an interim residential tariff:

  > *"The authority* [PURA] *may modify such rate for new customers under this subsection based on changed circumstances and may establish an interim tariff rate prior to the expiration of the residential solar investment program pursuant to subsection (b) of section 16-245ff as an alternative to such program, provided any residential customer utilizing a tariff pursuant to this subsection at such customer's electric meter shall not be eligible for any incentives offered pursuant to section 16-245ff at the same such electric meter and any residential customer utilizing any incentives offered pursuant to section 16-245ff at such customer's electric meter shall not be eligible for a tariff pursuant to this subsection at the same such electric meter.*

  To "foster the sustained orderly development of a local solar industry," during the 2018 legislative session of the Connecticut General Assembly, the Green Bank advocated for the inclusion of this provision to support the gradual transition from net metering to the tariff. The thinking was that rather than have an abrupt transition from net metering to the tariff, that there would be a transitionary period whereby an interim tariff was offered to allow market participants (e.g., contractors and customers) an opportunity to "pilot" the new compensation structure to "work out the kinks" before its full implementation. PURA could establish a tariff for the "buy all – sell all" option of the tariff policy, which wouldn't require that AMI be in place to begin the implementation of the tariff policy.

Performance-Based Incentive Structure
There are a number of funding and/or cost recovery mechanisms that PURA could access to support the performance-based incentive of the Program administered by the EDCs. Beyond the Grid Side System Enhancement and ZREC proposals noted above, there are:

- **Conservation Adjustment Mechanism** – per CGS 16-245m, the EDCs can access funds through the Conservation Adjustment Mechanism ("CAM") to provide funding support through the C&LMP.

- **Utility Ownership or Operation of Energy Storage Systems** – per CGS 16-244e, PURA may authorize the EDCs to recover costs and investments for energy storage systems that they build, own, or operate through a fully reconciling component of electric rates for all customers of the electric distribution company until their next rate case. At the next rate case, costs and investments by Avangrid shall be recoverable through base distribution rates.

I.2.	Provide a cost recovery proposal for all program administration and EM&V costs (e.g., regulatory asset, reconciling mechanism, etc.), and indicate whether the proposal is different from the cost recovery proposal for compensation. Provide justification; and

The Green Bank proposes to provide the upfront incentive through the Program, initially, using resources from the Clean Energy Fund (i.e., CGS 16-245n), and subsequently through program performance-based cost recovery through one of the mechanisms noted in I1 above – preferably the EEP Program. This Program seeks to utilize a combination of behind the meter residential solar PV with battery storage,[111] to create more benefits for the participant, ratepayers, and society. Despite challenges with data collection from a nascent industry, the Green Bank is attempting to advance in Connecticut, the Green Bank is an advocate for cost recovery that demonstrates transparent and measurable results.

The Green Bank proposes to cost recover the incentives and program administrative costs based on the performance of the Systems through the Program at the end of each of the first three (3) years of operation of the System within each step based on the following performance milestones achieved by the participating projects:

- **Year 1** – ensuring that the System (i.e., battery storage and behind the meter residential solar PV) are "up and running" as a complete unit as determined by a Green Bank inspector and confirmed to be "online" and "visible" with the DRMS partner (e.g., Virtual Peaker);

- **Year 2** – default settings for passive dispatch (e.g., ISO-NE summer peak period) are in reasonable remote operation and "controllable" with the DRMS

[111] CGS 16-243v defines behind the meter solar PV and battery storage as "enhanced demand side management technologies"

(e.g., Virtual Peaker), and that data management, collection, and analysis is in process for EM&V purposes; and

- **<u>Year 3</u>** – the Systems within the portfolio of projects supported by the Program are within 20% of the overall PACT/UCT of [X] for the Program.

As the market for battery storage matures through fostering the sustained orderly development of a local battery storage industry, the cost recovery proposed by the Green Bank can be further eased with measurable and demonstrable results. In other words, as the Program progresses and the market matures, such a specific cost recovery protocol will become unnecessary as the market will "know what to expect" if they want to participate and receive ongoing ratepayer incentives.

<u>Preference in the EEP Program as the Funding Mechanism for the Program</u>
The Green Bank prefers the EEP Program as the funding mechanism because it believes that the upfront declining block incentive design is consistent with the public policy, including:

- **<u>Certificate of Public Convenience</u>** – PURA deemed the Green Bank eligible for the EEP Program by awarding a Certificate of Public Convenience given its demonstration of managerial, financial, and technical competency;

- **<u>Payback Ratio</u>** – proposed program design of the upfront declining incentive block structure, delivering no less than a two on the PACT, including, in addition, working with the EDCs to increase the overall Program PACT/UCT and increasing ratepayer and societal benefits through the active dispatch of the System;

- **<u>Technology Eligibility</u>** – proposed program design of the technologies being consistent with "enhance demand-side management technologies" as outlined in the statute, including "customer-side emergency dispatchable generation resources" (i.e., electric storage with 20% emergency back-up) and "customer-side renewable energy generation" (i.e., behind the meter residential solar PV);

- **<u>Technology Investment</u>** – not less than 75% of the ratepayer investment in the Program shall be used for the technologies themselves; and

- **<u>Legislatively Approved Resources</u>** – annual ratepayer support for the EEP program of $60 million.

PURA could simply reopen Docket No. 18-12-35, request that the Green Bank submit its RFPD from Docket No. 17-12-03(RE03), and approve it under the EEP Program.

If PURA would prefer another funding mechanism for the Green Bank's cost recovery, the Green Bank would of course be amenable to that approach.

I.3.	Include plans for the periodic review of program costs, including capital investments and ongoing operating expenses, in each cost recovery proposal.

With the goal of delivering 50 MW of electric storage by the end of 2025 and following the EM&V for the Program (see Appendix 7), the following would be an outline of the review of program costs, including cost recovery requests based on the performance of the Program – see Table 24.

Table 24. Overview of Program Cost Review by PURA and Requests of Cost Recovery by the Green Bank

Item	Date	Cost Recovery
Launch the Program	January 1, 2021	No
Six-Month Review	June 1, 2021	No
2021 Review	January 2022	Yes
2022 Review	January 2023	Yes
2023 Review	January 2024	Yes
2024 Review	January 2025	Yes
2025 Review	January 2026	Yes
2026 Review	January 2027	Yes
2027 Review	January 2028	Yes

For example, within the 2022 review (i.e., in January of 2023) there might be several cost recovery requests from the Green Bank to PURA based on the performance of the Program, including:

- **Year 1 Projects** – those projects that were installed in 2021, will be assessed on the default setting for passive dispatch performance, and the data management and collection performance; and

- **Year 2 Projects** – those projects that were installed in 2022 that are in full operation.

In addition to the review of program costs for cost recovery, there would be quarterly reports to PURA within the appropriate docket on the program-level metrics (e.g., incentives disbursed), evaluation performance metrics (e.g., peak demand reduction to ISO-NE protocol), operating and reliability performance metrics (e.g., back-up power and dispatch events), and customer data (e.g., number of projects supported by household income).

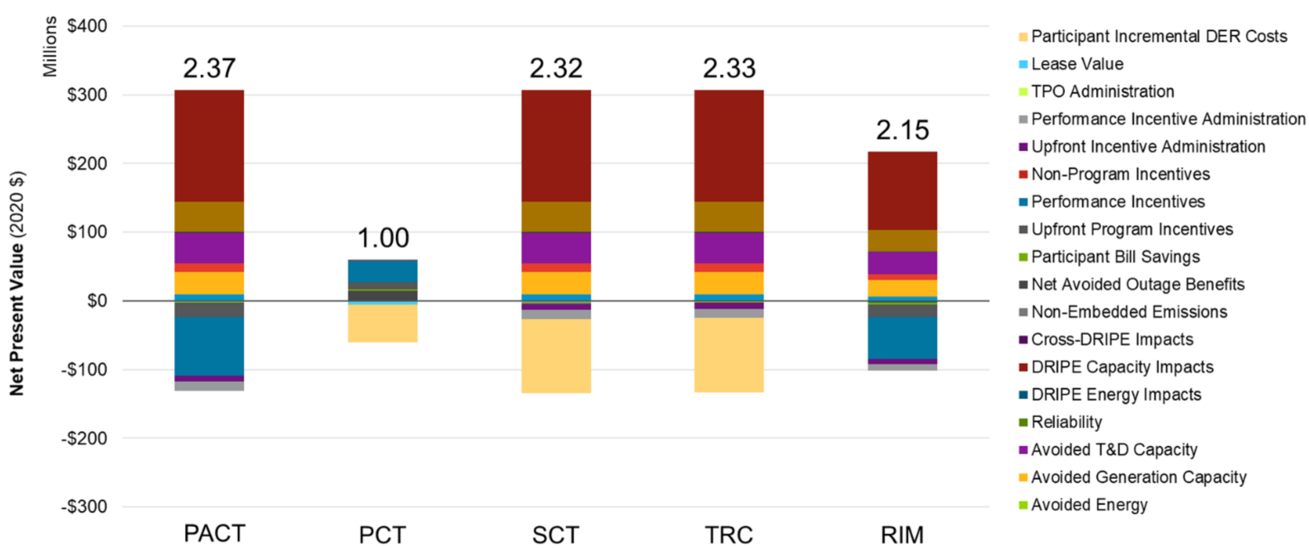
J. Cost-Benefit Analysis

The benefits and costs of the Solarize Storage program were analyzed from several different perspectives. Table 25 presents the various costs tests and the benefit-cost ratio of the program that was calculated for each cost test. Figure 27 shows the Net Present Value of all costs and benefits of the Program for each Cost Test as well as the calculated benefit-cost ratios. The benefits of the program are greater than the costs from each of the perspectives analyzed, which indicates a highly beneficial program for all stakeholders.

Table 25. Net Present Value and Benefit-Cost Ratio for Ratepayers

Cost Test	Program Administrator Cost Test (PACT)[112]	Participant Cost Test (PCT)	Societal Cost Test (SCT)	Total Resource Cost Test (TRC)	Ratepayer Impact Measure (RIM)
Benefit-Cost Ratio	2.37	1.00	2.32	2.33	2.15

Figure 27. Benefit-Cost Ratios of each Cost Test[113]



The following sections provide further detail about the cost tests included in the analysis. Sections J.1. through J.4. specifically focus on the Ratepayer Impact Measure (RIM) cost test. Sections J.5. and J.6. then introduce the Participant Cost Test (PCT), Program Administrator Cost Test (PACT), Societal Cost Test (SCT), and Total Resource Cost Test (TRC). The comprehensive set of inputs and assumptions used in these analyses can be found in Appendix 1 and Appendix 8.

The Upfront Incentive Program will run from 2021-2025 and will be comprised of five capacity blocks, each with an associated incentive level. In this analysis it is assumed that one incentive step, or capacity block, will be completed in each year. Table 26 shows the incentive steps and respective capacity block and program year.

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[112] The PACT referred to here is for the combined upfront and performance-based incentive program. Details about the PACT for the individual program administrators are included in Section J.5. and Appendix 1.

[113] Ibid.

Table 26. Capacity Blocks by Program Year and Calendar Year

Incentive Step	**Estimated # of Participants**	**Capacity Block** (MW)	**Program Year**	**Calendar Year**
1	400	2.0	2021	2021
2	700	3.5	2022	2022
3	1,300	6.5	2023	2023
4	2,600	13.0	2024	2024
5	5,000	25.5	2025	2025
Total	**10,000**	**50.0**		

J.1. Provide a cost-benefit analysis following the directions below that shows how such proposal will provide positive net present value to all electric ratepayers over the course of the full program:[114]

The benefits and costs to ratepayers for the battery storage program were evaluated to determine the overall Benefit-Cost Ratio. The RIM cost test calculates the benefits and costs of the program that will impact the electric ratepayers. Table 27 shows the present value of benefits and costs, as well as the net present value and the calculated benefit-cost ratio. Sections J.2 and J.3 and Appendix 1 provide more detail about the costs and benefits included in this analysis, inputs and assumptions, and methods of calculation.

Table 27. Net Present Value and Benefit-Cost Ratio for Ratepayers

	Present Value
Present Value of Benefits	$214,900,000
Present Value of Costs	$99,800,000
Net Present Value	$115,100,000
Benefit-Cost Ratio	2.15

J.1.1. Provide a sensitivity analysis showing the cost-benefit under various levels of participation.

The cost-benefit is not highly sensitive to varying levels of participation. As shown in Table 28, the RIM Benefit-Cost Ratio ranges from 2.07 to 2.21 with the number of participants ranging from 7,500 to 12,500.

The energy and capacity benefits scale linearly with the level of participation, as do the ESS costs and incentive payments. These items make up the majority of the value of all benefits and costs, thus the benefit-cost ratio does not vary much. The costs that do not scale linearly with level of participation are the program administration costs.

The upfront incentive program administration costs are largely fixed costs thus do not

[114] Respondents shall use a discount rate of seven percent and inflation rate of two percent to calculate net present value. Respondents may also provide an analysis using other discount and inflation rates, as they deem appropriate. Respondents must provide justification for any other discount and inflation rates.

depend on number of participants. In the range of levels of participation shown in Table 28, the Staffing and Marketing costs are not expected to change. The portion of the budget that will vary with the number of participants is allocated toward software costs, which fall under Program Development and EM&V. These costs are expected to vary by $120/participant.[115]

The Active Dispatch Program Administration Costs have a larger portion of variable costs. About half of the estimated costs are per device fees for the software integration. These fees total to about $720/participant.[116]

Table 28. Net Present Value and Benefit-Cost Ratio for Ratepayers Under Varying Levels of Participation

	-25%	**-10%**	**Expected Participation**	**+10%**	**+25%**
Total Number of Participants	7,500	9,000	10,000	11,000	12,500
Present Value of Benefits (millions)	$161	$193	$215	$236	$269
Present Value of Costs (millions)	$78	$91	$100	$109	$121
Net Present Value (millions)	$83	$102	$115	$128	$147
RIM Benefit-Cost Ratio	**2.07**	**2.13**	**2.15**	**2.18**	**2.21**

J.2.	Clearly identify each cost and benefit category included in this cost-benefit analysis (e.g., avoided capacity Demand Reduction Induced Price Effect);

The RIM cost test analyzes the impacts of the benefits and costs of the program on the Connecticut Ratepayers. The following benefits and costs are monetized in the analysis:

- Benefits: Avoided Energy, Avoided Generation Capacity, Avoided T&D Capacity, Reliability, DRIPE Energy Impacts, DRIPE Capacity Impacts, Cross-DRIPE Impacts

- Costs: Lost Utility Revenue, Upfront Incentives, Performance Incentives, Upfront Incentive Program Costs (e.g., Administration), Performance Incentive Program Costs (e.g., Administration)

These benefit and cost categories are discussed in further detail below.

- **Avoided Energy** - This is the value of avoiding the generation of or the purchase of electric energy within ISO New England’s wholesale energy market due to net energy savings. For the Program this is a negative benefit, as battery round-trip efficiency losses lead to a net increase in energy consumption.

- **Avoided Generation Capacity Benefits** - By reducing system peak loads, the

[115] Cost per participant is $1/month. Assume participation for 10 years.
[116] Cost per participant is $6/month. Assume participation for 10 years.

Program reduces the need for marginal generation capacity to come online during system peaks. Avoided capacity costs in Connecticut are based on actual and forecasted clearing prices in ISO New England's forward capacity market.

- **Avoided Transmission and Distribution Benefits** - In addition to avoiding generation costs, peak load reductions from energy storage systems also contribute to deferring or avoiding investments in load-related transmission and distribution infrastructure, due to both reduced load growth and reduced loading of existing equipment. In Connecticut this value is the summation of three different components. First, all of New England pays for Pool Transmission Facilities (PTF), which is tracked by ISO-NE. This value does not include the potential avoided costs associated with local distribution or non-PTF transmission infrastructure that could be captured through a localized peak reduction. The value of these localized benefits is defined by the EDCs.

- **Reliability** - Reducing the peak load allows for increasing reserve margins, which improves system reliability. That is, peak load reduction – along with the regulatory framework designed to increase available peak capacity such as the ISO-NE forward capacity market and state mandated resource generation quotas like for offshore wind – produces greater buffer for system capacity to be able to handle demand during a peak event. This, in turn, reduces the likelihood of an outage, which would have otherwise been a cost to consumers who would have been unable to take power from the system.

- **DRIPE Energy Benefits** - Connecticut participates in a competitive wholesale energy market through ISO-NE, where prices have a positive correlation with the magnitude of energy demand. Therefore, reducing the level of energy consumption leads to reduced market clearing prices. Within Connecticut this is known as Demand Reduction Induced Price Effect (DRIPE). This benefit could be thought of as incremental to the Avoided Energy benefit; while Avoided Energy captures the value of saving some amount of energy at some price, this benefit captures the value of reducing the price that is paid for the remaining energy demand. Since Connecticut participates in the larger ISO-NE marketplace, there are both intrastate and rest-of-pool components to DRIPE, which are both captured in Connecticut's benefit cost tests. As with Avoided Energy, for the Program this is a negative benefit, as battery round-trip efficiency losses lead to a net increase in energy consumption.

- **DRIPE Capacity Benefits** - Analogous to DRIPE Energy Benefits, Connecticut also participates in a competitive capacity market through ISO-NE, where prices correlate with the magnitude of the maximum power demand. Again, reducing forecasted peak demand leads to reduced market clearing prices. Within Connecticut this is known as Demand Reduction Induced Price Effect (DRIPE). This benefit could be thought of as incremental to the Avoided Generation Capacity benefit; while Avoided Generation Capacity captures the value of saving some amount of peak demand at some price, this benefit captures the value of reducing the price that is paid for the remaining peak demand. Since Connecticut participates in the larger ISO-NE marketplace, there are both intrastate and rest-of-pool components to DRIPE, which are both captured in Connecticut's benefit cost tests.

- **Cross-DRIPE Benefits** - Cross-DRIPE accounts for the interplay between gas prices and electricity prices. Since much of the region's annual gas consumption is used for generating electricity and, inversely, much of the region's electricity is produced by gas-fired generators, their prices are closely related. As DRIPE Energy leads to reduced electricity prices, that reduction leads to decreased gas prices, which further reduces electricity prices. For Connecticut this manifests itself as an additional benefit for reduced energy consumption. However, for the Program this is a negative benefit, as battery round-trip efficiency losses lead to a net increase in energy consumption.

- **Lost Utility Revenue (AKA Customer Bill Savings)** - For customers on time-of-use ("TOU") rates, batteries shift net energy consumption from higher priced on-peak hours to lower priced off-peak hours. This leads to reduced customer electricity bills, which passes onto the EDCs as lost utility revenue. Due to revenue decoupling in Connecticut, this is a cost in the RIM test for the Program.

- **Upfront Incentives** - The upfront program incentive is designed to reduce the actual cost that the customer pays for the ESS. The upfront incentive starts at $280 per kWh capacity[117] in the first year of the program. The incentive then declines with each capacity block, over which time it is also expected that costs of the system decline due to greater market saturation. LMI customers receive a greater incentive to mitigate financial barriers to participation and to increase the PCT for LMI customers by about 50%, as discussed in Section D.7. Table 29 below shows the value of the upfront incentive for non-LMI and LMI customers in each step.

- **Performance Incentives** - The performance-based incentives are paid on an annual basis to customers that opt-in to the active dispatch program. The value of the performance incentive is constant for each capacity block, as shown in Table 29. The participant can receive performance incentives for the lifetime of the battery (10 years), which is also shown in Table 29 as the nominal value of the performance incentives over the lifetime.

Table 29. Upfront and Performance Incentives Block Structure

Incentive Step	**Non-LMI Upfront Incentive** ($/kWh)	**LMI Upfront Incentive** ($/kWh)	**Performance Based Incentive Over Time** ($/kW)	**Nominal Value of Performance Based Incentives** ($/kW)
1	$280	$560	$225	$11,250
2	$240	$480	$225	$11,250
3	$200	$410	$225	$11,250
4	$170	$330	$225	$11,250

[117] Incentives are adjusted based on the capacity of the ESS. This is the effective incentive amount for the Tesla Powerwall (5 kW, 13.5 kWh).

5	$130	$260	$225	$11,250

- **Upfront Incentive Program Costs (e.g., Administration)** – Non-incentive program costs including all expenses that the Connecticut Green Bank incurs in operating the upfront incentive and passive dispatch program. As discussed in Section G, these costs are broken down into Staffing, Program Development & Administration, Marketing, and EM&V and are expected to total $9.25 million from 2021-2035.

- **Performance Incentive Program Costs (e.g., Administration)** – Non-incentive program costs including all expenses that the EDCs incur in operating the performance incentive and active dispatch program.

J.3.	Clearly quantify each cost and benefit category included in this cost-benefit analysis. Provide values for each cost and benefit category for each program year, including all data inputs and assumptions, and provide such cost-benefit analysis in Excel in a format similar to the below template:[118]

Table 30 shows the value of each cost and benefit for each installation year of the program. The values shown are the net present values of the cost or benefit that will accrue for twenty years after the date of installation. The net present value of all costs and benefits are summed for each installation year and the net present value for the entire program is calculated. Refer to Appendix 1 for a comprehensive list of assumptions and inputs used in the analysis. Additionally, the comprehensive cost-benefit model is provided in Appendix 8. Table 30 can be found in tab J.3.

[118] Provide the requested cost-benefit analysis in an unlocked Excel workbook with no hidden formulas or macros.

Table 30. Costs and Benefits to Ratepayers by Installation Year

Benefit Cost Analysis Results by Capacity Block - RIM (2020$)						
Installation Year	**2021**	**2022**	**2023**	**2024**	**2025**	**Program Total**
Avoided Energy	-$80,000	-$130,000	-$230,000	-$430,000	-$800,000	-$1,670,000
Avoided Generation Capacity - Passive	$230,000	$420,000	$820,000	$1,690,000	$3,280,000	$6,440,000
Avoided Generation Capacity - Active	$840,000	$1,550,000	$3,030,000	$6,200,000	$11,950,000	$23,570,000
Avoided T&D Capacity - Passive	$410,000	$690,000	$1,220,000	$2,320,000	$4,250,000	$8,890,000
Avoided T&D Capacity - Active	$1,490,000	$2,490,000	$4,410,000	$8,410,000	$15,420,000	$32,220,000
Reliability - Passive	$10,000	$30,000	$50,000	$80,000	$140,000	$310,000
Reliability - Active	$50,000	$100,000	$170,000	$290,000	$470,000	$1,080,000
DRIPE Energy Impacts	-$10,000	-$20,000	-$30,000	-$60,000	-$110,000	-$230,000
DRIPE Capacity Impacts - Passive	$1,030,000	$1,930,000	$3,700,000	$8,160,000	$15,990,000	$30,810,000
DRIPE Capacity Impacts - Active	$3,900,000	$7,250,000	$13,830,000	$30,110,000	$58,450,000	$113,540,000
Cross-DRIPE Impacts	$0	$0	-$10,000	-$10,000	-$10,000	-$30,000
Participant Bill Savings	-$160,000	-$270,000	-$480,000	-$920,000	-$1,700,000	-$3,530,000
Upfront Program Incentives	-$1,470,000	-$2,090,000	-$3,060,000	-$4,690,000	-$6,550,000	-$17,860,000
Performance Incentives	-$3,040,000	-$4,970,000	-$8,630,000	-$16,130,000	-$28,990,000	-$61,760,000
Upfront Incentive Administration	-$1,590,000	-$1,140,000	-$1,090,000	-$1,300,000	-$1,740,000	-$6,860,000
Performance Incentive Administration	-$1,090,000	-$1,090,000	-$1,440,000	-$2,310,000	-$3,810,000	-$9,740,000
Benefit	$7,870,000	$14,310,000	$26,960,000	$56,760,000	$109,030,000	$214,930,000
Cost	$7,350,000	$9,560,000	$14,700,000	$25,350,000	$42,790,000	$99,750,000
Total Net Benefits	$520,000	$4,750,000	$12,260,000	$31,410,000	$66,240,000	$115,180,000
Benefit Cost Ratio	1.07	1.50	1.83	2.24	2.55	2.15

Total Program Net Present Value	**$115,180,000**
Total Program Benefit Cost Ratio	**2.15**

All values shown are NPV in 2020$, assuming a discount rate for the RIM of 7.0% and inflation of 2.0%

J.4.	Provide written justification, references, and supporting data for the inclusion of each cost and benefit category. Also, provide written justification for the calculation methodology used for each category and the likelihood the proposed program provides such benefit or incurs such cost;

Support for the benefits and costs listed in Section J.2. includes the following sources:

a) **2019-2021 Conservation and Load Management Plan ("C&LMP"), submitted by Eversource Energy, United Illuminating, Connecticut Natural Gas Corporation, and Southern Connecticut Gas, filed March 1, 2020** [119] - Includes the cost effectiveness screening framework for energy efficiency and demand management resources in Connecticut according to the EDCs and approved by the State

b) **Distributed Energy Resources in Connecticut – Draft ("Value of DERs in Connecticut – Draft Study"), prepared by the Connecticut Department of Energy and Environmental Protection (DEEP) and Connecticut Public Utilities Regulatory Authority (PURA), filed July 1, 2020 under Docket No.19-06-29** [120] - "Provides a high-level analysis of the benefits different DERs provide to Connecticut", including behind-the-meter solar PV paired with electric storage, as determined by DEEP and PURA

c) **Avoided Energy Supply Cost Components in New England ("AESC"), by Synapse Energy Economics, et. al., last amended October 24, 2018** [121] - Monetizes the benefits identified in the latest C&LMP, and its methodology is used to quantify some benefits in the Value of DERs in Connecticut – Draft Study

d) **National Standard Practice Manual for Energy Efficiency ("NSPM"), prepared by The National Efficiency Screening Project, published May 18, 2017** [122] - The preeminent framework for assessing cost effectiveness energy resources, referenced by DEEP as the key driver for re-evaluating Connecticut's approach to cost effectiveness testing in 2018 [123]

e) **Database of State Efficiency Screening Practices ("DSESP"), prepared by The National Efficiency Screening Project, last updated March 24, 2020** [124] - Summarizes energy resource cost effectiveness testing protocols for all 50 states

A detailed justification for the inclusion of each key benefit and cost category based largely on these sources follows:

[119] Available at: https://www.energizect.com/connecticut-energy-efficiency-board/current-and-approved-clm-plans
[120] Available at: http://www.dpuc.state.ct.us/dockcurr.nsf/(Web+Main+View/All+Dockets)?OpenView&StartKey=19-06-29
[121] Available at: https://www.synapse-energy.com/project/avoided-energy-supply-costs-new-england
[122] Available at: https://www.nationalenergyscreeningproject.org/the-national-standard-practice-manual-for-energy-efficiency/
[123] See https://portal.ct.gov/DEEP/Energy/Conservation-and-Load-Management/Benefit-Cost-Testing
[124] Available at: https://www.nationalenergyscreeningproject.org/state-database-dsesp/

- **Avoided Energy**
    - Reason for Inclusion: This is a benefit in the C&LMP (pg. 35) and Value of DERs in Connecticut – Draft Study (pg. 15) and is therefore included for consistency with Connecticut cost effectiveness testing.
    - Method of Calculation: The annual energy savings by ISO New England defined costing period[125] is calculated based on assumed energy storage dispatch profiles, then monetized according to the value of Avoided Energy in Connecticut from the AESC. This method is consistent with the C&LMP.
    - Likelihood: The Program is essentially guaranteed to accrue this benefit to some extent, as changes in energy consumption due to the Program will directly lead to different levels of energy purchased in ISO-NE's wholesale market. Note that every state that performs cost effectiveness testing for energy resources monetizes this benefit category according to the DSESP. The magnitude of this benefit is likely to be negative (as is modeled), since the round-trip efficiency losses of the battery lead to net energy losses.

- **Avoided Generation Capacity**
    - Reason for Inclusion: This is a benefit in the C&LMP (pg. 35) and Value of DERs in Connecticut – Draft Study (pg. 26) and is therefore included for consistency with Connecticut cost effectiveness testing.
    - Method of Calculation: The average annual peak savings during the ISO New England defined summer peak capacity hours[126] is calculated based on assumed energy storage dispatch profiles for the passive dispatch benefit, while a peak savings of 5 kW is assumed for the active dispatch. This value is then monetized according to the value of Avoided Generation Capacity in Connecticut from the AESC. This method is consistent with the C&LMP.
    - Likelihood: The Program is essentially guaranteed to accrue this benefit to some extent, as changes in peak demand due to the Program will directly lead to different levels of power contracted in ISO-NE's forward capacity market. Note that every state that performs cost effectiveness testing for energy resources monetizes this benefit category according to the DSESP. The magnitude of this benefit is likely to be positive, as the program administration and EM&V will ensure that participants dispatch to help reduce peak demand.

- **Avoided T&D Capacity**
    - Reason for Inclusion: This is a benefit in the C&LMP (pg. 35) and Value of

[125] The four periods are: (1) summer on-peak, defined as 7 am – 11 pm on non-holiday weekdays in June – September, (2) summer off-peak, defined as 11 pm – 7 am on non-holiday weekdays and all hours on weekends and holidays in June – September, (3) winter on-peak, defined as 7 am – 11 pm on non-holidays weekdays in January – May and October – December, and (4) winter off-peak, defined as 11 pm – 7 am on non-holiday weekdays and all hours on weekends and holidays in January – May and October – December. These are defined by ISO-NE here: https://www.iso-ne.com/participate/support/glossary-acronyms/

[126] Defined as 1 pm – 5 pm on non-holiday weekdays in June – August

DERs in Connecticut – Draft Study (pg. 27, 60) and is therefore included for consistency with Connecticut cost effectiveness testing.

- Method of Calculation: The average annual peak savings during the ISO New England defined summer peak capacity hours is calculated based on assumed energy storage dispatch profiles for the passive dispatch benefit, while a peak savings of 5 kW is assumed for the active dispatch. This value is then monetized according to the value of Avoided Pooled Transmission Facilities in Connecticut from the AESC and the value of avoided localized transmission and distribution from the C&LMP. This method is consistent with the C&LMP.
- Likelihood: The Program is likely to accrue this benefit to some extent. Materialization of this benefit requires (1) that investment in transmission and distribution infrastructure is otherwise necessary to meet peak demand over the analysis timeframe and (2) the Program creates (2a) *enough* peak reduction in (2b) *time* and at the (2c) *location* necessary to defer or avoid those infrastructure investments. As discussed in the Value of DERs in Connecticut – Draft Study, it's difficult to identify the baseline need for infrastructure investments but it's likely that there would be one. As to the impact of the Program on addressing that need, the Program is designed to reduce peak demand by bringing on 50 MW of battery capacity within 5 years, which would likely be enough to help alleviate any need that would have arose over the next 15 years. The locational aspect of the savings is also a consideration for the distribution portion of the benefit. As the Value of DERs in Connecticut – Draft Study identifies, the benefit to specific substations could exceed $125/kW (pg. 58), but across all of Connecticut the benefit may be far less. For that reason, the values identified in the AESC are used to monetize this benefit.

- **Reliability**

  - Reason for Inclusion: This is a benefit in the C&LMP (pg. 35) and Value of DERs in Connecticut – Draft Study (pg. 54) and is therefore included for consistency with Connecticut cost effectiveness testing.
  - Method of Calculation: The average annual peak savings during the ISO New England defined summer peak capacity hours is calculated based on assumed energy storage dispatch profiles for the passive dispatch benefit, while a peak savings of 5 kW is assumed for the active dispatch. This value is then monetized according to the value of Reliability in Connecticut from the AESC. This method is consistent with the C&LMP.
  - Likelihood: The Program is likely to accrue this benefit to some extent. As the AESC explains, there are at least four ways in which load reductions improve generation reserves (pg. 224), and ISO-NE has shown that increased reserve margins lead to improved reliability. Reducing the frequency and duration of outages reduces consumer costs, though it may be difficult to value. However, the value of lost load defined by the AESC (pg. 218-224) is well sourced and driven largely by savings for commercial

and industrial customers, which is why it is used here to monetize this benefit.

- **DRIPE Energy Impacts**

  - Reason for Inclusion: This is a benefit in the C&LMP (pg. 35) and Value of DERs in Connecticut – Draft Study (pg. 16) and is therefore included for consistency with Connecticut cost effectiveness testing.
  - Method of Calculation: The annual energy savings by ISO New England defined costing period is calculated based on assumed energy storage dispatch profiles, then monetized according to the value of intrastate and rest-of-pool DRIPE Energy in Connecticut from the AESC depending on install year, assuming the average weighted value between cleared and uncleared resources. This method is consistent with the C&LMP.
  - Likelihood: The Program is highly likely to accrue this benefit to some extent. As with the Avoided Energy benefit, changes in energy consumption due to the Program will directly lead to different levels of energy purchased in ISO-NE's wholesale market, which will somewhat indirectly lead to changes in the eventual clearing prices of that market. While this benefit is harder to quantify than the Avoided Energy benefit, it has still been shown to exist by the NSPM wherever there are competitive energy markets.

- **DRIPE Capacity Impacts**

  - Reason for Inclusion: This is a benefit in the C&LMP (pg. 35) and Value of DERs in Connecticut – Draft Study (pg. 22) and is therefore included for consistency with Connecticut cost effectiveness testing.
  - Method of Calculation: The average annual peak savings during the ISO New England defined summer peak capacity hours is calculated based on assumed energy storage dispatch profiles for the passive dispatch benefit, while a peak savings of 5 kW is assumed for the active dispatch. This value is then monetized according to the value of intrastate and rest-of-pool Capacity DRIPE from the AESC. This method is consistent with the C&LMP.
  - Likelihood: The Program is highly likely to accrue this benefit to some extent. As with the Avoided Generation Capacity benefit, changes in peak demand due to the Program will directly lead to different levels of peak capacity contracted for in ISO-NE's forward capacity market, which will somewhat indirectly lead to changes in the eventual clearing prices of that market. While this benefit is harder to quantify than the Avoided Generation Capacity benefit, it has still been shown to exist by the NSPM wherever there are competitive capacity markets.

- **Cross-DRIPE Impacts**

  - Reason for Inclusion: This is a benefit in the C&LMP (pg. 35) and is therefore included for consistency with Connecticut cost effectiveness testing.

- Method of Calculation: The annual energy savings is calculated based on assumed energy storage dispatch profiles, then monetized according to the value of DRIPE Energy in Connecticut from the AESC. This method is consistent with the C&LMP.
- Likelihood: The Program is likely to accrue this benefit, but to a very small extent (and as a negative benefit). As described in the AESC (pg. 185), since much of the electricity generation in the region is from natural gas power plants, reducing the electricity demand reduces the demand for natural gas leading to lower costs for natural gas, thereby reducing the operating cost of the natural gas power plant and further reducing the cost of electricity. While the AESC determines a value for this reduction which is used in the BCA, the slightly increased level of energy consumption from battery round-trip efficiency losses will likely only have a minor effect on raising costs through the supply chain.

- **Lost Utility Revenue (AKA Participant Bill Savings)**

  - Reason for Inclusion: This is the key cost category whose inclusion defines the RIM test according to the NSPM (pg. 114).
  - Method of Calculation: The annual energy savings by utility TOU rate period[127] is calculated based on assumed energy storage dispatch profiles, then monetized according to the average TOU rates by utility, assuming annual rate growth of 2.61%.[128]
  - Likelihood: The Program is highly likely to accrue this cost to ratepayers as the TOU peak periods with higher costs coincide with the period of battery dispatch by design.

- **Upfront Incentives**

  - Reason for Inclusion: This is the cost of upfront incentives provided to participants, which is included in the UCT and RIM according to the NSPM (pg. 114) and the C&LMP (pg. 35).
  - Method of Calculation: The assumed effective upfront incentive per participant is applied to the number of assumed participants.
  - Likelihood: The Program is essentially guaranteed to accrue this cost as participants receive incentives for enrolling.

- **Performance Incentives**

  - Reason for Inclusion: This is the cost of performance incentives provided to participants, which is included in the UCT and RIM according to the NSPM (pg. 114) and the C&LMP (pg. 35).

[127] For both Eversource and UI, the TOU peak period is defined as 12 pm – 8 pm on non-holiday weekdays and the TOU off-peak period is defined as all other hours.

[128] Annual escalation rate of 2.61% based on 20-yr CAGR for Connecticut rates based on EIA data (1997 – 2017)

- Method of Calculation: The assumed effective performance incentive per participant is applied to the assumed level of peak reduction for each of the assumed participants.
- Likelihood: The Program is essentially guaranteed to accrue this cost as participants receive incentives for performing in active dispatch.

▪ **Upfront Incentive Program Costs (e.g., Administration)**

- Reason for Inclusion: This is the non-incentive cost associated with the upfront incentive program, which is included in the UCT and RIM according to the NSPM (pg. 114) and the C&LMP (pg. 35).
- Method of Calculation: The assumed fixed and variable components of the program cost are applied.
- Likelihood: The Program is essentially guaranteed to accrue this cost as the passive dispatch program is administered.

▪ **Performance Incentive Program Costs (e.g., Administration)**

- Reason for Inclusion: This is the non-incentive cost associated with the performance incentive program, which is included in the UCT and RIM according to the NSPM (pg. 114) and the C&LMP (pg. 35).
- Method of Calculation: The assumed fixed and variable components of the program cost are applied.
- Likelihood: The Program is essentially guaranteed to accrue this cost as the active dispatch program is administered.

J.5.	Include a separate cost-benefit analysis for the participating electric customers, in a format similar to the above template. Such participant cost-benefit analysis should clearly identify and quantify each cost and benefit category and any other sources of funding (e.g., federal tax credits) included in the cost-benefit analysis. Such participant cost-benefit analysis may include a valuation of the emergency power provided by the electric storage system;

The participant cost test (PCT) analyzes the costs and benefits specific to the electric customers that participate in the ESS program. The following costs and benefits are included in the PCT:

Benefits: Net Avoided Outage Benefits, Participant Bill Savings, Upfront Program Incentives, Performance Incentives, and Non-Program Incentives (Federal Tax Credit)

Costs: Upfront ESS Costs, ESS Lease Value

The costs and benefits that were not discussed in Section J.2. are further discussed below.

- **<u>Net Avoided Outage Benefits</u>** - This is the assumed value to the participant of emergency power provided by the electric storage. Note that this is a subset of the Reliability benefit discussed in Section J.2., but as it applies exclusively to the participant. For that reason, typical value of lost load analysis (such as in the AESC, pg. 218-244) isn't entirely applicable, since the individuals that would purchase an energy storage system differ from the general electricity-consuming population precisely by how much they value this benefit. For this analysis a "revealed preference" approach was taken, wherein the purchase of an energy storage system is assumed to replace the one-time purchase of a similarly sized gas-powered generator.[129] This method strictly captures value of emergency power to the customer and fails to value the lower emissions of battery storage as backup or the ability to better utilize existing solar PV generation.

- **<u>Non-Program Incentives</u>** - Because the ESS is assumed to be charged entirely by solar energy, it is eligible for a credit under the Investment Tax Credit ("ITC"), which deducts a percentage of the installed cost of the ESS after incentives from the homeowner federal taxes. In 2021, an ITC of 22% of installed costs of the system net incentives is available to homeowners. After 2021, the value of the ITC goes to 0% for residential systems.[130] ESS that are owned by a Third-Party Owner or EDC and leased to the customer are eligible for the commercial ITC. The value of the ITC for commercial systems is also 22% of installed costs of the system net incentives in 2021. In 2022 and all remaining years of the program, the ITC value drops to 10%.

- **<u>Upfront ESS Cost</u>** - This is the full installed cost of the energy storage system, including the technology, installation, and any ongoing O&M.

- **<u>ESS Lease Value</u>** - The program is designed to include an option for a Third-Party or EDC to own the ESS and lease the system to the program participant. This shifts the burden of the upfront capital cost by amortizing it over 10 years through the value of the lease. In this scenario it is assumed that the TPO or EDC receives all of the incentive payments and bear all of the upfront costs of the ESS. The value of the incentives and ITC effectively get passed to the customer in the form of a reduced lease payment. The participant pays an ongoing monthly lease fee for 10 years.

The values and categories of the benefits and costs vary slightly between different types of participants and ESS ownership models. The cost-benefit analysis includes 16 different project types, broken down by Utility, Type of Installation, Ownership Model, and Income Level. All of these categories are binary, meaning a potential participant will fall into one category or the other – the participant with either be an Eversource or a United Illuminating customer, will either install PV in conjunction with the ESS or already has PV, will own the ESS or lease the ESS, and will be categorized as LMI or Non-LMI based on income. Table 31 shows how the participants are distributed across each of these metrics.

[129] Guidehouse analysis of gas-powered generators in the residential market found that they typically cost around $400 per kW of generation capacity.

[130] https://uscode.house.gov/view.xhtml?req=(title:26%20section:48%20edition:prelim)

Table 31. Project Type Categorization

Metric	Category	% of Participants
Utility	Eversource	80%
	United Illuminating	20%
Type of Installation	New PV Installation	30%
	Retrofit to Existing PV	70%
Ownership Model[131]	Customer Owned	69%
	Lease from TPO or Utility[132]	31%
Income Level	Non-LMI	95%
	LMI	5%

Table 32 shows the breakdown of participants across the 16 project types that result from the distributions shown above. Note that there are only 12 types of participants because it is assumed that all LMI customers will lease the ESS.

Table 32. Project Type Participation Breakdown

Utility	Type of Installation	Ownership Model	Income Level	% of Participants
Eversource	New PV Installation	Customer Owned	LMI	0.0%
Eversource	New PV Installation	Customer Owned	Non-LMI	15.7%
Eversource	New PV Installation	Lease from TPO or Utility	LMI	1.2%
Eversource	New PV Installation	Lease from TPO or Utility	Non-LMI	7.1%
Eversource	Retrofit	Customer Owned	LMI	0.0%
Eversource	Retrofit	Customer Owned	Non-LMI	36.7%
Eversource	Retrofit	Lease from TPO or Utility	LMI	2.8%
Eversource	Retrofit	Lease from TPO or Utility	Non-LMI	16.5%
United Illuminating	New PV Installation	Customer Owned	LMI	0.0%
United Illuminating	New PV Installation	Customer Owned	Non-LMI	3.9%
United Illuminating	New PV Installation	Lease from TPO or Utility	LMI	0.3%
United Illuminating	New PV Installation	Lease from TPO or Utility	Non-LMI	1.8%
United Illuminating	Retrofit	Customer Owned	LMI	0.0%
United Illuminating	Retrofit	Customer Owned	Non-LMI	9.2%

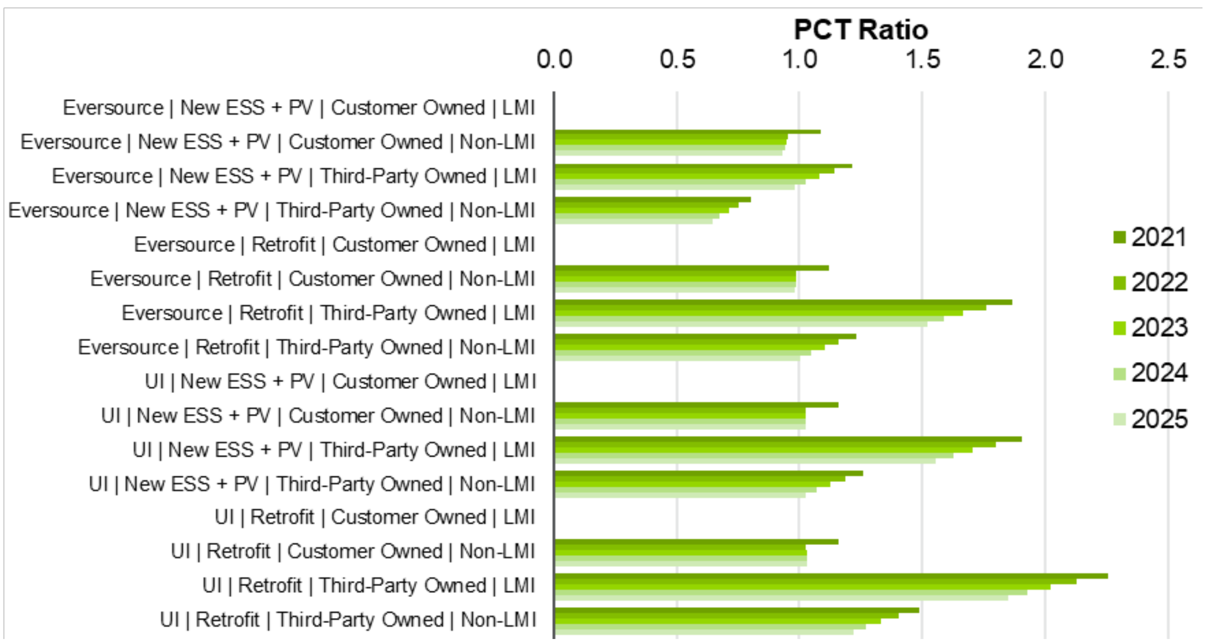
[131] Survey results were used to determine the breakdown of ownership model type
[132] It is assumed that all LMI customers participate in the Lease Model

United Illuminating	Retrofit	Lease from TPO or Utility	LMI	0.7%
United Illuminating	Retrofit	Lease from TPO or Utility	Non-LMI	4.1%

Figure 28 shows the PCT Benefit-Cost ratio by install year and project type. There are several explanations for the general trends seen in the chart:

- United Illuminating customers realize slightly higher bill savings due to differences in the rate structures
- LMI participants pay a lower lease rate than Non-LMI customers

Figure 28. PCT Benefit-Cost Ratio by Program Year and Project Type



The program-level costs and benefits are calculated as weighted values based on the project type and installation year. Table 33 presents a summary of the costs, benefits, net present value, and the benefit-cost ratio of the ESS Program for the PCT. See Table 34 for a further breakdown of the costs and benefits over the duration of the program. (Table 34 can also be found in Appendix 8, in tab J.5.)

Table 33. Net Present Value and Benefit-Cost Ratio for Program Participants

	Value
Present Value of Benefits	$59,900,000
Present Value of Costs	$60,190,000
Net Present Value	-$290,000
Benefit-Cost Ratio	1.00

Table 34. Costs and Benefits to Program Participants by Installation Year

Benefit Cost Analysis Results by Capacity Block - PCT (2020$)						
Installation Year	**2021**	**2022**	**2023**	**2024**	**2025**	**Program Total**
Net Avoided Outage Benefits	$740,000	$1,200,000	$2,070,000	$3,840,000	$6,860,000	$14,710,000
Participant Bill Savings	$120,000	$190,000	$330,000	$620,000	$1,120,000	$2,380,000
Upfront Program Incentives	$890,000	$1,230,000	$1,760,000	$2,620,000	$3,560,000	$10,060,000
Performance Incentives	$1,730,000	$2,750,000	$4,640,000	$8,440,000	$14,750,000	$32,310,000
Non-Program Incentives	$440,000	$0	$0	$0	$0	$440,000
Lease Value	-$240,000	-$420,000	-$760,000	-$1,470,000	-$2,750,000	-$5,640,000
Participant Incremental DER Costs	-$3,230,000	-$4,960,000	-$8,100,000	-$14,230,000	-$24,030,000	-$54,550,000
Benefit	$3,920,000	$5,370,000	$8,800,000	$15,520,000	$26,290,000	$59,900,000
Cost	$3,470,000	$5,380,000	$8,860,000	$15,700,000	$26,780,000	$60,190,000
Total Net Benefits	$450,000	-$10,000	-$60,000	-$180,000	-$490,000	-$290,000
Benefit Cost Ratio	1.13	1.00	0.99	0.99	0.98	1.00

Total Program Net Present Value	**-$290,000**
Total Program Benefit Cost Ratio	**1.00**

All values show n are NPV in 2020$, assuming a discount rate for the PCT of 10.0% and inflation of 2.0%

J.6.	In addition to the requested cost-benefit analysis and data requested above, respondents *may* also include metrics such as the utility cost test, participant cost test, ratepayer impact measure, and the total resource cost test using the data provided in response to the above requirements. Respondents may also provide additional cost-benefit analyses from other jurisdictions;

Similar benefit-cost analyses were performed for the Program Administrator Cost Test (PACT), the Utility Cost Test (UCT), the Societal Cost Test (SCT) and the Total Resource Cost Test (TRC). The benefit and cost categories included in these cost tests are the same as those discussed in Sections J.2 and J.5, with the exception of one benefit category included in the SCT:

- **Avoided Non-Embedded Emissions** - Though the Program will lead to net increases in energy consumption due to round-trip efficiency losses associated with cycling the battery, the Program may lead to net reductions in emissions if the battery charges during times with lower emission rates and discharges during times with higher emission rates. That seems likely since the energy storage will charge from solar PV production and discharge when peaking generation is operating. However, the AESC only provides electric emission levels by ISO-NE defined energy costing period, which is not granular enough to identify the benefit (in fact, it implies emission rates are lower during on-peak periods than off-peak periods). On the other hand, the Value of DERS in Connecticut – Draft Study implies that there is some level of benefit from incremental reduced emissions from behind the meter energy storage beyond the paired solar PV. However, that study assumed a slightly different dispatch model for the energy storage than what is used in this analysis. This BCA analysis conservatively uses the AESC values, consistent with the C&LMP, resulting in a negative benefit for avoided non-embedded emissions.

The results of the PACT are presented below. Refer to Appendix 8 for the analysis of the UCT, SCT, and TRC.

The PACT analyzes the costs and benefits specific to the administrators of the ESS program. The PACT of the entire proposed program includes all the costs and benefits from both the upfront incentive and performance-based incentive programs. The PACT can also be calculated for the two pieces of the program separately. The PACT for the upfront incentive program, administered by the Connecticut Green Bank, includes the costs to the Connecticut Green Bank for program administration and upfront incentives, and the benefits accrued through the passive dispatch settings. The PACT for the performance-based incentive program, administered by the Utilities, includes the same costs and benefits specific to the active dispatch program.[133]

[133] This PACT is technically a UCT because the performance-based incentive program is run by the Utilities. For consistency, this is considered a PACT as it is combined with the upfront incentive program PACT to calculate a combined PACT

The following costs and benefits are included in the PACT:

Benefits: Avoided Energy, Avoided Generation Capacity, Avoided T&D Capacity, Reliability, DRIPE Energy Impacts, DRIPE Capacity Impacts, Cross-DRIPE Impacts

Costs: Incentives, Program Administration

Table 35 presents a summary of the costs, benefits, net present value, and the benefit-cost ratio of the upfront incentive program.

Table 35. Net Present Value and Benefit-Cost Ratio of the Upfront Incentive Program

	Value
Present Value of Benefits	$62,780,000
Present Value of Costs	$29,330,000
Net Present Value	$33,450,000
Benefit-Cost Ratio	2.14

Table 36 presents a summary of the costs, benefits, net present value, and the benefit-cost ratio of the performance-based incentive program.

Table 36. Net Present Value and Benefit-Cost Ratio of the Performance Based Incentive Program

	Value
Present Value of Benefits	$163,130,000
Present Value of Costs	$66,660,000
Net Present Value	$96,470,000
Benefit-Cost Ratio	2.45

Table 37 presents a summary of the costs, benefits, net present value, and the benefit-cost ratio of the upfront incentive program.

Table 37. Net Present Value and Benefit-Cost Ratio of the Combined Upfront and Performance-Based Incentive Programs

	Value
Present Value of Benefits	$304,250,000
Present Value of Costs	$128,110,000
Net Present Value	$176,140,000
Benefit-Cost Ratio	2.37

Refer to Appendices I and VIII (tab J.6.) for the values of all costs and benefits for each capacity block.

J.7.	Respondents *may* also include non-quantifiable or hard-to-quantify benefits in any cost-benefit analysis so long as they are: (1) treated separately from quantifiable benefits; (2) clearly defined; and (3) clearly attributable to the proposal and associated technologies. Justification for

> the inclusion of any non-quantifiable or hard-to-quantify benefits must be provided along with any available models or methodologies for quantification, where applicable.

There are several non-quantifiable or hard-to-quantify benefits that this program may realize but are not quantified in the benefit-cost analyses. These benefits include, but are not limited to the following:

- **Macroeconomic Benefits** - The high level of forecasted investment in energy storage spurred by the Program will lead to macroeconomic benefits in Connecticut. The Value of DERs in Connecticut – Draft Study (pg. 40-51) indicates that this adds considerable value, but only provides a proxy value based on behind-the-meter solar PV of $10.6 per MWh of net DER energy generation. For standalone behind-the-meter energy storage there is small, negative net energy generation, so it is difficult to apply this value separately from the paired solar PV, whose benefits are not included in this BCA.

- **Net Participant Non-Energy Benefits** - There are potentially other benefits that accrue to the participant from owning a battery that are not directly associated with the usage of the energy storage system. For example, installing and interconnecting the energy storage system may increase property value. Without additional information, this BCA assumes that these benefits are negligible.

- **Net Societal Non-Energy Benefits** – Similar to net participant non-energy benefits, other benefits may accrue to society from increased energy storage adoption beyond the key factors discussed here. Without additional information, this BCA assumes that these benefits are negligible.

- **Avoided Ancillary Services** - Besides from the currently modeled use case of peak shaving, batteries could be used to support the ISO-NE ancillary services market. These batteries could potentially be used to generate revenue from that market outside of the summer peak season, which would bring additional benefits. However, this analysis assumes that the batteries would not be used in that way.

- **Market Revenues** – Instead of the currently modeled use case of passively dispatching during peak periods and actively dispatching on peak days, the batteries could be used for arbitrage to shift energy from times of low cost to times of high cost. Then instead of receiving energy market-based benefits like Avoided Energy, the batteries would generate revenue from directly participating in those markets. However, this analysis assumes that the batteries would not be used in that way.

These benefits are not included in the Benefit-Cost analyses as the values are either assumed to be negligible or are too difficult to reasonably quantify or justify.

K. Data Privacy and Security Plan

K.1.	Proposals must include a recommended data privacy and cybersecurity plan that:

The Green Bank would rely on three robust platforms to maintain data privacy and cybersecurity, including two platforms that the Green Bank has utilized since 2012 to administer the Residential Solar Investment Program (RSIP), namely Clean Power Research's (CPR) PowerClerk[134], and AlsoEnergy's LocusNOC (AlsoEnergy purchased Locus Energy) residential solar PV monitoring platform[135], and a third platform, Virtual Peaker's DRMS[136], which would be used for ESS dispatch and data management.

The PowerClerk platform collects customer identifier data (e.g., name, address, utility account number), incentive application and completion data and documentation input by RSIP contractors and processed by RSIP staff, including equipment specifications, sales, lease and PPA agreements, electric bills, site plans, shade reports, packing slips, utility interconnection approval documentation, energy audit information, completion forms, and inspection information. Similar information, as applicable would be collected in PowerClerk for the ESS technologies applying to the Green Bank for upfront incentives. PowerClerk is a robust distributed energy resource program management platform used by numerous state incentive programs, and CPR is a highly reputable, long-standing technology provider in the distributed energy resources industry. Utility companies such as Eversource Energy in Connecticut also use PowerClerk for program management such as for interconnection application processing.

Secondly, the Green Bank utilizes AlsoEnergy's LocusNOC platform to monitor solar PV production data from RSIP projects, transmitted to the AlsoEnergy platform from several revenue grade meter providers that have been qualified by the Green Bank to be eligible for use in RSIP, including AlsoEnergy, SolarEdge, Solar-Log and Enphase RGMs. Data from these RGMs is transmitted to the AlsoEnergy platform and ultimately utilized by the Green Bank for monetizing solar PV RECs to cost recover RSIP incentives and program administration costs through the sale of SHRECs through an MPA with the EDCs.

Similarly to RSIP, for the ESS Program, ESS technologies would need to become eligible to participate in the program. Monitoring and performance data associated with ESS projects is available to the customer on cloud-based software platforms maintained by each technology provider. Therefore, data security also relies on the security of each of the ESS technology provider software platforms. Customer access to their ESS data on their ESS technology provider platforms is password protected. Data privacy considerations for ESS data can be more sensitive than for solar PV data,

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[134] https://www.cleanpower.com/products/powerclerk/
[135] https://home.alsoenergy.com/
[136] https://www.virtual-peaker.com/

depending on how the ESS is used and whether it reflects customer energy usage, whereas solar PV monitoring is simply measuring solar PV system output.

Virtual Peaker connects cloud-to-cloud with the proprietary APIs of battery technology providers. These connections allow for data to stream back to Virtual Peaker multiple times a minute – typical using customer WiFi, though other communications protocols are supported. Virtual Peaker also supports a number of open standards, including OpenADR 2.0b. While its direct to device use cases are limited at this time, OpenADR would allow for a connection to other DRMS / DERMs systems being utilized by the EDCs. The Virtual Peaker platform is built using the most advanced security frameworks for cloud-based applications. The following is a sampling of the security measures in place by default:

- Two-factor authentication for all utility and customer logins
- Role based security that prevents users from accessing privileged data
- Encryption in transit keeps the moving data secure whether inside or outside Virtual Peaker's networks
- Encryption at rest protects databases even if a hacker gains physical access
- Secure means of transferring files through an SFTP site.

K.1.1.	Aligns with industry standards, best practices, and any state or federal regulations designed to protect customer data and prevent cybersecurity attacks;

On an annual basis, an external audit is performed on all Green Bank information technology systems and associated processes, which includes obtaining a SOC 3 report from all information technology platforms utilized by the Green Bank. A SOC 3 report is a is a shortened summary of the SOC 2 Type 2 audit report, made available for users who want assurance about the service provider's controls but don't need a full SOC 2 report. A SOC 3 report can be conferred by the service auditor only in cases where the service provider receives an unqualified audit opinion for SOC 2. SOC 2 compliance indicates that Service Organization Controls comply with standards for operational security, availability and confidentiality. The SOC 3 reports obtained by the Green Bank from all information technology providers are reviewed by external auditors to ensure that Green Bank systems meet acceptable standards for internal controls for security, availability, processing integrity, confidentiality and privacy. These five areas are the focuses of the American Institute of Certified Public Accountants (AICPA) Trust Services Principles and Criteria.

K.1.2.	Includes data aggregation standards (e.g., 15/15 for residential customers and 15/20 for industrial customers) and the ability and methods to pseudo-anonymize or anonymize data, when applicable;

The Green Bank and its program partners will give careful consideration to customer privacy, including with respect to standards and best practices for aggregating and anonymizing data, including data that will become publicly available such as through program evaluation reports. Consideration will be given to standards such as the 15/15 rule[137], anonymization methodology and research findings[138], and other potentially applicable practices pertaining to data analysis and customer privacy.[139]

K.1.3.	Addresses data ownership, data custodianship, and their roles and responsibilities and include data flows and system touch points that identify data ownership (customer/utility), data custodianship, and aggregated or anonymized data ownership;[140] and

Data ownership, custodianship, and roles and responsibilities are managed through the software platforms described above including CPR's PowerClerk, AlsoEnergy's residential solar PV monitoring platform, Virtual Peaker's DRMS, and ESS technology provider platforms. In the Green Bank platforms, access to the data is based on user role and type of action to be performed. As previously stated in K.1, ESS data privacy may be more sensitive than for solar PV data, for example, and therefore a DRMS that serves to centralize ESS data monitoring and management would be especially critical for program administrators. Note that the Virtual Peaker dispatch platform is not an owner but rather a custodian of data.

K.1.4.	Includes provisions for access to the data by the Authority and other government agencies such as the Department of Energy and Environmental Protection.

ESS project and performance data could be provided to the authority and to DEEP on an anonymized and aggregated basis, such as is required to meet periodic reporting requirements. Any other access to data could only be provided in conformance with data security considerations and data privacy requirements for customers.

L. Technology Eligibility

L.1.	Discuss how the proposed program design determines eligibility for electric storage technologies, including any recommended restrictions on the make or type of electric storage systems. Provide justification, including the respondent's experience with electric storage and how said experience informed the recommended technology eligibility and system restrictions;

The program will maintain a list of eligible energy storage technologies that will be updated on an ongoing basis. Battery technologies will be considered (and approved or not approved) for inclusion as eligible based on their ability to satisfy program

137 https://www.elevateenergy.org/wp/wp-content/uploads/1515-Rule-Factsheet-FINAL.pdf
138 https://techcrunch.com/2019/07/24/researchers-spotlight-the-lie-of-anonymous-data/
139 https://eq-research.com/blog/the-aggregated-challenges-of-regulating-energy-usage-data/
140 As a reference, respondents may want to review the New York State PSC's DSIP Cyber Security framework created by the Joint Utility Cybersecurity working group and the U.S. DOE's Data Guard Energy Data Privacy Program.

requirements and goals including but not limited to the following:

- Must be commercially available technologies[141] with appropriate technical certifications, including those listed in L.3.1, L.3.6, reflecting adequate capabilities, testing and quality control with respect to industry standards.
- Being able to meet the passive and active dispatch needs of the program, including existing or intended software integration with dispatch platforms utilized in the program, and ability for technology to receive remote software upgrades.
- Safety considerations, and other characteristics described in section L of this proposal (e.g., roundtrip efficiency, sufficient warranty periods and device longevity in terms of years and number of cycles).
- Customer service and technical support provided by battery manufacturer.

The criteria provided here were discussed with battery manufacturers and would be further refined in consultation with both manufacturers and contractors, as is Green Bank practice in developing and finalizing program guidelines. The Green Bank also has experience with battery storage technologies that have been installed as part of residential solar PV projects incentivized through RSIP and battery storage projects financed through its Smart-E loan program.

L.2.	Discuss if both AC- and DC-coupled systems would be eligible under this proposal and any requirements for the meters used to calculate the proposed compensation model. If possible, also provide:

Both AC- and DC-coupled systems would be eligible under this proposal.

If the solar PV portion of the system has or will receive an incentive from RSIP (or another program such as the forthcoming tariff), then it will be important to assure that the revenue grade meter (RGM) that measures solar PV production is only measuring solar production. In the case of a DC-coupled solar plus battery storage system, the solar PV and the battery share an inverter, and the revenue grade meter RGM sits between those systems and the grid. In the situation where a battery might charge from the grid (e.g., in anticipation of or right after a storm event or outage, to assure that the battery is at full capacity), that energy would pass through the RGM. If the energy from the grid wasn't all used on site and the battery later discharged all or some of that energy back to the grid, then the RGM might count that energy as though it originated from the PV system (since the RGM can't tell where it originated). The easiest way around this is to require that the RGM is bidirectional and registers energy from the grid as "negative" so that it is capturing the net production from the solar.

[141] For example, there are numerous battery storage technologies based on lithium ion chemistries that are commercially available and that could meet the eligibility requirements of this program. That said, it would be preferable not to limit the program to lithium ion-based battery storage devices in the event that technology development and commercialization with other energy storage technologies progresses in a short enough timeframe allow them to meet the program requirements.

L.2.1.	Wire diagrams of the eligible AC- and DC-coupled configuration(s); and

Figure 29. AC-Coupled Configuration

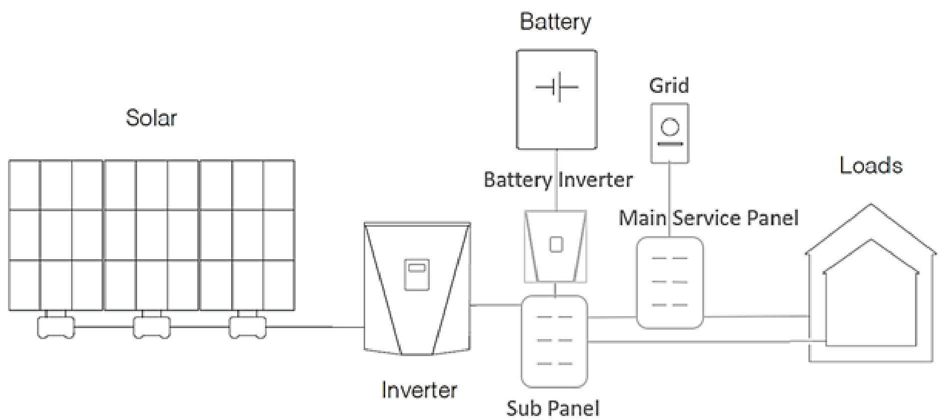
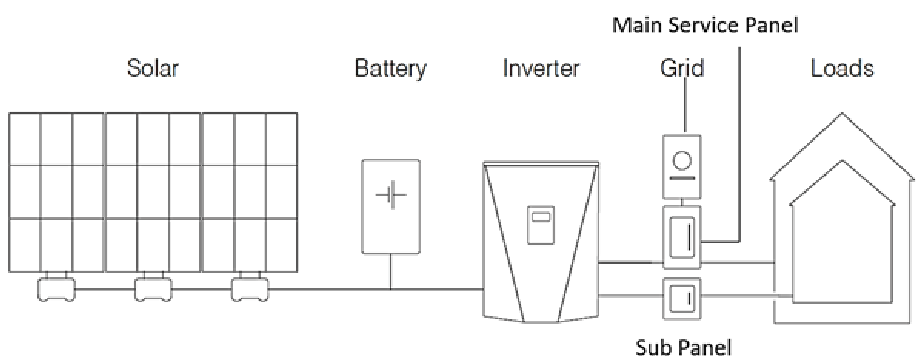


Figure 30. DC-Coupled Configuration



L.2.2.	Specifications of such metering requirements, including a list of eligible meters

As explained in L.2, metering requirements for DC-coupled systems require that the solar PV production meter is bidirectional. A bidirectional RGM used in RSIP is the AlsoEnergy LGate CAT1 RGM, but other meters would be approved as eligible for the program as long as they are verified to be bidirectional, or if the metering configuration is otherwise demonstrated to not interfere with solar PV production monitoring as is needed for projects in the RSIP or potentially a future program (e.g., forthcoming tariff).

L.3.	Discuss proposed technical and other requirements of the storage system including, if not provided elsewhere:

See section L.1.

L.3.1. Inverter certification requirements (IEEE, UL);

UL 1741 and IEEE 1547 are the key inverter certification requirements. See L.3.7 for details.

L.3.2. Energy storage specifications (round trip efficiency, battery chemistry, etc.);

The following table provides technical specifications for example battery models.

Table 38. Technical Specifications for Example Battery Storage Technologies

Battery Manufacturer and Model	Real Power, Maximum Continuous (kW)	Usable Energy Capacity (kWh)	Roundtrip Efficiency [142]	AC or DC Coupled	Battery Chemistry[143]
Tesla Powerwall 2	5	13.5	90%	AC	Lithium Nickel Manganese Cobalt Oxide (LiNiMnCoO2) (NMC)
Sonnen eco	3-8	5-20 (in 2.5 kWh steps)	95%	AC	Lithium iron phosphate (LiFePO4)
Sonnen ecoLinx	8	12-20 (in 2 kWh steps)			
Sonnen ecoLinx 30	8	30			
Generac PWRcell 9	3.4	8.6	96.5%	DC	Lithium Nickel Manganese Cobalt Oxide (LiNiMnCoO2) (NMC)
Generac PWRcell 12	4.5	11.4			
Generac PWRcell 15	5.6	14.3			
Generac PWRcell 17	6.7	17.1			
Panasonic EverVolt Standard	4.6	11.4	AC Coupled: 85% DC Coupled: 90%	AC or DC	Lithium Nickel Manganese Cobalt Oxide (LiNiMnCoO2) (NMC)
Panasonic EverVolt Plus	5.5	17.1			
LG Chem RESU10H	5	9.3	94.5	DC	Lithium Nickel Manganese Cobalt Oxide (LiNiMnCoO2) (NMC)

[142] Roundtrip efficiency losses are realized when the amount of energy that the ESS outputs when discharging is slightly less than the amount of energy that the ESS took in during charging. This is primarily because some energy is lost as heat during the electrochemical reaction that stores electrical energy as chemical potential energy in the ESS, though some energy is also lost as heat in the circuitry of the battery and due to small loads in the ESS like sensors and lights.

[143] Battery chemistry is subject to updated information and is dynamic based on manufacturer developments (e.g., changes in the battery chemistry that may be used as products evolve).

L.3.3. System warranty requirements;

The following table provides technical specifications for example battery models.

Table 39. Warranty Information for Example Battery Storage Technologies

Battery Manufacturer and Model	Warranty
Tesla Powerwall 2	10 years or 37 MWh throughput, 70% guaranteed end of warranty capacity
Sonnen eco	10 years or 10,000 cycles
Sonnen ecoLinx	15 years or 15,000 cycles
Generac PWRcell	10 years of throughput of 22.6 MWh, 30.2 MWh, 37.8 MWh, and 45.3 MWh for the PWRcell 9, 12, 15, and 17 respectively
Panasonic EverVolt	10 years or 7.56 MWh throughput per module, 60% guaranteed end of warranty capacity
LG Chem RESU	10 years or 22.4 MWh throughput, 60% guaranteed end of warranty capacity

L.3.4. Grid connected requirements;

All grid-connected batteries must meet the requirements of the “Guidelines for the Interconnection of Residential Single Phase Certified Inverter-Based Generating Facilities of 20kW (ac) or Less.” If battery storage is included, it must be indicated on the interconnection application and the battery capacity (kW) must be specified. If the total AC rating is greater than 20 kW, then the battery and any other components of the system (e.g., solar plus battery storage) must be reviewed through the “Guidelines for Generator Interconnection Fast Track and Study Processes.”

For solar PV plus battery storage systems interconnecting to the grid, interconnection standards implemented by the EDCs require that batteries are in non-export modes so that they will not export to the grid unexpectedly and potentially overload the local circuit. Batteries may only export to the grid within an active demand response program, in response to scheduled peak events. Interconnection standards do not prevent batteries from charging from the grid, however, batteries deployed with solar PV are set up to charge only from the PV in order to qualify for the federal ITC.

L.3.5. Cybersecurity protocol requirements;

See response to question K.1.

In addition, the Energy Storage Association provides some guidance on cybersecurity in their white paper, “ESA Corporate Responsibility Initiative: U.S. Energy Storage

Operational Safety Guidelines."[144]

L.3.6.	Standards and Codes requirements; and

Per L.3.1, UL 1741 and IEEE 1547 are the key inverter certification requirements.

In addition, the 2018 editions of the International Fire Code, International Residential Code and the NFPA 1 Fire Code first introduced requirements aimed specifically at modern ESS applications, with a focus on lithium-ion battery installations. Requirements were further refined in the 2021 editions of those model codes, and in the 2020 edition of NFPA 855[145], the Standard for the Installation of Stationary Energy Storage Systems. These codes and standards all require electrochemical ESSs to be listed in accordance with UL 9540, the Standard for Safety of Energy Storage Systems and Equipment, which was first introduced in November 2016. As installation code requirements are updated to reflect new industry developments, research, and testing, UL 9540 has evolved to better meet the safety needs of industry and the regulatory community. ESS size and separation requirements in particular have been addressed in the second edition of UL 9540.[146]

The current CT state building code is available here: https://portal.ct.gov/DAS/Office-of-State-Building-Inspector/Connecticut-State-Building-Code/Regulations.

The Energy Storage Association white paper, "ESA Corporate Responsibility Initiative: U.S. Energy Storage Operational Safety Guidelines"[147] references several additional resources that list codes and standards applicable to energy storage including "Energy Storage System Safety, Development and Adoption of Codes and Standards."[148]

Two additional resources, produced by Sandia National Labs and Pacific Northwest National Labs, are:

- Energy Storage System Guide for Compliance with Safety Codes and Standards[149]
- Design and Installation of Electrical Energy Storage Systems - Code Compliance Brief[150]

L.3.7.	Interoperability standards for control and monitoring of the system.

[144] https://energystorage.org/wp/wp-content/uploads/2019/12/U.S.-Energy-Storage-Operational-Safety-Guidelines.pdf
[145] https://www.nfpa.org/codes-and-standards/all-codes-and-standards/list-of-codes-and-standards/detail?code=855, and https://www.nfpa.org/News-and-Research/Publications-and-media/NFPA-Journal/2019/May-June-2019/Features/Energy-Storage-Systems
[146] https://www.ul.com/news/ul-9540-energy-storage-system-ess-requirements-evolving-meet-industry-and-regulatory-needs
[147] https://energystorage.org/wp/wp-content/uploads/2019/12/U.S.-Energy-Storage-Operational-Safety-Guidelines.pdf
[148] https://www.sandia.gov/energystoragesafety-ssl/wp-content/uploads/2018/08/development-adoption-brief-final-8-31-18.pdf
[149] https://www.sandia.gov/ess-ssl/publications/SAND2016-5977R.pdf
[150] https://basc.pnnl.gov/code-compliance/design-and-installation-electrical-energy-storage-systems-code-compliance-brief

UL 1741 and IEEE 1547 are relevant for interoperability with the grid.

The IEEE 1547, Interconnecting Distributed Resources with Electric Power Systems,[151] series of interconnection standards with electric power systems (EPS) covers the technical specifications for, and testing of, the interconnection and provides requirements relevant to the performance, operation, testing, safety considerations, and maintenance of the interconnection. It includes general requirements, response to abnormal conditions, power quality, islanding, and test specifications and requirements for design, production, installation evaluation, commissioning, and periodic tests.

The NREL report, "IEEE 1547 and 2030 Standards for Distributed Energy Resources Interconnection and Interoperability with the Electricity Grid,"[152] provides helpful context and background, including the following paragraph, "The Institute of Electrical and Electronics Engineers (IEEE) Standard 1547 has been a foundational document for the interconnection of distributed energy resources (DER) with the electric power system or the grid. 1547 is unique as the only American National Standard addressing systems-level DER interconnected with the distribution grid. It has had a significant effect on how the energy industry does business, and it should continue to influence the way electric power systems operate far into the future. IEEE 1547 has helped to modernize our electric power systems infrastructure by providing a foundation for integrating clean renewable energy technologies as well as other distributed generation and energy storage technologies. IEEE 1547 provides mandatory functional technical requirements and specifications, as well as flexibility and choices, about equipment and operating details that are in compliance with the standard."

UL 1741 is the Standard for Inverters, Converters, Controllers and Interconnection System Equipment for Use With Distributed Energy Resources[153], covering:

- 1.1 These requirements cover inverters, converters, charge controllers, and interconnection system equipment (ISE) intended for use in stand-alone (not grid-connected) or utility-interactive (grid-connected) power systems. Utility-interactive inverters, converters, and ISE are intended to be operated in parallel with an electric power system (EPS) to supply power to common loads.
- 1.2 For utility-interactive equipment, these requirements are intended to supplement and be used in conjunction with the Standard for Interconnecting Distributed Resources With Electric Power Systems, IEEE 1547, and the Standard for Conformance Test Procedures for Equipment Interconnecting Distributed Resources with Electric Power Systems, IEEE 1547.1.
- 1.3 These requirements cover AC modules that combine flat-plate photovoltaic modules and inverters to provide AC output power for stand-alone use or utility-interaction, and power systems that combine other alternative energy sources with inverters, converters, charge controllers, and interconnection system equipment (ISE), in system specific combinations.

[151] https://standards.ieee.org/content/dam/ieee-standards/standards/web/documents/tocs/1547set.pdf
[152] https://www.nrel.gov/docs/fy15osti/63157.pdf
[153] https://standardscatalog.ul.com/ProductDetail.aspx?productId=UL1741

- 1.4 These requirements also cover power systems that combine independent power sources with inverters, converters, charge controllers, and interconnection system equipment (ISE) in system specific combinations.
- 1.5 The products covered by these requirements are intended to be installed in accordance with the National Electrical Code, NFPA 70.
- 1.6 These requirements also cover rapid shutdown equipment and systems.

L.4.	Discuss compliance requirements with state and local laws and codes including the EDCs' interconnection process;

See L.3.4 regarding the EDCs' interconnection process and L.3.6 regarding standards and codes broadly.

"The New York Battery Energy Storage System Guidebook for Local Governments,"[154] published in January 2020 provides guidelines for municipalities with respect to battery storage system permitting and inspection processes.

L.5.	Provide the various modes of operation of eligible battery management system (backup power only, clean power only, other, combination); and

The following is a summary of the modes of operation for an example battery storage system, the Tesla Powerwall 2[155]:

- Backup-only. Reserves 100% of the Powerwall energy to provide power to the home in the event of an outage. The battery is idle until it detects a grid outage. Then battery will discharge to the home.
- Self-powered: The solar is charging the battery during the day. At night when solar is no longer producing, the battery discharges to the home.
- Advanced - Time-based control[156]: The battery can be programmed to meet the time of use hours selected. There are two types:
    - **Balanced** – This goal is to balance sustainability (self-consumption) and savings. Powerwall will charge from excess solar during off-peak and shoulder (if required). Powerwall will discharge during all periods, minimizing exports during shoulder and off-peak.
    - **Cost-Savings** – The goal is to maximize savings. Powerwall will charge from excess solar during off-peak and shoulder (if required). Powerwall will discharge during peak and discharge in other periods to 'make room' for solar based on energy forecast.

Modes can be combined. In addition, the Powerwall has two special modes, Storm

[154] https://www.nyserda.ny.gov/-/media/Files/Programs/clean-energy-siting/battery-storage-guidebook.pdf
[155] https://www.tesla.com/support/energy/powerwall/mobile-app/mobile-app-overview
[156] https://www.tesla.com/support/energy/powerwall/mobile-app/time-based-control

Watch and Preconditioning, for which the battery identifies unique situations and automatically switches to the mode most able to enhance performance. The homeowner is not able to select or adjust these modes.[157]

L.6.	Provide proposed testing, commissioning and de-commissioning requirements, if not provided in response to the program administration requirements above.

Battery storage testing is done by battery storage manufacturers. In addition, contractors conduct testing and commissioning at the installation site. Contractors will be required to be trained and certified to install battery storage systems, relying on manufacturer training and certification. Decommissioning can be done by the contractor, though manufacturers can provide support if the original contractor is no longer in business. All of these processes must be conducted in accordance with manufacturer requirements, as well as all applicable codes and standards, including those described in section L.

M. Other Program Considerations

M.1.	Discuss whether this proposal complements the electric utilities' pay-for-performance program through the Conservation and Load Management Plan for which electric storage is eligible;

Review of Conservation and Load Management Plan ("C&LMP")

The C&LMP[158] includes "Active Demand Response Solutions (Residential)" for both Eversource and United Illuminating. The 240-page C&LMP includes the word "storage" 15 times. In comparison, the Green Bank's 91-page Comprehensive Plan for FY 2017 through FY 2019[159] includes the term 49 times, and the 27-page Comprehensive Plan for FY 2020 includes the term 9 times.

For Eversource, the C&LMP acknowledges that in 2018 and 2019, Eversource began deploying residential battery storage projects in *Massachusetts* (emphasis added), and that it is actively pursuing cost-effective ways to integrate residential battery storage into an Active Demand Response ("ADR") program in Connecticut in 2020. The C&LMP notes that Eversource has issued a three-state RFP for demand reduction vendors for targeted technologies, including battery storage, and that the results in Massachusetts deployments will be used to inform the Connecticut program rollout in 2020.

For Avangrid, the C&LMP acknowledges that Avangrid is considering a residential battery option that could easily be offered under the current Avangrid BYOD ADR program and platform in support of demand response events to assist the

[157] https://www.tesla.com/support/energy/powerwall/mobile-app/additional-modes
[158] https://portal.ct.gov/-/media/DEEP/energy/ConserLoadMgmt/Final-2020-Plan-Update-Text-11-1-19.pdf?la=en

management of the company's distribution system.

The C&LMP does include the following budget items, which may be appropriate with respect to the electric utilities' pay-for-performance program:

- Residential Demand Response – $5.4 million for 2020, $7.4 million for 2021, and $5.2 million for 2022; and
- Performance Management Incentive – $11.6 million for 2020, $10.4 million for 2021, and $10.2 million for 2022

The C&LMP also includes "Statewide Electric and Natural Gas Costs and Benefits," which may be appropriate with respect to the electric utilities' pay-for-performance program:

- Residential DR Cost – total costs of $5.4 million and $7.3 million for 2020 and 2021 respectively for each of the Utility Cost, Modified Utility Cost, and Total Resource Cost;
- Residential DR Benefit – there are no benefits identified in the C&LM Plan;
- Residential DR Benefit-Cost Ratios – given that there aren't any benefits identified in the C&LM Plan, there are no benefit-cost ratios for Utility Cost Test ("UCT"), Modified Utility Cost Test ("MUCT"), nor Total Resource Cost Test ("TRC"); and
- Peak kW Impact from Residential DR of 9,003 kW 11,319 kW for 2020 and 2021 respectively.

The Evaluation Recommendations within the C&LMP recognize that "There is a great deal of space in the market to support solar and energy-storage measures," including a response from the utilities that "Although solar is not currently a supported C&LM measure [because residential solar PV is a statutory program administered by the Green Bank], the Companies agree with this finding and are pursuing residential energy storage as part of a suite of demand response offerings, as well as through the all-electric home Residential New Construction package."

<u>Complementary Proposal to the C&LMP</u>

Although the details on the electric utilities' pay-for-performance program as it applies to residential battery storage are unclear, and specifically residential battery storage in combination with behind-the-meter residential solar PV (i.e., a program the Green Bank administers), the Program proposed by the Green Bank would complement such a program through a combination of incentives, including:

- **<u>Upfront Incentive</u>** – through solar PV systems installed through the RSIP, the Green Bank would administer the Program to provide an upfront declining incentive block structure to increase the number of participants to achieve the Target through passive dispatch of the system, while delivering on the PURA objectives under this RFPD under Docket No. 17-12-03(RE03); and

- **<u>Performance-Based Incentive</u>** – through the EDCs, as well as participating TPOs, the C&LMP's ADR program would provide an ongoing performance-based incentive directly to participants (or third-parties) over a specified period based on the active dispatch of the system.

M.2.	Discuss whether this proposal complements the current Residential Solar Investment Program, the Low and Zero Emissions Renewable Energy Credit (LREC/ZREC) Program, and/or the current net metering program;

<u>Review of Low and Zero Emissions Renewable Energy Credit Program</u>
The Program focuses on the System that pairs behind-the-meter residential solar PV, in combination with electric storage. Per CGS Section 2(f) of CGS 16-245gg, "any customer of an electric distribution company that is eligible for the residential solar investment program shall not be eligible for small zero-emission renewable energy credits pursuant to section 16-244s." Given this, the proposal has no relation to the ZREC, nor the LREC programs.

<u>Review of Residential Solar Investment Program (and Comprehensive Plan of the Green Bank)</u>
The Program is an *absolute* (emphasis added) complement to the RSIP, which is a program administered by the Green Bank. The Green Bank has proposed concepts of the Program within its various Comprehensive Plans, through the EEP Program in Docket No. 18-12-35, and proposed legislation in coordination with DEEP and PURA (i.e., HB 5351). "Storage" is included in the Green Bank's statutory definition of "Clean Energy". And storage, in combination with solar PV (i.e., not separate from), is eligible to participate in the federal investment tax credit, improving the participant economics (i.e., PCT).

Within the Green Bank's FY 2017 through FY 2019 Comprehensive Plan, it notes "In order to secure renewable energy's place in the future, advances in battery storage and other distributed energy resources will be required to *modernize the grid* (emphasis added) and seamlessly integrate cleaner, cheaper, and more reliable sources of energy into our infrastructure." The plan goes on to then specify how independent evaluation of cost-effectiveness of residential solar PV can go beyond the participant and to the grid when it states "Based on the results of Cadmus' cost-effectiveness evaluation of RSIP and signs of an emerging market for energy storage, the Green Bank is looking at opportunities to support the deployment of energy storage and other technologies that will provide comprehensive energy solutions for customers as well as contribute to utility and stakeholder efforts to improve and *modernize the grid* (emphasis added)."

Within the Green Bank's FY 2020 and Beyond Comprehensive Plan, it notes "In collaboration with DEEP and the EDCs through the Joint Committee, efforts are being made to enable residential solar PV in combination with battery storage to deliver greater benefits to participating households as well as electric ratepayers on the electric grid." The plan goes on to propose a 500- participant project and 2-MW target, if through the EEP Program, such a program is supported.

The Green Bank has received through Docket No. 18-09-34 a certificate of public convenience from PURA demonstrating its adequate financial resources, managerial ability, and technical competency to participate in the EEP Program. And the Green Bank has applied to PURA through Docket No. 18-12-35 to implement an electric storage program in combination with behind-the-meter residential solar PV systems.

Complementary Proposal to the RSIP

As noted above, the Program is an *absolute* (emphasis added) complement to the RSIP. The Program proposed by the Green Bank would complement the RSIP through a combination of incentives, including:

- **Upfront Incentive** – through solar PV systems installed through the RSIP, the Green Bank would administer the Program to provide an upfront declining incentive block structure to increase the number of participants to achieve the target through passive dispatch of the system, while delivering on the PURA objectives under this RFPD under Docket No. 17-12-03(RE03); and

- **Performance-Based Incentive** – through the EDCs, as well as participating TPOs, the C&LMP's ADR program would provide an ongoing performance-based incentive directly to participants (or third-parties) over a specified period based on the active dispatch of the system.

M.3.	Discuss the considerations this proposal creates for the design of the renewable energy tariffs and associated programs authorized in § 16-244z of the Connecticut General Statutes;

The Program proposed would apply only to behind-the-meter residential solar PV projects installed that are grandfathered under net metering (i.e., CGS 16-244z), unless PURA sought the Green Bank's assistance in implementing battery storage within the tariff-based compensation structure. The Program's benefit-cost estimations (i.e., PCT and PACT) can be used to inform the setting of an appropriate tariff, including an interim tariff, for both the solar PV system, as well as an adder for battery storage.

- **Section (a)(1)(C)(3)** – customers may elect (a) tariff for the purchase of all energy and renewable energy certificates on a cents per kWh basis (i.e., "buy all – sell all" or "BASA"), or (b) tariff for any energy produced by a facility and not consumed in the period of time established by PURA and all renewable energy certificates on a cents per kWh basis (i.e., "use–buy–sell" or "UBS").

  With regards to the Program, and the inclusion of solar PV within the System, battery storage costs could be offset by the federal ITC assuming the tariff structure were being implemented at the same time the ITC existed. And the benefits from the solar PV (i.e., reasonable rate of return through the tariff rate) would offset the expenses of battery storage for the Participant improving the PCT.

- **Section (a)(1)(C)(5)** – the established tariff rate is set to decline for each solicitation (i.e., maximum selected purchase price of energy and renewable energy certificates on a cents-per-kWh basis in any given solicitation shall not exceed such maximum selected purchase price for the same resources in the prior year's solicitation).

  With regards to the Program, and the inclusion of solar PV within the System, PURA could make a determination that there are changed circumstances in the market (e.g., loss of the ITC) that warrant modifying the rate of the tariff (e.g., increasing the tariff by the loss of the value of the ITC to ensure a "reasonable rate of return" for the customer).

- **Section (b)(1)** – the established tariff for the residential solar PV project that achieves a reasonable rate of return that is just, reasonable, and adequate based on the cost of installing the residential solar PV project. The tariff rate is set by PURA with guidance from the Comprehensive Energy Strategy ("CES") for the period of time the net amount produced by the solar PV system and not simultaneously consumed by the home, including PURA's assessment of time-of-use ("TOU") rates or other dynamic pricing within such periods for (a) real-time, (b) one-day, or (c) any fraction of a day not to exceed one day.

  The Green Bank would suggest that PURA consider establishing a BASA interim tariff before the end of the RSIP to support the orderly transition from net metering to a tariff. During this period of transition, the market would have the following options: (a) net metering with access to spot market prices for the Class I RPS renewable energy certificates, (b) net metering with access to a reduced level of the small ZREC incentive as recommended above, or (c) BASA option set at a tariff rate that provides a reasonable rate of return given the forthcoming changes in the ITC.

- **Section (b)(2)** – tariff for utility purchase of all energy and RECs for a period not to exceed 20 years for the BASA and UBS options at various periods of time (e.g., real-time, one-day, portion of a day, etc.). The challenge for the implementation of the tariff, is that Eversource is not prepared to provide all period options because they are on an antiquated metering system, while Avangrid is prepared because it has AMI.

  The Green Bank would suggest that once an EDC has the appropriate AMI in place that can successfully and efficiently implement the metering, billing, and tariff requirements of the policy, that the EDC be allowed to offer their own solar PV and battery storage systems through lease financing. As long as installed cost data is made transparent to the market, providing EDCs with a "carrot" to own and finance residential solar PV and battery storage systems will further "foster the sustained orderly development of a local solar PV and battery storage industry," while successfully transitioning from net metering to a tariff-based compensation structure. The tariff rates for both the solar PV and the battery storage can be set to support a reasonable rate of return for the EDC that is commensurate with the homeowner.

- **<u>Section (c)(1)(C)(3)</u>** – PURA can modify the tariff rate to incorporate energy storage into the tariff while encouraging locational targeting of such facilities on the distribution system, establishing appropriate TOU rates or dynamic pricing, and incorporating other energy policy benefits identified in the CES.

  The Green Bank would suggest that "cost-effectiveness" tests be used to determine an appropriate level of incentives for the battery storage only systems, versus a battery storage system in combination with solar PV, in order to provide a reasonable rate of return that is just, reasonable, and adequate for the Participant.

M.4.	Discuss whether this proposal would allow for electric storage systems to also maximize other value streams, such as through the wholesale markets, future wholesale ancillary service markets, or as part of a Non-Wires Alternative (NWA) program; and

As noted above in response to E.1.1., the Program proposes to align all energy and environmental attributes of the Systems installed through the Program to maximize value to the participant, ratepayers, and society. If it was determined that maximizing other value streams in wholesale markets, ancillary service markets, or as part of a non-wires alternative program, then the Green Bank, working with PURA and the EDCs, would determine an appropriate path forward in terms of participation and monetization.

Based on the Green Bank's experience with real-time metering of behind the meter system performance, it is important that a strong data collection, management, and analysis system be developed and implemented so as to ensure that the Systems can participate in such future markets or programs should they create value for participants, ratepayers, and/or society. The Green Bank's identification and inclusion of a dispatch software partner (e.g., Virtual Peaker), that is similar to what Power Clerk and Also Energy provided for the RSIP, will be significantly important to the success of the Program.

M.5.	Discuss how this proposal is distinguishable from current or envisioned programs or markets.

As noted above, the Program proposed, takes the "best practices" from other battery storage incentive programs in the Northeast region (i.e., Massachusetts, New York, and Vermont), in combination with the Survey and industry best practices, to design a combination upfront declining incentive block structure administered by the Green Bank, with an ongoing performance-based incentive administered by the EDCs. The Program increases benefits to participants, ratepayers, and society through combining DERs – behind the meter residential solar PV with battery storage.

N. Other Program Design Elements

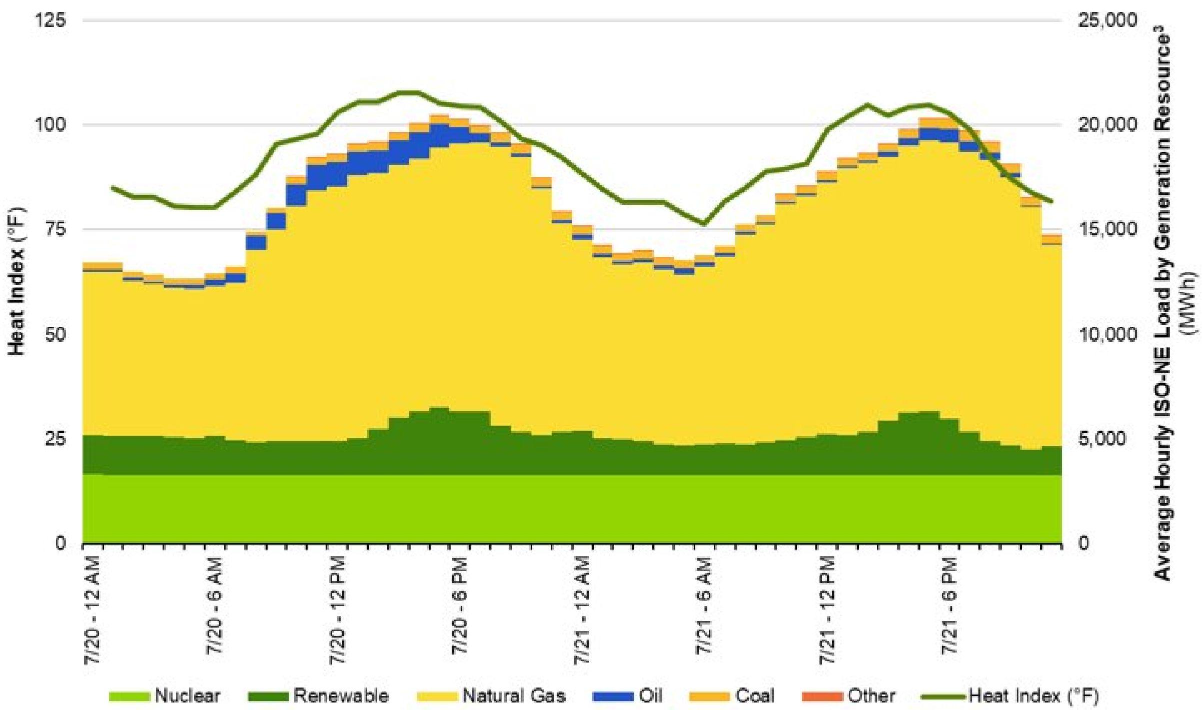
N.1.	Provide an estimate of the greenhouse gas emission reductions provided by the proposed program design on an average per unit basis (e.g., per MWh or MW) and in the aggregate. Discuss the methodology and underlying assumptions used to derive such estimates;

The combination of behind the meter residential solar PV with battery storage, enables additional greenhouse gas ("GHG") emission reductions to occur beyond the production of zero emission energy from the solar PV system. The reduction of air pollution, including GHG emissions,[160] and the associated public health benefits,[161] from solar PV can be estimated.

Additional benefits in terms of increased air pollution reduction from solar PV in combination with battery storage could also be estimated. For example, as solar PV produces zero-emission energy over the course of a day, through the use of battery storage that zero-emission energy resource can be dispatched to maximize emission reductions by displacing other polluting fossil fuel sources – see Figure 31.

Figure 31. Heat Index at Bradley international Airport compared to the Average Hourly Load by Generation

Resource on July 20 and 21, 2019



In the situation above, emission-free solar power could have been stored in the battery through the morning and dispatched in the early evening to displace more polluting fossil fuel resources – see Appendix 3 and Appendix 4.

N.2.	Discuss who would be responsible for the disposal/recycling/decommissioning of the energy storage system at the end of its useful life, as well as an estimate of the associated monetary and non-monetary costs associated with this action;

Decommissioning of a system would typically be done by a contractor. Disposal and recycling may be done by the homeowner contacting the manufacturer to get information on acceptable disposal or recycling options, which will depend on the battery chemistry, which in turn will impact the potential value that could be obtained. For example, Lithium Iron Phosphate batteries are recyclable. Batteries that include Cobalt in the battery chemistry will require additional consideration so that the cobalt can be properly disposed of or recycled[162] based on applicable laws (e.g., EPA, RCRA), but cobalt is also a valuable metal if able to be recycled.

Challenges and considerations with recycling are described in the article "It's time to get serious about recycling lithium-ion batteries."[163] Note as well that the recycling potential of batteries that have been used in electric vehicles versus in stationary applications

162 https://www.sciencedaily.com/releases/2019/04/190401115823.htm
163 https://cen.acs.org/materials/energy-storage/time-serious-recycling-lithium/97/i28

may differ depending on the age of the batteries and how the batteries were used.

The Energy Storage Association white paper "End-of-Life Management of Lithium-ion Energy Storage Systems"[164] provides information regarding the state of battery storage decommissioning, disposal and recycling, including the following excerpts:

- "It is becoming more common for contract language to specify that system decommissioning responsibilities and their costs lie with the operations and maintenance provider or EPC contractor, even though the EPA deems the owner liable for proper treatment of removed equipment. Under such arrangements, the contractor identified as responsible typically provides all decommissioning services (including restoration of the site to original state if required, and removal of the equipment). However, the details of how decommissioning is to be done, or what happens to the decommissioned battery, have not commonly been specified in the contracts."

- "Most U.S. grid-connected energy battery storage systems have only recently been installed and system lifetimes can span more than 15 years; therefore few storage systems in the U.S. have confronted end-of-life issues and undergone decommissioning. Thus, end-of-life alternatives to disposal for ESS facilities have not yet developed into a consistently regulated and economically viable activity. However, the U.S. storage industry is preparing to develop responsible industry practices."

N.3.	If the vendor is responsible for the disposal/recycling/decommissioning of the energy storage system, describe the proposed process; and

See N.2, and further note that these processes will differ depending on battery chemistry and specific manufacturer recycling practices.

N.4.	Provide any other information regarding this proposal that is pertinent to Docket No. 17-12-03RE03, including approval or successful implementation of any program design elements included in this proposal that have been successfully adopted in other jurisdictions.

There is no additional information provided, except that the inputs into the Program (e.g., targets, steps, incentive levels, etc.) can be modified to assess the "cost-effectiveness" for participants, ratepayers, and society – see Appendix 8 for "Cost Effectiveness Model".

[164] https://energystorage.org/wp/wp-content/uploads/2020/04/ESA-End-of-Life-White-Paper-CRI.pdf

II. STORAGE PROPOSAL SUMMARY TEMPLATE

The Authority instructs respondents to use the below template to summarize the proposed program design, in addition to the submission of detailed responses to the above program design requirements.

Electric Storage Program Design Proposal	
Brief Description	Solarize Storage (“Program”) proposes an upfront declining incentive block structure administered by the Green Bank through its Comprehensive Plan, an ongoing performance-based incentive administered by the EDCs through their C&LMP, and easy and affordable access to financing to encourage residential customers to install and then allow passive and active dispatch of battery storage on their behind-the-meter solar PV systems (“System”).
Program Length & Deployment Target(s)	The Program seeks to deploy 50-MW of battery storage by the end of 2025 (“Target”) reaching approximately 10,000 households. The Systems installed through the Program, and the achievement of the Target, will increase benefits to participants, ratepayers, and society.
Requested Flexibility or Scalability Triggers	Within “cost effectiveness” parameters, the ability to be flexible with the level of incentives to ensure deployment of the Systems, as well as scalable with respect to increasing the Target to increase benefits for participants, ratepayers and society. By being more flexible and scalable with interim deployment targets, the Program will further meet the three objectives for electric storage programs outlined in the Request for Proposed Designs (“RFPD”) by PURA.
Program Eligibility	The Program is only eligible to residential customers that install battery storage in combination with solar PV. If PURA would like to request that the Green Bank develop additional program designs beyond the Program proposed, then the Green Bank would consider it.

<table>
<tr>
<td>Compensation Structure</td>
<td>
The Program’s compensation structure includes (1) declining upfront incentive block structure administered by the Green Bank, and (2) ongoing performance-based incentive administered by the EDCs modelled on the summer season incentive from the Connected Solutions Program in Massachusetts – see Table 40.
Table 40. Upfront and Performance-Based Incentive Structures
<table>
<tr><th>Incentive Step</th><th>Effective Non-LMI Upfront Incentive ($/kWh)</th><th>Effective LMI Upfront Incentive ($/kWh)</th><th>Performance Based Incentive Over Time Summer Season ($/kW)</th></tr>
<tr><td>1</td><td>$280</td><td>$560</td><td>$225</td></tr>
<tr><td>2</td><td>$240</td><td>$480</td><td>$225</td></tr>
<tr><td>3</td><td>$200</td><td>$410</td><td>$225</td></tr>
<tr><td>4</td><td>$170</td><td>$330</td><td>$225</td></tr>
<tr><td>5</td><td>$130</td><td>$260</td><td>$225</td></tr>
</table>
To encourage low-to-moderate income (“LMI”) households to participate in the Program, there is an additional incentive.
If amendable, through CGS 16a-40m, PURA could authorize the use of a “Residential Clean Energy On-Bill Repayment Program” for the Green Bank to implement that would help support the Program, as well as the implementation of the tariff (i.e., CGS 16-244z).
</td>
</tr>
<tr>
<td>Compensation Level & Calculation Methodology</td>
<td>The incentive levels were determined using a combination of (1) willingness to pay survey (“Survey”), (2) Survey results benchmarked against Northeast region “best practice” battery storage incentive programs, and (3) a “cost-effectiveness” calculator to determine appropriate levels of incentive to encourage the deployment of the System, while increasing the benefits of the System to participants, ratepayers, and society. The Program is available to homeowners, Third-Party Owners (TPO’s) and the Electric Distribution Companies (“EDC”) (“Participants”).</td>
</tr>
<tr>
<td>Ownership Model</td>
<td>
The ownership model for the Program, includes:

Participant purchases and owns the system;
Participant leases the system from a TPO; or
Participant leases the system from an EDC.

</td>
</tr>
</table>

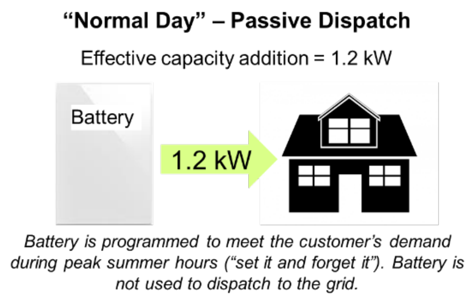
<table>
<tr>
<td>Operational Control Model</td>
<td>

The Program Participants receive emergency back-up from battery storage, while allowing passive and active dispatch of the System by the Green Bank and the EDCs – see Figure 32.

Figure 32. Operational Control of Solarize Storage

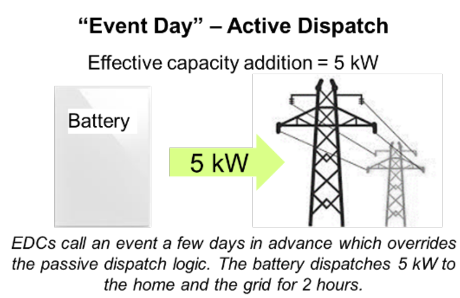
Through a default setting, the System will serve in a passive dispatch mode (i.e., “set it and forget it”) in order to receive the upfront incentive from the Green Bank through the Comprehensive Plan – see Figure 33.

Figure 33. "Set It and Forget" to Reduce ISO-NE Summer Peak Periods



Through the active dispatch of the System for between 30-60 events a year by the EDCs (and participating TPOs), there is an ongoing performance-based incentive from the EDCs through the Conservation and Load Management Plan (“C&LMP) – see Figure 34.

Figure 34. Active Dispatch based on Events to Further Reduce Peak Demand



</td>
</tr>
</table>

Program Administration	The Program will have two administrators – the Green Bank for the upfront declining incentive block structure focused on delivering the Target by enabling emergency back-up and passive demand dispatch of the System, and the EDCs for the ongoing performance-based incentive structure supporting the active dispatch of the System. Together, the benefits to participants, ratepayers, and society will be increased.
Evaluation, Measurement & Verification Plan	The Evaluation, Measurement & Verification (EM&V) Plan documents the objectives, activities, and key sources of data that will be required to evaluate the Program administered by the Green Bank. The EM&V Plan will be overseen by Guidehouse (formerly Navigant Consulting). Guidehouse was selected through a Request for Qualifications ("RFQ") and subsequent Request for Proposals ("RFP") by the Green Bank. Guidehouse has experience providing impact and customer experience evaluation of residential battery storage programs across the country, including evaluation of the ConnectedSolutions Program in Massachusetts for National Grid and Unitil, the Liberty Utilities Home Battery Storage Pilot, and the Arizona Public Service Storage Rewards Program.
Evaluation Metrics	The EM&V Plan identifies several metrics to determine the success of the Program, including: ▪ Program level metrics (e.g., incentives disbursed, installed capacity deployed, etc.); ▪ Evaluation performance metrics (e.g., peak demand savings (kW)); ▪ Operating and reliability performance characteristics (e.g., fraction of usable solar energy used for emergency back-up power; and ▪ Customer data (e.g., demographics, satisfaction, etc.) To support the EM&V Plan, there will be quarterly, biannual, and annual reporting.
Reporting Requirements & Frequency	The Green Bank, in collaboration with its dispatch software partner and EM&V contractor, proposes quarterly reporting of program level metrics and customer data on the first day of the month of the start of a quarter (i.e., January 1, April 1, July 1, and October 1), annual evaluation performance reporting on March 1, and operating and reliability performance reports on January 1 and July 1.

<table>
<tr>
<td>Ratepayer Cost-Benefit (by year)</td>
<td>For the ratepayer “cost-benefit” (i.e., Ratepayer Impact Measure – “RIM”) by year – see Appendix 8, tab J.3 within the proposal. The “Net Cost-Benefit” for the Program with respect to the ratepayer is 2.15 with a net present value of $115,180,000.</td>
</tr>
<tr>
<td>Administrative Costs</td>
<td>The Program includes $9.25 million in Administrative Costs for the Green Bank over 15 years from 2021 through 2035 – see Table 41.

Table 41. Administrative Costs for the Green Bank for Solarize Storage (2021-2035)

<table>
<tr><th>Administrative Costs</th><th>Total</th></tr>
<tr><td>Staff</td><td>$4,500,000</td></tr>
<tr><td>Program Development and Administration</td><td>$2,750,000</td></tr>
<tr><td>Marketing</td><td>$250,000</td></tr>
<tr><td>Evaluation, Measurement, and Verification</td><td>$1,750,000</td></tr>
<tr><td>Total</td><td>$9,250,000</td></tr>
</table>

<u>Staff</u> – $500,000 per year (2021-2025), $250,000 per year (2026-2030), and $150,000 per year (2031-2035);
<u>PDA</u> - $250,000 per year (2021-2025) and $150,000 per year (2026-2035);
<u>Marketing</u> - $50,000 per year (2021-2025); and
<u>EM&V</u> – $200,000 per year (2021-2025), $100,000 per year (2026-2030), and $50,000 per year (2031-2035)

$2,312,000 of the PDA costs are for software technology for data collection provided by Power Clerk and the demand response management system (“DRMS”) provided by Virtual Peaker to support EM&V the passive demand or default dispatch of the System.</td>
</tr>
</table>

Compensation Costs	The Program uses an upfront declining incentive block structure from the Green Bank to encourage non-LMI and LMI households to install battery storage in combination with their solar PV system for battery storage and passive dispatch requiring an estimated $23,047,500 in incentives – see Table 42.

Table 42. Estimate of Total Upfront Incentives by Step for the LMI and Non-LMI Participants

Incentive Step	Estimated # of Participants	Capacity (MW)	Effective Upfront Incentive for Non-LMI Participants ($/kWh)	Effective Upfront Incentive for LMI Participants ($/kWh)	Average Battery Storage Incentive per System
1	400	2.0	$280	$560	$3,950
2	700	3.5	$240	$480	$3,400
3	1,300	6.5	$200	$410	$2,900
4	2,600	13.0	$170	$330	$2,350
5	5,000	25.5	$130	$260	$1,850
Total	**10,000**	**50.0**			**$2,300**

The Program also incorporates into its design, an EDC-administered ongoing performance-based incentive program for active dispatch modeled after the Connected Solutions Demand Response Program in Massachusetts at a rate of $225/kW for summer season events over a 10-year period (i.e., $1,125 per year or $11,250 over 10 years) requiring an estimated nominal value of $112,500,000 in incentives.

The Program, in its current design, would provide $135,547,500 in incentives (i.e., nominal value) with an average incentive of $13,550 per participant – see Table 43.[165]

Table 43. Average Nominal Incentive per Participant for an Upfront Incentive from the Green Bank and Ongoing Performance-Based Incentive from the EDCs

Incentive Step	Estimated # of Participants	Capacity Block (MW)	Average Upfront Battery Storage Incentive per System	Nominal Value of Ongoing Performance Based Incentive
1	400	2.0	$3,950	$11,250
2	700	3.5	$3,400	$11,250
3	1,300	6.5	$2,900	$11,250
4	2,600	13.0	$2,350	$11,250
5	5,000	25.5	$1,850	$11,250
Total	**10,000**	**50.0**	**$2,300**	**$11,250**

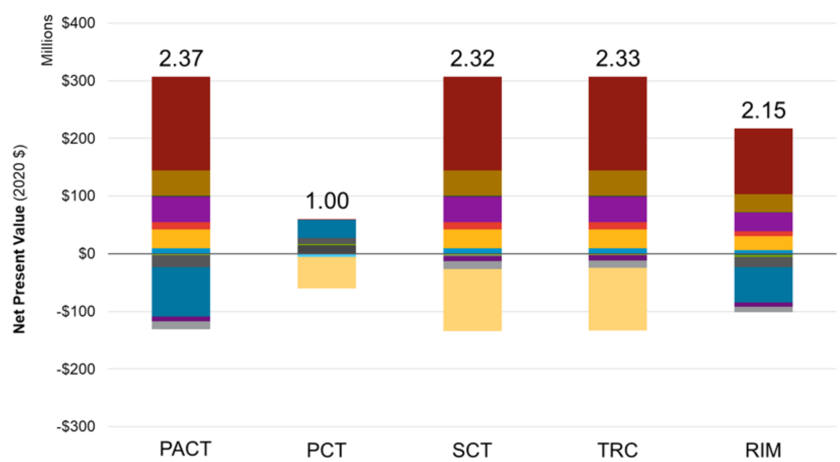
165 It should be noted that the Green Bank believes that the ConnectedSolutions Demand Response Program incentive level may be higher than necessary, and could be revisited in order to require the Participant to pay more for the System as opposed to ratepayers.

Other Costs (by category)	Based on publicly available information, the Green Bank estimates that the EDCs will incur $7,155,000 in costs to administer the ongoing performance-based incentives offered through the Program.[166] The Green Bank would suggest that PURA seek a specific budget from the EDCs with respect to their administration of the ongoing performance-based incentive to support the active dispatch aspects of the System.
Total Program Costs	For the administration of the upfront declining incentive block structure of the Program, in support of emergency back-up and passive dispatch of the System, the Green Bank estimates the program costs to be $32,297,500 comprising: ▪ Upfront Incentives for Battery Storage – $23,047,500 ▪ Technology Software Costs for data collection (i.e., Power Clerk) and DRMS for Passive Dispatch (i.e., Virtual Peaker) – $2,312,000 ▪ Administrative Costs for Green Bank (less Technology Software Costs) – $6,938,000 The Green Bank estimates that for the ongoing performance-based incentive within the Program, in support of the active dispatch of the System, that the EDCs will be administering, estimates program costs are $119,655,000 comprising: ▪ Ongoing Performance Based Incentives for Battery Storage – $112,500,000 ▪ Administrative Costs for EDCs – $7,155,000 The EDCs through their proposal would have to confirm their performance-based incentives and administrative costs.

Benefits (by category)

The Program delivers benefit to cost ratios greater than one for all "cost-effectiveness" tests, including the Program Administrator Cost Test ("PACT"), Participant Cost Test ("PCT"), Societal Cost Test ("SCT"), Total Resource Cost Test ("TRC"), and Ratepayer Impact Measure ("RIM") – see Figure 35.

Figure 35. "Cost-Effectiveness" Tests for Solarize Storage



Total Program Benefits

The Total Program Benefits (and Costs) of the Program for each of the "cost-effectiveness" tests for battery storage only– see Table 44.

Table 44. Present Value of Benefits and Costs, Net Present Value, and Benefit-Cost Ratios for Solarize Storage for Battery Storage Only

	PACT	PCT	SCT	TRC	RIM
Present Value of Benefits	$304,250,000	$59,910,000	$302,660,000	$304,250,000	$214,940,000
Present Value of Costs	$128,110,000	$60,190,000	$130,580,000	$130,580,000	$99,780,000
Net Present Value	$176,140,000	-$280,000	$172,080,000	$173,670,000	$115,160,000
Benefit-Cost Ratio	2.37	1.00	2.32	2.33	2.15

Battery storage in combination with residential solar PV increases the Program benefits – see Table 45.

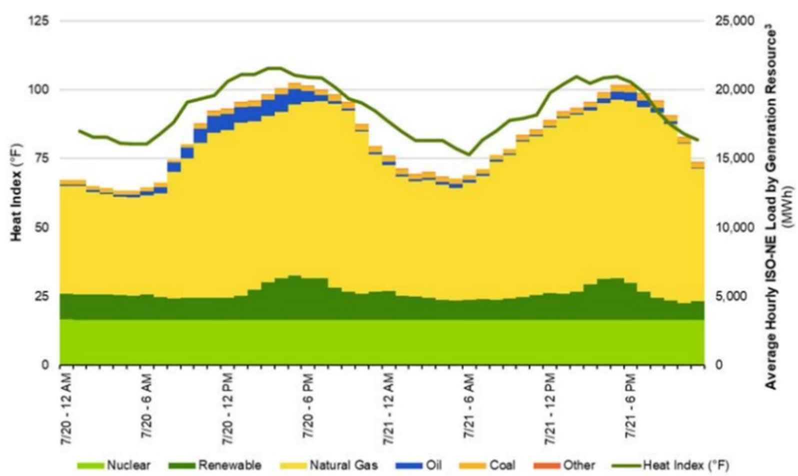
Table 45. Present Value of Benefits and Costs, Net Present Value, and Benefit-Cost Ratios for Solarize Storage for Battery Storage in Combination with Solar PV

	PACT	PCT	SCT	TRC	RIM
Present Value of Benefits	$379,690,000	$87,108,000	$387,090,000	$379,690,000	$263,800,000
Present Value of Costs	$136,120,000	$103,390,000	$200,120,000	$200,120,000	$138,290,000
Net Present Value	$243,570,000	-$16,282,000	$186,970,000	$179,570,000	$125,510,000
Benefit-Cost Ratio	2.79	0.84	1.93	1.90	1.91

Pairing battery storage with residential solar PV increases total benefits (and costs) for participants, ratepayers and society.

Program NPV	(See response to "Total Program Benefits" above)
Other Benefits	(See response to "Total Program Benefits above") The combination of DERs like residential solar PV and battery storage increase benefits to participants, ratepayers and society. By continuing to pair DER technologies, including renewable heating and cooling, electric vehicles, and other technologies, with the System, will support Connecticut decarbonization and grid modernization efforts.
Data Privacy and Security Plan	The Green Bank would rely on three robust platforms to maintain data privacy and cybersecurity, including two platforms that the Green Bank has utilized since 2012 to administer the Residential Solar Investment Program (RSIP), namely Clean Power Research's (CPR) PowerClerk[167], and AlsoEnergy's LocusNOC (AlsoEnergy purchased Locus Energy) residential solar PV monitoring platform[168], and a third platform, Virtual Peaker's DRMS[169], which would be used for battery storage dispatch and data management.
Technology Eligibility	The program will maintain a list of eligible battery storage technologies that will be updated on an ongoing basis. Battery technologies will be considered (and approved or not approved) for inclusion as eligible based on their ability to satisfy program requirements and goals including, but not limited to the following: ▪ Must be commercially available technologies, with appropriate technical certifications, reflecting adequate capabilities, testing and quality control with respect to industry standards.[170] ▪ Ability to meet the passive and active dispatch needs of the program, including existing or intended software integration with dispatch platforms utilized in the program. ▪ Safety considerations, and other characteristics (e.g., roundtrip efficiency, sufficient warranty periods and device longevity in terms of years and number of cycles). ▪ Customer service and technical support provided by battery manufacturer.

[167] https://www.cleanpower.com/products/powerclerk/
[168] https://home.alsoenergy.com/
[169] https://www.virtual-peaker.com/
[170] For example, there are numerous battery storage technologies based on lithium ion chemistries that are commercially available and that could meet the eligibility requirements of this program. That said, it would be preferable not to limit the program to lithium ion-based battery storage devices in the event that technology development and commercialization with other energy storage technologies progresses in a short enough timeframe allow them to meet the program requirements.

Other Program Considerations	The Program proposed is consistent with both the Comprehensive Plans of the Green Bank,[171][172] and the Conservation and Load Management Plan of the EDCs.[173]
Other Program Design Elements	*Air Pollution Emission Reductions* The combination of behind the meter residential solar PV with battery storage, enables additional greenhouse gas ("GHG") emission and other air pollution reductions to occur beyond the production of zero emission energy from the solar PV system – environmental protection benefits can be estimated. For example, as solar PV produces zero-emission energy over the course of a day, through the use of battery storage that zero-emission energy resource can be dispatched to maximize emission reductions by displacing other polluting fossil fuel sources – see Figure 36. . **Figure 36. Heat Index at Bradley International Airport Compared to the Average Hourly Load Generation Resource on July 20 and 21, 2019**  In the situation above, emission-free solar power could have been stored in the battery through the morning and dispatched in the early evening to displace more polluting fossil fuel resources. *Alternative Program Design Scenarios* Guidehouse has developed a "Cost Effectiveness Model" for the Program that allows for various scenarios to be assessed and sensitivities to be run. This model is being submitted as CONFIDENTIAL by the Green Bank given its commercial value, however, is being provided to PURA as part of the filing under Docket No. 17-12-03(RE03).

[171] https://www.ctgreenbank.com/wp-content/uploads/2018/08/Comp-Plan_FY17-FY19_Final_072718.pdf
[172] https://ctgreenbank.com/wp-content/uploads/2020/07/Green-Bank_Revised-Comprehensive-Plan_062620a.pdf
[173] https://portal.ct.gov/-/media/DEEP/energy/ConserLoadMgmt/Final-2020-Plan-Update-Text-11-1-19.pdf?la=en

III. APPENDICES

Appendix 1 – Battery Storage Program Design

Guidehouse

Battery Storage Program Design

Benefit-Cost and Customer Survey Considerations for Program Design Scenarios

Appendix I
July 2020

Table of Contents

Willingness to Pay Survey

Guidehouse

Survey Research Objectives

The survey gathered data on customer interest and willingness to pay for battery storage for previous RSIP and Smart-E residential customers. The survey also identified aspects of battery storage that are most valuable to customers and key customer demographics. This data informed the Green Bank's program design and the cost effectiveness analysis.

Research Objective	Survey Questions
Is the customer eligible to complete the survey? Has the customer participated in another Green Bank program, or already have solar panels?	Q1a-Q3
How satisfied are customers with the RSIP program? Did they pursue energy efficiency as a result of the required audit?	Q4-Q5
How interested are customers in battery storage and what would be their motivation to purchase battery storage? How interested are customers in solar and what would be their motivation to purchase a solar system?	Q6-Q21
How important is an upfront incentive and federal tax credit and at what incentive level would customers be willing to purchase a battery storage system?	Q22-Q28a
Would customers be willing to agree to programming and automatic dispatch to support summer peak load reduction and/or allow a utility or third-party to dispatch that system in exchange for upfront and/or performance-based incentives?	Q29-Q32
Are customers interested in financing for battery storage, and if so, what terms are most important to them?	Q33-Q35
What customer demographics and segments are ideal targets for battery storage? How does customer preferences change for general market versus low to moderate income customers?	Q36-Q39
Do customers have any additional feedback or concerns about battery storage?	Q40
What email address should the gift card be sent to?	Q41

Customer Survey Overview

Characteristics	Description
Qualified respondent	Previous RSIP and Smart-E residential customers
Sample size	20,200
Survey completes	1,864
Response rate	9%
Estimated survey length	43 questions, 15 minutes
Survey timeline	June 24-July 9, 2020
Survey mode	Online
Incentive	$10 Dunkin' gift card for first 300 respondents

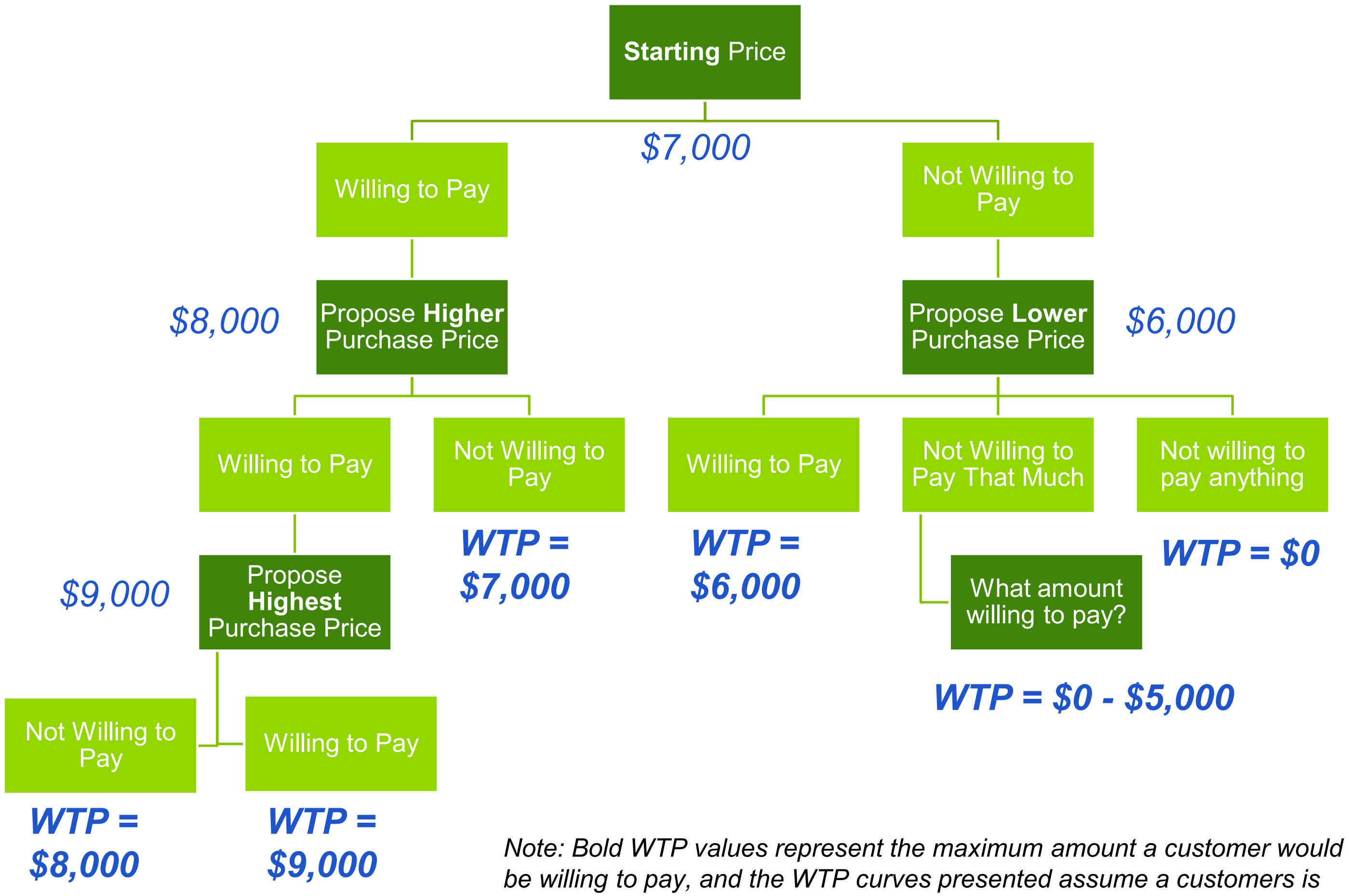
Willingness to Pay

Survey respondents were asked if they would be willing to pay (WTP) for battery storage assuming an $11,000 system cost and a randomly-selected starting upfront incentive level of $3,000, $4,000, $5,000 or $6,000. The respondent was shown a hypothetical starting purchase price for the storage system, including the incentive discount, and asked if they would be interested in purchasing a battery storage system at that price.

Based on the willingness to pay at the starting price, customers were asked about a second, and potentially third, scenario, as described in the figure to the right.

The analysis assumes all respondents who are willing to pay a given price are also willing to pay at a lower price. The number of respondents willing to pay is then used to calculate the percent of all respondents who would be willing to pay at each price.

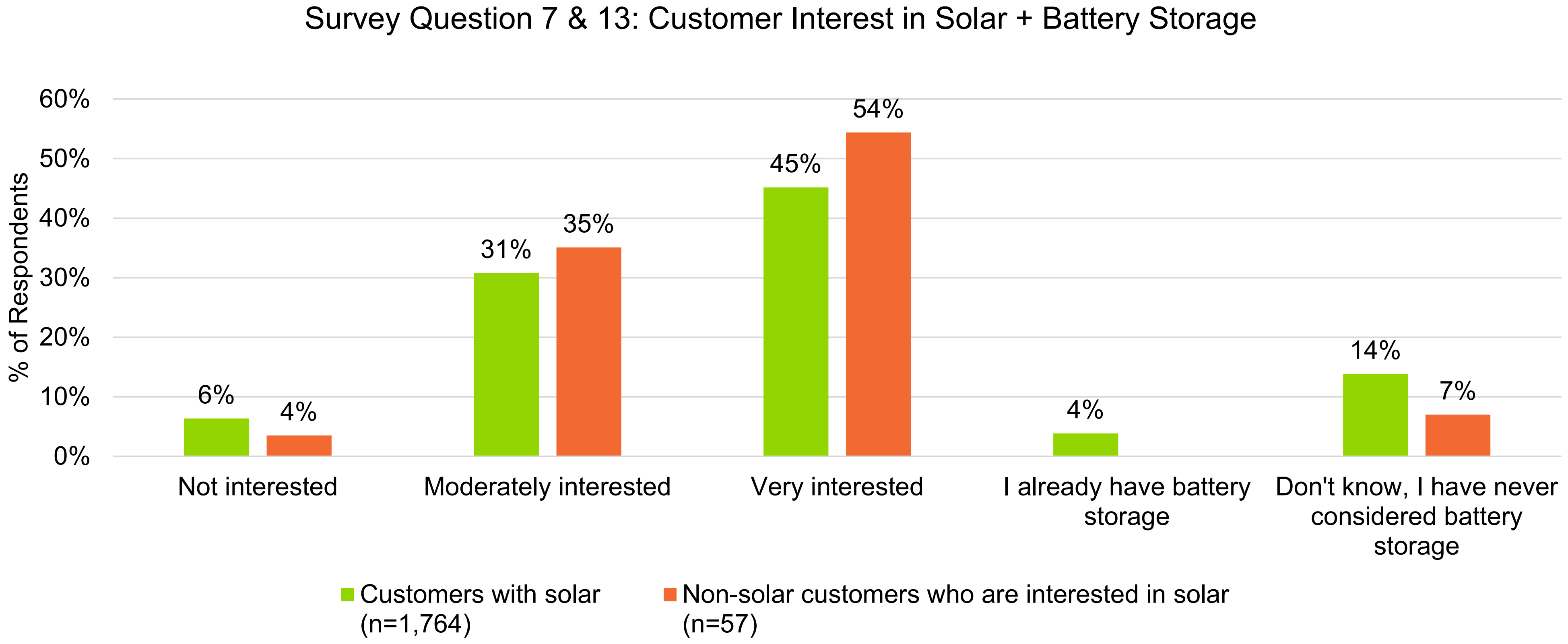
Example of scenarios proposed to customer assuming $11,000 battery storage system cost, a proposed $4,000 starting upfront incentive, and, therefore, a $7,000 starting purchase price.



Note: Bold WTP values represent the maximum amount a customer would be willing to pay, and the WTP curves presented assume a customers is willing to pay at any price up to their maximum WTP value.

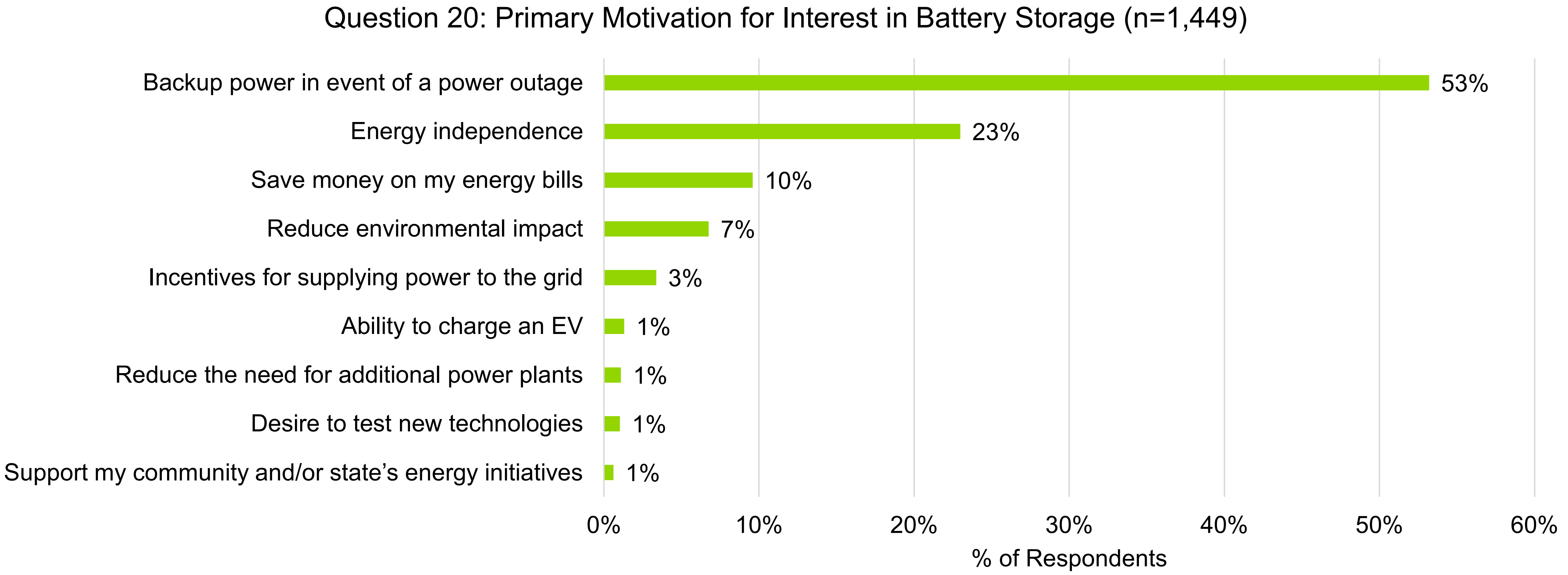
Customer Interest in Solar + Battery Storage

The majority of RSIP and Smart-E respondents are interested in installing a battery storage system that would store energy generated by solar PV panels.



Customer Motivations for Interest in Battery Storage

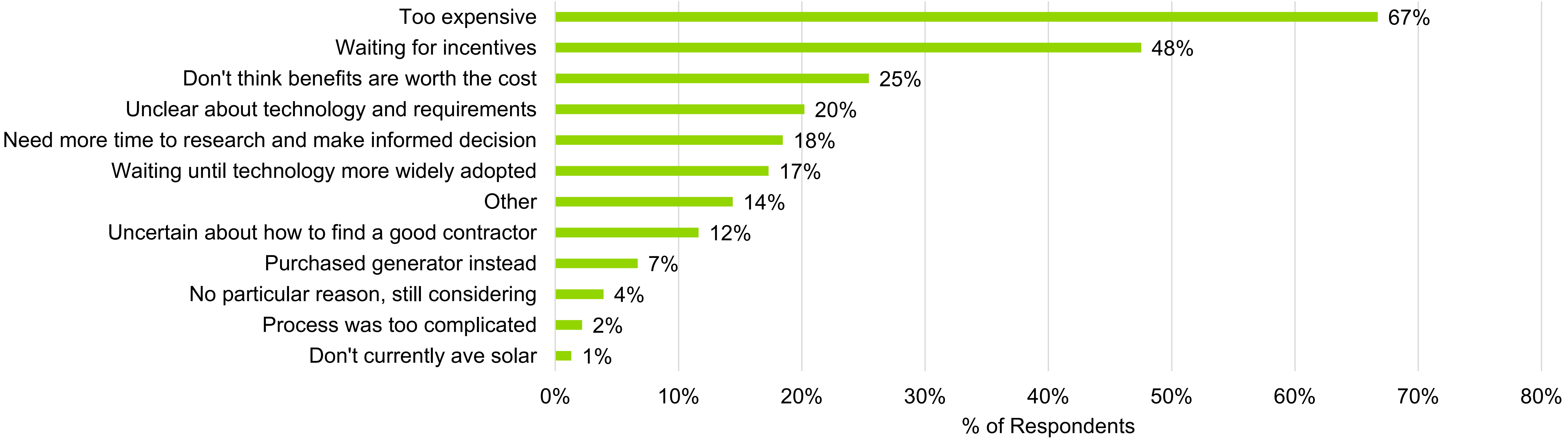
More than half of respondents cite backup power as the primary motivation for their interest in battery storage.



Customer Reasons for Not Purchasing Battery Storage

Respondents who previously considered purchasing battery storage, but did not go through with a purchase, cited concerns with the high cost of a system and a desire to wait for incentives to become available.

Question 15: Customer reasons for not purchasing battery storage (n=688)

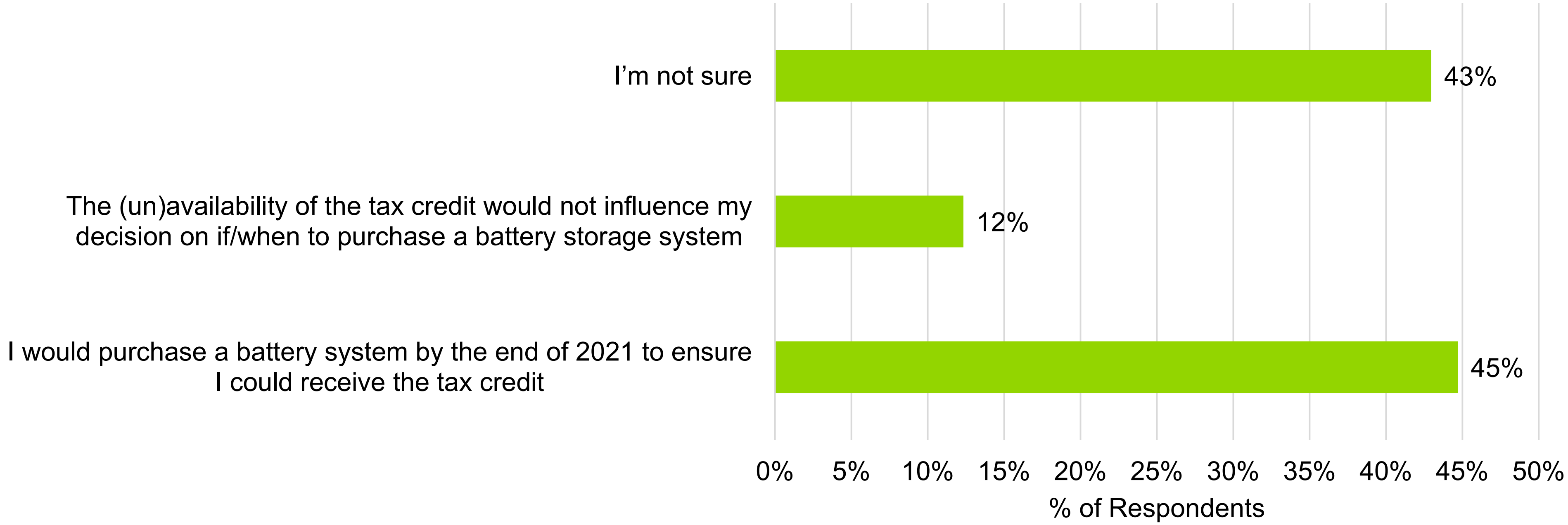


Note: Respondents could provide multiple responses

Federal Tax Credit

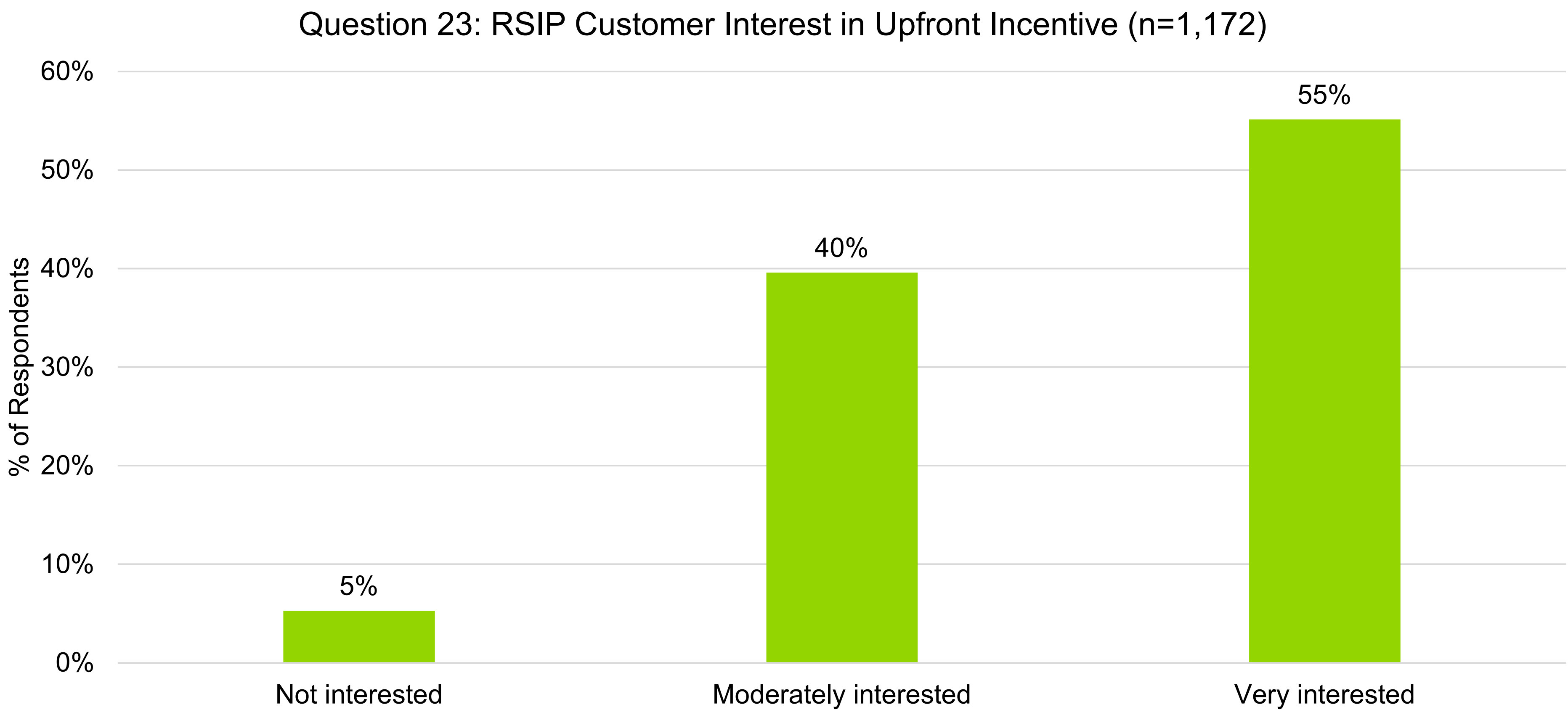
Many survey respondents (Question 22; 78 percent) are not aware of the federal tax credit, and the survey results indicate the credit would influence 45 percent of respondents to purchase battery storage by the end of 2021.

Question 28a: Tax Credit Influence on Decision to Purchase (n=1,727)



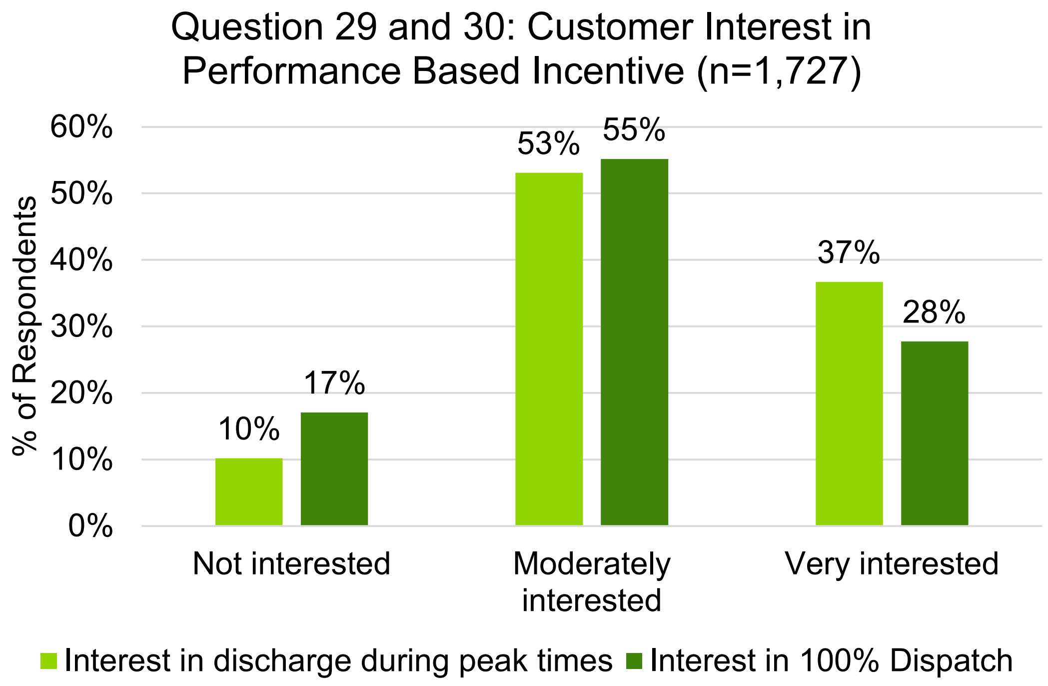
Customer Interest in Upfront Incentive

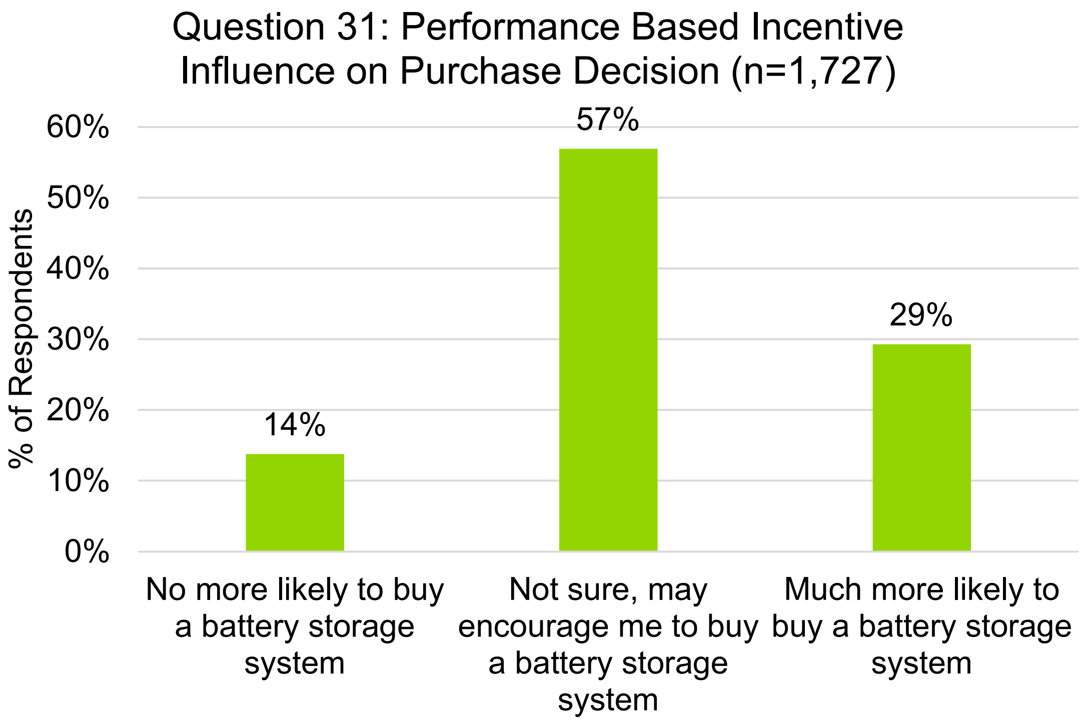
Almost all RSIP survey respondents expressed interest in an upfront incentive for battery storage similar to the RSIP incentive.



Performance Based Incentive

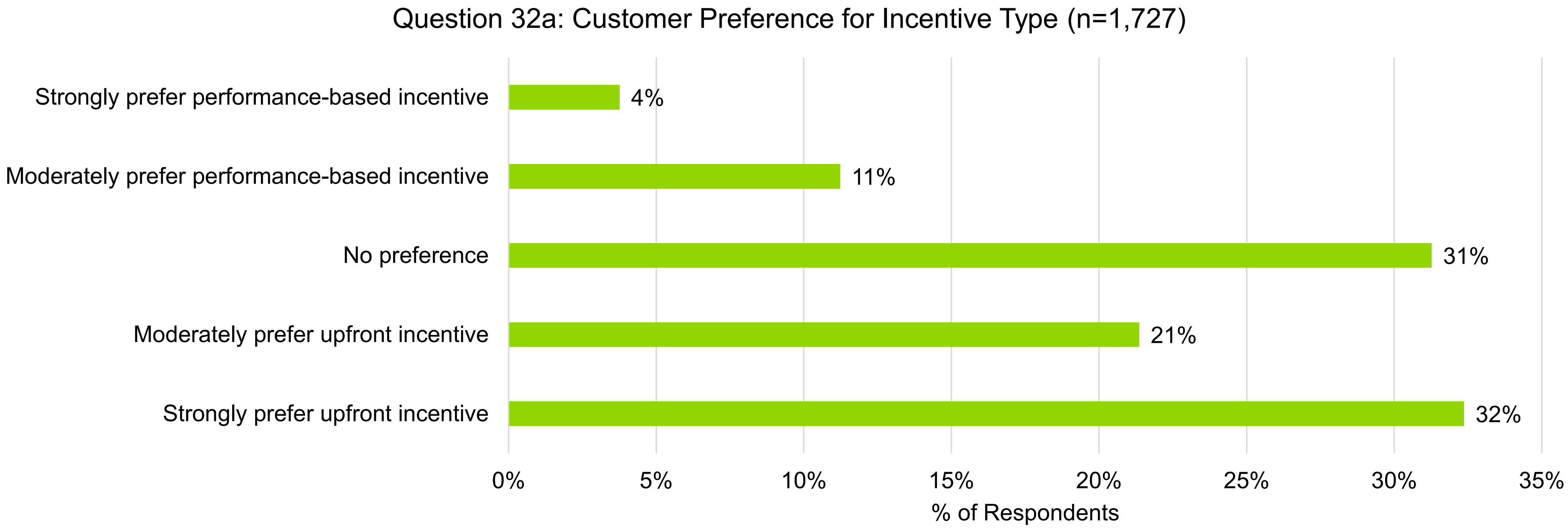
Most respondents are interested in a performance based incentive and nearly 30 percent of respondents say the availability of this incentive would make them more likely to purchase a system.





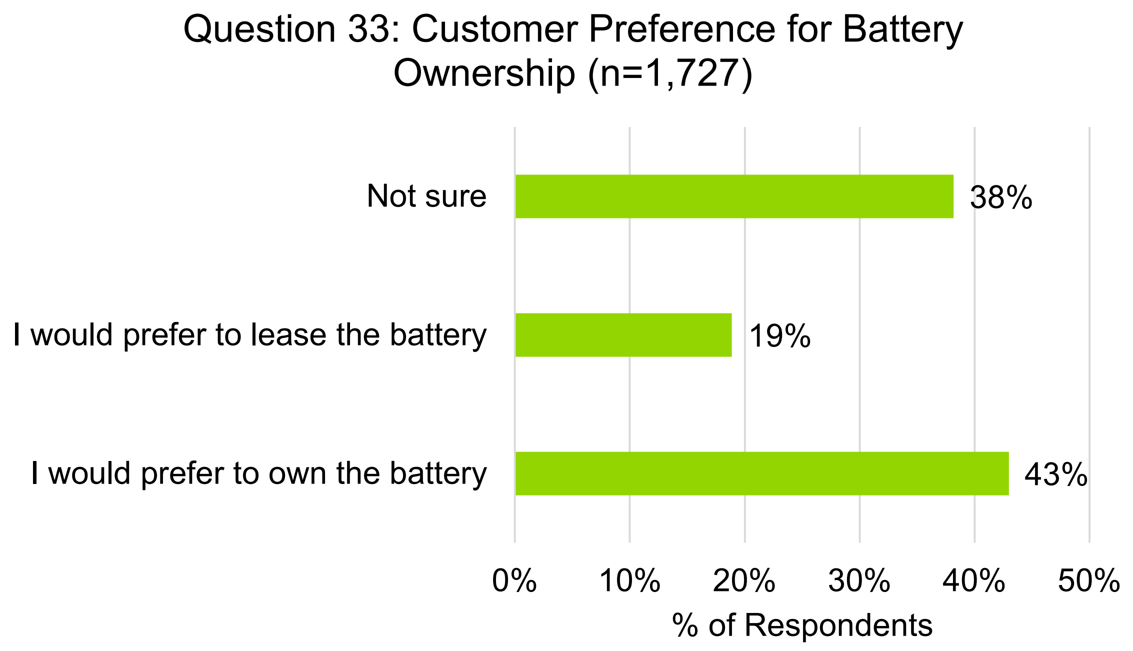
Customer Preference for Incentive Type

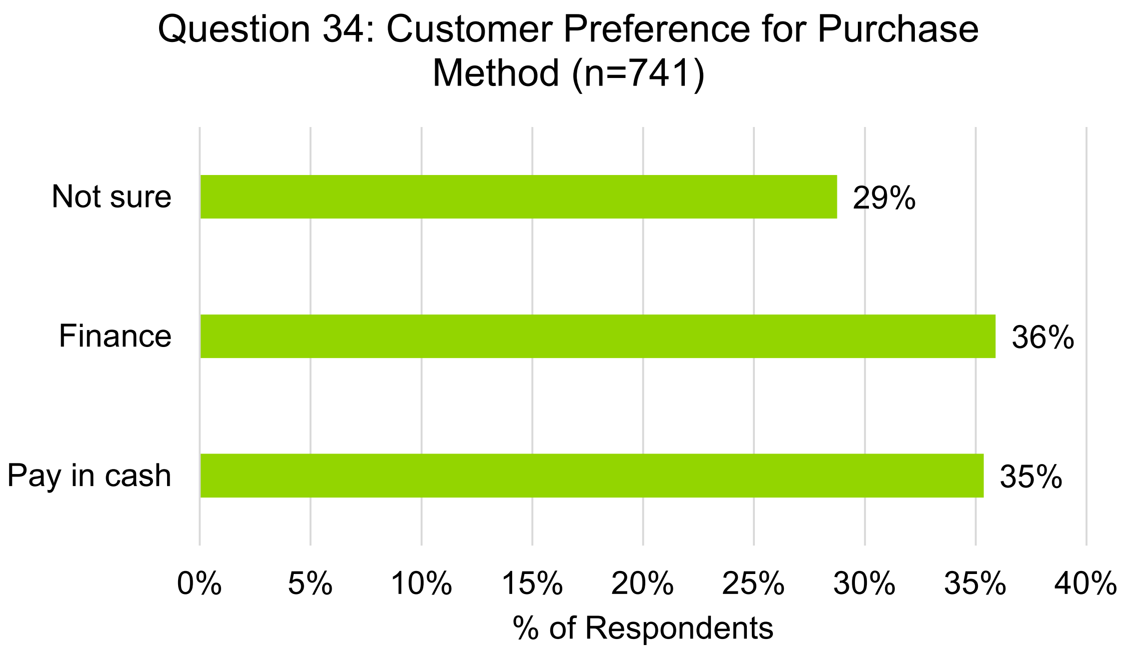
If respondents could only receive one type of incentive, respondents who have a preference tend to prefer an upfront incentive versus a performance-based incentive.



Battery Ownership Structure and Financing

Respondents who have a preference for ownership structure most frequently want to own the battery and amongst these respondents there is a 50/50 split in preference to pay in cash vs. finance.

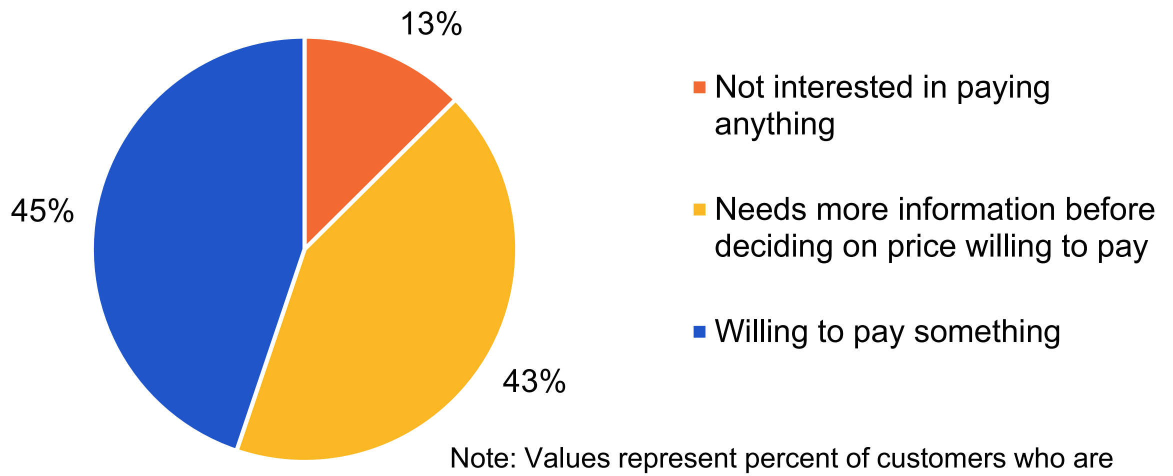




Willingness to Pay for Battery Storage

Almost half of respondents are willing to pay something for battery storage. Many respondents indicate they would need more information before deciding how much they would be willing to pay; these results are similar regardless of income level.

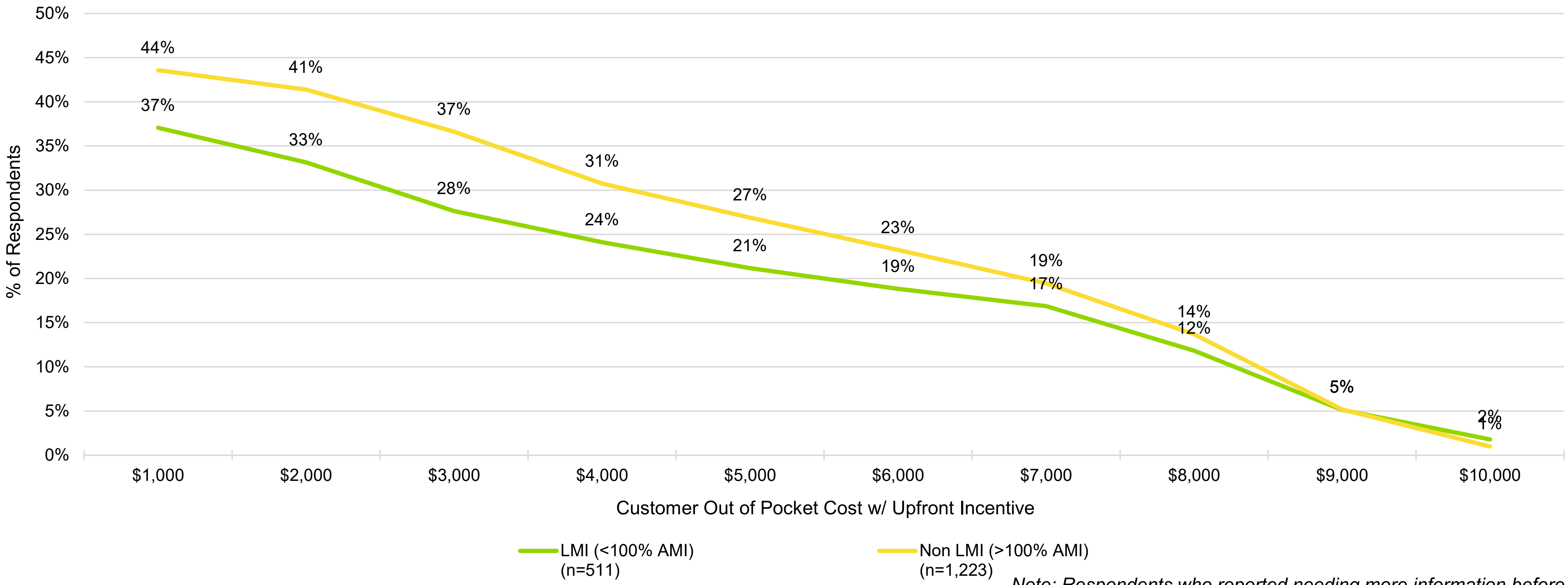
Questions 24-28: Respondent Willingness to Pay for Battery Storage (n=1,727)



Note: Values represent percent of customers who are interested in battery storage

Willingness to Pay for Battery Storage

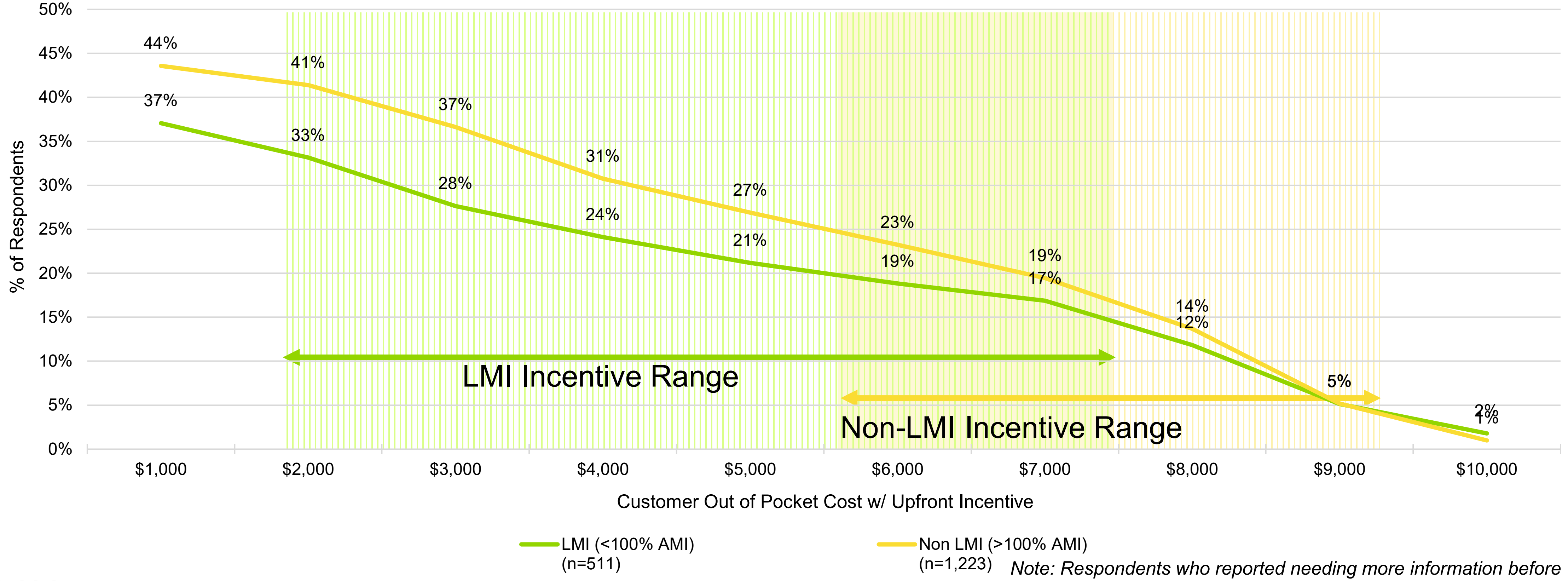
In general, respondent interest in purchasing battery storage drops steadily as the purchase price increases (incentive decreases) and willingness to pay varies by income level.



Note: Respondents who reported needing more information before deciding how much they are willing to pay are counted as not willing to pay at any price. The WTP curves presented assume a customer is willing to pay at any price up to their maximum WTP value.

Incentives based on Willingness to Pay

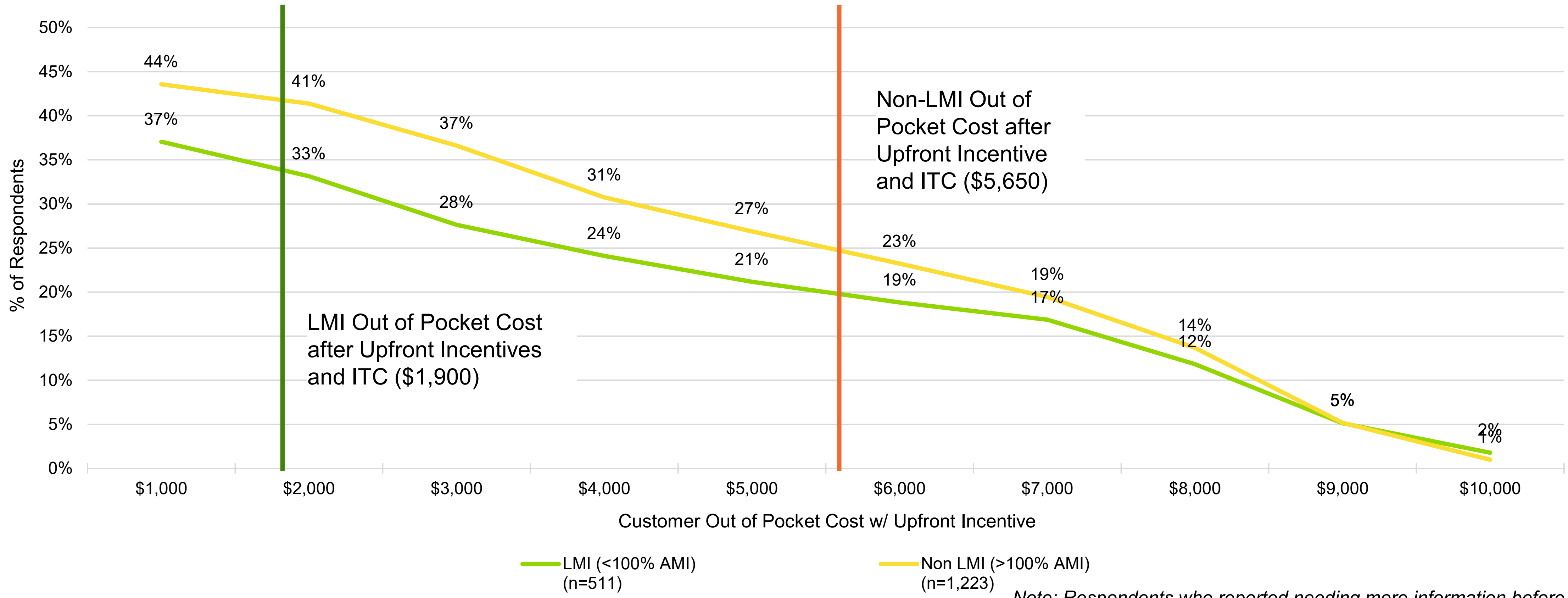
The proposed upfront declining incentive block structure will create demand for battery storage at various customer income levels; out of pocket costs after the upfront incentive and ITC range from $5,700 to $9,300 for Non-LMI customers and $1,900 to $7,500 LMI customers.



Note: Respondents who reported needing more information before deciding how much they are willing to pay are counted as not willing to pay at any price. The WTP curves presented assume a customer is willing to pay at any price up to their maximum WTP value.

Willingness to Pay for Battery Storage

25% of Non-LMI and 34% of Non-LMI respondents report being willing to pay at the starting customer out of pocket cost in the proposed program design, which includes an upfront incentive and the ITC.

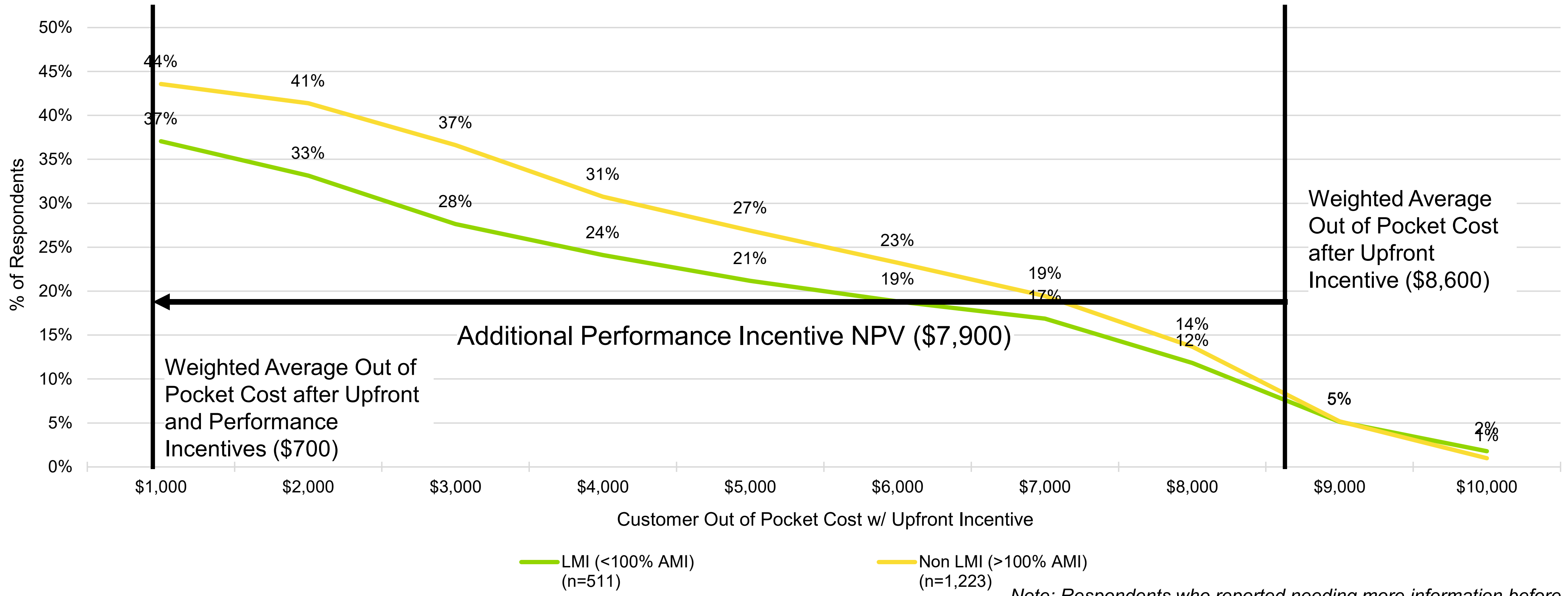


Note: Respondents who reported needing more information before deciding how much they are willing to pay are counted as not willing to pay at any price. The WTP curves presented assume a customer is willing to pay at any price up to their maximum WTP value.

Guidehouse

Willingness to Pay for Battery Storage

The performance based incentive will further bolster customer interest when paired with the upfront incentive and will support the goal to minimize ratepayer costs while maximizing participant, ratepayer, and societal benefits



Note: Respondents who reported needing more information before deciding how much they are willing to pay are counted as not willing to pay at any price. The WTP curves presented assume a customer is willing to pay at any price up to their maximum WTP value.

Guidehouse

Benchmark Programs

Guidehouse

Benchmark Program Method of Comparison

Guidehouse benchmarked similar battery storage programs, with an emphasis on programs offered in the Northeast, to inform the Green Bank's strategy for the proposed program design.

- To benchmark battery storage programs, Guidehouse estimated peer program participants' net present value (NPV). The analysis includes the following factors, as appropriate for the given peer program:
  - Availability of the ITC
  - Availability of financing or lease programs for participants
  - Upfront incentives offered by the program
  - Performance based incentives offered by the program
  - Standardized storage system costs

Benchmarked Programs from Peer Program Administrators

NEW YORK STATE OF OPPORTUNITY. | NYSERDA

GREEN MOUNTAIN POWER

PSEG LONG ISLAND

Benchmark Program Method of Comparison

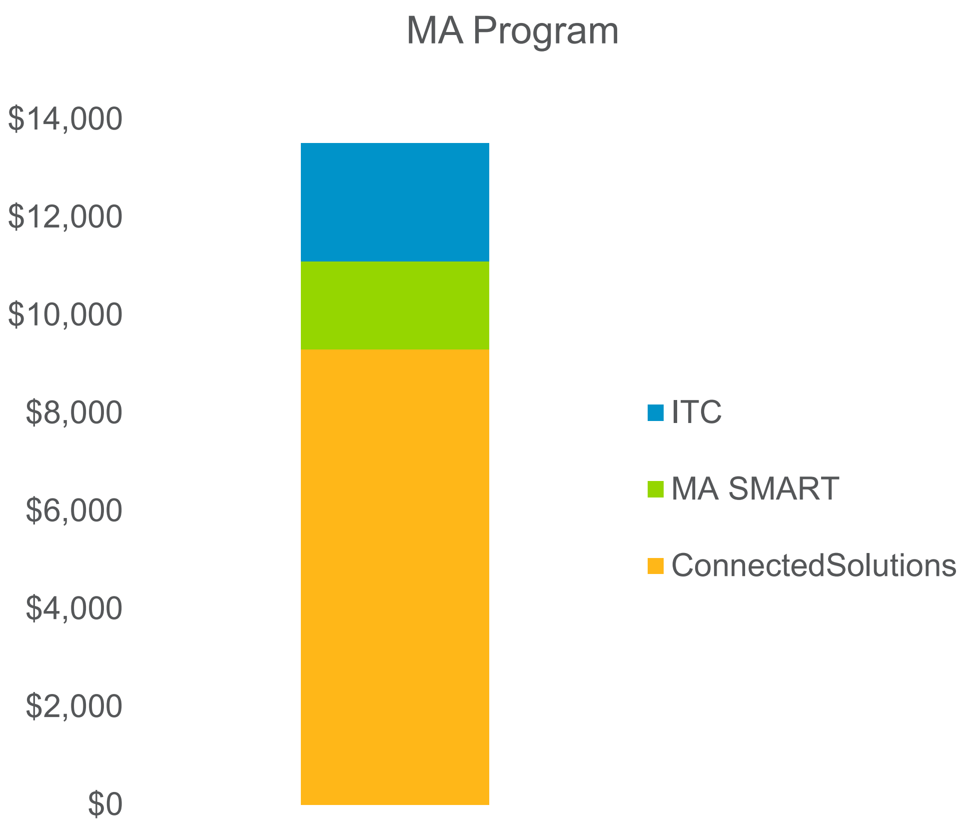
For the analysis Guidehouse assumed battery storage system capacity and costs were similar to the proposed CT program

- Storage System Capacity
  - 5 kW
  - 13.5 kWh
  - 20% backup reserve maintained at all times
- Storage System Costs
  - Installed Cost = $11,000
  - Ongoing O&M Costs = $174/yr. (NPV = $1,069)
  - Financing Charges = $1,156 (NPV, assuming 2.99% interest rate)
- ITC
  - 22% (assume all projects completed in 2021)
  - Value based on upfront incentive value subtracted from installed cost
- Calculation Parameters
  - 10% Discount Rate
  - Costs over time period 2021-2030

Massachusetts Programs

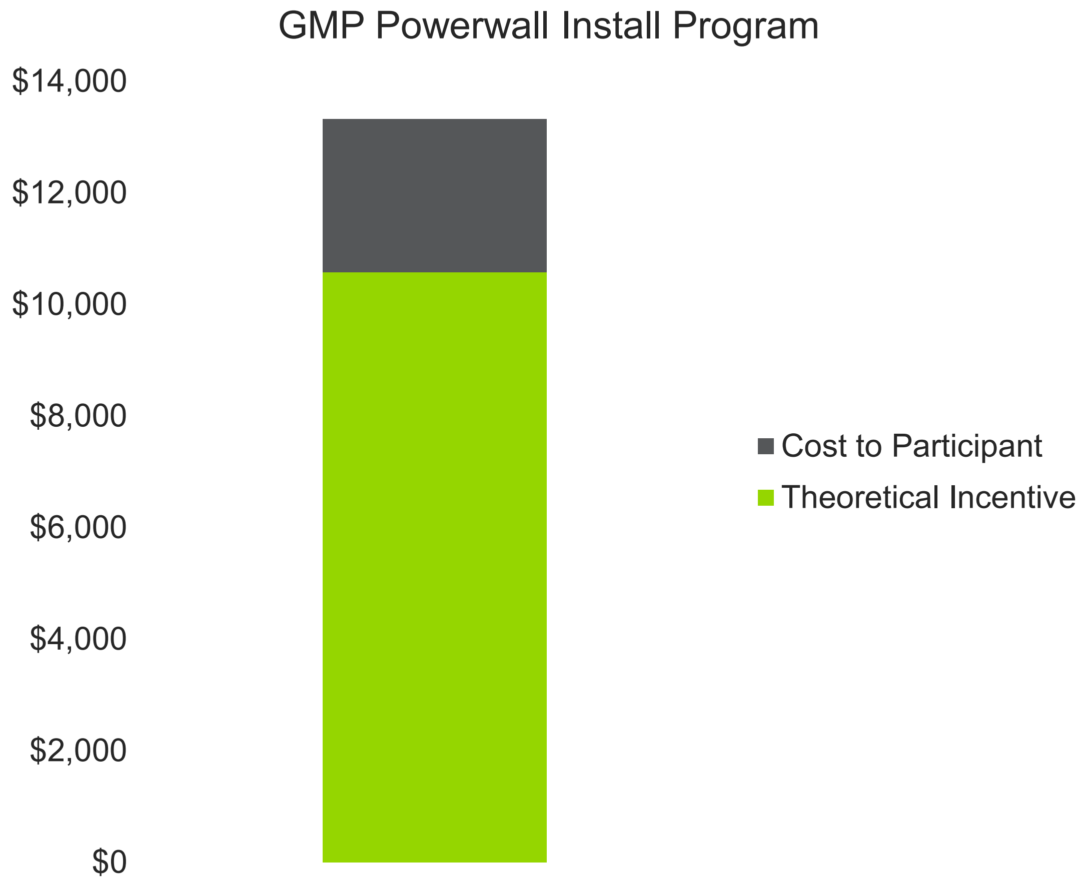
MA Customers can participate in the ConnectedSolutions and MA SMART Residential Battery Storage Incentive Programs

- ConnectedSolutions
  - $500/kW Summer Performance Incentive
  - $25/kW Winter Performance Incentive
- MA SMART
  - $0.0505/kWh Performance Incentive



Green Mountain Power Powerwall Program

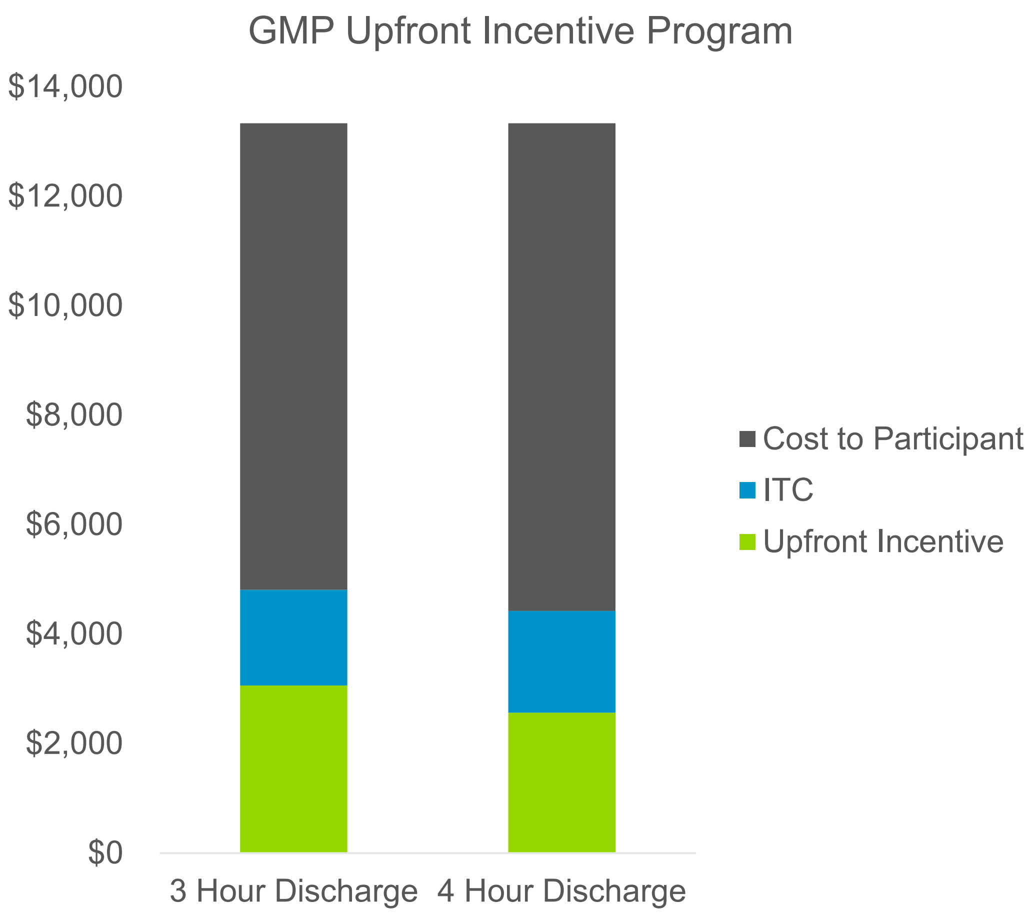
- Upfront cost of $5,500 for two Powerwalls
  - – Equates to $2,750 for one Powerwall
  - – Lease option for $55/month



Guidehouse

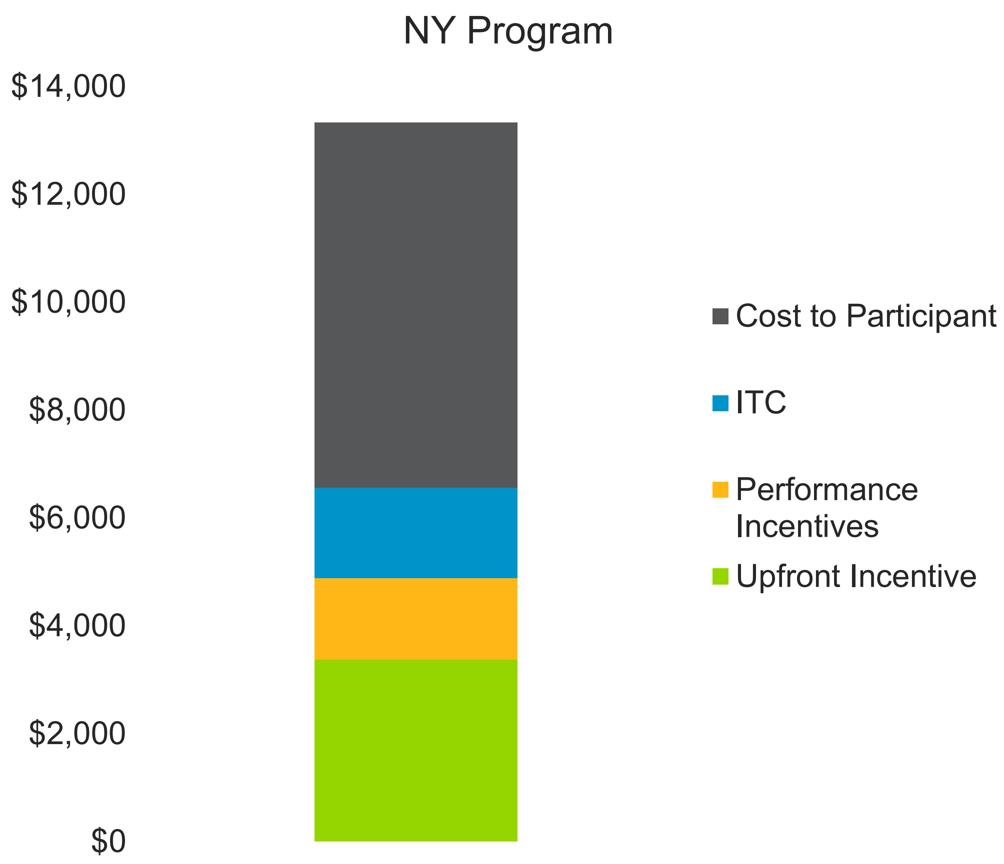
Green Mountain Power Upfront Incentive Program

- Upfront Incentive of $850/kW for 3-hour discharge or $950/kW for 4-hour discharge
  - 3-hour discharge = 3.6 kW of available capacity
  - 4-hour discharge = 2.7 kW of available capacity



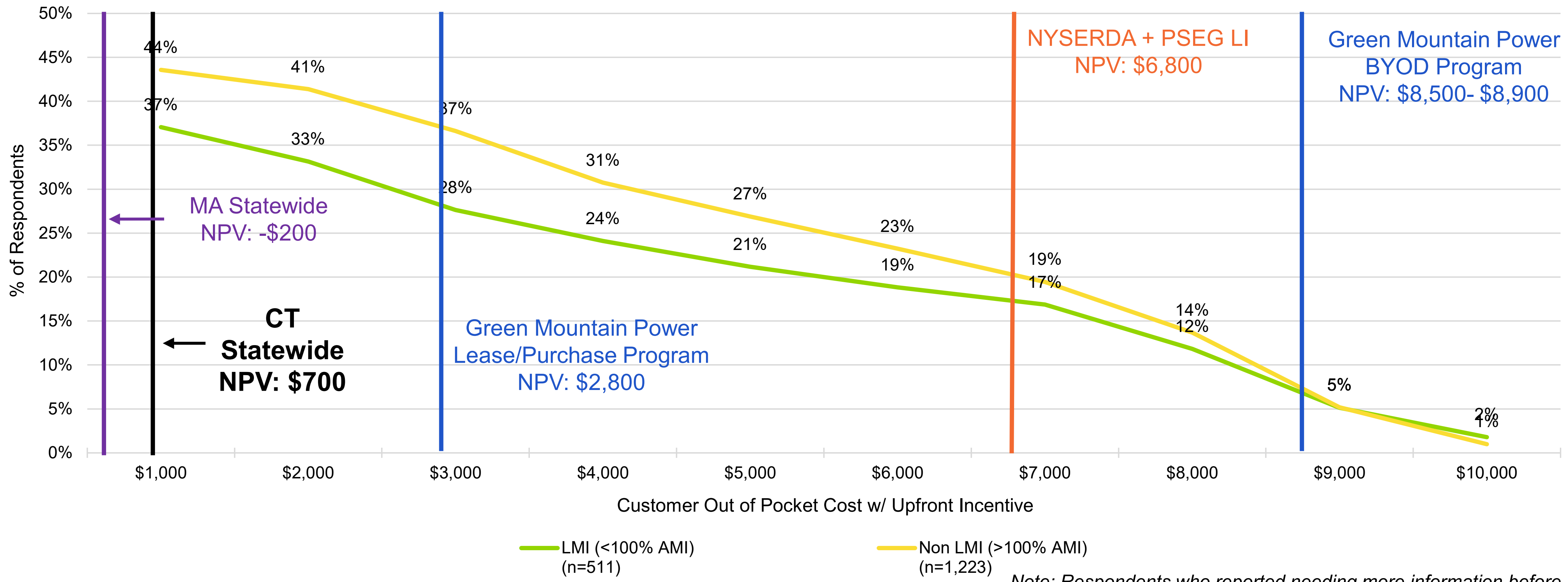
New York (Long Island) Incentive Program

- NYSERDA Upfront Incentive
  - $250/kWh of installed capacity
- PSEG-LI Performance Incentive
  - $8/kW-mo. May-Sept
  - $0.25/kWh dispatch during DR events
    - Assume 9 events x 10.8 kWh (available capacity)



Willingness to Pay for Battery Storage

The figure below shows peer program participant NPVs mapped to the relevant values on the willingness-to-pay curve.



Note: Respondents who reported needing more information before deciding how much they are willing to pay are counted as not willing to pay at any price. The WTP curves presented assume a customer is willing to pay at any price up to their maximum WTP value.

Cost Effectiveness Analysis

Program Design Considerations

Potential roles and responsibilities for program administrators and participants

Battery Ownership	Passive Dispatch "Set It and Forget It" Program Administrator	Active Dispatch Program Administrator
Homeowners TPOs AVANGRID EVERSOURCE ENERGY	CONNECTICUT GREEN BANK SM	AVANGRID EVERSOURCE ENERGY

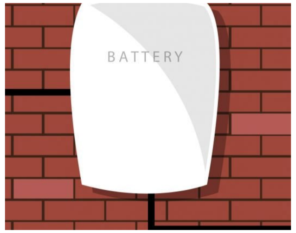
Benefits & Costs Allocated to Program Administrators and Participants

	CT Energy Storage Program Administrators	Program Participant
Benefits	• Avoided Generation Capacity • Avoided Distribution Capacity • Avoided Transmission Capacity • Avoided DRIPE Capacity	• Incentive Payments • Bill Savings • Avoided Outages (low cost backup power solution)
Costs	• Incentive Payments • Program Administration	• Upfront Battery Cost

Program Design

The program can be broken down into three main pieces: battery ownership, passive dispatch program, and active dispatch program

Battery Ownership



Several options for battery ownership and leasing:

1. Participant purchases and owns ESS
2. Participant leases the ESS from TPO
3. Participant leases the ESS from EDC

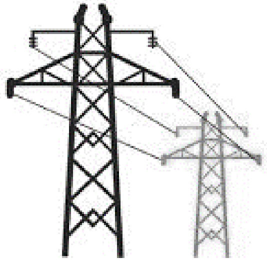
Passive Dispatch

Connecticut Green Bank provides up-front incentive; requires "Set it and forget it" dispatch programming

The incentive is received by either:

- The customer, who purchases and owns the battery
- The TPO or EDC who owns the battery and leases it to the participant; the value of the incentive essentially gets passed to the participant through the lease rate

Active Dispatch



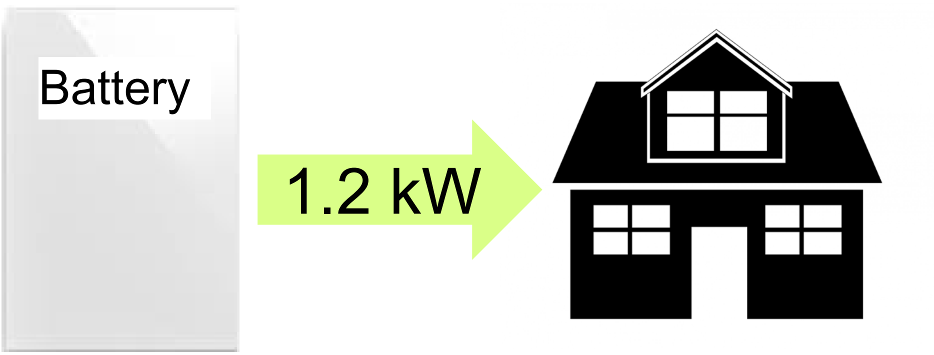
Participants opt-in to active dispatch program administered by the EDCs. The EDCs pays participant or TPO based on performance.

Passive vs Active Dispatch Benefit Calculations

1.2 kW of benefits are attributed to the passive dispatch program, and 3.8 kW of benefits are attributed to the passive dispatch program.

"Normal Day" – Passive Dispatch

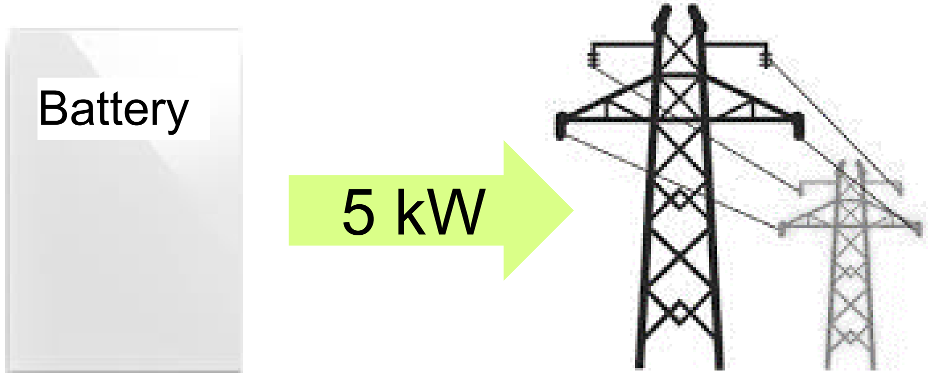
Effective capacity addition = 1.2 kW



Battery is programmed to meet the customer's demand during peak summer hours ("set it and forget it"). Battery is not used to dispatch to the grid.

"Event Day" – Active Dispatch

Effective capacity addition = 5 kW

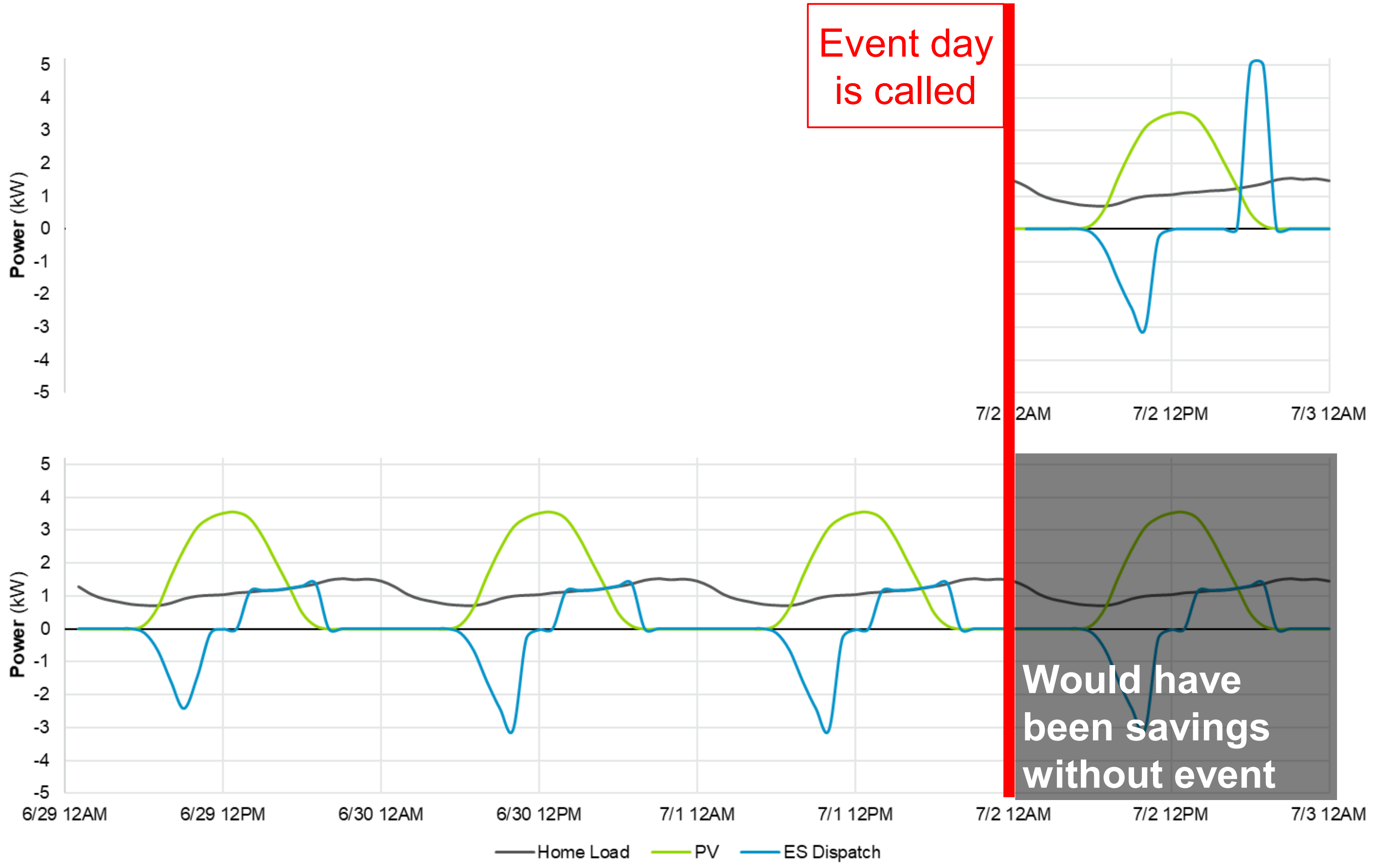


EDCs call an event a few days in advance which overrides the passive dispatch logic. The battery dispatches 5 kW to the home and the grid for 2 hours.

Active dispatch cannot claim the full 5 kW of benefits because in the absence of the event, the battery would have been able to claim 1.2 kW of benefits. Thus, while physically the battery is discharging 5 kW, only 3.8 kW of benefits can be claimed.

Passive and Active Dispatch in Practice

Active dispatch overrides passive settings, but passive is now baseline



- As a requirement for receiving the upfront incentive, the battery is set to “self-consumption mode” (or similar) upon installation
  – The battery now would dispatch daily during peak time
- On an event day, the active dispatch administrator would assume control of the battery, and dispatch fully during event
  – The active dispatch would see 100% of peak reduction, but since the battery would have dispatched anyway it can’t claim 100% of the benefits

Guidehouse

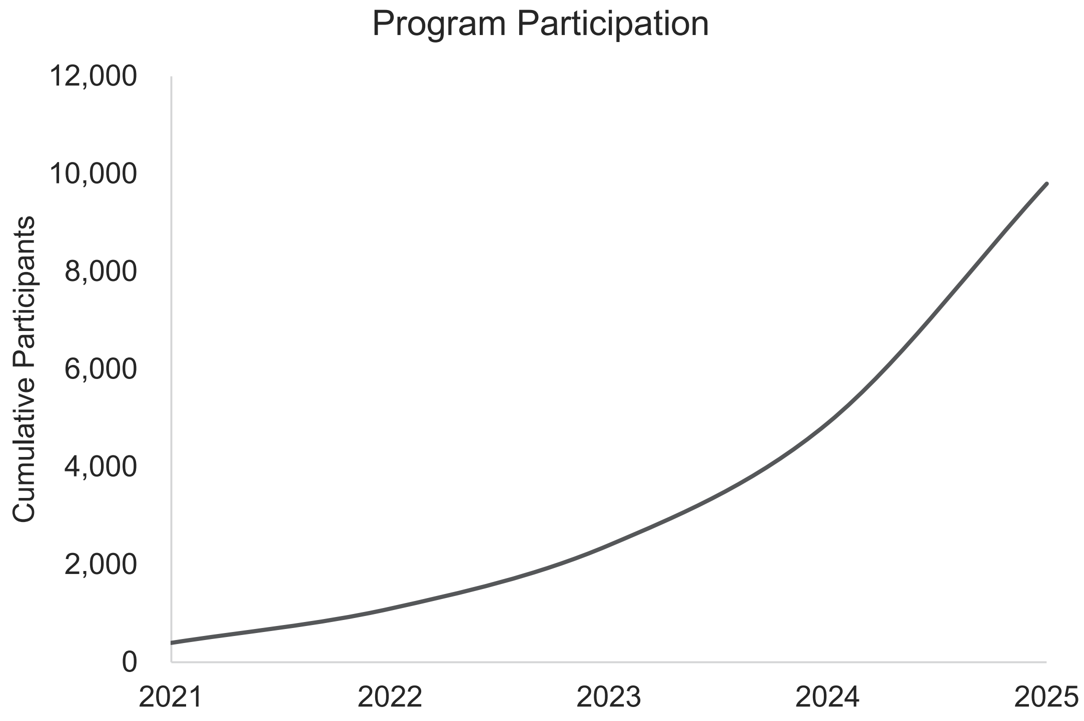
Cost Effectiveness Model Inputs & Assumptions

Guidehouse

Program Participation

Participation is projected to increase in each year of the program, resulting in a total of 10,000 participants and 50 MW.

Year	Number of Participants	Installed MW
2021	400	2.0
2022	700	3.5
2023	1,300	6.5
2024	2,600	13.0
2025	5,000	25.0
Total	**10,000**	**50.0**



Incentive Structure

Declining incentive structure optimized for PACT, PCT, and Customer WTP

Year	Capacity Block	Effective Upfront Incentive ($/kWh)[1]		Nominal Value of Ongoing Performance Incentives ($/kW) [2]
		Non-LMI	LMI	
2021	2.0	$280	$560	$2,250
2022	5.5	$240	$480	$2,250
2023	13.0	$200	$410	$2,250
2024	25.0	$170	$330	$2,250
2025	50.0	$130	$260	$2,250

1. Incentive is adjusted based on kWh and kW Capacity – in this case (Tesla Powerwall: 5kW, 13.5 kWh) the incentive is limited by the kW Power
2. Performance incentive = $225/kW and assumes participation for 10 years

Incentive Structure

Declining incentive structure optimized for PACT, PCT, and Customer WTP

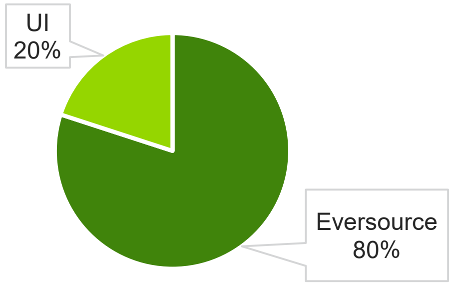
Year	Capacity Block	Effective Upfront Incentive ($/participant)[1]		Nominal Value of Performance Incentives ($/participant)	Nominal Value of Total Incentives ($/participant)	
		Non-LMI	LMI		Non-LMI	LMI
2021	2.0	$3,750	$7,500	$11,250	$15,000	$18,750
2022	5.5	$3,250	$6,500	$11,250	$14,500	$17,750
2023	13.0	$2,750	$5,500	$11,250	$14,000	$16,750
2024	25.0	$2,250	$4,500	$11,250	$13,500	$15,750
2025	50.0	$1,750	$3,500	$11,250	$13,000	$14,750

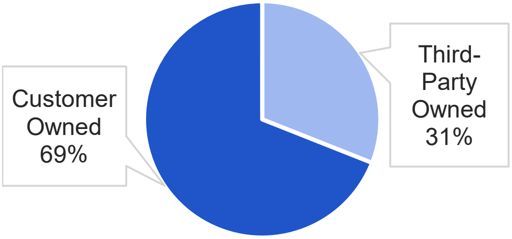
1. Assuming customer purchases a Tesla Powerwall (5 kW, 13.5 kWh)

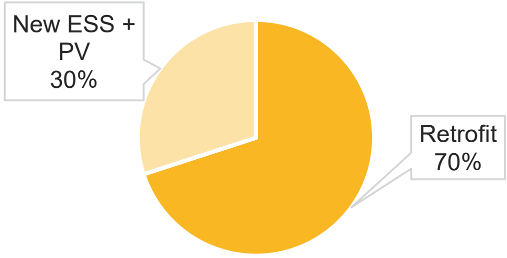
Project Type Breakdown

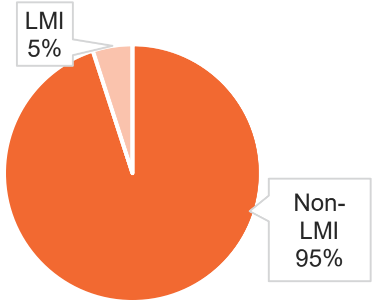
Participants are distributed across 16 different project types

EDC	Eversource	80%
	UI	20%
Install Type	New ESS + PV	30%
	Retrofit ESS to existing PV	70%
Ownership Model[1,2]	Customer Owned	69%
	Lease	31%
Income Level	Non-LMI	95%
	LMI	5%









1. Assume all LMI customers Lease
2. Based on Survey Results of ownership preference

Project Type Breakdown

Participants are distributed across 16 different project types

Utility	Type of Installation	Ownership Model	Income Level	Number of Participants	% of Participants
Eversource	New PV Installation	Customer Owned	Non-LMI	1,573	15.7%
Eversource	New PV Installation	Lease from TPO or Utility	LMI	120	1.2%
Eversource	New PV Installation	Lease from TPO or Utility	Non-LMI	707	7.1%
Eversource	Retrofit	Customer Owned	Non-LMI	3,671	36.7%
Eversource	Retrofit	Lease from TPO or Utility	LMI	280	2.8%
Eversource	Retrofit	Lease from TPO or Utility	Non-LMI	1,649	16.5%
UI	New PV Installation	Customer Owned	Non-LMI	393	3.9%
UI	New PV Installation	Lease from TPO or Utility	LMI	30	0.3%
UI	New PV Installation	Lease from TPO or Utility	Non-LMI	177	1.8%
UI	Retrofit	Customer Owned	Non-LMI	918	9.2%
UI	Retrofit	Lease from TPO or Utility	LMI	70	0.7%
UI	Retrofit	Lease from TPO or Utility	Non-LMI	412	4.1%
All				**10,000**	**100%**

Program Costs

Costs of Administration of Upfront and Performance-Based Incentive Programs

Upfront Incentive Program Costs Breakdown

Program Year	Staffing	Program Development and Admin	EM&V	Marketing
2021	$500,000	$250,000	$200,000	$50,000
2022	$500,000	$250,000	$200,000	$50,000
2023	$500,000	$250,000	$200,000	$50,000
2024	$500,000	$250,000	$200,000	$50,000
2025	$500,000	$250,000	$200,000	$50,000
2026	$250,000	$150,000	$100,000	$0
2027	$250,000	$150,000	$100,000	$0
2028	$250,000	$150,000	$100,000	$0
2029	$250,000	$150,000	$100,000	$0
2030	$250,000	$150,000	$100,000	$0
2031	$150,000	$150,000	$50,000	$0
2032	$150,000	$150,000	$50,000	$0
2033	$150,000	$150,000	$50,000	$0
2034	$150,000	$150,000	$50,000	$0
2035	$150,000	$150,000	$50,000	$0

Active Dispatch Program Costs

Program Year	Fixed Cost ($)	Variable Cost ($)
2021	$477,000	$28,800
2022	$477,000	$79,200
2023	$477,000	$172,800
2024	$477,000	$360,000
2025	$477,000	$720,000
2026	$477,000	$720,000
2027	$477,000	$720,000
2028	$477,000	$720,000
2029	$477,000	$720,000
2030	$477,000	$720,000
2031	$477,000	$691,200
2032	$477,000	$640,800
2033	$477,000	$547,200
2034	$477,000	$360,000
2035	$477,000	$187,200

Technology Assumptions

ESS and PV Inputs based on Vendor discussions, RSIP data, and Guidehouse estimates

Technology Costs / Characteristics			
Average Characteristic	**Average Value in 2020 (2020 $)**	**Nominal Escalation Rate through 2025 (%/yr)**	**Source**
PV Installed Cost ($)	$28,240	-3%	Based on previous year RSIP
PV O&M Cost ($/yr)	$75	1%	Guidehouse estimate
PV Lifetime (Years)	20	N/A	Guidehouse estimate
PV Degradation Factor (%/yr)	0.50%	N/A	Guidehouse estimate
ESS Installed Cost ($)	$11,000	-3%	Vendor discussions
ESS Weighted Financing Cost ($)	$1,156	N/A	Loan Calculator
ESS O&M Cost ($/yr)	$225	-5%	Vendor discussions
ESS Replacement Cost ($)	$5,000	-5%	Vendor discussions
Retrofit Install Cost Adder ($)	$500	-3%	Guidehouse estimate
ESS Lifetime (Years)	10	N/A	Vendor discussions
ESS Degradation Factor (%/yr)	2.00%	N/A	Guidehouse estimate

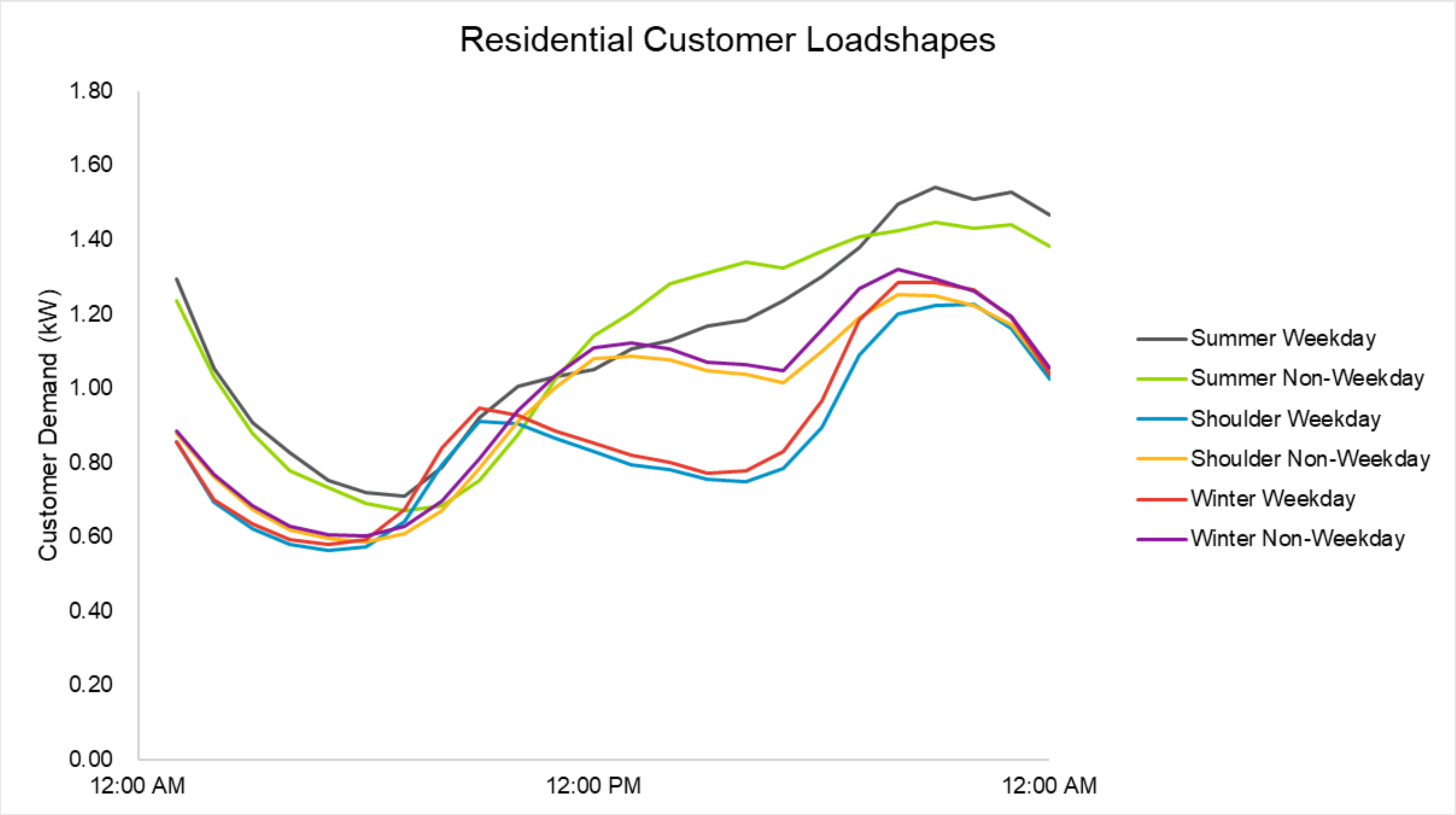
Technology Assumptions

ESS specs based on Tesla Powerwall; operational parameters determined by program design aspects

Use Case Parameters				
Parameter	**Units**	**Eversource**	**UI**	**Source**
System Specifications				
% of Load Served by PV	%	80%	80%	Guidehouse estimate
Peak load	kW	3.6	3.6	Guidehouse estimate
PV pow er	kW (DC)	8.0	8.0	Guidehouse estimate
ESS pow er	kW	5.0	5.0	Based on Tesla Pow erw all
ESS energy	kWh	13.5	13.5	Based on Tesla Pow erw all
ESS efficiency		92%	92%	Guidehouse estimate
ESS duration	hr	2.7	2.7	Guidehouse estimate
ESS available energy	kWh	10.8	10.8	Guidehouse estimate
ESS available duration	hr	2.16	2.16	Guidehouse estimate
Operational parameters				
Backup reserve	%	20%	20%	Guidehouse estimate
	kWh	2.7	2.7	Guidehouse estimate
	hr	0.54	0.54	Guidehouse estimate
Charging options		Solar Only	Solar Only	Guidehouse estimate
PV export value		Retail	Retail	Guidehouse estimate
Selected rate		TOU	TOU	Guidehouse estimate
Storage export options		Not allow ed	Not allow ed	Guidehouse estimate
Storage export value		N/A	N/A	Guidehouse estimate
Selected loadshape		Eversource w /o EH	Eversource w /o EH	Guidehouse estimate
Selected utility rates		Eversource	UI	Guidehouse estimate
Passive Dispatch Start		1:00 PM	1:00 PM	Guidehouse estimate
Passive Dispatch End		8:00 PM	8:00 PM	Guidehouse estimate

Customer Loadshape

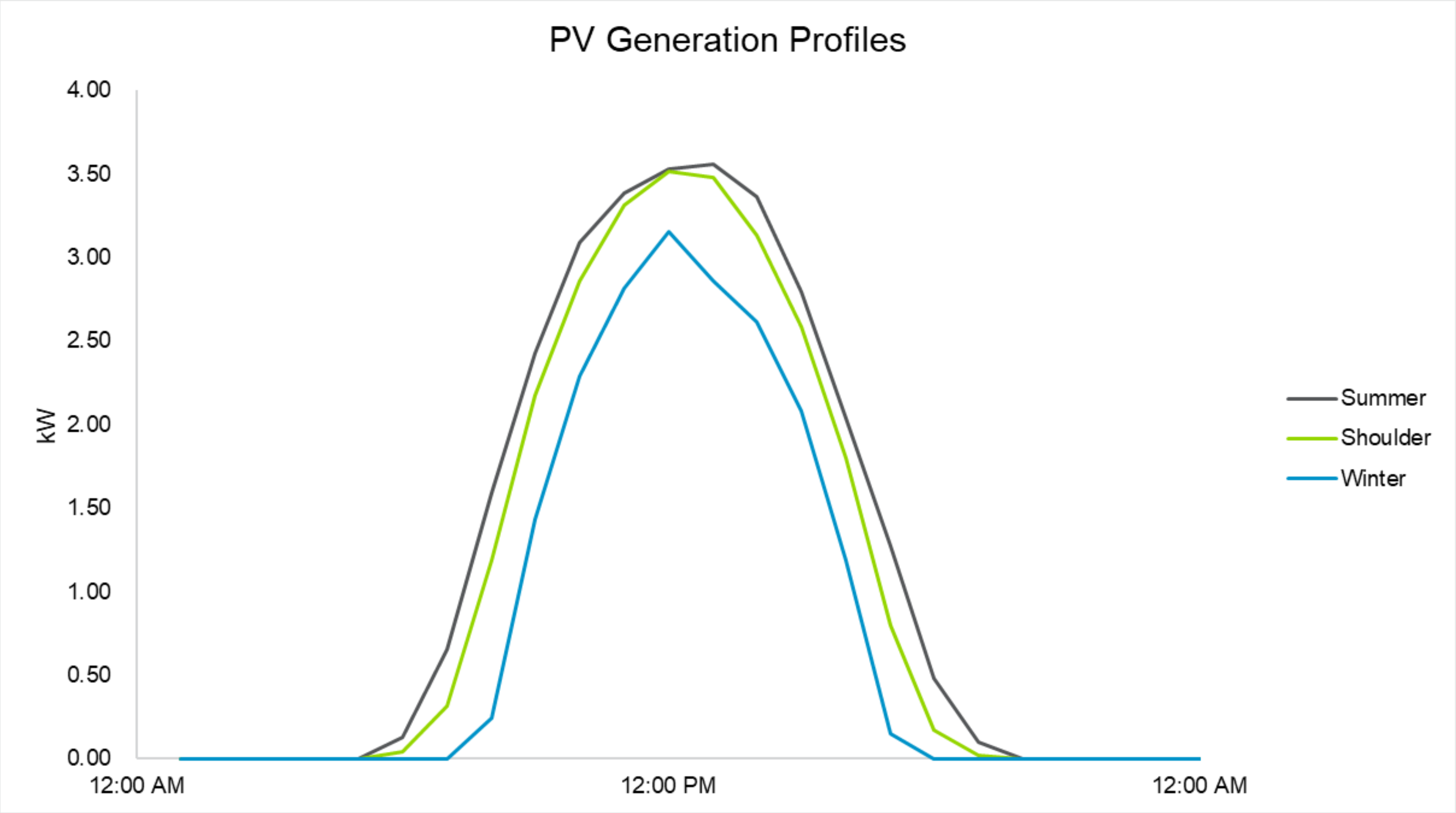
Hourly data was used to model the dispatch and resulting energy impacts of PV and ESS during Summer, Winter, and Shoulder seasons



Source: Guidehouse analysis of Eversource Profile Segment data: https://www.eversource.com/content/ct-c/about/about-us/doing-business-with-us/energy-supplier-information/electric-Connecticut

PV Generation

Hourly PV generation projections were used to model the dispatch and charging profiles



Source: NREL PV Watts Calculator
Based on 8 kW PV system

Cost Test Parameters

Financial parameters and cost/benefit categorization used in net present value and cost-benefit calculations

Benefit Cost Test Definitions	
Source: Guidehouse Analysis	
Cost Test	**Discount Rate**
PACT_Combined	3.0%
PACT_Passive	3.0%
PACT_Active	3.0%
PCT	10.0%
SCT	3.0%
TRC	3.0%
RIM	7.0%

Benefit Cost Test Assumptions	
Source: Guidehouse Analysis	
Assumption	**Value**
Inflation Rate (%)	2.00%
Retail Rate Escalation Rate (%)	2.61%
Base Year for Inflation	2020
Benefit/Cost Lifetime (Years)	20
Benefits in Install Year	50%

Program-Level Benefit Cost Test Definitions							
Source: Guidehouse Analysis							
Benefit/Cost Stream	**PACT_Combined**	**PACT_Passive**	**PACT_Active**	**PCT**	**SCT**	**TRC**	**RIM**
Avoided Energy	Benefit	Benefit	Benefit		Benefit	Benefit	Benefit
Avoided Generation Capacity - Passive	Benefit	Benefit			Benefit	Benefit	Benefit
Avoided Generation Capacity - Active	Benefit		Benefit		Benefit	Benefit	Benefit
Avoided T&D Capacity - Passive	Benefit	Benefit			Benefit	Benefit	Benefit
Avoided T&D Capacity - Active	Benefit		Benefit		Benefit	Benefit	Benefit
Reliability - Passive	Benefit	Benefit			Benefit	Benefit	Benefit
Reliability - Active	Benefit		Benefit		Benefit	Benefit	Benefit
DRIPE Energy Impacts	Benefit	Benefit	Benefit		Benefit	Benefit	Benefit
DRIPE Capacity Impacts - Passive	Benefit	Benefit			Benefit	Benefit	Benefit
DRIPE Capacity Impacts - Active	Benefit		Benefit		Benefit	Benefit	Benefit
Cross-DRIPE Impacts	Benefit	Benefit	Benefit		Benefit	Benefit	Benefit
Non-Embedded Emissions					Benefit		
Market Revenue	Benefit	Benefit	Benefit		Benefit	Benefit	Benefit
Avoided Ancillary Services	Benefit	Benefit	Benefit		Benefit	Benefit	Benefit
Job Creation Benefits					Benefit		
Net Societal Non-Energy Benefits					Benefit		
Net Participant Non-Energy Benefits				Benefit	Benefit		
Net Avoided Outage Benefits				Benefit			
Participant Bill Savings				Benefit			Cost
Upfront Program Incentives	Cost	Cost		Benefit			Cost
Performance Incentives	Cost		Cost	Benefit			Cost
Non-Program Incentives				Benefit			
Upfront Incentive Administration	Cost	Cost			Cost	Cost	Cost
Performance Incentive Administration	Cost		Cost		Cost	Cost	Cost
TPO Administration							
Lease Value				Cost			
Participant Incremental DER Costs				Cost	Cost	Cost	

Guidehouse

Electricity Rates & Peak Period Definitions

Eversource and UI TOU and Flat Rate data used to calculate participant bill savings; Peak periods defined by ISO-NE and EDC Rates

Table 13. Rate Structure (Nominal $/kWh)

Source: Eversource Flat Tariff Rate 1 (Effective May 1, 2018 - 1.05-01-18), Eversource TOU Tariff Rate 7 (Effective May 1, 2018 - 7.05-01-18), UI Flat Tariff Rate R (Effective July 1, 2018 - C.P.U.C.A. No. 996), UI TOU Tariff Rate RT (Effective July 1, 2018 - C.P.U.C.A. No. 997)

Utility	Rate	Season	Period	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
Eversource	Non-TOU	Summer	Peak	0.21	0.21	0.22	0.22	0.23	0.24	0.24	0.25	0.25	0.26	0.27	0.27	0.28	0.29	0.30
Eversource	Non-TOU	Summer	Off-Peak	0.21	0.21	0.22	0.22	0.23	0.24	0.24	0.25	0.25	0.26	0.27	0.27	0.28	0.29	0.30
Eversource	TOU	Summer	Peak	0.29	0.29	0.30	0.31	0.32	0.32	0.33	0.34	0.35	0.36	0.37	0.38	0.39	0.40	0.41
Eversource	TOU	Summer	Off-Peak	0.17	0.18	0.18	0.19	0.19	0.20	0.20	0.21	0.21	0.22	0.22	0.23	0.24	0.24	0.25
Eversource	Non-TOU	Winter	Peak	0.21	0.21	0.22	0.22	0.23	0.24	0.24	0.25	0.25	0.26	0.27	0.27	0.28	0.29	0.30
Eversource	Non-TOU	Winter	Off-Peak	0.21	0.21	0.22	0.22	0.23	0.24	0.24	0.25	0.25	0.26	0.27	0.27	0.28	0.29	0.30
Eversource	TOU	Winter	Peak	0.29	0.29	0.30	0.31	0.32	0.32	0.33	0.34	0.35	0.36	0.37	0.38	0.39	0.40	0.41
Eversource	TOU	Winter	Off-Peak	0.17	0.18	0.18	0.19	0.19	0.20	0.20	0.21	0.21	0.22	0.22	0.23	0.24	0.24	0.25
UI	Non-TOU	Summer	Peak	0.28	0.28	0.29	0.30	0.31	0.31	0.32	0.33	0.34	0.35	0.36	0.37	0.38	0.38	0.39
UI	Non-TOU	Summer	Off-Peak	0.28	0.28	0.29	0.30	0.31	0.31	0.32	0.33	0.34	0.35	0.36	0.37	0.38	0.38	0.39
UI	TOU	Summer	Peak	0.44	0.45	0.46	0.47	0.48	0.50	0.51	0.52	0.54	0.55	0.56	0.58	0.59	0.61	0.62
UI	TOU	Summer	Off-Peak	0.18	0.19	0.19	0.20	0.20	0.21	0.21	0.22	0.22	0.23	0.23	0.24	0.25	0.25	0.26
UI	Non-TOU	Winter	Peak	0.26	0.27	0.28	0.28	0.29	0.30	0.31	0.32	0.32	0.33	0.34	0.35	0.36	0.37	0.38
UI	Non-TOU	Winter	Off-Peak	0.26	0.27	0.28	0.28	0.29	0.30	0.31	0.32	0.32	0.33	0.34	0.35	0.36	0.37	0.38
UI	TOU	Winter	Peak	0.39	0.40	0.41	0.42	0.43	0.45	0.46	0.47	0.48	0.49	0.51	0.52	0.53	0.55	0.56
UI	TOU	Winter	Off-Peak	0.18	0.19	0.19	0.20	0.20	0.21	0.21	0.22	0.22	0.23	0.23	0.24	0.25	0.25	0.26

Table 3. Peak Period Definitions

Sources: AESC 2018, UI TOU Pricing, Eversource TOU Pricing

Period	Months	Time
Winter Peak Savings	Oct - May	Weekdays, 7 AM - 11 PM
Winter Off-Peak Savings	Oct - May	All other hours
Summer Peak Savings	Jun - Sep	Weekdays, 7 AM - 11 PM
Summer Off-Peak Savings	Jun - Sep	All other hours
TOU Peak for both EDCs	All	Weekdays, 12 PM - 8 PM
TOU Off-Peak for both EDCs	All	All other hours
ISO-NE Winter Capacity Peak	Dec - Jan	Weekdays, 5 PM - 7 PM
ISO-NE Summer Capacity Peak	Jun - Aug	Weekdays, 1 PM - 5 PM

Note Rates continue through 2050 (not shown here)

Avoided Costs

The avoided cost data is from the 2018 AESC Study

Table 5. Electric Energy Costs (Nominal $)				
Source: AESC 2018, Appendix B; Tab "CT_nominal", Retail Cost of Electric Energy				
Period	**Units**	**2021**	**2022**	**2023**
Winter Peak	$/kWh	0.0694	0.0671	0.0704
Winter Off-Peak	$/kWh	0.0652	0.0613	0.0629
Summer Peak	$/kWh	0.0592	0.0561	0.0542
Summer Off-Peak	$/kWh	0.0505	0.0460	0.0435

Table 6. Electric Capacity Costs (Nominal $)				
Source: AESC 2018, Appendix B; Tab "CT_nominal", Retail Cost of Electric Capacity & Tr				
Capacity Cost Subset	**Units**	**2021**	**2022**	**2023**
Retail Cost of Capacity - Cleared	$/kW-yr	68.69	67.31	70.09
Retail Cost of Capacity - Uncleared	$/kW-yr	0.00	0.00	27.20
Retail Cost of Capacity - Weighted Average	$/kW-yr	34.34	33.66	48.65
Distribution Capacity Cost	$/kW-yr	0.91	0.93	0.95
Transmission Capacity Cost	$/kW-yr	32.78	33.44	34.11
Pooled Transmission Facilities Capacity Cost	$/kW-yr	99.75	101.75	103.78

- Avoided electric energy costs are provided by year
  - This actually ends up as a net negative for retrofit ES projects due to efficiency losses
- Capacity Costs include generation capacity, distribution, transmission, and PTF transmission costs

Note Avoided Costs continue through 2050 (not shown here)

Avoided Costs (Cont'd)

The avoided cost data is from the 2018 AESC Study

Table 7. Wholesale Non-Embedded Costs (Nominal $)				
Source: AESC 2018, Appendix B; Tab "CT_nominal", Wholesale Non-Embedded Costs				
Period	Units	2021	2022	2023
Winter Peak	$/kWh	0.0459	0.0465	0.0472
Winter Off-Peak	$/kWh	0.0468	0.0475	0.0482
Summer Peak	$/kWh	0.0447	0.0453	0.0460
Summer Off-Peak	$/kWh	0.0450	0.0456	0.0463

Table 7. Intrastate Wholesale Energy DRIPE Costs (Nominal $)				
Source: AESC 2018, Appendix B; Tab "CT_nominal", Intrastate Wholesale Energy DRIPE				
Period	Units	2021	2022	2023
Winter Peak	$/kWh	0.0153	0.0156	0.0149
Winter Off-Peak	$/kWh	0.0111	0.0109	0.0100
Summer Peak	$/kWh	0.0136	0.0137	0.0120
Summer Off-Peak	$/kWh	0.0091	0.0088	0.0075
Winter Peak	$/kWh	0.0143	0.0154	0.0163
Winter Off-Peak	$/kWh	0.0104	0.0108	0.0110
Summer Peak	$/kWh	0.0127	0.0136	0.0131
Summer Off-Peak	$/kWh	0.0085	0.0087	0.0082
Winter Peak	$/kWh	0.0093	0.0144	0.0161
Winter Off-Peak	$/kWh	0.0067	0.0101	0.0109
Summer Peak	$/kWh	0.0082	0.0127	0.0129
Summer Off-Peak	$/kWh	0.0055	0.0081	0.0081
Winter Peak	$/kWh	0.0000	0.0093	0.0151
Winter Off-Peak	$/kWh	0.0000	0.0065	0.0102
Summer Peak	$/kWh	0.0000	0.0082	0.0121
Summer Off-Peak	$/kWh	0.0000	0.0053	0.0076
Winter Peak	$/kWh	0.0000	0.0000	0.0098
Winter Off-Peak	$/kWh	0.0000	0.0000	0.0066
Summer Peak	$/kWh	0.0000	0.0000	0.0078
Summer Off-Peak	$/kWh	0.0000	0.0000	0.0049

- This emissions value captures emissions not included in avoided energy values.
  - Note that peak values are actually lower than off-peak values, leading to a negative value for retrofit ES
- DRIPE costs vary by installation year due to decay rates
  - Connecticut also includes intrastate and rest-of-pool values

Note Avoided Costs continue through 2050 (not shown here)

Avoided Costs (Cont'd)

The avoided cost data is from the 2018 AESC Study

Table 8. Intrastate Retail Capacity DRIPE Costs (Nominal $)				
Source: AESC 2018, Appendix B; Tab "CT_nominal", Intrastate Retail Capacity DRIPE				
Capacity Cost Subset	Units	2021	2022	2023
Retail Capacity DRIPE - Cleared	$/kW-yr	18.97	14.56	9.83
Retail Capacity DRIPE - Uncleared	$/kW-yr	0.00	0.00	0.00
Retail Capacity DRIPE - Weighted Average	$/kW-yr	9.49	7.28	4.91
Retail Capacity DRIPE - Cleared	$/kW-yr	23.50	19.51	14.89
Retail Capacity DRIPE - Uncleared	$/kW-yr	0.00	0.00	0.00
Retail Capacity DRIPE - Weighted Average	$/kW-yr	11.75	9.75	7.44
Retail Capacity DRIPE - Cleared	$/kW-yr	28.32	24.16	19.95
Retail Capacity DRIPE - Uncleared	$/kW-yr	0.00	0.00	0.00
Retail Capacity DRIPE - Weighted Average	$/kW-yr	14.16	12.08	9.97
Retail Capacity DRIPE - Cleared	$/kW-yr	0.00	29.11	24.71
Retail Capacity DRIPE - Uncleared	$/kW-yr	0.00	0.00	0.00
Retail Capacity DRIPE - Weighted Average	$/kW-yr	0.00	14.56	12.36
Retail Capacity DRIPE - Cleared	$/kW-yr	0.00	0.00	29.78
Retail Capacity DRIPE - Uncleared	$/kW-yr	0.00	0.00	0.00
Retail Capacity DRIPE - Weighted Average	$/kW-yr	0.00	0.00	14.89

Table 9. Intrastate Wholesale Cross-DRIPE Costs (Nominal $)				
Source: AESC 2018, Appendix B; Tab "CT_nominal", Intrastate Wholesale Cross-DRIPE				
Capacity Subset	Units	2021	2022	2023
Wholesale Cross-DRIPE	$/kWh	0.0053	0.0054	0.0041
Wholesale Cross-DRIPE	$/kWh	0.0047	0.0049	0.0041
Wholesale Cross-DRIPE	$/kWh	0.0029	0.0043	0.0037
Wholesale Cross-DRIPE	$/kWh	0.0000	0.0027	0.0032
Wholesale Cross-DRIPE	$/kWh	0.0000	0.0000	0.0020

- There are cleared and uncleared retail capacity DRIPE costs. Weighted average values are used here
- Cross-DRIPE captures the benefit of reduced gas prices due to reduced electricity prices, and further reduced electricity prices from those reduced gas prices

Note Avoided Costs continue through 2050 (not shown here)

Avoided Costs (Cont'd)

The avoided cost data is from the 2018 AESC Study

Table 10. Rest-of-Pool Wholesale Energy DRIPE Costs (Nominal $)				
Source: AESC 2018, Appendix B; Tab "CT_nominal", Rest-of-Pool Wholesale Energy DRI				
Capacity Subset	Units	2021	2022	2023
Winter Peak	$/kWh	0.0604	0.0617	0.0526
Winter Off-Peak	$/kWh	0.0437	0.0432	0.0358
Summer Peak	$/kWh	0.0508	0.0515	0.0399
Summer Off-Peak	$/kWh	0.0343	0.0331	0.0253
Winter Peak	$/kWh	0.0565	0.0610	0.0575
Winter Off-Peak	$/kWh	0.0409	0.0428	0.0392
Summer Peak	$/kWh	0.0475	0.0510	0.0437
Summer Off-Peak	$/kWh	0.0321	0.0328	0.0277
Winter Peak	$/kWh	0.0366	0.0571	0.0569
Winter Off-Peak	$/kWh	0.0265	0.0400	0.0388
Summer Peak	$/kWh	0.0308	0.0477	0.0432
Summer Off-Peak	$/kWh	0.0208	0.0307	0.0274
Winter Peak	$/kWh	0.0000	0.0370	0.0532
Winter Off-Peak	$/kWh	0.0000	0.0259	0.0363
Summer Peak	$/kWh	0.0000	0.0309	0.0404
Summer Off-Peak	$/kWh	0.0000	0.0199	0.0256
Winter Peak	$/kWh	0.0000	0.0000	0.0345
Winter Off-Peak	$/kWh	0.0000	0.0000	0.0235
Summer Peak	$/kWh	0.0000	0.0000	0.0262
Summer Off-Peak	$/kWh	0.0000	0.0000	0.0166

Table 11. Rest-of-Pool Retail Capacity DRIPE Costs (Nominal $)				
Source: AESC 2018, Appendix B; Tab "CT_nominal", Rest-of-Pool Retail Capacity DRIPE				
Capacity Subset	Units	2021	2022	2023
Retail Capacity DRIPE - Cleared	$/kW-yr	60.43	46.66	31.66
Retail Capacity DRIPE - Uncleared	$/kW-yr	0.00	0.00	0.00
Retail Capacity DRIPE - Weighted Average	$/kW-yr	30.21	23.33	15.83
Retail Capacity DRIPE - Cleared	$/kW-yr	74.86	62.53	47.97
Retail Capacity DRIPE - Uncleared	$/kW-yr	0.00	0.00	0.00
Retail Capacity DRIPE - Weighted Average	$/kW-yr	37.43	31.26	23.99
Retail Capacity DRIPE - Cleared	$/kW-yr	87.87	75.47	62.63
Retail Capacity DRIPE - Uncleared	$/kW-yr	0.00	0.00	0.00
Retail Capacity DRIPE - Weighted Average	$/kW-yr	43.93	37.73	31.32
Retail Capacity DRIPE - Cleared	$/kW-yr	0.00	93.32	79.64
Retail Capacity DRIPE - Uncleared	$/kW-yr	0.00	0.00	0.00
Retail Capacity DRIPE - Weighted Average	$/kW-yr	0.00	46.66	39.82
Retail Capacity DRIPE - Cleared	$/kW-yr	0.00	0.00	93.48
Retail Capacity DRIPE - Uncleared	$/kW-yr	0.00	0.00	0.00
Retail Capacity DRIPE - Weighted Average	$/kW-yr	0.00	0.00	46.74

- Rest-of-Pool DRIPE measures the benefits in other New England states. The 2019-2021 CT C&LM calls for both Intrastate and ROP DRIPE benefits to be included.

Note Avoided Costs continue through 2050 (not shown here)

Avoided Costs (Cont'd)

The avoided cost data is from the 2018 AESC Study

Table 12. Reliability Value (Nominal $)				
Source: AESC 2018, Appendix B; Tab "CT_nominal", Reliability				
Value Subset	**Units**	**2021**	**2022**	**2023**
Wholesale Reliability - Cleared	$/kW-yr	0.37	0.30	0.22
Wholesale Reliability - Uncleared	$/kW-yr	8.24	8.62	8.95
Wholesale Reliability - Weighted Average	$/kW-yr	4.31	4.46	4.59
Retail Reliability - Weighted Average	$/kW-yr	5.02	5.20	5.35
Wholesale Reliability - Cleared	$/kW-yr	0.48	0.38	0.33
Wholesale Reliability - Uncleared	$/kW-yr	8.24	8.62	8.95
Wholesale Reliability - Weighted Average	$/kW-yr	4.36	4.50	4.64
Retail Reliability - Weighted Average	$/kW-yr	5.08	5.25	5.41
Wholesale Reliability - Cleared	$/kW-yr	0.48	0.38	0.33
Wholesale Reliability - Uncleared	$/kW-yr	8.24	8.62	8.95
Wholesale Reliability - Weighted Average	$/kW-yr	4.36	4.50	4.64
Retail Reliability - Weighted Average	$/kW-yr	5.08	5.25	5.41
Wholesale Reliability - Cleared	$/kW-yr	0.48	0.38	0.33
Wholesale Reliability - Uncleared	$/kW-yr	8.24	8.62	8.95
Wholesale Reliability - Weighted Average	$/kW-yr	4.36	4.50	4.64
Retail Reliability - Weighted Average	$/kW-yr	5.08	5.25	5.41
Wholesale Reliability - Cleared	$/kW-yr	0.48	0.38	0.33
Wholesale Reliability - Uncleared	$/kW-yr	8.24	8.62	8.95
Wholesale Reliability - Weighted Average	$/kW-yr	4.36	4.50	4.64
Retail Reliability - Weighted Average	$/kW-yr	5.08	5.25	5.41

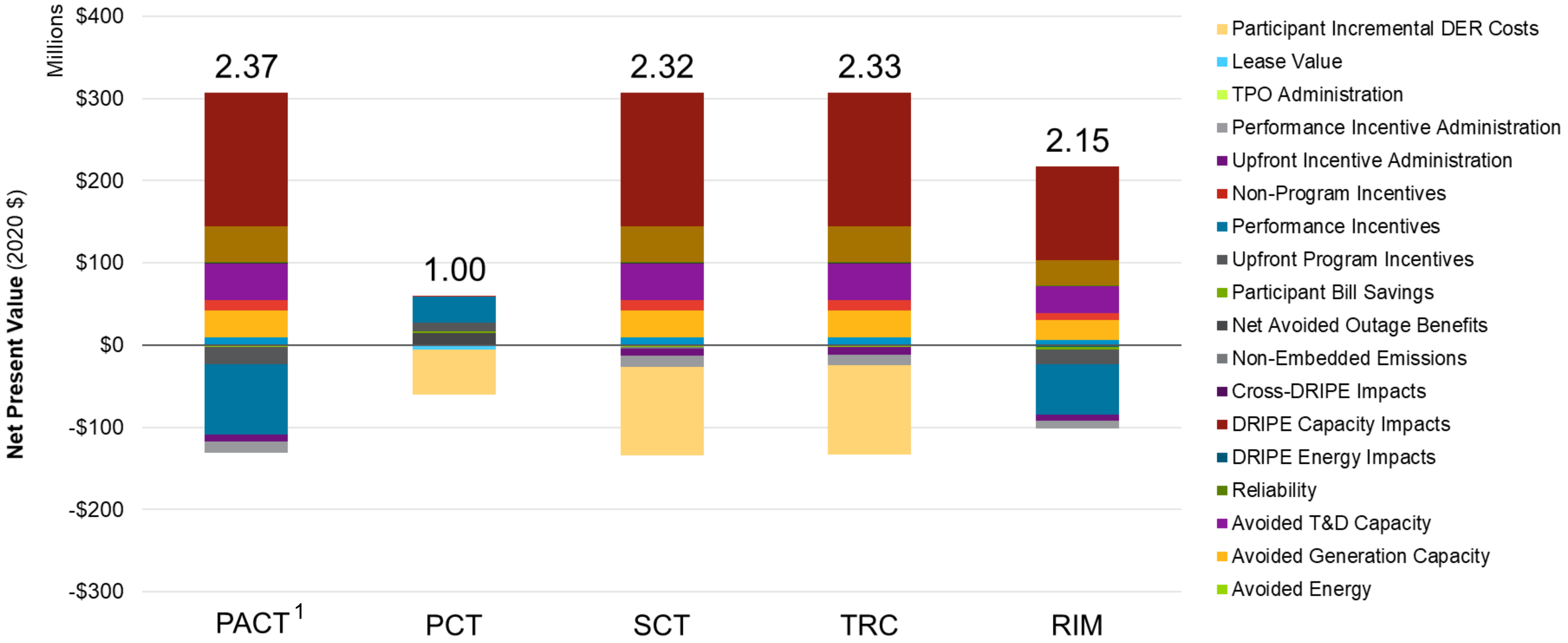
- Reliability is included as a benefit in the UCT and TRC in the 2019-2021 CT C&LM plan

Note Avoided Costs continue through 2050 (not shown here)

Cost-Effectiveness Analysis Results

Program-Level Benefit-Cost Analysis

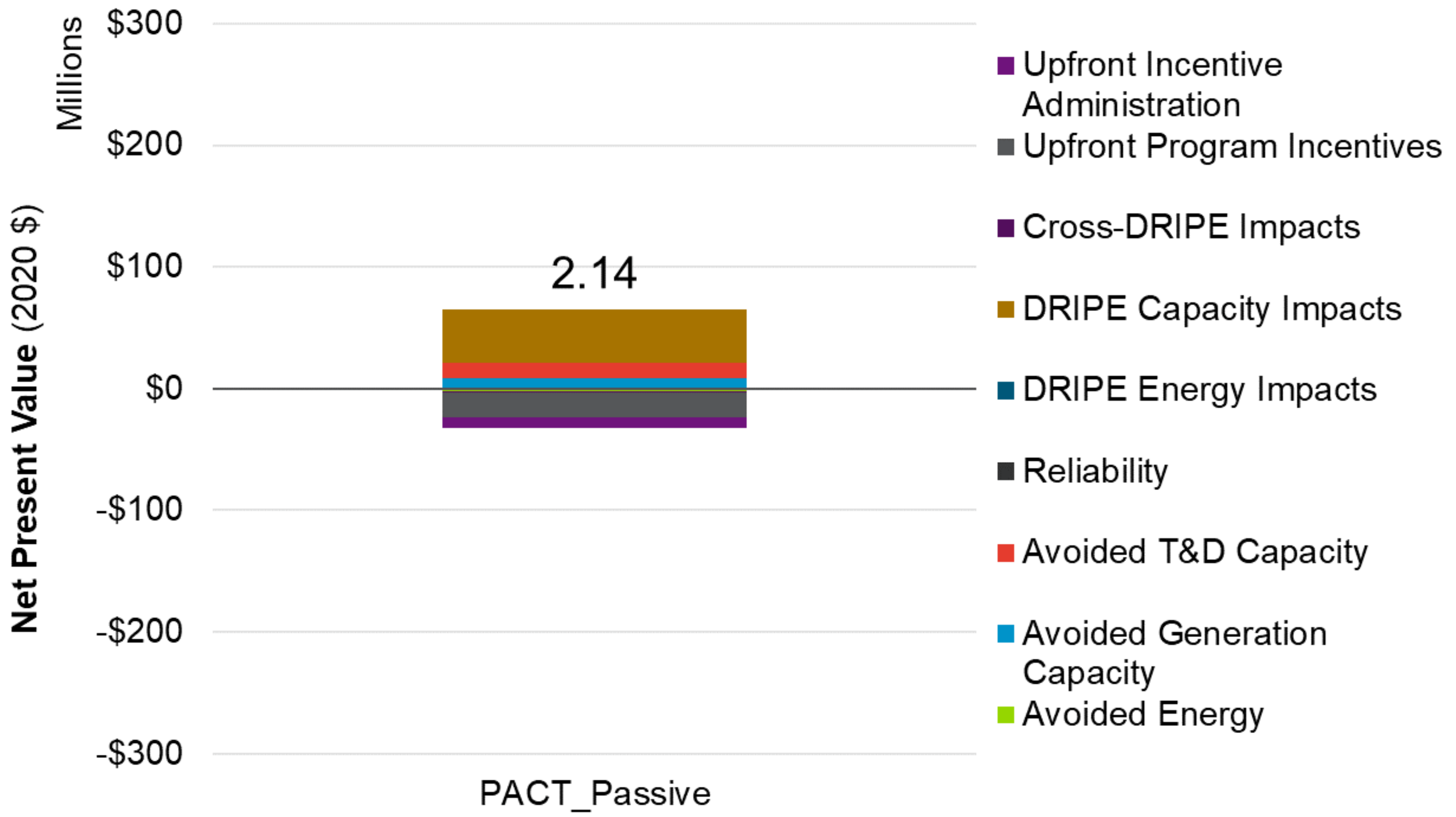
PACT, PCT, SCT, TRC, and RIM Overview



1 The PACT of the Combined Program (Upfront Incentive Program run by Connecticut Green Bank + Performance-Based Incentive Program run by the EDCs)

Program Administrator Cost Test: Connecticut Green Bank

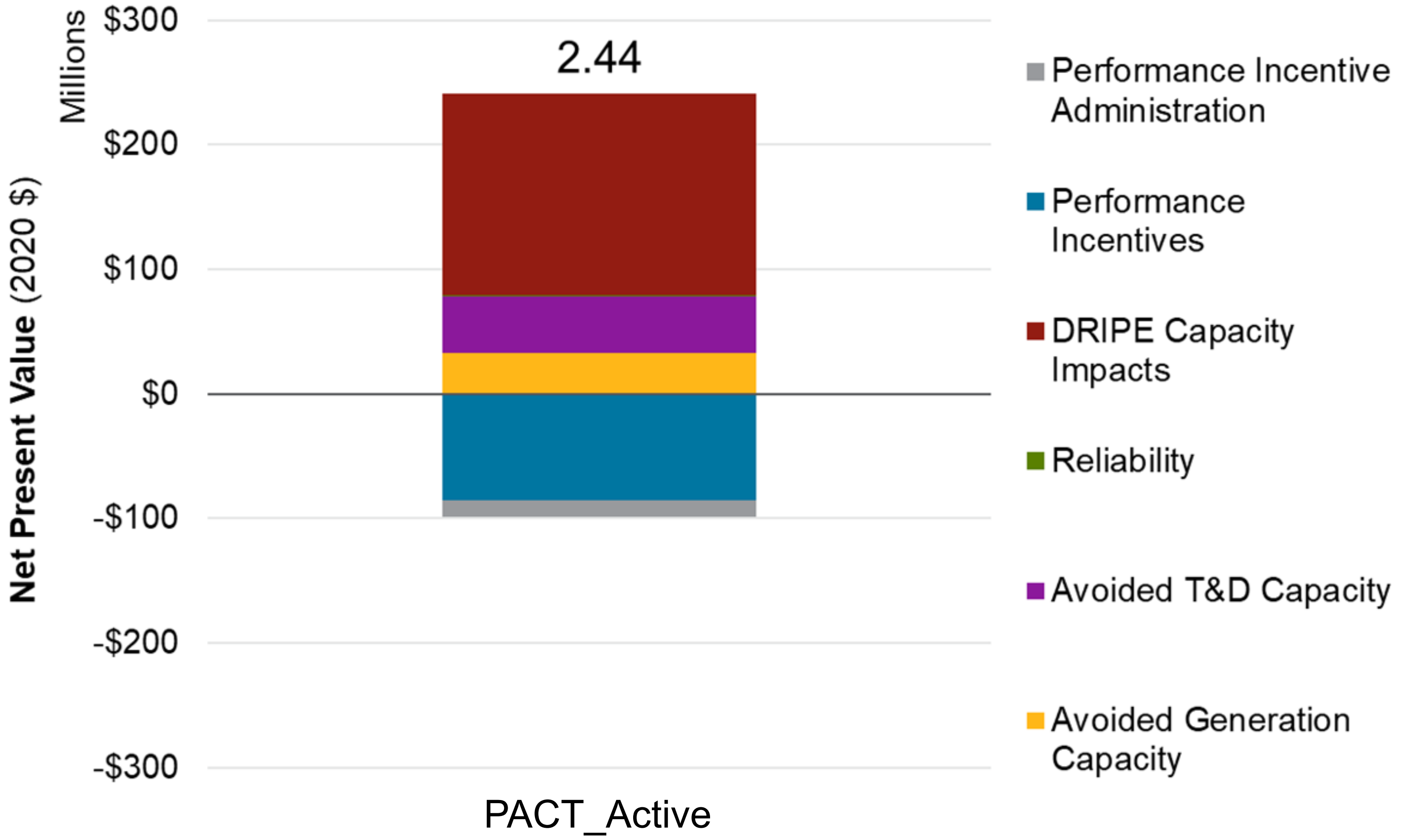
PACT Results for the upfront incentive program



Capacity Block	PACT Ratio
2.0	0.63
5.5	1.08
12.0	1.57
25.0	2.28
50.0	3.14
Program Level	**2.14**

Program Administrator Cost Test: EDCs[1]

Active Dispatch Program

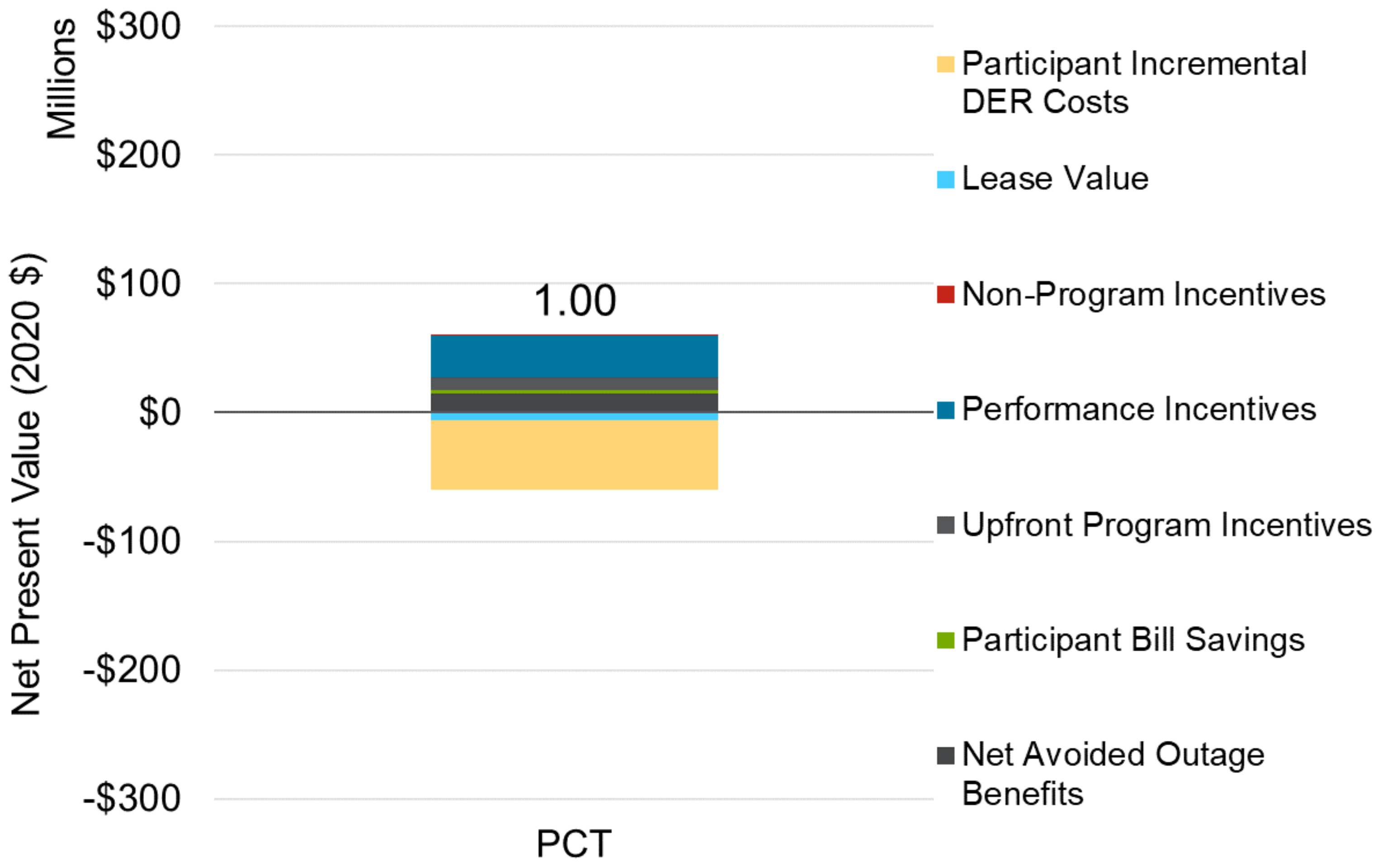


Program Year	PACT Ratio
2021	0.24
2022	0.46
2023	0.60
2024	0.68
2025	1.50
2026	1.73
2027	2.60
2028	3.31
2029	3.83
2030	3.37
Program Level	**2.45**

1 Because the EDCs administer the performance-based incentive program, the PACT is technically also a UCT. For consistency, this is considered a PACT as it examines the active dispatch/performance based incentive program and is combined with the upfront incentive program PACT to calculate a program-level, or combined, PACT

Participant Cost Test

Program-Level PCT



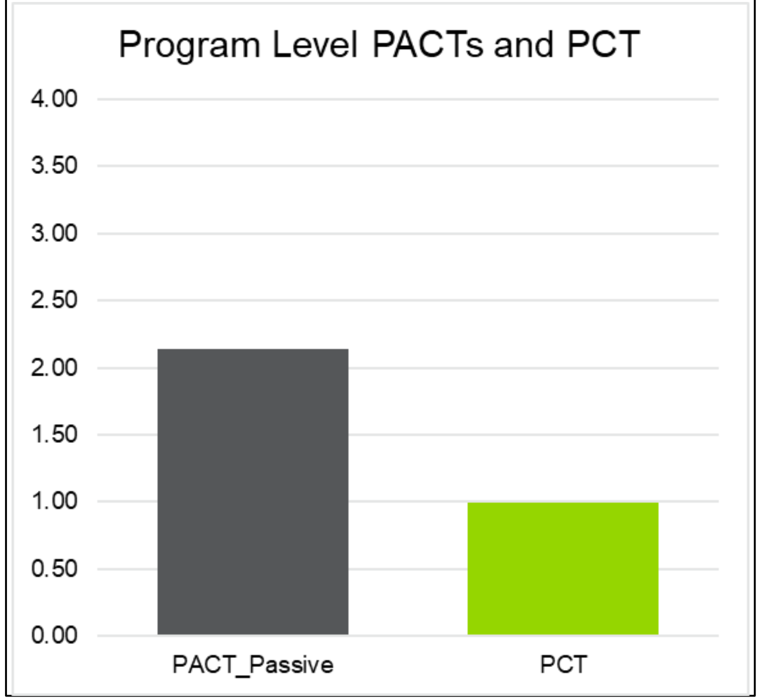
Capacity Block	PCT Ratio
2.0	1.13
5.5	1.00
12.0	0.99
25.0	0.99
50.0	0.98
Program Level	**1.00**

Impacts of PV on the BCA

Adding PV to the analysis increases the PACT, decreases the PCT

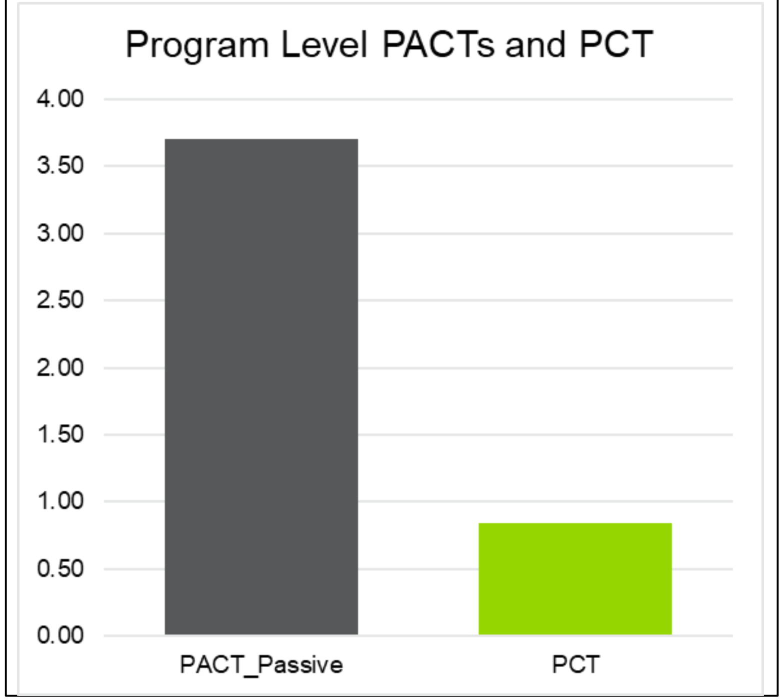
ESS Only

PACT = 2.14, PCT = 1.00



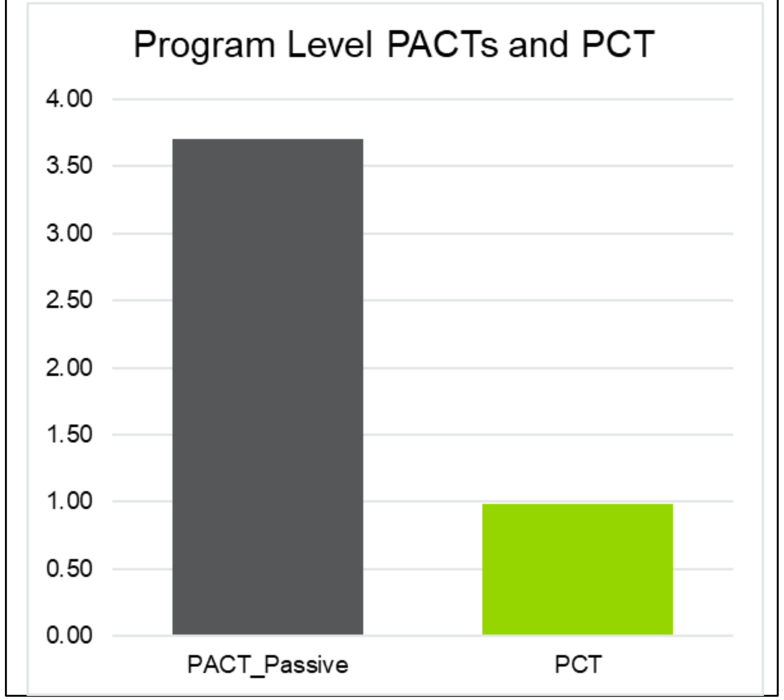
ESS + PV

PACT = 3.70, PCT = 0.84



ESS + PV (incl. ITC post 2021)

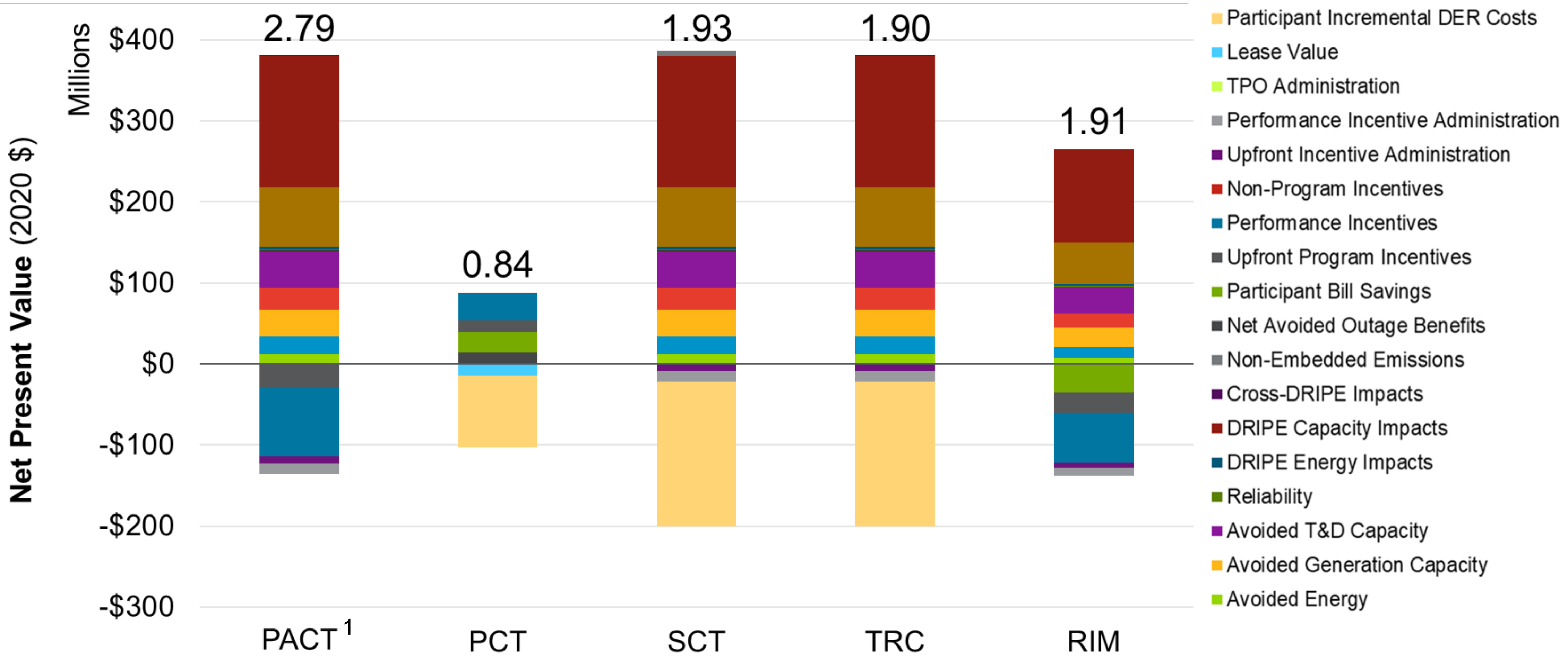
PACT = 3.70, PCT = 0.98



Guidehouse

Impact of Including PV in the Analysis

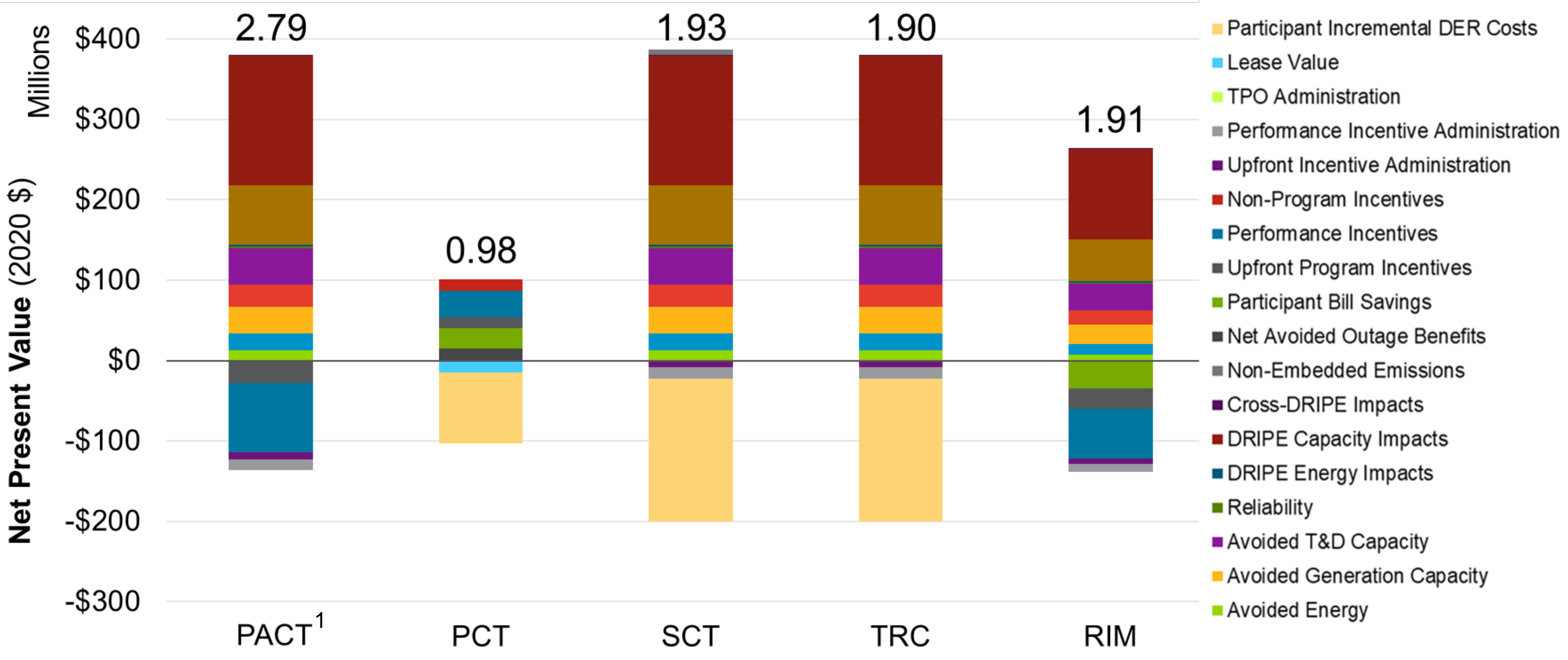
PACT increases; PCT, SCT, TRC, and RIM decrease slightly



1 The PACT of the Combined Program (Upfront Incentive Program run by Connecticut Green Bank + Performance-Based Incentive Program run by the EDCs)

Impact of Including PV and Extended ITC in the Analysis

PACT increases; PCT, SCT, TRC, and RIM decrease slightly



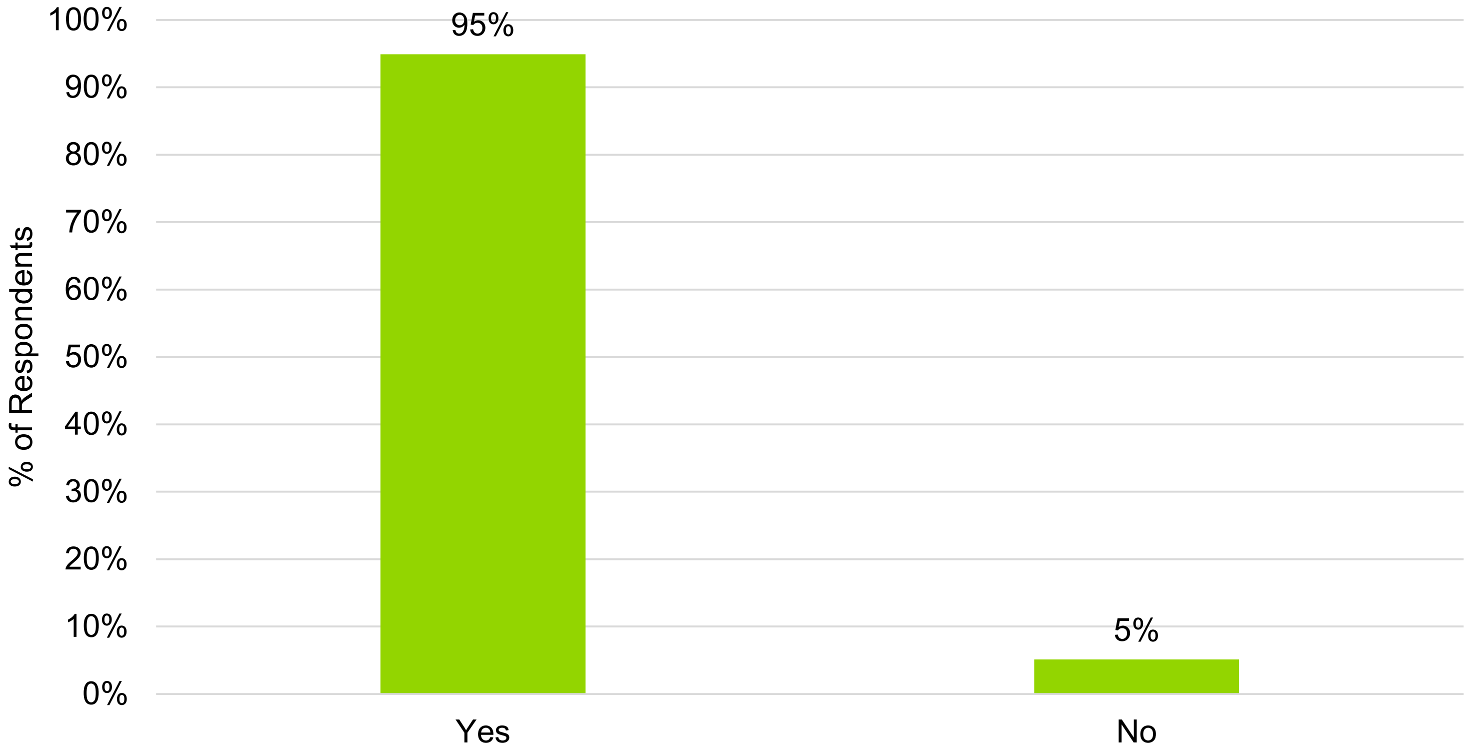
1 The PACT of the Combined Program (Upfront Incentive Program run by Connecticut Green Bank + Performance-Based Incentive Program run by the EDCs)

Supplemental Survey Results

Guidehouse

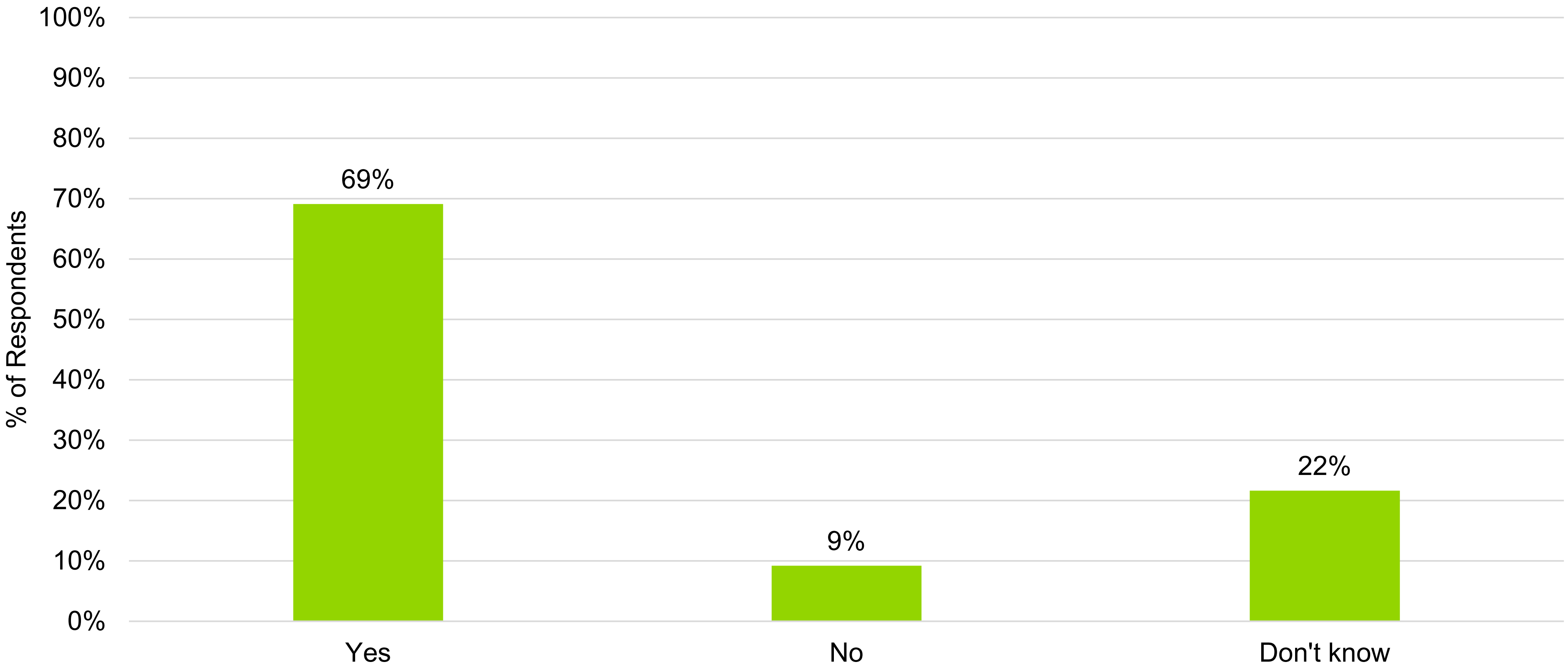
Question 1a: Do you have a solar photovoltaic (PV) system installed at your home for generating electricity?

(n=1,864)



Question 1: Did you participate in the Connecticut Green Bank's Residential Solar Investment Program (RSIP) and receive a financial incentive from the program to install a solar PV system?

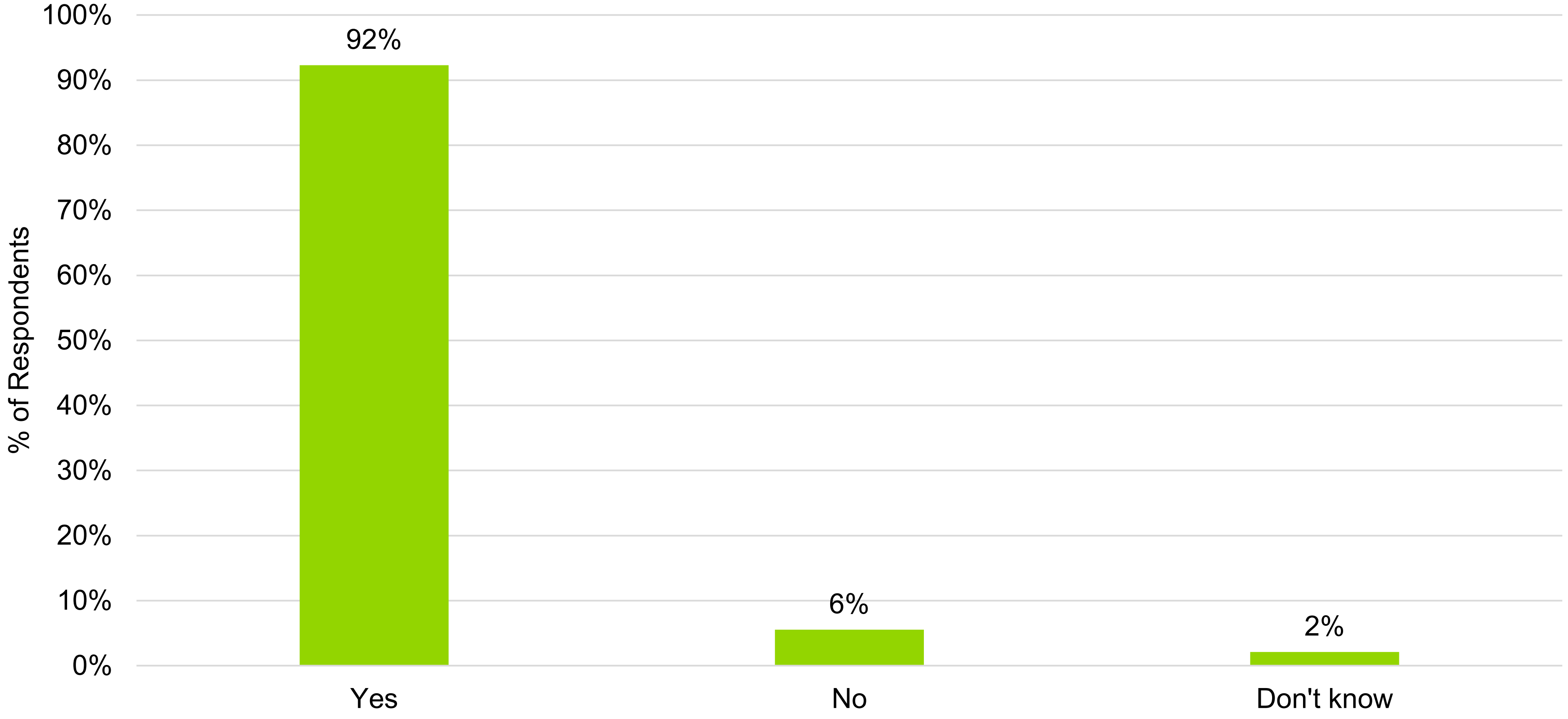
(n=1,769)



Note: Only asked of customers flagged as RSIP in the sample and who report having solar panels in Question 1a.

Question 2: Did you participate in the Connecticut Green Bank's Smart-E Loan Program to receive financing to help you upgrade your home's energy performance (e.g., solar energy, energy efficiency, other)?

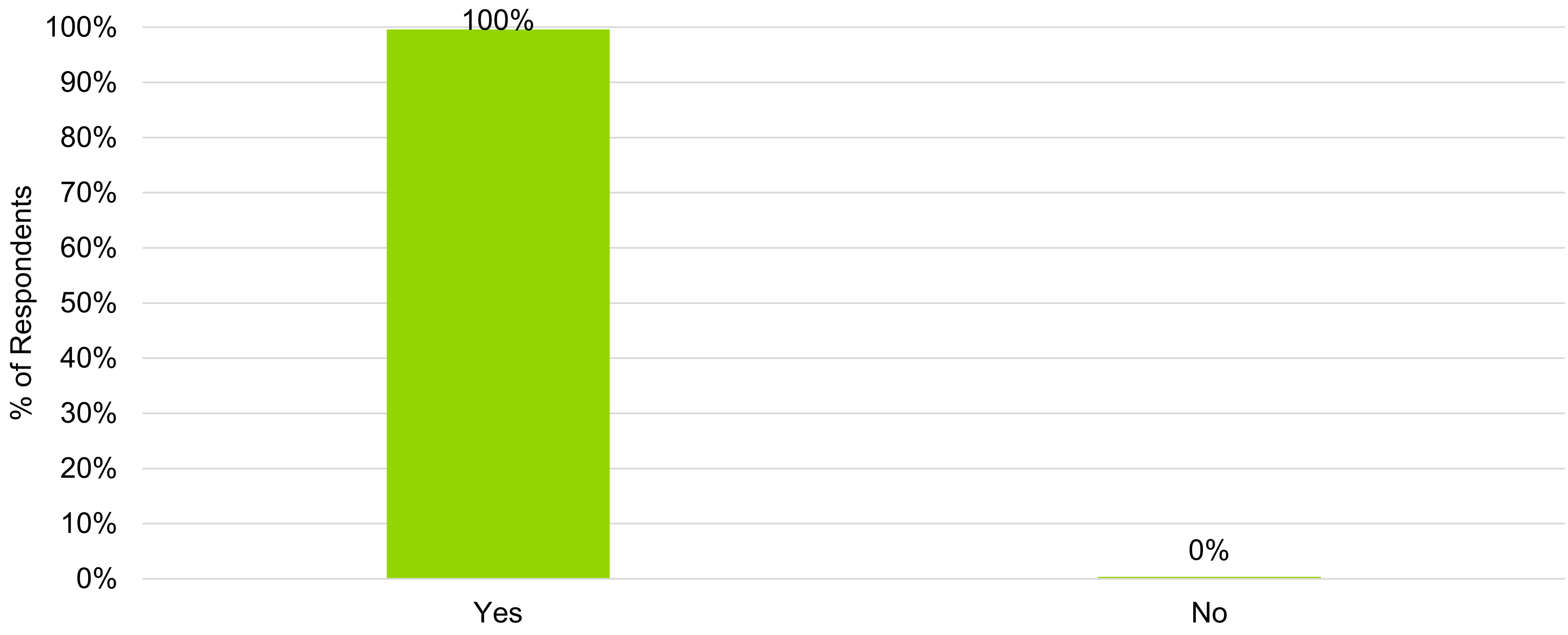
(n=1,630)



Note: Only asked of customers flagged as Smart-E in the sample.

Question 3: Are you the owner of your home?

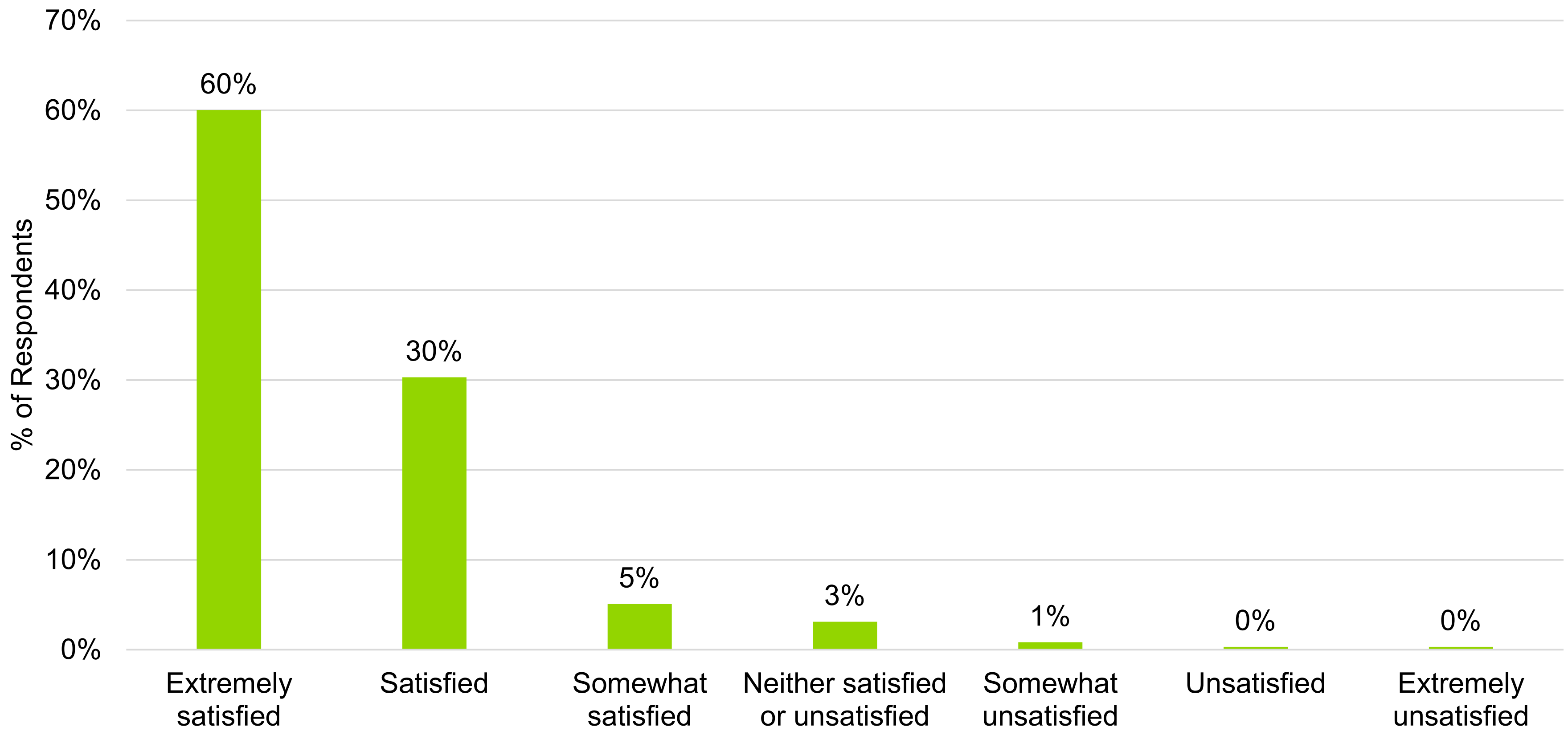
(n=1,864)



Note: Respondents who were not homeowners .were terminated.

Question 4: Please describe your satisfaction with your participation in the RSIP, the Green Bank's solar incentive program.

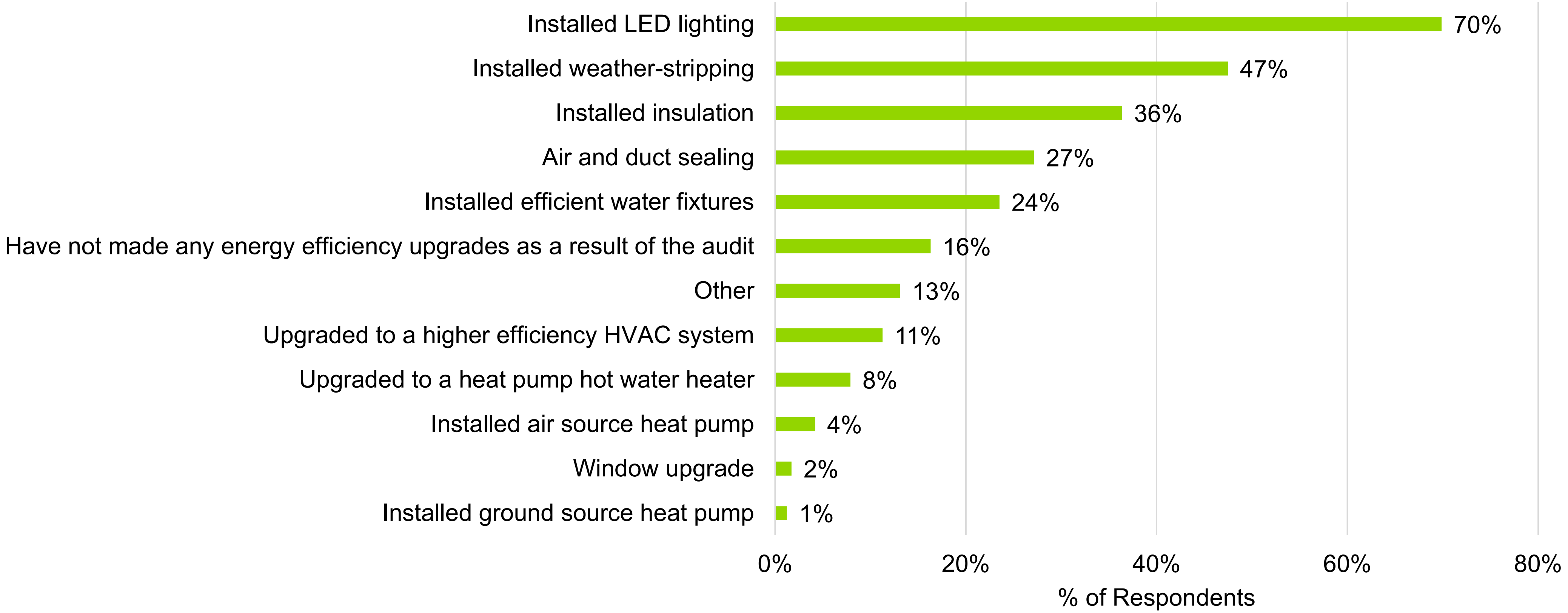
(n=1,221)



Note: Only asked of RSIP respondents.

Question 5: As a requirement of your participation in the RSIP program an energy audit was conducted. What upgrades have you made to your home as a result of the audit, if any? Please select all that apply.

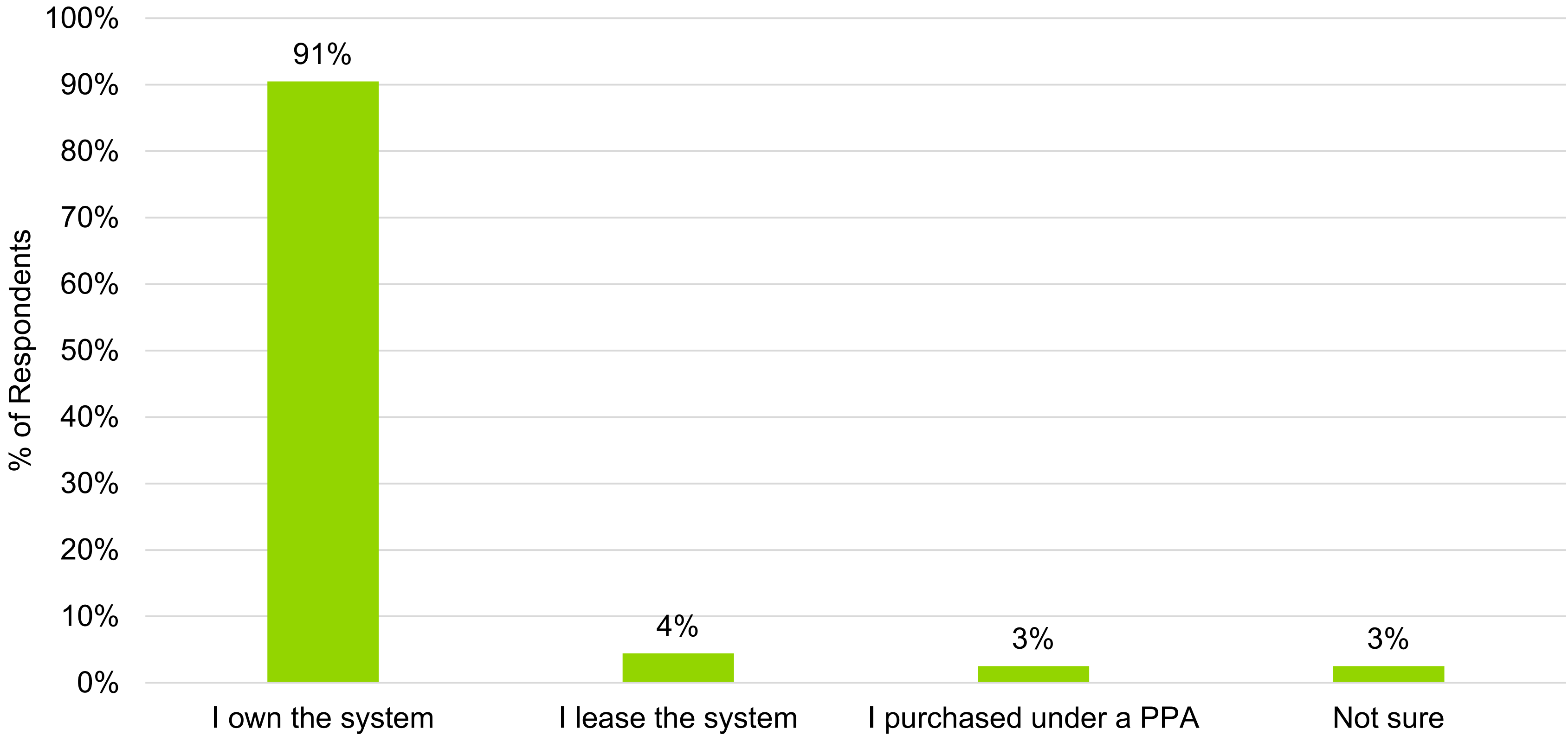
(n=1,215)



Note: Only asked of RSIP respondents.

Question 6: Do you own or lease your solar PV system?

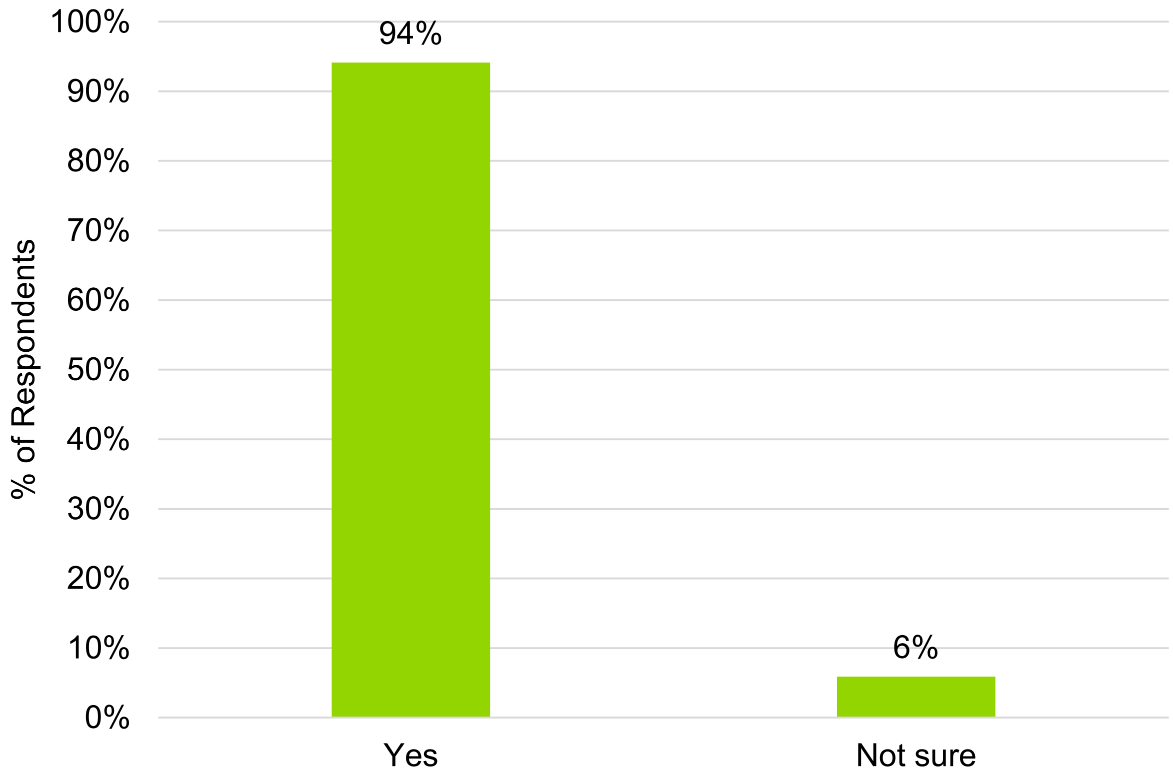
(n=68)



Note: Only asked of Smart-E customers who already have solar.

Question 8: Is the battery storage you already have installed connected to or being charged from your solar PV panels?

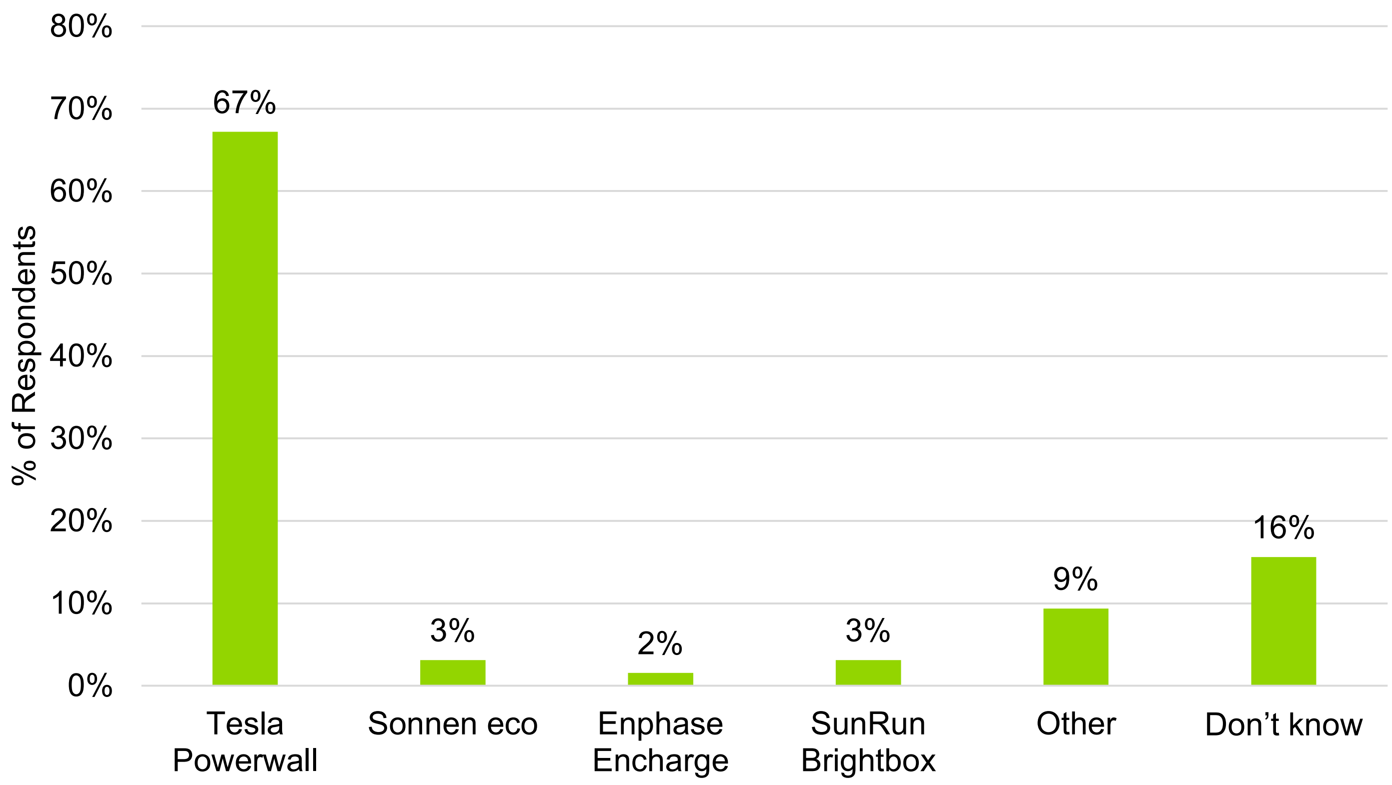
(n=68)



Note: Only asked of respondents who already have battery storage.

Question 9: What type of battery storage do you currently have for your solar PV panels?

(n=64)



Note: Only asked of respondents who already have battery storage combined with solar.

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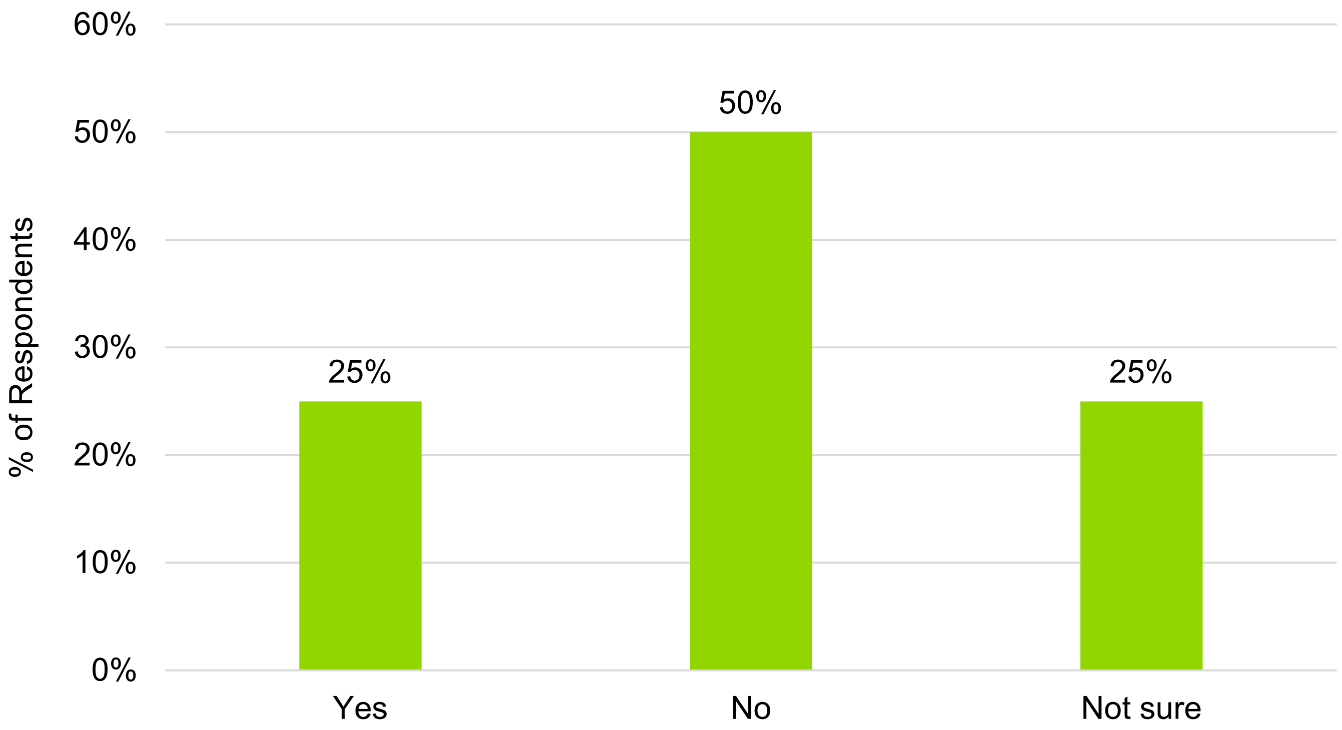
Question 10: Do you participate in a demand response program with your utility or third party owner using this battery storage system through which you provide power to the grid during times of high electricity demand?

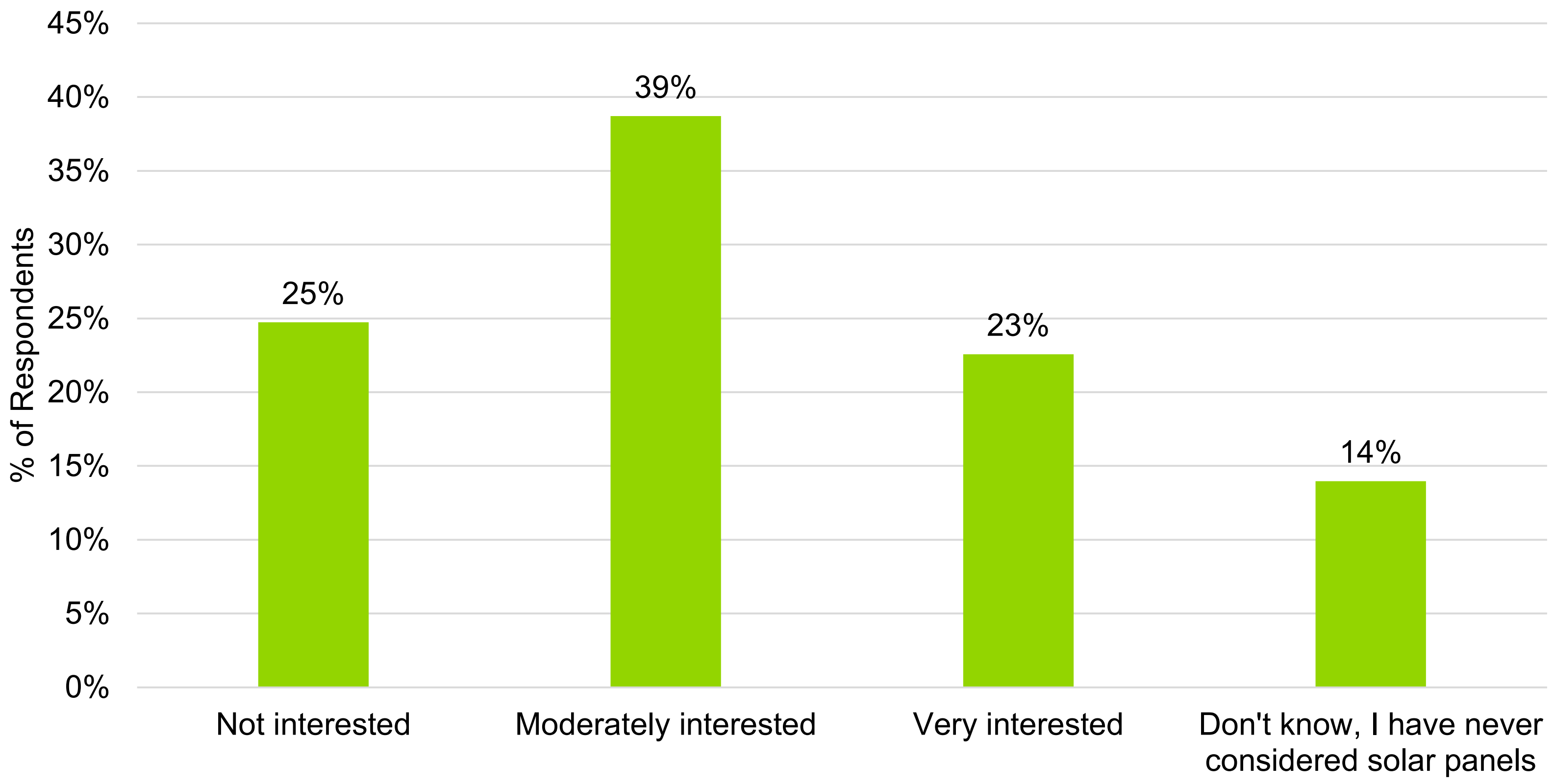
(n=64)



Note: Only asked of respondents who already have battery storage combined with solar.

Question 11: How interested are you in installing a solar PV system at your home?

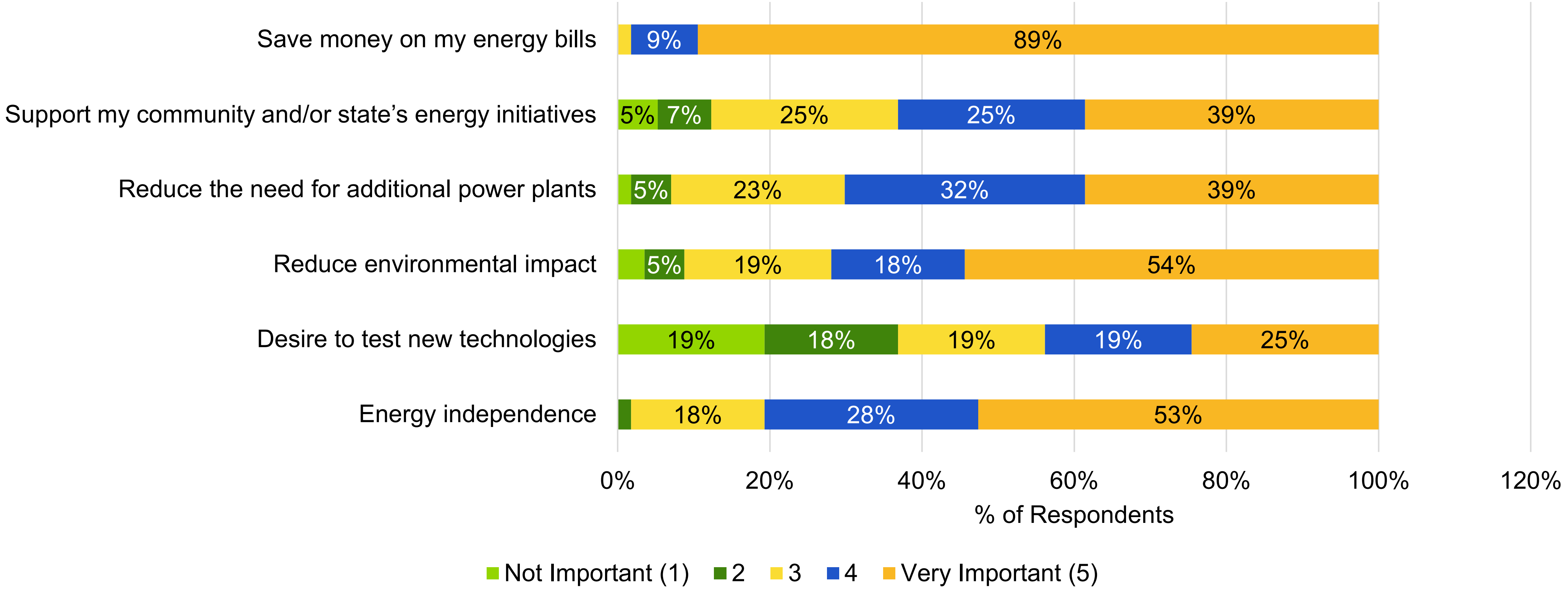
(n=93)



Note: Only asked of respondents who don't already have solar.

Question 12: How important are the following motivations in driving your interest in solar PV?

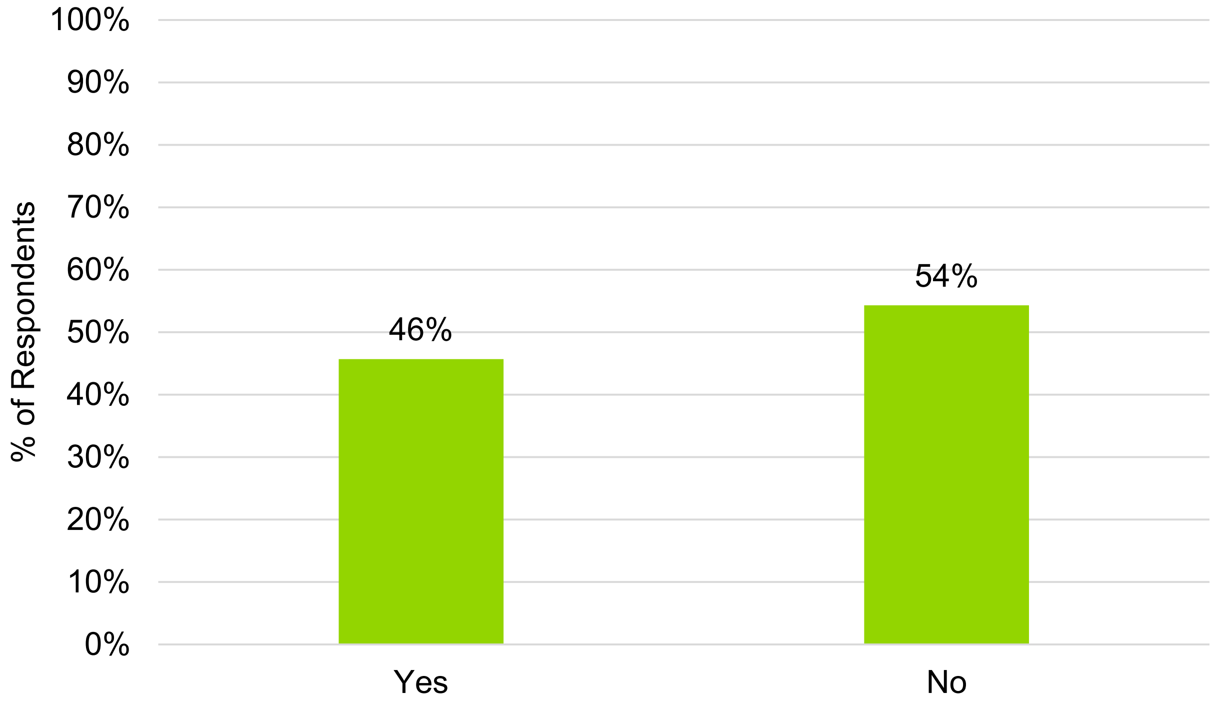
(n=57)



Note: Only asked of respondents who don't already have solar and are interested in solar.

Question 14: Have you previously considered purchasing a battery storage system?

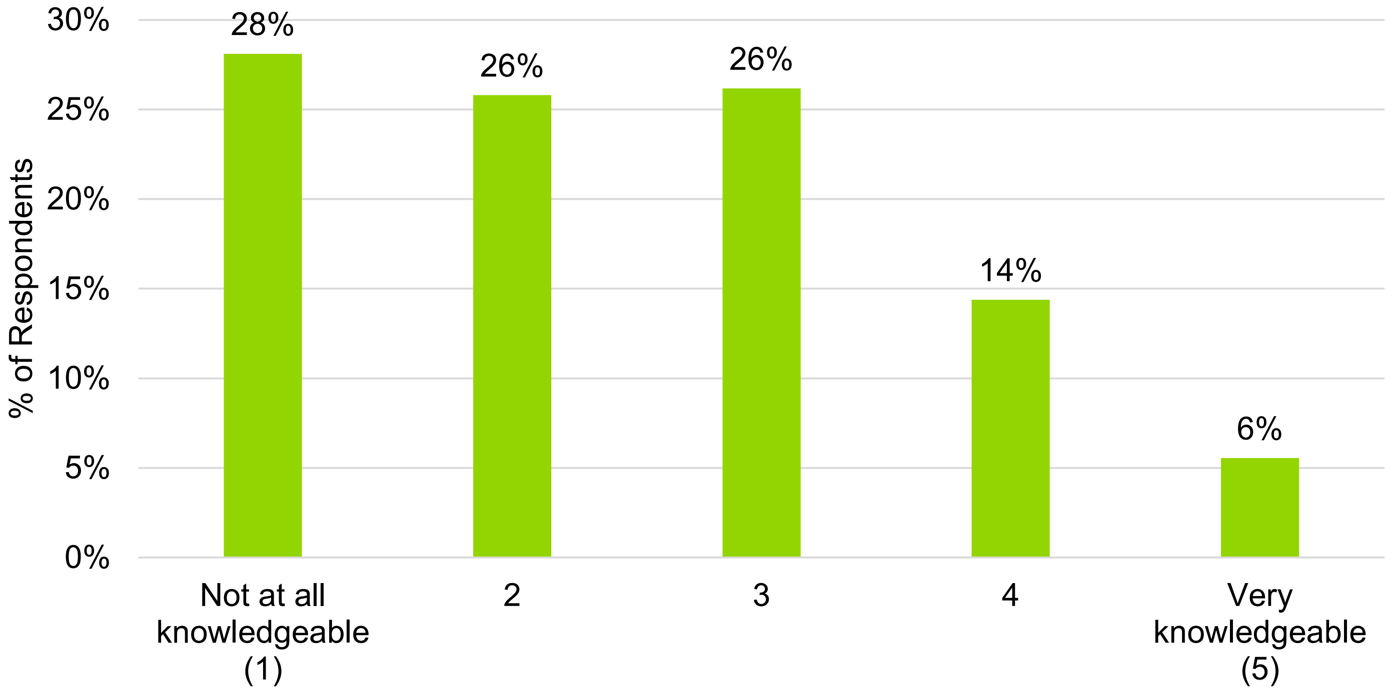
(n=1,505)



Note: Only asked of respondents who have previously considered battery storage.

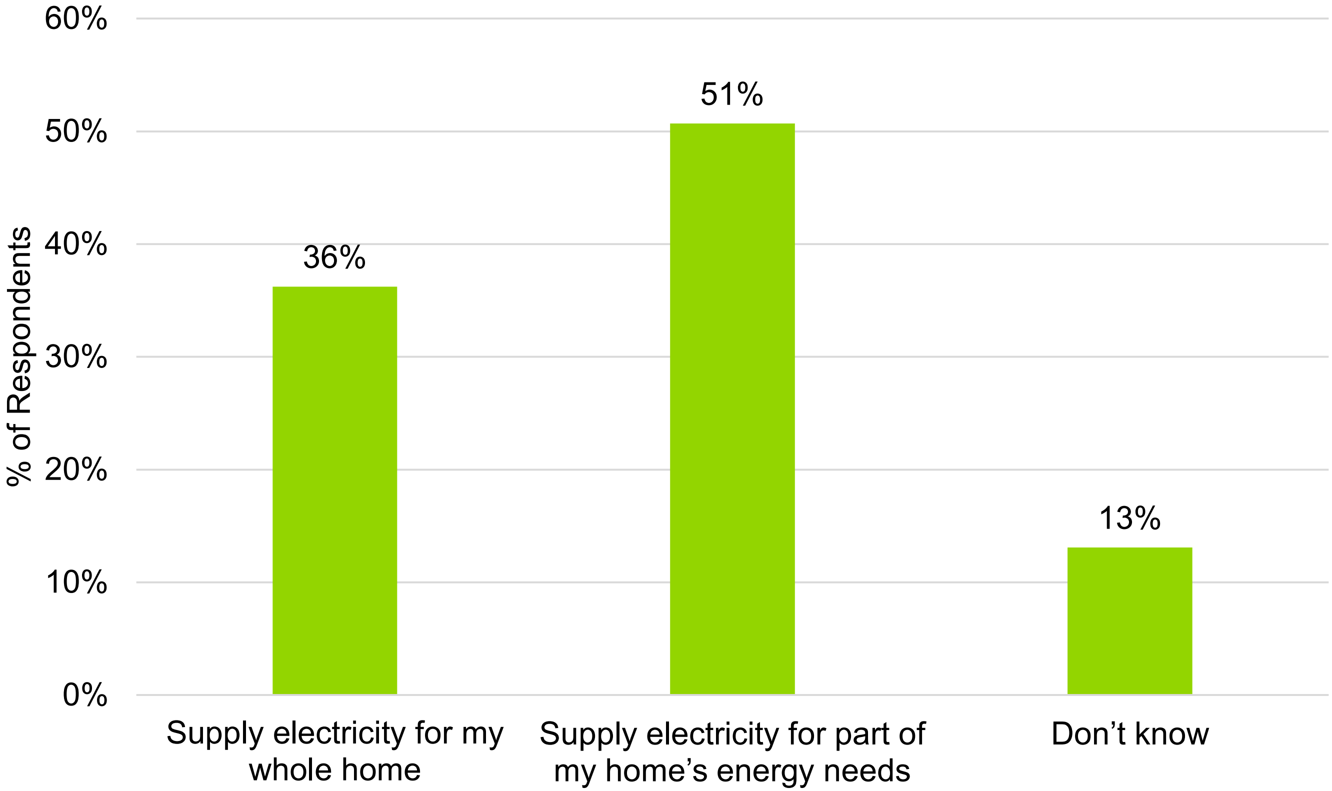
Question 16: How would you rate your knowledge of residential battery storage technology?

(n=1,857)



Question 17: What are your expectations for the amount of power a battery storage system can supply to your home in the event of a power outage or during times when your solar PV system is not producing electricity?

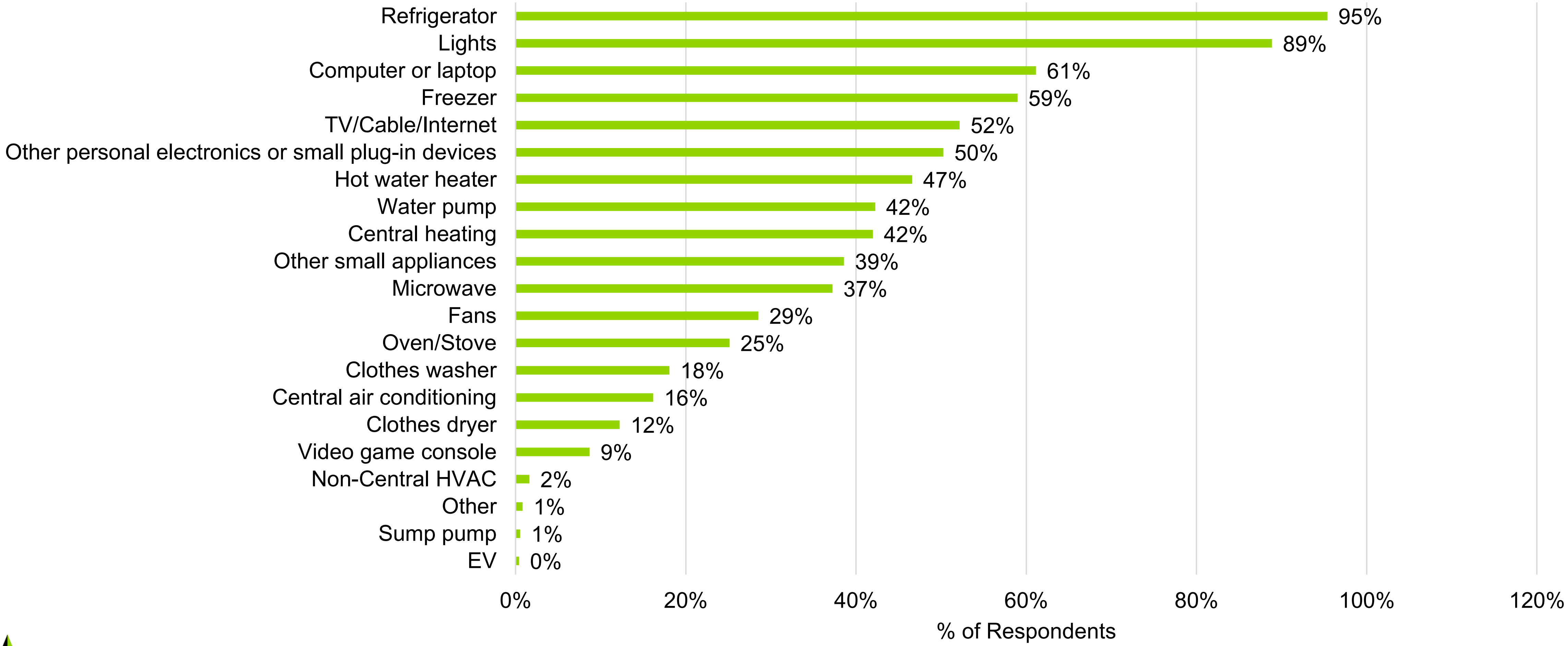
(n=1,452)



Note: Only asked of respondents who don't already have battery storage and have considered battery storage.

Question 18: What are your expectations for the items the electricity stored in the battery storage system would be able to power in your home? Please select all that apply.

(n=736)

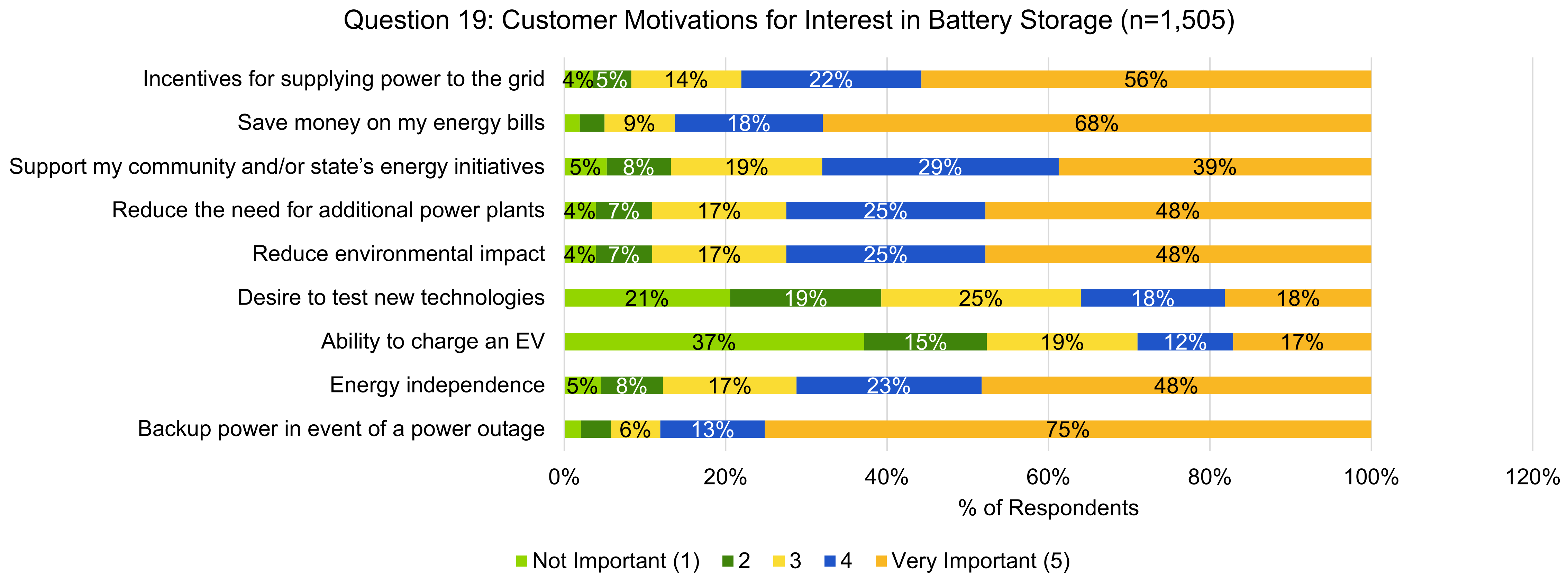


Guidehouse

Note: Only asked of respondents who expect the battery i provide partial power.

Question 19: How valuable are the following aspects of battery storage to you in considering the purchase of a battery storage system?

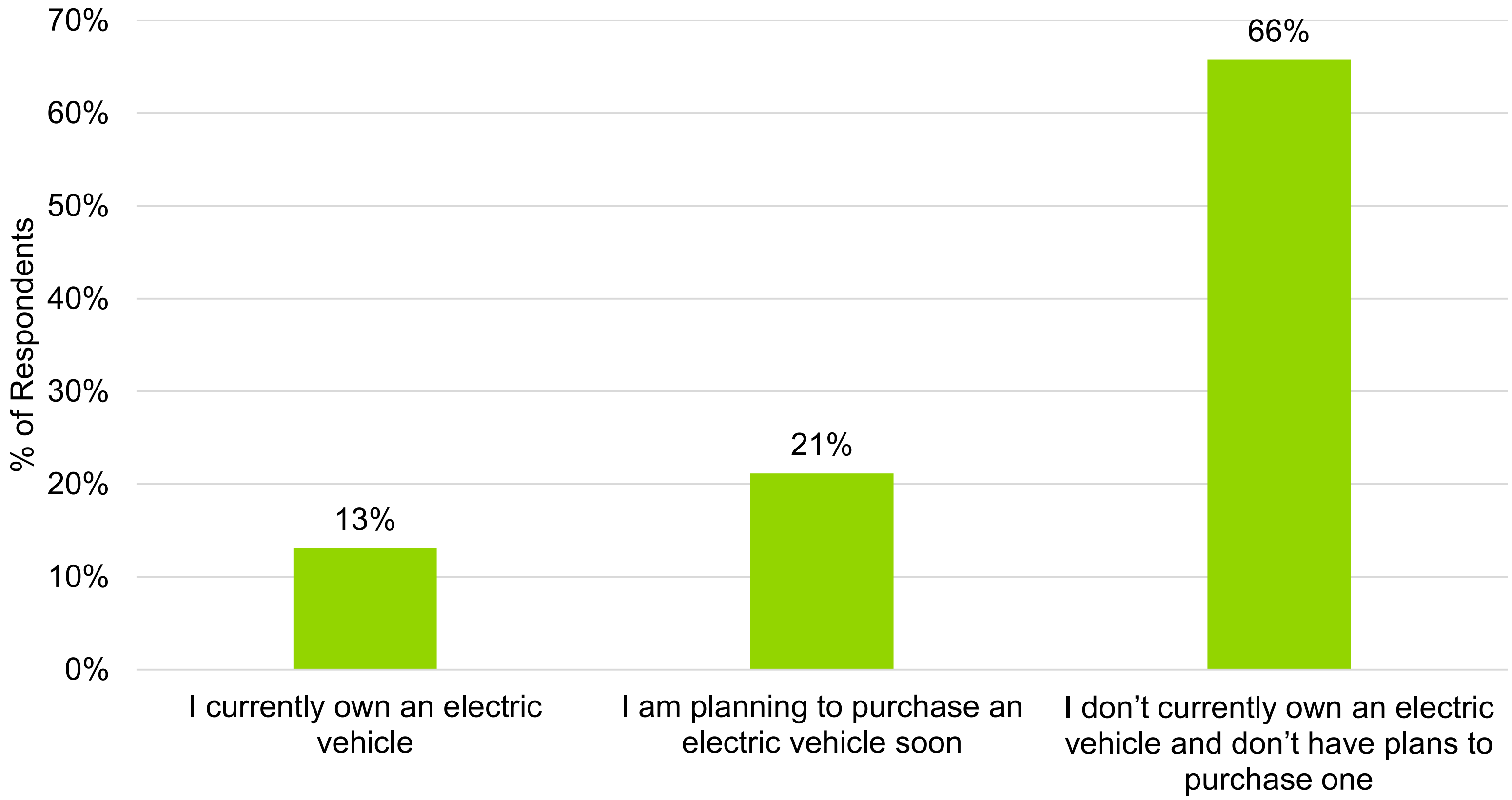
(n=1,505)



Note: Only asked of respondents who don't already have battery storage and have considered it.

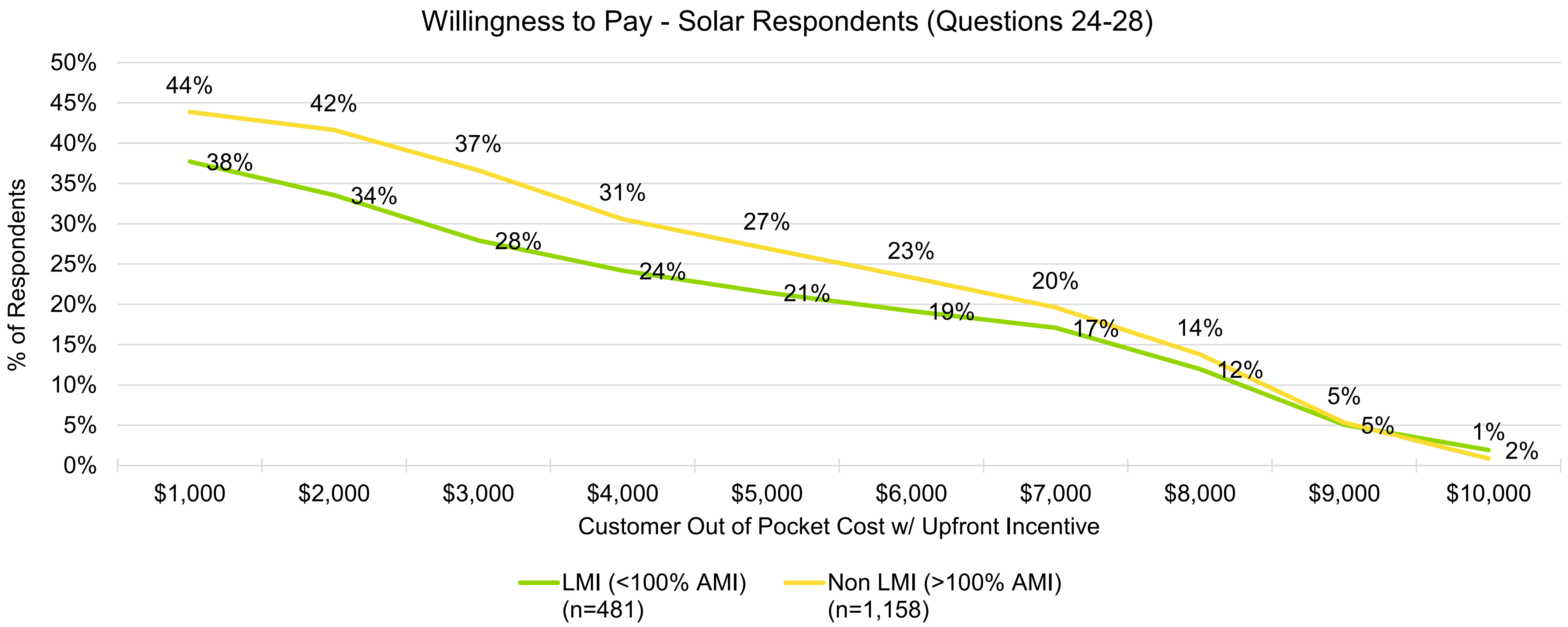
Question 21: Do you currently own an electric vehicle or have plans to purchase one?

(n=1,857)



Willingness to Pay for Battery Storage

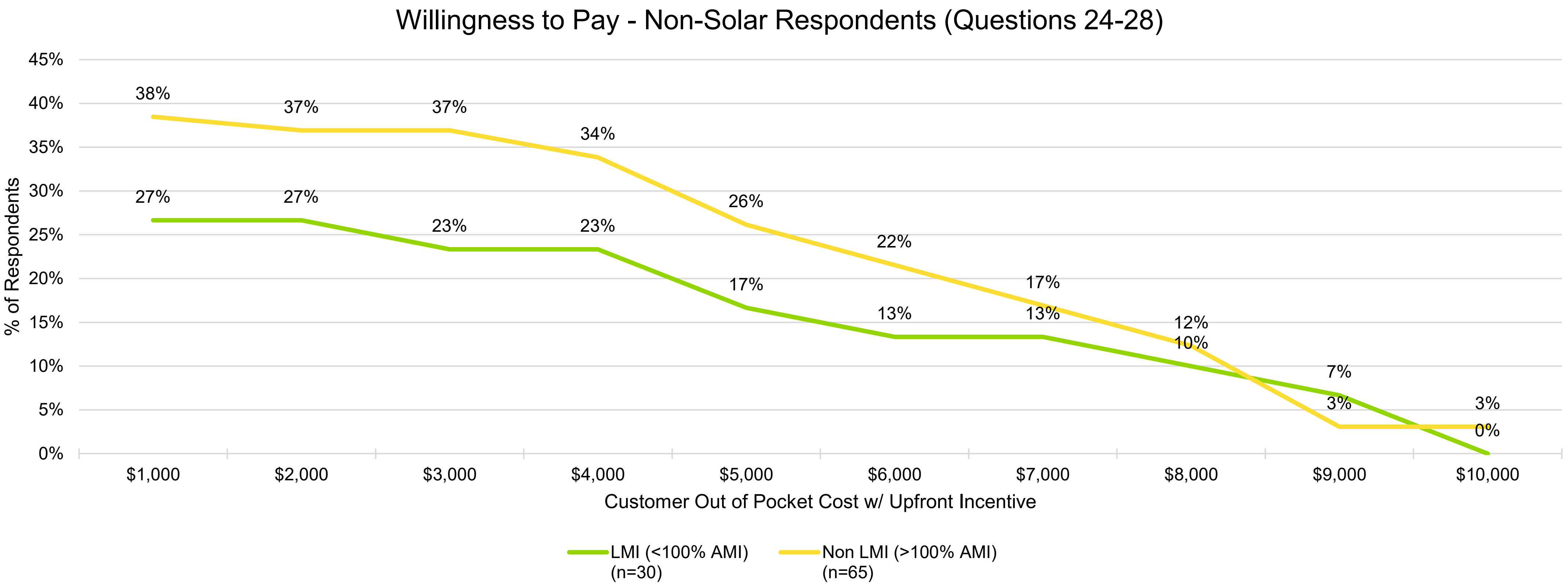
Solar Respondents Only



Note: Respondents who reported needing more information before deciding how much they are willing to pay are counted as not willing to pay at any price. The WTP curves presented assume a customer is willing to pay at any price up to their maximum WTP value.

Willingness to Pay for Battery Storage

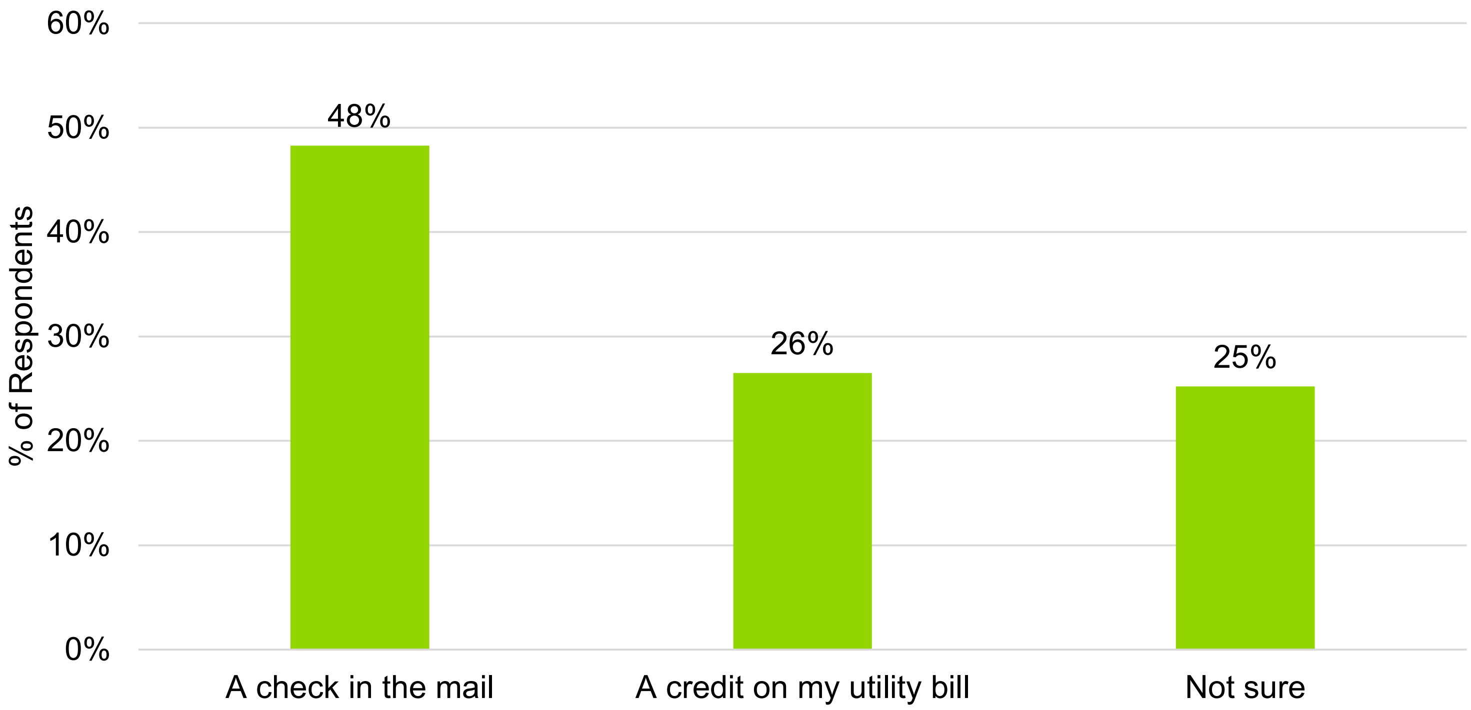
Non-solar Respondents Only



Note: Respondents who reported needing more information before deciding how much they are willing to pay are counted as not willing to pay at any price. The WTP curves presented assume a customer is willing to pay at any price up to their maximum WTP value.

Question 32: How would you prefer to receive the performance-based incentive?

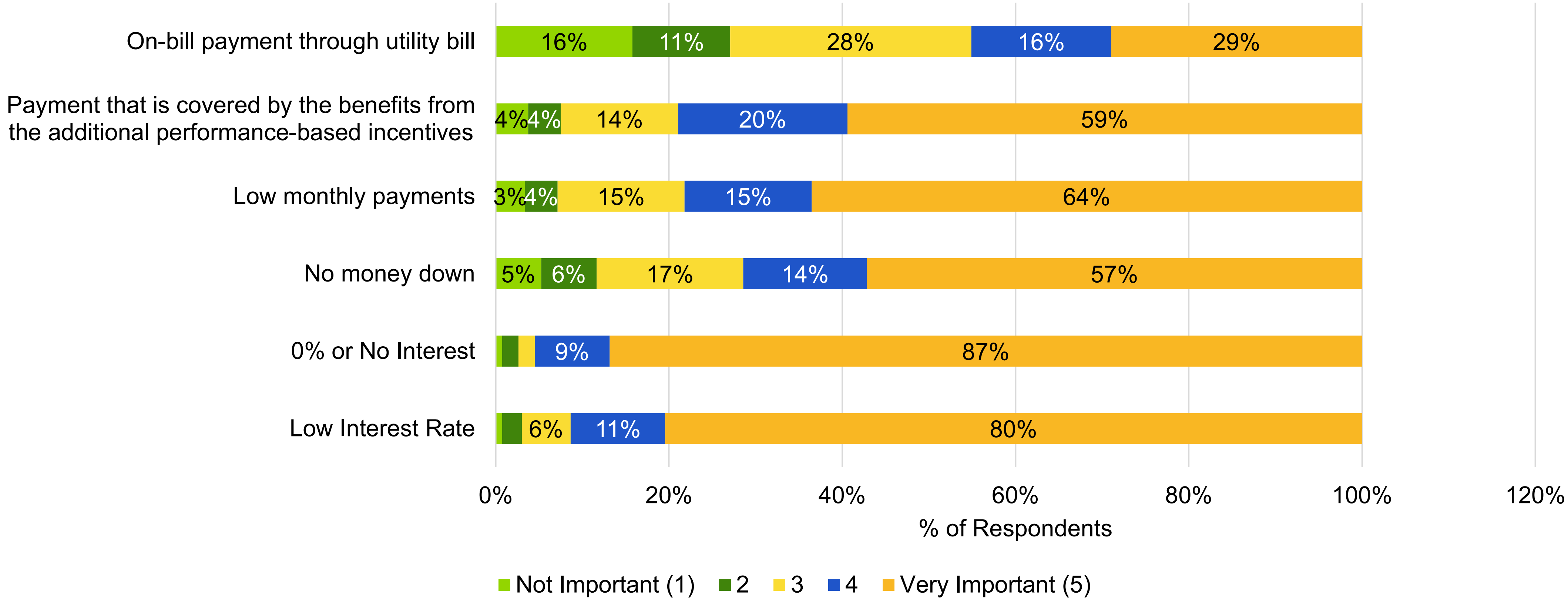
(n=1,551)



Note: Only asked of respondents who are interested in the performance based incentive.

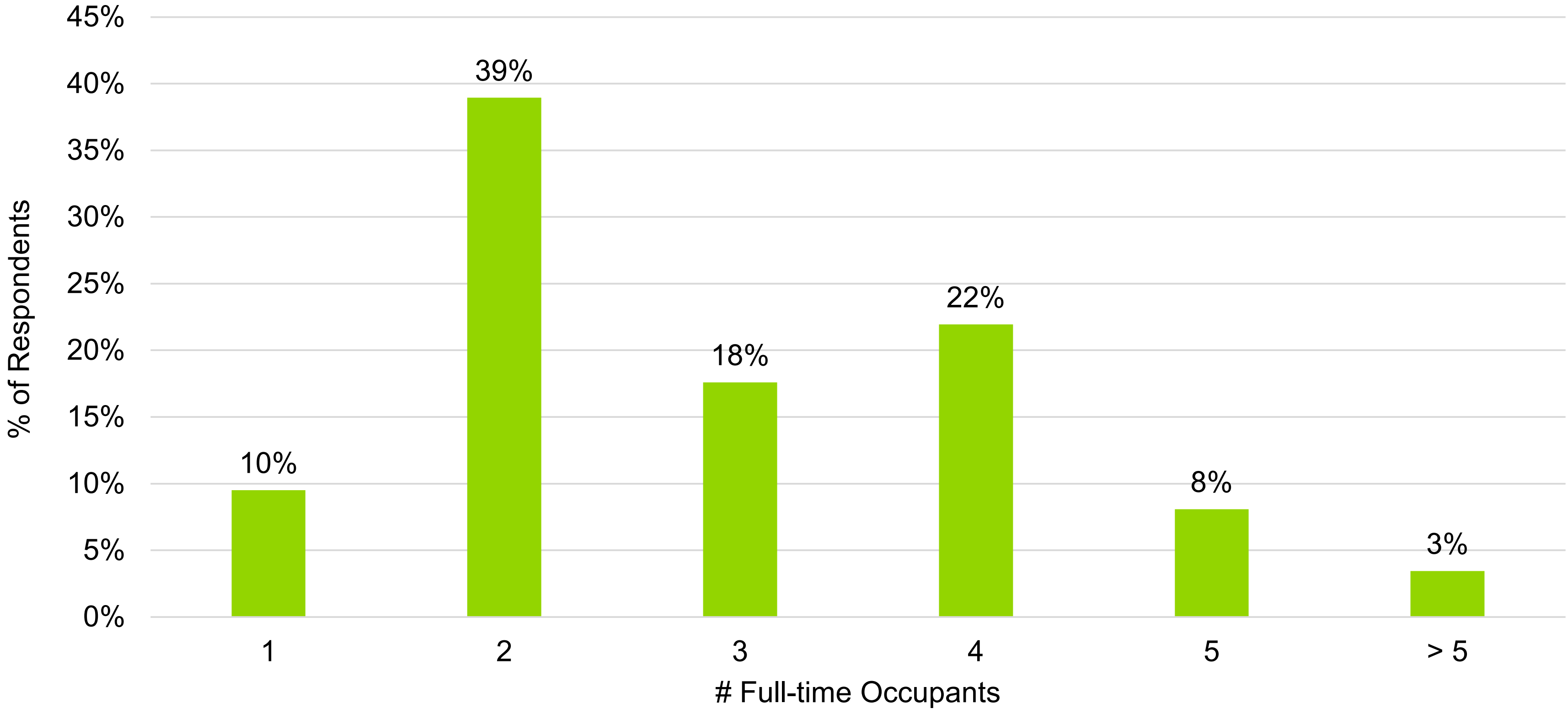
Question 35: How important are the following terms of battery storage financing to you in considering the purchase of a battery storage system?

(n=266)



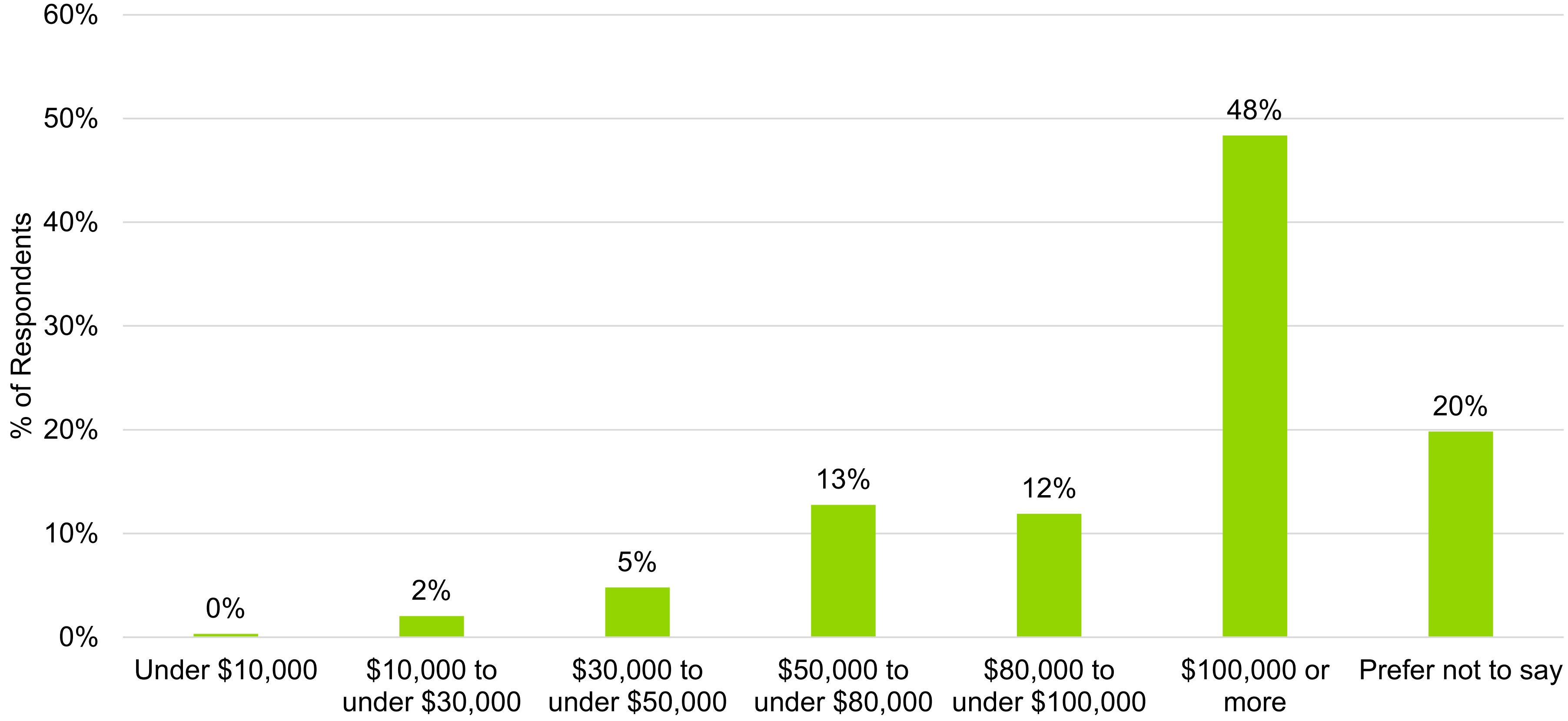
Question 36: Including yourself, how many full-time occupants are there in your household?

(n=1,682)



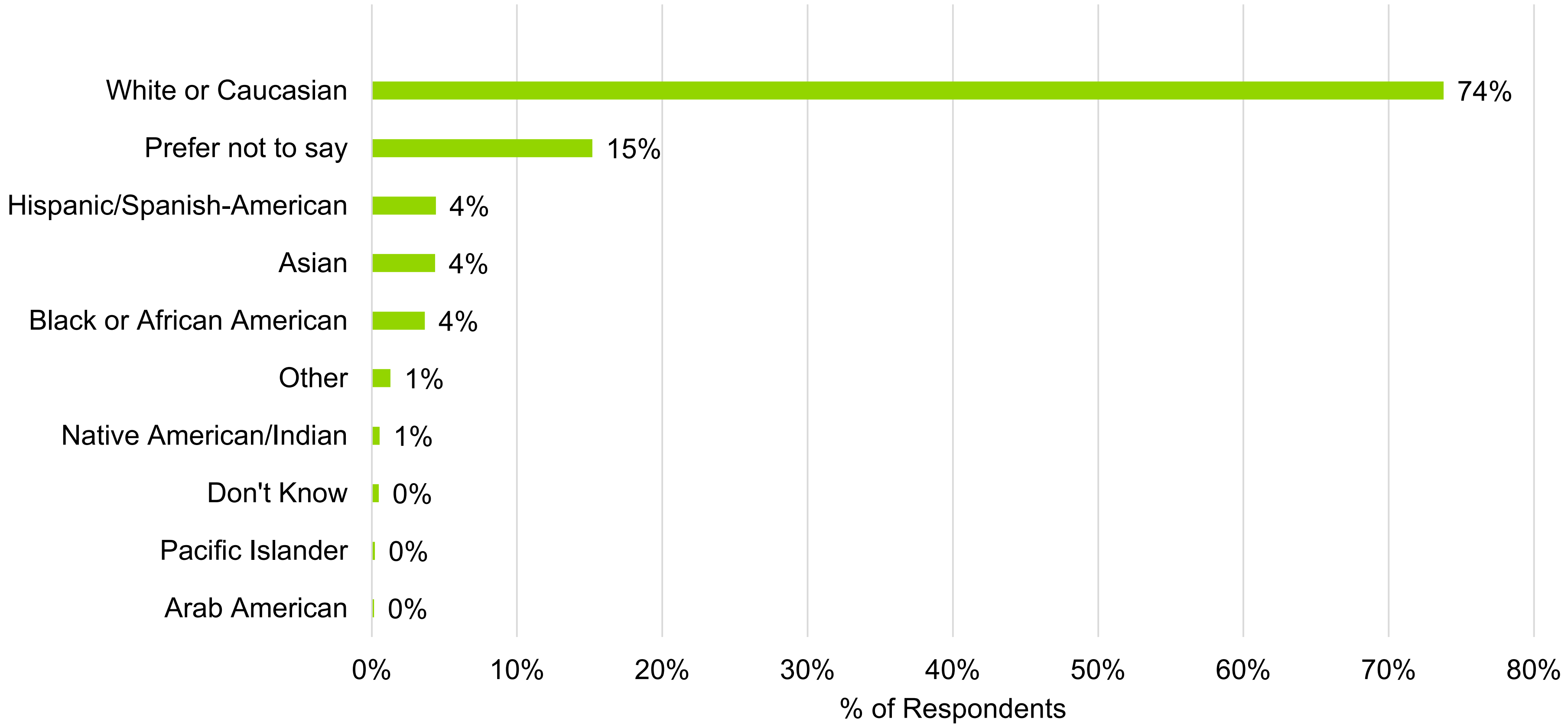
Question 37: Please select the category that best describes your total household income last year before taxes.

(n=1,857)



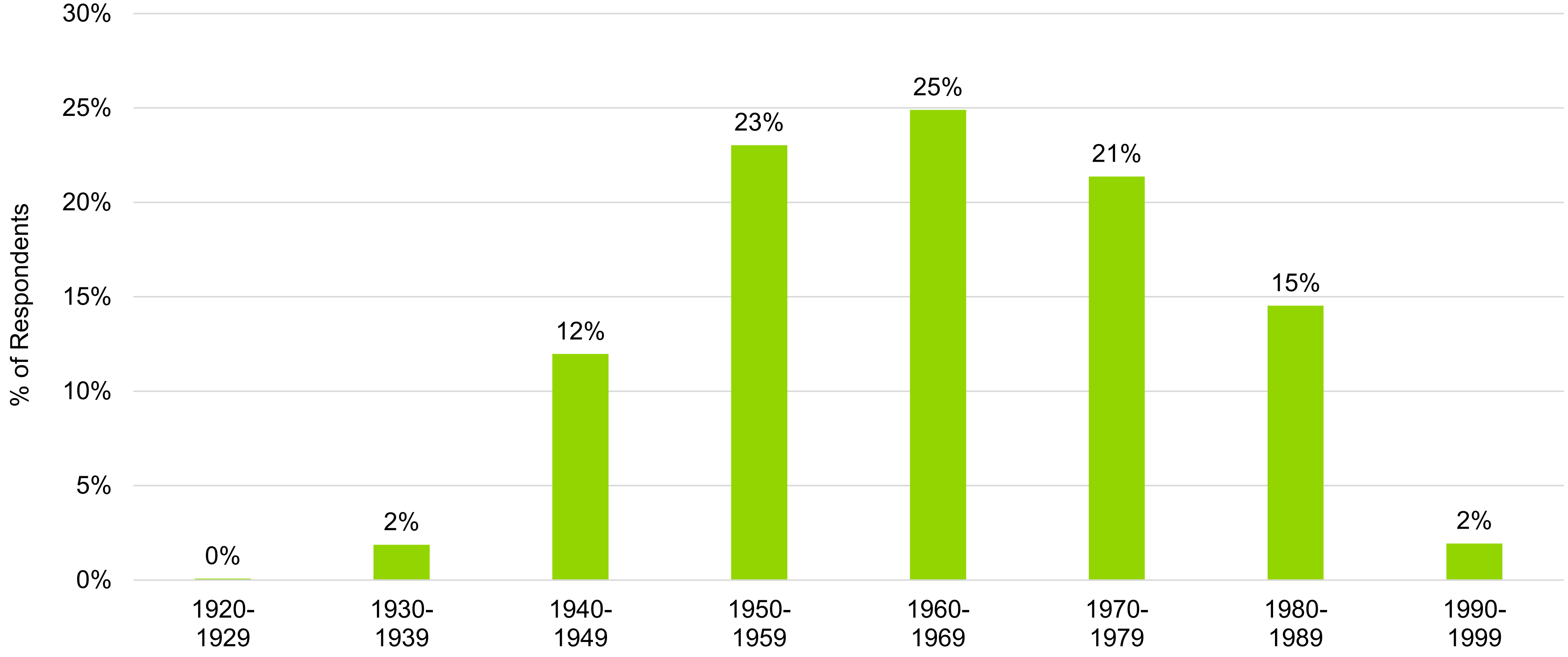
Question 38: Which of the following best describes your ethnicity?

(n=1,857)



Question 39: In what year were you born?

(n=1,441)



Appendix 2 – Residential Solar Survey Instrument

Connecticut Green Bank RE03 RFPD Response
Battery Storage and Solar PV – Residential Customer Survey

Survey Background and Administration

This document includes Guidehouse's proposed sampling methodology and draft survey instrument for Connecticut Green Bank's (Green Bank) response to the Public Utilities Authority's (PURA) request for program design related to energy storage.

The evaluation team will administer this online survey to participants of the Green Bank's Residential Solar Investment Program (RSIP) through which residential customers received funding for the installation of solar photovoltaic (PV) panels at their home as well as Smart-E customers who received financing to upgrade their home's energy performance. The key objective of this survey is to determine customer interest in and willingness to pay for battery storage systems to be installed in connection with their existing solar PV system or as part of a package with a new solar PV system.

Guidehouse plans to field this survey online via an emailed survey link to all participants. The survey is structured to gather data on customer interest in, and willingness to pay for battery storage, in addition to understanding the aspects of battery storage that are most valuable to customers and key customer demographics or segments to target for battery storage. Guidehouse made the following key assumptions in the development of this sample and survey design:

1. The survey will be fielded to RSIP customers who have existing solar PV systems, and Smart-E customers who may or may not have solar PV systems.
2. The program design will require customers to agree to passive dispatch of the storage, in combination with the behind-the-meter solar PV system they installed through the RSIP, to manage peak summer demand, in order to receive the upfront incentive for battery storage through the Green Bank.
3. The program design may also include additional funding mechanisms:
    a. Performance Incentive (i.e., for active demand response or system dispatch through the Electric Distribution Companies (EDC) and/or Third-Party Owners (TPO)
    b. Financing. such as on-bill financing
4. The survey design assumes a baseline installed cost of $11,000 based on previous modelling assumptions made by the Green Bank and Guidehouse.

Table 1 identifies the survey characteristics, Table 2 outlines the research questions.

Table 1. Survey Characteristics

Characteristics	Description
Statement of purpose	Identify customer sentiment towards solar and battery storage and various funding mechanisms, explore willingness to pay to inform incentive levels and program targets, identify target customer demographics or customer segments or targeted locations
Qualified respondent	Previous RSIP and Smart-E residential customers
Sample size	20,200
Target number of completes	3,000
Survey invitations	Will invite a subset of RSIP and Smart-E participants

Estimated survey length	43 questions, 15 minutes
Survey timeline	June 24-July 9, 2020
Survey mode	Online

Table 2. Research Objectives

Research Objective	Survey Questions
Is the customer eligible to complete the survey? Has the customer participated in another Green Bank program, or already have solar panels?	Q1a-Q3
How satisfied are customers with the RSIP program? Did they pursue energy efficiency as a result of the required audit?	Q4-Q5
How interested are customers in battery storage and what would be their motivation to purchase battery storage? How interested are customers in solar and what would be their motivation to purchase a solar system?	Q6-Q21
How important is an upfront incentive and federal tax credit and at what incentive level would customers be willing to purchase a battery storage system?	Q22-Q28a
Would customers be willing to agree to programming and automatic dispatch to support summer peak load reduction and/or allow a utility or third-party to dispatch that system in exchange for upfront and/or performance-based incentives?	Q29-Q32
Are customers interested in financing for battery storage, and if so, what terms are most important to them?	Q33-Q35
What customer demographics and segments are ideal targets for battery storage? How do customer preferences change for general market versus low to moderate income customers?	Q36-Q39
Do customers have any additional feedback?	Q40
What email address should the gift card be sent to?	Q41

Initial Email Invitation

Subject Line: Share Your Feedback about **Battery Storage on Your Home** – First 300 Respondents Receive $10 Dunkin' Gift Card

Dear [CUSTOMER_NAME]:

The Connecticut Green Bank invites you to complete a 15-minute survey to share your opinions on residential solar energy and battery storage, because you previously received either an incentive for your solar project or financing for a clean energy project through the Green Bank. Your valuable feedback will help inform our strategy related to battery storage and the design of a program offering through which customers like you could receive an incentive for a battery storage system.

As a token of our appreciation for completing the survey, a **$10 Dunkin' Gift Card** will be provided to the first 300 customers who complete the survey. The gift card will be emailed to eligible respondents.

If you cannot complete the survey all at one time or you accidentally exit the survey mid-course, you can resume the survey where you left off by clicking on the link from this email.

Please click on the link below to take this short survey:

[SURVEY LINK, IN BUTTON FORM]

Thank you in advance for completing the survey and for supporting the Connecticut Green Bank!

Sincerely,

Bryan Garcia
President & CEO, Connecticut Green Bank
845 Brook Street, Rocky Hill, CT 06067

**Gift cards will be emailed out 2-4 weeks after survey completion.*

Follow the link below to opt out of future emails of this nature from Connecticut Green Bank.

[OPT-OUT LINK]

Reminder Email Invitation

Subject Line: Share Your Feedback about **Battery Storage on Your Home** – First 300 Respondents Receive $10 Dunkin' Gift Card

Dear [CUSTOMER_NAME]:

Recently, the Connecticut Green Bank invited you to complete a 15-minute survey to share your opinions on residential solar energy and battery storage. Your valuable feedback will help inform our strategy related to battery storage and the design of a program offering through which customers like you could receive an incentive for a battery storage system.

As a token of our appreciation for completing the survey, a **$10 Dunkin' Gift Card** will be emailed to the first 300 customers who complete the survey.

Please click on the link below to take this short survey:

[SURVEY LINK, IN BUTTON FORM]

If you cannot complete the survey all at one time or you accidentally exit the survey mid-course, you can resume the survey where you left off by clicking on the link from this email.

Thank you in advance for completing the survey and for supporting the Connecticut Green Bank!

Sincerely,

Bryan Garcia
President & CEO, Connecticut Green Bank
845 Brook Street, Rocky Hill, CT 06067

**Gift cards will be emailed out 2-4 weeks after survey completion.*

Follow the link below to opt out of future emails of this nature from Connecticut Green Bank.

[OPT-OUT LINK]

Landing page

[INCLUDE CONNECTICUT GREEN BANK LOGO IN HEADER THROUGHOUT SURVEY]

CONNECTICUT GREEN BANK

Thank you for taking a few moments to answer these questions about battery storage. This is a **15-minute survey** and all responses will remain anonymous.

[Show if Quota Met, Completed Surveys >300]: We have more than 300 respondents to the survey and the $10 Dunkin' ® Gift Card is no longer available. We still welcome your feedback if you would like to take the time to complete this survey.

Verification

Q1a. Do you have a solar photovoltaic (PV) system installed at your home for generating electricity?

1. Yes
2. No

[If Q1a = Yes >> Q1, else skip to skip logic before Q2]

Q1. Did you participate in the Connecticut Green Bank's Residential Solar Investment Program (RSIP) and receive a financial incentive from the program to install a solar PV system? This incentive would have been obtained by your solar installer on your behalf prior to installation to help reduce the cost of going solar.

1. Yes
2. No
3. Not sure

[If Smart-E = Yes >> Q2, else skip to Q3]

Q2. Did you participate in the Connecticut Green Bank's Smart-E Loan Program to receive financing to help you upgrade your home's energy performance (e.g., solar energy, energy efficiency, other)?

1. Yes
2. No
3. Not sure

Q3. Are you the owner of your home?

1. Yes
2. No

[If Q3=2 >> End survey]

- [End text: Thank you for taking the time to respond to our survey. Based on your responses you do not qualify for the $10 Dunkin' ® Gift Card. To learn more about the Green Bank's programs please visit https://ctgreenbank.com/.]

RSIP Experience

[If RSIP Customer ask about RSIP Experience Q1=1>> Q4 else skip to Interest and Motivations]

Q4. Please describe your satisfaction with your participation in the RSIP, the Green Bank's solar incentive program.

1. Extremely satisfied
2. Satisfied
3. Somewhat satisfied
4. Neither satisfied or unsatisfied
5. Somewhat unsatisfied
6. Unsatisfied
7. Extremely unsatisfied

Q5. As a requirement of your participation in the RSIP program an energy audit was conducted. What upgrades have you made to your home as a result of the audit, if any? Please select all that apply.

1. Upgraded to a heat pump hot water heater
2. Upgraded to a higher efficiency HVAC system
3. Installed air source heat pump
4. Installed ground source heat pump
5. Installed insulation
6. Installed LED lighting
7. Installed efficient water fixtures
8. Air and duct sealing
9. Installed weather-stripping
10. Other: [Text Box]
11. Have not made any energy efficiency upgrades as a result of the audit

Interest and Motivations

[If customer has solar and is a Smart-E customer, Q1a = Yes and Smart-E = 'Yes' >> Q6, else skip to Q7]

Q6. Do you own or lease your solar PV system?

1. I own the system
2. I lease the system
3. I purchase the energy produced from the solar PV system from a third-party owner (this is called a "power purchase agreement or PPA")
4. Not sure

[If customer already has solar Q1a = 1 >> Q7, else skip to Q14]

A battery storage system can be installed in connection with a solar PV system. Electricity generated by the solar panels is stored in the battery for later use, such as after the sun goes down, during times of high demand on the electric grid, or during a power outage.

Q7. How interested are you in installing a battery storage system that would store energy generated by your solar PV system?

1. Not interested
2. Moderately interested
3. Very interested
4. I already have battery storage

5. Don't know, I have never considered battery storage

[If customer already has battery storage Q7=4 >> Q8, else skip to Q11]

Q8.Is the battery storage you already have installed connected to or being charged from your solar PV panels?

1. Yes
2. No
3. Not sure

[If customer already has battery storage combined with solar PV Q8=1 >> Q9, else skip to Q11]

Q9.What type of battery storage do you currently have for your solar PV panels?

1. Tesla Powerwall
2. LG Chem RESU
3. Sonnen eco
4. Enphase Encharge
5. Electriq Powerpod
6. Generac PWRcell
7. EverVolt
8. SunPower Equinox
9. SunRun Brightbox
10. SolarEdge
11. Other: [Text Box]
12. Don't know

Q10. Do you participate in a demand response program with your utility or third party owner using this battery storage system through which you provide power to the grid during times of high electricity demand?

1. Yes
2. No
3. Don't know

[If customer doesn't already have solar Q1a = 2 >> Q11, else skip to Q13]

Q11. How interested are you in installing a solar PV system at your home?

1. Not interested
2. Moderately interested
3. Very interested
4. Don't know, I have never considered solar panels

[If customer doesn't already have solar and is interested Q11 = 2 or 3 >> Q12, else skip to Q13]

Q12. How important are the following motivations in driving your interest in solar PV? Please rank on a scale of 1 to 5 with 1 being "not at all important" and 5 being "very important".

1. Energy independence and ability to self-power my home
2. Desire to test new technologies
3. Reduce my environmental impact by powering my home with cleaner electricity
4. Reduce the need for additional power plants
5. Support my community and/or state's energy initiatives

6. Save money on my energy bills

[If customer doesn’t already have solar and is interested in solar panels Q11 = 2 or 3 >> Q13, else skip to Q16]

Q13. How interested are you in installing a battery storage system that would store energy generated by solar PV panels? *Electricity generated by the solar panels is stored in the battery for later use, such as after the sun goes down, during times of peak demand on the electric grid, or during a power outage.*

1. Not interested
2. Moderately interested
3. Very interested
4. Don’t know, I have never considered battery storage

[If customer doesn’t already have battery storage and has considered battery storage Q7 != 4 or 5, or Q13 !=4 >> Q14, else skip to Q21]

Q14. Have you previously considered purchasing a battery storage system?

1. Yes
2. No

[If customer previously considered purchasing a battery storage system Q14 = 1 >> Q15, else skip to Q16]

Q15. Why haven’t you purchased a battery storage system? Please select all that apply.

1. Too expensive
2. Waiting to see if incentives will be offered to reduce cost
3. Unclear about the technology and requirements
4. Want to wait until technology is more widely adopted
5. Uncertain about how to find a good contractor
6. Process was too complicated
7. Did not think benefits would be worth the cost
8. Haven’t had enough time to research and make informed decision
9. Purchased a generator instead
10. No particular reason, still considering purchasing a system [MUTUALLY EXCLUSIVE]
11. [If customer doesn’t already have solar Q6 != 1] I don’t currently have solar panels
12. Other: [TEXT BOX]

Q16. How would you rate your knowledge of residential battery storage technology?

1. Not at all knowledgeable
2.
3.
4.
5. Very knowledgeable

[If customer already has solar, does not already have a battery system or has never considered battery storage Q1a = 1 or Q7 != 4 or 5 >>Q17, else skip to Upfront Incentives]

Q17. What are your expectations for the amount of power a battery storage system can supply to your home in the event of a power outage or during times when your solar PV system is not producing electricity (e.g., on a cloudy day or overnight)?
1. Supply electricity for my **whole** home
2. Supply electricity for **part** of my home's energy needs
3. Don't know

[If customer expects the battery to provide partial power Q17 = 2 >>Q18, else skip to Q19]

Q18. What are your expectations for the items the electricity stored in the battery storage system would be able to power in your home? Please select all that apply.
1. Lights
2. Central air conditioning
3. Central heating
4. Hot water heater
5. Refrigerator
6. Freezer
7. Oven
8. Clothes washer
9. Clothes dryer
10. Fans
11. Computer or laptop
12. TV
13. Video game console
14. Microwave
15. Water pump
16. Other small appliances
17. Other personal electronics or small plug-in devices
18. Other: [TEXT BOX]

[f customer doesn't already have battery storage and has considered it Q7 = 1 OR 2 OR 3, OR Q13 = 1 OR 2 OR 3]

Q19. How valuable are the following aspects of battery storage to you in considering the purchase of a battery storage system? Please rank on a scale of 1 to 5 with 1 being "not at all valuable" and 5 being "very valuable".
1. Ability to have backup power in the event of a power outage
2. Energy independence and ability to self-power my home
3. Ability to charge an electric vehicle at night using solar power stored in the battery
4. Desire to test new technologies and create a smart home
5. Reduce my environmental impact by powering my home with cleaner electricity
6. Reduce the need for additional power plants
7. Support my community and/or state's energy initiatives
8. Save money on my energy bills
9. Receiving additional incentives from utilities for supplying power from the battery storage system to the grid

[If customer already has battery storage or is interested in battery storage Q7 = 2 or 3 or 4 or Q13 = 2 or 3 >> Q20, else skip to Q21]

Q20. What factor would you say is the **primary** motivation for your interest in installing a battery storage system?

1. Ability to have backup power in the event of a power outage
2. Energy independence and ability to self-power my home
3. Ability to charge an electric vehicle at night using solar power stored in the battery
4. Desire to test new technologies and create a smart home
5. Reduce my environmental impact by powering my home with cleaner electricity
6. Reduce the need for additional power plants
7. Support my community and/or state's energy initiatives
8. Save money on my energy bills
9. Receiving additional incentives from utilities for supplying power from the battery storage system to the grid

Q21. Do you currently own an electric vehicle or have plans to purchase one?
1. I currently own an electric vehicle
2. I am planning to purchase an electric vehicle soon
3. I don't currently own an electric vehicle and don't have plans to purchase one

Upfront Incentives

[If customer doesn't already have battery storage Q7 != 4 >>Q22, else skip to Demographics and Segmentation]

The Connecticut Green Bank is seeking input from customers regarding battery storage incentives. We are exploring a program offering through which residential customers could receive an upfront incentive (i.e., rebate or cost reduction) for the installation of a battery storage system connected to their solar PV panels.

To be eligible to receive the incentive, customers would be required to allow the battery storage system to be automatically programmed to meet their homes' on-site energy needs during times of peak summer demand. Participants would still receive emergency back-up power through the battery system (e.g., at least 20% of electricity stored at all times, plus up to 100% during times of grid outage or looming weather-related impacts).

Q22. Are you aware that there may be a federal tax credit for battery storage if it is installed in connection with and is charged by a solar PV system?
1. Yes
2. No

[If RSIP customer, RSIP = "Yes" >>Q23, else skip to Q24]

Q23. How interested are you in receiving an upfront incentive for battery storage from the Green Bank similar to the incentive you received through the RSIP program for your solar PV system?
1. Not interested
2. Moderately interested
3. Very interested

[If customer interested in upfront incentive Q23 != 1 >> Q24, else skip to Demographics and Segmentation]

For the following questions, the prices presented are examples to understand what you would be willing to pay for battery storage with an upfront incentive and do not yet include the potential federal tax credit (which would reduce the price further).

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Q24. If you were offered an incentive of $[X] on a $11,000 battery storage system, making your purchase price $[11,000 – X], would you be interested in purchasing a system? [X= randomly selected value between $3,000, $4,000, $5,000 and $6,000]

1. I *would* be interested in purchasing at that cost
2. I *would not* be interested in purchasing at that cost
3. Not sure [Treated as No]

[If customer was interested in first proposed incentive level, test at lower level. Q24=1 >> Q25]

Q25. What if the incentive for the battery storage system was $[X - 1,000] on an $11,000 battery storage system, making your purchase price $[12,000 – X], would you still be interested in purchasing a system?

1. I *would still* be interested in purchasing at that cost
2. I *would not* be interested in purchasing at that cost
3. Not sure [Treated as No]

[If customer was interested in second, lower proposed incentive level, test at even lower level Q25=1, “Yes” >> Q26]

Q26. What if the incentive for the battery storage system was $[X – 2,000] on an $11,000 battery storage system, making your purchase price $[13,000 – X], would you still be interested in purchasing a system?

1. I *would still* be interested in purchasing at that cost
2. I *would not* be interested in purchasing at that cost
3. Not sure [Treated as No]

[If customer was not interested in first proposed incentive level, test at higher incentive level Q24=2, “No” or 3, “Not Sure” >>Q27]

Q27. What if the incentive for the battery storage system was $[X + 1,000] on an $11,000 battery storage system, making your purchase price $[10,000 – X], would you be interested in purchasing a system?

1. Yes
2. I would be interested in paying something, but not that much
3. I would not be interested in paying anything for battery storage
4. I would need more information about the technology before deciding at what price I would be interested in purchasing a system

[If customer interested in paying something, but not that much Q27 = 2 >>Q228, else skip to Additional Financing Mechanisms]

Q28. What amount would you be willing to pay for a battery storage system?

1. Less than $1,000
2. $1,000-2,000
3. $2,000-3,000
4. $3,000-4,000
5. [DO NOT SHOW IF X=6,000] $4,000-5,000
6. [DO NOT SHOW IF X=6,000 or 5,000] $5,000-6,000
7. [DO NOT SHOW IF X=6,000, 5,000, or 4,000] $6,000-7,000
8. I would not be interested in paying anything for battery storage
9. Don’t know

Q28a. The federal tax credit for purchase of battery storage with solar is scheduled to expire in December 2021. Customers who are eligible receive a 26% tax credit for systems installed in 2020, and 22% for systems installed in 2021. How influential is the tax credit on the timing of your decision to purchase a battery system?

1. I would purchase a battery system by the end of 2021 to ensure I could receive the tax credit
2. The (un)availability of the tax credit would not influence my decision on if/when to purchase a battery storage system
3. I'm not sure

Additional Financing Mechanisms

In addition to the upfront incentive, an additional performance-based incentive may be available. This performance-based incentive would require you to allow the utility or a qualified third-party to discharge some of the electricity in your battery storage system in times of high demand when the electric grid is stretched to capacity. Participation in these programs still allow you to retain a percentage of the energy in your battery for backup power needs in the event of a power outage.

In return for use of your system, you would receive compensation based on the system performance (i.e., the amount of electricity provided by your battery) when the utility or a third-party owner discharges your system. Your payment would be based on your contribution during peak events (and you could opt out of specific events). We estimate customers could earn as much as $700 per year through this additional performance-based incentive.

Q29. In addition to receiving an upfront incentive for the installation of a battery storage system, how interested would you be in receiving an additional performance-based incentive in exchange for allowing your battery to be discharged during peak times?

1. Not interested
2. Moderately interested
3. Very interested

Q30. How interested would you be in allowing the utility or a third-party to dispatch 100% of the energy in your battery in return for a performance-based incentive as long as the dispatch did not occur during a potential power outage or interfere with your ability to use your battery when needed for backup power?

1. Not interested
2. Moderately interested
3. Very interested

Q31. How much more likely would you be to purchase battery storage if this additional, performance-based incentive were available?

1. No more likely to buy a battery storage system
2. Not sure, may encourage me to buy a battery storage system
3. Much more likely to buy a battery storage system

[If customer interested in performance-based incentive Q29 = 2 or 3 >>Q32, else skip to Q33]

Q32. How would you prefer to receive the performance-based incentive?

1. A check in the mail
2. A credit on my utility bill
3. Not sure

Q32a. If you had to choose between receiving only an upfront incentive versus only a performance-based incentive of equivalent value, which would you prefer?

1. Strongly prefer upfront incentive
2. Moderately prefer upfront incentive
3. No preference
4. Moderately prefer performance-based incentive
5. Strongly prefer performance-based incentive

Connecticut Green Bank is also considering financing options for battery storage systems. Financing would eliminate or lower the upfront "out of pocket" cost of the battery storage system. Instead, you would repay the cost of the battery through a charge on your monthly utility bill or through another third-party payment.

Q33. If you were to purchase and install a battery storage system, would you prefer to own the battery or lease it from a third-party (the third-party would own and maintain the battery)?

1. I would prefer to own the battery
2. I would prefer to lease the battery
3. Not sure

[If customer would prefer to own Q33 = 1 >> Q34, else skip to Q36]

Q34. If you were to install a battery system that you owned, would you prefer to pay in cash or finance the purchase?

1. Pay in cash
2. Finance
3. Not sure

[If customer would prefer to finance Q34 = 2 >> Q36, else skip to Demographics and Segmentation]

Q35. How important are the following terms of battery storage financing to you in considering the purchase of a battery storage system? Please rank on a scale of 1 to 5 with 1 being "not important" and 5 being "very important".

1. Low interest rate
2. 0% interest rate or no interest
3. No money down
4. Low monthly payments
5. Payment that is covered by the benefits from the additional performance-based incentives
6. On-bill payment through utility bill

Demographics and Segmentation

Q36. Including yourself, how many full-time occupants are there in your household? (Optional) [NUMERIC OPEN END 1-97; ALLOW BLANK AS REFUSED]

Q37. Please select the category that best describes your total household income last year before taxes. Remember, this information is used for statistical purposes only. (Optional)

1. Under $10,000
2. $10,000 to under $30,000
3. $30,000 to under $50,000
4. $50,000 to under $80,000
5. $80,000 to under $100,000
6. $100,000 or more
7. Prefer not to say

Q38. Which of the following best describes your ethnicity? Please select all that apply. (Optional) [MULTIPLE RESPONSE, ALLOW UP TO 5 RESPONSES]

1. White or Caucasian
2. Black or African American
3. Arab American
4. Hispanic/Spanish-American
5. Asian
6. Native American/Indian
7. Pacific Islander
8. Other, Specify: [TEXT BOX]
9. Don't Know
10. Prefer not to say

Q39. In what year were you born? (Optional) [NUMERIC OPEN END 1900-2015; ALLOW BLANK AS REFUSED]

Survey Close

Q40. Do you have any questions or concerns about battery storage that weren't covered in this survey that you want to share?
[Text Box]

[If Quota not met, Completed Surveys < 300 >> Q41, else show closing text 2]

Q41. Please confirm your email address in order to receive your $10 Dunkin' ® gift card if you are among the first 300 respondents.

1. [Text Box]
2. None

[Closing text 1: Thank you for taking the time to complete this survey]

Appendix 3 – Solar Battles the New England Heat Wave (Fact Sheet)

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Appendix 3

Solar Battles the New England Heatwave

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

Rising Temperatures Lead to Rising Load and Increased Public Health Risks


Hartford Courant

July 31, 2019

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

By Christine Dempsey and Zach Murdock

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

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

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

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

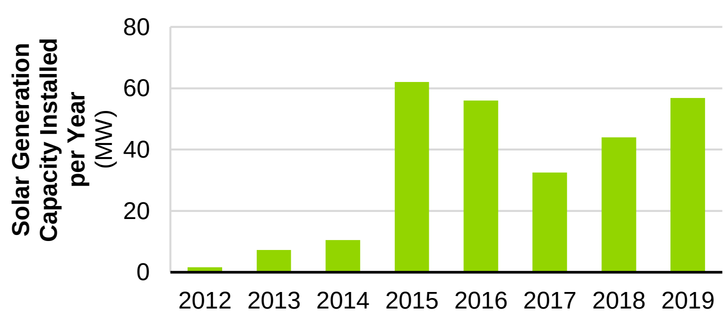
"Tuesday was so hot and humid, authorities warned people about two problems: The excessive heat and bad air." [1]

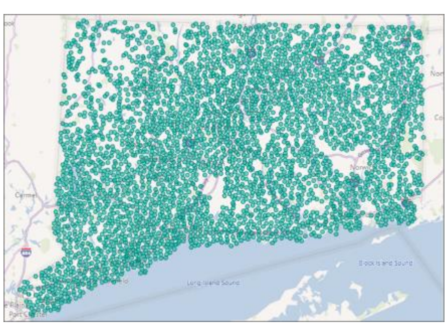
Sunny, humid days lead to higher temperatures and consequently higher air conditioning usage. This stresses the electric grid, resulting in increased power coming from coal plants. Pollutants emitted by such plants include nitrogen oxides (NOx) and volatile organic compounds, which react in sunlight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

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

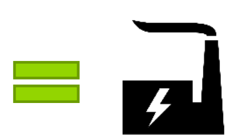
Connecticut's Distributed Solar Power Plant

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

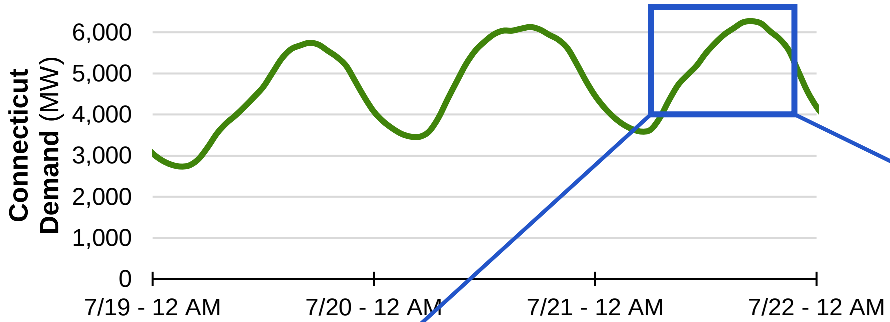




This is over half the size of the coal-fired plant at Bridgeport Harbor Generating Station in Bridgeport, CT, one of three coal power plants operating in New England on July 21st.[5]

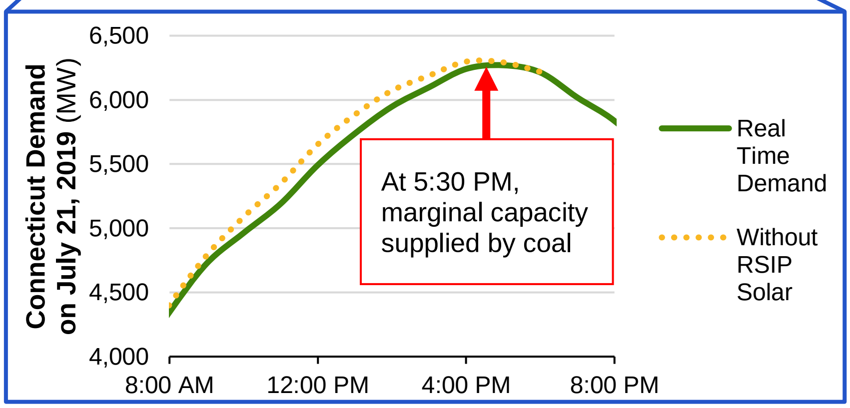


Peak Load Reduction Benefit to Ratepayers from Homes that Installed Solar PV



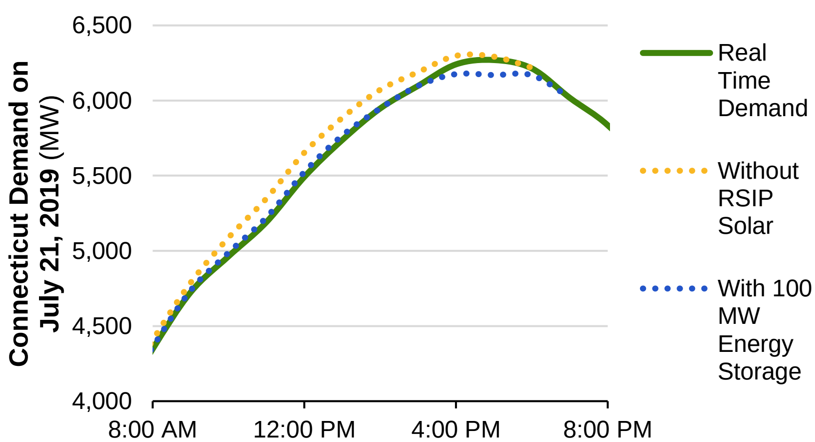
This graph shows the actual hourly electricity demand in Connecticut during the July weekend heat wave.[6]

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



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

Additional Benefit of Combining Residential Solar with Energy Storage



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

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

Sources:

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

Appendix 4 – Solar Battles the New England Heating Wave (Analysis)

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Solar Battles the New England Heatwave

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

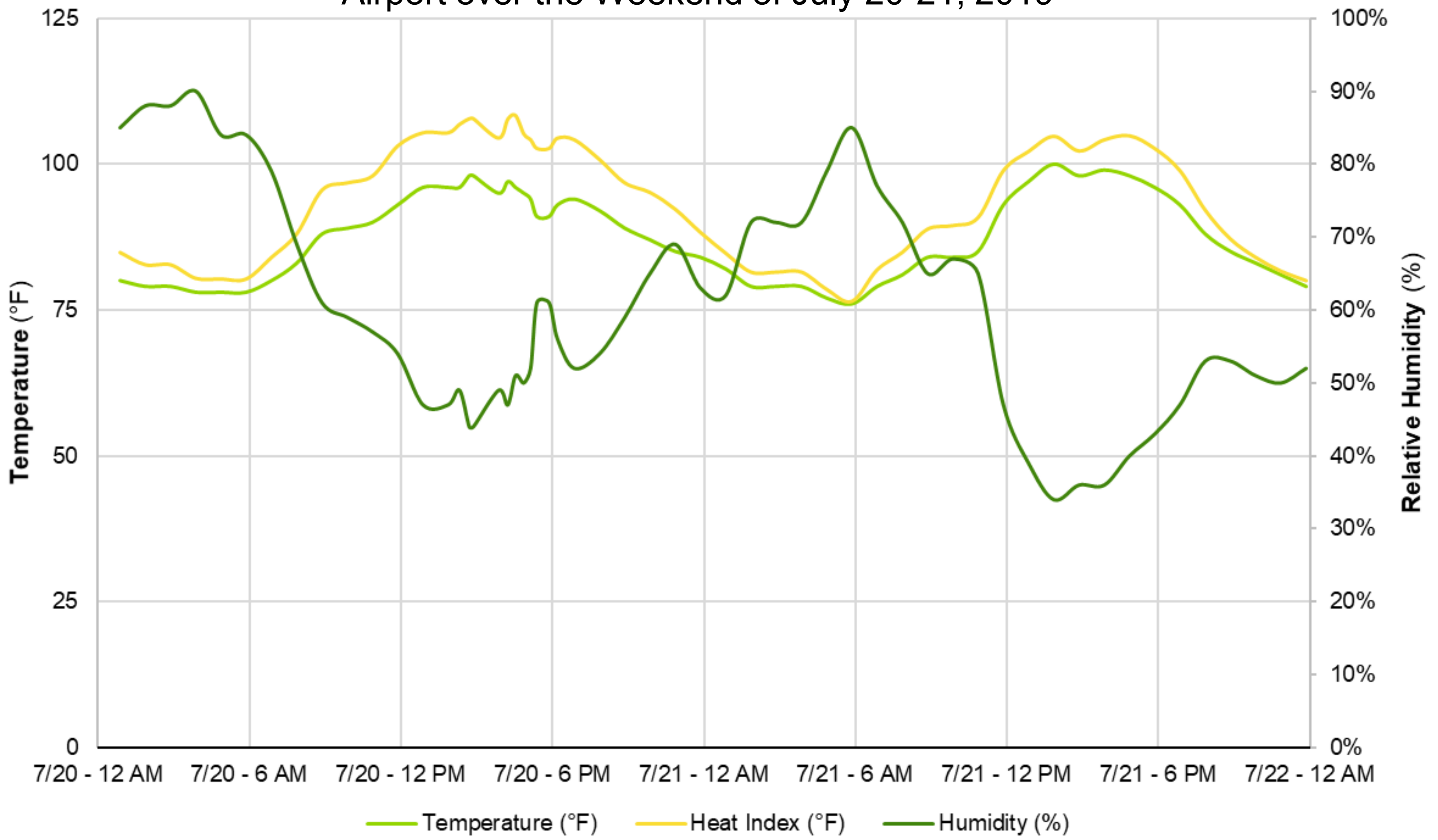
Appendix 4
June 12, 2020

2019 Summer Heatwave

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

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

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



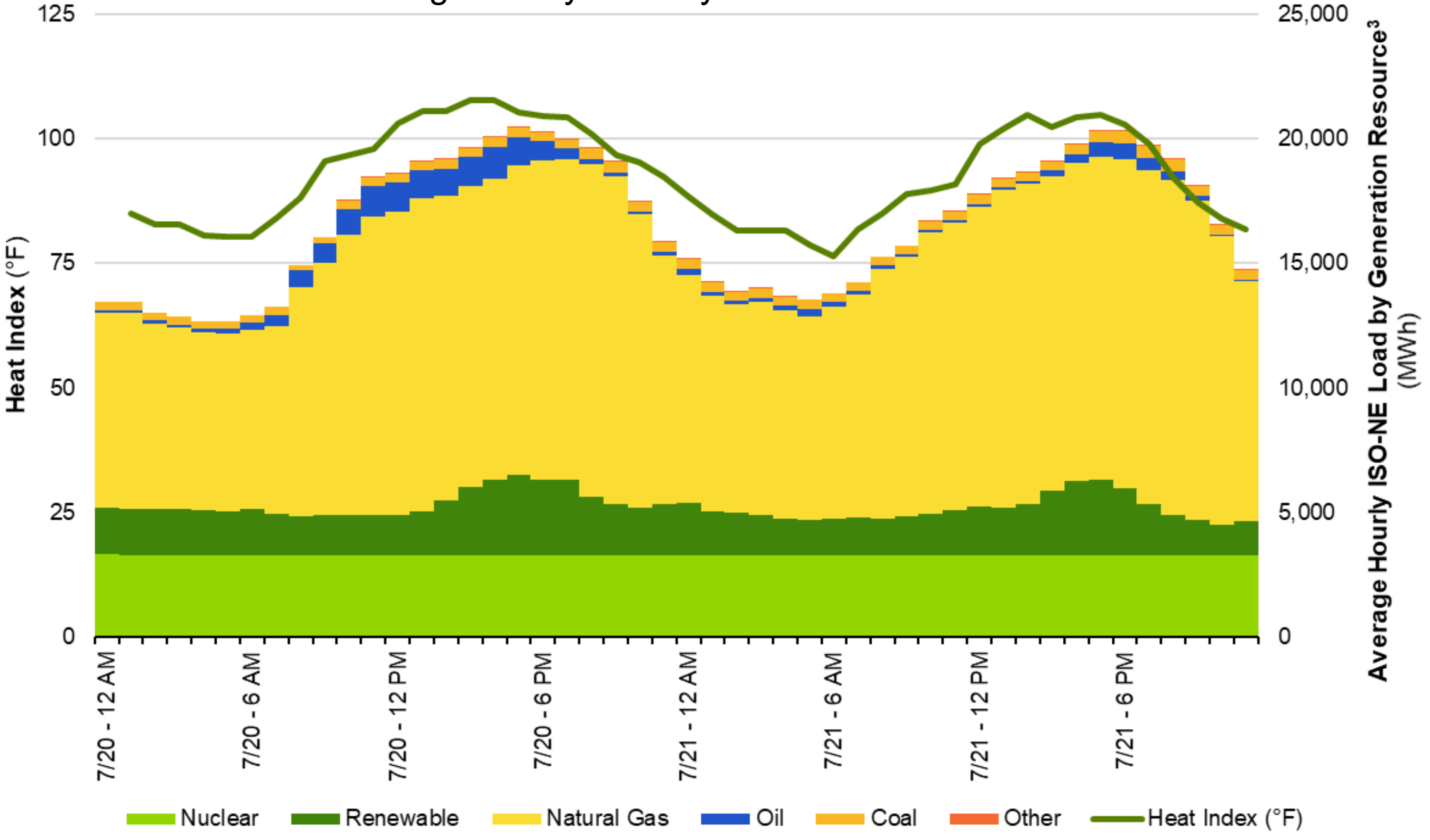
Sources:

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

Electric Grid's Response to the Heatwave

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

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



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

Sources:

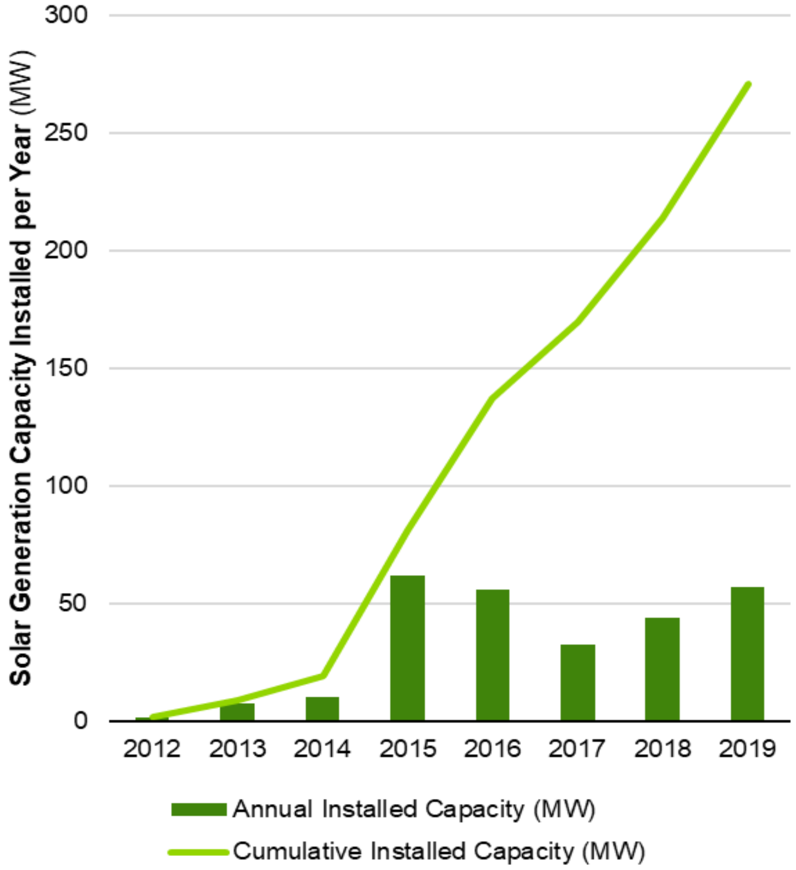
3. "Dispatch Fuel Mix" for July 20-21, 2019 from ISO-NE, averaged over hour of day, available at https://www.iso-ne.com/isoexpress/web/reports/operations/-/tree/gen-fuel-mix
4. "*Summer 2019: Lowest regional grid electricity use in at least 16 years.*" ISO Newswire, 2 Oct. 2019

Connecticut's Distributed Solar Power Plant

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

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

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



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

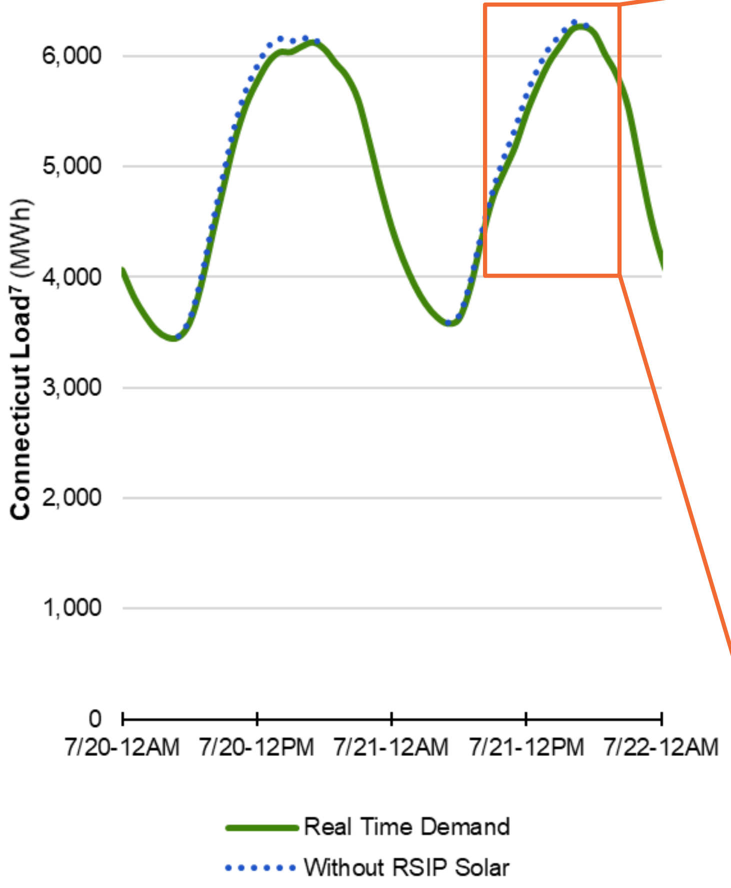
Sources:

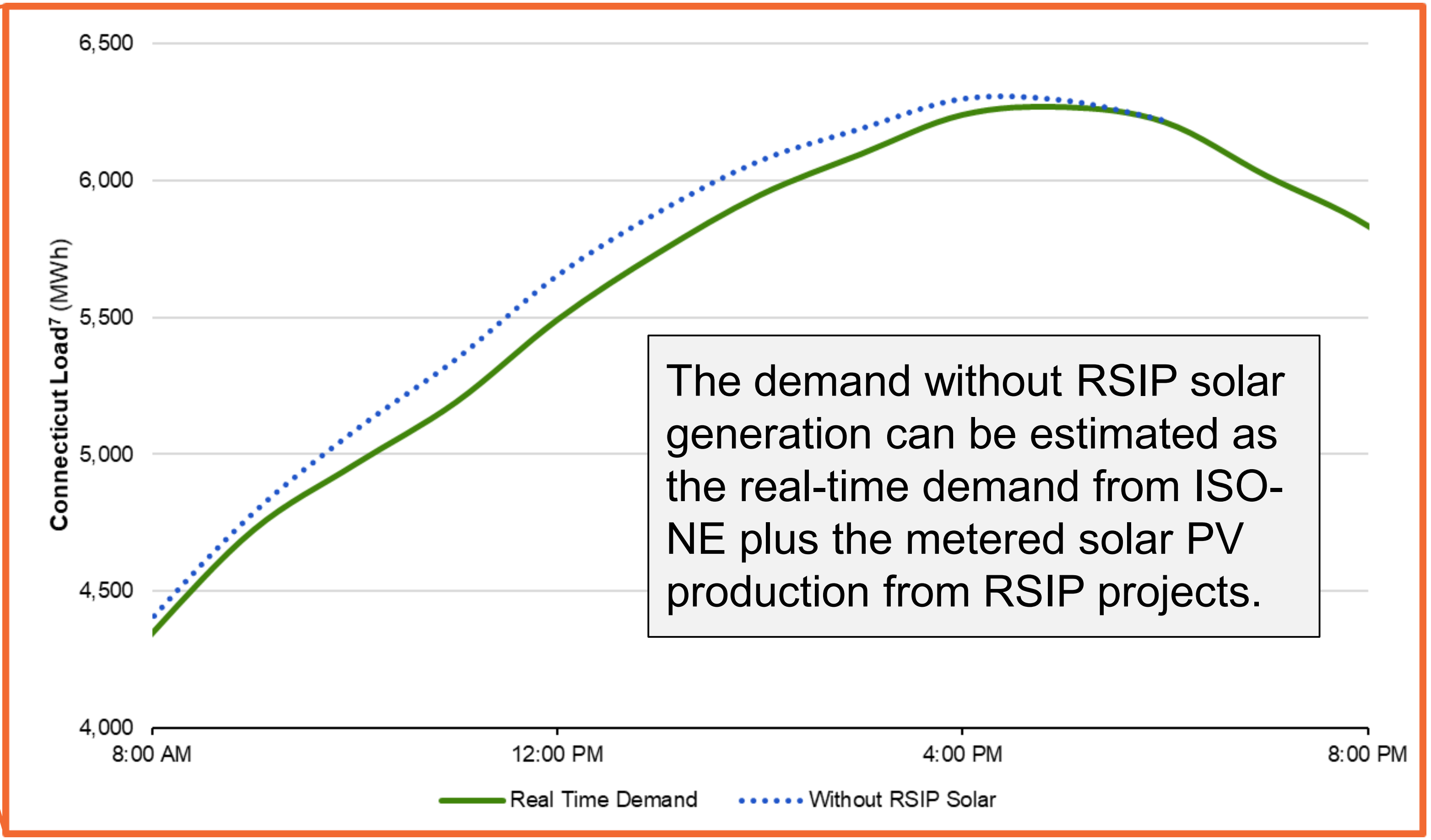
5. RSIP Data as of February 25, 2020
6. Brunelli, Peter. *"Weekend Energy Use Neared N.E. Megawatt Record."* ecoRI News, 22 Jul. 2019

Peak Load Reduction Attributable to RSIP

Removing RSIP generation from actual demand illustrates its effect

Real Time Hourly Electricity Demand in Connecticut [7]



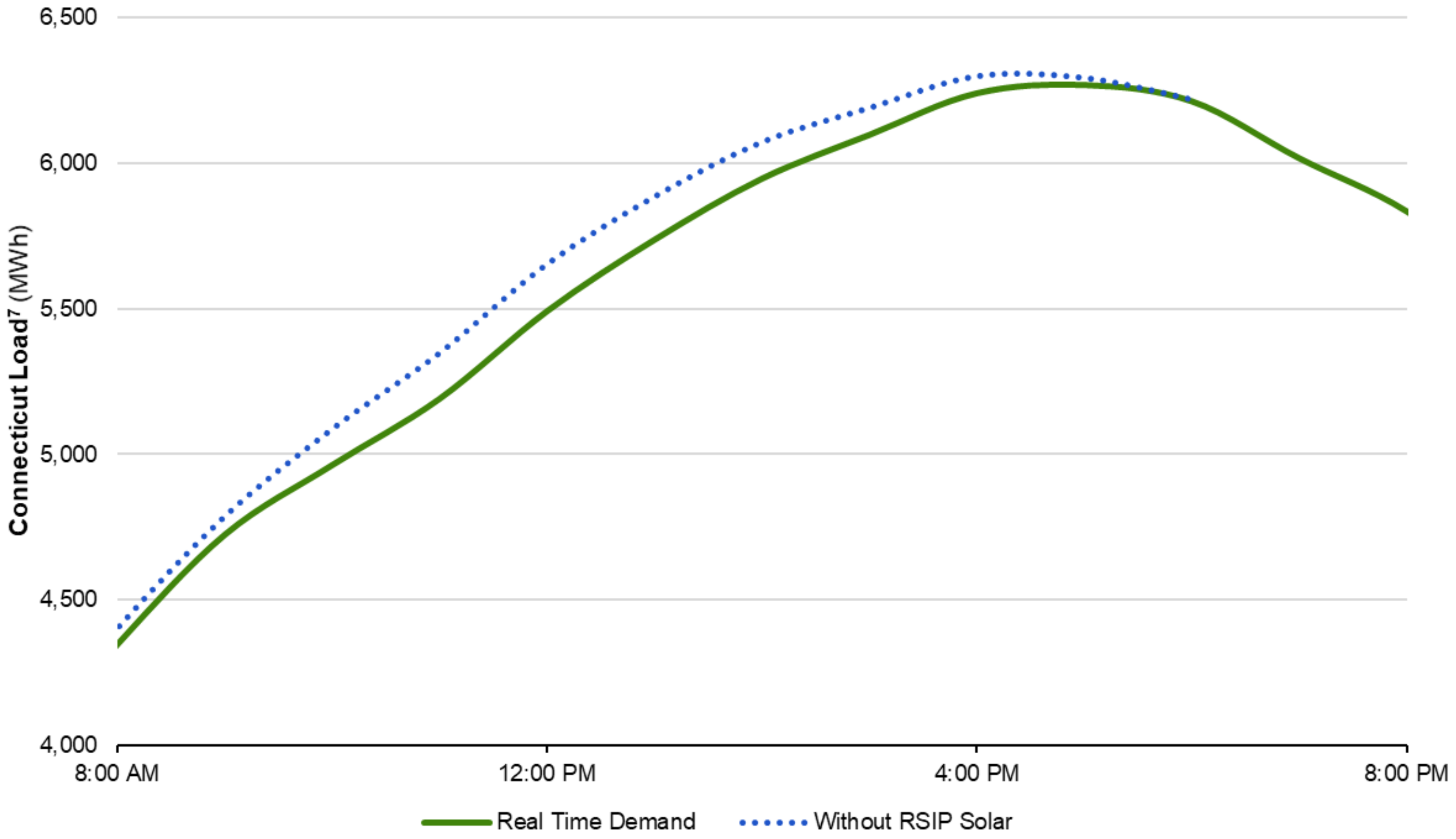


The demand without RSIP solar generation can be estimated as the real-time demand from ISO-NE plus the metered solar PV production from RSIP projects.

Peak Load Reduction Attributable to RSIP

The difference in demand with and without RSIP presents its benefit

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



Sources:

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

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Monetary Benefit of Peak Load Reduction from RSIP

Peak reduction provides direct monetary benefits to ratepayers

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

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

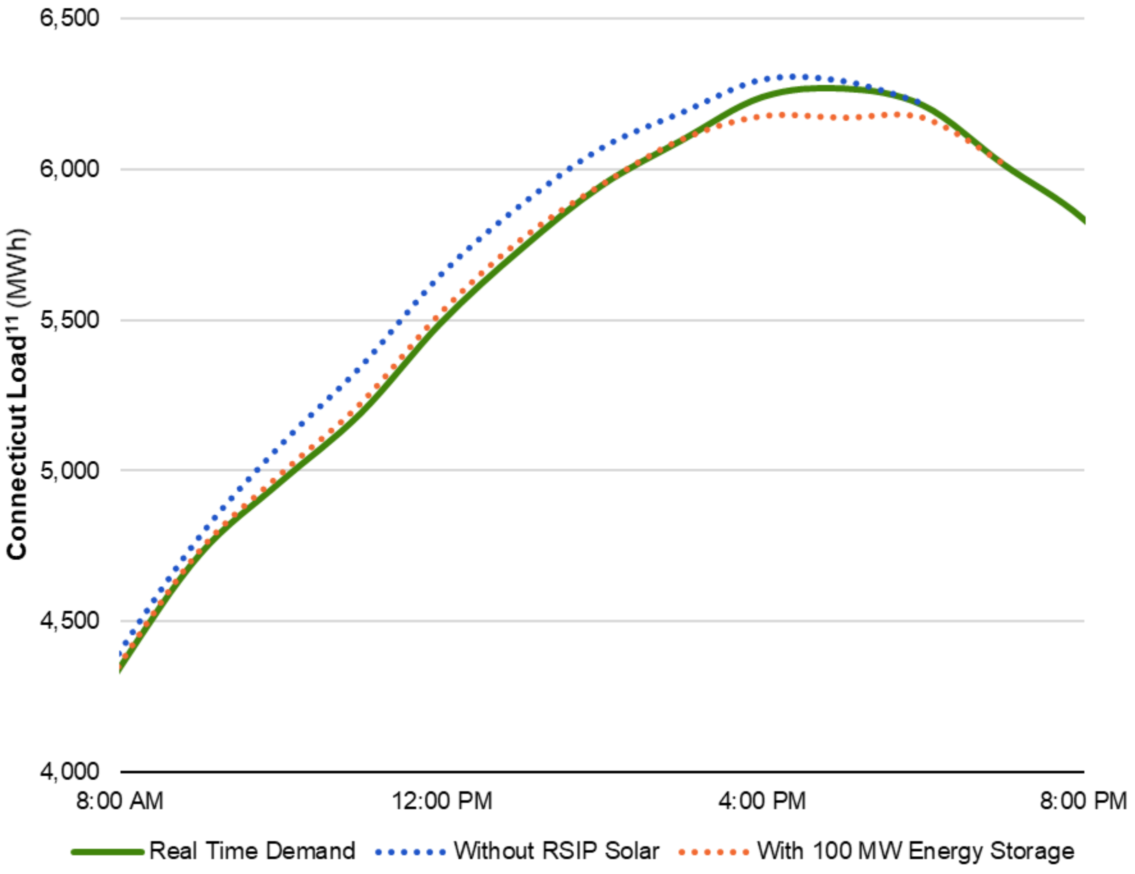
Sources:

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

Combining Solar with Energy Storage

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

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



Sources:

11. RSIP Data as of February 25, 2020. Assumes 100 MW x 200 MWh of energy storage with 90% round-trip efficiency charged throughout the day via RSIP solar and discharged optimally over a three hour event
12. ISO-NE, https://www.iso-ne.com/about/key-stats/electricity-use/

Appendix – Methodology Notes

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

Appendix 5 – Smart-E Loan Battery Storage (Flyer)

Appendix 5

What if your home could power itself?

LIMITED-TIME LOW RATES

NO MONEY DOWN / FLEXIBLE TERMS

Batteries allow you to make the most out of your solar energy.

Battery storage paired with solar PV gives you a new way to control your home's power supply and keep the lights on during an outage.

- 5, 7 and 10-year terms available
- Finance battery storage at 2.99% up to $25,000
- Low blended rates available for battery storage paired with solar, up to $40,000

Learn more about batteries in Solar United Neighbor's Battery Guide

Get started with a Smart-E Loan today at www.ctgreenbank.com/smartebattery

Who can add a battery?

Batteries can be added to an existing solar PV system

OR

included in a new solar plus storage installation

smart-e loan

CONNECTICUT GREEN BANK

continued >>

Batteries make your home more resilient by allowing you to decide when and how your solar power is consumed.

How do batteries work?

Typically when your solar PV system produces more electricity than your home needs at that time (like when the sun is out but you're at work), it gets sent back to the utility grid. Batteries allow you to store that extra electricity and use it to power your home later.

If there is a grid outage event, you can use your stored solar energy to power certain loads in your home like your lights and refrigerator until the grid comes back online. Since your batteries are recharged by solar, your battery will recharge itself each day when the sun comes out.

Cleaner: Unlike generators that run on fossil fuels, batteries charged by solar energy are a cleaner option for powering your home during an outage.

Customizable: Batteries can be customized to meet your home's energy needs. Ask your contractor about designing a system that works for you.

Affordable: With the Smart-E loan special offer you can finance your battery installation with low-interest rates for a 5, 7 or 10 year term!

Learn more about batteries in Solar United Neighbor's Battery Guide

Get started with a Smart-E Loan today at www.ctgreenbank.com/smartebattery

SOLAR UNITED NEIGHBORS

smart-e loan

CONNECTICUT GREEN BANK

Appendix 6 – Smart-E Loan Battery Storage (Program Guidelines)

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

CONNECTICUT
GREEN BANK

Smart-E Loan Special Offer
Battery Storage
RFQ and Program Guidelines

Revised July 1, 2020

Applications are accepted on a rolling submission basis until all Smart-E Loan Special Offer funds are exhausted.

Questions or clarifications about this RFQ and/or Program Guidelines should be directed to:

Connecticut Green Bank
ATTN: Residential Solar Investment Program
845 Brook Street, Rocky Hill, CT 06067-3444
860.563.0015
smallsolar@ctgreenbank.com, and copy smarte@ctgreenbank.com

Executive Summary

The Connecticut Green Bank ("Green Bank") is providing an interest rate buydown ("IRB") for customers that are purchasing a residential battery storage system. Customers that finance the purchase and installation of a residential battery storage system ("Battery") through the Connecticut Green Bank's Smart-E loan program on July 1, 2020 or later will qualify for an interest rate of 2.99% for their choice of a 5, 7 or 10-year loan term, provided they meet the terms and conditions in this RFQ and Program Guidelines.[1] Battery systems must be paired with, or associated with, a new or existing solar PV system to qualify for this special offer. If a customer is installing a new solar PV system with a battery, only the battery equipment and associated installation costs are eligible for the 2.99% interest rate. Additionally, the special offer applies to battery storage system and associated equipment/installation up to a maximum amount of $25,000. Standard Smart-E interest rates apply to all other project costs. See Section 2.2.7 for details. The 2.99% special offer rate will be available until all IRB program funds are exhausted.

Section 2 – Terms and Conditions

2.1 Contractor Requirements

The Smart-E Loan Battery Storage Special Offer Eligible Contractor Application form is available at cgbrsip.powerclerk.com. All Contractor Applicants must be an approved RSIP installer and an approved Smart-E Contractor in order to apply to offer the Smart-E Special Offer to its customers. All Contractor Applicants must provide the following documentation to apply to become an Eligible Contractor for the Smart-E Loan Battery Storage Special Offer.

1. **Form A – Contractor Application Certification**

2. **Company Contact Information –** Contractor Applicants shall provide their Company name and complete contact information for at least two primary contacts including the names, roles and contact information (email addresses and phone numbers) of company staff that will be involved in battery storage sales and installation, as well as associated paperwork and PowerClerk processing.

3. **Battery System Installation Capability** – Contractor Applicants shall provide relevant information from the list below and the Green Bank will determine, at its sole discretion, whether the information provided is sufficient to support an application to install solar PV plus battery systems using Smart-E Special Offer financing. If insufficient information is provided, the Green Bank may request additional information.

   List of information or documentation that may be provided to convey qualifications:

   - Description or documentation of experience and/or training in battery storage system design, installation, and/or operation and maintenance, or broader technical capability that contractor will be relying on for solar PV plus battery system deployments.
   - A representative list of prior solar PV plus battery system installations including customer names and addresses and basic system specifications, and customer references if available.
   - Any relevant licenses or certifications not already provided for the RSIP including any battery manufacturer-issued certifications.
   - Brief biographies or resumes for individuals that will be involved in battery storage work for the applying company.

[1] Customers who have qualified or have been pre-approved for the Smart-E Loan can qualify for the special offer rate provided they have not closed on their loan prior to July 1, 2020.

- A list of any subcontracting companies and individuals that will be working on battery storage work for the applying company, their experience with battery storage installations and a copy of the subcontracting agreement (as required under the general RSIP RFQ) if not already provided to the Green Bank.

4. Technical Information

- Describe the typical battery storage installations you anticipate installing as part of the Smart-E Special Offer, including manufacturer, model, system coupling (i.e., DC or AC), and typical battery storage system size(s) in terms of maximum continuous output rating (kW) and usable energy capacity (kWh). The Green Bank will let you know if further information is needed to approve the battery storage system you are planning to use for the Smart-E Special Offer, in accordance with section 2.2.
- Provide a typical one-line electrical diagram or equipment and metering configuration diagram for the solar PV plus battery storage system(s) you will be installing, including the location of the revenue-grade solar PV production meter (required for RSIP) as well as all major equipment, the electrical service, and the grid.

2.2 Battery System Eligibility Criteria

1. The Battery must be grid-tied, installed behind a residential customer meter and coupled with a solar PV system.
2. Both AC and DC-coupled battery systems are eligible for the Smart-E Loan Special Offer.
3. All Battery components must utilize commercially available battery storage technologies approved for use by the Green Bank at the Green Bank's sole discretion.
4. Batteries must be based on lithium chemistry. Other commercially available battery systems may be considered by Green Bank on a case by case basis at the sole discretion of Green Bank.
5. The Customer and Contractor must abide by the most recent versions of the applicable electric distribution company's ("EDC") Guidelines for the Interconnection of Residential Single-Phase Certified Inverter-Based Generating Facilities of 20kW (ac) or Less" or the "Guidelines for Generator Interconnection Fast Track and Study Processes" and receive approval to interconnect the solar PV system and battery from the applicable EDC.
6. The battery system must have a usable energy capacity of at least 4 kWh.
7. Cost allocation and eligibility for Smart-E special offer rate of 2.99%:

   Contractors must submit the Smart-E Storage Special Offer worksheet or equivalent information in a similar format to show which project costs will be financed at the special offer rate, using the following guidance:

   - <u>Solar PV only costs</u>: cannot be financed at the special offer rate.
   - <u>New battery storage installations paired with existing solar PV</u> (i.e., battery storage retrofit): the entire cost of the battery storage project is eligible for the Smart-E special offer rate up to $25,000. Project costs above $25,000 can be financed at the Smart-E standard rate.
   - <u>New solar PV plus battery storage installations</u>: all battery equipment costs, including the cost of battery-specific inverter(s) or shared battery/solar PV inverter(s), and 50% of the labor and soft costs associated with the entire solar PV plus battery storage project are eligible for the Smart-E special offer rate of 2.99%, up to a maximum amount of $25,000. Solar PV equipment, solar-only inverters and the remaining labor and project soft costs are not eligible for the Smart-E special offer rate. Battery-specific project costs above $25,000 and other ineligible project costs may be financed at regular Smart-E interest rates. A calculator will be provided to enable calculation of a blended interest rate for projects that have a portion that qualifies for the special offer rate and a portion that will be financed at a regular rate.

2.3 Metering/Monitoring

1. On behalf of the Customer, the Contractor must install an RSIP-approved revenue grade meter (“RGM”) for measuring solar PV production. Existing solar PV installations that are retrofit with battery storage may continue to use their existing RGM provided the conditions in provision 1a, below, are met:
    a) Solar plus battery storage installations with DC-coupled batteries must utilize a bi-directional revenue-grade meter that will track solar PV production and is capable of netting any potential power flow from the distribution grid into the battery. Currently approved meters for use with projects installed using a Smart-E Loan Special Offer are the AlsoEnergy/Locus Energy LGate120 meter and the AlsoEnergy/Locus Energy LGate CATM1 Vision revenue-grade meter. Contractors that wish to install a different meter must obtain approval from Green Bank and demonstrate that bi-directional tracking features are enabled, and that the data will be transmitted to the Green Bank Locus platform.
    b) AC-coupled solar PV and battery systems may use any RSIP-approved RGM.
2. Contractors are responsible for installing and ensuring operation of meters and metering equipment and implementing a metering configuration that ensures that the RGMs are capturing all PV production regardless of the system set up and metering configuration. Green Bank reserves the right to request adjustments to meters, metering equipment, and/or metering configuration if deemed inaccurate or not meeting expectations.

2.4 Data Access

1. Contractor and Homeowner agree to release any and all battery storage system monitoring and performance data to the Green Bank as specified in the Smart-E Loan Special Offer Battery Storage Terms and Conditions.
2. Project data may be released to and used by program partners or other third parties for research, evaluation or other purposes. Data that is publicly released shall either be anonymized or aggregated unless otherwise agreed to by the Homeowner. Data may also be used by the Green Bank to evaluate the effectiveness of financing offerings, where applicable.
3. Homeowner releases and holds harmless the Green Bank and its employees, officers and agents, affiliates, and any program partners, from any and all liability associated with the dissemination and use of account and program information and project data.

2.5 General Provisions

- The Customer and Contractor are required to abide by the RSIP terms and conditions and the Smart-E Loan Special Offer terms and conditions.
- All Contractors must submit to PowerClerk along with the sales contract the most current versions of the following documents (provided at https://cgbrsip.powerclerk.com).
    - RSIP Terms and Conditions – should already be incorporated into the solar PV sales contract for RSIP projects
    - Green Bank Smart-E Special Offer Battery Storage Terms and Conditions – can be signed separately and uploaded to PowerClerk OR incorporated into a solar PV and battery storage sales contract, along with the RSIP Terms and Conditions, noting that any updated RSIP contracts must be submitted to Green Bank for approval before use
- All solar PV and Battery storage installations must comply with applicable federal, state and local law, regulation, code, licensing, permit, interconnection and inspection requirements, including

but not limited to the Connecticut Building Code and the National Electric Code (NEC). All components must be UL listed (or equivalent) where applicable.

- Green Bank reserves the right to inspect any battery storage installation that participates in the Smart-E Loan Special Offer.
- Participation in the Smart-E Loan Special Offer does not preclude the customer from participating in any other compensation programs available to battery storage, including demand response programs.

Section 3 – PowerClerk Application Process

3.1 Submission Requirements

- Battery storage equipment and cost information should be input into PowerClerk – please refer to the Smart-E Special Offer Battery Storage PowerClerk instructions document on the PowerClerk login page (https://cgbrsip.powerclerk.com).

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Section 4 - Terms and Conditions of Smart-E Loan Battery Storage Special Offer Participation

The following Connecticut Green Bank ("Green Bank") Smart-E Special Offer terms and conditions for residential battery storage systems are agreed to by the Contractor and Homeowner.

Smart-E Loan Special Offer
Battery Storage
Terms and Conditions

Version July 1, 2020

The Eligible Contractor ("Contractor") agrees to the following terms and conditions between the Contractor and Homeowner if a Smart-E Loan Special Offer rate is requested, will ensure that the Homeowner provides signature as proof of agreement, and that this signed document is submitted to the Green Bank.

1. Wherever a rule or requirement in the RSIP Terms and Conditions refers to a solar PV system, the battery storage system will be considered associated with the solar PV system and will be covered by RSIP rules and requirements to the maximum extent applicable. Current versions of the RSIP Terms and Conditions and this Smart-E Loan Special Offer Terms and Conditions are available at: cgbrsip.powerclerk.com. This provision applies to both existing and new solar PV installations coupled with battery storage that participate in the Smart-E Loan Special Offer.
2. As provided for in the RSIP terms and conditions, the Green Bank shall be entitled to all Renewable Energy Certificates (RECs) and any other tradable energy or environmental-related commodity produced by or associated with the PV system during its useful life, including but not limited to greenhouse gas credits, emissions credits, tradable carbon credits, and all other types of tradable project-related commodities however named that are presently known or designated or created in the future. This includes RECs generated from PV systems sized greater than 20 kW-PTC, unless such RECs are measured separately from the portion of the system receiving a Green Bank incentive.

   The Green Bank shall be entitled to any tradable energy or environmental-related commodity, including capacity attributes, associated with a battery system purchased with the Smart-E Loan Special Offer rate, such as those required to participate in the ISO New England forward capacity market. However, the homeowner or the homeowner's designee (e.g., the Green Bank or other party) may enroll the battery storage system in a demand response program, requiring release of demand reduction benefits to the demand response program administrator.
3. Contractor and Homeowner agree that the contractor will install an RSIP-approved revenue grade meter ("RGM") for measuring solar PV production. Green Bank reserves the right to request adjustments to meters, metering equipment, and/or metering configuration if deemed inaccurate or not meeting expectations. Existing solar PV installations that are retrofit with a battery may continue to use their existing RGM provided the conditions in provision 3a, below, are met:
   a) Solar plus battery storage installations with DC-coupled batteries must utilize a bi-directional revenue-grade meter that will track solar PV production and is capable of netting any potential power flow from the distribution grid into the battery. Currently approved meters for use with projects installed using a Smart-E Loan Special Offer are the AlsoEnergy/Locus Energy LGate120 meter and the AlsoEnergy/Locus Energy LGate CATM1 Vision revenue-grade meter. Contractors that wish to install a different meter must obtain approval from Green Bank and demonstrate that bi-directional tracking features are enabled, and that the data will be transmitted to the Green Bank Locus platform.

4. Contractor and homeowner certify that the battery being financed with the Smart-E Loan Special Offer is a lithium based battery (unless otherwise approved by Green Bank) with a minimum usable capacity of 4kWh.
5. Contractor agrees to meet all PowerClerk submission requirements referenced in Section 3 of the Smart-E Loan Special Offer Battery Storage RFQ and Program Guidelines.
6. Contractor and Homeowner agree to the following data releases:
    1. Contractor and Homeowner agree that the Green Bank will be granted access to all battery storage system monitoring and performance data. Access to the data will include performance and operational data tracked by the battery system manufacturer and/or other third party owner.
    2. Any project data may be released to and used by program partners or other third parties for research, evaluation or other purposes. Data that is publicly released shall either be anonymized or aggregated unless otherwise agreed to by the Homeowner. Data may also be used by the Green Bank to evaluate the effectiveness of financing offerings, where applicable.
    3. Homeowner releases and holds harmless the Green Bank and its employees, officers and agents, affiliates, and any program partners, from any and all liability associated with the dissemination and use of account and program information and project data.

Please direct correspondence regarding these terms and conditions to the Green Bank at smallsolar@ctgreenbank.com, and copy smarte@ctgreenbank.com or call (860) 563.0015.

I have read and agree to the above terms and conditions. I understand that signing this form does not guarantee approval for the Smart-E Loan Special Offer rate.

______________________________ ______________________
Customer Signature Date

____
Customer Printed Name

____
Utility Service Address

____
Mailing Address (if different)

Appendix 7 – Evaluation, Measurement and Verification Plan

Appendix 7

Solarize Storage
Annual EM&V Plan

This Evaluation, Measurement, and Verification (EM&V) Plan documents the objectives, activities, and key sources of data that will be required to evaluate the Program administered by the Green Bank.

Evaluation Objectives

1. Verify that the electric storage systems promoted by the Program are installed and are functioning as intended in association with the behind-the-meter residential solar PV systems.
2. Determine program-level performance metrics, including peak demand savings (kW) for summer and winter seasons from the System
3. Assess customer and contractor satisfaction and opportunities for program enhancements to “cost effectively” meet the Program Targets
4. Calculate the Program’s cost-effectiveness

Evaluation Activities

1. Review and analysis of installation, performance, and financial data in application database to verify that storage systems promoted by the Program are installed and functioning as intended
2. Review and analysis of information from application database and Green Bank to quantify program-level performance metrics
3. Review and analysis of metering data for solar, residential load, storage to quantify evaluation performance metrics
4. Review and analysis of project and program-level costs to verify that the Program cost-effectiveness objectives are being met
5. Program participant survey to verify installation, assess the customer experience, and estimate net program impacts[1]
6. Complete the Program cost effectiveness analysis, by applying the Program Administrator Cost Test (PACT) to calculate the Program cost effectiveness with actual performance data[2]
7. Assess and recommend improvements to Program efficiency by conducting contractor in-depth interviews
8. Annual PURA reporting of evaluation findings and recommendations

Evaluation Activity Metrics

This section focuses on the evaluation activities that are necessary for the Program evaluation.

1. Verify that technologies promoted by the Program are installed and functioning as intended through a review operating and reliability performance characteristics, including
    - Fraction of usable stored energy reserved for backup power, as well as passive and active demand response by location
    - Number of backup power incidents and peak dispatch events, and battery availability for the incident and events by location
    - Number of operating failures
    - Estimated cost of O&M including truck rolls
2. Review and analysis of installation, performance, and financial data in application database to calculate and report program-level metrics, including but not limited to:
    - Program incentive funds disbursed ($)
    - Program administrative costs ($)
    - Number of projects, location of projects, program participants, contractors, and battery vendors and models
    - Installed capacity (kW and kWh) of battery storage systems
    - Average project metrics such as:
        - Incentive per unit ($/unit)
        - Battery storage systems size (kW)
        - Battery storage systems size (kWh)
        - AC vs DC coupled
3. Review and analysis of project-level metering data to estimate and report evaluation performance metrics, including but not limited to:
    - Peak demand savings (kW) for summer and winter based on ISO-NE definition – passive demand response (i.e., "Set It and Forget It")
    - Peak demand savings (kW) for summer and winter based on TPO or EDC dispatch – active demand response (i.e., "Active Dispatch")
    - Energy (kWh) by period (summer on-peak, summer off-peak, winter on-peak, winter off-peak based on ISO-NE definitions), expected annual and expected lifetime, for solar/energy storage/customer load.
    - Peak demand savings (kW) coincident with the ISO-NE annual peak
    - Total amount of solar PV produced and ESS energy charged and discharged
    - Customer bill savings ($)
    - Energy storage charge and discharge patterns
    - Energy storage performance characteristics (e.g., efficiency, any other parameters readily available from energy storage system).
    - Existence and type of usage meter or source of usage data (e.g., battery system, utility meter data, other non-utility meter)
    - Review and analysis of project and program-level costs to verify that the Program cost-effectiveness objectives are being met. Review total program costs including incentive and technology costs from the applications database, and administrative costs from the Green Bank

4. Verify that systems are installed and functioning as intended by designing and conducting a participant survey (online or phone) that also addresses, for example,
    - Customer motivations/drivers for program participation
    - Customer satisfaction and experience with program enrollment, program contractors, ongoing participation in events, program-related communications, and the installed battery storage technologies
    - Battery usage
    - Customer demographics (e.g., household income)
    - Quantification of undocumented costs (ongoing participant O&M)
5. Confirm that program cost effectiveness goals are realized through the Program Administrator Cost Test (PACT).
    - Leverage program-level metrics obtained, as described above in Evaluation Activity Metrics 2
    - Use PACT BCA tool that includes Avoided Energy Supply Cost 2018 Study and relevant future updates to the study and the BCA methodology
    - Assess annual and cumulative program-level performance
6. Assess and recommend improvements to program efficiency by conducting contractor interviews and/or surveys (online or phone) that addresses, for example,
    - Contractor satisfaction with program administration
    - Opportunities for program improvement
    - Contractor successes and challenges
    - Identify opportunities for improvement to increase contractor satisfaction and customer acquisition
    - Customer acquisition costs
    - Participating contractor firmographics
7. Provide annual report of evaluation findings and recommendations
    - The report will include
        - Description of evaluation objectives and evaluation activities[3]
        - Summary of key evaluation findings including system performance
        - Identification of any data collection or performance-related issues
        - Recommendations
    - The annual evaluation report will be provided to PURA

Utility Cost Test Components and Inputs

Utility Cost Test (UCT)					
Cost/Benefit Stream		Characteristic		Valuation	
		Parameter	Source	Parameter	Source
Benefits[1]	**Avoided Energy**	Energy Savings by Period	Metering Data	Cost of Energy	2018 AESC Study for CT
	Avoided Generation Capacity	Summer Peak Savings[2]	Metering Data	Capacity Cost	2018 AESC Study for CT
	Avoided T&D Capacity	Summer Peak Savings[2]	Metering Data	Transmission, Distribution, and Pooled Transmission Facilities	Electric Distribution Companies (EDC) Studies and 2018 AESC Study for CT
	Reliability	Summer Peak Savings[2]	Metering Data	Reliability	2018 AESC Study for CT
	DRIPE Energy Impacts	Energy Savings by Period	Metering Data	Energy DRIPE	2018 AESC Study for CT
	DRIPE Capacity Impacts	Summer Peak Savings[2]	Metering Data	Capacity DRIPE	2018 AESC Study for CT
	Cross-DRIPE Impacts	Annual Energy Savings	Metering Data	Cross-DRIPE	2018 AESC Study for CT
Costs	**Program Incentives**	Average Battery Storage System Size	CGB Data	Per-unit Incentive Level	CGB data
	Program Administration Costs	N/A	CGB Data	Fixed Admin	CGB Data

1. *The evaluation will assume a NTG of 1.0.*
2. *Winter Peak Savings would be evaluated in addition if updated avoided cost study monetizes benefit for winter peak reduction*

Appendix 8 – Cost-Effectiveness Model [CONFIDENTIAL]

CONFIDENTIAL

Submitted separately from the written report.

Appendix 9 – Letter of Support from Solar Connecticut

Appendix 9

July 28, 2020

Mr. Jeffrey R. Gaudiosi
Executive Secretary
Public Utilities Regulatory Authority
10 Franklin Square
New Britain, CT 06051

Re: DOCKET NO. 17-12-03 RE03: PURA INVESTIGATION INTO DISTRIBUTION SYSTEM PLANNING OF THE ELECTRIC DISTRIBUTION COMPANIES – ELECTRIC STORAGE

Dear Mr. Gaudiosi:

On behalf of SolarConnecticut's (SolarConn) solar installer members I am happy to write in support of the Connecticut Green Bank's proposal into Docket No. 17-12-03RE03 relating to its proposed administration of a battery storage incentive program in collaboration with the electric distribution companies and other stakeholders.

The Green Bank's proposal calls for 50 MW of solar + battery storage by the end of 2025. Under the proposal, ratepayers will benefit from declining upfront incentives, ongoing performance-based incentives, and financing options. With this proposal, Connecticut begins a long-awaited transition to battery storage. A measure that will strengthen Connecticut businesses, help ratepayers control their energy costs, and keep Connecticut on pace with its clean energy goals. This incentive proposal is long overdue. I fully expect that home solar installers operating in Connecticut will support a program that helps create a sustained a local battery storage industry, while delivering more benefits to participants, ratepayers, and society through solar + battery storage technologies.

Solar businesses operating in Connecticut have long benefited from how the Green Bank has designed and administered incentive programs in the past. The Residential Solar Investment Program ("RSIP") is a good example. The public/private RSIP partnership has created many hundreds of new jobs in Connecticut and generated millions in economic/environmental benefits to the state all while steadily reducing the ratepayer-funded incentives.

The Green Bank has shown its policies can sustain the orderly development of a local solar industry. SolarConn knows the Green Bank's capabilities. And we trust them to administrate a program for battery storage as a complementary technology. Additionally, I would encourage Green Bank to create a similar program for small business ratepayers.

Thank you for considering this CT Green Bank proposal.

Sincerely,

Michael Trahan

Michael Trahan
Executive Director

P.O. Box 515 • Higganum, CT 06441 • 860-256-1698 • mtrahan@solarconnecticut.org •
www.solarconnecticut.org

Appendix 10 – Letter of Support from REEBA

Renewable Energy and Efficiency Business Association, Inc.

Appendix 10

July 24, 2020

Mr. Jeffrey R. Gaudiosi, Esquire
Executive Secretary
Public Utilities Regulatory Authority
10 Franklin Square
New Britain, CT 06051

Re: DOCKET NO. 17-12-03 RE03: PURA INVESTIGATION INTO DISTRIBUTION SYSTEM PLANNING OF THE ELECTRIC DISTRIBUTION COMPANIES – ELECTRIC STORAGE

Dear Mr. Gaudiosi:

The Renewable Energy and Efficiency Business Association ("REEBA") expresses its support for Connecticut Green Bank's ("Green Bank's") proposal into Docket No. 17-12-03RE03 relating to its proposed administration of a battery storage incentive program in collaboration with the electric distribution companies and other stakeholders.

Many REEBA members may engage with the Green Bank primarily for commercial project finance purposes for energy efficiency or distribution generation projects. We are well acquainted however with the Green Bank's successful administration of incentive programs as well, notably the Residential Solar Investment Program ("RSIP"). This program has pressured down market reliance on public incentives over time, and through its contractor participation terms sets the bar for well-behaved market activity. Since 2011 the Green Bank has demonstrated its capabilities in this regard.

The Green Bank's proposal will seek to deploy 50 MW of battery storage in combination with residential solar PV systems, by the end of 2025. Through a combination of declining upfront incentives, ongoing performance-based incentives, and financing options, the program "cost effectively" delivers benefits to participants, ratepayers and society by deploying electric storage systems in combination with solar PV. The Green Bank would also consider administering additional program designs such as for battery storage in combination with small commercial solar PV.

Thank you for your consideration in support of the Green Bank's proposal.

Sincerely,

James Daylor

James P. Daylor
President / REEBA
james.daylor@jci.com / 508.561.0759

REEBA is a Section 501(c)(6) tax-exempt professional and trade organization. Its membership includes renewable energy developers, energy services companies, and municipalities interested in implementing clean energy technologies. REEBA's purpose is to provide its members with current business, regulatory, and legislative information that will enable the members to keep abreast of developments in the renewable energy and energy efficiency industries as they pertain to the deployment of renewable energy and energy efficiency sources, technologies, and measures in Connecticut.

Appendix 11 – Letter of Support from Vivint Solar

vivint.Solar

July 30, 2020

Mr. Jeffrey R. Gaudiosi, Esquire
Executive Secretary
Public Utilities Regulatory Authority
10 Franklin Square
New Britain, CT 06051

Re: DOCKET NO. 17-12-03 RE03: PURA INVESTIGATION INTO DISTRIBUTION SYSTEM PLANNING OF THE ELECTRIC DISTRIBUTION COMPANIES – ELECTRIC STORAGE

Dear Mr. Gaudiosi:

Vivint Solar expresses its support for Connecticut Green Bank's ("Green Bank's") proposal into Docket No. 17-12-03RE03 relating to its proposed administration of a battery storage incentive program in collaboration with the electric distribution companies, the solar PV and battery storage industries, and other stakeholders.

The Green Bank's proposal seeks to deploy 50 MW of battery storage in combination with existing or new residential solar PV by the end of 2025, serving potentially 10,000 homes across both Avangrid and Eversource service territories. The program would provide an upfront incentive administered by the Green Bank, through a declining incentive block structure, in combination with a performance-based incentive through active demand response programs managed by the Electric Distribution Companies. In our experience, this blend of programs has been the most successful at making energy storage accessible for residential customers.

The incentives are determined using conventional "cost effectiveness" testing to optimize Connecticut's investment, in combination with "best practice" programs benchmarked in the Northeast region and a customer willingness to pay survey. As the program incentive scales down over time, the benefit to all ratepayers will increase.

As the administrator of the Residential Solar Investment Program ("RSIP"), the Green Bank has approved incentives for nearly 335 MW or 42,000 residential solar PV projects since 2012, and is uniquely positioned to drive adoption in the nascent battery storage market while enabling the EDCs to maximize ratepayer benefits through active dispatch of these resources. Working with the Green Bank, the local industry has over time helped to reduce the need for ratepayer funded incentives, while being among the leading states for solar PV deployment in the Northeast. The Green Bank has fostered the sustained orderly development of a local solar industry and is in a position to support the same for battery storage through the proposal. The Green Bank would also consider administering additional program designs such as for battery storage in combination with small commercial solar PV.

vivint.Solar™

As a third-party system owner and installer of solar and storage systems, we have provided our advice to the Green Bank in the design of a battery storage incentive program. We encourage PURA to support the overarching elements of this proposal and have confidence in the Green Bank's ability to deliver a successful, cost-effective program to the state of Connecticut.

Thank you for your consideration.

Sincerely,

Kyle Wallace
Sr. Manager of Public Policy
Vivint Solar

Appendix 12 – Letter of Support from PosiGen

PosiGen
Pure Positive Energy

July 28, 2020

Mr. Jeffrey R. Gaudiosi, Esquire
Executive Secretary
Public Utilities Regulatory Authority
10 Franklin Square
New Britain, CT 06051

Re: DOCKET NO. 17-12-03 RE03: PURA INVESTIGATION INTO DISTRIBUTION SYSTEM PLANNING OF THE ELECTRIC DISTRIBUTION COMPANIES – ELECTRIC STORAGE

Dear Mr. Gaudiosi:

PosiGen Solar expresses its strong support for Connecticut Green Bank's ("Green Bank's") proposal into Docket No. 17-12-03RE03 relating to its proposed administration of a battery storage incentive program in collaboration with the electric utilities and other stakeholders.

PosiGen, which serves primarily lower income and minority ratepayers in Connecticut, hopes to work with the Green Bank to support the program, given its intention to both foster development of a local battery storage industry, and deliver more and equitable benefits to participants, ratepayers, and society through combined solar PV and battery storage systems. It has been an honor to work with the Green Bank's talented and dedicated staff over the past 4+ years as we helped Connecticut to become the first state in the country to enable lower income ratepayers to reach solar parity with higher income ones.

The Green Bank has done an exceptional job administrating its incentive programs, most notably the Residential Solar Investment Program ("RSIP"). Working with the Green Bank, the local industry has over time helped to reduce the need for ratepayer funded incentives, while being among the leading states for solar PV deployment in the Northeast. The Green Bank has fostered the sustained, orderly and efficient development of a local solar industry since 2011 and is in an exceptional position to support the same for battery storage through this proposal.

The Green Bank's proposal will seek to deploy 50 MW of battery storage in combination with residential solar PV systems by the end of 2025. Through a combination of declining upfront incentives, ongoing performance-based incentives, and financing options, the program can cost effectively deliver benefits to participants, ratepayers and society by deploying electric storage systems in combination with solar PV.

Thank you for your consideration in support of the Green Bank's proposal.

Sincerely,

Elizabeth Galante
Sr. Vice President of Business Development
PosiGen Solar
819 Central Avenue, Suite 210
New Orleans, Louisiana 70121

Appendix 13 – Letter of Support from SunPower

SUNPOWER®

July 30, 2020

Mr. Jeffrey R. Gaudiosi, Esquire
Executive Secretary
Public Utilities Regulatory Authority
10 Franklin Square
New Britain, CT 06051

Re: DOCKET NO. 17-12-03 RE03: PURA INVESTIGATION INTO DISTRIBUTION SYSTEM PLANNING OF THE ELECTRIC DISTRIBUTION COMPANIES – ELECTRIC STORAGE

Dear Mr. Gaudiosi:

SunPower Corporation expresses its support for Connecticut Green Bank's ("Green Bank's") proposal into Docket No. 17-12-03RE03 relating to its proposed administration of a battery storage incentive program in collaboration with the electric distribution companies, the solar PV and battery storage industries, and other stakeholders.

The Green Bank's proposal seeks to deploy 50 MW of battery storage in combination with existing or new residential solar PV by the end of 2025, serving potentially 10,000 homes across both Avangrid and Eversource service territories. The program would provide an upfront incentive administered by the Green Bank, through a declining incentive block structure, in combination with a performance-based incentive through active demand response programs managed by the Electric Distribution Companies. The incentives are determined using conventional "cost effectiveness" testing to optimize Connecticut's investment, in combination with "best practice" programs benchmarked in the Northeast region and a customer willingness to pay survey.

As the administrator of the Residential Solar Investment Program ("RSIP"), the Green Bank has approved incentives for nearly 335 MW or 42,000 residential solar PV projects since 2012, and is uniquely positioned to drive adoption in the nascent battery storage market while enabling the EDCs to maximize ratepayer benefits through active management of these resources. Working with the Green Bank, the local industry has over time helped to reduce the need for ratepayer funded incentives, while being among the leading states for solar PV deployment in the Northeast. The Green Bank has fostered the sustained orderly development of a local solar industry and is in a position to support the same for battery storage through the proposal. The Green Bank would also consider administering additional program designs such as for battery storage in combination with small commercial solar PV.

Northeast Regional Office | 262 Washington Street | Suite 700 | Boston MA 02108
sunpower.com

As a third-party system owner, battery technology provider, and a supplier/development partner with multiple local Connecticut solar developers, we have lended our advice to the Green Bank in the design of a battery storage incentive program. We believe that this proposal is an essential first step to transforming Connecticut's electricity system. We encourage PURA to support the overarching elements of this proposal and have confidence in the Green Bank's ability to deliver a successful, cost-effective program to the state of Connecticut. We further look forward to similar programs in the commercial and industrial space, as well as long-term solar and storage programs for distributed energy customers in Connecticut.

Thank you for your consideration.

Sincerely,

Robin K. Dutta
Market Development & Policy – Eastern US
SunPower Corporation
robin[dot]dutta[at]sunpower[dot]com
202.341.9513

Appendix 14 – Letter of Support from Generac

July 30, 2020

Mr. Jeffrey R. Gaudiosi, Esquire
Executive Secretary
Public Utilities Regulatory Authority
10 Franklin Square
New Britain, CT 06051

Re: DOCKET NO. 17-12-03 RE03: PURA INVESTIGATION INTO DISTRIBUTION SYSTEM PLANNING OF THE ELECTRIC DISTRIBUTION COMPANIES – ELECTRIC STORAGE

Dear Mr. Gaudiosi:

Generac Power Systems expresses its support for Connecticut Green Bank's ("Green Bank's") proposal into Docket No. 17-12-03RE03 relating to its proposed administration of a battery storage incentive program in collaboration with the electric distribution companies and other stakeholders.

We have seen battery incentives in other regions have a significant impact on ratepayers adding energy storage to solar PV systems. We expect many of our Certified Installers supporting the Connecticut market will want to engage with the Green Bank for the purposes of supporting the program, since it is intended to both foster the sustained orderly development of a local battery storage industry, while delivering more benefits to participants, ratepayers, and society through the combined system of solar PV and battery storage technologies.

We are well acquainted with the Green Bank's successful administration of incentive programs as well, notably the Residential Solar Investment Program ("RSIP"). Working with the Green Bank, the local industry has over time helped to reduce the need for ratepayer funded incentives, while being among the leading states for solar PV deployment in the Northeast. The Green Bank has fostered the sustained orderly development of a local solar industry and is in a position to support the same for battery storage through the proposal.

The Green Bank's proposal will seek to deploy 50 MW of battery storage in combination with residential solar PV systems, by the end of 2025. Through a combination of declining upfront incentives, ongoing performance-based incentives, and financing options, the program "cost effectively" delivers benefits to participants, ratepayers and society by deploying electric storage systems in combination with solar PV.

Thank you for your consideration in support of the Green Bank's proposal.

Sincerely,

Michael Rather
VP of Sales

Appendix 15 – Letter of Support from sonnen

sonnen

July 30, 2020

Mr. Jeffrey R. Gaudiosi, Esquire
Executive Secretary
Public Utilities Regulatory Authority
10 Franklin Square
New Britain, CT 06051

Re: DOCKET NO. 17-12-03 RE03: PURA INVESTIGATION INTO DISTRIBUTION SYSTEM PLANNING OF THE ELECTRIC DISTRIBUTION COMPANIES – ELECTRIC STORAGE

Dear Mr. Gaudiosi:

sonnen, INC. expresses its support for Connecticut Green Bank's ("Green Bank's") proposal into Docket No. 17-12-03RE03 relating to its proposed administration of a battery storage incentive program in collaboration with the electric distribution companies and other stakeholders.

Many of sonnen, INC's employees may engage with the Green Bank for the purposes of supporting the program, since it is intended to both foster the sustained orderly development of a local battery storage industry, while delivering more benefits to participants, ratepayers, and society through the combined system of solar PV and battery storage technologies. We are well acquainted with the Green Bank's successful administration of incentive programs as well, notably the Residential Solar Investment Program ("RSIP"). Working with the Green Bank, the local industry has over time helped to reduce the need for ratepayer funded incentives, while being among the leading states for solar PV deployment in the Northeast. The Green Bank has fostered the sustained orderly development of a local solar industry and is in a position to support the same for battery storage through the proposal. Since 2011 the Green Bank has demonstrated its capabilities in this regard and would be well positioned to extend them into the administration of a program for battery storage as a complementary technology.

The Green Bank's proposal will seek to deploy 50 MW of battery storage in combination with residential solar PV systems, by the end of 2025. Through a combination of declining upfront incentives, ongoing performance-based incentives, and financing options, the program "cost effectively" delivers benefits to participants, ratepayers and society by deploying electric storage systems in combination with solar PV. The Green Bank would also consider administering additional program designs such as for battery storage in combination with small commercial solar PV.

Thank you for your consideration in support of the Green Bank's proposal.

Sincerely,

Kellie A. Bertsch
Territory Manager

sonnen, Inc. | 2048 Weems Rd | Tucker, GA 30084
+1 (310) 853-2404 | www.sonnenusa.com

Appendix 16 – Letter of Support from Tesla

Appendix 17 – Letter of Support from Panasonic

Panasonic®

July 27, 2020

Mr. Jeffrey R. Gaudiosi, Esquire
Executive Secretary
Public Utilities Regulatory Authority
10 Franklin Square
New Britain, CT 06051

Re: DOCKET NO. 17-12-03 RE03: PURA INVESTIGATION INTO DISTRIBUTION SYSTEM PLANNING OF THE ELECTRIC DISTRIBUTION COMPANIES – ELECTRIC STORAGE

Dear Mr. Gaudiosi:

Panasonic Life Solutions Compnay of North America expresses its support for Connecticut Green Bank's ("Green Bank's") proposal into Docket No. 17-12-03RE03 relating to its proposed administration of a battery storage incentive program in collaboration with the electric distribution companies, the solar PV and battery storage industries, and other stakeholders.

The Green Bank's proposal seeks to deploy 50 MW of battery storage in combination with existing or new residential solar PV by the end of 2025, serving potentially 10,000 homes across both Avangrid and Eversource service territories. The program would provide an upfront incentive administered by the Green Bank, through a declining incentive block structure, in combination with a performance-based incentive through active demand response programs managed by the Electric Distribution Companies. The incentives are determined using conventional "cost effectiveness" testing to optimize Connecticut's investment, in combination with "best practice" programs benchmarked in the Northeast region and a customer willingness to pay survey.

As the administrator of the Residential Solar Investment Program ("RSIP"), the Green Bank has approved incentives for nearly 335 MW or 42,000 residential solar PV projects since 2012, and is uniquely positioned to drive adoption in the nascent battery storage market while enabling the EDCs to maximize ratepayer benefits through active management of these resources. Working with the Green Bank, the local industry has over time helped to reduce the need for ratepayer funded incentives, while being among the leading states for solar PV deployment in the Northeast. The Green Bank has fostered the sustained orderly development of a local solar industry and is in a position to support the same for battery storage through the proposal. The Green Bank would also consider administering additional program designs such as for battery storage in combination with small commercial solar PV.

As a manufacturer of PV modules & energy storage system hardware, we have lent our advice to the Green Bank in the design of a battery storage incentive program. We encourage PURA to support the overarching elements of this proposal and have confidence in the Green Bank's ability to deliver a successful, cost-effective program to the state of Connecticut.

Thank you for your consideration.

Sincerely,

Erik Anderson

Erik Anderson
Regional Sales Manager, Solar & Battery Products – Northeastern USA
Panasonic Life Solutions Company of North America
Two Riverfront Plaza, 5th Floor
Newark, NJ 07102

Appendix 18 – Letter of Support from Yale University

Yale SCHOOL OF THE ENVIRONMENT

Kenneth Gillingham
Associate Professor
195 Prospect Street
New Haven, Connecticut 06511
(p) 203-436-5465
kenneth.gillingham@yale.edu

July 20, 2020

To Whom it May Concern,

I'm writing this letter in support of the Connecticut Green Bank's proposal into the Grid Modernization docket (Docket Number 17-12-03(RE03)) on the topic of "Solarize Connecticut Storage."

Climate change is a serious threat to Connecticut, our nation, and the world. As Connecticut continues to decarbonize its electricity supply with intermittent renewables, fast-dispatch energy storage will become an indispensable element of the electricity grid that enables reliable and affordable electricity service. The Green Bank's proposal aims to deploy 50 megawatts of battery storage combined with solar energy by the end of 2025. A hallmark of this program is that it is a carefully designed program using data from market research and an analysis to aim for the greatest "bang-for-the-buck." The program design also involved full set of stakeholders, including from the local solar industry. It is rare to see a program designed with so much forethought and I applaud the Green Bank for their careful work.

The proposal will also very nicely complement work underway at the Yale Center for Business and the Environment using community-based marketing strategies to promote the adoption of combined solar and storage systems. It would especially be a very nice complement to a $1.65 million grant proposal I have written to the U.S. Department of Energy to bring in federal funding to Connecticut to promote solar+storage solutions. Should both proposals be funded, I anticipate rapid growth in the solar+storage market in Connecticut, creating jobs and helping the state continue to decarbonize its economy.

Feel free to be in touch with any questions.

Sincerely,

Kenneth Gillingham

Kenneth Gillingham
Yale School of the Environment
Yale Department of Economics
Yale School of Management