

Agriculture Market Evaluation

Advancing Agriculture Energy Technologies (AAET), Agriculture Technical Services, and Greenhouse Lighting and Systems Engineering (GLASE) Consortium

Baseline Period (2018-2019)

Final Report

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Acronyms and Abbreviations

AAET	Advancing Agriculture Energy Technologies
BIPV	building-integrated photovoltaics
CEA	controlled environment agriculture
CEATF	Clean Energy for Agriculture Task Force
CEF	Clean Energy Fund
CO ₂	carbon dioxide
CO ₂ e	carbon dioxide equivalent
ft	feet
GHG	greenhouse gas
GLASE Consortium	Greenhouse Lighting and Systems Engineering Consortium
GPE	goal prior to exit
HPS	High Pressure Sodium lights
HRV	heat recovery ventilator
HVAC	heating, ventilation, and air conditioning
LED	light-emitting diode
MMBtu	one million British Thermal Units
MW	megawatt
MWh	megawatt-hour
NYS	New York State
NYSERDA	New York State Energy Research and Development Authority
PLC	programmable logic controller
ROI	return on investment
TH	testable hypothesis
VFD	variable-frequency drive
VSD	variable-speed drive
USDA	U.S. Department of Agriculture

Glossary

Controlled environment agriculture (CEA) auxiliary service providers: Individuals who work at a company that provides services or products designed to improve energy efficiency in controlled environment agriculture facilities.

Controlled environment agriculture facilities: A facility that grows crops within an enclosed structure such as a greenhouse or building. The facility can control various variables including the lighting, temperature, carbon dioxide, humidity, and nutrients.

Indirect impacts: Indirect impacts are energy savings and other benefits resulting from measure adoption associated with indirect program influence. In other words, indirect impacts are energy efficiency savings resulting from adoption of technologies or practices because of a NYSERDA initiative but not directly funded by a NYSERDA initiative. An example of an indirect impact from the AAET Initiative would be a farmer seeing a demonstration site (funded through the AAET Initiative) on a neighbor's farm, learning about the demonstration site, and installing the energy efficient technology on her own farm because of the demonstration site. The savings from the energy efficient technology would be indirect impacts.

1 Introduction

The Clean Energy for Agriculture Task Force (CEATF)¹, created by Governor Andrew Cuomo and comprised of leading agricultural organizations, farms, universities, individuals, and state agencies active in the State’s agriculture sector, developed a Strategic Plan that identified numerous strategies to address barriers and assist farms. Based on the strategic initiatives in the Strategic Plan, New York State Energy Research and Development Authority (NYSERDA) developed three major initiatives under the Clean Energy Fund² to aid the agriculture sector:

1. Advancing Agriculture Energy Technologies (AAET)
2. Agriculture Technical Services (includes Best Practices and Agriculture Energy Audits)
3. Greenhouse Lighting and Systems Engineering (GLASE) Consortium

This report presents the methodology and results from the baseline year (2018-2019) market evaluation of NYSERDA’s Agriculture Initiatives. At the time that this study began, these three initiatives were either still in the planning stages or at the beginning of implementing their plans. The baseline year market evaluation assesses market indicators prior to the initiatives ramping up in the market. It is intended to give a snapshot of what the market looks like (e.g., market awareness of energy efficiency technologies, market adoption of energy efficiency technologies) before any intervention by NYSERDA. The baseline year market evaluation is the first step in a longitudinal study to assess the market indicators over time and provides data points for comparison to future years.

1.1 Initiative Description

NYSERDA has three major initiatives designed to aid the agricultural industry, described as follows.³

¹ More information about the Clean Energy for Agriculture Task Force is available at <https://www.nysesda.ny.gov/About/Publications/Clean-Energy-for-Agriculture-Task-Force-Strategic-Plan>.

² More information about the Clean Energy Fund is available at <https://www.nysesda.ny.gov/About/Funding/Clean-Energy-Fund>.

³ Throughout this report, **green** is used for the AAET initiative, **maroon** is used for the Agriculture Technical Services initiative, and **blue** is used for the GLASE initiative.

- **Advancing Agriculture Energy Technologies:**⁴ The goal of the AAET initiative is to “demonstrate advanced, underused, or emerging technologies or processes to illustrate and document the value proposition of technologies for targeted energy use on farms.” The initiative is issuing competitive solicitations for technology vendor and farm teams to demonstrate technologies in the market. The initiative is also developing case studies to share with the market.
- **Agriculture Technical Services:**⁵ This initiative includes two components: Agriculture Energy Audits, which provide comprehensive audits to farmers, and Best Practices, which provide information, tools, and resources to agriculture market.
- **Greenhouse Lighting and Systems Engineering Consortium:**⁶ The GLASE Consortium aims to “target energy-related improvements in greenhouse system operations by optimizing energy efficiency, crop yield and quality.” The initiative involves establishing a consortium and recruiting market actors in the controlled environment agriculture market to become consortium members.

1.2 Summary of Evaluation Objectives and Methods

NYSERDA developed Clean Energy Fund Investment Plans⁷ for each of its initiatives. The Clean Energy Fund Investment Plans include the testable hypotheses⁸, goals prior to exit⁹, and

⁴ Additional details on AAET are located in the *Clean Energy Fund Investment Plan: Agriculture. Portfolio: Market Development*. Matter Number 16-00681, In the Matter of the Clean Energy Fund Investment Plan. Revised November 1, 2017. <https://www.nyserra.ny.gov/About/Funding/Clean-Energy-Fund>

⁵ Additional details on Agriculture Technical Services are located in the *Clean Energy Fund Investment Plan: Multi-Sector Solutions Chapter. Portfolio: Market Development*. Matter Number 16-00681, In the Matter of the Clean Energy Fund Investment Plan. Revised November 1, 2017. <https://www.nyserra.ny.gov/About/Funding/Clean-Energy-Fund>

⁶ Additional details on GLASE are located in the *Clean Energy Fund Investment Plan: Agriculture. Portfolio: Market Development*. Matter Number 16-00681, In the Matter of the Clean Energy Fund Investment Plan. Revised November 1, 2017. <https://www.nyserra.ny.gov/About/Funding/Clean-Energy-Fund>

⁷ More information and links to the Clean Energy Fund Investment Plans are available at <https://www.nyserra.ny.gov/About/Funding/Clean-Energy-Fund>.

⁸ A testable hypothesis is part of the theory of change. It is an if-then statement that states if there is an action, then a result will occur. An example is “If underutilized/emerging energy efficient technologies and processes are identified and proven effective, with guidance on financing, farmers will adopt technologies.”

⁹ A goal prior to exit is a goal that the initiative is trying to reach before the initiative can stop intervening in the market.

indicators¹⁰ for each initiative. The Clean Energy Fund Investment Plans also include the logic model for the initiatives.

The Market Evaluation Team (Navigant) had two objectives: 1) to assess the testable hypotheses, goals prior to exit, and indicators¹¹ for each of NYSERDA’s Agriculture Initiatives, and 2) to estimate the indirect impacts¹² from the initiatives. Table 1 outlines the high-level objectives, purpose, and methods for the market evaluation.

Table 1. Agriculture Market Evaluation Objectives and Methods

Objective	Purpose	Method
Assess the initiatives’ testable hypotheses and goals prior to exit by measuring the related indicators	Estimate effects of intervention on market	Primary data collection ^a : Surveys with: <ul style="list-style-type: none"> • Non-participant farms • Agriculture Energy Audit participants • Non-participant lighting manufacturers • Non-participant controlled environment agriculture auxiliary service providers • Non-participant controlled environment agriculture facilities • Non-participant grocery retailers^b Secondary research ^c : Reviewed 17 sources to provide additional insight on the research questions.
Estimate indirect impacts from the initiatives ^d	Understand the impact the initiatives are having in the market in terms of MWh (megawatt-hour), MMBtu (one million British Thermal Units), and CO2e (carbon dioxide equivalent) emissions reductions	<ul style="list-style-type: none"> • Develop the Indirect Impacts Tool^e • Secondary research • Surveys with Agriculture Energy Audit participants • Surveys with non-participant farms

^a Appendix F details the primary data collection activities.

^b The Market Evaluation Team started the non-participant grocery retailers survey, drafted the survey instrument, identified a sample frame, and completed seven pre-tests. However, the team closed the survey after achieving seven completes due to the GLASE Consortium deciding to no longer include this market actor as a focus. The decision from the GLASE Consortium came after attending a Produce Marketing Association (PMA) conference and realizing that the current benefits of the GLASE Consortium were greater to other groups than to grocery retailers.

^c Appendix G details the secondary research.

¹⁰ An indicator can encompass near-term through longer-term changes in market conditions expected to result from the activities/outputs of an intervention. Outcome indicators will have a baseline value and progress will be measured periodically through Market Evaluation.

¹¹ NYSERDA developed the market progress indicators to track the progress of market adoption and transformation. Measuring the indicator over time shows how the market is changing.

¹² Indirect impacts are energy savings and other benefits resulting from measure adoption associated with indirect program influence. (Source: NYSERDA, “Appendix C. Indirect Benefits Evaluation Framework”). Refer to the Indirect Benefits Evaluation Framework for more information available at <https://portal.nyserra.ny.gov/servlet/servlet.FileDownload?file=00Pt000000HlyBmEAL>.

^d Based on the time the initiatives were in the market, the Market Evaluation Team only estimated indirect impacts from the Agriculture Technical Services – Agriculture Energy Audits this evaluation cycle.

^e Appendix H details the indirect impacts methodology.

The Market Evaluation Team, in partnership with the phone survey contractor APPRISE, completed surveys with market actors (see Table 2 for the market actor groups) to meet the evaluation objectives. This table shows the initiative, the market actor group, and the definition of the respondent that was included in the market actor group. The Market Evaluation Team did not weight the survey responses.

Table 2. Surveys by Market Actor Group

Source: Market Evaluation Team

Initiative	Market Actor Group	Market Actor Respondent
AAET	Non-Participant Farms	A grower or farmer that has not participated in a NYSERDA agriculture program or demonstration site
Agriculture Technical Services	Agriculture Energy Audit Participants	A grower or farmer that has participated in the NYSERDA Agriculture Energy Audit Program under the Clean Energy Fund and transition funding period and it has been over a year since their participation
GLASE Consortium	Non-Participant Lighting Manufacturers	Works for a company that manufactures LED chips, fixtures or lighting controls to controlled environment agriculture facilities
	Non-Participant Controlled Environment Agriculture (CEA) Auxiliary Service Providers	Individual who works at a company that provides services or products designed to improve energy efficiency in controlled environment agriculture facilities
	Non-Participant CEA Facilities	Controlled environment agriculture facility operating in NYS that is not currently a member of the GLASE Consortium
	Non-Participant Grocery Retailers ^a	Grocery retailers that sell produce

^a The Market Evaluation Team started the non-participant grocery retailers survey, drafted the survey instrument, identified a sample frame, and completed seven pre-tests. However, the team closed the survey after achieving seven completes due to the GLASE Consortium deciding to no longer include this market actor as a focus. The decision from the GLASE Consortium came after attending a Produce Marketing Association (PMA) conference and realizing that the current benefits of the GLASE Consortium were greater to other groups than to grocery retailers. The Market Evaluation Team did not analyze the data from these responses.

Table 3 lists the testable hypothesis and goals prior to exit for each initiative, with an emphasis on the focus in the first year of the evaluation (2018-2019). Appendix B contains additional detail on the testable hypotheses, goals prior to exit, indicators, and survey questions for each initiative. This appendix is a summary of a larger Excel table that the Market Evaluation Team developed in order to create survey questions for the indicators. The Excel file was reviewed and approved by NYSERDA and GLASE Consortium staff prior to implementing the surveys. Each question is directly linked to an indicator (e.g., an example indicator is “Number of farmers confident energy efficiency measures shall produce promised benefits” and the corresponding question is “Are you confident that energy efficiency measures deliver on their promised benefits?”).

Table 3. Agriculture Initiatives’ Testable Hypotheses and Goals Prior to Exit

Source: NYSERDA AAET & GLASE Consortium Market Evaluation Research Questions memo (contained in Appendix B)

Initiative	Testable Hypothesis ^a	Goal Prior to Exit (GPE) ^a
AAET	<ul style="list-style-type: none"> TH1: If underutilized/emerging energy efficient technologies and processes are identified and proven effective, with guidance on financing, farmers will adopt technologies. 	<ul style="list-style-type: none"> GPE 1: Reliable market sources compile, develop, and maintain current information on advanced clean energy technologies for use by local information exchange networks. GPE 2: Advanced technologies are installed by farms outside of demonstration projects. GPE 3: Agriculture vendors and suppliers use energy efficiency as a tool to sell their products.
Agriculture Technical Services	<ul style="list-style-type: none"> If end users are provided technical resources, they will have greater confidence and understanding of the value of energy efficiency, leading to projects being implemented. If a customer has a plan showing potential energy savings, project costs, and return on investment (ROI), they will be motivated to choose energy efficiency. 	<ul style="list-style-type: none"> NYSERDA best practice materials are incorporated into other best practice efforts that lack this information (e.g., Cornell Cooperative Extension). List of qualified energy-focused firms is used as a reference and resource by the marketplace without NYSERDA assistance. Consultants, energy service companies, and other energy-focused firms embrace the piloted business models and incorporate these models as a standard service.
GLASE	<ul style="list-style-type: none"> TH1: If greenhouse operators implement technologies to control lighting, ventilation, and carbon dioxide (CO₂) systems, they will save 70% to 86% on electricity. TH2: If the Consortium successfully forms teams with cross-cutting expertise in greenhouse controls then those teams will help growers implement packaged energy solutions. If the Consortium successfully disseminates information, paid memberships will occur, and the Consortium will be self-sustaining. If influential manufacturers and end users are involved in the Consortium as partners/demonstration sites, they will accelerate the adoption of energy efficiency technologies in greenhouses 	<ul style="list-style-type: none"> GPE 1: Availability of products in the market that can reduce electricity costs and result in savings in greenhouses between 70% to 86%. GPE 2: Up to 25% indirect savings from market penetration of control systems and lighting technologies in NY tomato & lettuce greenhouse acreage. The Consortium is self-funded through partnerships, membership fees, fee-based trainings and services, and royalties and licenses of patentable products. Demonstrated electricity savings are achieved through greenhouse system solutions. Up to four hardware and software products and up to three services are commercialized and eight provisional patents are filed by the Consortium by the end of the initiative.

^a For this evaluation year, the Market Evaluation Team focused on the testable hypotheses and goals prior to exit shown in bold colored text. The team focused on these because the initiatives are ramping up in the market and many aspects were not yet ready to assess.

2 Market Characterization and Assessment

This section presents the results of the market evaluation of NYSERDA's Agriculture Initiatives: AAET, Agriculture Technical Services, and the GLASE Consortium. This section includes an agriculture market overview, an agriculture market assessment by initiative, and the indirect impacts resulting from the agriculture initiatives.

2.1 Agriculture Market Overview

The Market Evaluation Team summarized the relevant results from the 2017 Census of Agriculture¹³ to provide an overview of the agriculture market in New York State (NYS) (see Figure 1).

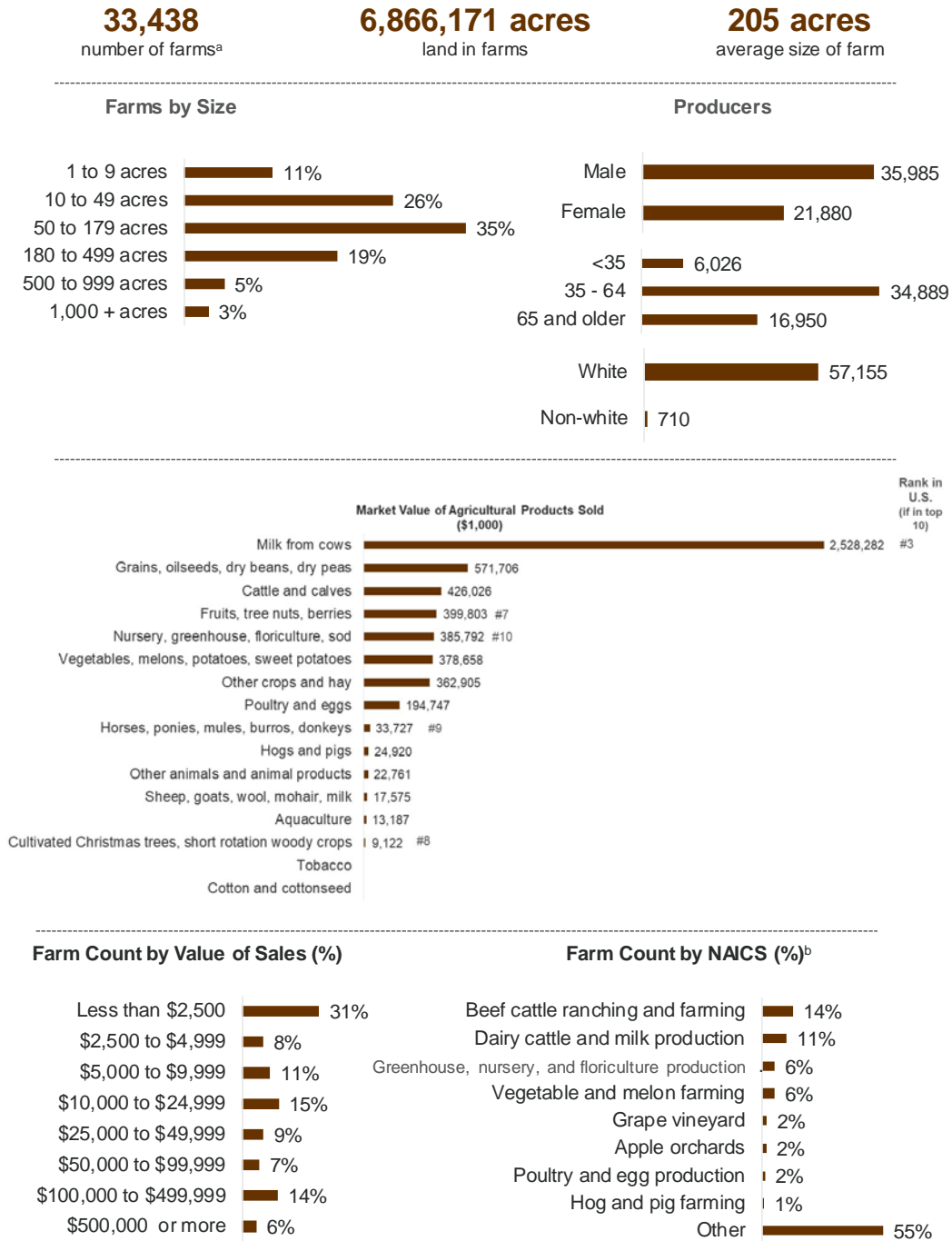
NYS farms also have these attributes:

- 96% are family farms
- 77% have internet access
- 27% hire farm labor
- 17% sell directly to consumers
- 4% farm organically

¹³ U.S. Department of Agriculture, *2017 Census of Agriculture, State Profile, New York*, Available at https://www.nass.usda.gov/Publications/AgCensus/2017/Online_Resources/County_Profiles/New_York/cp_99036.pdf (accessed on September 10, 2019)

Figure 1. New York State Profile from the 2017 Census of Agriculture

Source: U.S. Department of Agriculture, 2017 Census of Agriculture, New York State and County Data, Volume 1, Geographic Area Series, Part 32, AC-17-A-32, Issued April 2019.



^a A farm is defined by the U.S. Department of Agriculture as “any place from which \$1,000 or more of agricultural products were produced and sold, or normally would have been sold, during the year.”

^b Other includes Oilseed & grain farming, other crop farming, sheep & goat farming, aquaculture, other animal production, and other fruit and tree nut farming.

2.2 Agriculture Market Assessment

This section contains the findings on the indicators by initiative, testable hypothesis, and goal prior to exit (see Table 3).¹⁴ Note that the Market Evaluation Team only assessed a subset of all indicators because of the timing of the rollout of the initiatives.

2.2.1 Advancing Agricultural Energy Technologies

The testable hypothesis (TH) for all goals under AAET is the same (**TH 1**): If underutilized/emerging energy efficient technologies and processes are identified and proven effective, with guidance on financing, farmers will adopt technologies. The Market Evaluation Team assessed the **one** testable hypothesis, **three** goals prior to exit (GPEs), and **eight** indicators for AAET. This section is organized by the testable hypothesis and goal prior to exit grouping.

- Table 4 shows the results of the indicators for **GPE 1**: Reliable market sources compile, develop, and maintain current information on clean energy technologies for use by local information exchange networks.
- Thirty-seven percent of non-participant farms have sought out information or training on implementing energy efficient technologies, and a little over one-third (35%) of non-participant farms have heard of NYSERDA's energy audits program.
- Table 6 shows the results of the indicators for **GPE 2**: Advanced technologies are installed by farms outside of demonstration projects.
- Table 7 shows the results of the indicators for **GPE 3**: Agriculture vendors and suppliers use energy efficiency as a tool to sell their products.

Under each table, additional detail and graphics are provided for each indicator.

¹⁴ Appendix A contains findings not directly related to an indicator assessed during this year's evaluation. Appendix B contains additional detail on the market evaluation research questions.

Table 4. AAET Indicators with TH 1 and GPE 1

Source: Market Evaluation Team analysis of Non-Participant Farms survey data

Initiative: AAET				
TH 1: If underutilized/emerging energy efficient technologies and processes are identified and proven effective, with guidance on financing, farmers will adopt technologies.				
GPE 1: Reliable market sources compile, develop, and maintain current information on clean energy technologies for use by local information exchange networks.				
#	Indicator	Question	Sub-Question	Baseline Year (2018-2019) Results
				Market Actor: Non-Participant Farms ^a
TH1-GPE1-I1	List of underutilized or emerging technologies identified	For each type of technology listed below, please indicate if you are aware of that technology.	N/A	Figure 2
		What other energy efficient technologies specific to agriculture are you aware of that were not asked about?	N/A	Table 5
TH1-GPE1-I2	Number of farmers confident energy efficiency measures shall produce promised benefits	On a scale of 1 to 5 with 1 being not confident at all and 5 being very confident, how confident are you that energy efficient technologies like the ones we just discussed live up to each of the following promised benefits?	Improved performance	Figure 3 1: 7% (n=6) [2%–12%] 2: 9% (n=7) [4%–14%] 3: 49% (n=40) [40%–58%] 4: 17% (n=14) [10%–24%] 5: 18% (n=15) [11%–25%]
			Increased reliability	Figure 3 1: 13% (n=11) [7%–19%] 2: 10% (n=8) [5%–15%] 3: 48% (n=39) [39%–57%] 4: 16% (n=13) [9%–23%] 5: 13% (n=11) [7%–19%]
			Operational and maintenance savings	Figure 3 1: 7% (n=6) [2%–12%] 2: 10% (n=8) [5%–15%] 3: 45% (n=38) [36%–54%] 4: 22% (n=18) [15%–30%] 5: 15% (n=12) [9%–22%]
			Energy bill savings	Figure 3 1: 7% (n=6) [2%–12%] 2: 10% (n=8) [5%–15%] 3: 28% (n=23) [20%–36%]

Initiative: AAET				
TH 1: If underutilized/emerging energy efficient technologies and processes are identified and proven effective, with guidance on financing, farmers will adopt technologies.				
GPE 1: Reliable market sources compile, develop, and maintain current information on clean energy technologies for use by local information exchange networks.				
#	Indicator	Question	Sub-Question	Baseline Year (2018-2019) Results
				Market Actor: Non-Participant Farms ^a
				4: 33% (n=27) [24%–42%] 5: 22% (n=18) [14%–30%]
TH1-GPE1-I3	List of perceived barriers and benefits identified by farmers	What benefits do you see with adopting energy efficient technologies?	N/A	Figure 4 Lower energy bills: 92% (n=75) [87%–97%] Lower operational and maintenance costs: 68% (n=56) [60%–76%] Environmental sustainability: 60% (n=49) [51%–69%] Improved equipment reliability: 34% (n=28) [25%–43%] Improved crop quality: 16% (n=13) [9%–23%] Increased crop yield: 11% (n=9) [5%–17%] Other: 9% (n=7) [5%–17%]
		What barriers, if any, do you see with adopting energy efficient technologies?	N/A	Figure 5 Upfront costs: 90% (n=74) [85%–95%] Length of payback period: 68% (n=56) [60%–76%] Performance or reliability of technologies: 42% (n=34) [32%–50%] Time or effort to learn about new technologies: 40% (n=33) [31%–49%] Other: 11% (n=9) [5%–17%]
TH1-GPE1-I4	Number of farmers requesting information or training on implementing energy efficiency and greenhouse gas (GHG) reducing projects	Have you sought out information or training on implementing energy efficient technologies?	N/A	Yes: 37% (n=30) [28%–46%] No: 62% (n=51) [53%–71%] Don't know: 1% (n=1) [0%–3%]

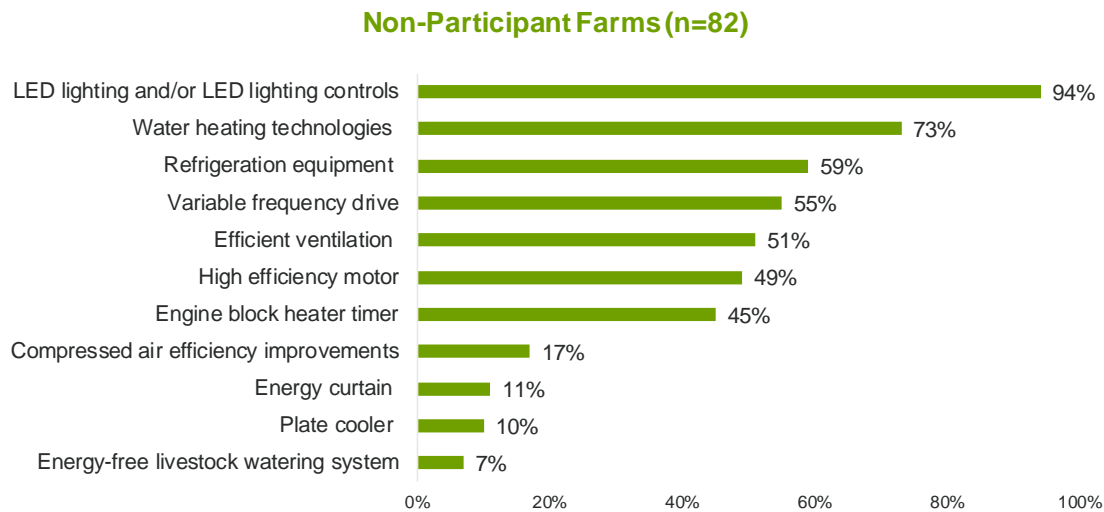
^a The Market Evaluation Team calculated the statistics around survey questions that linked to an indicator. The upper and lower bounds are show in this column in brackets (e.g., [5%–15%]) at a 90% confidence level.

TH1-GEP1-I1: List of underutilized or emerging technologies identified.

Figure 2 shows the awareness of energy efficient technologies by non-participant farms. The Market Evaluation Team provided respondents with a list of 11 technologies and asked if they were aware of each technology. The majority (94%) of non-participant farm respondents are aware of LED lighting and/or LED lighting controls.¹⁵ Seventy-three percent of farms are aware of water heating technologies, 59% of refrigeration equipment, and 55% of variable frequency drives. Table 1 in Appendix A shows the awareness of energy efficient technologies by farm type. As would be expected, farms are less aware or not aware of the technologies that they do not use (e.g., no vineyards are aware of energy-free livestock watering systems because they do not use them).

Figure 2. AAET - For each type of technology listed below, please indicate if you are aware of that technology.^a

Source: Market Evaluation Team analysis of Non-Participant Farms survey data



^a This was a multiple response question, so the total number of answer choices selected can be greater than the number of respondents that answered the question. This can cause the total response percentages to exceed 100%. Percentages represent the proportion of respondents that responded “Yes.” Appendix A includes this question by farm type.

In addition to the pre-defined list, the Market Evaluation Team asked non-participant farms if they were aware of other energy efficient technologies not on the list. Table 5 contains those responses. Renewable technologies were mentioned by many respondents. Photovoltaic/solar was

¹⁵ In the initial program design, the AAET Initiative planned to focus on non-lighting technologies for the demonstration sites. The strategy to focus on non-lighting technologies is consistent with this finding of awareness of energy efficient lighting technologies.

mentioned by 18 respondents, wind by five respondents, and geothermal heating and cooling by four respondents. The non-participant farms are not aware of some underutilized or emerging technologies identified in the secondary research (see Appendix G), like ozone laundry for sterilizing equipment in the dairy sector. These underutilized or emerging technologies that were not mentioned in the survey may be good opportunities for demonstration sites because non-participant farms are not aware of them.

Table 5. AAET - What other energy efficient technologies specific to agriculture are you aware of that were not asked about?^a

Source: Market Evaluation Team analysis of Non-Participant Farms survey data

Technology	Non-Participant Farms (n=82)
Photovoltaic/solar	22% (n=18) [14%–30%]
Wind	6% (n=5) [2%–10%]
Geothermal heating and cooling	5% (n=4) [1%–9%]
Radiant heating	2% (n=2) [0%–5%]
Ag Waste convert to Power, Winery produced CO2 collection and re-use	1% (n=1) [0%–3%]
Anaerobic digestion	1% (n=1) [0%–3%]
Alternative energy	1% (n=1) [0%–3%]
Biogas	1% (n=1) [0%–3%]
Cooling tower for river discharge.	1% (n=1) [0%–3%]
Fuel efficiency	1% (n=1) [0%–3%]
Heat Pumps	1% (n=1) [0%–3%]
Bio-fuel production and use	1% (n=1) [0%–3%]
BIPV (building-integrated photovoltaics)	1% (n=1) [0%–3%]
Burner efficiency	1% (n=1) [0%–3%]
Converting diesel to bio-fuel	1% (n=1) [0%–3%]
Heating chamber insulation	1% (n=1) [0%–3%]
HRV (heat recovery ventilator)	1% (n=1) [0%–3%]
Insulation	1% (n=1) [0%–3%]
Non-friction vacuum pumps	1% (n=1) [0%–3%]
Radiant heated floors	1% (n=1) [0%–3%]
Renewable cooling system of harvesting ice	1% (n=1) [0%–3%]
Simple timers to cycle motors and appliances off for short periods of time	1% (n=1) [0%–3%]
Steam reclamation	1% (n=1) [0%–3%]
Stop start for motors	1% (n=1) [0%–3%]
Systems controls	1% (n=1) [0%–3%]
Vacuum sensor	1% (n=1) [0%–3%]
Woods monitoring systems	1% (n=1) [0%–3%]

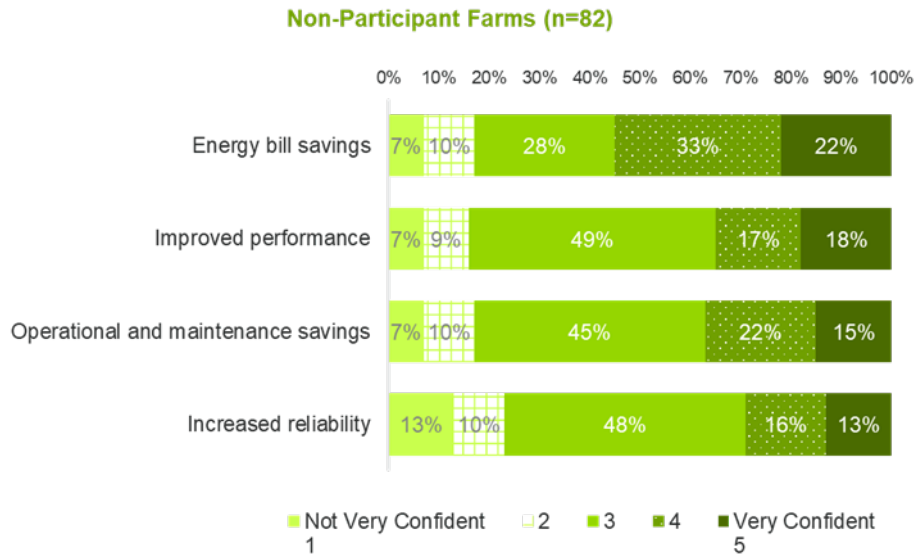
^a This was an open-ended question, so the total number of answer choices provided can be greater than the number of respondents that answered the question. This can cause the total response percentages to exceed 100%. Appendix A includes this question by farm type.

TH1-GEP1-I2: Number of farmers confident energy efficiency measures shall produce promised benefits.

Figure 3 shows the respondents’ confidence in the benefits of energy efficient technologies. Fifty-five percent of respondents felt very confident or confident that energy efficient technologies would produce promised energy bill savings. The remaining 45% of respondents were indifferent to not confident at all that energy efficient technologies would produce promised energy bill savings. For the improved performance, operational and maintenance savings, and increased reliability metrics, the plurality of respondents was neither confident nor not at all confident (i.e., a 3 on a scale of 1-5).

Figure 3. AAET - How confident are you that energy efficient technologies live up to each of the following promised benefits?

Source: Market Evaluation Team analysis of Non-Participant Farms survey data



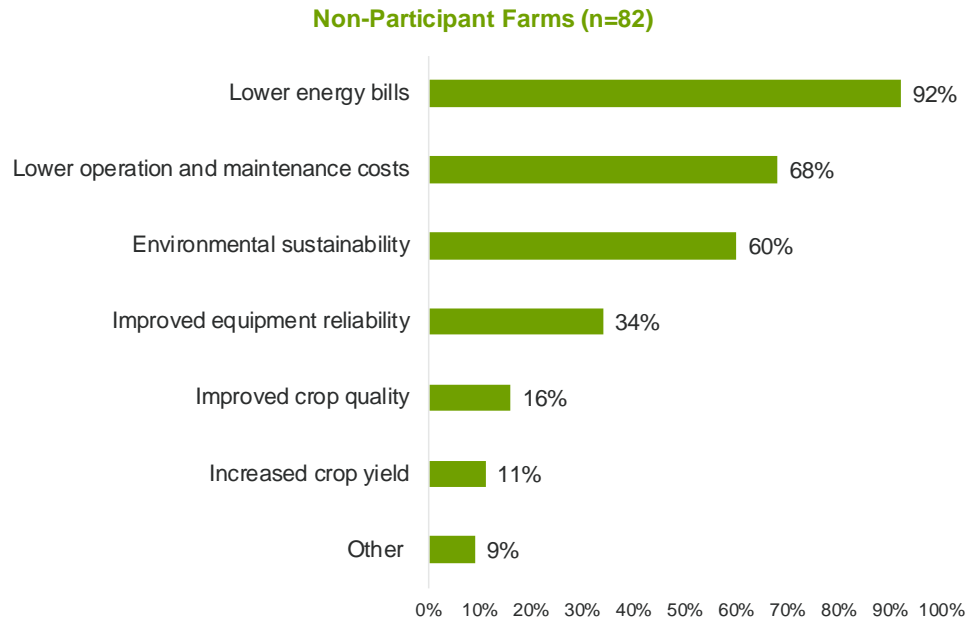
TH1-GEP1-I3: List of perceived barriers and benefits identified by farmers.

Figure 4 shows the benefits and Figure 5 shows the barriers to adopting energy efficient technologies as noted by non-participant farm respondents. For the benefits, the survey provided options and then asked respondents to list others. Ninety-two percent of farmers selected lower energy bills as a benefit to adopting energy efficient technologies; however, only 55% felt very confident or confident they would produce this benefit.

For the barriers, the survey provided options and then asked respondents to note others. Most respondents identified financial barriers. Ninety percent of respondents selected upfront costs as a barrier and 68% of respondents selected length of payback period.

Figure 4. AAET - What benefits do you see with adopting energy efficient technologies?^a

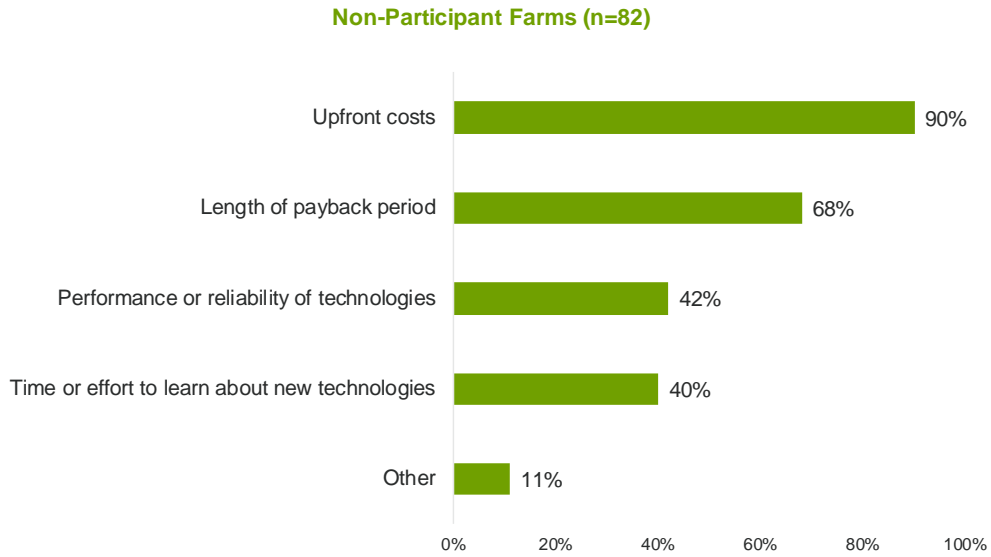
Source: Market Evaluation Team analysis of Non-Participant Farms survey data



^a This was a multiple response question, so the total number of answer choices selected can be greater than the number of respondents that answered the question. This can cause the total response percentages to exceed 100%. Other responses included reliability and climate change mediation.

Figure 5. AAET - What barriers, if any, do you see with adopting energy efficient technologies?^a

Source: Market Evaluation Team analysis of Non-Participant Farms survey data



^a This was a multiple response question, so the total number of answer choices selected can be greater than the number of respondents that answered the question. This can cause the total response percentages to exceed 100%. Other responses included finding local companies that carry and service them and installation issues.

TH1-GPE1-I4: Number of farmers requesting information or training on implementing energy efficiency and GHG reducing projects.

Thirty-seven percent of non-participant farms have sought out information or training on implementing energy efficient technologies, and a little over one-third (35%) of non-participant farms have heard of NYSERDA's energy audits program.

Table 6. AAET Indicators with TH 1 and GPE 2

Source: Market Evaluation Team analysis of Non-Participant Farms survey data

Initiative: AAET			
TH 1: If underutilized/emerging energy efficient technologies and processes are identified and proven effective, with guidance on financing, farmers will adopt technologies.			
GPE 2: Advanced technologies are installed by farms outside of demonstration projects.			
#^a	Indicator	Question	Baseline Year (2018-2019) Results
			Market Actor: Non-Participant Farms
TH1-GPE2-I1	Number of farms outside of demonstration projects installing advanced technologies	This question asks about which energy efficient technologies you may have installed or implemented. For each type of technology, please indicate if you have installed or implemented that technology on any of your agricultural operations or facilities in New York State. Please also include the year that you installed or implemented the technology. If you installed the technology in multiple years, please list each year.	Figure 6
TH1-GPE2-I3	Number of farms outside of demonstration sites knowledgeable of energy efficiency opportunities for underutilized and emerging technologies	For each type of technology listed below, please indicate if you are aware of that technology or are not aware of that technology. ^b	Figure 6

^a The Market Evaluation team did not assess the second indicator for this GPE, TH1-GPE2-I2 (Number of underutilized or emerging technologies by type, implemented as a result of the dissemination of NYSERDA’s informational materials), this evaluation year because NYSERDA had not yet disseminated information materials.

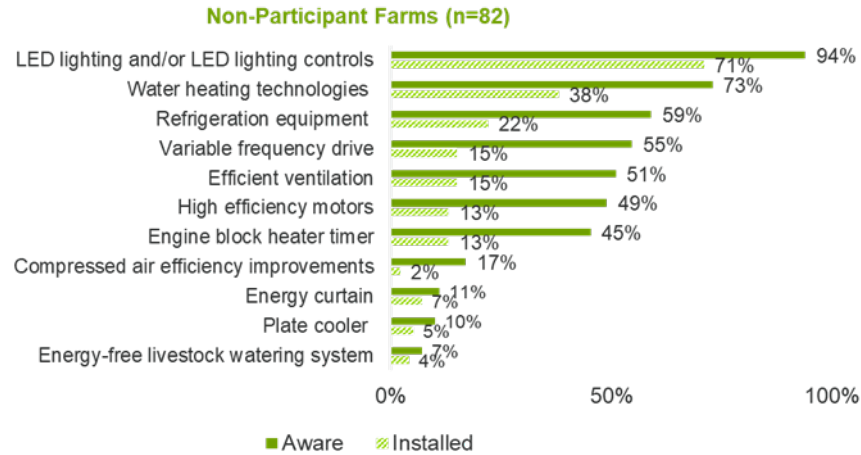
^b This question appears in other locations in the report.

TH1-GPE2-I1: Number of farms outside of demonstration projects installing advanced technologies and TH1-GPE2-I3: Number of farms outside of demonstration sites that are knowledgeable of energy efficiency opportunities for underutilized and emerging technologies

Figure 6 compares a non-participant farm respondent’s awareness to their installation of energy efficient technologies. Ninety-four percent of respondents are aware of LED lighting and/or LED lighting controls, and 71% of respondents have installed LED lighting and/or LED lighting controls. Other technologies had a less than 40% installation rate.

Figure 6. AAET - For each type of technology below, please indicate if you are aware of that technology. Which of the following energy efficient technologies have you installed?^a

Source: Market Evaluation Team analysis of Non-Participant Farms survey data



^a This was a multiple response question, so the total number of answer choices selected can be greater than the number of respondents that answered the question. This can cause the total response percentages to exceed 100%.

Table 7. AAET Indicators with TH 1 and GPE 3

Source: Market Evaluation Team analysis of Non-Participant Farms survey data

Initiative: AAET			
TH 1: If underutilized/emerging energy efficient technologies and processes are identified and proven effective, with guidance on financing, farmers will adopt technologies.			
GPE 3: Agriculture vendors and suppliers use energy efficiency as a tool to sell their products.			
#	Indicator	Question	Baseline Year (2018-2019) Results
			Market Actor: Non-Participant Farms ^a
TH1-GP3-I1 TH1-GP3-I5	Number of farms aware of federal incentives and assistance programs	Which of the financial resources below are you aware of for installing energy efficient technologies in the agriculture sector?	Figure 7 Utility: 48% (n=40) [39%–57%] State: 54% (n=45) [45%–63%] Federal: 31% (n=25) [22%–39%] Other: 4% (n=3) [0%–8%]
TH1-GP3-I2 TH1-GP3-I3 TH1-GP3-I4	Number of farms using external financial resources, including utility programs, to implement energy efficiency measures, process improvements, or advanced technology measures	Have you ever participated in an energy efficiency program or received financial incentives from any of the following sources for an agriculture-related project?	Figure 7 Utility: 31% (n=25) [22%–39%] State: 22% (n=18) [14%–30%] Federal: 16% (n=13) [9%–23%] Other: 1% (n=1) [0%–3%]

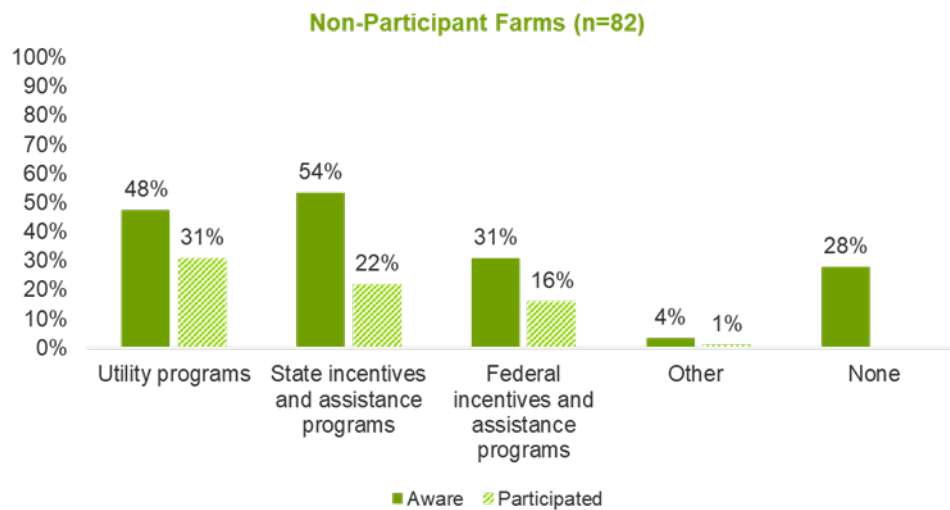
^a The Market Evaluation Team calculated the statistics around survey questions that linked to an indicator. The upper and lower bounds are shown in this column in brackets (e.g., [5%–15%]) at a 90% confidence level.

TH1-GEP3-I1/I5: Number of farms aware of federal incentives and assistance programs and TH1-GEP3-I2/I3/I4: Number of farms using external financial resources, including utility programs, to implement energy efficiency measures, process improvements, or advanced technology measures

Figure 7 compares the percentage of non-participant farm respondents that are aware of financial resources to those that have participated in a program providing financial resources. The majority of non-participant farm respondents (54%) are aware of state incentives and assistance programs, such as programs offered by NYSERDA, while 22% have participated in those programs. Twenty-eight percent of non-participant farm respondents are not aware of any financial assistance programs (represented as None in Figure 7).

Figure 7. AAET - Which of the financial resources below are you aware of for installing energy efficient technologies in the agriculture sector? Have you ever participated in an energy efficiency program or received financial incentives from any of the following sources for an agriculture-related project?^a

Source: Market Evaluation Team analysis of Non-Participant Farms survey data



^a This was a multiple response question, so the total number of answer choices selected can be greater than the number of respondents that answered the question. This can cause the total response percentages to exceed 100%. Percentages represent the proportion of respondents that responded “Yes.” Utility programs include those offered by National Grid, New York State Electric and Gas, Rochester Gas & Electric, Central Hudson Gas & Electric, or Con Edison. State incentives and assistance programs include those such as programs offered by NYSERDA. Federal incentives and assistance programs include those such as the USDA Environmental Quality Incentives Program or USDA Rural Energy for America Program. The question about participation was only asked of those respondents who were aware of a financial assistance program.

2.2.2 Agriculture Technical Services

The Market Evaluation Team did not assess any hypotheses, goals prior to exit, or indicators for Agriculture Technical Services. Appendix A contains additional findings that are not directly related to an indicator. NYSERDA asked the Market Evaluation Team to add questions to the

surveys that were not directly related to an indicator because it would be helpful to the initiative. For example, the survey included questions about the respondent's level of satisfaction with different elements of the Agriculture Energy Audit. This question was not linked to an indicator.

2.2.3 Greenhouse Lighting and Systems Engineering Consortium

The Market Evaluation Team assessed two testable hypotheses, two goals prior to exit, and two indicators for the GLASE Consortium. This section is organized by testable hypothesis and goal prior to exit grouping.

- Table 8 shows the results of the indicators for **TH 1**: If greenhouse operators implement technologies to control lighting, ventilation, and CO₂ systems, they will save 70% to 86% on electricity and **GPE 1**: Availability of products in the market that can reduce electricity costs and result in savings in greenhouses between 70% to 86%.
- Table 11 shows the results of the indicators for **TH 2**: If the consortium successfully forms teams with cross-cutting expertise in greenhouse controls then those teams will help growers implement packaged energy solutions and **GPE 2**: Up to 25% indirect savings from market penetration of control systems and lighting technologies in NY tomato & lettuce greenhouse acreage.

Under each table, additional detail and graphics are provided for each indicator.

Table 8. GLASE Consortium Indicators with TH 1 and GPE 1

Source: Market Evaluation Team analysis of Non-Participant Lighting Manufacturers and Non-Participant Controlled Environment Agriculture Auxiliary Service Providers survey data

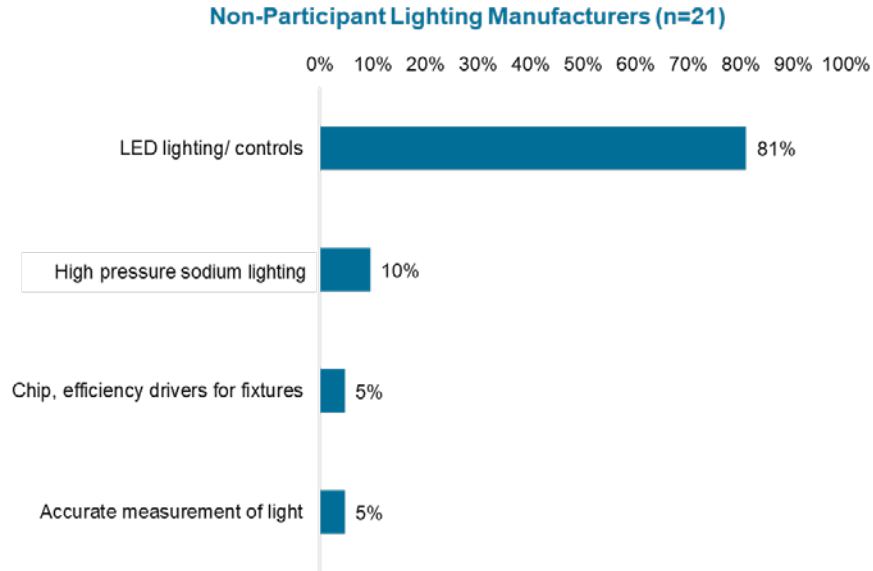
Initiative: GLASE Consortium				
TH 1: If greenhouse operators implement technologies to control lighting, ventilation, and CO ₂ systems, they will save 70% to 86% on electricity.				
GPE 1: Availability of products in the market that can reduce electricity costs and result in savings in greenhouses between 70% to 86%.				
#	Indicator	Question	Baseline Year (2018-2019) Results	
			Market Actor: Non-Participant Lighting Manufacturers	Market Actor: Non-Participant Controlled Environment Agriculture (CEA) Auxiliary Service Providers
TH1-GPE1-I1	Number of products available in the market that can reduce electricity costs and result in savings in greenhouses between 70% and 86%	What products and systems are available in the market? What would you say is the most important lighting technology or system to increase the energy efficiency of greenhouses and other controlled environment agriculture facilities?	Figure 8	Table 9
		What would you say is the most important lighting technology or system to increase the <i>profitability</i> of greenhouses and other controlled environment agriculture facilities?	Figure 9	Table 10

TH1-GPE1-I1: Number of products available in the market that can reduce electricity costs and result in savings in greenhouses between 70% and 86%

Figure 8, Table 9, Figure 9, and Table 10 address this indicator. The responses from the non-participant lighting manufacturers were more consistent; they are grouped and shown in graphical form. Non-participant lighting manufacturers (81%) identified LED lighting/controls as the most important lighting technology to increase the **energy efficiency** of greenhouses and other controlled environment facilities, while 52% identified LED lighting/controls as the most important lighting technology to increase the **profitability** of greenhouses and other controlled environment facilities. The non-participant CEA auxiliary service providers had varying responses.

Figure 8. GLASE Consortium - What would you say is the most important lighting technology or system to increase the energy efficiency of greenhouses and other controlled environment agriculture facilities?^a

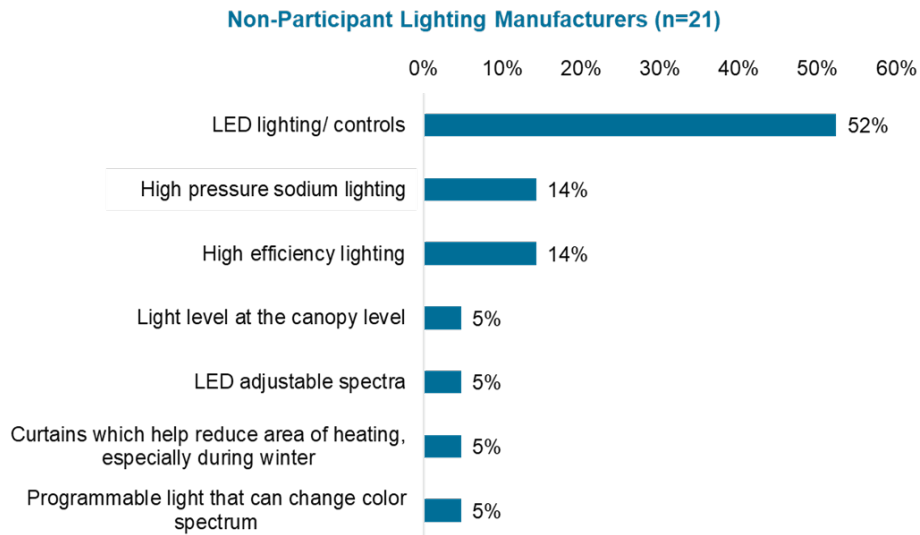
Source: Market Evaluation Team analysis of Non-Participant Lighting Manufacturers survey data



^a This was an open-ended question and some respondents provided more than one answer. Total may exceed 100%.

Figure 9. GLASE Consortium - What would you say is the most important lighting technology or system to increase the profitability of greenhouses and other controlled environment agriculture facilities?^a

Source: Market Evaluation Team analysis of Non-Participant Lighting Manufacturers survey data



^a This was an open-ended question and some respondents provided more than one answer. Total may exceed 100%.

Table 9. GLASE Consortium - What products and systems are available in the market to increase the energy efficiency of greenhouses and other controlled environment agriculture facilities?^a

Source: Market Evaluation Team analysis of Non-Participant Controlled Environment Agriculture Auxiliary Service Providers survey data

Technology	Non-Participant Controlled Environment Agriculture Auxiliary Service Providers (n=39)
No response	21% (n=8)
Automation for temp and humidity control can save 12%-15% of energy cost, CO ₂ control would increase yield, water and fertilizer management program	3% (n=1)
Boilers	3% (n=1)
Cogeneration, gas driven chillers, efficient lighting	3% (n=1)
Controlled heating and cooling, shading, vents	3% (n=1)
Don't know	8% (n=3)
EE fans with VSDs, LED lights, condensing furnaces, dehumidification systems, chillers	3% (n=1)
Electric solar and electric wind	3% (n=1)
Higher efficiency furnaces, heat curtains	3% (n=1)
I think that newer lighting technologies can do this, including networked lighting controls. There are also heating controls available.	3% (n=1)
Latest technologies in cooling systems and heating systems	3% (n=1)
LED lighting, energy curtains, radiant heating systems, more efficient traditional heating systems	3% (n=1)
LED lighting, HVAC improvements	3% (n=1)
LED lighting, instead of high pressure sodium, Hort Americas are the sole distributor GE horticultural lighting products	3% (n=1)
LED lighting, variable speed ventilation with VFD	3% (n=1)
LED lighting, VFDs, ventilation controls, motors, pumps, daylighting controls, moisture control, BMS	3% (n=1)
LED lights, controllers, heat recovery systems, geothermal exchanges	3% (n=1)
LED technologies are more efficient, passive cooling design, wet walls, cogeneration, based on size and scale of the budget	3% (n=1)
Lighting LED, Recirculating systems, irrigation, double boilers, heating strategies using vertical air flow fans.	3% (n=1)
Lighting, controls, fans, VFDs	3% (n=1)
Lighting, infrared film, environmental control, heat curtain/shade cloth, HVAC and dehumidification equipment	3% (n=1)
More efficient LEDs, more efficient HVAC systems, more efficient dehumidifiers	3% (n=1)
Not my area	3% (n=1)
Plant growth LED lighting, chilled water refrigeration systems, energy recovering systems, environmental control systems that optimizes energy consumption in the facility	3% (n=1)
PLC (programmable logic controller) control systems, networking systems, variable frequency drive systems, smart systems	3% (n=1)
Solar	3% (n=1)

Technology	Non-Participant Controlled Environment Agriculture Auxiliary Service Providers (n=39)
T12/T8 fluorescent lights. Controls for lighting. Sub metering.	3% (n=1)
Using systems that work in collaboration with one another to ensure maximum crop yield in the most efficient way possible. Using controllers allows for greenhouses to track their energy consumption, water usage, and allows them to determine the optimal usage of their resources.	3% (n=1)
Variable speed drives, LED lighting	3% (n=1)
Various heating systems, energy curtains, control system itself is operating correctly could save on energy	3% (n=1)

^a This was an open-ended question.

Table 10. GLASE Consortium - What products and systems are available in the market that can increase the profitability of controlled environment agriculture facilities?^a

Source: Market Evaluation Team analysis of Non-Participant Controlled Environment Agriculture Auxiliary Service Providers survey data

Technology	Non-Participant Controlled Environment Agriculture Auxiliary Service Providers (n=39)
No response	21% (n=8)
Advanced greenhouse control systems	3% (n=1)
All products Casella Organics sell, such as calcium, soil amendments	3% (n=1)
Automation, can grow more vegetables on same plant	3% (n=1)
Control systems help increase profitability because you can monitor every aspect of your greenhouse to ensure you're investing the right amount of money in the right aspect of your greenhouse (example. spending the necessary money to have a proper irrigation system)	3% (n=1)
Controlled heating and cooling, shading, vents	3% (n=1)
Controllers, boilers	3% (n=1)
Dissolved oxygen generators, LED lighting, monitoring systems such as sensors (ThirtyMHZ, sensor technology - IoT of greenhouses) to cut cost and use the least amount energy	3% (n=1)
Don't know	5% (n=2)
Electric solar and electric wind	3% (n=1)
Higher yielding plant varieties, cheaper consumable (nutrients), higher quality nutrients that speed up growth, more powerful lights that can improve speed of growth, CO2 enrichment, certain additives that can help plant root growth and nutrient absorption	3% (n=1)
I would also say networked lighting controls and heating controls, which can maximize the proliferation of the plants.	3% (n=1)
Latest technologies in cooling systems and heating systems, new bio-pesticides that are more effective, better fertilizers/substrates	3% (n=1)
LED grow lights, products from following manufactures - PRIVA, Argus, Wadsworth, heat curtains, HVAC - mini splits, chilled water systems, geothermal/heat pumps, dehumidification - standalone dehumidifiers, heat recovery products, economizers	3% (n=1)

Technology	Non-Participant Controlled Environment Agriculture Auxiliary Service Providers (n=39)
LED lighting increasing crop yield, and complete energy management system to control environment to resulting in greater production.	3% (n=1)
LED lighting, energy curtains, radiant heating systems, more efficient traditional heating systems - depending on crops grown and price one can get for it	3% (n=1)
LED lighting, HVAC improvements	3% (n=1)
LED lights, energy efficient HVAC, VSDs (variable-speed drive)	3% (n=1)
Lighting fixtures, drive motors, system controls, controls to avoid peak energy.	3% (n=1)
Lights, controls, VFDs (variable-frequency drive)	3% (n=1)
Not my area	3% (n=1)
Productive equipment, measuring labor usage, weighing harvest goods. Market value to find cost of labor	3% (n=1)
Really understanding your target market and in the planning stages outline key objectives and goals with a proper business plan. having a solid management and leadership team that guides the business from start to harvest	3% (n=1)
Same products depending on the company	3% (n=1)
Smart systems (proprietary software)	3% (n=1)
solar	3% (n=1)
The prior mentioned ones	3% (n=1)
Their lights and aeroponic systems with a controlled way to grow plants without soil and less water	3% (n=1)
Variable speed drives, LED lighting	3% (n=1)
Various table systems with movable table systems that allow for moving products in the greenhouses, computer control systems that can save on labor costs as opposed to individuals	3% (n=1)
Ventilation	3% (n=1)

^a This was an open-ended question.

Table 11. GLASE Consortium Indicators with TH 2 and GPE 2

Source: Market Evaluation Team analysis of Non-Participant Controlled Environment Agriculture Facilities survey data

Initiative: GLASE Consortium			
TH 2: If the consortium successfully forms teams with cross-cutting expertise in greenhouse controls then those teams will help growers implement packaged energy solutions.			
GPE 2: Up to 25% indirect savings from market penetration of control systems and lighting technologies in NY tomato & lettuce greenhouse acreage			
#	Indicator	Question	Baseline Year (2018-2019) Results
			Market Actor: CEA Facilities ^a
TH2-GPE2-I1	Average market penetration of improved technologies in New York greenhouse acreage in the lettuce and tomato sectors	This question asks about which energy efficient technologies you may have installed or implemented in your controlled environment agriculture facilities in New York State. For each type of technology, please indicate if you have installed or implemented that technology in any of your facilities in New York State. Please also include the year that you installed or implemented the technology. If you installed the technology in multiple years, please list each year.	Figure 10 Efficient ventilation 56% (n=29) [45%–67%] Energy curtain 40% (n=21) [29%–51%] LED lighting/ LED lighting controls 38% (n=20) [27%–49%] High efficiency motors 29% (n=15) [19%–39%] Variable frequency drive (VFD) on pumps or fan motors 27% (n=14) [17%–37%] Water heating technologies 27% (n=14) [17%–37%] Refrigeration equipment 21% (n=11) [12%–30%] Engine block heater timer 8% (n=4) [2%–14%] Compressed air efficiency improvements 2% (n=1) [0%–5%] Other 6% (n=3) [1%–11%]
		What is the total canopy area in square feet across all of your controlled environmental agriculture facilities in New York State?	mean=37,674 square feet n=47
		What is the total acreage of controlled environmental agriculture facilities in NYS that grow lettuce or tomatoes?	Tomatoes: 96 acres grown under glass or other protection Other greenhouse vegetables and fresh cut herbs: 28 acres grown under glass or other protection ^b

^a The Market Evaluation Team calculated the statistics around survey questions that linked to an indicator. The upper and lower bounds are show in this column in brackets (e.g., [5%–15%]) at a 90% confidence level.

^b Source: USDA, *2017 Census of Agriculture*, Table 39. Floriculture and Bedding Crops, Nursery Crops, Propagative Materials Sold, Sod, Food Crops Grown Under Glass or Other Protection, and Mushroom Crops: 2017 and 2012. https://www.nass.usda.gov/Publications/AgCensus/2017/Full_Report/Volume_1_Chapter_1_State_Level/New_York/t36_1_0039_0040.pdf

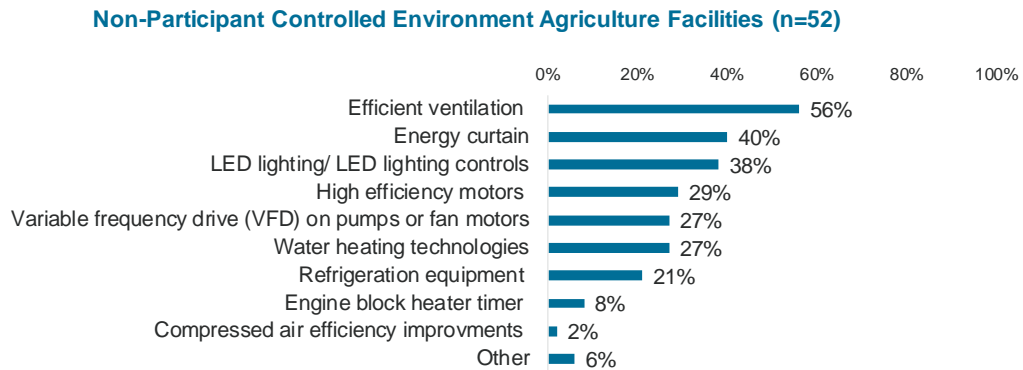
TH2-GPE2-I1: Average market penetration of improved technologies in New York greenhouse acreage in the lettuce and tomato sectors

Non-Participant CEA facility respondents have installed a variety of technologies in their facilities. Figure 10 shows the technologies installed or implemented in NYS for all facilities and

by lettuce and tomato sectors only. Efficient ventilation was the primary technology installed by all facilities and the lettuce and tomato sectors.

Figure 10. GLASE Consortium - For each type of technology, please indicate if you have installed or implemented that technology in any of your facilities in New York State.^a

Source: Market Evaluation Team analysis of Non-Participant Controlled Environment Agriculture Facilities survey data



Category	LED lighting and/or LED lighting controls	Efficient ventilation	Variable frequency drive	High efficiency motors	Engine block heater timer	Refrigeration equipment	Water heating technologies	Energy curtain	Other
Lettuce	10% (n=8)	16% (n=13)	6% (n=5)	9% (n=7)	1% (n=1)	9% (n=7)	6% (n=5)	12% (n=10)	2% (n=2)
Tomatoes	9% (n=7)	20% (n=16)	6% (n=5)	10% (n=8)	1% (n=1)	9% (n=7)	9% (n=7)	16% (n=13)	2% (n=2)

^a This was a multiple response question, so the total number of answer choices selected can be greater than the number of respondents that answered the question. This can cause the total response percentages to exceed 100%. Other responses included biomass wood, hot water boilers, oil boilers, rice coal burner, and solar array.

2.3 Indirect Impacts

Indirect impacts are energy savings and other benefits resulting from measure adoption associated with indirect program influence.¹⁶ In other words, indirect impacts are energy efficiency savings resulting from adoption of technologies or practices because of a NYSERDA initiative but not directly funded by a NYSERDA initiative. An example of an indirect impact from the AAET Initiative would be a farmer seeing a demonstration site (funded through the AAET Initiative) on a neighbor’s farm, learning about the demonstration site, and installing the energy efficient

¹⁶ NYSERDA, “Appendix C. Indirect Benefits Evaluation Framework”. Refer to the Indirect Benefits Evaluation Framework for more information available at <https://portal.nyseda.ny.gov/servlet/servlet.FileDownload?file=00Pt000000HIyBmEAL>.

technology on her own farm because of the demonstration site. The savings from the energy efficient technology would be indirect impacts.

The Market Evaluation Team worked collaboratively with NYSERDA to outline the methodology to assess progress and forecast indirect impacts from NYSERDA's agriculture initiatives.¹⁷ The team only estimated indirect impacts for the Agriculture Energy Audits component of the Agriculture Technical Services initiative in 2019. Agriculture Energy Audits had been conducted since the start of the Clean Energy Fund (CEF), allowing enough time for indirect impacts to accrue.¹⁸

What are indirect impacts from the Agriculture Energy Audits?

Once an audit is conducted through the Agriculture Energy Audits component, EnSave (the program administrator) assists with the installation of measures and application of utility incentives (if applicable). This activity is counted as direct savings. Any additional measures installed outside of this touch point, or after EnSave, are counted towards indirect savings. This activity typically occurs within the second year after the audit has been completed. The Market Evaluation Team worked closely with NYSERDA to define the indirect impacts for this component.

The Market Evaluation Team did not estimate indirect impacts for the other agriculture initiatives for the following reasons:

- AAET: Demonstration sites were not yet established.
- Agriculture Technical Services, Best Practices component: NYSERDA had not yet circulated best practice guides.
- GLASE Consortium: Became active in late 2018, leaving insufficient time to accrue indirect impacts.

For the Agriculture Technical Services, Agriculture Energy Audits component, the market evaluation team captured indirect impacts from participants only above and beyond what was tracked by EnSave¹⁹, both those who installed measures identified in the audit without EnSave administrative assistance and those who installed measures not identified in the audit. The Market Evaluation Team tracked this information through the Agriculture Energy Audit Participants

¹⁷ The indirect impacts methodology is detailed in the Indirect Impact Methodology memo found in Appendix H.

¹⁸ Refer to Appendix H for detail on initiative activity and timeline for measuring market progress and updating the forecast.

¹⁹ EnSave serves as the program administrator for the Agriculture Energy Audits program. Their involvement includes customer outreach, answering questions, and following up with customers for a period of time after the audit.

Survey. Non-participants may go on to install measures attributable to NYSERDA as result of word of mouth (e.g., a neighbor had an audit and shared information). The Market Evaluation Team tracked this information through the non-participant farm survey.

The Market Evaluation Team estimated indirect impacts for the Agriculture Energy Audits component based on findings from the 2019 market evaluation and compared these results to the initial NYSERDA estimates for cumulative savings for each initiative (Table 12). The market evaluation estimate for indirect impacts (cumulative annual) by 2020 is 4,476 MWh, 2,219 MMBtu, and 2,473 CO₂e emissions reductions (metric tons). The market evaluation estimate for 2020 represents indirect impact savings measured in 2019 and forecast for 2020. In 2021 and beyond, the market evaluation estimates also represent forecast values.

Note that the Agriculture Energy Audits and Best Practices are in separate sections in Table 12. Initial NYSERDA estimates for the Agriculture Technical Services initiative were based solely on the Best Practices component; NYSERDA did not estimate impacts for the Agriculture Energy Audits component of the initiative.

Table 12. Indirect Impacts Summary

Sources: NYSERDA Estimates: NYSERDA Solicitation: “Advancing Agriculture Energy Technologies (AAET) & Greenhouse Lighting and Systems Engineering (GLASE),” AAET_GLASE_Technical Services Combined Evaluation lan.docx, sent on December 13, 2017; Market Evaluation Estimates: Market Evaluation Team Indirect Impacts Tool and analysis of Agriculture Energy Audit Participant survey data.

Initiative	Indirect Impact		2020	2025	2030	2020	2025	2030
			NYSERDA Estimates			Market Evaluation Estimates		
AAET	Energy Efficiency	MWh Cumulative Annual	-	1,810	4,020	Not estimated through this evaluation		
		MMBtu Cumulative Annual	-	-	-			
	Renewable Energy	MWh Cumulative Annual	-	-	-			
		MW	-	-	-			
	CO ₂ e Emissions Reduction (metric tons) Cumulative Annual		-	951	2,110			
Agriculture Technical Services (Best Practices)	Energy Efficiency	MWh Cumulative Annual	976	2,307	2,307	Not estimated through this evaluation		

Initiative	Indirect Impact		2020	2025	2030	2020	2025	2030
			NYSERDA Estimates			Market Evaluation Estimates		
		MMBtu Cumulative Annual	484	1,144	1,144			
	Renewable Energy	MWh Cumulative Annual	-	-	-			
		MW	-	-	-			
	CO2e Emissions Reduction (metric tons) Cumulative Annual		540	1,275	1,275			
Agriculture Technical Services (Agriculture Energy Audits)^a	Energy Efficiency	MWh Cumulative Annual	NYSERDA did not estimate indirect impacts for the Agriculture Energy Audits Initiative			4,476	8,953	8,953
		MMBtu Cumulative Annual				2,219	4,438	4,438
	Renewable Energy ^b	MWh Cumulative Annual				-	-	-
		MW				-	-	-
	CO2e Emissions Reduction (metric tons) Cumulative Annual					2,473	4,946	4,946
GLASE Consortium	Energy Efficiency	MWh Cumulative Annual	112,000	278,000	364,000	Not estimated through this evaluation		
		MMBtu Cumulative Annual	-	-	-			
	Renewable Energy	MWh Cumulative Annual	-	-	-			
		MW	-	-	-			
	CO2e Emissions Reduction (metric tons) Cumulative Annual		59,000	146,000	191,000			
Total	Energy Efficiency	MWh Cumulative Annual	112,976	282,114	370,322	4,476	8,953	8,953
		MMBtu Cumulative Annual	484	1,144	1,144	2,219	4,438	4,438
	Renewable Energy	MWh Cumulative Annual	-	-	-	-	-	-
		MW	-	-	-	-	-	-

Initiative	Indirect Impact	2020	2025	2030	2020	2025	2030
		NYSERDA Estimates			Market Evaluation Estimates		
	CO2e Emissions Reduction (metric tons) Cumulative Annual	59,540	148,226	194,385	2,473	4,946	4,946

^a The Market Evaluation Team worked closely with NYSERDA to define the indirect impacts for this component. Once an audit is conducted through the Agriculture Energy Audits component, EnSave assists with the installation of measures and application of utility incentives (if applicable). This activity is counted as direct savings. Any additional measures installed outside of this touch point, or after EnSave, are counted towards indirect savings. This activity typically occurs within the second year after the audit has been completed.

^b Renewable energy savings were not calculated in this evaluation.

3 Findings and Recommendations

This section presents the high-level findings and recommendations from the baseline year (2018-2019) market evaluation of NYSERDA's Agriculture Initiatives: Advancing Agriculture Energy Technologies (AAET), Agriculture Technical Services, and Greenhouse Lighting and Systems Engineering (GLASE) Consortium.

FINDING 1²⁰: Thirty-five percent of non-participant farms have heard of NYSERDA's Agriculture Energy Audits Initiative.

RECOMMENDATION 1 for the Agriculture Technical Services – Agriculture Energy

Audits Initiative: Based on this finding, there is an opportunity to increase awareness of NYSERDA's Agriculture Energy Audits Initiative among farms. Initial ideas of ways to increase awareness include:

- NYSERDA could host farm dinners in regions with low participation in the Agriculture Energy Audits Initiative but a high concentration of farms. These farm dinners could be held at one farm in a region and invite other farms in that same region. They could include a meal and discussion of NYSERDA's energy audits program. These dinners could be held at a farm that has participated in the Agriculture Energy Audits Initiative and has made energy efficiency upgrades to the farm. In this situation, the dinner would also include a tour of the farm and the energy efficient equipment. Alternatively, the farm dinner could be held at a farm that has not participated in the Agriculture Energy Audits Initiative, and the farm dinner could include a mini-audit to show attendees what an audit would entail. These hands-on demonstrations would be valuable to farms' awareness and interest in the audit.
- If not already doing so or not recently done, NYSERDA could advertise the energy audits program by partnering with local and state farm organization such as New York State Agricultural Society, New York Farm Bureau, and Northeast Organic Farming Association of New York (NOFA-NY). These organizations posted the Non-Participant Farms survey link on their social media and newsletters for the market evaluation and thus may be open to a partnership with NYSERDA.

²⁰ Source of Finding: Non-Participant Farms survey shown in Section 2.2.1 in the Final Report under heading "TH1-GPE1-I4: Number of farmers requesting information on training on implementing energy efficiency and GHG reducing projects"

FINDING 2²¹: Nearly 50% of non-participant farms gave a 3 on a scale of 1 to 5 with 1 being not confident at all and 5 being very confident that energy efficiency technologies provide improved performance, operational and maintenance savings, and increased reliability.

RECOMMENDATION 2 for the Agriculture Technical Services – Best Practices Initiative:

NYSERDA should ensure that the already planned best practices guides include detailed and easy to understand information about how energy efficiency technologies lead to improved performance, operational and maintenance savings, and increased reliability, in addition to energy bill savings. NYSERDA could also consider developing case studies on specific farms and energy efficient technologies on those farms, specifically a case study on how particular technologies on a specific farm lead to improved performance, operational and maintenance savings, and increased reliability.

FINDING 3²²: Lighting manufacturers and CEA auxiliary service providers perceive access to CEA facilities as the main benefit of joining the GLASE Consortium. However, CEA facilities²³ are the least aware of and the least interested in the GLASE Consortium. These findings suggest that if the GLASE Consortium can get more CEA facilities to become members, they would attract more lighting manufacturers and CEA auxiliary service providers. Details below.

- Lighting manufacturers and CEA auxiliary service providers perceive access to CEA facilities as the main benefit of joining the GLASE Consortium.
 - 81% of lighting manufacturers noted access to agricultural producers through trade shows and the GLASE Consortium newsletter as a benefit.
 - 20% of CEA auxiliary service providers noted access to GLASE Consortium members, including agricultural producers as a benefit.
- CEA facilities are the least aware of and the least interested in the GLASE Consortium.

²¹ Source of Finding: Non-Participant Farms survey shown in Figure 3 in the Final Report.

²² Source of Finding: Appendix A: Additional Findings, Section A.3 GLASE Additional Findings. This finding and recommendation were noted by the GLASE Consortium following the presentation of evaluation findings and modified slightly by the Market Evaluation Team.

²³ The GLASE Consortium is targeting CEA facilities that use supplemental lighting systems for more than 1 hour per day, are energy intensive, or require an advanced lighting control system. The CEA facilities that responded to the survey were broader than this target (i.e., used various types of lighting for various hours per day).

- 19% of non-participant CEA facilities had heard of the GLASE Consortium compared to 26% of non-participant CEA auxiliary service providers and 57% of non-participant lighting manufacturers.
- 42% of non-participant CEA facilities were interested in participating in free GLASE Consortium initiatives, such as webinars or short courses compared to 64% of non-participant CEA auxiliary service providers and 86% of non-participant lighting manufacturers.

RECOMMENDATION 3 for the GLASE Consortium: This finding leads to a few suggested recommendations:

- The GLASE Consortium should develop a new outreach strategy to connect with more CEA facilities. Having more CEA facilities as part of the Consortium could lead to more interest from lighting manufacturers and CEA auxiliary service providers. The CEA facilities noted the following benefits of the GLASE Consortium were attractive. Therefore, the GLASE Consortium could use these ways to attract them:
 - Access to the GLASE Consortium’s case studies, technical reports, and proof-of-concept trials before they decide on upgrades. The GLASE Consortium could consider strategies such as access to one free resource before being a member to show this group the value.
 - Talk directly to the GLASE Consortium’s horticultural researchers.
 - Leverage the GLASE Consortium’s leading-edge innovations in integrated CO₂, lighting, and shade control systems to save operational costs.
- The GLASE Consortium could also create different tiers of membership fees with different benefits for the CEA facilities. At the time of this study, the membership cost for CEA facilities was one flat fee. With a large range of membership prices and benefits, the GLASE Consortium may be able to attract small, medium and large CEA facilities. The different tiers could be tied to the benefits listed above (i.e., access to resources is one fee while talking to the GLASE Consortium is another fee).

4 Methods

This section provides a high-level overview of the primary data collection methods, secondary research methods, and indirect impacts methods. Additional details are available in the appendices.

4.1 Primary Data Collection Methods

The Market Evaluation Team collected data with market actors through survey efforts. This section outlines the surveys, the respondent profile, and the analysis methods. The appendices contain additional details on the survey efforts.

- Appendix C details the sample design.
- Appendix D provides the final survey instruments.
- Appendix E contains the final postcards used for recruitment.
- Appendix F provides additional details on the survey efforts.

4.1.1 Market Actor Surveys

The Market Evaluation Team, in partnership with the phone survey contractor APPRISE, completed 381 surveys with market actors between October 2018 and August 2019 (see Table 13). Most surveys targeted market actors who had not participated in a NYSERDA agriculture initiative (i.e., non-participants). The exception was for the Agriculture Energy Audit Participants Survey, which targeted farms that had participated in a Agriculture Energy Audit (i.e., participants).

Table 13. Completed Surveys by Market Actor Group

Source: Market Evaluation Team

Initiative	Market Actor Group	Market Actor Respondent	Completed Surveys
AAET	Non-Participant Farms	A grower or farmer that has not participated in a NYSEDA agriculture program or demonstration site	82
Agriculture Technical Services	Agriculture Energy Audit Participants	A grower or farmer that has participated in the NYSEDA Agriculture Energy Audit Program under the Clean Energy Fund and transition funding period and it has been over a year since their participation	180
GLASE Consortium	Non-Participant Lighting Manufacturers	Works for a company that manufactures LED chips, fixtures or lighting controls to controlled environment agriculture facilities	21
	Non-Participant Controlled Environment Agriculture (CEA) Auxiliary Service Providers	Individual who works at a company that provides services or products designed to improve energy efficiency in controlled environment agriculture facilities	39
	Non-Participant CEA Facilities	Controlled environment agriculture facility operating in NYS that is not currently a member of the GLASE Consortium	52
	Non-Participant Grocery Retailers ^a	Grocery retailers that sell produce	7
	Total		381

^a The Market Evaluation Team started the non-participant grocery retailers survey, drafted the survey instrument, identified a sample frame, and completed seven pre-tests. However, the team closed the survey after achieving seven completes due to the GLASE Consortium deciding to no longer include this market actor as a focus. The decision from the GLASE Consortium came after attending a Produce Marketing Association (PMA) conference and realizing that the current benefits of the GLASE Consortium were greater to other groups than to grocery retailers. The Market Evaluation Team did not analyze the data from these responses.

The Market Evaluation Team programmed all surveys using Qualtrics²⁴, an online survey platform. Respondents could complete the survey at their convenience using a link provided via the various outreach methods (e.g., email, postcard, organization’s online post). APPRISE also called contacts and completed the survey over the phone if desired by respondents. APPRISE used the online survey link to complete the survey over the phone. Therefore, all survey responses were collected in the same format via Qualtrics.

The survey process for each survey is detailed in the figures below (Figure 11 - Figure 16). For all surveys, the Market Evaluation Team conducted pre-tests to test the survey outreach scripts and survey instrument. The team adjusted the scripts and survey instruments as needed based on the response and feedback received during the pre-tests.

²⁴ For more information on the Qualtrics platform, see www.qualtrics.com/Survey-Platform/Features

Figure 11. Non-Participant Farms Survey Process

Source: Market Evaluation Team

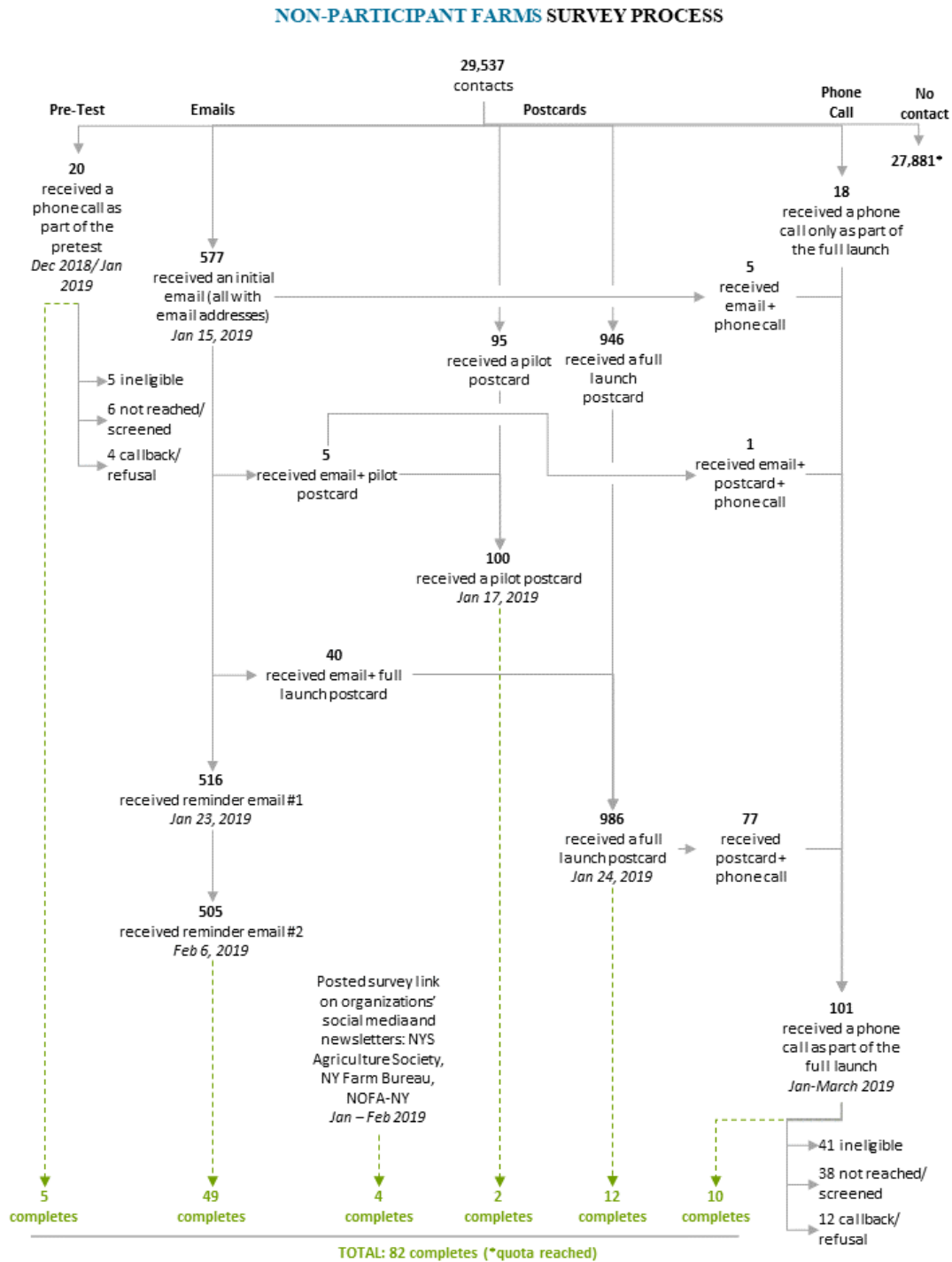


Figure 12. Agriculture Energy Audit Participants Survey Process

Source: Market Evaluation Team

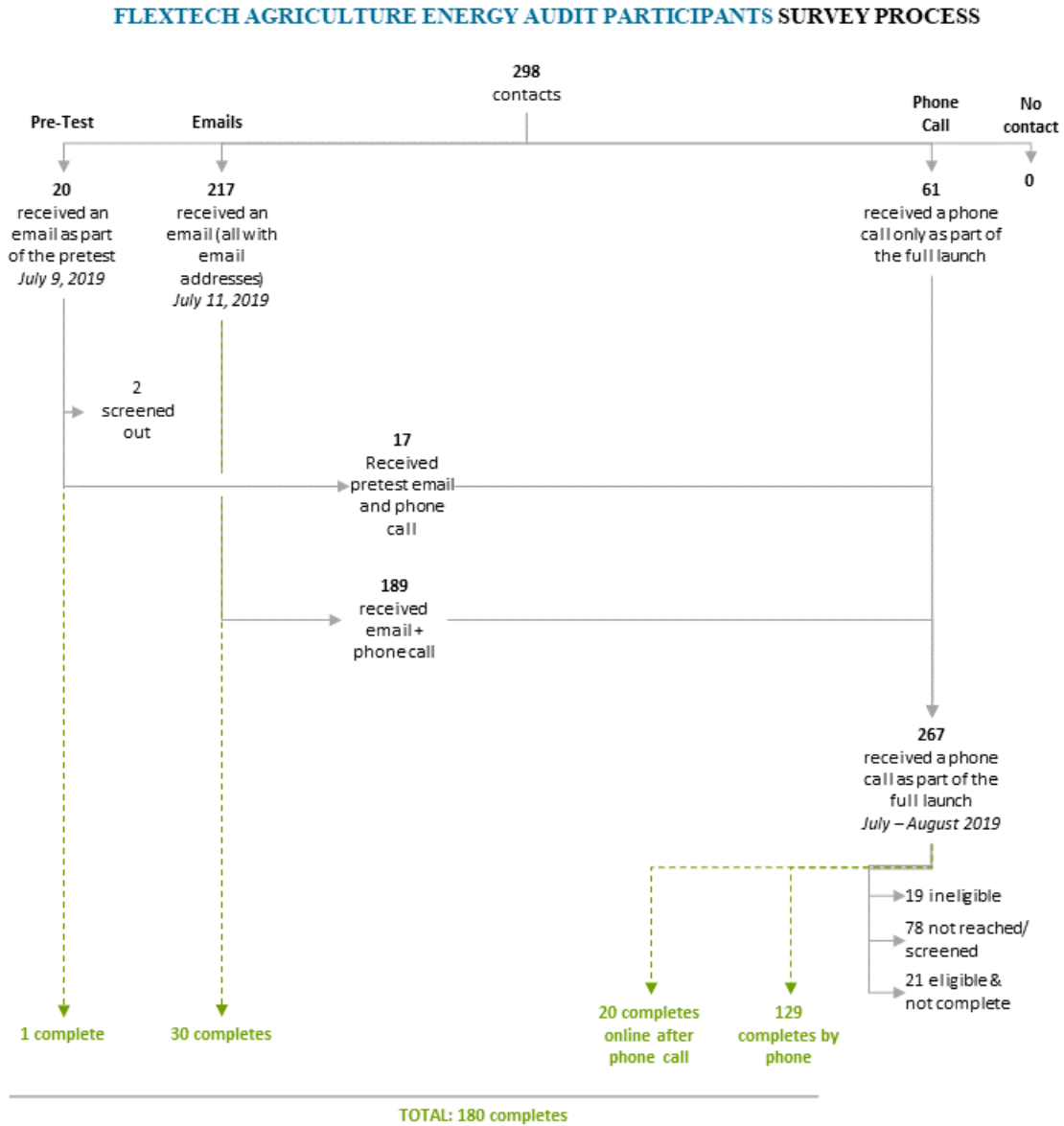


Figure 13. Non-Participant Lighting Manufacturers Survey Process

Source: Market Evaluation Team

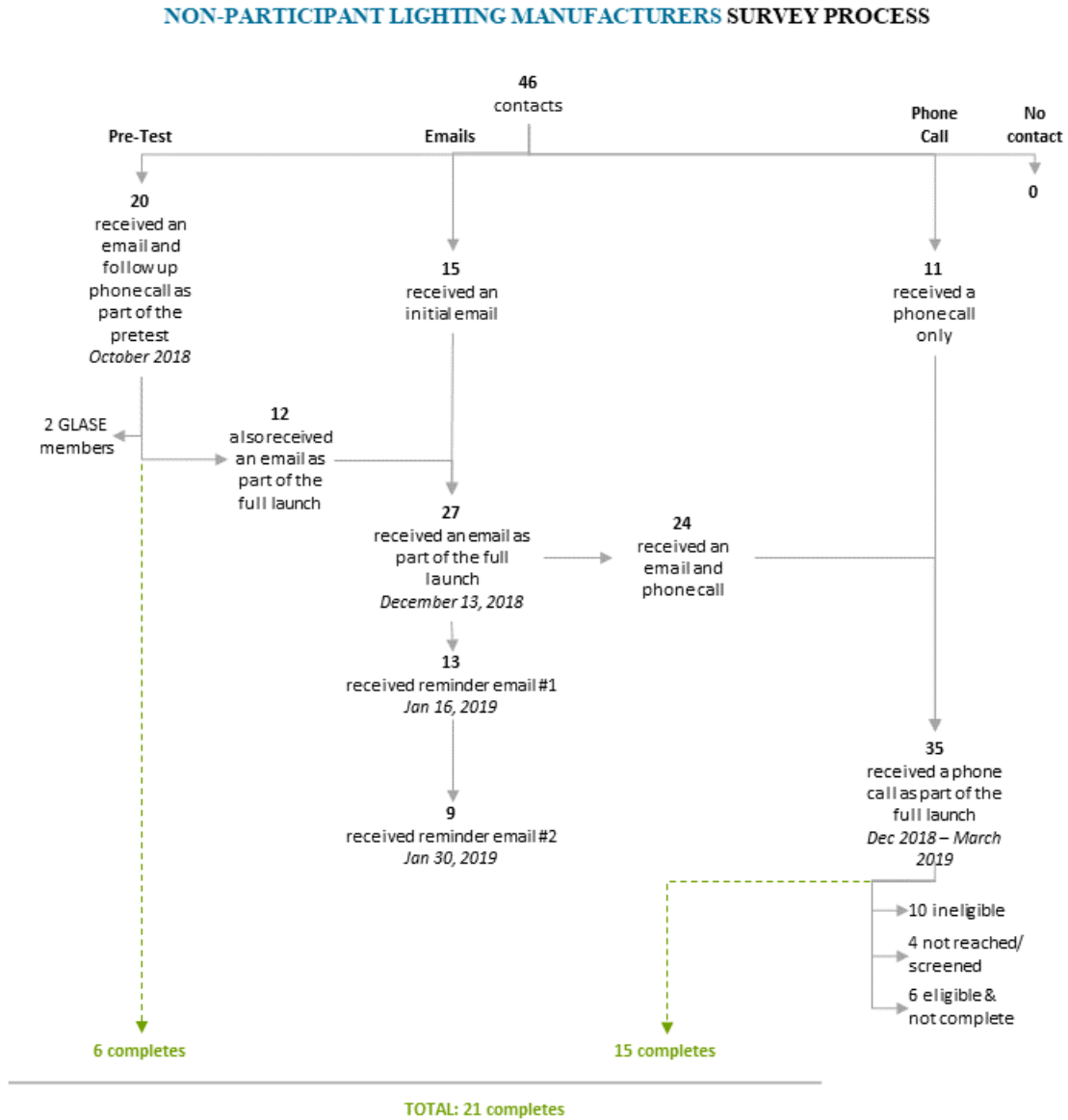


Figure 14. Non-Participant CEA Auxiliary Service Providers Survey Process

Source: Market Evaluation Team

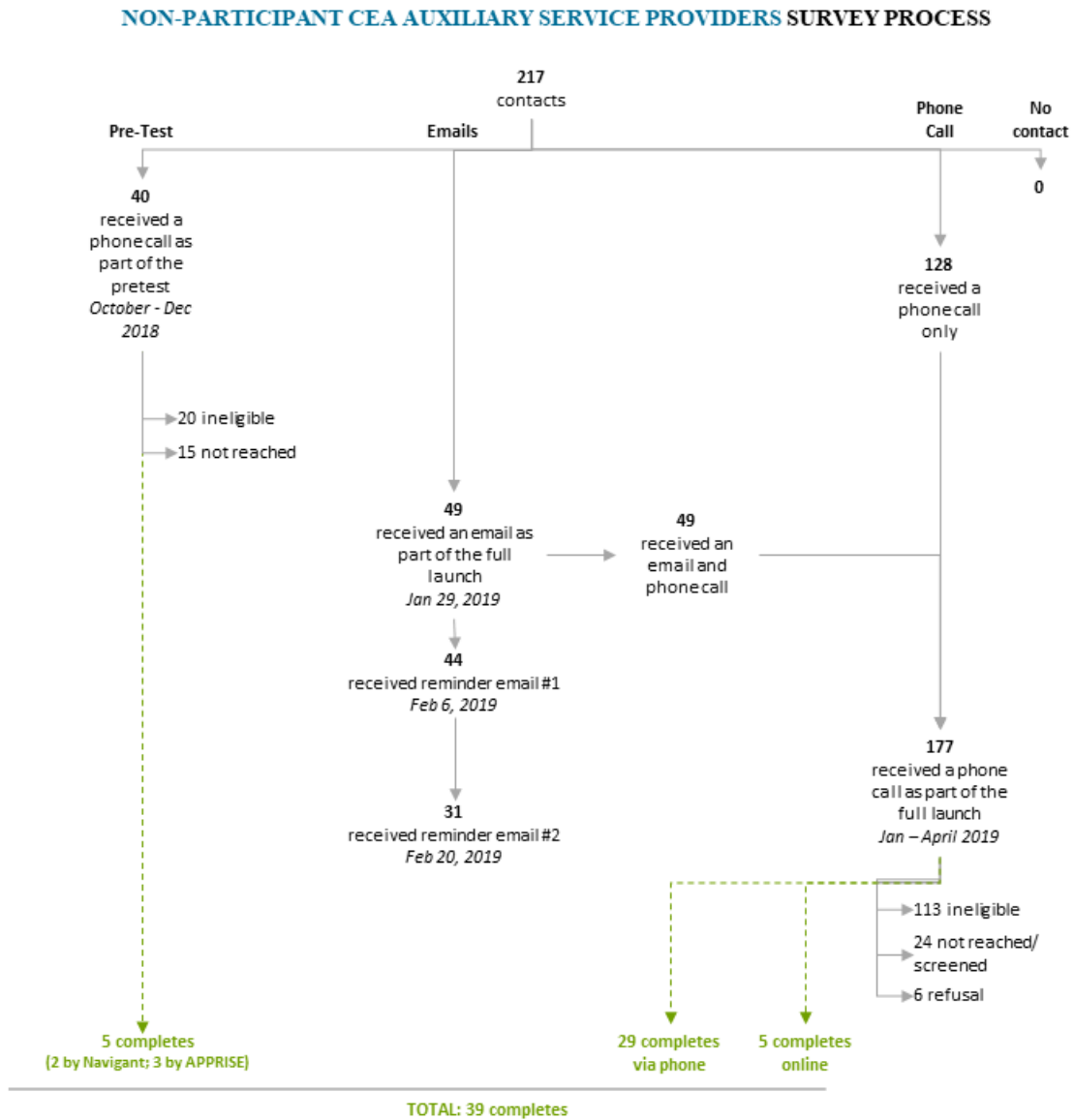


Figure 15. Non-Participant CEA Facilities Survey Process

Source: Market Evaluation Team

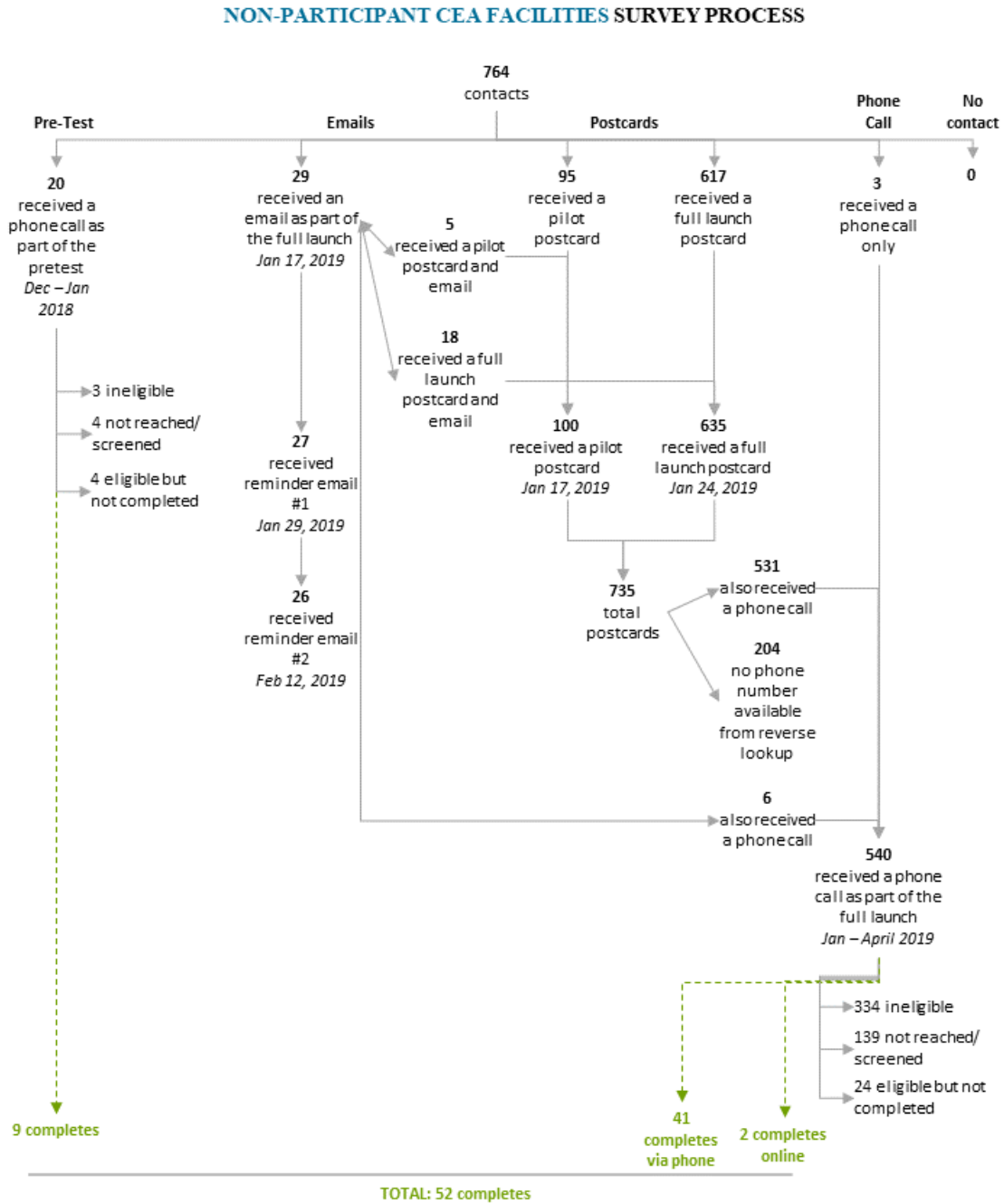
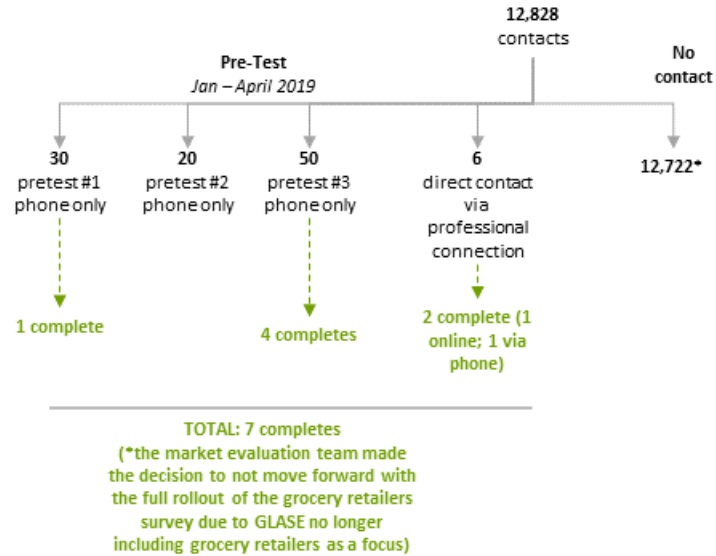


Figure 16. Non-Participant Grocery Retailers Survey Process

Source: Market Evaluation Team

NON-PARTICIPANT GROCERY RETAILERS SURVEY PROCESS



The primary challenge with these survey efforts was identifying a reliable contact list for the non-participant market actors (e.g., identifying companies that provide services to CEA facilities in NYS, identifying appropriate contacts at grocery retailers because they are large and complex organizations, and combining tax data and InfoGroup data for non-participant farms and greenhouses/CEA facilities). Appendix F details challenges with each survey effort.

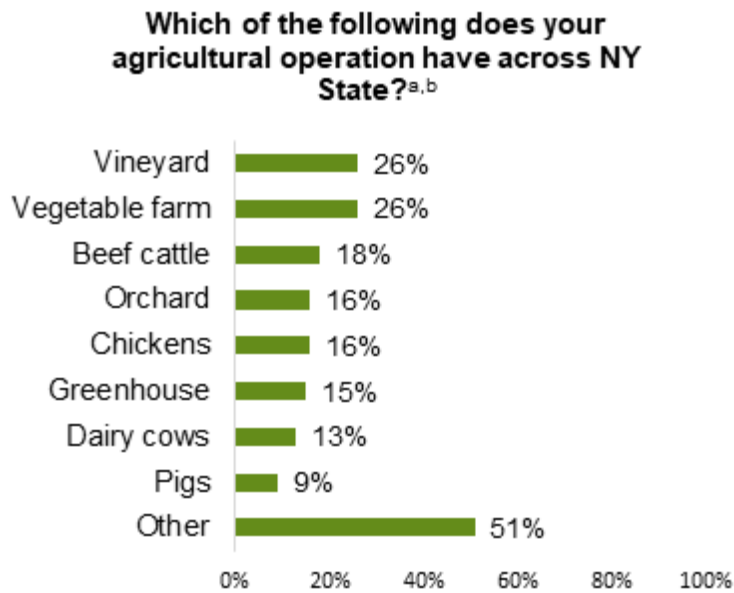
4.1.2 Respondent Profile

This section contains the respondent profile for each of the completed²⁵ surveys.

AAET: Non-Participant Farms Survey (Figure 17): Twenty-six percent of respondents had a vineyard, and 26% of respondents had a vegetable farm. Fifty-one percent of respondents indicated that they had other agriculture operations, which included alpacas, corn, fruit, grain crops, and maple.

Figure 17. AAET: Non-Participant Farms Survey Profile

Source: Market Evaluation Team analysis of Non-Participant Farms survey data



^a Other responses included alpacas, corn, fruit, grain crops, and maple.

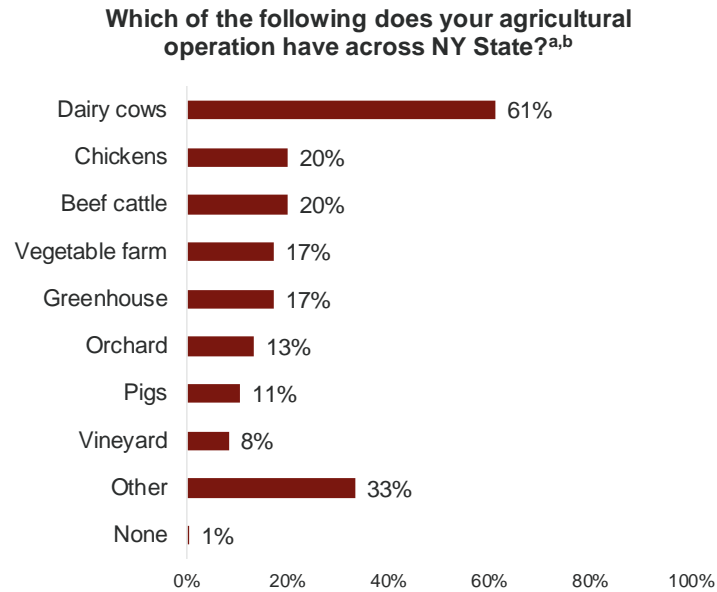
^b This was a multiple response question, so the total number of answer choices selected can be greater than the number of respondents that answered the question. This can cause the total response percentages to exceed 100%.

²⁵ The Market Evaluation Team started the non-participant grocery retailers survey, drafted the survey instrument, identified a sample frame, and completed seven pre-tests. However, the team closed the survey after achieving seven completes due to the GLASE Consortium deciding to no longer include this market actor as a focus. The decision from the GLASE Consortium came after attending a Produce Marketing Association (PMA) conference and realizing that the current benefits of the GLASE Consortium were greater to other groups than to grocery retailers.

Agriculture Technical Services: Agriculture Energy Audit Participants Survey (Figure 18): Sixty-one percent of respondents' agriculture operations included dairy cows. Twenty percent also indicated that they had chickens and beef cattle.

Figure 18. Agriculture Technical Services: Agriculture Energy Audit Participants Survey Profile

Source: Market Evaluation Team analysis of Agriculture Energy Audit Participants survey data



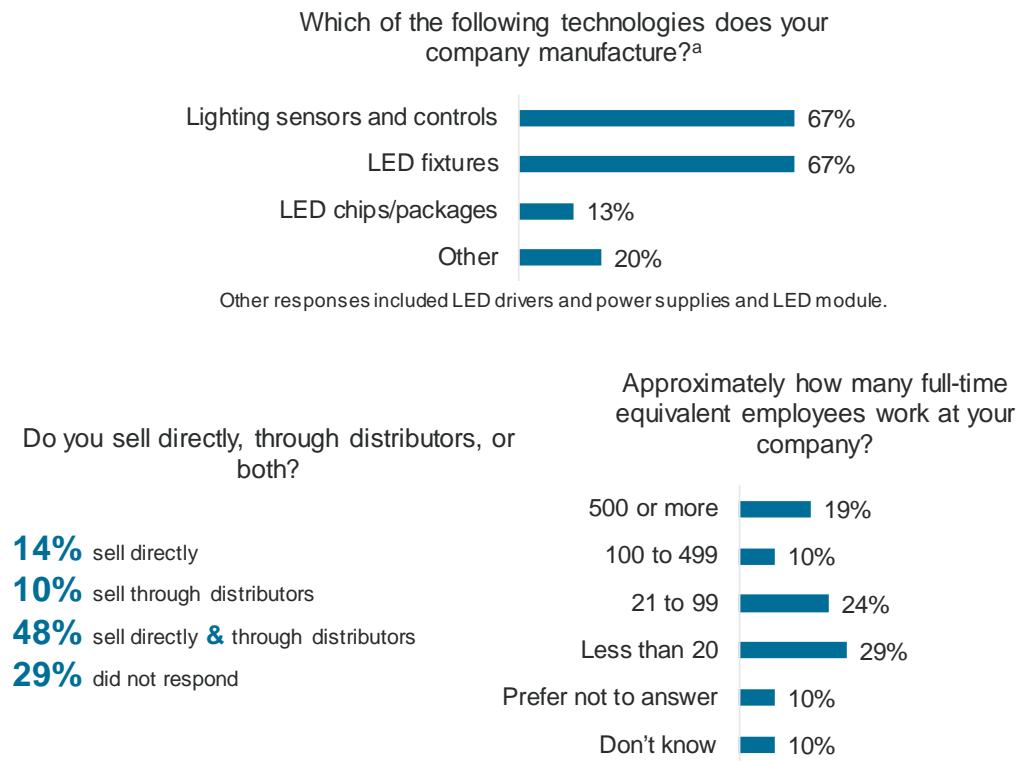
^a Other responses included: corn, crops, goats, horses, and maple

^b This was a multiple response question, so the total number of answer choices selected for a question can be greater than the number of respondents that answered the question. This can cause the total response percentages to exceed 100%.

GLASE Consortium: Non-Participant Lighting Manufacturers Survey (Figure 19): Sixty-seven percent of respondents manufacture lighting sensors and controls and LED fixtures. Forty-eight percent of respondents sell directly and through distributors, 14% sell directly, and 10% sell through distributors. The respondent companies tended to be medium to small, with 29% having less than 20 full-time equivalent employees.

Figure 19. GLASE Consortium: Non-Participant Lighting Manufacturers Survey Profile

Source: Market Evaluation Team analysis of Non-Participant Lighting Manufacturers survey data



^a This was a multiple response question, so the total number of answer choices selected can be greater than the number of respondents that answered the question. This can cause the total response percentages to exceed 100%.

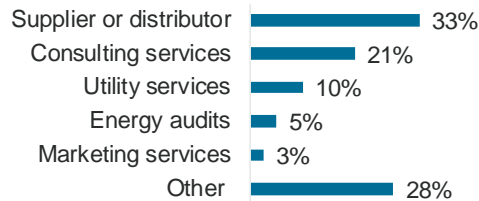
GLASE Consortium: Non-Participant Controlled Environment Agriculture (CEA)

Auxiliary Service Providers Survey (Figure 20): Service provider respondents were suppliers or distributors (33%), consulting services (21%), utility services (10%), energy auditors (5%), marketing services (3%), or other company types (28%). The respondent companies tended to be small, with 44% having less than 20 full-time equivalent employees.

Figure 20. GLASE Consortium: Non-Participant Controlled Environment Agriculture (CEA) Auxiliary Service Providers Survey Profile

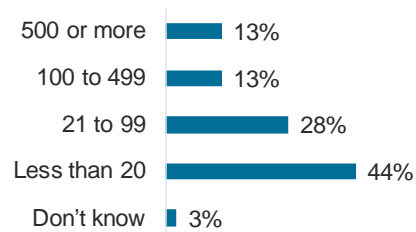
Source: Market Evaluation Team analysis of Non-Participant CEA Auxiliary Service Providers survey data

Which of the following best describes the main services your company provides agricultural customers that operate greenhouses or other controlled environment agriculture facilities in New York State?



Other responses included climate control and irrigation systems and education.

Approximately how many full time equivalent employees work at your company?

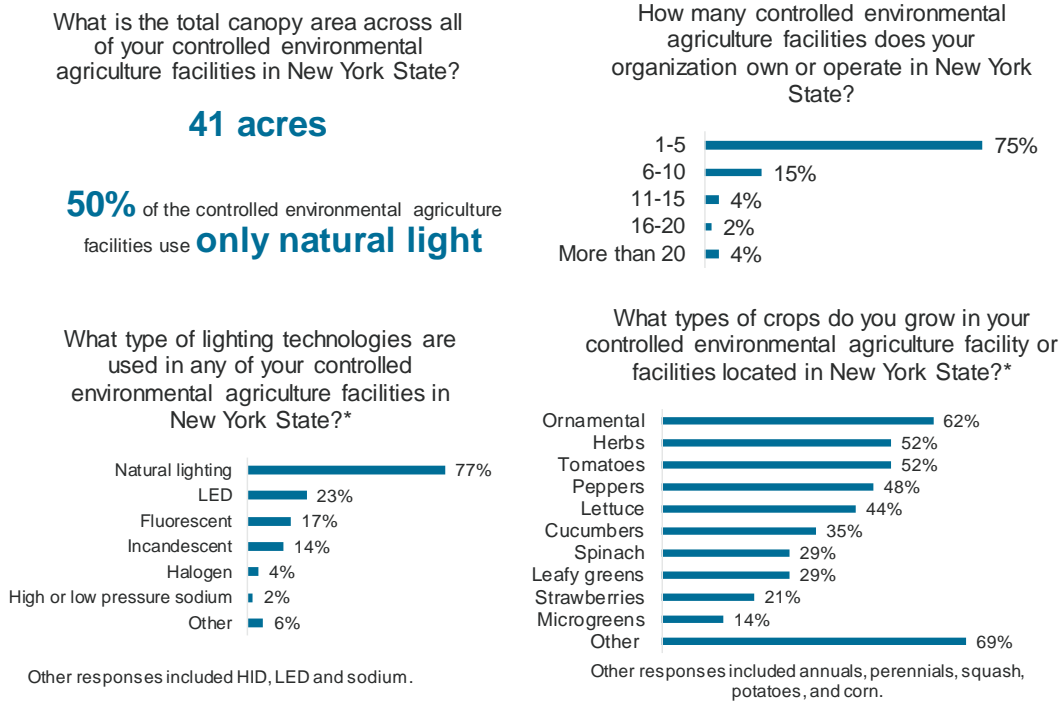


GLASE Consortium: Non-Participant Controlled Environment Agriculture (CEA)

Facilities Survey (Figure 21): The total canopy area of respondents’ CEA facilities in NYS was 41 acres.²⁶ The majority (75%) of respondents’ organizations owned or operated one to five facilities in NYS. Fifty percent of the respondents use only natural light in their facilities, showing that the respondent group included all types of greenhouses and under cover operations, instead of only CEA facilities.

Figure 21. GLASE Consortium: Non-Participant CEA Facilities Survey Profile

Source: Market Evaluation Team analysis of Non-Participant Controlled Environment Agriculture Facilities survey data



^a This was a multiple response question, so the total number of answer choices selected can be greater than the number of respondents that answered the question. This can cause the total response percentages to exceed 100%.

²⁶ This value does not include one response that was a farm with multiple locations across the Northeast (not just NYS) because their response was greater than the total under cover acreage in NYS according to the Census. The Market Evaluation Team assumes that this respondent included all operations, not just those in NYS.

4.1.3 Analysis

The Market Evaluation Team fielded the surveys using Qualtrics and analyzed the survey data in SPSS²⁷. The team cleaned the data prior to analysis.

4.2 Secondary Research Methods

A detailed understanding of existing information and data sources relevant to the project is essential to providing the greatest benefit at the lowest cost. As an initial step in the approach to this study, the Market Evaluation Team reviewed existing materials relevant to the evaluation objectives. The Market Evaluation Team started the secondary research with sources identified in the work plan and supplemented them with the team's industry knowledge of other resources. In total, the Market Evaluation Team reviewed 17 sources. These sources included the United States Department of Agriculture's Census of Agriculture, articles from agriculture publications, and Navigant Research reports.

The secondary research provided an overview of the NYS agriculture sector and additional information to answer the research questions, such as lists of underutilized or emerging technologies in the agriculture sector and total acreage of CEA facilities in NYS that grow lettuce or tomatoes. Appendix G contains the secondary research findings to support the market evaluation of NYSERDA's Agriculture Initiatives.

4.3 Indirect Impacts Methods

The Market Evaluation Team developed a specific methodology (e.g., variables and algorithms) to describe how data, results from pilot projects, and other information shall be used to assess the indirect impacts²⁸ or market activity that is attributable to NYSERDA's initiatives. The Market Evaluation Team created an Indirect Impacts Tool in Excel using the methodology. Appendix H contains this detailed methodology.

²⁷ SPSS is short for Statistical Package for the Social Sciences. Research agencies commonly use SPSS to analyze survey data.

²⁸ Indirect impacts are energy savings and other benefits resulting from measure adoption associated with indirect program influence. (Source: NYSERDA, "Appendix C. Indirect Benefits Evaluation Framework"). Refer to the Indirect Benefits Evaluation Framework for more information available at <https://portal.nyserra.ny.gov/servlet/servlet.FileDownload?file=00Pt000000HIyBmEAL>.