Capturing the value of LED horticultural lighting: a market research study

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ABSTRACT

Ontario's horticultural sector has experienced significant growth in recent years, with much of this expansion concentrated in specific regions. The high electricity consumption associated with grow lighting makes this sector a significant contributor to local grid constraints. However, technological advancements have positioned LED grow lighting as a viable alternative to more established technologies such as high-pressure sodium (HPS). Incentive programs have been introduced to encourage the adoption of LED grow lighting and controls in greenhouses. Accurate evaluation of these programs requires current knowledge of both the technology and how they are utilized by growers across various crop types It also requires a deeper understanding of the factors driving choices in this competitive industry, where lighting is a critical factor in crop production. To support this, in-depth interviews were conducted with a variety of market actors to provide qualitative insights into market perceptions, barriers and decision-making processes influencing technology adoption. The study finds that growers are generally risk-averse, with production priorities outweighing energy efficiency considerations. Technology awareness and adoption also varies significantly by crop type. While outreach and education will be important strategies to mitigate hesitancy around adopting new technologies in the future, financial incentives will continue to play a critical role in achieving acceptable returns on investment. Ongoing market monitoring of the sector will be necessary, given the rapid pace of change and the specialized nature of the sector.

Introduction

Greenhouse Energy Efficiency in Ontario

Ontario's greenhouse sector is a major contributor to both the provincial and national economies of Canada. Ontario is home to over 4,700 acres of greenhouse area, accounting for over 70 percent of Canada's total. Of this, approximately 3,900 acres are dedicated to vegetable and fruits production and 800 acres to florals (IESO 2022). Nearly two-thirds of the total market share measured in revenue is comprised of fruits and vegetables, with florals comprising the remaining third. While florals production is concentrated in the Niagara region, the southwestern part of the province has become a major hub for fruits and vegetables. This activity is highly concentrated in Essex County, which hosts over 80 percent of Ontario's vegetable greenhouse area, the highest concentration of vegetable greenhouses in North America.

In recent years, growers have been intensifying operations by increasing production within existing facility square footage, and installing new lighting is one way to do this. However, this necessitates service upgrades due to the high electricity demand of grow lighting. Grid constraints limit the pace at which demand can grow in this small area, which results in delays to new customer connections. This has emerged as a barrier to growth. The Independent Electricity System Operator (IESO), which is mandated to deliver demand side management programs in Ontario, has addressed this challenge in part by offering financial support for growers to install energy efficient lighting systems, which can significantly reduce

their impact on the grid. In 2020, the IESO introduced a time-limited offer that provided triple the standards incentives rate for one year. Since then, prescriptive, and more recently, custom incentives have been offered, covering up to 50 percent of eligible project costs. The IESO offers prescriptive measures for top lighting, inter-lighting and controls. While the program has strategically prioritized certain regions, greenhouses across the province are eligible for incentives.

The IESO's greenhouse offerings have proven highly popular, resulting in 180 GWh of net verified electricity savings in 2024. The majority of these savings (142 GWh across 35 projects) originated from the targeted regions of Southwestern Ontario. Greenhouse measures alone accounted for 48 percent of verified energy savings in the IESO's flagship Retrofit Program in 2024, highlighting the sector's importance within the province's energy efficiency efforts (Alhayek et al. 2025).

To assess the local peak demand impact of these greenhouse measures, IESO's Transmission Planning and Integrated Conservation Planning groups analyzed the three transformer stations serving the greenhouse concentration in Southwest Ontario (Windsor-Essex). These sub-systems face rapid load growth from greenhouse operations and peak uniquely in November–December between 8:00 – 11:00 a.m. unlike the rest of the province, which peaks in summer.

Evaluated greenhouse projects with hourly load data during this local peak accounted for over 71 GWh of verified energy savings. Results showed greenhouse lighting systems have a high coincidence with the local peak, with a weighted average coincidence factor of 77%, meaning 77% of connected demand savings align with the 8:00 – 11:00 a.m. peak. This is significantly higher than coincidence with the provincial summer peak.

The IESO Windsor-Essex Integrated Regional Resource Plan highlights capacity constraints as greenhouse development outpaces existing supply stations (IESO 2025). Coincident peak demand reductions driven by IESO's greenhouse offerings help mitigate the reliability risks while capacity upgrades are planned.

Table 1 below shows the savings impact of the IESO's prescriptive greenhouse lighting and controls offering between 2022 and 2024.

Table 1. Savings from Greenhouse Lighting and Controls Measures

Program Year	Number of Projects	Energy Savings (verified, GWh)	Local Peak Demand Savings (verified, MW)
2022	42	107	32
2023	29	133	57
2024	73	180	52

Research Drivers and Objectives

The IESO regularly evaluates its in-market programs to verify their impact on electricity energy and demand reductions, as well as to identify opportunities for ongoing program and process improvement. Horticultural offerings are evaluated as part of the broader evaluation of the Retrofit Program. Evaluation data has proven invaluable to deepening the IESO's understanding of relevant technologies and informing updates to measures and assumptions where necessary. Given the scale of savings in greenhouse lighting projects and the rapid pace market evolution, the IESO opted to undertake additional market research to supplement the standard evaluation process and provide a more comprehensive view of the sector. The IESO partnered with Resource Innovations, the evaluator for the SaveOnEnergy Retrofit Program and Targeted Greenhouse Program, to conduct a market characterization

study of the horticultural sector in Ontario. The remainder of this paper presents the findings from the market characterization effort.

The main objective of the study was to update the IESO's understanding of Ontario's horticulture market and to inform potential enhancements future program design. To achieve this, the study explored the following topics:

- Lighting and lighting controls technologies used in Ontario's horticultural sector, along with the current market share of each technology
- Historic and emerging trends influencing the market share of these technologies
- Key market actors, their roles and interactions, and the journey of products through the supply chain
- How decisions are made regarding the adoption of energy-efficient lighting equipment, including the challenges and barriers to adoption

Results are used to inform ongoing program design updates, including the selection of appropriate baselines for prescriptive measures, the development of effective incentives, and the identification of optimal program delivery approaches. A secondary goal of the study was to explore non-lighting greenhouse technologies with potential for energy efficiency. The study assessed grower awareness of technologies including HVAC systems, heat recovery applications, solar photovoltaic systems, and battery storage solutions. These findings are presented in Appendix A.

Study Methodology

Data was collected primarily from in-depth interviews (IDIs) with market actors. To inform the interview process, secondary research was conducted, including literature review and jurisdictional scan. This review aimed to assess the historic progression of technology, analyze the current state of the horticulture market, and project future trends. The research focused on collecting data relevant to program design elements, including baseline equipment, incentive structure, and program delivery strategies.

Interview guides were developed for each market actor group. These guides were tailored to ensure the responses produced comparable data and allowed for the inference of meaningful conclusions. Interviews focused on the following topics:

- Background information (e.g., crop market share, lighting technologies used, production trends, technology innovations)
- Grower awareness and understanding of lighting and non-lighting technology
- Market actor interactions and the horticulture lighting supply chain in Ontario
- Decision-making related to horticulture lighting
- Energy efficiency programs
- Non-lighting measures.

A list of contacts from key market actors was developed through engagement with government and industry associations, including the Ontario Ministry of Agriculture, Food, and Rural Affairs (OMAFRA), the Ontario Greenhouse Vegetable Growers Association (referred to as the association in this report), the Ontario Greenhouse Alliance, and Flowers Canada. Past participants in the IESO's Retrofit Program also contributed to the contact pool.

In total, interviews were conducted with 20 individuals across 13 organizations. Table 2 presents the number of completed interviews by respondent and organization for each market actor group.

Table 2. Number of Respondents and Organizations Covered by Interviews

Market Actor Type	Completes - Respondents	Completes- Organization
Association	4	3
Ministry (OMAFRA)	3	1
Grower	4	4
Manufacturer	6	4
Delivery Agent	3	1
Total	20	13

For each completed interview, the study team analyzed transcripts to compile findings and observations addressing the study objectives.

Market Characteristics

Overview

According to the Ontario Fruit and Vegetable grower association, Southern Ontario hosts the highest concentration of greenhouses in North America. The main vegetable and fruit crops grown in Ontario are cucumbers, tomatoes, and peppers, with each accounting for roughly one third of the total market share. Interviewees noted that these crops have been grown in Ontario for over a century. Recently, however, a small but growing share of greenhouse acreage has shifted towards strawberries, lettuce, and eggplant. This shift reflects a broader trend in Ontario driven by increasing consumer demand for locally grown fresh berries. Overall, the vegetable greenhouse market in Ontario has experienced consistent growth, with revenues increasing by approximately 6 percent annually over the past decade. This growth trajectory is expected to continue, supported by rising demand for locally sourced produce.

Interviews with floriculture association members revealed that the floriculture sector grows about 300 different plant varieties a year, including potted plants, tropical plants, bedding plants, and cut flowers. While the floriculture industry experienced a surge in demand during the COVID-19 pandemic as – driven by increased interest in indoor decor–, Ontario's floriculture industry has been on a decline due to increasing import competition from California and Mexico.

Technologies Used by Greenhouses in Ontario

Lighting systems

In-depth interviews provided valuable insights into the types of lights and lighting control technologies used in Ontario, as well as the considerations behind their selection. According to interviewees, approximately 20 to 30 percent of greenhouses in Ontario have some form of lighting installed. Across all market actor groups, interviewees consistently indicated that HPS remains the most prevalent lighting type in Ontario greenhouses. However, they also noted that nearly all new installations use LED lighting, driven by energy efficiency benefits and incentives available.

Perceptions of the current market share between HPS and LED lighting varied widely across interviewees, even within the same market actor groups. Some reported as much as 98% HPS and 2% LED, while others estimated the market to be 60-70% HPS and 30-40% LED. A small portion of the market was also noted to use hybrid applications of both LED and HPS lights. Given this variability, the exact market breakdown remains unclear, though there is general understanding that HPS dominates the existing horticultural lighting stock.

When asked why HPS remains the most common lighting technology in Ontario, interviewees unanimously cited the high capital cost of switching to LEDs. While incentive programs are available, many growers feel the financial support is not enough to offset the capital investment. Additionally, many growers perceive LED technology as relatively "risky", preferring the reliability and familiarity of HPS, which they consider tried and tested. Some also believe HPS lighting to be more energy efficient than LED lighting because the heat it emits reduces the need for additional HVAC systems (which is commonly natural gas).

Interviewees noted that growers consider LED lighting more suitable for certain crops. For instance, LED lights are preferred for lettuce and strawberries due to their tunable light spectrum and low heat emission. In contrast, HPS lights are preferred for tomatoes, cucumbers and florals because of their broad light spectrum, which more closely mimics natural sunlight. Florals are almost always grown with HPS lighting due to the wide variety of plant types grown in a single space, each with different light needs. For monoculture crops like tomatoes and cucumber, LED lights can be tailored to specific plant requirements, making them more suitable in such settings. That said, LED use is more common for

cucumbers than tomatoes, as cucumbers require less heat. Table 3 summarizes the preferred lighting types by crop type, and the reasons behind those preferences.

Table 3. Light Type Preferred by Growers, by Crop Type

Crop Type	Most Common Light Type Used	Decision Criteria
Tomatoes	HPS	• Broad light spectrum • Generates heat • Mimics natural sunlight
Cucumbers		
Florals		
Lettuce	LED	• Tunable light spectrum • Lack of heat
Strawberries		
Peppers	None	• Sunlight is sufficient

Among the growers interviewed, one used only HPS lighting, another used only LED lighting, while the remaining two growers utilized a hybrid approach combining both HPS and LED lighting. Those opting for a hybrid application aimed to maximize efficiency, benefiting from the heat generated by HPS lighting and the spectrum tunability of LED lighting.

Lighting control systems

Based on interview responses, any greenhouse grower with lighting can generally be expected to also have some form of lighting control system. This is mainly because lighting is typically integrated into a broader environmental control system that also controls temperature, CO_2 levels, ventilation, and irrigation. Manufacturers and growers interviewed view greenhouse equipment -including lights- as part of a comprehensive integrated system. Thus, growers will adjust their control systems to incorporate lighting controls should they have lights installed.

Interviewees reported a wide range of lighting control systems currently in use. For high-pressure sodium (HPS) lighting, the most common approach remains simple on/off capability. Because HPS lighting is still the dominant technology in Ontario's horticulture sector, these basic controls remain the most prevalent. In contrast, light-emitting diode (LED) systems are typically paired with more advanced "smart" control solutions. These can monitor light levels and plant growth, use algorithmic capabilities to adjust lighting parameters, and often include automated dimming to reduce plant stress and save energy. Timing controls also help regulate photoperiods, which are critical for flowering and fruiting.

Smart lighting solutions for LEDs increasingly incorporate sensors and Internet of Things (IoT) connectivity, providing real-time monitoring and remote-control capabilities. This integration allows growers to make more precise adjustments, driving improvements in crop quality, increasing yields, and reducing operational costs. These capabilities are not feasible with HPS technology and have become a key driver for the adoption of LEDs

Research on LED lighting and plant growth is advancing rapidly, necessitating continuous updates to remain current. Recent years have seen significant progress in LED control technologies through collaborations among lighting manufacturers, growers, and academic institutions. While the fruit and vegetable segment has been the focus of most research and adoption, interviewees noted that there is limited evidence on effective lighting controls for floriculture, creating uncertainty about best practices in that subsector.

Across Ontario, the leading providers of integrated environmental and lighting control systems were consistently reported as Grow Wise by Signify Lighting, Priva, Hoogendoorn, and Argus. Any grower with a modern control system is likely to be using solutions from one of these companies.

Awareness of Lighting Technology

Manufacturers, OMAFRA staff, and association members were asked to share their perceptions of grower awareness and understanding of horticulture lighting technologies. Growers were also invited to assess their own awareness and understanding. The following sections summarize these findings and identify potential knowledge gaps among growers in the horticulture lighting sector. Growers' understanding was explored in relation to lighting and lighting controls, as well as for newer energy efficient lighting, particularly LEDs.

Grower awareness of lighting and controls in general

Market actors interviewed generally perceived grower awareness and understanding of horticulture lighting technology to be relatively high. All market actors were asked to rate their perception of growers' understanding of both lighting and lighting control technologies using a scale of one to five, where one is no understanding at all, and five is complete understanding. Table 4 highlights the average rating reported across the different market actor groups.

Table 4. Average Rating of Perception of Grower Understanding of Lighting and Controls

Market Actor	 Associations (N=4)	 OMAFRA (N=3)	 Growers (N=4)	 Manufacturers (N=6)
Average Rating of Understanding	4.7	4.9	4.8	3

Market actors who rated grower awareness highly noted that growers are well-informed about available lighting technologies, as lighting plays a critical role in their operations. They also noted that the dense concentration of greenhouses in Southwestern Ontario also facilitates knowledge sharing within the grower community. While growers may not always know the most effective lighting specifications for each crop, they recognize the importance of supplemental lighting and are willing to conduct their own research to inform decisions.

Differences in perception of grower knowledge level of available lighting technologies and controls across crop subsectors were also observed. Two respondents highlighted that cannabis growers tend to have more advanced understanding of lighting technologies, as their crops are heavily reliant on controlled environments. One respondent noted that floriculture growers may lag behind in awareness of the latest lighting technologies, since innovation in this subsector has traditionally focused less on climate and lighting control. In contrast, vegetable growers – often operating under fixed selling price/contracts – have limited flexibility to raise prices in response to rising input cost. As a result, vegetable growers are more motivated to adopt technological strategies to reduce their overall production cost while maintaining or improving crop yields.

Grower awareness of energy efficient lighting

All market actor groups viewed grower awareness and understanding of newer energy efficient lighting – particularly LEDs – as generally high. To remain competitive, growers must stay up to date with advancements in lighting technologies. However, as with general lighting knowledge, interviewees reported variations in the depth of awareness across different types of growers and facilities. Smaller facilities may face time and resource constraints that limit their ability to research and adopt new technologies, as owners often need to balance multiple responsibilities, including plant care. Similarly, older facilities with lower ceiling heights may be less compatible with newer technologies designed for

higher ceilings installations. Crop type also plays a significant role in technology adoption. Floriculture growers, who tend to update systems less frequently, may have a more limited familiarity with advanced lighting solutions. In contrast, vegetable and cannabis growers – whose crops are highly responsive to controlled lighting – often demonstrate a deeper understanding and are more proactive in adopting advanced technologies to optimize growth.

Despite the overall high level of understanding and awareness among growers, the following areas were identified as opportunities for further knowledge building:

- Lighting recipes that work for each crop
- Incentives available
- The importance of controls and how the sensors function
- How lights will impact overall production practices
- Case studies of successful applications of LED lighting

Supply Chain for Horticulture Lighting and Lighting Controls

The global horticulture lighting market has experienced significant growth and is projected to continue expanding, with a Compound Annual Growth Rate (CAGR) of 18.1 percent forecasted between 2022 and 2029 (Global Market Estimates 2024). European manufacturers maintain a strong influence in the production of greenhouse supplemental lighting lamps. In contrast, the Asia Pacific region dominates the production of panel-style LED lighting. Meanwhile, North America is emerging as a leader in the development of indoor farming lighting solutions, such as multi-linear or spider-style modules. This trend is likely driven by the region's growing investment in vertical farming and plant factory infrastructure.

To identify the key manufacturers of LED lighting in Ontario's greenhouse sector, applications submitted to IESO's greenhouse initiatives between 2020 and 2023 were reviewed. Philips, Agrolux, and Fluence currently hold a dominant position in the market (estimated at 68% market share). However, Canadian manufacturers – such as P.L. Lights and Solum Technologies – are increasingly entering Ontario greenhouses. Their presence is expected to expand further as local suppliers gain traction and the market continues to evolve.

Product journey

Interviews with market actors highlight a significant difference in the supply chain journey between HPS and LED lighting products. For HPS lighting, the process typically begins with the greenhouse owner – often also the lead grower – deciding that supplemental lighting is needed and opting for HPS as the preferred technology. Since HPS lights tend to be uniform in design and functionality aside from wattage options, there are usually no further decisions required regarding product selection. The grower will then engage a contracting company, which will then source the lights from a supplier. An installation team carries out the installation of the lighting in the greenhouse.

LED lighting projects involve additional consultation largely due to considerations around light spectrum and colour. Prior to committing to LED lighting, greenhouse growers or owners typically explore available financial incentives to reduce higher upfront cost – often a key factor in the decision-making process. Once the decision is made, growers engage with a range of stakeholders, including lighting suppliers/distributors, contractors, and potentially specialized consultants. The sales pathway for LED systems generally flows from manufacturers to suppliers or distributors to growers. However, there are instances where manufacturers sell directly to growers. In such cases, growers may initiate contact, or manufacturers may proactively reach out to offer early access to new technology as part of research and development. Some manufacturers may also provide opportunities for growers to participate in light trials, allowing them to test the suitability of the technology for their specific crops. Figure 1 below shows the LED lighting product journey.

Control system manufacturers typically collaborate directly with LED lighting manufacturers to ensure that correct specifications are integrated into the control system. These manufacturers also maintain relationships with growers and owners of greenhouses, providing technical support and maintenance of the control system.

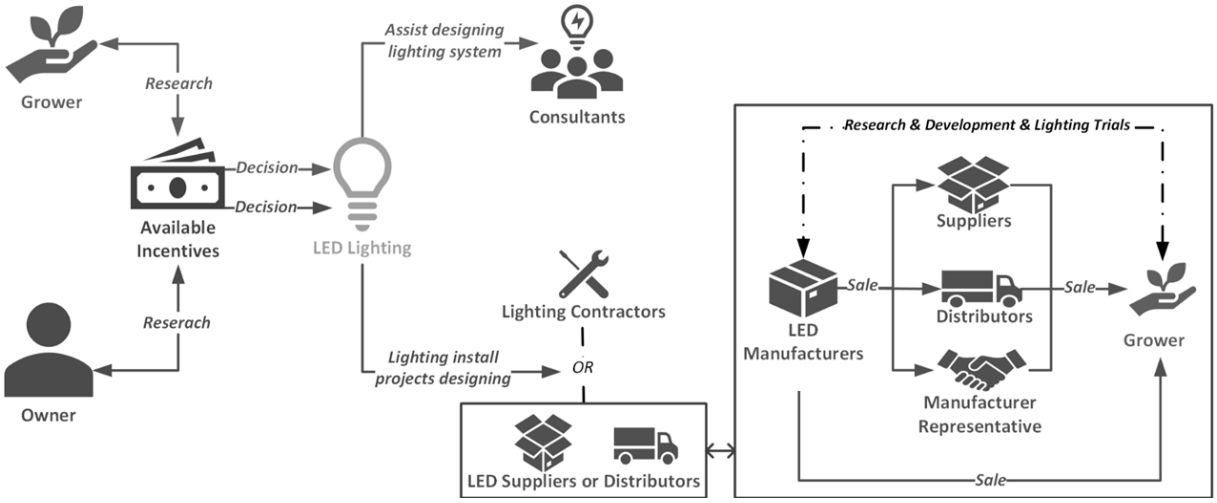

Figure 1. LED Lighting Product Journey

Adopting Energy Efficient Lighting Technology

Characterizing lighting technology decisions

All respondents indicated that greenhouse owners are responsible for decision making regarding lighting technology. However, these decisions are typically made in consultation with growers to ensure the selected lighting aligns with the specific needs of the greenhouse environment and crops being grown. Growers consider multiple factors when selecting lights. Figure 2 outlines these considerations, categorized into two main groups: 1) plant-related factors, and 2) non-plant related factors.

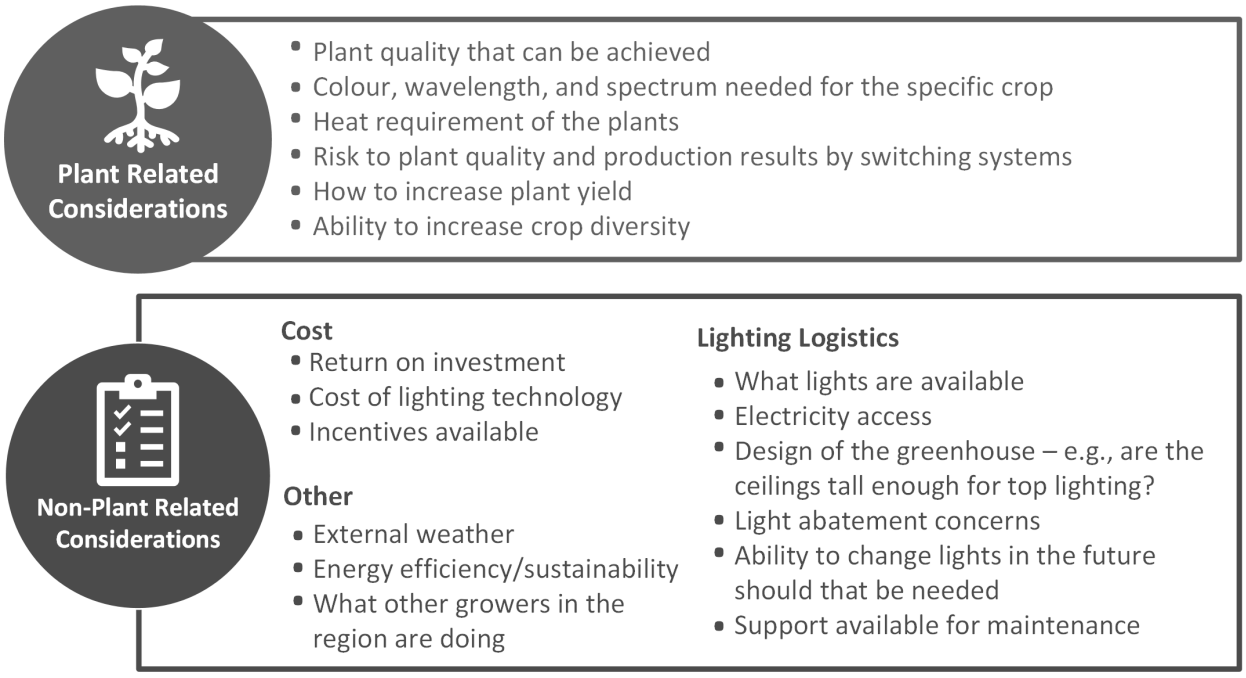

Figure 2. Factors Considered When Choosing Lights

Challenges in adopting efficient technology

A consistent set of challenges were identified as barriers to the broader adoption of LED lighting technology in the greenhouse sector. The primary challenges are summarized below.

- **Insufficient research on crop-specific lighting needs**: to fully benefit from LEDs growers must understand the optimal "lighting recipe" – the combination of light intensity, duration, and spectrum – for each crop. This challenge is especially pronounced in the floriculture sector, where less research is available compared with the vegetable sector.

- **High sensitivity to risk:** Concerns about crop quality and production can create apprehension around moving away from proven technologies – especially in retrofit situations. The rapid pace of innovation also contributes to hesitation, as some fear their investment may quickly become obsolete.

- **High capital cost**: Manufacturers and growers reported that LED lighting often have ROI of around ten years, whereas growers are typically seeking an ROI of under five years.

Reducing cost barriers is the primary focus of energy efficiency programs. However, complementary strategies – such as case studies and partnerships with research institutions – may be beneficial in addressing knowledge gaps and ease grower apprehension.

Future Trends

Market actor interviews generally support the IESO's understanding of the trends occurring in the sector. Interviewees were asked to identify both recent developments and their expectations for the next five to ten years. The findings are summarized into the following key areas:

- **A shift toward greenhouse lighting in general**: Growers are increasingly adding lights to their greenhouses, making unlit facilities less common. This trend has enabled a move toward year-round crop production in Ontario.

- **A shift toward LED lighting**: While adoption has been gradual and with some hesitation, market actors unanimously agree that the future of the horticulture lighting market lies in LEDs. Manufacturers report that LED sales have doubled year over year for the past decade. The growth of vertical farming helping drive this demand and incentives have also made LEDs more economically feasible for growers. Prices are expected to continue declining, which alongside program incentives, will help reduce the upfront investment required.

- **Increase in quality of LED light technology**: LED lights have become more energy efficient, and according to manufacturers, research into dynamic pulse lighting suggests that this efficiency will continue to improve. Furthermore, LED lights are now dimmable, the range of available light spectrums has expanded, and light lifespans are increasing. Future research is expected to drive further improvement in LED lighting technologies, including greater output efficiency, improved colour spectrum options, dimming capabilities, higher quality diodes, and greater reliability.

- **Increase in smart controls and smart technology:** as LED lights have become more commonly installed, controls have followed. In the future, growers are expected to rely more on controls. These systems are also expected to become more flexible, allowing for greater fine-tuning to meet specific growers needs.

- **Advancements in research on crop needs**: The horticulture industry is gaining deeper understanding of how tailor lighting parameters to the specific needs of each crop type. Future research into crop-specific lighting needs, particularly in the floriculture sector, is expected to support adoption of LED systems.

It is also important to note that Canadian regulatory trends may, in the future, accelerate the transition away from mercury containing products such as HPS lights. Federal regulations prohibit the import and manufacture of HPS lamps used for general lighting by 2029; however, lamps used for growing plants are currently exempt (Government of Canada 2025). Market research indicates that some large suppliers may be removing HPS lighting from their product catalogue pre-emptively. It is important for the IESO to continue monitoring the regulatory and market environment as LED alternatives become more economical. However, recent evaluations confirm the findings of this study, which is that HPS remains the most economically viable option for growers in absence of incentives.

Outcomes

Research supports the overall understanding that IESO's incentives have been highly effective in driving grower adoption of LEDs in new installations. Growers continue to experience delays in upgrading electrical connections to support planned additions of greenhouse lighting to their facilities, an issue which has downstream implications on economic growth. LEDs can reduce the grid impact of these greenhouse expansions, but financial support remains necessary to reducing the ROI of LEDs compared with HPS. This is also reflected by high Net-To-Gross (NTG) ratios. In program year 2024, the IESO's greenhouse lighting offering received an NTG ratio of 92.4% (Alhayek et al. 2025). This demonstrates that the majority of participants would not have chosen LED lighting in the absence of the program.

As the sector continues to evolve, there are both continued growth opportunities and emerging challenges in supporting its development. Given the rapid pace of technological change, IESO is closely monitoring the greenhouse measures and assumptions, including baseline and efficient case wattages and hours of use. [1] Along with evaluation results, this study's findings have informed recent changes to IESO's prescriptive measures. Recent updates to measure savings assumptions were made to the vegetable LED grow light measure to more accurately estimate savings, and align incentives to estimated savings. Additionally, the horticultural inter-lighting measure has been refined to differences in crop type and application – distinguishing between vertical and non-vertical farming. These changes aim to reduce the risk associated with variability in project conditions.

Over the longer term, it is important for the IESO to continue monitoring this transitioning market to keep financial incentives aligned with the need. However, there may be a meaningful role for incentives to encourage the adoption of newer, higher-efficiency LEDs over older, lower-efficiency models. Incentives could also help accelerate the early replacement of existing HPS systems—particularly in vegetable greenhouses, where LED grow lights have a relatively long Effective Useful Life (EUL) of 21 years. The study indicates that retrofitting existing low-efficiency lighting systems with LEDs remains a more challenging proposition for growers, but this could be possible with more support. In the near term , continued assistance will be important to continue to help the sector adopt more efficient technologies

[1] For documentation of all measures and technical assumptions, see 2025 Prescriptive Measures and Assumptions List - Technical Supplement.

Appendix A: Non-Lighting Technologies

A secondary goal of the study was to explore market attitudes toward opportunities for efficiency in greenhouses beyond lighting and lighting controls. Some potential technologies of interest included solar photovoltaic (PV) and battery storage solutions, heat recovery, climate control systems, irrigation management, soil management, and pest control systems. It should be noted that the IESO's programs have historically been limited to electricity system benefits (i.e., energy savings and demand reduction). This can at times create a disconnect with the needs of growers, who are focused on maximizing production relative to cost inputs. Furthermore, a more holistic sustainability program might consider additional goals such as water efficiency, natural gas savings, or emissions reduction. Given the program's objective of supporting economic growth while minimizing the impact on the electricity grid, solar PV, battery storage, and potentially HVAC systems were of greatest interest to the IESO study team due to their potential for managing electricity use.

The Retrofit program currently offers incentives for non-lighting measures of interest to greenhouses, such as variable frequency drives, high-efficiency ventilation exhaust fans, recirculation ventilation fans, and dual and natural exhaust vents. The IESO recently piloted a solar PV and battery storage measure targeted to the greenhouse sector, but uptake was low. Process evaluation results pointed to major barriers being cost – particularly for the battery component – and growers' comfort level with the technology.

The market research indicates mixed perceptions regarding grower understanding of non-lighting technologies, with association members reporting a higher perception of grower understanding compared to OMAFRA members and most manufacturers. One respondent highlighted that while that every grower is aware of these technologies, they tend to have less understanding of those they consider a lower priority for their operations. Growers (n=4) interviewed supported this view, emphasizing that they are fully knowledgeable about measures that impact them but are less familiar with technologies they have not adopted to that are not directly relevant to their production. Currently, lighting remains a primary focus for growers as it plays a critical role in supporting production. Looking ahead, as lighting measures become increasingly saturated and less viable as a source of incremental savings, future program directions may need to adopt a more holistic approach that incorporates technologies beyond lighting. However, significant barriers remain in shifting grower attention away from lighting, as many are hesitant to invest in measures they perceive as less directly tied to their core production priorities.

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