Agriculture Market Evaluation

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

Market Update 1

Final Report

Prepared for:

New York State Energy Research and Development Authority

Albany, New York

Jeremy Simpson, Project Manager

Carley Murray, Senior Project Manager

Prepared by:

Guidehouse Inc.

Boulder, Colorado

Beth Davis, Associate Director

Annelise Huber, Managing Consultant

Matt Rankins, Managing Consultant

Brent Barkett, Director

APPRISE

Princeton, New Jersey

David Carroll, Managing Director

Dan Bausch, Project Director

NYSERDA Contract 104546A

September 2023

NYSERDA Record of Revision

Document Title
Agriculture Market Evaluation: Market Update 1 Advancing Agriculture Energy Technologies (AAET), Agriculture Energy Audit Program, and Greenhouse Lighting and Systems Engineering (GLASE) Consortium September 2023

Revision Date	Description of Changes	Revision on Page(s)
September 2023	Original Issue	Original Issue

Notice

This report was prepared by Guidehouse while performing work contracted for and sponsored by the New York State Energy Research and Development Authority (hereafter "NYSERDA"). The opinions expressed in this report do not necessarily reflect those of NYSERDA or the State of New York, and reference to any specific product, service, process, or method does not constitute an implied or expressed recommendation or endorsement of it. Further, NYSERDA, the State of New York, and the contractor make no warranties or representations, expressed or implied, as to the fitness for particular purpose or merchantability of any product, apparatus, or service, or the usefulness, completeness, or accuracy of any processes, methods, or other information contained, described, disclosed, or referred to in this report. NYSERDA, the State of New York, and the contractor make no representation that the use of any product, apparatus, process, method, or other information will not infringe privately owned rights and will assume no liability for any loss, injury, or damage resulting from, or occurring in connection with, the use of information contained, described, disclosed, or referred to in this report.

NYSERDA makes every effort to provide accurate information about copyright owners and related matters in the reports we publish. Contractors are responsible for determining and satisfying copyright or other use restrictions regarding the content of reports that they write, in compliance with NYSERDA's policies and federal law. If you are the copyright owner and believe a NYSERDA report has not properly attributed your work to you or has used it without permission, please email print@nyserda.ny.gov.

Information contained in this document, such as web page addresses, are current at the time of publication.

Table of Contents

List of Figures

List of Tables

1 Introduction

The New York State Public Service Commission approved the Clean Energy Fund (CEF) in January 2016—modified in September 2021—to commit to clean energy and efficiency measures in recognition that deploying programs at scale can address pressing environmental and energy challenges while providing opportunity for New York State. Based on agriculture-related objectives laid out in the CEF Compiled Investment Plan, New York State Energy Research and Development Authority (NYSERDA) developed three major CEF initiatives[1]:

1. **Advancing Agriculture Energy Technologies (AAET)[2]:** The AAET initiative aims to "accelerate the adoption and market penetration of underused and emerging technologies by animal- and crop-production farms and demonstrate the value proposition of advanced, underused, or emerging energy efficient technologies or processes on farms." The initiative issues competitive solicitations for technology vendor and farm teams to demonstrate technologies in the market. The initiative also develops case studies to share with the market.
2. **Technical Services[3]:** This CEF initiative "engages energy consultants, solution providers and farm owners to provide objective, decision-quality analyses, information, and project pre-development support to advance efficiency, electrification and electrification-readiness solution assessment, scoping, implementation, and replication." This initiative includes two components: Agriculture Energy Audit Program, which provides comprehensive audits to farmers, and Best Practices, which provides information, tools, and resources to agriculture market.
3. **Greenhouse Lighting and Systems Engineering (GLASE) Consortium[4]:** The GLASE Consortium "brings together academia and marketplace knowledge and experience to enable new control systems, lighting products, and technical services" to "target energy-related improvements in greenhouse system operations by optimizing energy efficiency, crop yield and quality." The consortium recruits market actors in the controlled environment agriculture market to become members.

[1] More information about the Clean Energy Fund is available at https://www.nyserda.ny.gov/About/Funding/Clean-Energy-Fund

[2] Additional details on AAET are located in the *Clean Energy Fund Compiled Investment Plan: Agriculture. Portfolio: Market Development.* https://www.nyserda.ny.gov/About/Funding/Clean-Energy-Fund

[3] Additional details on Technical Services are located in the *Clean Energy Fund Compiled Investment Plan: Multi-Sector Solutions Chapter. Portfolio: Market Development*. https://www.nyserda.ny.gov/About/Funding/Clean-Energy-Fund

[4] Additional details on GLASE are located in the *Clean Energy Fund Compiled Investment Plan*: *https://www.nyserda.ny.gov/About/Funding/Clean-Energy-Fund*

This report presents the methodology and results from the updated market evaluation (Market Update 1) of NYSERDA's Agriculture Initiatives. This evaluation is a follow-up to a baseline evaluation published in 2019.[5] At the time that the baseline study began, the initiatives were in the process of implementing their plans and were thus still in the "baseline" phase. At the time of this update study, AAET and GLASE had not reached maturity to the point where we could evaluate CEF outcome indicators against baseline indicators, but it was possible to evaluate outcome indicators for Tech Services, for which the Market Evaluation Team did. In addition, this evaluation study focused on the Agriculture Energy Audit Program and the GLASE Consortium.

The Market Evaluation Team had three core objectives: 1) to evaluate the program processes and improvements for the Agriculture Energy Audit Program and the GLASE Consortium, 2) to characterize measures adopted that were recommended in the Agriculture Energy Audit Program, and 3) to estimate the indirect impacts from the GLASE Consortium.[6] Table 1 outlines the high-level objectives, purpose, and methods for the market evaluation.

Table 1. Agriculture Market Update 1 Evaluation Questions, Objectives, and Methods

The evaluation objectives included process improvements, measure characterization, and indirect impacts.
Source: Market Evaluation Team

Objective	Evaluation Question	Method
Evaluate the program processes and improvements for the Agriculture Energy Audit Program and the GLASE Consortium	• Are there any process improvement opportunities for the Agriculture Energy Audit Program? • Are there any differences in attitudinal responses from farms in disadvantaged communities (DACs) and non-DACs (if data available to compare)? • Are Agriculture Energy Audit Program audit participants aware of and interested in solar siting opportunities? • What was the impact of COVID on participants and members? • What are the answers to some program-specific questions for GLASE around member experiences, preferred communications, lighting approaches, and familiarity with and benefits of GLASE products and services?	Agriculture Energy Audit Program Participant Survey; GLASE member interviews
Characterize measures adopted that were recommended in the Agriculture Energy Audit Program	• Characterize measures adopted within the first year, second year, and third-plus years after audit completion in the Agriculture Energy Audit Program	Agriculture Energy Audit Program Participant Survey
Estimate the indirect impacts from the GLASE Consortium	• Estimate the effects of intervention on the Consortium members	GLASE member interviews

[5] The baseline study (2019 Agriculture Market Evaluation: Advancing Agriculture Energy Technologies (AAET), Agriculture Technical Services, and Greenhouse Lighting and Systems Engineering (GLASE) Consortium) is available at https://www.nyserda.ny.gov/About/Publications/Evaluation-Reports/Commercial-Industrial-Agriculture

[6] 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") https://portal.nyserda.ny.gov/servlet/servlet.FileDownload?file=00Pt000000HIyBmEAL

2 Market Characterization and Assessment Results

This section presents the results of the survey and interview research conducted to support the Agriculture Energy Audit Program and GLASE Consortium.

2.1 Agriculture Energy Audit Program

2.1.1 Measure characterization and measure adoption rates (MARs)

Measure adoption rates for the Agricultural Energy Audit Program will be evaluated through a separate impact evaluation study conducted by another evaluation contractor. However, the survey conducted through this evaluation collected responses from audit participants self-reporting which measures were installed in response to their audits. These initial responses have been used to develop initial estimates of measure adoption described below, but more concrete measure adoption rates will be reported for this program through the impact study of this program.

Survey respondents indicated that 36% of audit-recommended measures were installed and 55% of audit-recommended measures were not installed.[7] Of measures that were installed, 21% were within one year after, 8% were installed between one and two years after, and 7% were installed more than two years after the audit. Six percent of respondents did not know if measures were installed and 3% installed prior to the audit date, likely due to a recollection error. Of the measures installed, 4% were uninstalled.[8] While reasoning for uninstallation was not explicitly asked of survey respondents, some gave insight into their uninstallation in other verbatims including decreases in production operations (such as changing milking techniques or ceasing milking altogether) and LED lights not being bright enough for their needs.

Measure characterization also revealed that only 88, or 27%, of all Audit participant respondents reported installing all recommended measures, ranging in quantity of one to five measures, whereas 73% of all respondents, some with up to 11 recommended measures, installed some measures or no measures at all. The plurality of measure installation type was lighting for all farm types, as can be seen in Table 2.

[7] Results only account for measures installed within two years of 2020 audit completion, within three years of 2019 audit completion, within four years of 2018 audit completion, and within five years of 2017 audit completion.

[8] Reasons for uninstallation of measures were not specifically examined in this iteration of the market evaluation.

Table 2. Measure Characterization by Farm Type and Measure Type

Installing or upgrading LED lighting was the primary measure installed across all farm types.
Source: Market Evaluation Team

Farm Type	Install or Upgrade LED Lighting	Insulation	Hot Water Heater	Other Measure Examples (not inclusive of all measures)
Dairy (n=156)	42%	6%	4%	Ventilation (8%)
Greenhouses (n=16)	32%	14%	5%	Energy curtain, germination bench, grow mat
Orchards & Vineyards (n=17)	33%	0%	0%	Power strip, thermostat, condensing unit
Other[9] (n=126)	40%	6%	0%	Reverse osmosis (6%), solar PV (4%)
Row Crops (n=11)	31%	6%	0%	Timeclock, refrigerator, ventilation shutdown (VSD), barn fan

The top measures installed within one year, between one and two years, and more than two years after the audit stayed consistent. Of the total measures installed within one year of the audit, 39% were "install or upgrade LED lighting," 7% were "insulation," and 3% were "ventilation." Similarly, of the total measures installed between one and two years after the audit, 32% were "install or upgrade LED lighting," 7% were "insulation," and 6% were "ventilation" and of the total measures installed more than two years after the audit, 45% were "install or upgrade LED lighting," 4% were "insulation," and 9% were "ventilation."

2.1.2 Initiative experiences and process improvement opportunities

When asked to rate their experiences with aspects of the Agriculture Energy Audit Program on a Likert scale from 1 to 5, where 1 is 'very dissatisfied' and 5 is 'very satisfied,' survey respondents reported satisfaction most frequently with the quality of the auditor's performance and the ease of the application process.[9] Figure 1 shows respondents were most likely (80%) to report high satisfaction with the quality of an auditor's performance and the ease of the application process (76%).

Survey respondents reported satisfaction least frequently with energy savings from installed audit-recommended measures (39%) and with program issue resolution sufficiency (31%).[10] When asked why they had reported dissatisfaction, 47 substantive responses were given, including that the audit was unhelpful or gave recommendations for measures already installed (11%), the audit did not

[9] Q8. On a scale from 1 to 5 with '1' being Very Dissatisfied and '5' being Very Satisfied, please indicate your level of satisfaction with the following NYSERDA Agriculture Energy Audit Program elements:

[10] Though these questions were asked of all respondents and were not applicable to all, the satisfaction rate was lower for these factors than other factors.

suggest grants or financial resources to pay for recommendations (11%), the audit report took too long to receive (9%), and the recommendations and/or payback periods were unrealistic (9%).[11]

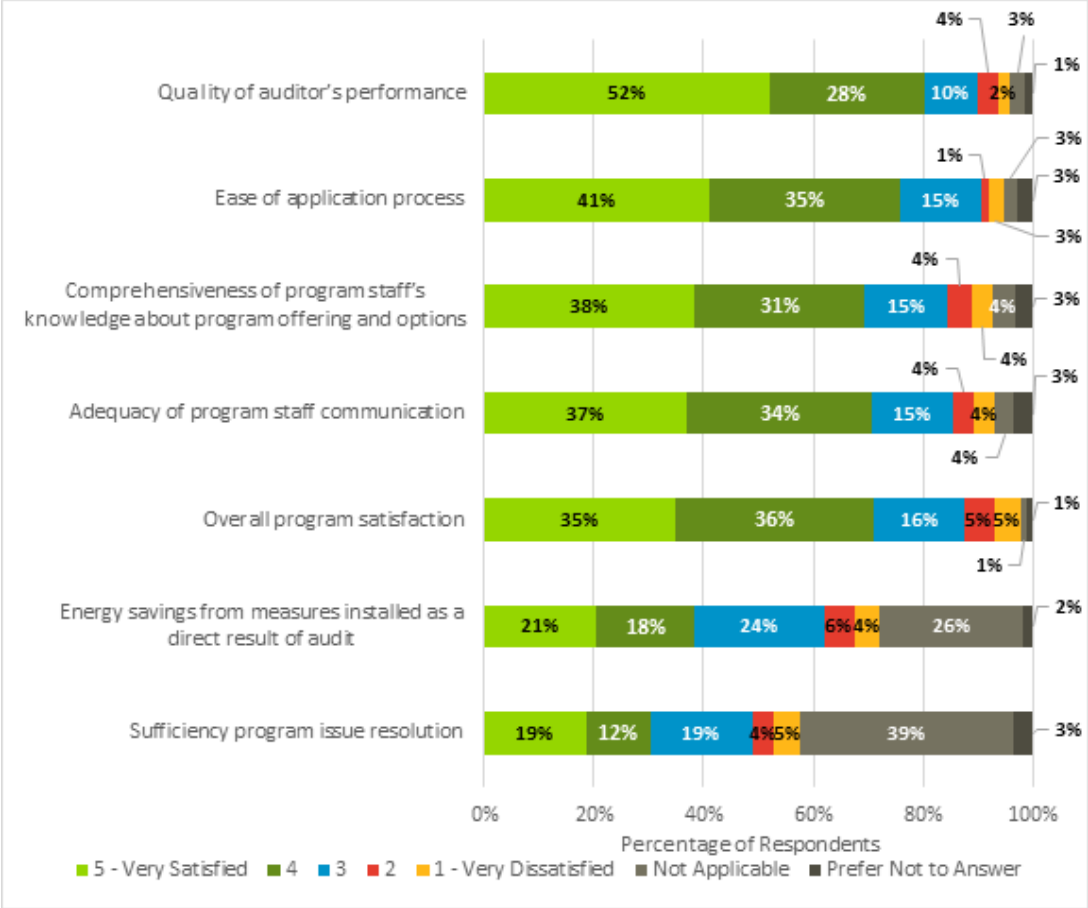
There was a reported high level of satisfaction with the auditor's performance (80% of 297 respondents); however, 15 verbatim responses reported that the audits do not provide information that farmers do not know already, and that farmers expect custom solutions to properly encapsulate the complexity of farms but receive prescriptive solutions and do not experience savings. Some respondents reported the size of a farming operation can impact the helpfulness of an audit such that large farms may find value, via savings and cost compared to benefits, where small farms cannot (10% of 31 respondents).

[11] Q9. Please, further explain or share your experience that has led to any dissatisfaction (indicated by a '1' or a '2') noted in the previous question.

Figure 1. Overall Program Satisfaction (n=297)[12]

Respondents were most satisfied with the quality of the auditor's performance and the ease of the application process and were least satisfied with the energy savings resulting from audit-recommended measures installed and with program issue resolution.

Source: Market Evaluation Team

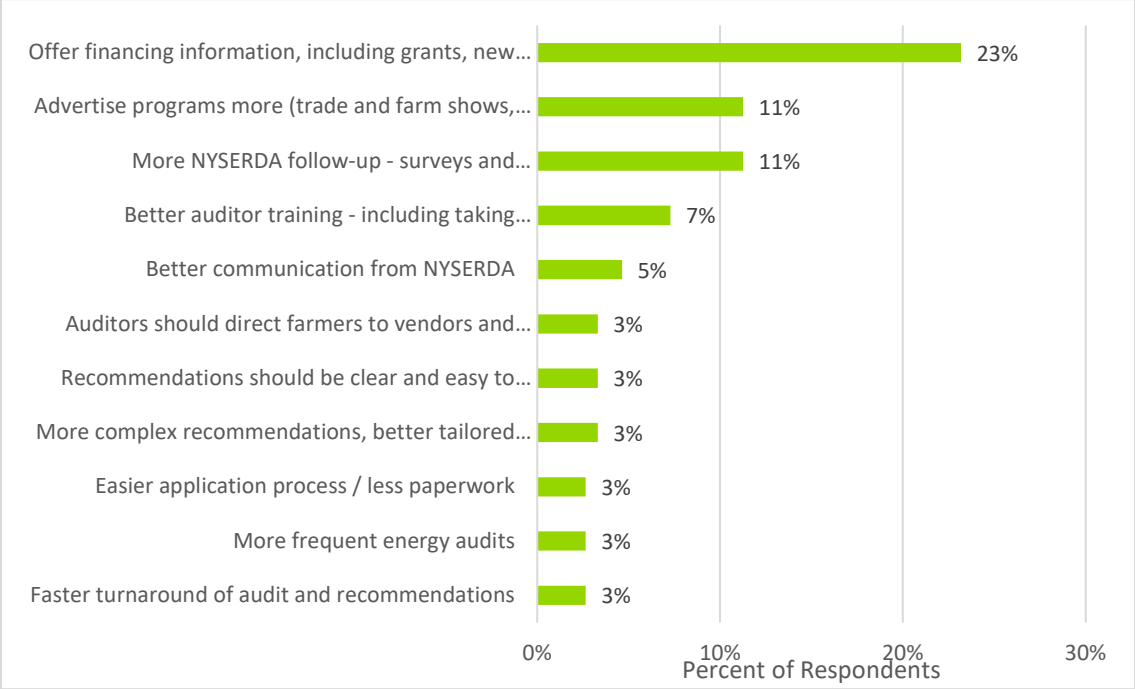


Respondents were asked which actions NYSERDA could take to improve the program or its processes. As Figure 2 shows, 23% of responses reported more financial information and assistance, including grants, cost share programs, and awareness of state and federal programs to support implementing recommended measures and energy efficiency changes. Auditor changes were mentioned in 14% of responses, which requested better training, such as taking actual measurements, and possessing commodity expertise on farms audited—especially for greenhouses and maple syrup production; more complex recommendations tailored to farms' unique needs; and directing farmers to vendors and suppliers to implement recommendations.

[12] Q8. On a scale from 1 to 5 with '1' being Very Dissatisfied and '5' being Very Satisfied, please indicate your level of satisfaction with the following NYSERDA Agriculture Energy Audit Program elements:

Additionally, 11% of respondents reported greater awareness of the audit program via more advertisement in locations that farmers and facility operators frequent and find effective such as at trade and farm shows. Respondents (11%) also reported a desire for more contact from the NYSERDA team including information about new incentives, programs, and technologies and more frequent follow-up from NYSERDA, including more frequent surveys and calls after audit reports are delivered.

Figure 2. Actions for Improvement (n=297)[13]
Respondents want NYSERDA to offer financing information, to advertise the program more, and to follow-up more.
Source: Market Evaluation Team



2.1.3 Awareness of and interest in renewable siting opportunities

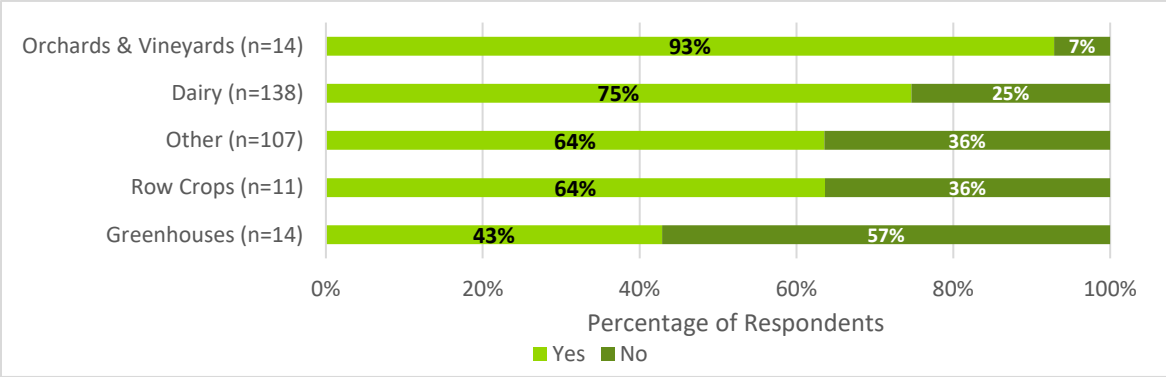
As shown in Figure 3, of the 297 respondents, most Orchards & Vineyards (93%) and Dairy (75%) respondents reported being approached by solar and/or wind developers, at least 32 points higher than Greenhouse respondents (43%). This could indicate that perceived availability of land may impact developers approaching certain production or operation types. Orchards & Vineyards and Dairy operations require more acres of land due to production type, which may encourage contact by developers who seek large scale renewables projects but misses the opportunities presented by other types of agricultural facilities to install smaller scale renewables, such as solar, mounted on rooftops.

[13] Q8. On a scale from 1 to 5 with '1' being Very Dissatisfied and '5' being Very Satisfied, please indicate your level of satisfaction with the following NYSERDA Agriculture Energy Audit Program elements:

Figure 3. Approached by Wind and Solar Developers[14]

Orchards & Vineyards and Dairy respondents were most likely to be approached by wind and solar developers.

Source: Market Evaluation Team

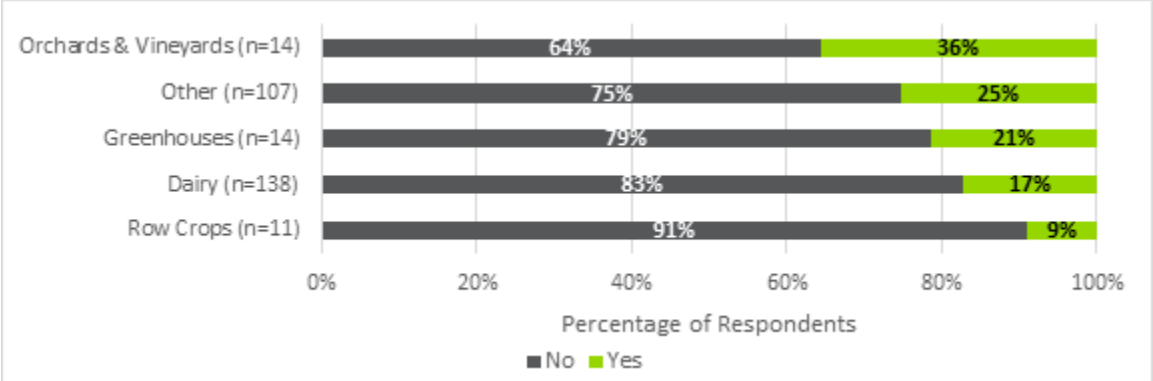


When asked if they had installed renewables at their operation or facility, most respondents had not. Figure 4 shows that Orchards & Vineyards respondents (36%) most frequently reported renewables technology installation, more than double the frequency of Dairy (17%) and quadruple the frequency of Row Crops (9%) respondents. Of the five Orchards & Vineyards respondents who did install renewables, 80% installed solar only and 20% installed wind.[15]

Figure 4. Installation of Wind or Solar Technology[16]

Orchards & Vineyards were most likely to have installed wind and/or solar technology.

Source: Market Evaluation Team



[14] Q24. Have you been approached by commercial wind or solar developers about potential opportunities on your agricultural properties or facilities at this facility site? Q24 by commodity results are statistically significant at the 95% CI with a p-value of .000

[15] Q25a. Did you add wind, solar, or both?

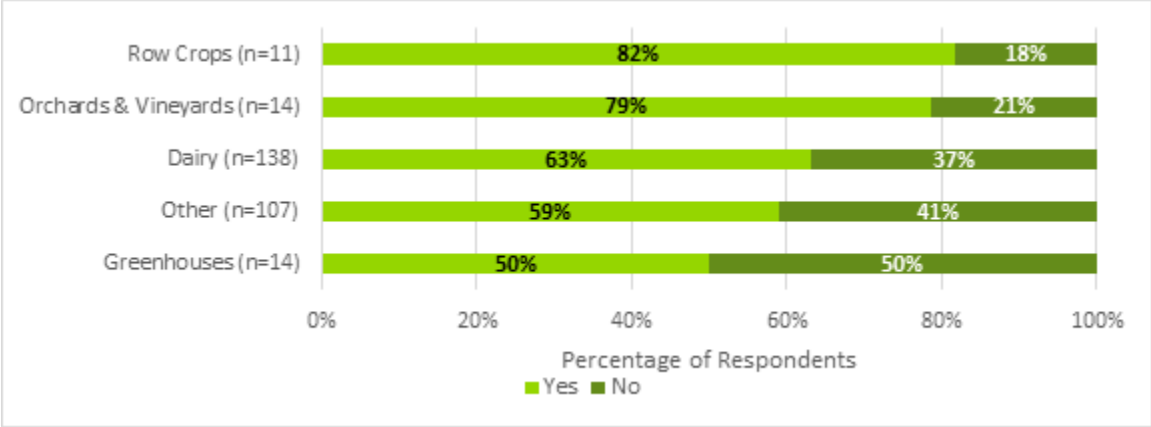
[16] Q25. Did you install any wind or solar technology at your facility in New York State? Q25 by commodity results are statistically significant at the 95% CI with a p-value of .000.

Of the Orchards & Vineyards respondents who have not installed renewables, they primarily reported that cost and compensation for installing renewables does not work financially for their operation.[17] Row Crops respondents were likely to report dissatisfaction with proposed locations of solar project siting, with respondents reporting that their roof is too old and that the fields are needed for growing crops or forage production for livestock. Row Crops respondents also reported local law and agency (i.e., the Adirondack Park Agency) prohibitions on wind.

2.1.4 COVID-19 impacts

Most participants' agricultural or business operations were affected by COVID-19-related shutdowns and policies. Figure 5 shows that Row Crops (82%) and Orchards & Vineyards (79%) were most likely to report COVID-19-related business impacts while half or more of all other commodity respondents reported impacts.

Figure 5. COVID-Related Shutdowns and Policies Impact on Business[18]
Row Crops and Orchards & Vineyards were most affected by COVID-related shutdowns and policies; half or more of all commodities reported being affected.
Source: Market Evaluation Team



As Figure 6 shows, when asked about the business aspects affected by COVID, respondents most frequently cited the supply of materials to operate with (at 85%) as negatively or very negatively affecting their business, 30 points or more higher than the reported negative impact on any other business aspect. Respondents identified financial standing (55%) as a negatively affected business aspect with the second-highest reported frequency.

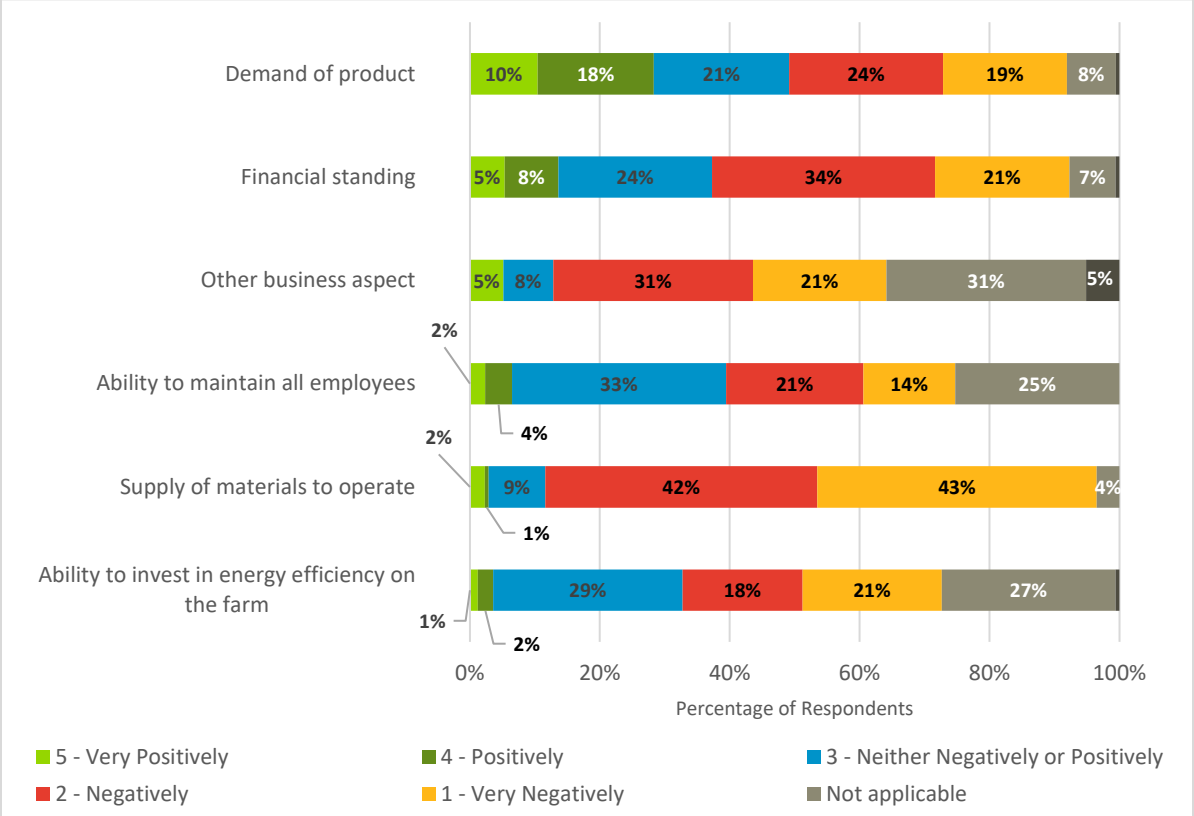
---

[17] Q26. You indicated in the previous question that you were contacted by a wind or solar developer, but you did not add any wind or solar technology to your facility in New York State. Would you please tell us any barriers that are preventing you from adopting wind or solar technology?

[18] Q28. Have the COVID-19-related shutdowns and policies affected your agricultural or business operations in New York State? Q28 by commodity results are statistically significant at the 95% CI with a p-value of .000.

Respondents most frequently cited product demand (28%) as a positively affected business aspect due to COVID. This could be attributed to increased at-home cooking during the pandemic or to transportation issues (i.e., the trucking driver strikes), which affected overall food supply and could have increased demand for more supplies from local areas or small farm operations. Other business aspects impacted primarily included employment—such as ability to hire new employees or to find labor, time spent on employee regulations, and employee sick time, construction of new facilities (i.e., a barn), and future planning was made more difficult.

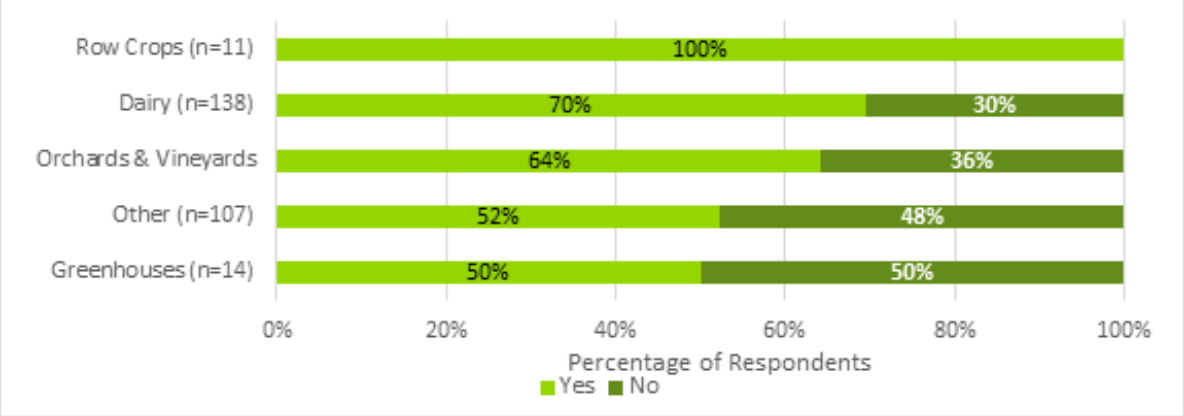
Figure 6. Business Aspects Affected by COVID (n=331)[19]
COVID most negatively affected the supply of participants' materials to operate and their financial standing and most positively affected the demand of their product.
Source: Market Evaluation Team



[19] Q29. Please indicate the aspect of your business impacted by COVID-19. Q29 results are statistically significant at the 95% CI with a p-value of .000.

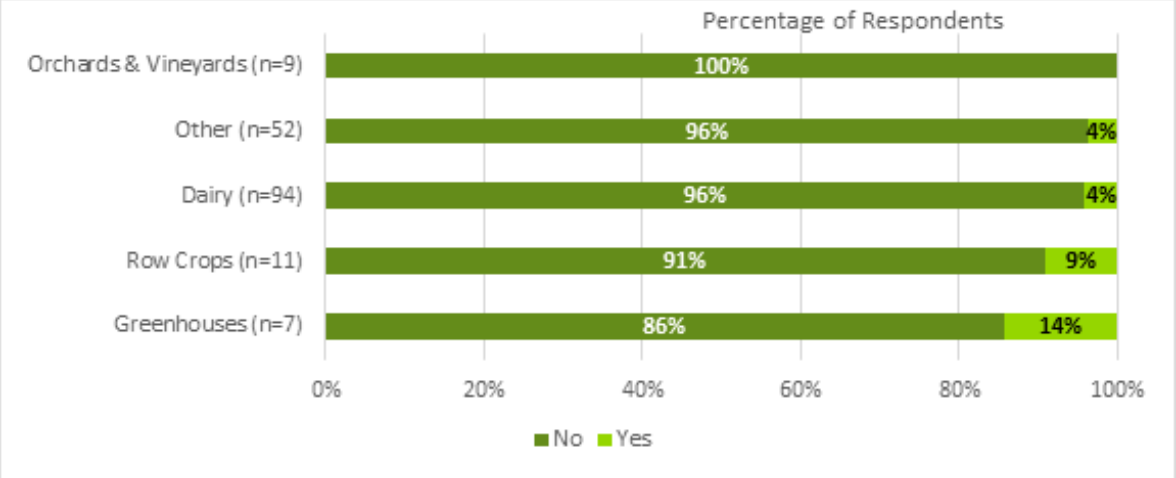
As Figure 7 shows, when asked if they had applied for COVID-19 relief, half or more of all commodity respondents reported they had, from 50% of Greenhouses to 100% of Row Crops.

Figure 7. Applied for COVID-19 Relief by Commodity[20]
Half or more of all commodity respondents reported they had applied for COVID-19 relief.
Source: Market Evaluation Team



Most respondents reported that they had not used COVID-19 relief funds to upgrade their technologies to be more energy efficient. As seen in Figure 8, Greenhouses (14%) most frequently reported using relief funds to upgrade technologies, 5 points higher than Row Crops (9%) and more than three times higher than Other (4%) or Dairy (4%) respondents.

Figure 8. Use of COVID-19 Relief Funds to Upgrade Technologies by Commodity[21]
Greenhouses were most likely, at 14% of respondents, to use COVID-19 relief funds to upgrade energy technologies.
Source: Market Evaluation Team



[20] Q30. Did you apply for any COVID-19 relief (Municipal, State, or Federal) for your agricultural operation or business? Q30 by commodity results are statistically significant at the 95% CI with a p-value of .000.

[21] Q33. In the previous question, you indicated receiving COVID-19 relief funds. Did you use any of the COVID-19 relief money to update any of the technologies to be more energy efficient in your facility in New York State? Q33 by commodity results are statistically significant at the 95% CI with a p-value of .000.

2.1.5 Direct and indirect impacts

Direct impacts for the Agriculture Energy Audit Program are defined as energy savings from recommended measures installed within one year of the audit, while indirect impacts are defined as energy savings from recommended measures installed more than one year after the audit.[22] EnSave ceases follow-up contacts with audit participants at the 1-year mark, which is a factor of demarcation between direct and indirect impacts. The Impact Evaluation Team for these programs is assessing the direct and indirect impacts for the market update as part of a separate contract. The direct and indirect impact assessment leverages the Agriculture Energy Audit Program participant survey developed and administered by the Market Evaluation Team, as well as customer utility information collected via survey. The methodology employed for the Market 1 Update evaluation may differ from the methodology used in the baseline study.

2.2 GLASE Consortium

2.2.1 Member experiences and preferred communications

The 26 interviewed GLASE members were asked how they had learned about NYSERDA's GLASE Consortium. Growers and non-growers[23] were most likely to report personal connections (5 responses), such as NYSERDA staff and Cornell advisory board members. Growers also cited conferences (3 responses) such as Cultivate.

Growers noted that they became a GLASE member because of access to research (3 responses), learning about lighting inputs (3 responses), and the direction of the market (2 responses), especially with interest in vertical growing. Non-growers joined GLASE for business development, to learn from universities and researchers, and to access lighting technology data and research and plant growth predictive information to help plants grow more efficiently.

When asked about barriers to joining GLASE, growers reported membership cost and awareness while non-growers reported only membership cost as the barrier to joining.[24]

Growers (n=5) were most likely to report the following as the most beneficial benefits: webinars, admission to workshops, participation at quarterly meetings, technical bulletins, and networking, as

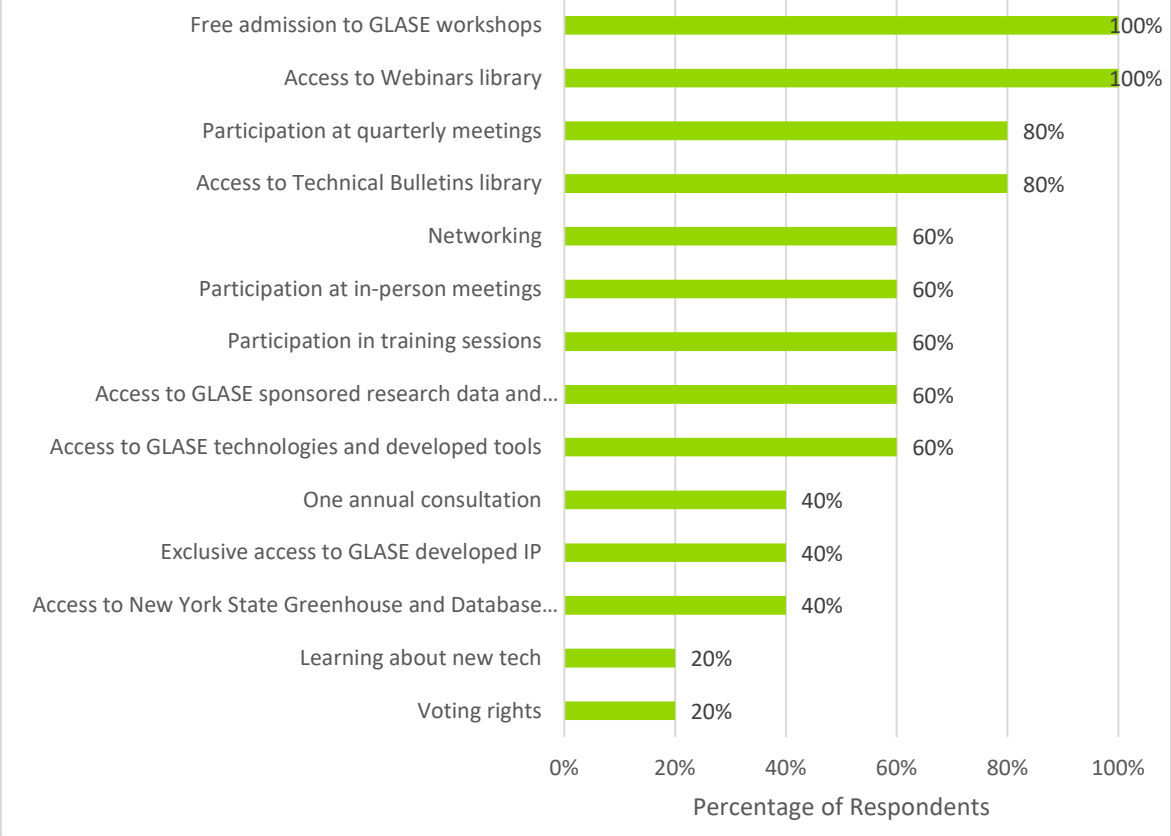
[22] This categorization of direct and impacts is unique to this NYSERDA program.

[23] Non-growers in the GLASE consortium refer to members who do not operate agricultural operations. Non-growers in GLASE are predominantly those who produce lighting technologies or engineer farming systems.

[24] A3. What barriers, if any, do you see with joining the GLASE Consortium?

Figure 9 shows. Non-growers were most likely to report technical bulletins and webinars library access, access to GLASE technologies, and workshops as aspects that they receive benefit from. Non-growers were also highly likely to cite access to and building relationships with growers as a benefit of GLASE membership.

Figure 9. Grower Benefits of GLASE Membership (n=5)[25]
Growers benefit the most from free access to GLASE workshops and access to the webinars library.
Source: Market Evaluation Team



Interviewees were asked about additional GLASE services that could benefit members.[26] Growers were most likely to report discounts on services such as facility audits and discounts on vendor-member products as potential offerings that would be beneficial. [27] Non-growers gave the most feedback on GLASE additions and suggested facilitating networking, reducing membership cost, and increasing member diversity to address the high ratio of non-growers to growers.

---

[25] A4. GLASE has a wide range of benefits for its members, but we would like to know which are beneficial to you/your organization. Please indicate which of the benefits listed below apply to your organization. Which are the three most critical benefits?

[26] A5. Are there any activities or other services that GLASE does not offer that would be beneficial to your organization?

[27] The Agriculture Energy Audit Program offers free facility audits and greenhouse benchmark reports and it seems like interviewees were not aware of these offerings.

When asked about their sources of information for the latest agriculture technologies, market updates, and news, growers and non-growers reported trade publications, newsletters, and LinkedIn. [28] Growers specified online publications such as HortiDaily.com and Vertical Farm Daily as sources of information. Non-growers also reported conferences as a main source of information.

All five growers reported that they participate in webinars or read technical publications and noted that webinars that deeply examine issues are most useful.[29] Growers reported information on production farms, the use of lighting, crop yield, new technologies, energy efficiency, and sustainability as the most valuable aspects of webinars and technical publications.[30]

2.2.2 Lighting approaches marketed to or in use by greenhouses/Controlled Environment Agriculture (CEA) facilities

Growers (n=4) were asked which lighting technologies their facilities use.

Table 3 shows that all growers reported using LEDs, in particular LED tubes, fixtures/troffers, color tunable, and color dimmable lights. One grower reported using a cannabis-specific light bar from TSR Grow while another reported using a growing-specific LUMINA lamp out of the Netherlands. Growers also reported using timers, threshold/light intensity, and daily light integral (DLI) lighting controls while two growers control natural lighting with a Joule meter and timer shades.

[28] O4. Where do you get information on the latest agriculture technologies, market updates, and news?

[29] O2. Do you participate in webinars and/or read technical publications?

[30] O2. a. What aspects of webinars or technical publications do you find to be the most valuable?

Table 3. Lighting Technologies Used, Reported by Growers[31] (n=4)

The lighting technologies used included LED, metal halide, and natural lighting and lighting control technologies such as timers, threshold light intensity, and DLI.

Source: Market Evaluation Team

Lighting	Specific Technology	Lighting Controls			
		Timer	Threshold (light intensity)	DLI	Other
LED					
	Screw-in LED	0	0	0	0
	Tube LED	2	1	0	1
	LED fixture/troffer	1	1	1	0
	Other: Cannabis-specific "light bar" from TSRgrow	1	0	0	1
	Other: Growing-specific LUMINA Lamp (from the Netherlands)	1	1	1	0
	Color tunable	1	1	2	0
	Dimmable	2	2	1	1
Metal halide					
	Pulse-start	0	0	0	0
	Standard	0	0	1	0
	Other	0	0	0	0
Natural lighting		1	0	0	2
Total by Type of Lighting Control		9	6	7	5

[1] Rows were removed for fluorescent, halogen, high- and low-pressure sodium, and mercury vapor lights, which '0' (zero) growers reported using.

Growers were asked about which time of year their facilities use the most lighting; two growers shared their information citing December through February and September through November as times of year with the highest usage.[32] These growers reported peak annual usage to occur at 17 and 12 hours per day, but both noted that this daily level of usage occurs year-round.[33]

Non-growers were asked which products they market. As Table 4 shows, six non-growers market LEDs with three marketing timers, three marketing threshold lighting controls, and three marketing DLI as lighting controls on that technology. One non-grower markets fluorescents with threshold lighting controls. Two non-growers market shade controls on natural lighting.

[31] L1. Please identify lighting technologies currently used in any of your facilities in New York State.

[32] L2. What time of year is the lighting usage highest in your indoor CEA facilities or greenhouses in New York State?

[33] L3. During the time of year when the lighting usage is highest in your facilities, what would you estimate is the average number of hours per day that the lights are on?

Table 4. Lighting Technologies Marketed, Reported by Non-Growers[34] (n=6)

The lighting technologies marketed included fluorescent, halogen, high- and low-pressure sodium, incandescent, LED, mercury vapor, metal halide, and natural lighting and lighting control technologies such as timers, threshold light intensity, and DLI.

Source: Market Evaluation Team

Lighting	Specific Technology	Lighting Controls				
		Timer	Threshold (light intensity)	DLI	Other	Retrofits with LEDs
Fluorescent						
	Linear fluorescent T12	0	1	0	0	2
	Linear fluorescent T8	0	1	0	0	3
	Linear fluorescent T5	0	1	0	0	3
	Circline fluorescent	0	0	0	0	2
	Cold cathode fluorescent	0	1	0	0	2
	Compact fluorescent (CFL)	0	1	0	0	2
	Other	0	1	0	0	0
Halogen			1		1	
High- or Low-Pressure Sodium						
	High-pressure sodium	0	1	0	2	4
	Low-pressure sodium	0	1	0	1	2
	Other	0	1	0	0	0
Incandescent			1			
LED						
	Screw-in LED	1	2	1	2	0
	Tube LED	1	2	1	2	1
	LED fixture/troffer	4	4	4	5	1
	Other	2	2	2	3	1
	Color tunable	4	4	4	5	1
	Dimmable	4	4	4	5	1
Mercury vapor		0	1	0	0	0
Metal halide						
	Pulse-start	0	1	0	1	0
	Standard	0	1	0	0	1
	Other	0	0	0	0	0
Natural lighting		0	1	0	2	0
Total by Type of Lighting Control		**16**	**34**	**16**	**30**	**28**

When asked what research areas interest members for additions to GLASE's work, growers identified energy efficacy and radiometry due to their role in vertical farming and photosynthetic efficiency. [35] Growers identified interest in experiments with lighting and control systems and piloting and demonstrating technologies in facilities out of interest in energy efficiency. Growers also identified interest in data on plant growth and AI/data analysis as the "way of the future" and because of its importance in maximizing production.

[34] L10. Please, identify lighting technologies that your organization currently works with (i.e., sells, produces, or advocates use of) in New York State.

[35] O3. GLASE is exploring different research areas as part of its work. Which of these research areas would be of interest to you? Select all that apply. Why is it interesting or important to you?

Non-growers identified the most interest in the development of spectrum or irradiance optimization and plant sensing, experiments with lighting and control systems, piloting and demonstrating technologies in facilities, and hemp/cannabis. Non-growers cited their interests due to business reasons to sell their products or services.

Additionally, GLASE interviewees reported interest in robotics, pollination, tissue culture, disease resistance, and integrated pest management to mitigate viruses and invasive species.

2.2.3 Familiarity of and benefits with GLASE products and services

When asked about important factors under consideration for upgrades, growers were equally likely to report the importance of upfront costs for equipment, payback period, energy efficiency, light brightness, color and range, lighting heat output, ease of use, and impact on crop yield when considering equipment for upgrades. Non-growers reported energy costs/energy savings, upfront costs, product lifetime, environmental controls, and building infrastructure as important aspects for facility owners to consider about equipment upgrades.

Interviewees were asked about the advantages of, and barriers to, adopting GLASE-developed lighting and control systems.[36,37] Growers reported that GLASE has made products more affordable for those entering the industry as well as creating systems that increase production and efficiency. One grower also identified as a developer of vertical farm technology with GLASE and reported that they engineer their own in-house technologies. As for barriers to adoption of GLASE-developed lighting and control systems, two growers cited cost, awareness, and accessibility of GLASE technologies.

As Table 5 shows, when asked about awareness of and/or installation of GLASE products and services offered to members, growers were most likely to report awareness and installation of the greenhouse light spectrum sensing system and were least aware of day-ahead market price and tunable LED light modules. Non-growers were most likely to report awareness of light and shade system implementation (LASSI), CO2-LASSI, and tunable LED light modules.

[36] L8. What benefits do you see with adopting lighting and control systems developed by the GLASE Consortium?

[37] L9. What barriers do you see with adopting lighting and control systems developed by the GLASE Consortium?

Table 5. Awareness and Installation of GLASE Products and Services by Members
Growers were aware of dynamic LASSI, CO2-LASSI, and greenhouse light spectrum sensing and had installed LASSI, CO2-LASSI, and greenhouse light spectrum sensing. Non-growers were aware of all technologies but were least aware of day-ahead pricing and remote sensing plant chlorophyll fluorometers.
Source: Market Evaluation Team

	Growers (n=4)			Non-Growers (n=9)	
	Aware of	Installed	Intend to Install	Aware of	Installed
Dynamic light and shade system implementation (LASSI)	3	1	1	7	N/A
Integrated light and CO2 controls (CO2-LASSI)	3	0	1	7	N/A
Day ahead market price (prioritizing energy use according to pre-determined day ahead market pricing structures)	0	0	0	4	N/A
Tunable LED light modules	1	0	0	7	N/A
Greenhouse light spectrum sensing system	3	2	0	5	N/A
Remote sensing plant chlorophyll fluorometer	2	0	1	4	N/A

2.2.4 COVID-19 impacts

When asked if COVID-19 affected membership in the GLASE Consortium, four interviewees—two growers and two non-growers—reported that COVID-19 had affected their membership, citing the lack of in-person networking and events.[38] Interviewed GLASE members reported that limited site visits and the option to meet in-person would have made it easier to participate in GLASE with consideration to COVID-19.[39]

Interviewees were asked if projects or activities were affected by COVID; three interviewees—two growers and one non-grower—reported impacts by COVID.[40] Two interviewees cited COVID affecting the supply chain, with the non-grower reporting delayed procurement of software development and parts and one grower citing delayed construction of new facilities. Additionally, one grower cited resulting restaurant closures as an impact resulting in the loss of their primary source of revenue and one grower cited isolation affecting collaboration for their business.

[38] C1. Did COVID-19 impact your membership in the GLASE consortium? [IF YES] How did COVID-19 impact your membership?

[39] C3. Was there anything that would have made it easier to participate in GLASE Consortium with consideration to COVID-19?

[40] C2. Were there projects or activities that were impacted because of COVID-19? If yes, how were those projects impacted?

2.2.5 Indirect impacts

While interviewed, growers and non-growers indicated their organizations have observed multiple positive impacts as a result of their GLASE memberships. Two commonalities between growers and non-growers are that both indicated that they have developed relationships with other growers, research facilities, and manufacturers, and that both groups benefitted from networking, research, and gaining industry insight because of their GLASE memberships.

Growers listed the following outcomes as a result of their GLASE memberships: implementing business decisions informed by research shared through GLASE resources, obtaining distributers and suppliers through GLASE resources, and influencing other growers in New York by raising the bar for energy efficiency.

Non-growers listed the following outcomes as a result of their GLASE memberships: awarding discounts to GLASE members to make data more accessible and affordable, making their product energy data metrics more user-friendly for growers, and obtaining more customers by means of exposure through GLASE.

3 Findings and Recommendations

This section presents high-level findings and recommendations from Market Update 1 of NYSERDA's Agriculture Initiatives.

Agricultural Energy Audit Program

Finding 1: There was a reported high level of satisfaction with the auditor's performance (80% of 297 respondents); however, 15 verbatim responses reported that the audits do not provide information that farmers do not know already, and that farmers expect custom solutions to properly encapsulate the complexity of farms but receive prescriptive solutions and do not experience savings. Some respondents reported the size of a farming operation can impact the helpfulness of an audit such that large farms may find value, via savings and cost compared to benefits, where small farms cannot (10% of 31 respondents).

Recommendation 1: NYSERDA and EnSave should work to identify more auditors that have agriculture sector expertise and use those auditors for farms such as small-scale farms or farms that indicate a need for agriculture expertise. For farms that note facilities resembling commercial/industrial facilities, an auditor without agriculture expertise may suffice.

Expected Result of Implementing Recommendation: This recommendation could increase audit report relevance to the participant, increase participant satisfaction, increase installation of recommendations, and increase energy savings.

NYSERDA Response to Recommendation: Implemented. The Agricultural Energy Audit program already selects auditor contractors to audit agricultural sites dependent on their expertise in agricultural sites in particular, to the extent possible while ensuring auditors are based in close proximity to the audit site.

Finding 2: Some respondents reported that the audit report took too long to receive (9%).

Recommendation 2: The NYSERDA Agriculture team should follow up with EnSave to troubleshoot why audit reports were delayed in getting to the recipient. From this information, NYSERDA should establish and reinforce expectations and timelines from application to audit to report to follow-up (e.g., internal flow diagram) among NYSERDA staff, EnSave staff, auditors, and participants to facilitate the delivery of audit report results quickly so that farmers can benefit as

much as possible. During the site visit, auditors should clearly communicate when participants will receive the audit report.

Expected Result of Implementing Recommendation: This recommendation could increase the usefulness of the audit and program, increase participation, increase energy savings, and increase program satisfaction.

Initial NYSERDA Response to Recommendation: Implemented. Currently, NYSERDA has ongoing conversations with EnSave and the FlexTech Consultants regarding our expectations, including expectations for timing of review and distribution of audit reports.

Finding 3: When asked about why respondents had reported dissatisfaction with the program, 47 substantive responses were given, including that the audit did not suggest grants or financial resources to pay for recommendations (11%) and unrealistic recommendations and/or payback periods (9%). Eleven verbatim responses reported little guidance and connection between the audit and how measure implementation will save money.

Recommendation 3: As part of the report, NYSERDA and EnSave should take advantage of the opportunity to communicate as much information as possible to participants. On the audit report cover, NYSERDA could display a webpage link that contains dynamic information that NYSERDA can update quickly as offerings change. This link should list program opportunities, details, or links to NYSERDA, federal, state, and utility websites that store information about financial incentives and program incentive offerings, links to become a GLASE member, industry newsletters and associated organizations, best practice guides, and information about the progress and learnings of NYSERDA demonstration sites and case studies. Dynamic links and additional information will assist NYSERDA and EnSave to work with auditors to strengthen the connection between audit, implementation, and savings. This could include promoting the use of a standard, publicly accessible tool such as those available through the Department of Energy and the National Renewable Energy Laboratory websites, to develop more accurate and standardized payback periods and/or financial impact awareness around recommendations.[41,42]

[41] Department of Energy. "Building Energy Modeling." Accessed 30 May 2023 from https://www.energy.gov/eere/buildings/building-energy-modeling.

[42] National Renewable Energy Laboratory. "BEopt: Building Energy Optimization Tool." Accessed 30 May 2023 from https://www.nrel.gov/buildings/beopt.html.

Expected Result of Implementing Recommendation: This recommendation could increase the usefulness of the audit and program, increase participation, increase energy savings, and increase program satisfaction.

Initial NYSERDA Response to Recommendation: Pending. NYSERDA is in the process of creating a list of incentive programs and grants to assist farms. This will be posted on NYSERDA's website and will remain a dynamic document to allow for updates, and the program's Implementation Contractor points audit participants to this website at the conclusion of an audit.

GLASE Consortium

Finding 4: Growers reported discounts on vendor-member services as an addition to the consortium's design that would address the high ratio of non-growers to growers. Non-growers reported intentional networking, reducing membership cost, and increasing member diversity as additions to the consortium's design that would address the high ratio of non-growers to growers. Members who were interviewed noted the need for growers to be more aware of the GLASE Consortium and reported trade shows, publications, newsletters (including publications like HortiDaily.com and Vertical Farm Daily), conferences, and LinkedIn as information sources.

Recommendation 4: NYSERDA should consider marketing the GLASE Consortium more aggressively, especially at trade shows and conferences, on LinkedIn, and in periodicals, newsletters, and technical publications such as HortiDaily.com and Vertical Farm Daily.[i] NYSERDA should consider opportunities to cross-promote the Consortium, such as through the Agricultural Energy Audit reports. More aggressive marketing should also include reducing grower membership cost and promoting free audits and greenhouse benchmarking reports offered through the Audit Program.

Expected Result of Implementing Recommendation: This recommendation could increase Consortium awareness, increase Consortium membership, increase membership diversity, and increase awareness of GLASE-related products and services.

Initial NYSERDA Response to Recommendation: Implemented. GLASE continues to search for ways to do more outreach. Currently, GLASE is in the process of finding a new Executive Director and this has slowed down some of the marketing in the last six months. Auditors in the Agricultural Energy Audit program already notify greenhouses at the conclusion of their audit of the opportunity to participate in GLASE. GLASE's board has full autonomy to structure membership fees to encourage participation.

4 Methods

This section provides a high-level overview of the primary data collection 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 participants and members through a survey and interview. This section outlines the data collection method, the respondent profile, and the analysis methods. The appendices contain additional details on the data collection efforts.

Appendix B provides the final Agriculture Energy Audit Program Survey Instrument
Appendix C provides the final Agriculture Energy Audit Program Survey Instrument Utility Questions Only
Appendix D provides the final GLASE Consortium Member Interview Guide
Appendix E provides the GLASE Consortium Member Interview Recruitment Email
Appendix F provides the GLASE Consortium Member Interview Follow-Up Email
Appendix G provides the GLASE Consortium Indirect Impact Methodology
Appendix H provides the disposition reports for the Agriculture Energy Audit Program Survey and GLASE Consortium Member Interviews

4.1.1 Agriculture Energy Audit Program participant surveys

The Market Evaluation Team completed 331 surveys with farms that had participated in a NYSERDA Agriculture Energy Audit between January 2017 and December 2020.

4.1.1.1 ***Survey summary***

NYSERDA Agriculture Energy Audits Program participants were invited to participate in the survey via email along with three follow-up reminder emails and follow-up phone calls for the full sample of participants. The Market Evaluation Team contacted 908 NYSERDA Agriculture Energy Audit participants from 2017 to 2020 to participate in a Qualtrics survey to give feedback on the NYSERDA Agriculture Energy Audit Program. Participants were also invited to participate in a utility account information follow-up survey that was fielded for 6 weeks between December 2022 and January 2023. The utility account information was used by the Impact Evaluation Team to conduct billing analysis; results of this billing analysis are not reported in this report.

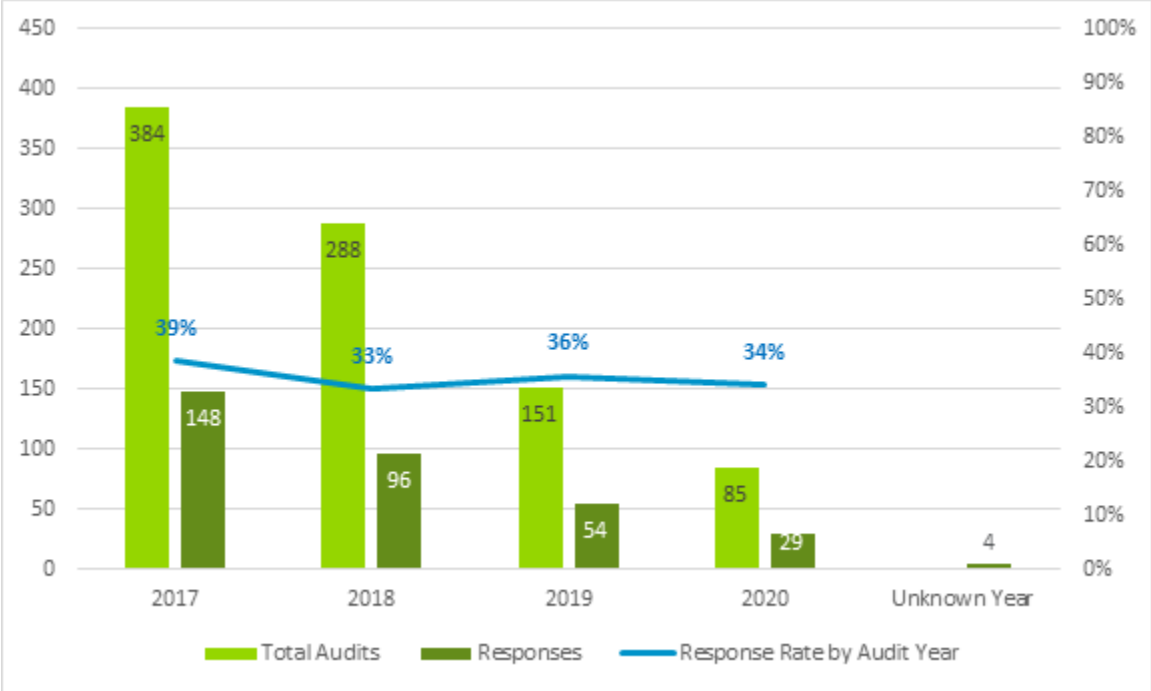
Participants were offered $25 Tango gift card for the completion of a survey and an additional $10 Tango gift card incentive for sharing their utility account information. Respondents completed the survey online and over the phone, with phone completions comprising a significant portion (79%) of

all completed surveys. The Market Evaluation Team fielded this survey for 8 weeks between November 2022 and January 2023 and achieved a response rate of 39% with approximately 27% of survey respondents offering utility information between the original survey and the utility account information follow-up survey. Follow-up phone calls and emails were also utilized to solicit the completion of the utility account information that most survey respondents (60%) reported willingness to share. Although 60% reported willingness to share, 37% of all survey respondents shared utility data in total.

4.1.1.2 ***Participant profiles***

Figure 10 shows nearly half of respondents were from audit year 2017, almost three times the frequency of 2019 audit participants and five times the frequency of 2020 audit participants.

Figure 10. Survey Responses by Audit Year (n=331)
Nearly half of all survey respondents participated in the audit program in 2017.
Source: Market Evaluation Team



As Figure 11 shows, dairy cows were the most reported commodity by survey respondents with 28% of all respondents reporting dairy cows as part of their farming operation with 'Other' commodities representing 20% of reported commodities, closely followed by those reporting growing vegetable farms (17%).

Figure 11. Participant Commodities (n=544)
Respondents gave 544 responses as to the commodities produced at their operation; dairy cows and 'Other' were the most frequently reported at 28% and 20%, respectively.
Source: Market Evaluation Team

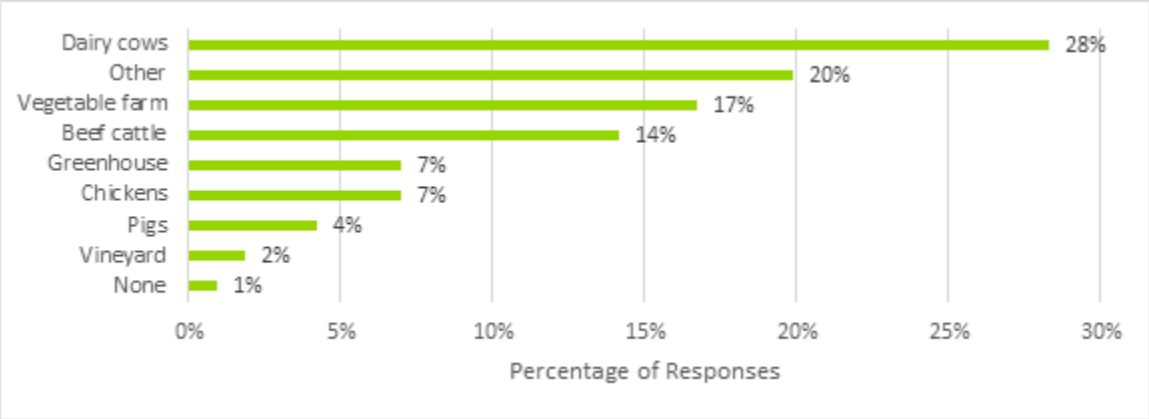
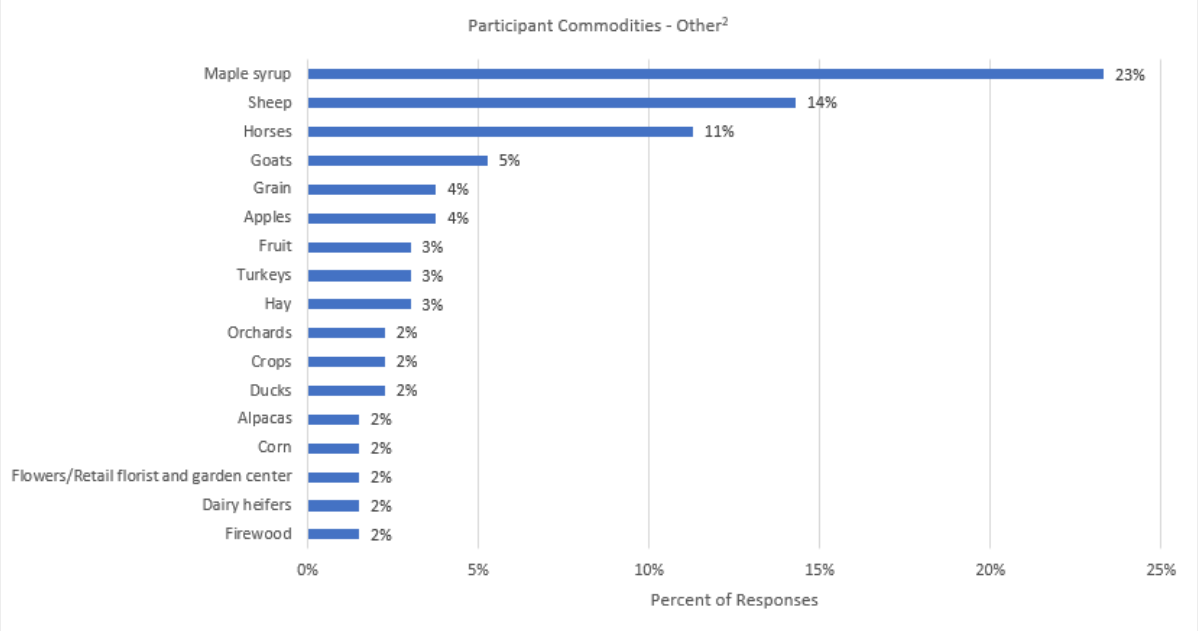


Figure 12 shows that of the 106 respondents who reported that they produce other commodities not listed, 133 responses were given. Maple syrup was the highest reported 'Other' commodity, accounting for 23% of additional reported commodities produced. Sheep (14%) and horses (11%) represented the second and third highest reported responses for 'Other' commodities produced.

Figure 12. Participant Commodities – Other (n=133)[43]
Maple syrup, sheep, and horses were the most common reported 'Other' commodities.
Source: Market Evaluation Team



[43] Total responses to the question: Q3. Which of the following does your agricultural operation located at [PIPE IN ADDRESS FROM FEAT] have? (Select all that apply.); total respondents to this question were 106.

4.1.2 GLASE Consortium member interviews

4.1.2.1 ***Interview summary***

The Market Evaluation Team contacted 26 GLASE Consortium members via email to participate in an interview. GLASE members completed the interviews over video calls that were conducted over the course of 6 weeks between May 2022 and June 2022 using a two-person interviewer and notetaker format. MS Forms software was used to collect information for questions from the structured interview guide developed by the Market Evaluation Team and NYSERDA during Spring 2022. GLASE Consortium interview requests achieved a response rate of 54%. Of the 14 GLASE Consortium members interviewed, five identified as growers and nine identified as non-growers.

4.1.2.2 ***Participant profiles***

GLASE interviewees reported their roles in organizations as President and/or CEO, research and development (R&D), chief technology officer, field application engineer, chief financial officer, chief operations officer, sales manager, and operations manager. Interviewed member organizations included lighting R&D businesses and CEA facilities such as greenhouses and vertical farm operations. Interviewed growers reported business locations in New York State, Wyoming, California, and Dubai and included CEA facilities ranging from 1 to 20 per operation location.

4.2 Analysis

The Market Evaluation Team fielded the Agriculture Energy Audit Program surveys using Qualtrics and analyzed the survey data in SPSS.[44] The team cleaned the data prior to analysis, including filtering the data using IBM SPSS statistical software to analyze only those survey responses in which all required responses were complete and came from eligible respondents (i.e., not screened out due to non-participation, unfamiliarity with the program).

The Market Evaluation Team ran crosstabulations to understand and analyze the relationships and intersections of datapoints within the survey, such as differences in frequencies of responses across farm types and audit years. The Market Evaluation Team ran a Paired Samples Correlation T-test to test for statistical significance in SPSS. Survey results were found to be statistically significant using a 2-tailed significance test.

[44] SPSS is the acronym for Statistical Package for the Social Sciences. Research agencies commonly use SPSS to analyze survey data.

The Market Evaluation Team conducted measure characterization across the measures installed and uninstalled. The Market Evaluation Team ran statistical analysis for frequencies and crosstabulations as well as calculating statistical significance on 33 substantive survey questions. The Market Evaluation Team used thematic analysis in MS Excel to analyze and quantify open-ended text responses, calculating frequencies of thematic responses where applicable, and reporting themes brought up by multiple respondents.

4.3 Indirect Impacts Methods

The Market Evaluation Team developed a methodology to assess indirect impacts from NYSERDA's GLASE initiative. The approach and results of the GLASE indirect impacts were qualitative using GLASE member interview responses.

The Market Evaluation Team reviewed the GLASE member organizations and categorized them into growers and non-growers. Possible expected indirect impacts were then brainstormed to inform the development of an interview guide, which was administered to all interviewed GLASE members. Indirect impacts findings from the interviews were then aggregated and summarized.

The GLASE Indirect Impacts Methodology Memo contains additional details on the Market Evaluation Team's indirect impacts methodology and can be found in Appendix G.

---

[i] A sample of indoor agriculture/greenhouse trade shows include the Northeast Greenhouse Conference and Expo: registration opens in summer 2023, the Indoor Ag-Con (national) in February, and other regional agriculture shows aligned with universities and on ag university campuses.