NYSERDA Innovation & Research Demonstration Project Impact Evaluation

Final Report

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NYSERDA Contract 104536A July 2020

NYSERDA Record of Revision

Document Title
NYSERDA Innovation & Research Demonstration Project Impact Evaluation – Final Report July 2020

Revision Date	Description of Changes	Revision on Page(s)

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1. Executive Summary

This report presents results of the New York State Energy Research and Development Authority's (NYSERDA) Innovation & Research Demonstration Projects from online surveys, phone verification, and project research efforts. DNV GL evaluated the portfolio of NYSERDA-funded demonstration projects that were completed between 2014 and 2018. The majority of projects in the population for this time period were funded under the Technology & Market Development (T&MD) portfolio.

Table 1-1 below presents the monetized impacts of the broad portfolio of NYSERDA-funded projects with completion dates between 2014 and 2018, as well as the one-year return on investment (ROI) in Table 1-2. Demonstration and replication projects together generated a monetized $155 million of benefits per year from NYSERDA investments of $47 million, giving an annual return of $3.32 per dollar invested. It is uncertain how many years this level of benefits will persist, however, different scenarios of total lifetime benefits based on 3, 5 and 10 year lifetimes are provided. For the 10-year lifetime, benefits exceed $1.5 billion.

Table 1-1: Annualized Monetized Impacts from Demonstration and Replication Projects

Impact Metric Category	Demonstration Project Impacts	Replication Project Impacts	Total Impact
Emissions Reduction	$307,000	$573,000	$880,000
Electricity Impacts	$582,000	$1,517,000	$2,099,000
Financial Impacts	$2,156,000	$7,796,000	$9,952,000
Fuel Impacts	$497,000	$385,000	$882,000
Other Impacts	$5,390,000	$133,496,000	$138,886,000
Power Impacts	$2,195,000	$311,000	$2,506,000
Waste Management	$210,000	$0	$210,000
Total annual impacts	**$11,337,000**	**$144,077,000**	**$155,414,000**

Table 1-2: Annualized Return on Investment

Measure	Value
Total Annual Impacts	$155,414,000
NYSERDA Investment	$46,865,000
Annual Return on Investment	**$3.32**

2. Introduction

This report presents results of the Innovation & Research Demonstration project impact evaluation for projects completed between 2014 and 2018. The evaluation team obtained objective information about a wide array of impacts from the emerging clean and energy-efficient technologies tested in demonstration projects. Specifically, the team surveyed key market actors through web-based surveys, in-depth phone interviews, and review of project reports, wherever available, to quantify and monetize the identified impacts.

2.1. Program Description

New York State Energy and Research Development Authority's (NYSERDA) Innovation Program engages a variety of approaches designed to advance the development of innovative, reliable, efficient, clean energy technologies and to increase market acceptance and adoption. Research and Development (R&D) demonstration projects are largely conducted within the Innovation & Research portfolio and are one of NYSERDA's many strategies for promoting these goals. Demonstration projects showcase the value and effectiveness of a new technology or process, or the application of an existing technology in a commercial setting. The funding recipients were mandated to demonstrate and obtain objective information on technical performance, cost, and environmental impacts of emerging clean and energy-efficient technologies. The results from those who did so and provided that information are documented in this report, expanded to the full population. The full population of projects comes from NYSERDA's tracking data base, in Salesforce™.

Demonstration projects cover a wide variety of technology areas and project types, including advanced materials, air and waste remediation, building systems, electric power delivery, energy storage, industrial products, heating and cooling, transportation, waste management, wastewater treatment, and others. While demonstration projects alone often generate benefits, they can achieve significant additional impacts through successful replications – generally greater benefits than the original demonstration project when multiple successful replications are executed. This evaluation quantifies benefits from both the original demonstration projects and replication projects.

Prior to this study, NYSERDA finalized three other studies of its R&D demonstration projects, covering projects completed between 2004 and 2013. The current evaluation builds on prior study methods and learning and updates the R&D demonstration survey with those projects completed between 2014 and 2018.

2.2. Summary of Evaluation Objectives and Methods

Table 2-1 lists evaluation objectives and main research topics. The primary objective of the study is to quantify and monetize the impacts of the NYSERDA-funded demonstration projects and identified replications occurring in the evaluation period.

Table 2-1: Evaluation Objectives and Main Research Questions

Impact Quantification		
Objective	**Evaluation Questions**	**Data Sources & Evaluation Methods**
Evaluated gross energy impacts of demonstration and replication projects	What are the annualized first-year electric (kWh), natural gas savings (MMBtu) and other energy savings?	Salesforce, survey, in-depth interviews, report reviews
Non-energy bill cost savings of demonstration and replication projects	What are the non-energy bill cost savings ($) associated with the NYSERDA funded demonstration and subsequent replication projects?	Salesforce, survey, in-depth interviews, report reviews
Revenue generated	What is the revenue generated ($) from demonstration and replication projects?	Survey, in-depth interviews, report reviews
Influence on demonstration projects and replications	To what degree do respondents identify NYSERDA as an important contributor in their decision to undertake and complete a demonstration project and in any replications that have occurred?	Survey
NYSERDA technology demonstration program Return on Investment (ROI)	What is the ratio of monetized benefits from all demonstration and replication projects divided by NYSERDA's direct investment in dollars?	Salesforce, survey, in-depth interviews, report reviews
Impact Optimization		
Objective	**Evaluation Questions**	**Data Sources & Evaluation Methods**
Characterize replication projects	What are the number, scale, and type of replication projects either funded or attributable to NYSERDA?	Salesforce, survey, in-depth interviews, report reviews
Factors leading to or hindering replication	What are the factors either leading to or hindering replication, and what is their relative strength?	Survey

DNV GL attempted a census of all projects completed in the study timeframe through online surveys, in-depth phone interviews (IDI), and review of project reports. Priorities for project report reviews were established in consultation with NYSERDA. The evaluation team attempted a census of surveys due to the large variety of demonstration project types and the relatively low number of total demonstration projects (150). Additionally, it was important to gather information from as many demonstration projects as possible to address characterization of any replication projects and to be able to extrapolate any findings to the broader portfolio. The tri-modal approach allowed data collection from as many participants as possible. With this broad-based data collection effort, DNV

GL determined nuanced indirect and non-energy impacts in addition to the direct impacts from demonstration projects.

3. Results, Findings, and Recommendations

3.1. Results

This section details the quantitative results and observations of the data collection and analysis activities. In total, the 150 demonstration projects received nearly $47 million in NYSERDA funding while returning an average of $155 million *per year*, resulting in an annual return on investment (ROI) of $3.32.

3.1.1. Data Collection Results and Observations

Table 3-1 summarizes the population of projects by NYSERDA program name. Some programs, such as Advanced Buildings, have high participation rates but relatively low funding for the average project. Other programs, such as Smart Grid Systems and Distributed Energy Integration, have fewer participants but higher average funding per project. The variety of participation and average funding across programs reflects the variety of unique projects under evaluation.

Table 3-1: Description of Projects in the Population by Program Name

NYSERDA Program Name	Count of Projects	Total NYSERDA Funding	Average NYSERDA Funding Per Project
Advanced Buildings	49	$10,436,606	$212,992
Clean Transportation	31	$6,580,530	$212,275
Onsite Power	25	$9,369,311	$374,772
Renewable Optimization and Energy Storage Innovation	26	$8,064,286	$310,165
Smart Grid Systems and Distributed Energy Integration	19	$12,413,799	$653,358
Totals or Averages	**150**	**$46,864,532**	**$312,430**

The evaluated population of NYSERDA funding recipients consists of demonstration projects completed between 2014 and 2018. It was difficult, if not impossible, to contact some individuals and firms behind these projects, markedly so for projects that were completed earlier in the study timeframe.

DNV GL used several data collection methods to determine the variety of impacts from individual projects. Each of the 77 total respondents had results from at least one method of data collection.

Table 3-2 lists the results of these efforts, showing counts by collection source and program name within the Innovation & Research portfolio.

Table 3-2: Data Collection by NYSERDA Program Name and Data Collection Method

NYSERDA Program Name	Projects in the Population (N)	Total Respondents (n)	Completed Online Survey	Completed IDI	Report Reviewed
Advanced Buildings	49	25	22	19	9
Clean Transportation	31	17	7	7	15
Onsite Power	25	11	8	6	6
Renewable Optimization and Energy Storage	26	12	6	4	8
Smart Grid Systems and Distributed Energy	19	12	12	7	3
Total	**150**	**77**	**55**	**43**	**41**

3.1.2. Impact Categorization

NYSERDA categorizes impact types as direct or indirect; direct impacts are outcomes of demonstration projects, while indirect impacts result from replication projects. For each of these impact types, several impact metrics were determined. The various impact metrics were grouped into categories, indicated in Table 3-3. The table summarizes the number of non-zero impacts reported for each impact type and metric category. Counts of individual metrics in each of these categories are reported in the tables that follow, along with program-level impacts.

The counts in Table 3-3 include a given responding project multiple times for each of its distinct metrics with non-zero impacts. For example, a project with electricity, gasoline, and No. 2 fuel oil savings would contribute three distinct metric impacts, and be counted once in the 'Electricity (MWh)' category and twice in the 'Fuel (various)' category counts. Between demonstration and replication projects, the 77 respondents reported 3,105 non-zero metric impacts.

Table 3-3: Non-Zero Impacts Identified in Data Collection by Type and Category

Impact Type	Impact Metric Category	Responding Projects with Non-Zero Impacts
Direct (Demonstration)	Electricity (MWh)	20
	Power (kW)	12
	Fuel (various)	27
	NEI: Financial ($)	18
	NEI: Emissions	54
	NEI: Other	19
	NEI: Waste Management	2
Indirect (Replication)	Electricity (MWh)	370
	Energy (kW)	8
	Fuel (various)	411
	NEI: Financial ($)	426
	NEI: Emissions	1,086
	NEI: Other	652
	NEI: Waste Management	0
Total Impacts Reported		**3,105**

3.1.3. Analysis Results and Observations

The following section presents the annualized and monetized results of DNV GL's analysis. This section concurrently presents the sources and methodologies for the monetization of the listed impact metrics. Each table in the following sections contains the following variables, with values for each labelled Impact Metric:

- **Responding Projects with Non-Zero Impacts:** Similar to the counts in Table 3-3, this variable shows the count of non-zero impacts at the impact metric level (not at the category level) based on 77 total respondents. A respondent is assumed to have had an impact of 0 for any metric for which the respondent did not report a non-zero value, with the exception that all respondents who reported electricity or fuel savings (except hydrogen) are counted as having CO_2e emissions impacts.

- **Annual Program Impacts**

  - **Estimated Impact:** Estimated annual impacts for the full population of 150 demonstration projects. The sample contained 77 total respondents. The evaluation team developed weights via post-stratification to account for non-response in the data collection efforts. . Label includes the common unit of measure for included metrics (kW, MWh, MMBtu).

- **Monetized ($):** The dollar value of the estimated program impacts; monetization factors and methods are included following each table.

- **90% Confidence Interval (of monetized value):** A confidence interval was calculated for each metric in its common units. The confidence interval bounds were then monetized to allow for comparison across metrics and categories. In some cases the lower end of the confidence interval falls below zero. Since impacts could be either positive or negative, the analysis did not restrict the confidence interval to be strictly non-negative. While positive impacts were generally more common than negative, so that extremely negative program-level impacts are less likely than more positive impacts, it was beyond the scope of this analysis to develop alternative, asymmetric confidence interval specifications. The symmetric intervals calculated should be understood to be approximations, providing a general indication of how certain the estimated impact is. For more detail regarding confidence interval calculation method and assumptions, see Section 4.2.

3.1.3.1. Demonstration Projects Impacts (Direct)

Table 3-4 shows the electricity impacts from demonstration projects. Annualized, expanded to the program population, and monetized, the value of annual electricity impacts amounts to over a half million dollars.

Table 3-4: Electricity Impacts from Demonstration Projects (Annualized)

Impact Metric	Responding Projects with Non-Zero Impacts (n=77)	Annual Program Impact*			
		Estimated Impact (MWh)	Monetized ($)	90% Confidence Interval	
				Lower Bound	Upper Bound
Electricity Savings	20	9,000	$582,000	$261,000	$903,000
Total			**$582,000**		

*Impacts are calculated using detailed numeric values, then rounded to the nearest thousand in the units displayed. As a result, multiplying a displayed impact by its monetization factor may not precisely match the displayed monetized value.

The item below describes the monetization factor for impact metrics in this category:

- Electricity Savings: DNV GL converted NYSERDA's average, industrial price per kWh of electricity from 2014 to 2018 ($0.062/kWh) to MWh: **$61.85/MWh**[1] .

[1] NYSERDA. (2020, February 7). Monthly Average Retail Price of Electricity - Industrial. Retrieved from https://www.nyserda.ny.gov/Researchers-and-Policymakers/Energy-Prices/Electricity/Monthly-Avg-Electricity-Industrial

Table 3-5 shows the power impacts from demonstration projects. Despite similar counts of non-zero impacts, power *production* impacts greatly exceed those of demand reduction; this is not a surprising result, as onsite generation is often sized close to 100% of peak load.

Table 3-5: Power Impacts from Demonstration Projects (Annualized)

Impact Metric	Responding Projects with Non-Zero Impacts (n=77)	Annual Program Impact*			
		Estimated Impact (kW)	Monetized ($)	90% Confidence Interval	
				Lower Bound	Upper Bound
Demand Reduction	7	1,000	$23,000	$6,000	$39,000
Power Production	5	75,000	$2,173,000	$150,000	$4,196,000
Total			**$2,195,000**		

*Impacts are calculated using detailed numeric values, then rounded to the nearest thousand in the units displayed. As a result, multiplying a displayed impact by its monetization factor may not precisely match the displayed monetized value. Emissions impacts from power impacts were *not* extrapolated except where reported separately by each demonstration respondent.

The items below describe the monetization factors for impact metrics in this category:

- Demand Reduction: DNV GL combined the 6-month summer-season and 6-month winter-season Rest of State (ROS) price per kW-month paid by bidders (weighted average) in the New York Independent System Operator (NYISO[2]) auction from 2014 to 2018 to monetize the annual impact.
    - The average for summer season capacity was $3.40/kW-summer month, for a six-month value of $20.42/kW-summer season.
    - The average for winter season capacity was $1.44/kW-winter month, for a six-month value of $8.61/kW-winter season.
    - In total, this provides an estimated value of **$29.03/kW-year**, the sum of the winter and summer six-month values.
- Power Production: DNV GL used the same value as for Demand Reduction, **$29.03/kW-year**.

2 NYISO. (2020). Installed Capacity: View Strip Auction Summary, Strip Auction Results for UCAP. Retrieved from http://icap.nyiso.com/ucap/public/auc_view_strip_detail.do

Table 3-6 shows the fuel impacts from demonstration projects. Impacts in this category originated from various uses such as heating (space and process) and vehicle use, before conversion to MMBtu.

Table 3-6: Fuel Impacts from Demonstration Projects (Annualized)

Impact Metric	Responding Projects with Non-Zero Impacts (n=77)	Annual Program Impact*			
		Estimated Impact (MMBtu)	Monetized ($)	90% Confidence Interval	
				Lower Bound	Upper Bound
Diesel	3	<1,000	$4,000	$0	$8,000
Gasoline	5	7,000	$166,000	$(34,000)	$365,000
Gasoline eq Hydrogen	3	3,000	$34,000	$(8,000)	$77,000
Propane	2	<1,000	$1,000	$0	$2,000
no2 Fuel Oil	1	<1,000	$11,000	$(4,000)	$25,000
no4 Fuel Oil	1	<1,000	$5,000	$(1,000)	$11,000
LNG	1	1,000	$5,000	$0	$11,000
Natural Gas	11	40,000	$271,000	$11,000	$531,000
Total			**$497,000**		

*Impacts are calculated using detailed numeric values, then rounded to the nearest thousand in the units displayed. As a result, multiplying a displayed impact by its monetization factor may not precisely match the displayed monetized value.

The items below describe the monetization factors for impact metrics in this category:

- Diesel: DNV GL converted EIA's Central Atlantic area average, on-highway price per gallon of diesel from 2014 to 2018 ($3.11/gallon) to MMBtu: **$22.39/MMBtu**[3].
- Gasoline: DNV GL converted EIA's New York state average price per gallon of gasoline from 2014 to 2018 ($2.72/gallon) to MMBtu: **$22.61/MMBtu**[4].
- Gasoline Gallon equivalent Hydrogen: DNV GL converted HES Hydrogen's average cost of production per kilogram of hydrogen ($1.40/kg) to the gallons of gasoline equivalent, then to MMBtu: **$11.42/MMBtu**[5].

[3] U.S. Energy Information Administration. (2020, February 24). *Weekly Retail Gasoline and Diesel Prices*. Retrieved from https://www.eia.gov/dnav/pet/pet_pri_gnd_dcus_sny_a.htm

[4] U.S. Energy Information Administration. (2020, February 24). *Weekly Retail Gasoline and Diesel Prices*. Retrieved from https://www.eia.gov/dnav/pet/pet_pri_gnd_dcus_sny_a.htm

[5] HES Hydrogen. (2019). *Hydrogen Fuel Cost vs Gasoline*. Retrieved from https://heshydrogen.com/hydrogen-fuel-cost-vs-gasoline/

- Propane: DNV GL converted NYSERDA's average price per gallon of propane from 2014 to 2018 ($2.70/gallon) to MMBtu: **$29.56/MMBtu**[6].

- no2 Fuel Oil and no4 Fuel Oil: DNV GL converted NYSERDA's average price per gallon of home heating oils from 2014 to 2018 ($3.00/gallon) to MMBtu: **$21.49/MMBtu**[7] **and $20.68/MMBtu, respectively.**

- Liquefied Natural Gas (LNG): DNV GL converted EIA's average price per Mcf exported LNG from 2014 to 2018 ($8.24/Mcf) to MMBtu: **$7.99/MMBtu**[8].

- Natural Gas: DNV GL converted NYSERDA's average, industrial price per Mcf natural gas from 2014 to 2018 ($6.99/Mcf) to MMBtu: **$6.78/MMBtu**[9]

Table 3-7 shows the non-energy-bill financial impacts from demonstration projects. The survey asked respondents to provide "cost savings" and "revenue" values immediately after and separately from the energy impact section. Cost-savings impacts greatly exceed revenue impacts. The value of non-energy-bill financial impacts exceeds the combined value of electricity, power, and fuel impacts.

Table 3-7: Financial Impacts from Demonstration Projects (Annualized)

Impact Metric	Responding Projects with Non-Zero Impacts (n=77)	Annual Program Impact*			
		Estimated Impact ($)	Monetized ($)	90% Confidence Interval	
				Lower Bound	Upper Bound
Cost-Savings	15	2,119,000	$2,119,000	$720,000	$3,518,000
Revenue Generated	3	37,000	$37,000	$(1,000)	$75,000
Total			**$2,156,000**		

*Impacts are calculated using detailed numeric values, then rounded to the nearest thousand in the units displayed. As a result, multiplying a displayed impact by its monetization factor may not precisely match the displayed monetized value.

[6] NYSERDA. (2020, March 06). *Monthly Average Propane Prices*. Retrieved from https://www.nyserda.ny.gov/Researchers-and-Policymakers/Energy-Prices/Propane/Monthly-Average-Propane-Prices

[7] NYSERDA. (2020, March 06). *Monthly Average Home Heating Oil Prices*. Retrieved from https://www.nyserda.ny.gov/Researchers-and-Policymakers/Energy-Prices/Home-Heating-Oil/Monthly-Average-Home-Heating-Oil-Prices

[8] United States Energy Information Administration. (2020, February 28). *Price of Liquefied U.S. Natural Gas Exports*. Retrieved from https://www.eia.gov/dnav/ng/hist/n9133us3M.htm

[9] NYSERDA. (2020, March 06). *Monthly Average Price of Natural Gas - Industrial*. Retrieved from https://www.nyserda.ny.gov/Researchers-and-Policymakers/Energy-Prices/Natural-Gas/Monthly-Average-Price-of-Natural-Gas-Industrial

DNV GL calculated demonstration project emissions impacts using the reported electricity and fuel impacts, together with the MPTA Phase I Report[10] for electric and most fuel emissions factors. The emission factor for LNG was obtained from the US. EPA State Climate Energy Program State Inventory Tool[11]. No respondent reported emissions savings from sources other than electricity or fuel. That is, all CO_2e emissions impacts stem from energy sources. Table 3-8 below itemizes impacts from each energy source, the related source (electricity or fuel) emissions factors, and the total calculated metric tons of CO_2e emissions avoided.

Table 3-8: Demonstration Projects Avoided Emissions by Source

Energy Source (unit)	Estimated Impact	Emissions Factor for Energy Source (MT CO2e per unit)	Annual Avoided Emissions* (MT CO2e)
Electricity (kWh)	9,413,000	0.0005003	5,000
Diesel (gal)	1,000	0.0102614	<1,000
Gasoline (gal)	61,000	0.0086205	1,000
Propane (gal)	<1,000	0.0056381	<1,000
no2 Fuel Oil (gal)	4,000	0.0103150	<1,000
no4 Fuel Oil (gal)	2,000	0.0108267	<1,000
LNG (MMBtu)	1,000	0.0586000	<1,000
Natural Gas (therms)	396,000	0.0053161	2,000
Natural Gas (Btu)	352,741,000	0.0000001	<1,000
Total			**8,000**

*Impacts are calculated using detailed numeric values, then rounded to the nearest thousand in the units displayed. As a result, multiplying a displayed impact by its monetization factor may not precisely match the displayed monetized value.

[10] Metrics, Tracking and Performance Assessment Working Group, Final Performance Metrics Report – Phase I, as accessed at http://documents.dps.ny.gov/public/Common/ViewDoc.aspx?DocRefId={683D9C82-174A-4CBE-875D-63F29B368903}

[11] https://www.epa.gov/statelocalenergy/state-inventory-and-projection-tool

Table 3-9 shows the air emissions and pollutant impacts from demonstration projects. DNV GL monetized CO_2e impacts only. Other pollutant impacts are not monetized since monetization for other pollutants is highly location sensitive, site sensitive, and not easily generalized.

Table 3-9: Avoided Air Emissions and Pollutant Impacts from Demonstration Projects (Annualized)

Impact Metric	Responding Projects with Non-Zero Impacts (n=77)	Annual Program Impact*			
		Estimated Impact	Monetized ($)	90% Confidence Interval	
				Lower Bound	Upper Bound
CO2e (metric tons)	44	7,000	$307,000	$10,069,000	$43,709,000
VOC (grams)	1	1,397,000	NA	NA	NA
CO (pounds)	2	21,000	NA	NA	NA
NO2 (metric tons)	4	<10	NA	NA	NA
PM (metric tons)	1	<1	NA	NA	NA
SO2 (metric tons)	2	<1	NA	NA	NA
Total			**$307,000**		

*Impacts are calculated using detailed numeric values, then rounded to the nearest thousand in the units displayed. As a result, multiplying a displayed impact by its monetization factor may not precisely match the displayed monetized value.

The item below describes the monetization factor for impact metrics in this category:

- Carbon dioxide equivalent (CO2e): Consistent with the Benefit Cost Analysis Framework adopted by the NYS Public Service Commission[12], this analysis used the U.S. Environmental Protection Agency's estimate of the social cost of carbon (SCC) at the 3 percent discount rate.[13] NYSERDA staff provided a spreadsheet that converted EPA's constant 2007$/MT to nominal $/US ton by year, and subtracted the corresponding cost of Regional Greenhouse Gas Initiative (RGGI) compliance. DNV GL used the resulting social cost of carbon net of RGGI compliance cost, in 2018 nominal $/US ton ($37.71) and converted that value to $/MT to produce the monetization value applied: **$41.13/metric ton**.

[12] A description of the DPS methodology is provided in Attachment B of the Order Establishing the Benefit Cost Analysis Framework (issued January 21, 2016 in NYS PSC Case 14-M-0101, Proceeding on Motion of the Commission in Regard to Reforming the Energy Vision).

[13] Interagency Working Group on Social Cost of Greenhouse Gases. (2016). *Technical Support Document: - Technical Update of the Social Cost of Carbon for Regulatory Impact Analysis - Under Executive Order 12866,* Table A-1. United States Government,

Table 3-10 shows the waste management impacts from demonstration projects. Respondents reported only two non-zero waste management impacts, though these impacts occurred more frequently in previous evaluations.

Table 3-10: Waste Management Impacts from Demonstration Projects (Annualized)

Impact Metric	Responding Projects with Non-Zero Impacts (n=77)	Annual Program Impact*			
		Estimated Impact ($)	Monetized ($)	90% Confidence Interval	
				Lower Bound	Upper Bound
Avoided Foam Waste (cubic feet)	1	5,000	$5,000	-$1,000	$11,000
Avoided Protective Packaging Waste (pounds)	1	205,000	$205,000	-$68,000	$478,000
Total			**$210,000**		

* Impacts are calculated using detailed numeric values, then rounded to the nearest thousand in the units displayed. As a result, multiplying a displayed impact by its monetization factor may not precisely match the displayed monetized value.

The items below describe the monetization factor for impact metrics in this category:

- Avoided Foam Waste: DNV GL used the cost per pound of Styrofoam to monetize the impact, assuming a general value of one pound per cubic foot[14]: **$1.00/pound[15]**.
- Avoided Protective Packaging Waste: DNV GL applied the same value to this impact metric: **$1.00/pound**

14 Various sources identify the weight of polystyrene foam to as high as 3.1 pounds per cubic foot while others show values as low as 0.7. For conservative estimates we have assumed one pound per cubic foot.

15 Chandra, M., Kohn, C., Pawlitz, J., & Powell, G. (2016). *REAL COST OF STYROFOAM.* Saint Louis University. Retrieved from https://greendiningalliance.org/wp-content/uploads/2016/12/real-cost-of-styrofoam_written-report.pdf

Table 3-11 shows the remaining non-energy impacts from demonstration projects, categorized as "Other Impacts". DNV GL designed the in-depth interview instrument to gather pre-monetized impacts where possible, and respondents reported the following impacts as such:

- Knowledge Creation
- Labor
- Marketability
- Operations & Maintenance (O&M)
- Product Quality or Reliability

The impacts in the "Other" category had the highest value in aggregate of any demonstration category, despite having a similar number of reported non-zero impacts.

This category contains some metrics with significant monetized impacts, most notably in Knowledge Creation, Marketability, and Product Quality. Reported O&M impacts from demonstration projects appeared relatively low in comparison to others in this category; however, through the volume of replication projects associated with O&M impacts, this category is highly important overall.

Table 3-11: Other Impacts from Demonstration Projects (Annualized)

Impact Metric	Responding Projects with Non-Zero Impacts (n=77)	Annual Program Impact*			
		Estimated Impact	Monetized ($)	90% Confidence Interval	
				Lower Bound	Upper Bound
Grid Access (minutes)	1	3,000	$189,000	$(19,000)	$396,000
Avoided Freight Idle Hours	1	1,000	$2,000	$0	$4,000
Passenger Vehicle Miles	2	1,283,000	$546,000	$(162,000)	$1,255,000
Water Savings (gallons)	1	52,000	<$1,000	$0	$0
Knowledge Creation (dollars)	2	1,367,000	$1,367,000	$223,000	$2,511,000
Labor (dollars)	3	328,000	$328,000	$(68,000)	$723,000
Marketability (dollars)	2	1,324,000	$1,324,000	$(186,000)	$2,833,000
O&M (dollars)	3	400,000	$400,000	$65,000	$734,000
Product Quality or Reliability (dollars)	3	1,235,000	$1,235,000	$94,000	$2,376,000
Water Quality (grams NO2)	1	1,000	NA	NA	NA
Total			**$5,390,000**		

*Impacts are calculated using detailed numeric values, then rounded to the nearest thousand in the units displayed. As a result, multiplying a displayed impact by its monetization factor may not precisely match the displayed monetized value.

The items below describe the monetization factor for impact metrics in this category. Metrics provided by respondents in dollars (knowledge creation, labor, etc) did not require additional monetization.

- Grid Access: DNV GL converted U.S. Department of Defense's value for a day of uninterrupted grid access ($179,087/day) to monetize the impact. Then, DNV GL conservatively cut the value in half to account for poor construct validity between the conversion factor and the true value of grid connection for these projects $**62.18/minute**[16].

[16]Maloney, P. (2018, May 7). *What is the Value of Electric Reliability for Your Operation?* Retrieved from Microgrid Knowledge: https://microgridknowledge.com/power-outage-costs-electric-reliability/

- Freight Idle Hours: DNV GL used U.S. Environmental Protection Agency's (EPA) equivalent freight idle hour to a gallon of diesel and proceeded with EIA's value per gallon of diesel: **$3.11/gallon** (United States Environmental Protection Agency, 2002)[17][18][19].

- Passenger Vehicle Miles: DNV GL adjusted AAA's average cost per mile ($0.57/mile) by the fuel component of that value ($0.14/mile): **$0.43/mile**[20]

- Water Savings: DNV GL converted City of Rochester's price per thousand gallons of water for those that use one million to thirteen million gallons per month ($2.53/thousand gallons) to gallons: **$0.003/gallon**[21]..

- Water Quality (grams NO2): DNV GL did not monetize impacts on water quality due to lack of an appropriate value.

3.1.3.1. Replication Project Impacts (Indirect)

Some demonstration projects succeeded enough that funding recipients replicated them, as summarized in Table 3-12. In total, respondents reported 601 replication projects. Most replications occurred in the Advanced Buildings program (357), followed by the Renewable Optimization and Energy Storage Innovation program (208). Demonstration projects that led to replications received about 12% of the total funding allocated to demonstration projects in the evaluated population.

DNV GL assumes a demonstration project leads to the same set and magnitude of impacts per replication as found from the demonstration project. Respondents had difficulty identifying direct demonstration impacts and any information about replications, let alone separately quantifying the impacts of each replication. Accordingly, the magnitude of demonstration project impacts and the number of replications drive the magnitude of replication impacts. This section presents the calculated impacts from replication projects, annualized, expanded to the population, and monetized.

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[17] United States Environmental Protection Agency. (2002, October). *A Glance at Clean Freight Strategies: Idle Reduction.* Retrieved from https://nepis.epa.gov/Adobe/PDF/P1000S9K.PDF

[18] U.S. Energy Information Administration. (2020, February 24). *Weekly Retail Gasoline and Diesel Prices*. Retrieved from https://www.eia.gov/dnav/pet/pet_pri_gnd_dcus_sny_a.htm

[19] AAA. (2017, August 23). *AAA Reveals True Cost of Vehicle Ownership*. Retrieved from https://newsroom.aaa.com/tag/driving-cost-per-mile/

[20] United States Environmental Protection Agency. (2018, May 10). *Greenhouse Gas Emissions from a Typical Passenger Vehicle*. Retrieved from https://www.epa.gov/greenvehicles/greenhouse-gas-emissions-typical-passenger-vehicle

[21] City of Rochester. (2019, July 1). *Directory of Water Services and Rates*. Retrieved from https://www.cityofrochester.gov/waterrates/

Table 3-12: Respondent Replication Projects and Total Demonstration Project Funding

NYSERDA Program Name	Demonstration Projects	Demonstration Projects with Replications	Reported Replications	Total funding for demonstration projects with any replications
Advanced Buildings	25	7	357	$1,111,533
Clean Transportation	17	2	7	$48,600
Onsite Power	11	3	14	$874,423
Renewable Optimization and Energy Storage Innovation	12	4	208	$1,355,023
Smart Grid Systems and Distributed Energy Integration	12	4	15	$2,898,583
Total	**77**	**20**	**601**	**$6,288,162**

Table 3-13 shows the electricity impacts from replication projects. Nine respondents reported a total of 370 replication projects with electricity savings for a total impact of 25,000 MWh.

Table 3-13: Electricity Impacts from Replication Projects (Annualized)

Impact Metric	Reported Non-zero Impacts (n=77)	Annual Program Impact*			
		Estimated Impact (MWh)	Monetized ($)	90% Confidence Interval	
				Lower Bound	Upper Bound
Electricity Savings	370	25,000	$1,517,000	$522,000	$2,512,000
Total			**$1,517,000**		

*Impacts are calculated using detailed numeric values, then rounded to the nearest thousand in the units displayed. As a result, multiplying a displayed impact by its monetization factor may not precisely match the displayed monetized value.

Table 3-14 shows the power impacts from replication projects. As for the demonstration projects, the aggregated impact from demand reduction remains far below that from power production. Combined, the value of power impacts from replication projects amounts to only 14% of that from demonstration projects.

Table 3-14: Power Impacts from Replication Projects (Annualized)

Impact Metric	Reported Non-zero Impacts (n=77)	Annual Program Impact&			
		Estimated Impact (kW)	Monetized ($)	90% Confidence Interval	
				Lower Bound	Upper Bound
Demand Reduction	2	<1,000	$9,000	$(2,000)	$21,000
Power Production	6	10,000	$301,000	$(41,000)	$644,000
Total			**$311,000**		

*Impacts are calculated using detailed numeric values, then rounded to the nearest thousand in the units displayed. As a result, multiplying a displayed impact by its monetization factor may not precisely match the displayed monetized value.

Table 3-15 shows the fuel impacts from replication projects.

Table 3-15: Fuel Impacts from Replication Projects (Annualized)

Impact Metric	Reported Non-zero Impacts (n=77)	Annual Program Impact*			
		Estimated Impact (MMBtu)	Monetized ($)	90% Confidence Interval	
				Lower Bound	Upper Bound
Diesel	0	0	$0	$0	$0
Gasoline	1	7,000	$153,000	$(46,000)	$352,000
Gasoline eq Hydrogen	0	0	$0	$0	$0
Propane	202	3,000	$101,000	$(10,000)	$212,000
no2 Fuel Oil	1	<1,000	$11,000	$(4,000)	$25,000
no4 Fuel Oil	0	0	$0	$0	$0
LNG	2	1,000	$10,000	$(1,000)	$22,000
Natural Gas	205	16,000	$110,000	$(9,000)	$228,000
Total			**$385,000**		

*Impacts are calculated using detailed numeric values, then rounded to the nearest thousand in the units displayed. As a result, multiplying a displayed impact by its monetization factor may not precisely match the displayed monetized value.

Table 3-16 shows the non-energy-bill financial impacts from replication projects. Again, cost-savings impacts greatly exceed those of revenue generated. As with demonstration project financial impacts, the survey asked respondents to provide "cost savings" and "revenue" values immediately after and separately from the energy impact savings section.

Table 3-16: Financial Impacts from Replication Projects (Annualized)

Impact Metric	Reported Non-zero Impacts (n=77)	Annual Program Impact*			
		Estimated Impact	Monetized ($)	90% Confidence Interval	
				Lower Bound	Upper Bound
Cost-Savings	421	7,751,000	$7,751,000	$2,794,000	$12,708,000
Revenue Generated	5	45,000	$45,000	$5,000	$85,000
Total			**$7,796,000**		

*Impacts are calculated using detailed numeric values, then rounded to the nearest thousand in the units displayed. As a result, multiplying a displayed impact by its monetization factor may not precisely match the displayed monetized value.

Using the same sources as for demonstration projects, DNV GL calculated replication project emissions impacts using the reported electricity and fuel impacts from replication projects. Table 3-17 below itemizes impacts from each energy source, the related source (electricity or fuel) emissions factors, and the total calculated metric tons of CO_2e emissions avoided.

Table 3-17: Replication Projects Calculated Emissions by Source

Impact Source (unit)	Estimated Impact	Emissions Factor	Emissions (MT CO2e)
Electricity (kWh)	24,526,000	0.0005003	12,000
Diesel (gal)	0	NA	0
Gasoline (gal)	56,000	0.0086205	<1,000
Propane (gal)	38,000	0.0056381	<1,000
no2 Fuel Oil (gal)	4,000	0.0103150	<1,000
no4 Fuel Oil (gal)	0	NA	0
LNG (MMBtu)	1,000	0.0586000	<1,000
Natural Gas (therms)	154,000	0.0053161	1,000
Natural Gas (Btu)	705,481,000	0.0000001	<1,000
Total			**14,000**

Table 3-18 shows the air emissions and pollutant impacts from replication projects.

Table 3-18: Avoided Air Emissions and Pollutant Impacts from Replication Projects (Annualized)

Impact Metric	Reported Non-zero Impacts (n=77)	Annual Program Impact*			
		Estimated Impact	Monetized ($)	90% Confidence Interval	
				Lower Bound	Upper Bound
CO_2e (metric tons)	781	14,000	$573,000	$51,636,000	$251,421,000
VOC (grams)	1	1,397,000	NA	NA	NA
CO (pounds)	1	20,000	NA	NA	NA
NO2 (metric tons)	151	<10	NA	NA	NA
PM (metric tons)	1	<1	NA	NA	NA
SO2 (metric tons)	151	<10	NA	NA	NA
Total			**$573,000**		

*Impacts are calculated using detailed numeric values, then rounded to the nearest thousand in the units displayed. As a result, multiplying a displayed impact by its monetization factor may not precisely match the displayed monetized value.

No respondents with waste management impacts reported replications.

Table 3-19 shows the Other Impacts from replication projects. The impacts in this category had the highest value in aggregate of any replication or demonstration category and had relatively high counts of reported non-zero impacts. It is worth noting that two demonstration projects that reported a high number of replications led to the bulk of these impacts.

As with demonstration projects, four metrics (O&M, Product Quality, Marketability, and Knowledge Creation) were significant and important drivers not only for Other Impacts, but for impacts overall; O&M impacts from replications has the highest monetized value of any examined in this study.

Table 3-19: Other Impacts from Replication Projects (Annualized)

Impact Metric	Reported Non-zero Impacts (n=77)	Annual Program Impact*			
		Estimated Impact	Monetized ($)	90% Confidence Interval	
				Lower Bound	Upper Bound
Grid Access (minutes)	0	0	$0	$0	$0
Avoided Freight Idle Hours	0	0	$0	$0	$0
Passenger Vehicle Miles	1	1,277,000	$544,000	$(165,000)	$1,253,000
Water Savings (gallons)	10	524,000	$1,000	$0	$2,000
Knowledge Creation (dollars)	208	37,183,000	$37,183,000	$12,502,000	$61,864,000
Labor (dollars)	10	20,000	$20,000	$3,000	$36,000
Marketability (dollars)	5	6,562,000	$6,562,000	$(985,000)	$14,108,000
O&M (dollars)	210	78,797,000	$78,797,000	$11,951,000	$145,643,000
Product Quality or Reliability (dollars)	208	10,389,000	$10,389,000	$1,262,000	$19,517,000
Water Quality (grams NO2)	0	0	$0	$0	$0
Total			**$133,496,000**		

*Impacts are calculated using detailed numeric values, then rounded to the nearest thousand in the units displayed. As a result, multiplying a displayed impact by its monetization factor may not precisely match the displayed monetized value.

3.1.3.2. Return on Investment (ROI)

In total, the demonstration projects returned an estimated $11 million per year , and an additional $144 million per year for the associated replications, resulting in a one year ROI of $3.32 shown in Table 3-20. To indicate the potential total impact,

Table 3-21 shows the total impacts extrapolated over average life scenarios of 1, 3, 5, and 10 years.

Table 3-20: NYSERDA Annual Return on Investment (Alphabetically, by Impact Metric)

Impact Metric Category	Monetized Annual Impact		Annual ROI		
	Demonstration	Replication	Demonstration	Replication	TOTAL
Air Emissions Reduction	$307,000	$573,000	$0.01	$0.01	$0.02
Electricity Impacts	$582,000	$1,517,000	$0.01	$0.03	$0.04
Financial Impacts	$2,156,000	$7,796,000	$0.05	$0.17	$0.21
Fuel Impacts	$497,000	$385,000	$0.01	$0.01	$0.02
Other Impacts	$5,390,000	$133,496,000	$0.12	$2.85	$2.96
Power Impacts	$2,195,000	$311,000	$0.05	$0.01	$0.05
Waste Management	$210,000	$0	$0.00	<$0.01	<$0.01
Total	**$11,337,000**	**$144,077,000**	**$0.24**	**$3.07**	**$3.32**

Table 3-21: Total Monetized Impact for Various Average Project Lives (alphabetically by Impact Metric)

Impact Metric Category	Average Project Life			
	One Year	Three Year	Five Year	Ten Year
Air Emissions Reduction	$880,000	$2,641,000	$4,401,000	$8,802,000
Electricity Impacts	$2,099,000	$6,297,000	$10,496,000	$20,991,000
Financial Impacts	$9,952,000	$29,855,000	$49,758,000	$99,517,000
Fuel Impacts	$881,000	$2,644,000	$4,406,000	$8,812,000
Other Impacts	$138,886,000	$416,659,000	$694,431,000	$1,388,862,000
Power Impacts	$2,506,000	$7,518,000	$12,530,000	$25,061,000
Waste Management	$210,000	$629,000	$1,048,000	$2,096,000
Total	**$155,414,000**	**$466,242,000**	**$777,071,000**	**$1,554,142,000**

3.2. Other Findings and Results

3.2.1. Replication Projects

Replication projects accounted for the largest share of the total impact value in the evaluated population due to the total quantity; of 77 respondents only 20 reported replications, but for a total of 601 replication projects. DNV GL used the data available for the quantification and monetization of impacts to explore the factors that affect the likelihood of project replication. This stock of data includes explicit survey responses about reasons for and barriers to replication, as well as the demonstration project tracking data provided by NYSERDA, from which DNV GL extrapolates some findings. No formal modelling was conducted to estimate how the likelihood of replication would change from funding one project or another.

The survey asked respondents to elaborate on the reasons for replication and barriers to replication. Respondents could select multiple reasons and barriers. Table 3-22 and Table 3-23 show the responses to each prompt from the survey respondents. Respondents indicated more total reasons supporting replications than barriers, most commonly indicating the technical experience gained as a motivating reason for replications, but also followed by demonstrable savings. Unsurprisingly, respondents most frequently referenced a lack of resources as a barrier, more than twice as commonly as any other barrier cited.

Table 3-22: Reasons for Replications

Replication Influences	Count of respondents
Demonstrable savings were achieved	12
Financing available	9
Lack of consumer interest	1
Location available	4
Operating conditions were right	10
Requested by building owner	5
Technical expertise gained	24
Willing participants	11
Total Reason Count	**76**

Respondents were able to provide more than one response.

Table 3-23: Barriers to Replications

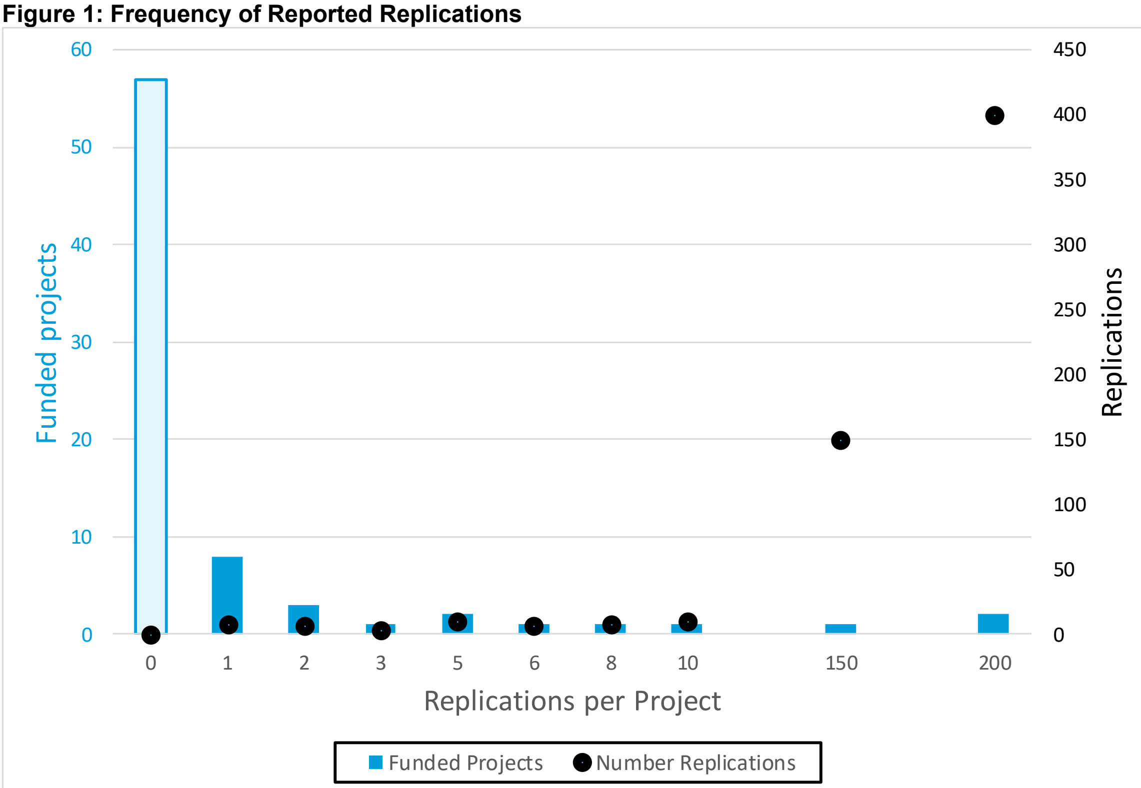
Replication Barriers	Count of respondents
Administrative issues	5
Interconnection costs	3
Lack of consumer interest	3
Lack of resources	14
Location issues	1
Production costs	6
Replicated by others instead	2
Specialization incompatibilities	1
Total Barriers Count	**35**

Respondents were able to provide more than one response.

The informal analysis by DNV GL sought to uncover other, non-reported factors behind demonstration projects that affect the likelihood of replication inherent in project data. Some potentially important factors from the exploration include the type of project, classified either through the program name or the project type from the survey, and the project duration. DNV GL found other important factors, as well, such as respondent role, that would not increase the likelihood of replication but would affect the extent to which data collectors obtain full information about replications and their impacts.

Figure 1 shows the different number of replications identified by the respondents. Most projects reported no replications. The most common number of replications (1), for projects that had any, occurred for 8 funded projects, while a few respondents reported substantial numbers of replications: Three projects constitute 90% of all replications.

Figure 1: Frequency of Reported Replications



The classification of demonstration project appears to be related to whether the funding provided will lead to replications. DNV GL uses two classifications of projects. These classifications, project type and program name, come from the survey respondents and the NYSERDA tracking data respectively. Even within a level of classification, the projects vary substantially, which offers one reason to investigate questions about replications more formally in the next evaluation.

Figure 2 breaks down the frequency of reported replications by project type; Figure 3, by program name. The most reported replications come from projects classified as product demonstration, onsite power production, advanced buildings, and renewable optimization and energy storage innovation. Features of individual projects in these classifications may be associated with increased likelihood of replication. Conversely, onsite process improvement, clean transportation, and smart grid projects likely require specific sites, leading to a lower likelihood of replication. Future evaluations or case studies could focus on these characteristics to better identify projects with a greater potential for higher ROI though successful replications.

Figure 2: Frequency of Reported Replication by Project Type

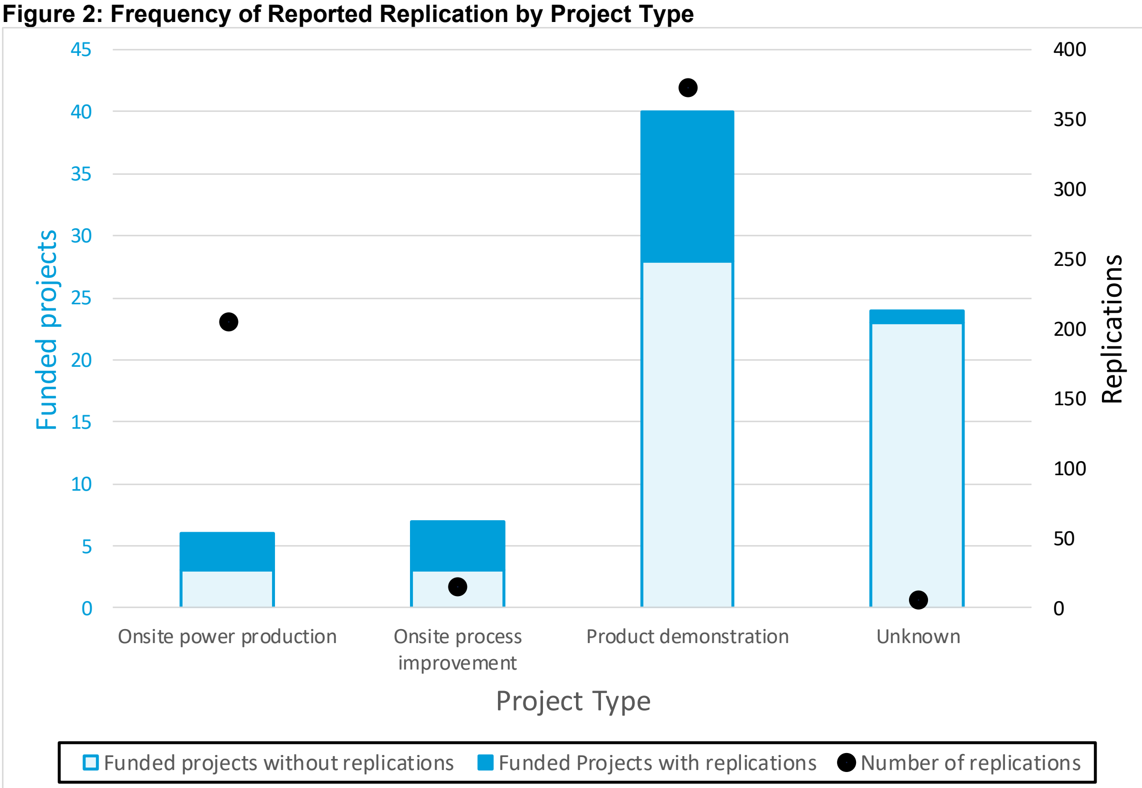
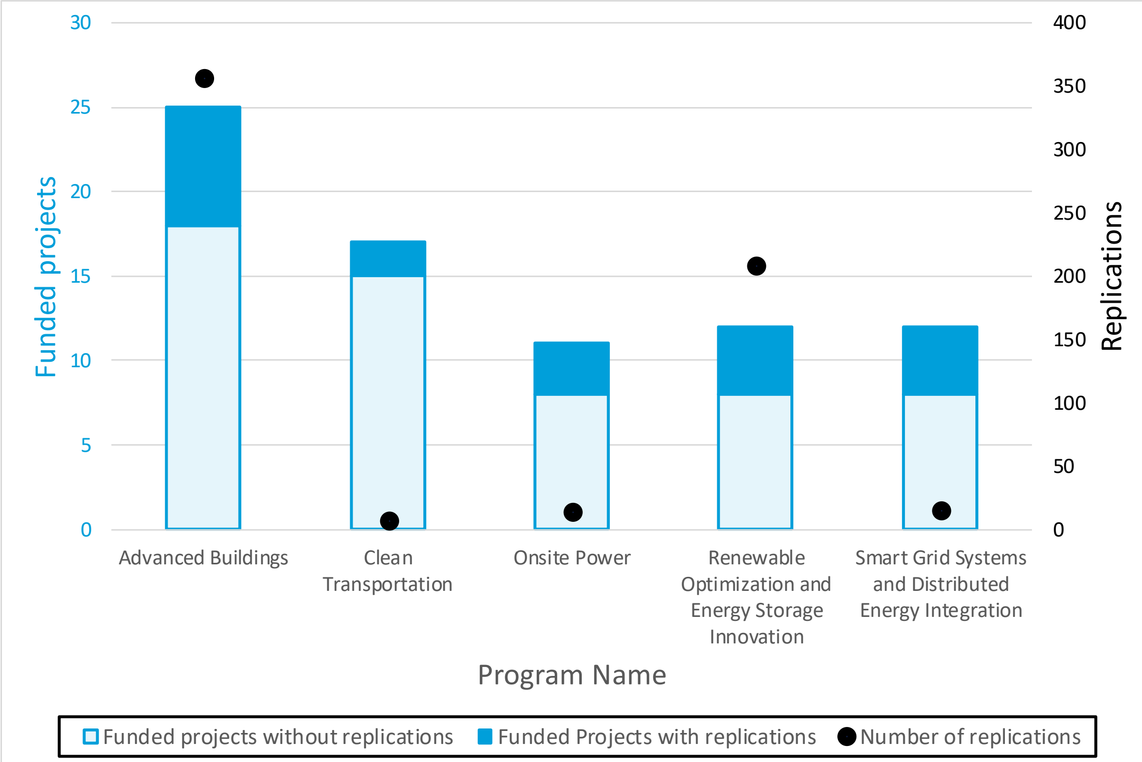
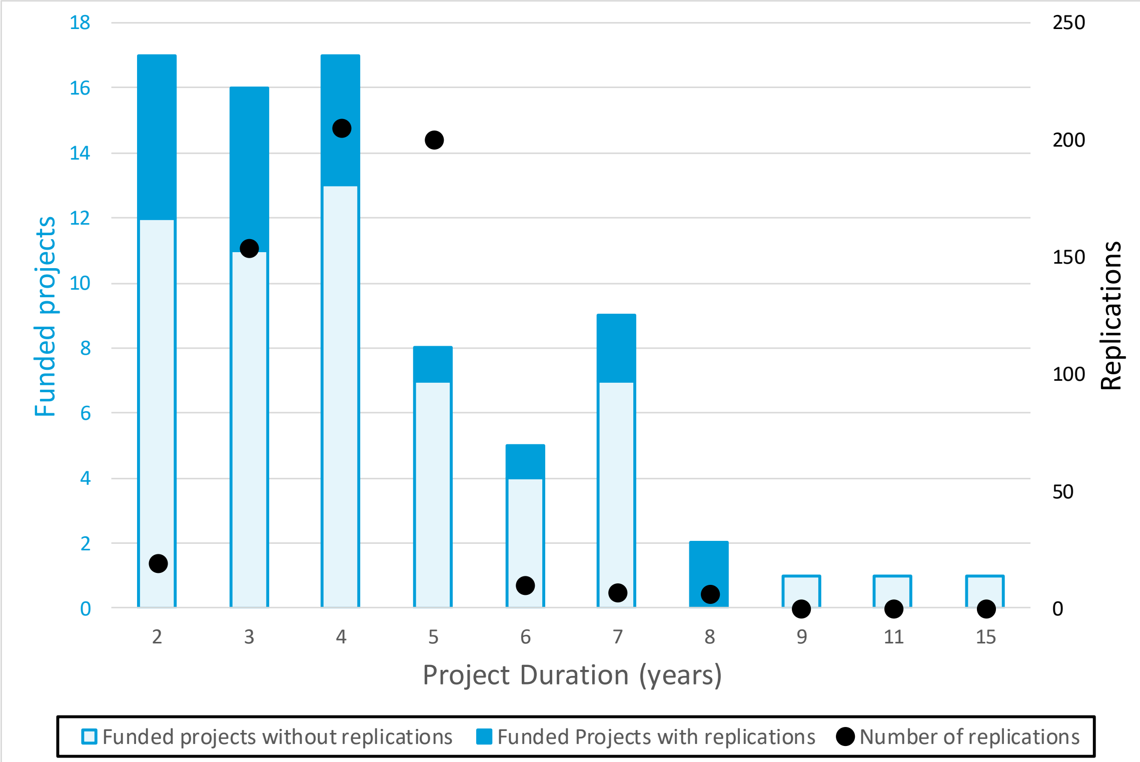


Figure 3: Frequency of Reported Replications by Program Name



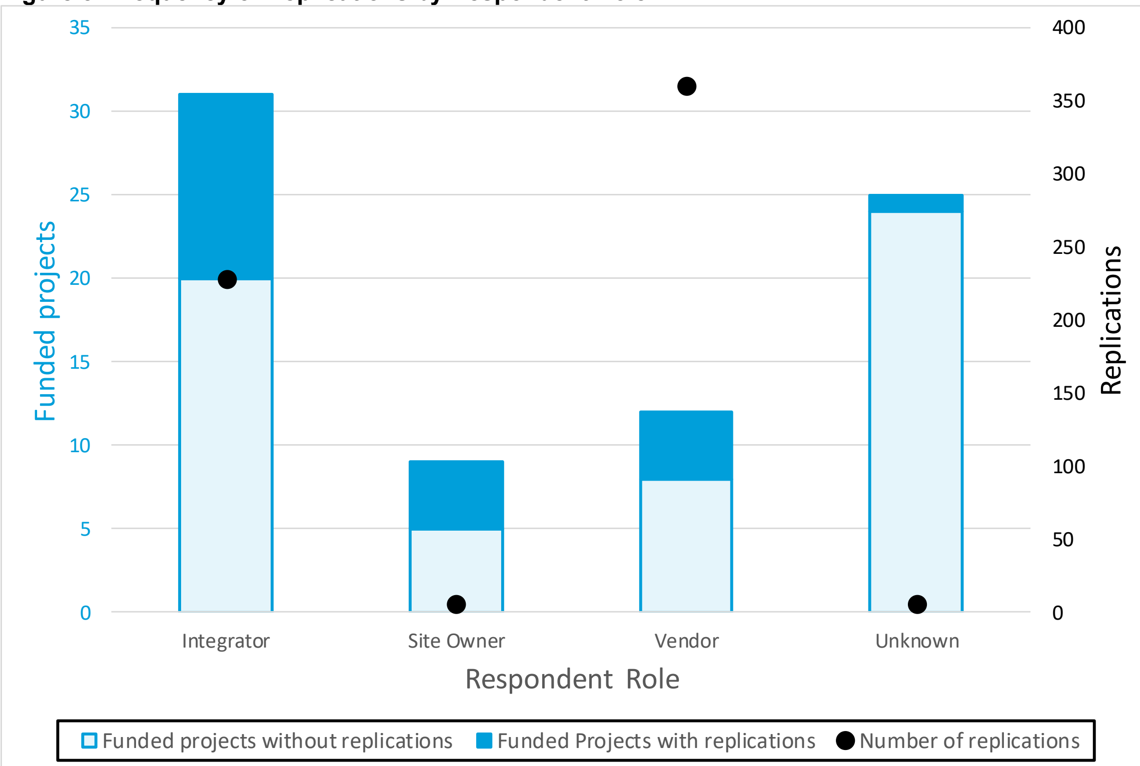
The duration of the project, defined as the time between the project open date and project close date, probably affects the likelihood of replication. Figure 4 shows frequency of reported replications by project duration. Respondents reported the most replications for projects with durations from three to five years. No respondent reported replications for projects with a one-year duration or for any duration longer than eight years. These findings indicate that project duration probably affects the likelihood of replication; one might expect incidence to trend upward with project duration, but it could be that larger duration projects are those that struggled whereas successful projects are proven and replicated within a couple of years. Other project-specific characteristics (for example, level of necessary stakeholder engagement or market trends for project inputs and outputs) may drive project duration.

Figure 4: Frequency of Reported Replications by Demonstration Project Duration



Along with the characteristics of projects that are related to the likelihood of its replication, DNV GL looked at the role of the respondent, a question posed only to the sample of respondents that completed the survey. Figure 5 shows the frequency of replications by respondent role. Compared to the site owners, respondents with the role of integrator or vendor reported more replications. It remains unclear whether respondents with the role of integrator or vendor know of or recall information about replications better than site owners, but a future evaluation might investigate further which respondent roles are most aware of or recall the most about replications. This issue remains important because a respondent who is not aware of or cannot recall replications will likely not report them, even if they occurred.

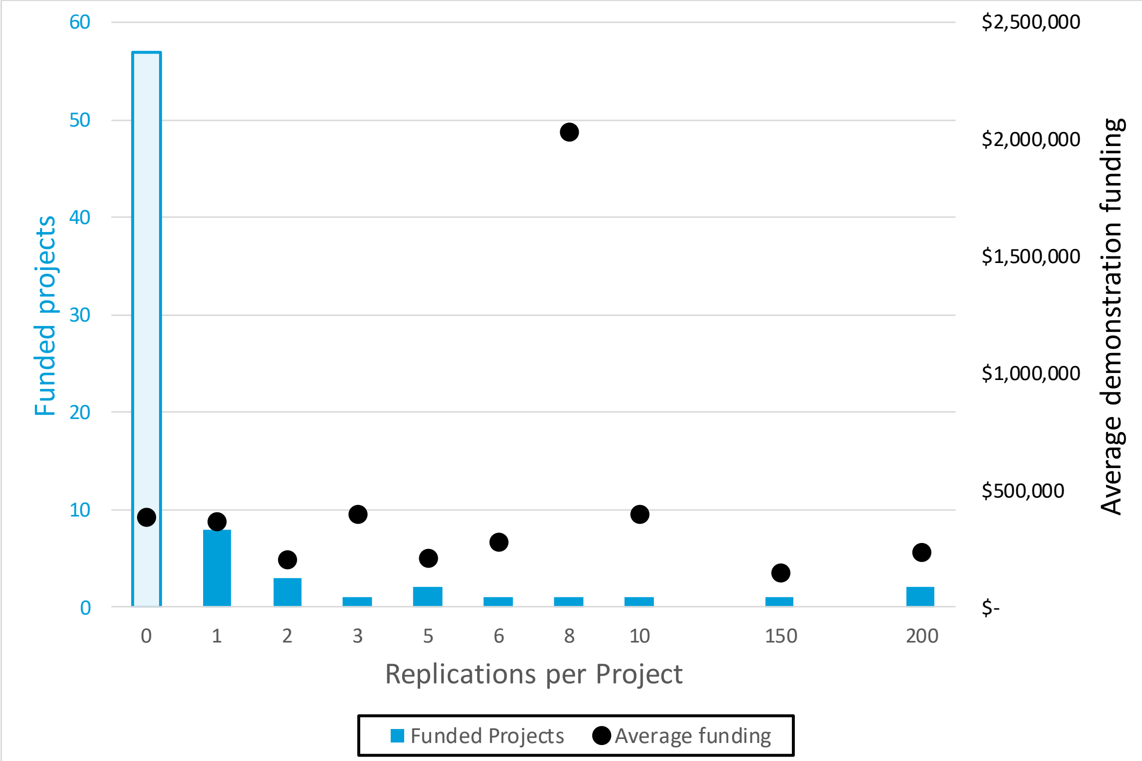
Figure 5: Frequency of Replications by Respondent Role



Finally, DNV GL investigated the average funding provided to achieve different levels of replication, as shown in Figure 6. This table does not indicate any systematic relationship between the likelihood of replications or the quality of replication responses and the funding level. The projects that respondents replicated most received levels of funding slightly below the population average. The top three replicated projects required less NYSERDA funding ($205,652) than the average demonstration project ($385,529), and those with no reported replications ($385,322).

Future evaluations would benefit from planning for a more rigorous approach to learning about replications, including more resources for thorough report reviews, formal modelling of factors that affect the likelihood of replication, and improved methodologies such as focused case studies of projects with high numbers of replications for identifying and calculating replication impacts.

Figure 6: Average Funding Provided to Achieve Different Levels of Replication



3.2.1. NYSERDA Influence

The survey posed questions about NYSERDA's influence, as well. First, it asked respondents about the importance of various influences provided by NYSERDA, including financial, name recognition, and technical assistance. Table 3-24 shows that respondents rated financial assistance as the most important influence, with an average of 4.6 out of 5. Thirty-nine (39) out of forty-nine (49) respondents indicated that financial assistance was 'Very Important'. Respondents rated name recognition and technical assistance as less important, with average scores of 3.3 and 2.5, respectively. These findings indicate that while on average financial assistance was important to the projects, technical assistance was not viewed as important for the average respondent. However, ten respondents did indicate that technical assistance was important to them, indicating that there is a need for this assistance, just not for the majority of projects.

Table 3-24: Importance of NYSERDA Assistance to Demonstration Projects

NYSERDA assistance offered	Very unimportant (0)	1	2	3	4	Very important (5)	Average
Financial Assistance (n=49)	1	1	0	3	5	39	4.6
Name Recognition Assistance (n =49)	6	3	2	12	11	15	3.3
Technical Assistance (n=48)	10	8	3	12	6	10	2.5

Second, the survey asked about the likelihood of demonstration project completion without NYSERDA's assistance. Unlike the numbers reflected in Table 3-24, a higher score in Table 3-25 demonstrates NYSERDA's assistance was less critical to project completion – a low score shows that it was more critical. Respondents indicated they would have not likely completed their projects without Financial Assistance with an average likelihood of completion of only 1.3 out of 5. Name Recognition and Technical Assistance, while not as critical, were shown to be important here – six projects stating that project completion was not likely at all without the technical assistance received. This reaffirms that while technical assistance is not important for every project, it is critical for some.

Table 3-25: Likelihood of Demonstration Project Completion Without NYSERDA Assistance

NYSERDA assistance offered	Not at all likely (0)	1	2	3	4	Very likely (5)	Average
Financial Assistance (n=49)	23	6	11	4	0	5	1.3
Name Recognition Assistance (n=46)	2	3	13	12	5	11	3.1
Technical Assistance (n=45)	6	2	7	6	5	19	3.3

3.3. Recommendations

DNV GL's key findings from this impact evaluation are provided in Table 3-26 below. For clarity and simplicity of adoption, only four primary findings are included.

Table 3-26: Findings

#	Specific Finding	Expanded Finding
1	Replication projects are most important to monetized returns.	Each replication of a demonstration project multiplies the impact of that demonstration project. Projects that have small demonstrable impacts can have very large total impacts if able to be widely replicated. Only 20 out of 77 demonstration project respondents reported project replication, but these replications accounted for impacts several times larger than all direct demonstration impacts combined.
2	Non-Energy Impacts are important.	The largest source of impacts came from indirect and non-energy impacts, especially non-energy impacts for both demonstrations and replications. A whole-impact analysis of projects is important in evaluating potentially impactful projects.
3	Contact information is out of date.	Surveys and interviews were extremely difficult to complete. This occurred for several reasons – some firms had undergone mergers or been acquired, some were out of business, for others the contact person had moved on or retired, with no obvious candidate available to speak to a project that was up to 6 years old.
4	Report gaps	Reports were available for only a fraction of completed projects. In addition, some reports did not contain any information about impacts or project outcomes. Report layout and contents varied widely.

Based on the evaluation findings, DNV GL offers three recommendations in Table 3-27. These recommendations are closely related and will allow for improved evaluation in future cycles. The combination of the first two recommendations to require standardized reporting from all award recipients would allow for a more automated evaluation of program impacts, freeing evaluation resources to examine other priorities, such as in-depth replication case studies.

Table 3-27: Recommendations

Recommendation	Explanation	Related Finding
Mandatory Reporting	Mandatory requirements for reporting is common practice in other public policy spheres. For example, state economic development agencies often require regular reporting for grants, loans, or other financial assistance (tax credits, etc) provided to businesses. Failure to do so can result in default, a required return of funding, or other measures such as fines or penalties if not remedied. NYSERDA currently requires regular metrics reporting for all demonstration projects. In order to ensure reporting completion, rigorous follow-up should be conducted by staff responsible for the contract with awarded demonstration projects, and mandatory reporting should be fully enforced as part of project closeout. It is recognized that post-closeout reporting is often a challenge, but follow up is encouraged at this stage as well, in order to identify full benefits.	3, 4
Standardized & Expanded Reporting	Reporting should be determined based on NYSERDA goals for documenting and evaluating impacts. It is important that reporting account for both direct (demonstration) and indirect (replication) impacts as well as energy and non-energy impacts. The ideal start for that is the instrument for this study which includes all metrics determined to be of interest to NYSERDA at study outset. NYSERDA's current metrics reporting instrument can be refined, as appropriate, based on the results of this evaluation. The evaluation survey instrument can also be expanded as needed to include new metrics or items of interest. For example, questions about the COVID pandemic could be introduced to gauge impact on demonstration or replication projects, if desired by NYSERDA leadership.	1, 2, 4
Replication Case Studies	Replications had an impact several times larger than the demonstration projects due to the large number of total replications and the fact that a minority of demonstration projects had substantial benefits. If ROI continues to be an important metric for NYSERDA's innovation efforts, then understanding replications and how to maximize them should be of program and evaluation interest. To do so, case studies can take an in-depth examination to: - Better determine the factors that contribute to a demonstration project being replicated - Identify variations between the replications of a given demonstration project - Identify the factors that contribute to a demonstration project not having successful replications, in spite of otherwise positive indicators NYSERDA currently conducts evaluation case studies that examine the total benefits of successful projects and should continue to do so with the above evaluation objectives in mind.	1, 2

4. Methods

The following section summarizes the methods used to collect and analyze data for sampled measures.

4.1. Data Collection Approach

DNV GL used three stages to survey respondents:

- **Online survey**: DNV GL sent survey invitations to all email addresses in the dataset received from NYSERDA. The evaluation team invited all contacts – up to three times via email – to participate in the online survey.

- **Telephone (in-depth interviews)**: The evaluation team invited those that did not complete the online survey to participate in phone interviews with DNV GL staff regarding non-energy impacts, first by follow-up email and then by phone attempts where available. Participants that completed the online survey were also contacted by phone to clarify items from the survey as well as to report non-energy impacts. DNV GL attempted to make contact up to six times with respondents. When a respondent identified a different individual as the best person to interview, DNV GL attempted to contact that individual as well.

- **Project Reports**: NYSERDA provided reports on some demonstration projects, but reports were not provided or available for the entire population of projects. DNV GL's report reviewers gathered information on impact metrics that respondents had reported but not quantified, impact metrics not reported at all, and on replications. In many cases, the only data collected for a project came from a report review.

4.2. Analysis Approach

4.2.1. Impact Selection

DNV GL collected data from several sources. In many cases, the quantity provided for an impact metric came from one source per project, though data collectors found quantities for the same project's impact metric from multiple sources. When this situation occurred, DNV GL applied a hierarchy of data quality to select a single quantity per project's impact metric, where the most reliable value comes from the report review, then from the online survey or the in-depth interviews.

DNV GL assumes all projects have the same set of potential impacts, and that the failure to report a quantity for an impact metric resolves to a quantity of zero for that project's impact metric.

4.2.2. Standardization

Metrics were reported in natural units such as kW, kWh, or gallons. The evaluation team converted the reported values to standard values, listed under values in **Error! Reference source not found.** (MWh, kW, MMBtu, etc).

4.2.3. Expansion

The evaluation team developed weights via post-stratification to account for non-response in the data collection efforts. The team post-stratified by program name and completion year. For each stratum so defined, the expansion weight is the number of demonstration projects in the stratum divided by the number of completes. For this evaluation, DNV GL defines a complete response as a demonstration project that provided information through at least one method of data collection. DNV GL staff applied the weights to the ratio of impacts to NYSERDA funding, then multiplied each ratio by total NYSERDA funding to expand impacts from the complete responses to the population.

4.2.4. Monetization

The evaluation team aggregated the standardized and expanded impacts from their natural units, then proceeded to monetize the impacts. Explanation for monetization of each metric is included in the results Section 3.1 and is summarized here in **Error! Reference source not found.** for ease of reference. Reported project impacts listed were standardized to the units identified in the value column, expanded to the population, totaled by metric, and the metric totals then monetized using the values listed below.

Table 4-1: Monetization factors

Metric	Value	Source (see Appendix D)
Electricity Savings	$61.85/MWh	(NYSERDA, 2020)
Demand Reduction	$29.03/kW	(NYISO, 2020)
Power Production	$29.03/kW	(NYISO, 2020)
Diesel	$22.39/MMBtu	(U.S. Energy Information Administration, 2020)
Gasoline	$22.61/MMBtu	(U.S. Energy Information Administration, 2020)
Gasoline eq Hydrogen	$11.42/MMBtu	(HES Hydrogen, 2019)
Propane	$29.56/MMBtu	(NYSERDA, 2020)
no2 Fuel Oil	$21.49/MMBtu	(NYSERDA, 2020)
no4 Fuel Oil	$20.68/MMBtu	(NYSERDA, 2020)
LNG	$7.93/MMBtu	(United States Energy Information Administration, 2020)
Natural Gas	$6.78/MMBtu	(NYSERDA, 2020)
CO2e		
CO2e ($2007)	$40/MT	(Interagency Working Group on Social Cost of Greenhouse Gases, 2016)
CO2e ($2018)	$43.17/UST	DPS spreadsheet provided by NYSERDA (New York State Department of Public Service, 2016)
Cost of RGGI Compliance ($2018)	$5.86/UST	DPS spreadsheet provided by NYSERDA (New York State Department of Public Service, 2016)
CO2e ($2018), net of RGGI cost	$37.31/UST	DPS spreadsheet provided by NYSERDA (New York State Department of Public Service, 2016)
CO2e ($2018)	$41.13/MT	$37.31/UST converted to $/MT
Avoided Foam Waste	$1.00/cubic foot	(Chandra, Kohn, Pawlitz, & Powell, 2016)
Avoided Protective Packaging Waste	$1.00/pound	(Chandra, Kohn, Pawlitz, & Powell, 2016)
Grid Access	$62.18/minute	(Maloney, 2018)
Avoided Freight Idle Hours	$3.11/hour	(United States Environmental Protection Agency, 2002)
Passenger Vehicle Miles	$0.43/mile	(AAA, 2017)
Water Savings	$0.003/gallon	(City of Rochester, 2019)

4.2.5. Confidence Interval Calculation and Assumptions

The confidence intervals are calculated as follows. Each estimated full-program impact was calculated by multiplying the total program funding F for the category by the ratio R, the impact per dollar of program funding, determined from the responding projects. The standard error of the ratio R was calculated by treating the 77 responding projects as a random sample from all 150 projects in the studied program period, and applying standard formulas for the standard error of a stratified ratio estimator. This calculation essentially assumes that there is no relationship between the likelihood that a project had a response and the magnitude of the impact per dollar that would be observed if the project did respond.

The standard error of the program impact SE(I) is then calculated by multiplying the standard error of the impact per dollar (SE(R)) by the total program funding F. That is,

Program Impact I = F x R

SE(I) = F x SE(R).

The standard error is a measure of the "typical" difference between the estimate and the true population value. The confidence interval is a window that brackets the point estimate, and has a given likelihood of including the true value. The report shows 90% confidence intervals, which have a 90% likelihood of including the true full-program value.

The confidence interval is the symmetric interval bounded by the estimated impact $\pm$ t x SE(I), where t is the appropriate t-statistic for a symmetric 90% confidence interval, based on the number of respondents. This confidence interval calculation assumes that the ratio estimator R is approximately normally distributed. Confidence intervals are wider/tighter when the impact per funding dollar is more/less variable across the respondents (including those with positive, negative, and zero impacts for a particular metric), or when there are fewer/more respondents in a particular category.

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