2021-2024 CDM Framework Targeted Greenhouse Program PY2024 Evaluation Results

Submitted to IESO

in partnership with NMR Group

Prepared by
Resource Innovations – Bashar Alhayek, Benjamin Cartwright
NMR Group – Joanne O'Donnell, Christine Smaglia, Denisse Manzo Gonzalez

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Resource Innovations

TD Canada Trust Tower

161 Bay Street, 27th Floor

M5J 2S1 Toronto, Canada

416.572.2433

resource-innovations.com

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Acronyms and Abbreviations

EM&V	Evaluation, measurement, and verification
EUL	Effective useful life
FR	Free-ridership
GW or GWh	Gigawatt or Gigawatt-hour
IDI	In-depth interview
IESO	Independent Electricity System Operator
kW or kWh	Kilowatt or Kilowatt-hour
LED	Light emitting diode
MW or MWh	Megawatt or Megawatt-hour
NTG	Net-to-gross
PY	Program year
SO	Spillover
TGP	Targeted Greenhouse Program

1 Executive Summary

The Independent Electricity System Operator (IESO) retained Resource Innovations, and their sub-contractor NMR Group, Inc., to conduct an evaluation of prescriptive greenhouse projects delivered under the Targeted Greenhouse Program (TGP) and Retrofit Program as part of the 2021-2024 Conservation and Demand Management (CDM) Framework. This memo presents the evaluation results for TGP projects reported between January 1st and December 31st, 2024 (PY2024) including Standard Greenhouse projects in the Retrofit Program for comparison.

1.1 Program Description

The Retrofit Program offers incentives to industrial, commercial, institutional, and multifamily residential facility customers that express interest in upgrading existing equipment with energy-efficient alternatives. The TGP was introduced on May 17, 2023. Under this program, prescriptive incentives for common horticultural measures, as well as new incentives for advanced lighting controls were made available for greenhouses in the South-West region of Ontario. This program was introduced to address local supply needs in this region driven by the growing greenhouse sector[1]. A Standard Greenhouse project is defined as an individual or company who installed greenhouse measures through the Retrofit Program. Whereas TGP projects were those participants that installed greenhouse measures and were specifically targeted in Southwest Ontario. Standard Greenhouse projects installed measures such as LED Grow Lights - Vegetable Greenhouses, LED Grow Lights - Cannabis Warehouses, and Horticultural Inter-Lighting LED Grow Lights. TGP projects installed LED Grow Lights - Vegetable Greenhouses, Horticultural Inter-Lighting LED Grow Light Fixtures and Greenhouse Advanced Lighting Controls measures. This report focuses on the PY2024 evaluation results for TGP projects and Standard Greenhouse project results have been added for comparison purposes. Additional Standard Greenhouse project results can be found in the 2021-2024 CDM Framework Retrofit PY2024 Evaluation Results report.

1.2 Summary of Results

An impact evaluation was performed to analyze the impact of the program's improvements and quantify the savings realized from implementing energy efficiency projects in greenhouses during PY2024. During the evaluation period, 75 projects were completed in the overall greenhouses stream, out of which 26 projects were reported as TGP projects. The first-year net verified energy and summer peak demand savings for TGP projects was 141,996 MWh and 962 kW, respectively. The first-year net verified energy and summer peak demand savings for Standard Greenhouse projects was 38,784 MWh and 254 kW,

[1] See West of London Bulk Transmission Report, 23/09/2021.

respectively. The net persisting energy and demand savings in 2026 is equal to the first-year net savings for both TGP and Standard Greenhouse projects. In total, TGP projects account for 79% of total net verified energy and summer peak demand savings achieved by the greenhouse stream with Standard Greenhouse projects representing the remaining 21%.

The results of the PY2024 TGP and Standard Greenhouse projects are presented in Table 1-1 and Table 1-2 below.

Table 1-1: PY2024 TGP Impact Results

Greenhouse Stream Savings	Gross Reported Savings	Realization Rate	Gross Verified Savings	Net-to-Gross Ratio	Net Verified Savings	Net Verified Energy Savings in 2026
Energy (MWh)	162,270	94.8%	153,752	92.4%	141,996	141,996
Summer Peak Demand (kW)	681	174.3%	1,055	92.4%	962	962

Table 1-2: PY2024 Standard Greenhouses Impact Results

Greenhouse Stream Savings	Gross Reported Savings	Realization Rate	Gross Verified Savings	Net-to-Gross Ratio	Net Verified Savings	Net Verified Energy Savings in 2026
Energy (MWh)	44,276	94.8%	41,970	92.4%	38,784	38,784
Summer Peak Demand (kW)	158	174.3%	275	92.4%	254	254

Note that in August 2025 IESO conducted an analysis to update greenhouse peak demand coincidence factors. Results can be found in the Capturing the Value of LED Horticultural Lighting: A Market Research Study[2] report which was developed for the 2025 International Energy Program Evaluation Conference.

[2] Cass Heide, et al., "Capturing the Value of LED Horticultural Lighting: A Market Research Study," (paper presented at the International Energy Program Evaluation Conference, Denver, CO, October 2025.)

The PY2024 TGP projects achieved a Program Administrator Cost (PAC) ratio of 2.94 and had avoided GHG emissions from electricity savings resulting in 29,511 Tonnes of CO_2 equivalent (CO_2e). Standard Greenhouse projects in PY2024 achieved a PAC ratio of 3.22 and had avoided GHG emissions from electricity savings resulting in 8,073 Tonnes of CO_2e. The PY2024 Retrofit Program evaluation report provides additional insight into the cost-effectiveness for Standard Greenhouse projects.

2 Impact Evaluation

An impact evaluation was performed to assess energy and summer peak demand savings attributable to the greenhouse stream and to quantify savings generated by implementing greenhouse projects during PY2024. Impact and net-to-gross evaluation methodologies are consistent with the province-wide Retrofit Program evaluation as highlighted in the PY2024 Retrofit Program evaluation report [3].

2.1 Project Participation and Sampling

A greenhouse stream participant is defined as an individual or company who completed a greenhouse project through the Retrofit Program during the evaluation period (January 1st and December 31st, 2024). All projects under the greenhouse stream were prescriptive applications only.

A total of 36 random sample projects were targeted in the greenhouse stratum, as shown in (Table 2-1). The sample size was designed to achieve a 90% confidence level with 10% precision, assuming a coefficient of variation of 0.5. The impact evaluation reviewed a total of 29 evaluation projects as part of the PY2024 greenhouses stream, out of which 18 projects were TGP projects. Although the evaluation did not achieve original sample size and precisions targets, the achieved precision level of 11.5% at a 90% confidence level remains within an acceptable range under industry standards.

Table 2-1: PY2024 Greenhouse Project and Sample Count

Track/Type	PY2024 Target Sample	PY2024 Achieved Sample	Project Count
Greenhouse Stream	36	29	75

2.2 Energy and Demand Savings

As mentioned in Section 1.2 the greenhouse stream consists of TGP and Standard Greenhouse projects. Table 2-2 presents the energy contributions[4] of the TGP and Standard Greenhouse projects to the greenhouse stream. TGP projects contributed 79% (141,996

[3] https://www.ieso.ca/en/Sector-Participants/Energy-Efficiency/Evaluation-Measurement-and-Verification
[4] Energy and Summer Peak Demand savings of the TGP projects include savings from the projects that consisted of space lighting measures only.

MWh) of the greenhouse stream's net verified energy savings where Standard Greenhouse projects contributed 21% (38,784 MWh).

Table 2-2: PY2024 Greenhouse Stream Energy Savings

Greenhouse Stream Category	Gross Reported Savings (MWh)	Gross Verified Savings (MWh)	Net Verified Savings (MWh)	Net Verified Energy Savings % Program Contribution	Net Verified Energy Savings at 2026 (MWh)
TGP	162,270	153,752	141,996	79%	141,996
Standard Greenhouses	44,276	41,970	38,784	21%	38,784

Table 2-3 presents the summer peak demand contributions of the TGP and Standard Greenhouse projects to the greenhouse stream. TGP projects contributed 79% (962 kW) and Standard Greenhouse projects contributed 21% (254 kW) of the greenhouse stream's net verified summer peak demand savings.

Table 2-3: PY2024 Greenhouse Stream Summer Peak Demand Savings

Greenhouse Stream Category	Gross Reported Summer Peak Demand Savings (kW)	Gross Verified Summer Peak Demand Savings (kW)	Net Verified Summer Peak Demand Savings (kW)	Net Verified Summer Peak Demand Savings % Contribution	Net Verified Summer Peak Demand Savings at 2026 (kW)
TGP	681	1,055	962	79%	962
Standard Greenhouses	158	275	254	21%	254

2.3 Impact Evaluation Results

Table 2-4 presents the energy and summer peak demand realization rates for the sampled greenhouse projects. The greenhouses stream achieved an energy realization rate of 94.79% at 11.5% precision at the 90% confidence level and a summer peak demand realization rate of 174.28% at 41.1% precision at the 90% confidence level. The high demand realization rate precision is largely due to the deemed demand savings, which

assumes little to no horticultural lighting operation during the IESO peak demand window[5]. However, site visits revealed that some sampled projects did operate horticultural lighting during the peak period, resulting in measured demand savings where none were assumed. Although these verified savings were relatively small, they caused variability in the verified savings. Given the low deemed baseline, even modest verified savings caused a large swing in realization rates, exaggerating the relative standard error. As a result, the wide precision band reflects both the low verified savings and the inconsistency between deemed and verified demand savings. Details regarding the main factors driving these realization rates can be found in the PY2024 Retrofit evaluation report. The energy realization rate was primarily due to lower verified hours of use for Inter-Lighting LEDs and lower overall conservation case wattages verified in greenhouse facilities through visual inspections and data collected during the evaluation site visits. The energy and summer peak demand realization rates were applied to all greenhouse stream projects including TGP projects.

Table 2-4: PY2024 Greenhouse Stream Sample Realization Rates and Precision

Measure Type	Energy Realization Rate	Energy RR Relative Precision	Summer Peak Demand Realization Rate	Demand RR Relative Precision
Greenhouse Stream	94.79%	11.5%	174.28%	41.1%

Overall, the greenhouse stream projects consisted of measures such as LED Grow Lights - Vegetable Greenhouses, LED Grow Lights - Cannabis Warehouses, Horticultural Inter-Lighting LED Grow Light Fixtures and Greenhouse Advanced Lighting Controls. These measures combined contributed to 48% of the net verified energy and 4% of the net verified summer peak demand savings to the Retrofit Program.

Standard Greenhouses accounted for 65% (49) and TGP accounted for the remaining 35% (26) of projects in the greenhouse stream. Though TGP projects accounted for only 35% of the greenhouse stream projects, these projects had an average net verified energy savings per project (5,461 MWh) nearly seven times higher than the average net verified energy savings per project of Standard Greenhouse projects (792 MWh). TGP had higher savings per project because they were located in the targeted area of South-West Ontario where there is a high concentration of larger greenhouse facilities.

[5] June 1st to Aug 31st from 1:00 PM to 7:00 PM

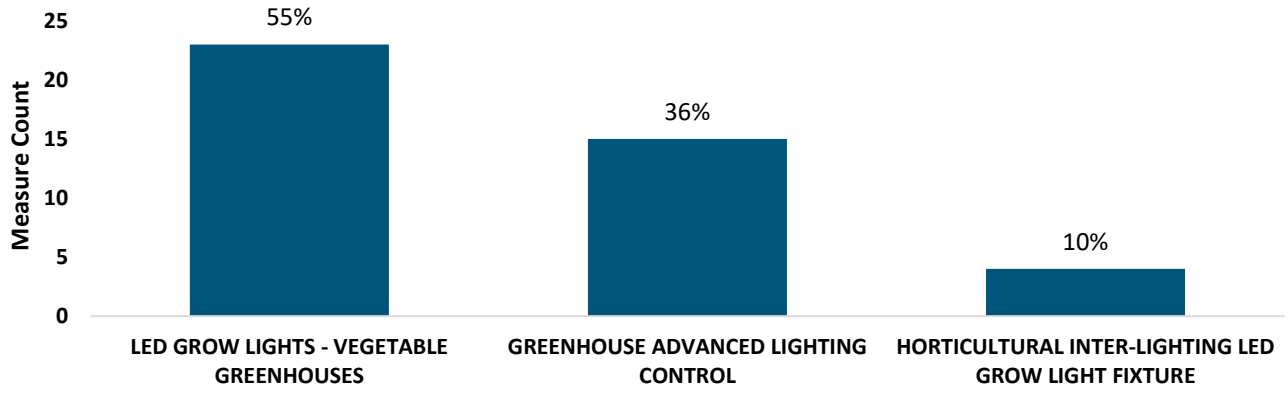
2.3.1 Targeted Greenhouse Program

Participation data consisted of 26 TGP projects of which18 were evaluated during the PY2024 evaluation cycle. Figure 2-1 displays the measure count percentage of these projects by measure category.

The TGP projects consisted of LED Grow Lights - Vegetable Greenhouses, Greenhouse Advanced Lighting Controls and Horticultural Inter-Lighting LED Grow Light Fixtures.

LED grow lights in vegetable greenhouses provided the most common TGP measure, accounting for 55%, followed by greenhouse advanced lighting controls at 36%.

Figure 2-1: Targeted Greenhouse Measure Count Percentages



LED grow lights in vegetable greenhouse measures achieved the highest net energy savings of 97,944 MWh (69%), with horticultural inter-lighting LED grow light fixtures achieving the second highest net energy savings of 26,733 MWh (19%). Even though advanced lighting controls made up 36% of overall measure counts, they only accounted for the remaining 16,680 MWh of net energy savings (12%). LED grow lights in vegetable greenhouses and horticultural inter-lighting LED grow light fixtures accounted for all of the 864 kW (100%) net summer peak demand savings with greenhouse advanced lighting controls having no reported or net verified summer peak demand savings. The additional 639 MWh and 98 kW net verified energy and demand savings resulted from space lighting projects.

2.4 Net-to-Gross

The NTG evaluation assessed free-ridership and spillover through surveys with program participants. A customized survey instrument was developed to ensure the responses produced comparable data and allowed for the inference of meaningful conclusions. Table 2-5 presents the survey methodology, the total population of participants with greenhouse projects who were invited to participate in the surveys, the total number of completed surveys, the response rate, and the sampling error at the 90% confidence level. Please note that CDM Retrofit Program Standard Greenhouse projects are included along with TGP projects for the NTG analysis. Additional details regarding the NTG evaluation methodology can be found in the PY2024 Retrofit evaluation report.

Table 2-5: NTG Evaluation Primary Data Sources

Respondent Type	Methodology	Population	Total Completes	Response Rate
Participants with Greenhouse Projects	Web and Phone Survey	53	17	32%

When conducting the participant survey, a census-based approach was used, which involved e-mailing all 53 companies who completed greenhouse projects to request their participation in the survey. A total of 17 participants responded to this request and completed the survey. The evaluation team developed the contact list of participants from program records provided by the IESO EM&V staff. The survey topics included Free-ridership and Spillover.

Table 2-6 presents the results of the PY2024 greenhouse stream NTG evaluation. The evaluation team targeted and achieved 90% confidence and 10% precision levels in the savings results. The PY2024 Retrofit Program evaluation report provides additional analyses performed to assist in interpreting these values.

Table 2-6: Greenhouse Stream NTG Results

Unique Participants	NTG Responses	Savings Weighted Free-ridership	Spillover – Energy	Spillover – Summer Demand	Weighted NTG – Energy	Weighted NTG – Summer Demand	Energy NTG Precision at 90% Confidence
53	17	7.6%	0.0%	0.0%	92.4%	92.4%	± 7.2%

3 Cost Effectiveness

Cost-effectiveness results for the overall greenhouse stream (TGP and Standard Greenhouse projects) are presented in the PY2024 Retrofit Program evaluation report. The section below details the cost-effectiveness results for the TGP projects which were conducted using IESO's CE Tool V9.1.

3.1 Targeted Greenhouse Program

The PY2024 TGP projects achieved a PAC ratio of 2.94. Table 3-1 presents the results.

Table 3-1: PY2024 TGP Cost-Effectiveness Results

PAC Test	PY2024
PAC Costs ($)	$28,213,605
PAC Benefits ($)	$82,850,022
PAC Net Benefits ($)	$54,636,416
PAC Net Benefit (Ratio)	2.94
Levelized Unit Energy Cost (LUEC)	**PY2024**
$/kWh	$0.02
$/kW	$2,517[6]

LED Grow Lights at vegetable greenhouses in TGP projects contributed the highest PAC benefits to the greenhouse stream at $66,069,143. Greenhouse Advanced Lighting Controls contributed the second highest PAC benefits of $8,701,082. These two measures produced PAC ratios of 3.38[7] and 2.34[8]. As mentioned in Section 2.3.1, LED grow lights in vegetable greenhouses contributed nearly 69% of the total TGP project's net verified energy savings. Measures such as Horticultural Inter-Lighting made up the remaining PAC benefits of $8,079,797.

[6] The $/kW LUEC for TGP projects is based on province wide-peak demand definition (June 1st to Aug 31st from 1:00 PM to 7:00 PM) and does not reflect the local South-West region peak demand benefits.
[7] Measure benefit to cost ratios do not include program admin costs. Admin costs are included in the tables showing overall program and track level CE results. Track-level CE results are directional in nature and to be used for comparison purposes.

4 Process Evaluation

The process evaluation for greenhouse participants was conducted as part of the broader process evaluation of the PY2024 Retrofit Program. The evaluation team assessed program processes through interviews and surveys with relevant program actors, including IESO staff, program delivery vendor staff, applicant representatives, contractors, and participants. The team developed customized interview guides or survey instruments for each respondent type to ensure responses produced comparable data and allowed for the inference of meaningful conclusions. Specific questions and topics related to the greenhouse projects were identified for each respondent. Table 4-1 presents the survey methodology, the total population invited to participate in the surveys or interviews, the total number of completed surveys, the response rate, and the sampling error at the 90% confidence level for each respondent type. Additional details regarding the process evaluation methodology can be found in the PY2024 Retrofit Program evaluation report.

Table 4-1: Process Evaluation Primary Data Sources

Respondent Type	Methodology	Population	Completed	Response Rate	90% CI Error Margin[8]
IESO Staff	Phone In-depth Interviews (IDIs)	4	4	100%	0%
Program Delivery Vendor Staff	Phone IDIs	3	3	100%	0%
Applicant Representatives and Contractors – Greenhouse Stream	Web Survey	4	1	25%	N/A
Participants – Greenhouse Stream	Web and Phone Survey	53	14[9]	26%	43.4%

[8] Error margin not displayed if the respondent count is below 30 unless census is achieved.
[9] The NTG evaluation included more respondents (n=17) than the process evaluation (n=14) as two respondents did not fully answer the process evaluation survey questions.

4.1 IESO Staff and Program Delivery Vendor Staff Perspectives

The following subsections highlight feedback received from IESO staff and program delivery vendor staff IDIs.

4.1.1 Key Findings

Key findings from IESO staff and program delivery vendor staff IDIs include the following:

- IESO staff and program delivery vendor staff suggestions for equipment and services to consider for the greenhouse stream included coil cleaning offerings for packaged thermal air conditioners (PTACs).

4.1.2 Equipment and Services Recommendations

IESO staff and delivery vendors were asked which, if any, additional horticultural equipment or services could be added to the greenhouse offerings in the future.

One delivery vendor indicated that they believed greenhouse customers are currently well-served by the existing equipment and services, and a third delivery vendor indicated that they were not sure given that greenhouse projects were not common in the program area they serve.

One IESO staff member noted that while there are more controllable lighting types available (e.g., controlling the color/spectrum and dimmability), they believe those lighting types are likely cost prohibitive, even if program incentives were to be offered, and that they were unsure about their energy savings.

4.2 Applicant Representative and Contractor Perspectives

The following subsections highlight feedback received from the applicant representative and contractor survey.

4.2.1 Key Findings

Key findings from the applicant representative and contractor survey include the following:

- Applicant representative and contractor suggestions for equipment and services to consider to offer greenhouse customers included strip curtains.

4.2.2 Equipment and Services Recommendations

When asked which, if any, additional greenhouse equipment or services could be added to the program in the future, one contractor recommended strip curtains.

4.3 Participant Perspectives

The following subsections highlight the feedback received from the participant survey.

4.3.1 Key Findings

Key findings from the participant survey include the following:

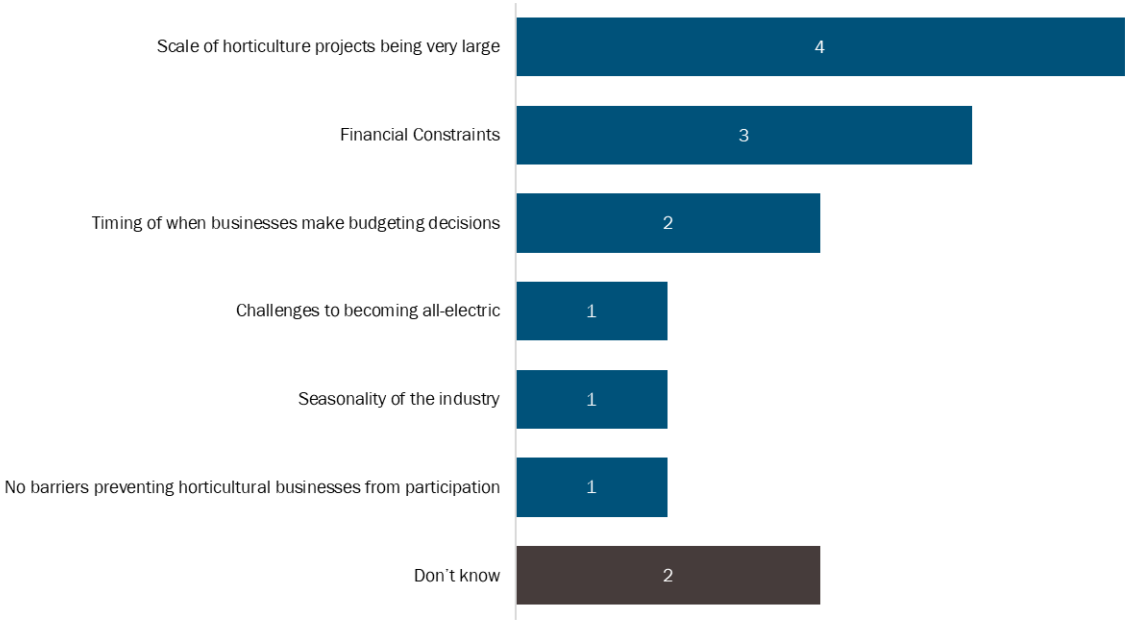
- Participants indicated that the large scale of horticulture projects and financial constraints may be barriers to other businesses completing greenhouse projects through the program.
- Participant suggestions for equipment and services to consider offering to greenhouse customers included adding energy curtains, fans, and power storage equipment as program offerings.

4.3.2 Barriers to Greenhouse Stream Participation

Respondents who had completed greenhouse projects through the program (n=14) identified several barriers that may be preventing horticultural businesses like theirs from participating in it (Figure 4-1). Responses were mixed, with the most commonly cited barriers including the large scale of horticulture projects (4 respondents), financial constraints (3 respondents), and the timing of when businesses make budgeting decisions (2 respondents).

Figure 4-1: Barriers to Participation in the Save on Energy Retrofit Program

(Open-ended and multiple responses allowed; n=14)

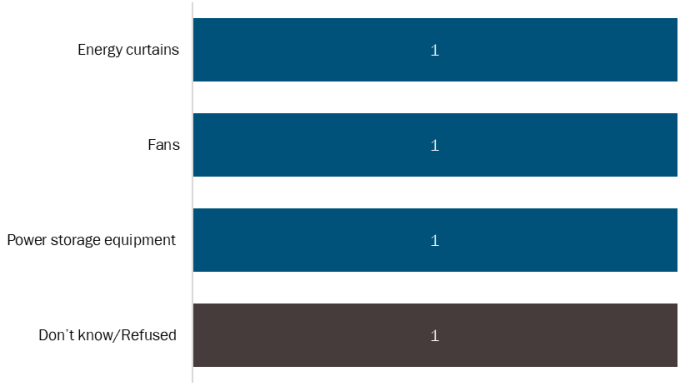


4.3.3 Equipment and Services Recommendations

Respondents were asked to suggest additional energy-efficient equipment or services to offer greenhouse customers in future years. A mix of recommendations is shown in Figure 4-2, including energy curtains, fans, and power storage equipment (mentioned by one respondent each).

Figure 4-2: Greenhouse Stream Equipment /Service Recommendations

(Open-ended and multiple responses allowed; n=4)



4.4 Progress Updates on Previous Recommendations

Progress Update 6: Greenhouse offerings are generally meeting customer needs, though some suggestions were provided for consideration. IESO staff and delivery vendors generally agreed that participants with greenhouse facilities were well-served by the program's related offerings. Suggestions for additional energy-efficient equipment to consider for participants with greenhouse facilities varied and included strip curtains (mentioned by one contractor and one participant), fans (mentioned by one participant), and power storage equipment (mentioned by one participant). Surveyed customers with greenhouse projects (n=14) identified several barriers that may be preventing horticultural businesses like theirs from participating in the program. Responses were mixed, with the most commonly cited barriers including the large scale of horticulture projects (4 respondents), financial constraints (3 respondents), and the timing of when businesses make budgeting decisions (2 respondents).

- **Improvement Opportunity 6a:** Explore the feasibility of incentivizing additional equipment recommended by interviewees and survey respondents for customers with greenhouse projects that align with program goals and cost-effectiveness targets (e.g., strip curtains, fans, power storage equipment).
- **Improvement Opportunity 6b:** Consider opportunities to further address participation barriers to completing greenhouse projects through the program. This could be done through reassuring customers that the program is equipped to provide support regardless of the scale of their projects, through revisiting incentives to ensure their continued relevance, and by better attuned to the timing of when horticultural businesses make budgeting decisions.