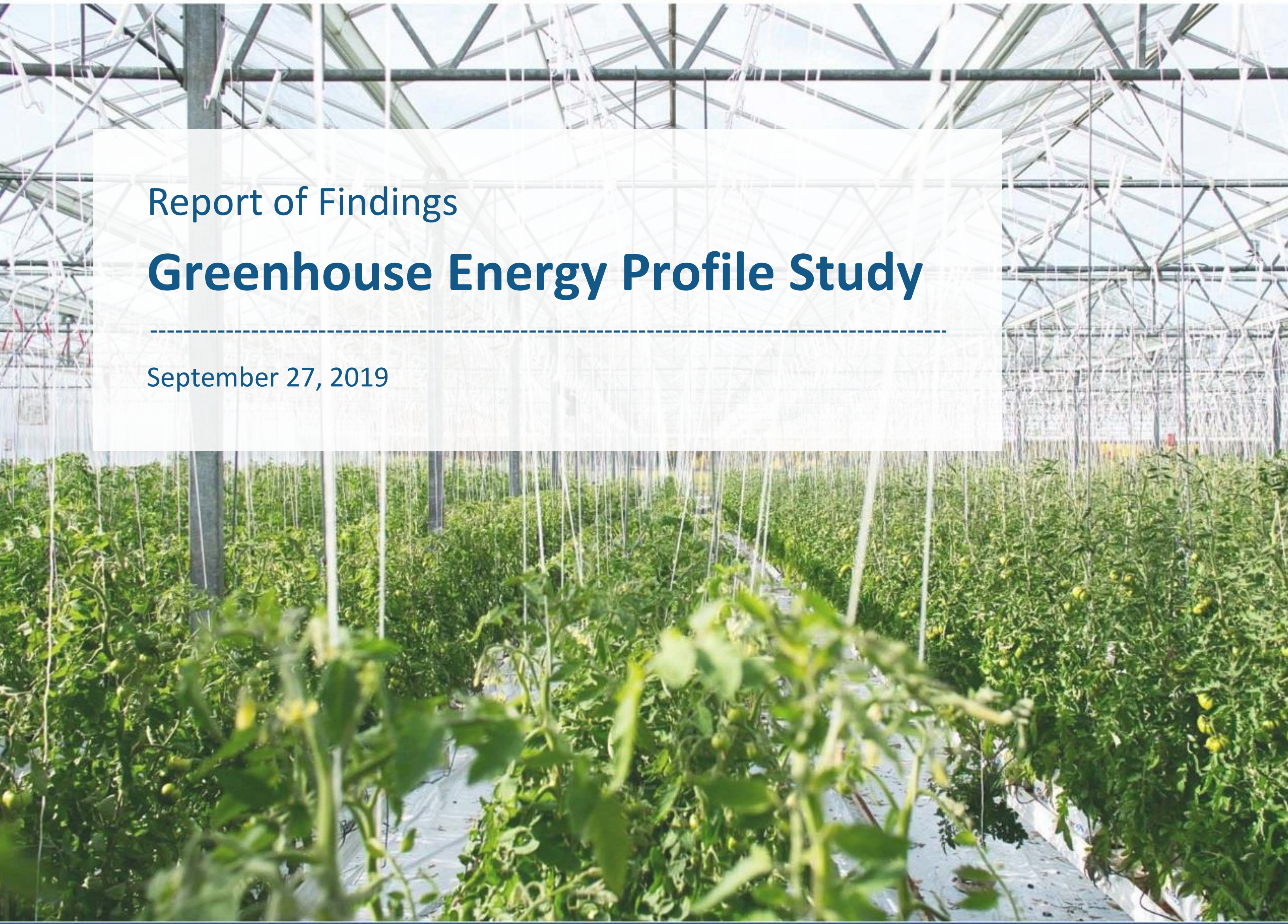


Report of Findings

Greenhouse Energy Profile Study

September 27, 2019

Independent Electricity System Operator
1600-120 Adelaide Street West
Toronto, ON M5H 1T1

Posterity Group
43 Eccles St, 2nd Floor – Unit 2
Ottawa, ON K1R 6S3

Contents

Executive Summary

The report was commissioned by the IESO with support of other utilities and agencies to uncover opportunities to further support growth in the sector and ensure that customers continue to have access to reliable and affordable energy. This information provides valuable data to the sector, utilities and government in helping plan for future needs, and is a first step in working together to provide innovative solutions for the sector to continue to thrive.

Since the 1990's, Canada has become one of the largest producers of greenhouse products in North America [1], with Ontario having the largest greenhouse sector in Canada relative to other provinces. In 2017, Ontario represented 60% of total national greenhouse area [2] and contributed 70% of farm gate value. In 2016, the Ontario greenhouse sector supported $3.2 billion to GDP and over 80,000 jobs [3].

This study assesses the energy use of Ontario's covered agriculture sector across four key sub-sectors: **vegetables & fruits**, **flowers & potted plants**, **greenhouse cannabis**, and **indoor cannabis**. Vertical farming is presented, but in less detail.

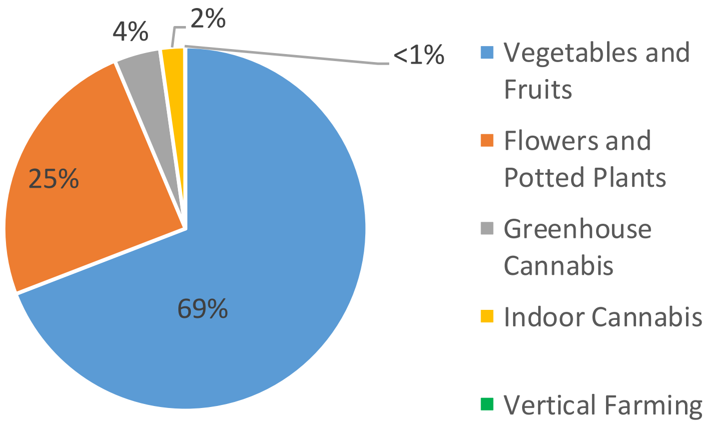
These sub-sectors are also examined across five regions: ***Essex***, ***Chatham-Kent***, ***Haldimand-Norfolk***, ***Niagara***, and the ***Rest of Ontario***. This report summarizes how energy is used across sub-sectors and regions in 2018 and forecasts energy use and savings potential from 2019 to 2024.

Scale of Ontario's Greenhouse Sector

The Essex region has the largest concentration of vegetable greenhouses in North America [4], Ontario is the third largest producer of greenhouse-grown flower products in North America [5], and Ontario is projected to become the largest cannabis production market in Canada [6].

In 2018 Ontario had 162[1] million ft^2 of covered agriculture; the vegetable sub-sector is the largest, followed by flowers.

Exhibit 1 – 2018: Proportion of Floor Area by Sub-sector



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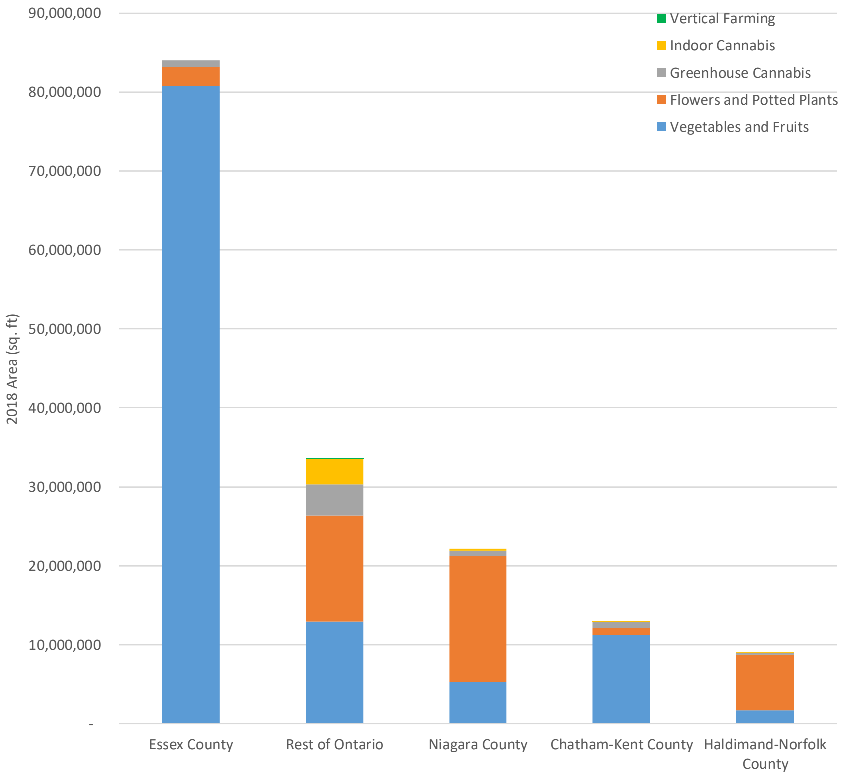
[1] All numbers in the executive summary have been rounded.

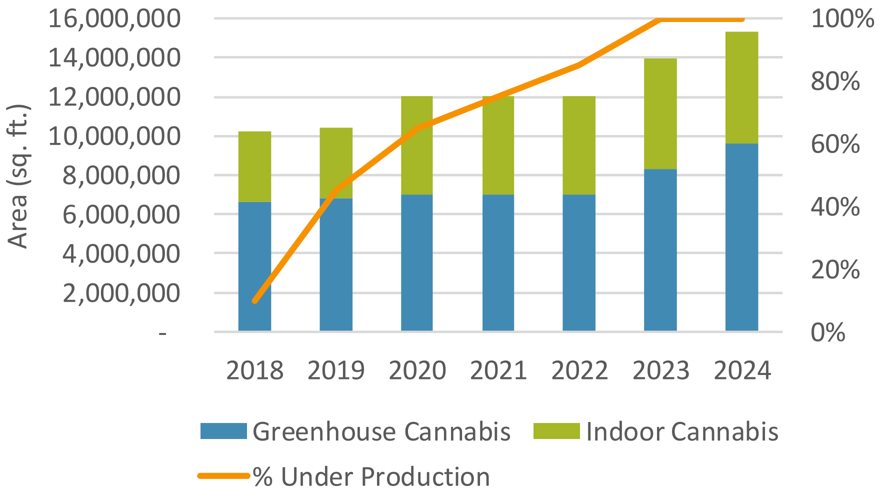
Most of the greenhouse floor area in Ontario is in Essex County. There is more greenhouse area in Essex County (84 million ft^2), than in the rest of Ontario combined (78 million ft^2).

Exhibit 2 – 2018: Floor Area by Sub-sector and Region



In 2018, cannabis producers had a footprint of 10 million ft^2, but only 10% of this was planted and growing product. The remaining facility area is expected to be utilized quickly, with 100% being built out by 2023.

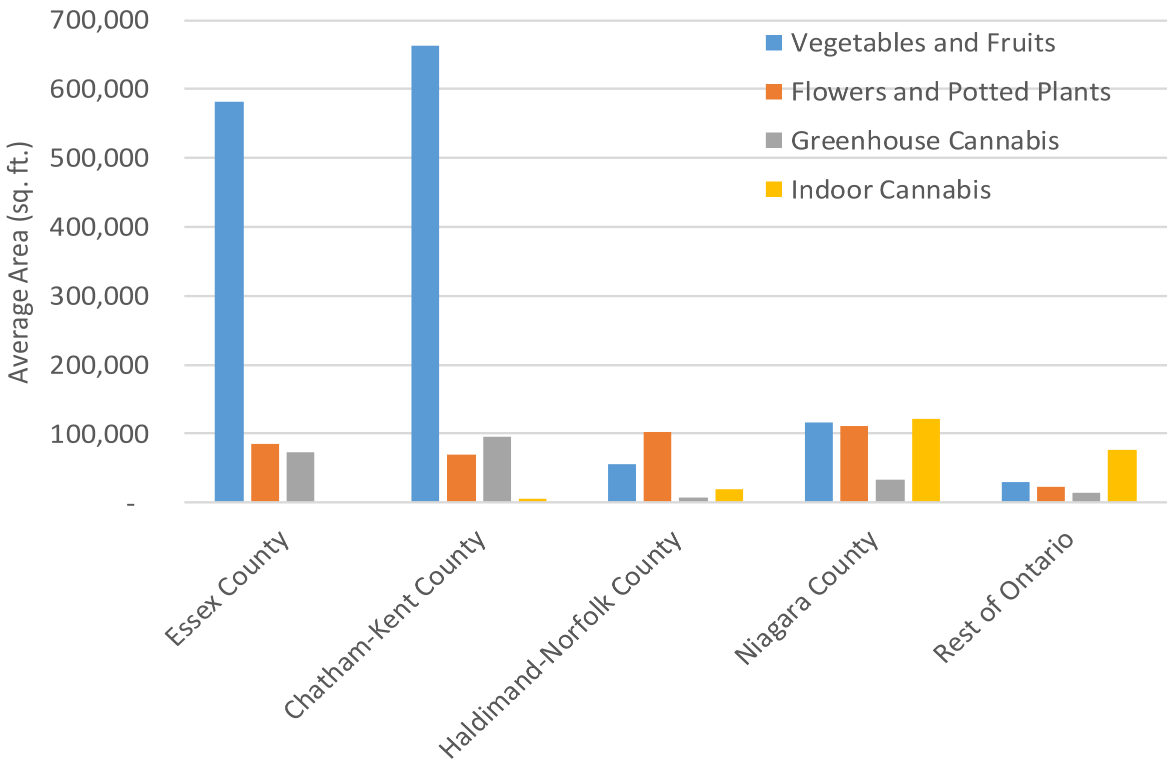
Exhibit 3 – 2018-2024: Total Area (sq. ft.) and % Under Production of the Cannabis Sector



Average facility size varies considerably by sub-sector (and sometimes also by region):

- The average vegetable greenhouse in Essex and Chatham-Kent is 9 times larger than the average in the rest of the province.
- The average flower greenhouse in Niagara and Haldimand-Norfolk is 2 times larger than the average in the rest of the province.
- The average cannabis greenhouse in Essex and Chatham-Kent is 4.5 times larger than the average in the rest of the province.
- The average indoor cannabis facility in Niagara is 3.5 times larger than the average in the rest of the province.

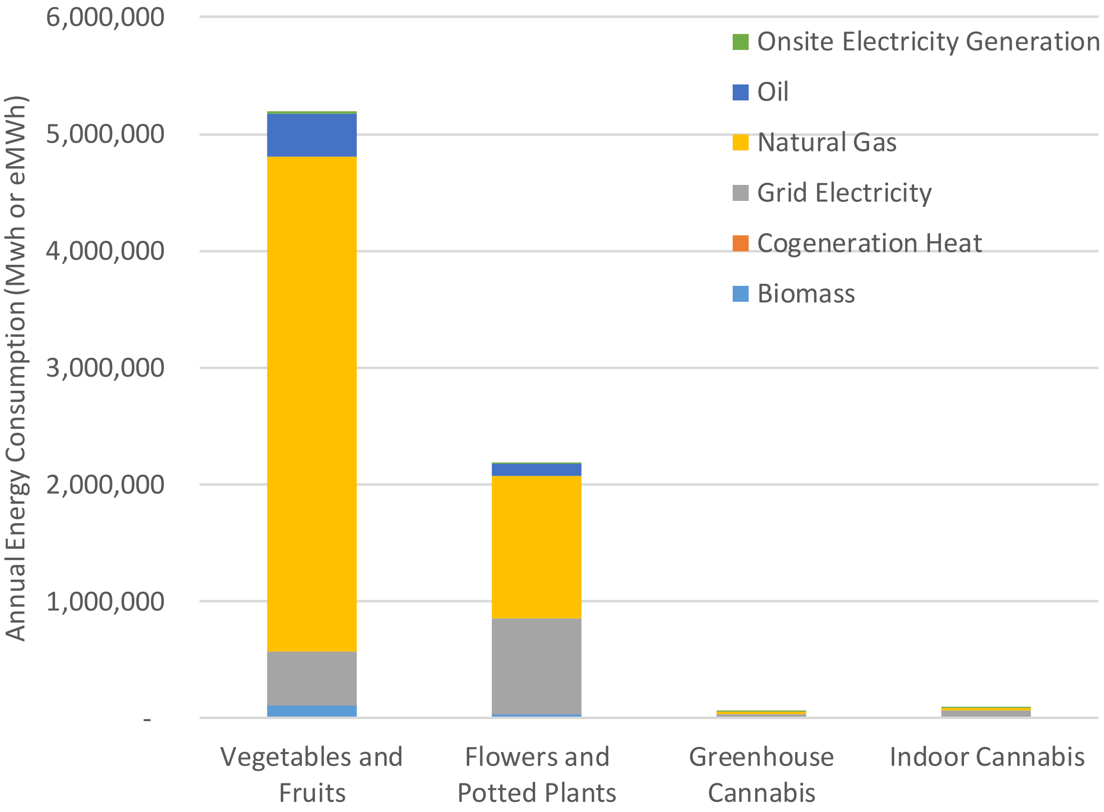
Exhibit 4 – Average Facility Size (ft^2) by Sub-sector by Region



How Energy is Used

In 2018 the sector consumed 7.5 eTWh of energy, 73% of this was fueled by natural gas and 18% from electricity. Most of the energy is consumed by the vegetable sub-sector.

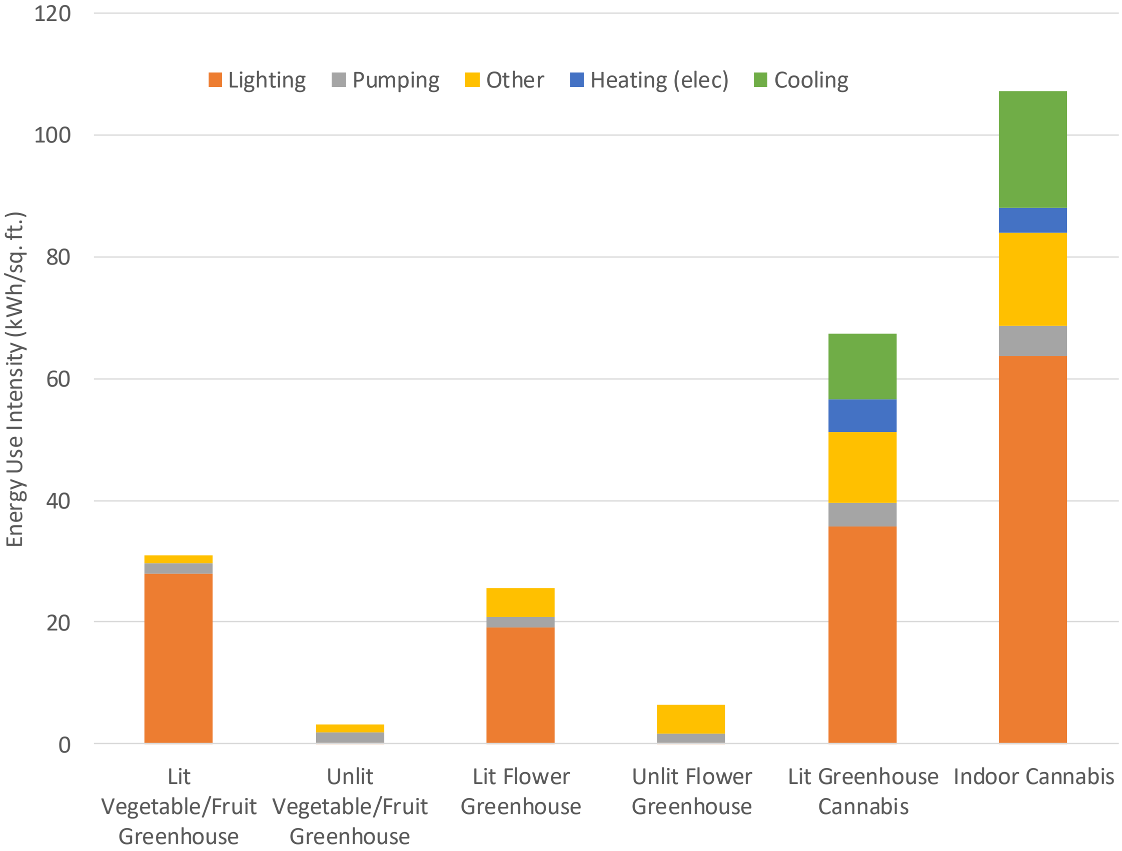
Exhibit 5 – 2018: Energy Consumption (MWh or eMWh) by Sub-sector and Fuel



Electricity end-use intensity (kWh/ft2) varies across the greenhouse sub-sectors and between lit and unlit facilities:

- A lit vegetable greenhouse consumes 10 times as much electricity as an unlit vegetable greenhouse, with essentially all the additional electricity used for lighting.
- A lit flowers greenhouse consumes 4 times as much electricity as an unlit vegetable greenhouse.
- Indoor cannabis facilities use almost 3.5 times more electricity per square foot than lit vegetable greenhouses.
- Indoor cannabis facilities use 1.4 times more electricity than cannabis produced in greenhouses.

Exhibit 6 – Electricity End Use Intensity by Facility Type (kWh/ft^2)



Horticulture Lighting

In 2018, more electricity was consumed for lighting (752,000 MWh) than for the other electrical end-uses combined (637,000 MWh). The predominant lighting technology in the greenhouse sector continues to be high-intensity discharge lighting, with high-pressure sodium (HPS) grow lights being used in a typical covered agriculture facility.

Lighting was also the most significant driver of greenhouse peak hour demand in regions with high concentration of lit greenhouses. Greenhouse peak hour is not coincident with the provincial system summer or winter peaks. This is because the greenhouse peak hour aligns with the peak lighting load at greenhouse facilities. In areas with high concentrations of greenhouses, this greenhouse peak hour is impacting local transformer stations.

Exhibit 7 – 2018: Electricity Consumption (MWh/yr.) by End Use and Sub-sector

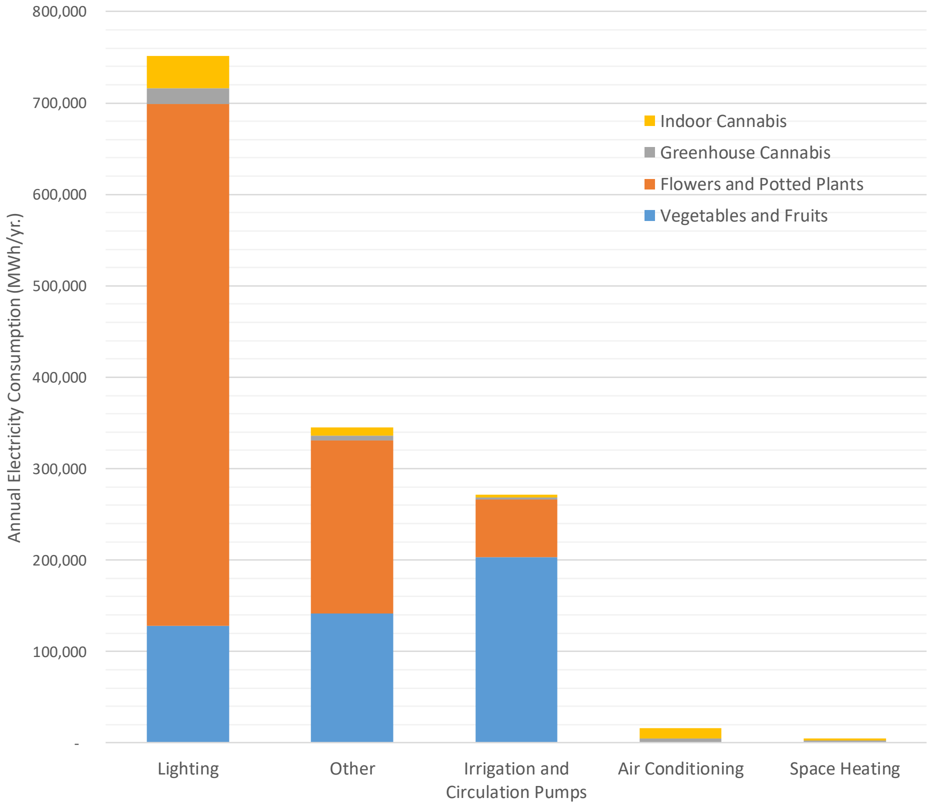
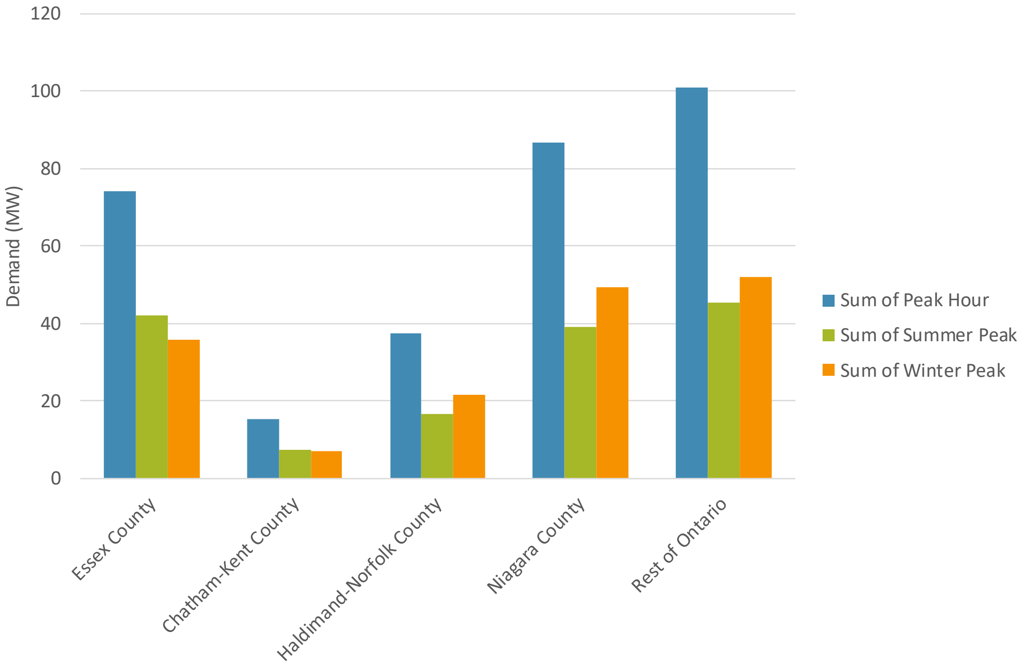


Exhibit 8 – 2018: Demand by Peak Period and Region



Forecasted Growth and Grid Constraints

Energy grid expansion (electric and gas) is occurring in areas where grid constraints exist and are anticipated to experience further demand. Notable growth is expected over the next six years due to:

- Increased acreage in the vegetable sub-sector.
- The build out of greenhouse and indoor facilities serving the newly developed cannabis sub-sector.
- The addition of horticulture grow lighting in the vegetable sector.

Exhibit 9 – Forecasted Growth in Area by Subsector (ft^2)

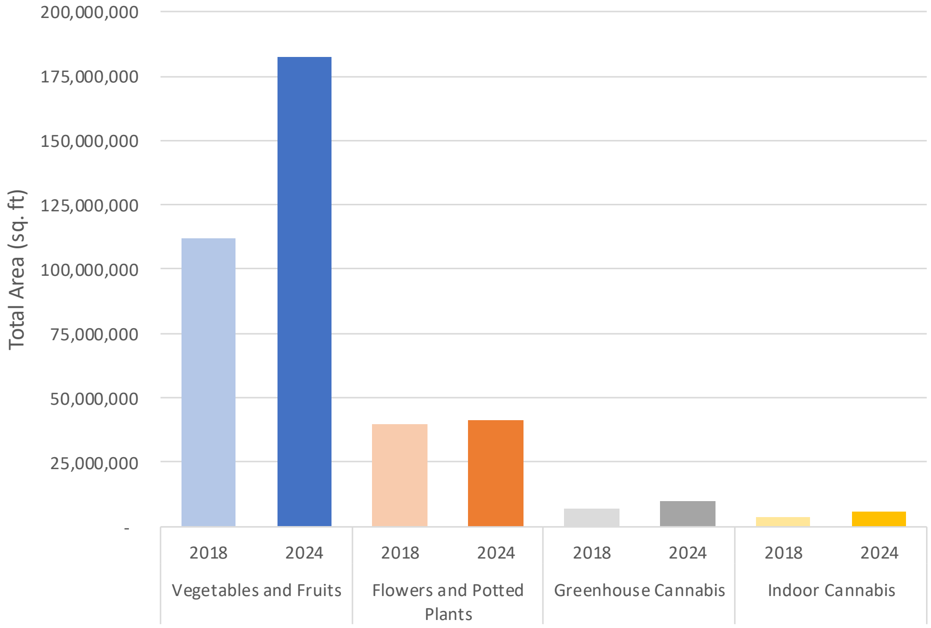
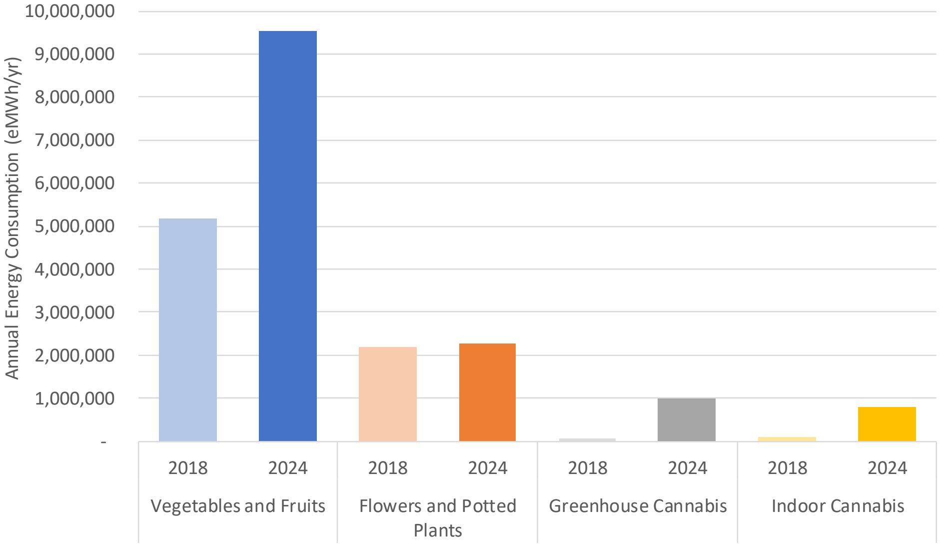


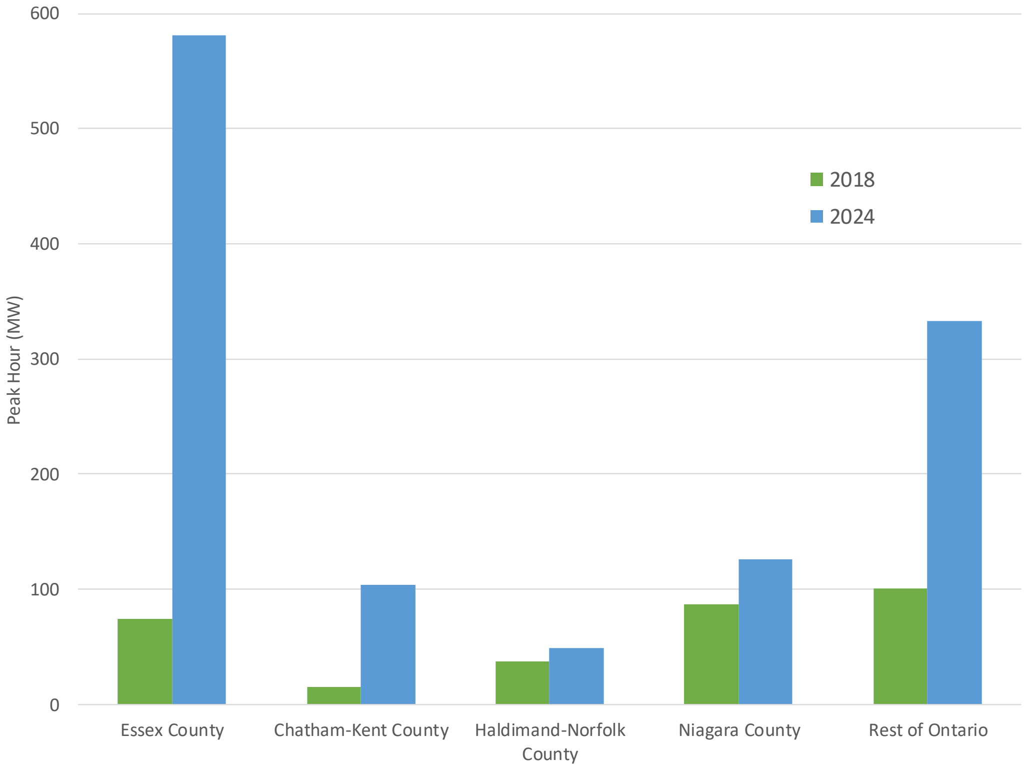
Exhibit 10 – Forecasted Growth in Energy Consumption by Sub-sector (eMWh/yr)



Due to the current concentration of vegetable greenhouses in the Essex region, the load profile for the area differs from the rest of the province. As more greenhouses across Ontario use supplemental lighting, and the footprint of the covered agriculture sector grows, other regions may take on the load profile that is currently unique to Essex.

The Essex region is predicted to have the highest peak hour in 2024, largely due to an increase in grow lighting in the region's vegetable sub-sector (from 4% of greenhouse area in 2018 to 29% of area in 2024).

Exhibit 11 – Forecasted Change in Peak Hour Demand by Region



Behind the Meter Tri-Generation

To address local connection constraints, growers that need additional capacity (e.g., due to the introduction of year-round artificial crop lighting) are taking matters into their own hands and installing gas-fired behind the meter tri-generation units. Tri-generation units (also known as combined heat and power [CHP] units) generate electricity and produce the by-products of heat and carbon dioxide. Tri-generation units are typically sized to offset lighting load and have the additional benefit of providing heat and CO_2 to the greenhouse[2]. Almost 70 MW of behind the meter generation is projected to be operational by the end of 2019; by 2024, this is expected to increase.

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[2] This study did not quantify the CO2 benefits from tri-generation units. The analysis focuses on the electricity generation and heat recovery; therefore we use tri-generation and CHP interchangeable throughout the report.

Near Term DSM Research Priorities

Energy supply planners, growers, and covered agriculture stakeholders should be focusing their attention in the immediate term on three priority areas so that research and funding effort can be applied judiciously to have the largest impact on supporting grid reliability through demand side management.

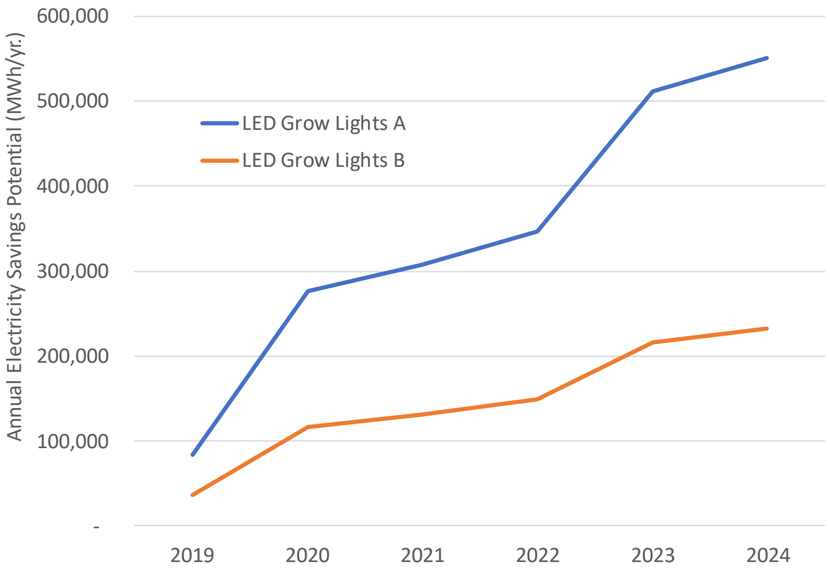
LED Grow Lighting

Although there is a lot of discussion in the covered agriculture sector about light-emitting diodes (LED) grow lights, it is not yet widely accepted as a viable replacement option for HPS fixtures. Until very recently, no horticulture lighting standards existed for manufacturers. Growers have been skeptical of performance of LED with as energy savings claims range from 20-60% and the costs of LEDs are currently four to five times the price of HPS fixtures.

In response to the increasing interest in LED lighting in plant growth applications, The American Society of Agricultural and Biological Engineers (ASABE) has developed new horticulture lighting standards. The DesignLights Consortium (DLC) has also recently developed a new performance standard for LED products and has a new Horticulture Qualified Products List. In the coming years these lighting standards should help to build trust between growers and lighting manufacturers and suppliers regarding performance information as LED technology continues to mature.

To illustrate the magnitude of the savings potential that will be possible in the future once LED becomes more widely accepted as a legitimate replacement option, the study presents analyses on two hypothetical savings scenarios. They show LED lighting could have an impact between 230 GWh/year and 550 GWh/year by 2024.

Exhibit 12 – Hypothetical Consumption Savings Potential for 2 LED Scenarios



Lighting Load Demand Response

Because grow lighting is a significant contributor to greenhouse load demand in regions with high concentrations of greenhouses (e.g. Essex, Niagara), demand response targeting lighting schedules could have a notable impact on peak reductions. In practice, this load could be shed by:

- Turning-off lighting (or reducing lighting levels) when the local grid is projected to peak (between 5am and 9am, weekdays, Jan, Feb and Dec);
- Staggering light cycles; or ,
- Potentially leveraging other technologies that could achieve the same impact (e.g., storage, behind the meter generation).

The good news is that demand response in the greenhouse sector has been around for a long time; in the 1980's well known methods for demand response were implemented in the covered agriculture sector by Ontario Hydro and other North American utilities. Today in Colorado, Xcel Energy is running a demand response program with greenhouse participants. Demand response aggregators are helping covered agriculture customers in Colorado earn revenue by reducing their lighting load for less than one hour a week [68].

Innovative Technology

Beyond the DSM opportunities discussed and analyzed in detail in this study, there are several promising innovative solutions Ontario's covered agriculture sector and energy supply planners will be paying close attention to in the coming years:

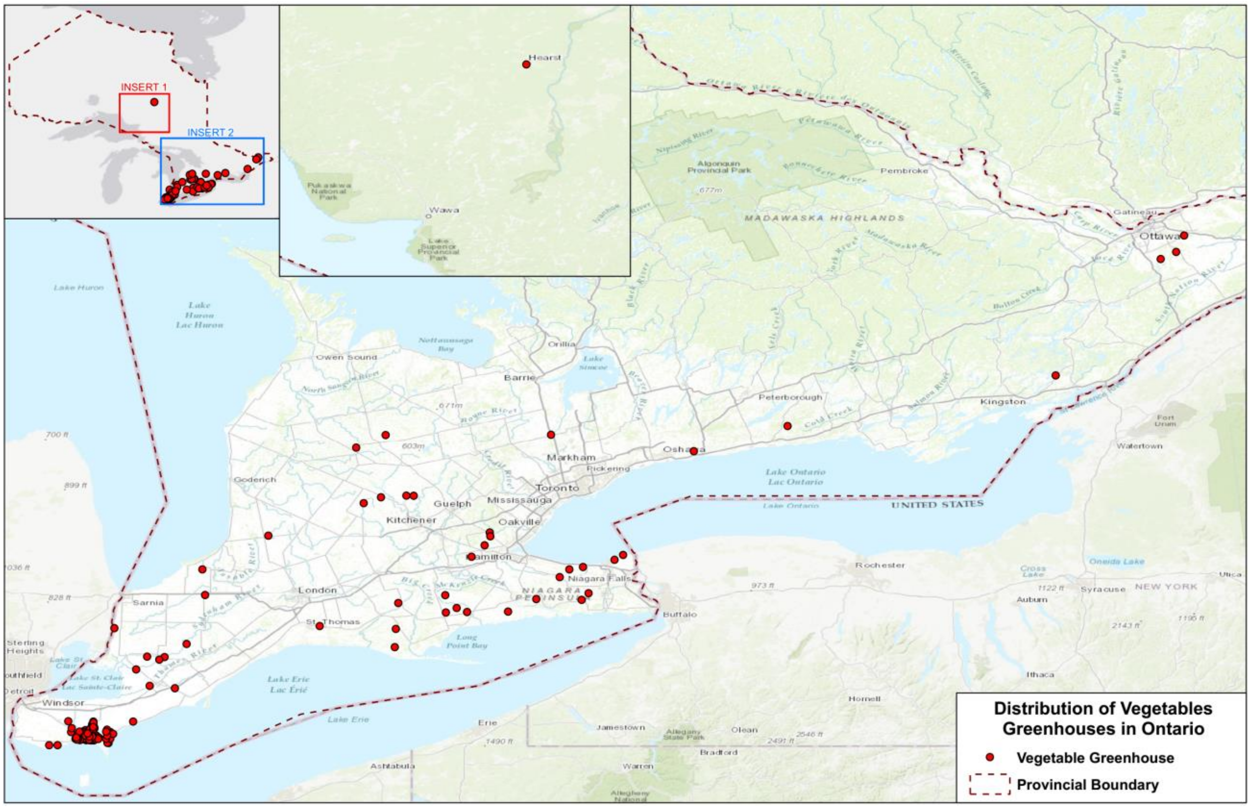
- Greenhouse-integrated semi-transparent solar photovoltaics
- Seasonal thermal energy storage assisted ground-source heat pump
- 'Nextgen' control systems leveraging advanced sensors and artificial intelligence
- Hybrid generation & storage
- Microgrids and asset networking

Covered agriculture growers have a long history of adoption of innovative practices and technologies and will continue to assess and adopt new solutions when sound business cases can be substantiated. Research and pilot testing of several promising technologies and energy solutions over the next five years is important to build credible business cases for DSM, to enable cost reduction and increased competitiveness, and ensure energy reliability and resilience.

Sub-Sector Highlights: Vegetables & Fruits

The vegetable and fruit greenhouse sub-sector is the largest and fastest growing segment of the horticulture sector in Canada [7]. As of 2017, most of the greenhouse acreage in Ontario produced vegetables. The main vegetable crops are tomatoes, peppers and cucumbers which account for almost 98% of total vegetable harvest, with each accounting for about one-third of vegetable production [8]. Other vegetable crops include lettuce, eggplant and herbs. Some fruits are also produced in greenhouses, including a variety of berries [9]. The 2017 farm gate value from Ontario greenhouse vegetables was $840 million, with more than 70% of produce exported to the U.S. [8]. In 2016, the export value of greenhouse vegetables was the highest of all fresh produce exports, accounting for about 40% of all fresh produce exports from Canada [7].

This sub-sector is concentrated in the Essex region. Of the 224 members of the Ontario Greenhouse Vegetable Grower (OGVG) association, 85% are in the Essex region [10]. Greenhouses are concentrated in this area in part due to the warm climate (relative to the rest of Canada) and close proximity to the U.S. [10].



Greenhouses used for these crops tend to have glass roofing, use energy screen systems, and heat with centralized steam or hot water systems, including after-market condenser systems. Structures are ventilated using horizontal fans and climate control is managed through integrated computer-controlled systems. These greenhouses are large natural gas consumers with their major end-uses being space heating. Vegetable greenhouses traditionally did not use supplemental grow lighting, but this beginning to change with growers looking to increase production to meet increasing demand. Lit vegetable greenhouses tend to consume a significant amount of electricity, and existing greenhouses introducing grow lighting is expected to be a significant driver of electricity growth in this sector over the next six years.

Between 2018 and 2024, electricity consumption in the vegetable sub-sector is forecasted in increase by 282%. Over the same time period, greenhouse peak hour demand is projected to increase by 552%.

- The vegetable sub-sector is forecast to grow by 5% per year for all regions over the next five years. Essex County is an exception, growing at an average of 9% year over year during the reference period. Due to a high number of connection requests in the area, growth is expected to follow the IESO's electricity demand growth forecast.
- The lit portion is expected to increase from 4% in 2018 to 8% by 2020 in all regions except Essex, where the lit percentage increases to 29% by 2024 (existing growers adding grow lighting is a significant contributor to the electricity demand forecast in the region).

Exhibit 13 – Vegetable Sub-sector Electricity Growth by Region (MWh/yr.)

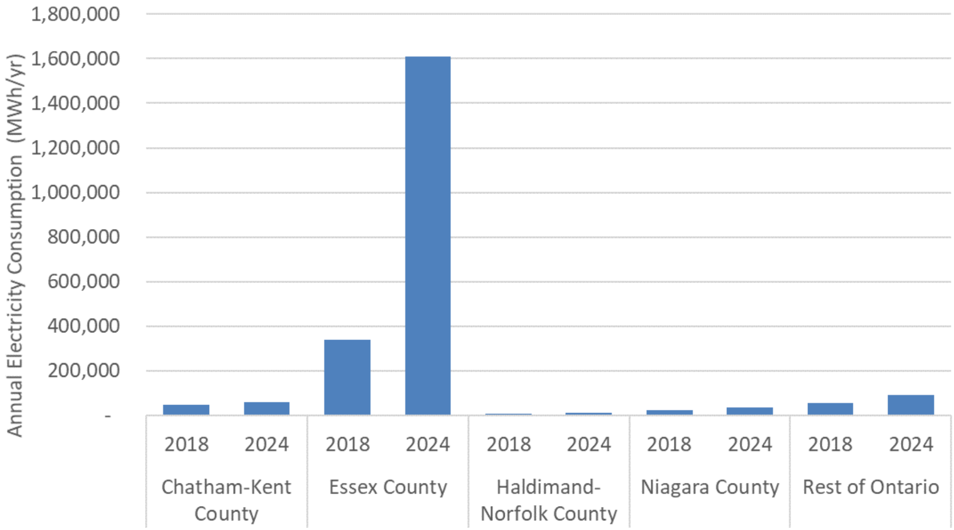
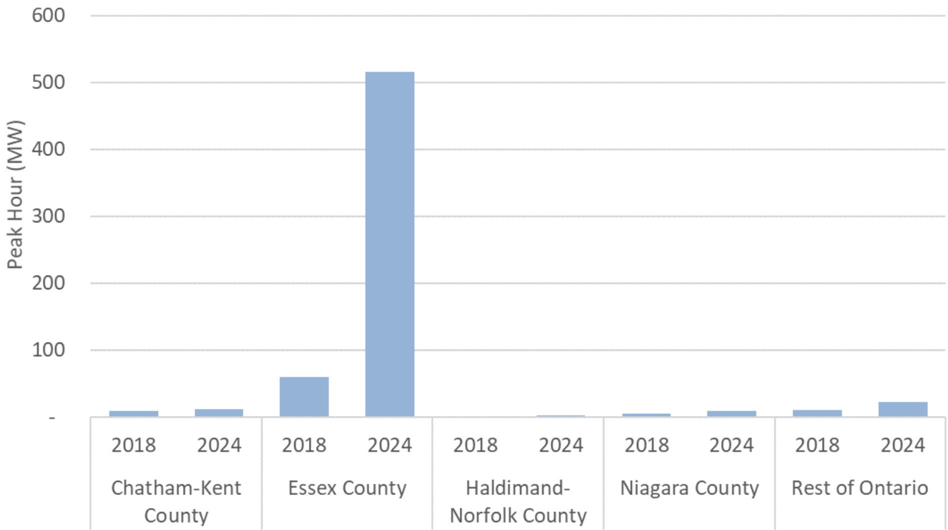


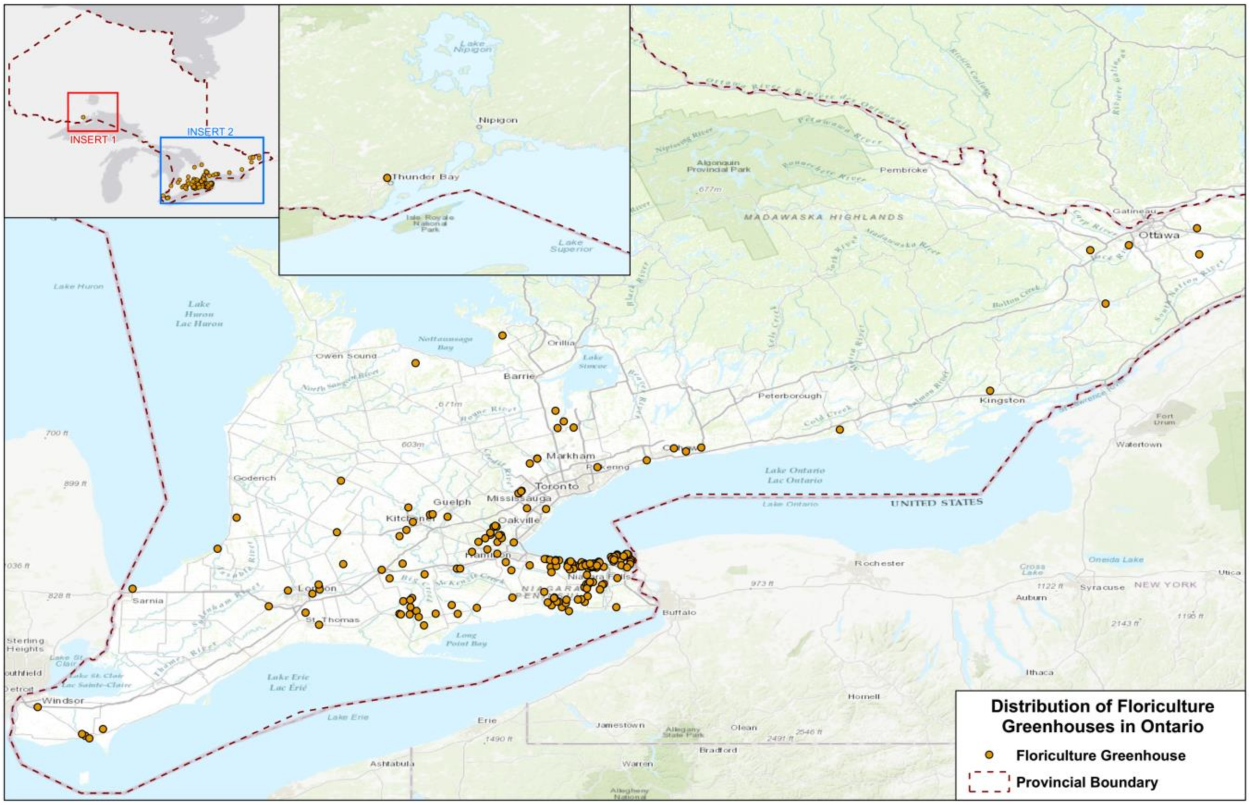
Exhibit 14 – Vegetable Sub-sector Peak Hour Demand Growth by Region (MW)



Sub-Sector Highlights: Flowers & Potted Plants

The flower and potted plant sub-sector includes flowering potted plants, cut flowers, and bedding plants in greenhouses and hoop houses. Ontario is the third largest producer of greenhouse-grown flower products in North America, with a farm gate value of $1.4 billion in 2012. The sub-sector in Ontario is concentrated in the Niagara region with a mixture of large wholesale growers and smaller retail-oriented growers. Many flower growers only operate 7.5 months of the year as winter offers lower consumer demand and higher energy costs.

Flower greenhouses tend to be small operations (below the provincial average of 2 acres for greenhouses in other sub-sectors). Structures typically have double layer polyethylene roofing, heat with gas-fired unit heaters and ventilate using horizontal fans.



The flowers sub-sector has declined in recent years, both in terms of number of growers and total acreage. The shrinkage in the sector is in part due to conversions of greenhouses to produce vegetables or cannabis, fewer exports to the US [5], and changing consumer preferences [11]. Sales of greenhouse flowers and plants declined by about 2% between 2016 and 2017 in Ontario [1].

Between 2018 and 2024, electricity consumption in the flowers sub-sector is forecasted in increase by 4%. Over the same time period, greenhouse peak hour demand is projected to increase by 4%.

- The flowers sector is forecasted to grow by increasing the size of existing facilities by 1% per year in Niagara region and 0.5% per year for all other regions.
- The lit portion is expected to remain the same at 75% over the next six years.

Exhibit 15 – Flower Sub-sector Electricity Growth by Region (MWh/yr.)

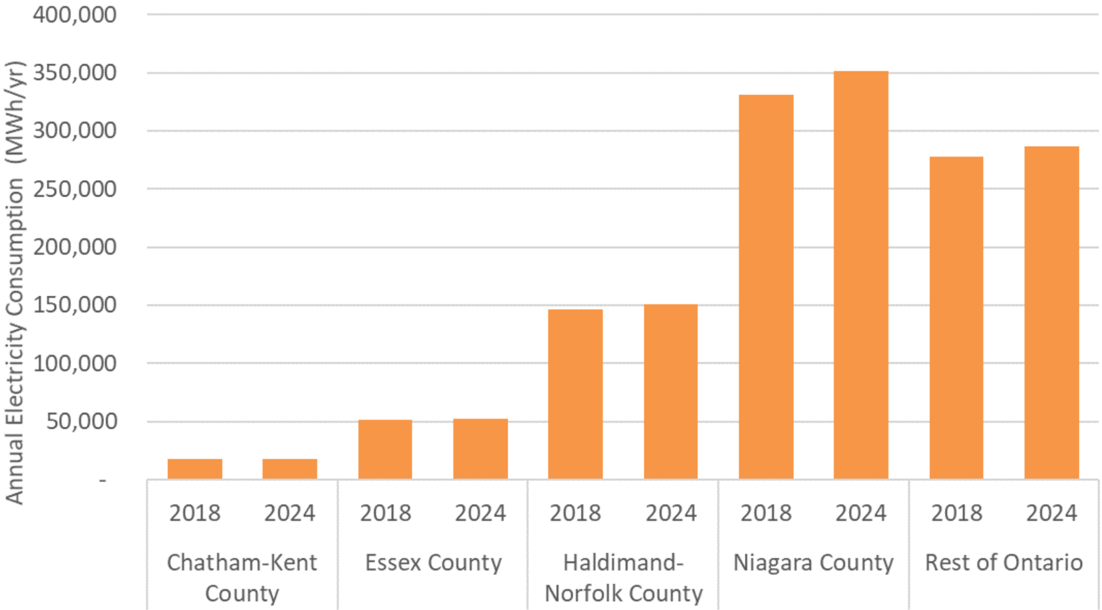
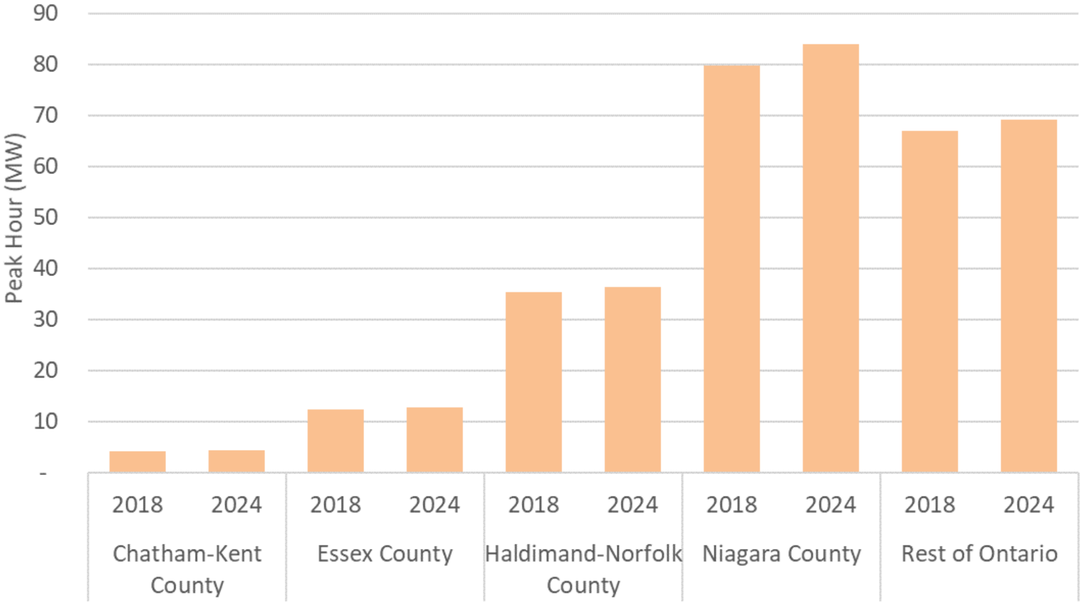
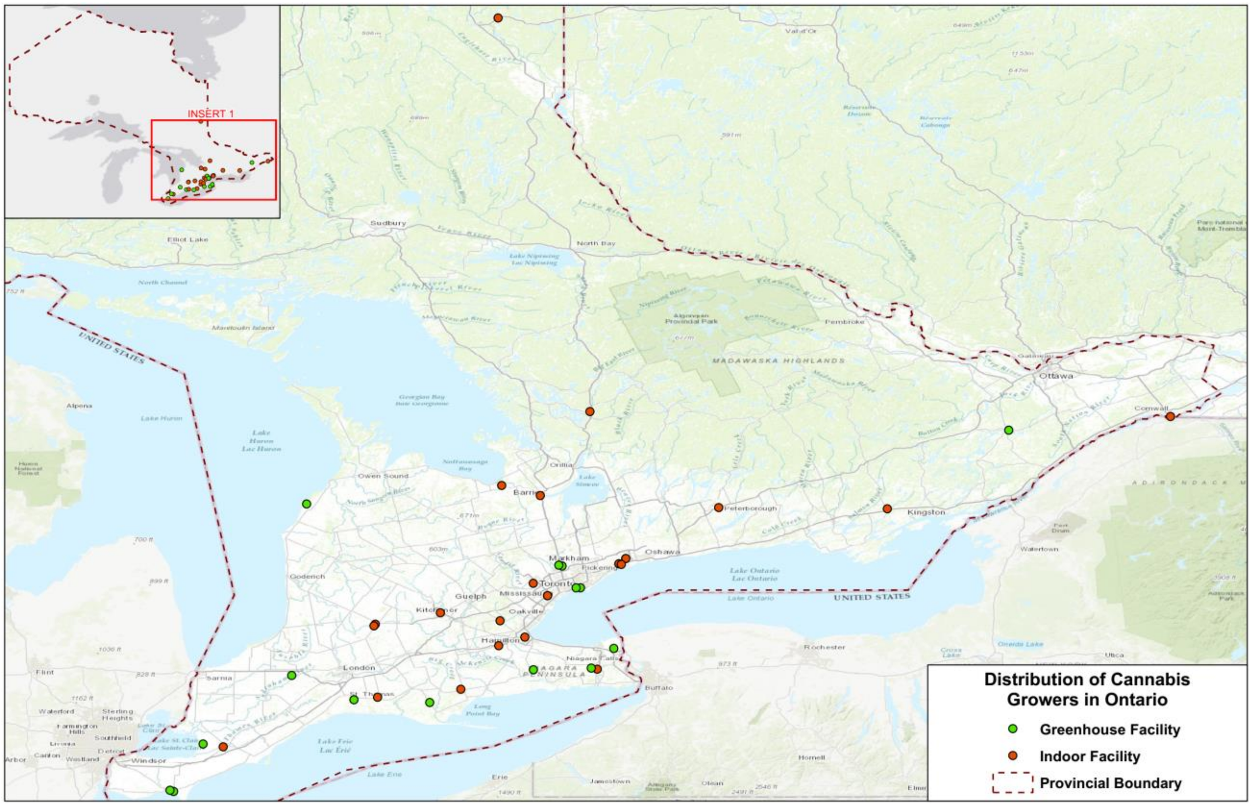


Exhibit 16 – Flower Sub-sector Peak Hour Demand Growth by Region (MW)



Sub-Sector Highlights: Cannabis

Sales of recreational cannabis in the province are projected to be $930 million in 2019 and go up to $2.38 billion in 2021. Currently, the Ontario cannabis market supports about 5,700 jobs, of which 58% are in the agricultural sector. Although supply was unable to meet demand when the online legal market was launched, the sector is expected to be able to meet demand by 2020 and Ontario is projected to be the largest cannabis market in Canada.



For the legal medicinal market, cannabis was typically grown indoors. Compared to the vegetable sub-sector, cannabis operations use significantly more electricity (e.g., indoor cannabis facilities use more almost 3.5 times more electricity per square foot than lit vegetable greenhouses), with some facilities that have electricity demand peaks in excess of 10MW.

For the recreational market, many growers are choosing greenhouses instead. Cannabis grown in greenhouses consumes 37% less electricity than cannabis grown indoors, offering producers cost savings. Greenhouses reduce the need for supplemental lighting and air conditioning – both of which are required for indoor operations and are costly. As the price of legal cannabis declines, producers will need to reduce operating costs to stay competitive [12]. Many greenhouse cannabis producers purchased existing greenhouses – often growing flowers – and converted them to their specific growing needs.

Ontario's capabilities and expertise in the greenhouse agriculture sector represent a unique opportunity for the province to export skills and knowledge to the cannabis sector in other regions across Canada and the U.S.

Greenhouse Cannabis

Between 2018 and 2024, electricity consumption in the greenhouse cannabis sub-sector is forecasted in increase by 1,909%. Over the same time period, greenhouse peak hour demand is projected to increase by 1,904%.

- Starting at 8% in 2018, the facility area that is planted and growing product is expected to be built out quickly, with 100% being built out by 2023. In addition to this, the sub-sector is projected to add another million ft2 a year in 2023 and 2024.
- Essex County is an exception, growing at an average of 9% year over year during the reference period. Due to a high number of connection requests in the area, growth is expected to follow the IESO's electricity demand growth forecast.
- The lit portion is expected to increase from 90% in 2018 to 100% by 2020 in all regions.

Exhibit 17 – Greenhouse Cannabis Electricity Growth by Region (MWh/yr.)

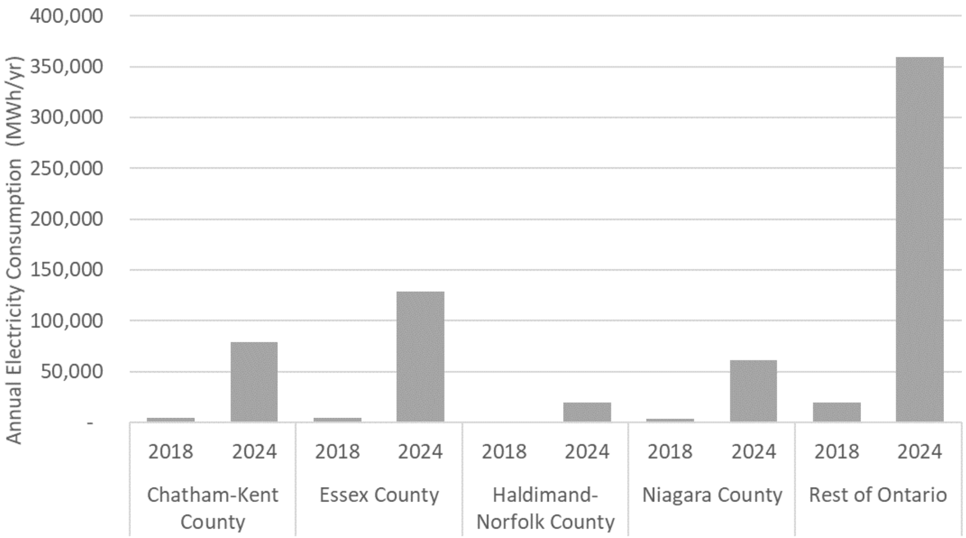
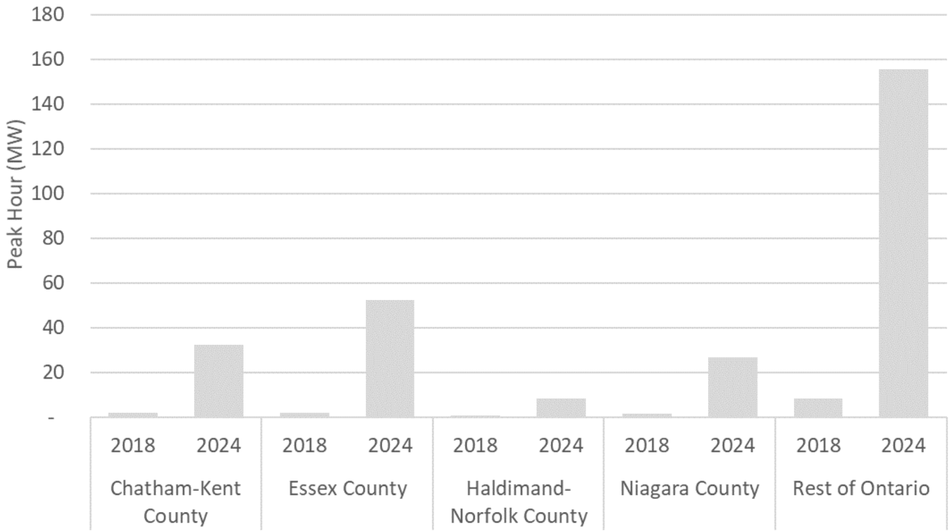


Exhibit 18 – Greenhouse Cannabis Peak Hour Demand Growth by Region (MW)



Indoor Cannabis

Between 2018 and 2024, electricity consumption in the indoor cannabis sub-sector is forecasted in increase by 912%. Over the same time period, greenhouse peak hour demand is projected to increase by 911%.

- Starting at 16% in 2018, the facility area that is planted and growing product is expected to be built out quickly, with 100% being built out by 2023. Beyond the growth in area used for production, no new indoor cannabis facilities are expected to be constructed, except for the Chatham-Kent region where a large indoor cannabis facility is coming online in 2020 (55% of the load is coming online in 2020 and remaining part of the facility will come online in 2023).
- The lit portion is expected to increase from 90% in 2018 to 100% by 2020 in all regions.

Exhibit 19 – Indoor Cannabis Electricity Growth by Region (MWh/yr.)

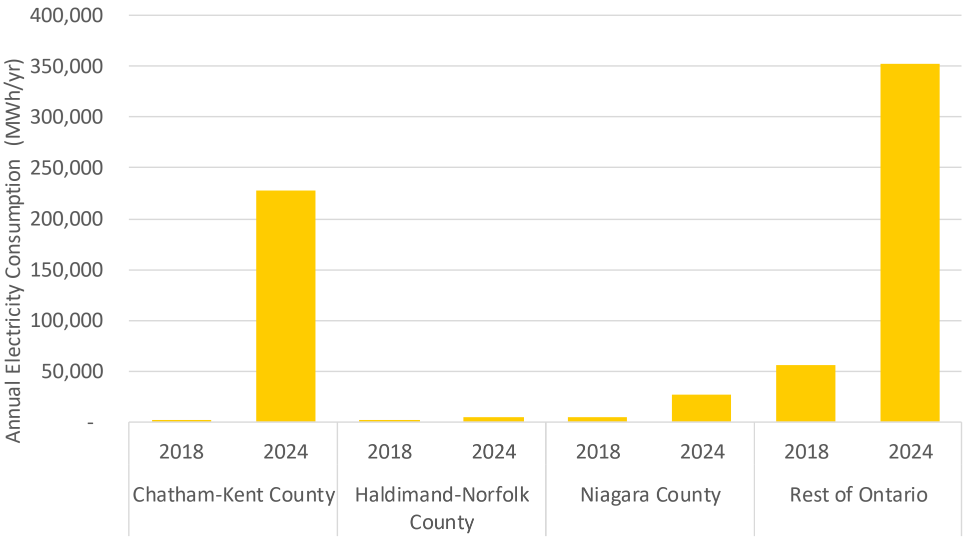
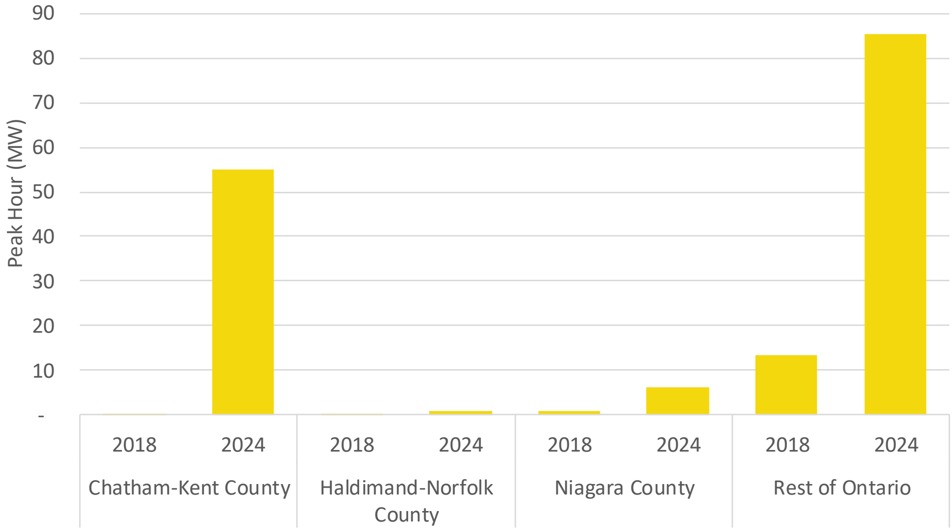


Exhibit 20 – Indoor Cannabis Peak Hour Demand Growth by Region (MW)



Acknowledgements

This report was prepared for the Independent Electricity System Operator (IESO) with additional funding provided by Enbridge Gas Inc. (Enbridge) and the Ontario Greenhouse Vegetable Growers (OGVG). The study engaged an Advisory Committee to provide sectoral insight and intelligence. We would like to thank all individuals on the Advisory Committee who generously contributed important sectoral information and data, as well as their time to review the study research inputs and assumptions and sectoral findings.

Organizations that provided data and input for the study are:

- Ag Energy
- Cannabis Council of Canada
- Enbridge Gas Inc.
- Entegrus Powerlines
- Essex Power
- Flowers Canada Ontario
- Hydro One
- Independent Electricity System Operator
- Niagara on the Lake Hydro
- Niagara Peninsula Energy
- Ontario Federation of Agriculture
- Ontario Greenhouse Vegetable Growers
- Ontario Ministry of Agriculture, Food and Rural Affairs

We would like to express our gratitude to each grower that participated in our focus group sessions, surveys and facility walk-throughs.

We also greatly appreciate the support received by market actors who participated in our interviews, including energy managers and organizations that manufacture greenhouses and/or supply equipment to greenhouse operations.

Acronyms and Definitions

Acronyms

CHP	Combined Heat and Power
CO_2	Carbon Dioxide
DR	Demand Response
DSM	Demand side management
eMWh	Equivalent Megawatt Hour
eTWh	Equivalent Terrawatt Hour
GWh	Gigawatt hour
HPS	High Pressure Sodium
HVAC	Heating, Ventilation, Air Conditioning
IESO	Independent Electricity System Operator
IRRP	Integrated Regional Resource Plan
kW	Kilowatt
kWh	Kilowatt-hour
LDC	Local distribution company
LED	Light-emitting Diodes
MW	Megawatt
MWh	Megawatt-hour
OEB	Ontario Energy Board
OGVG	Ontario Greenhouse Vegetable Growers
TRC	Total Resource Cost
VFD	Variable Frequency Drive

Definitions

Acre: 43,560 square feet

Area Built Out and Operating (%): Primarily used for cannabis facilities, this parameter indicates the amount of square footage in an existing facility that is fully operational, as opposed to square footage that is currently not being used for production.

Base Year: The base year is the first year of the study and is based on the most recent year for which data can be gathered on the parameters required to assess energy consumption. For this study, the base year is the energy and water consumption in 2018, the first year of the study period. The base year is broken down by region, sub-sector, end-use, fuel, and if a greenhouse has supplemental lighting or not.

Energy Savings Potential: The amount of energy (electricity or natural gas) that could be saved by implementing a specific technology (“measure”) or from adjusting operations to reduce energy consumption during a specific time period.

Lit Portion: The portion of facility area that has supplemental lighting.

Load Profiles: Load profiles illustrate the energy used in a specific time period (hour or month) to show when energy use is highest and lowest. For this study, load profiles were developed for electricity and natural gas in lit and unlit vegetable, flowers and cannabis facilities.

Peak Period: The time of day when energy demand is highest. Peak periods vary between seasons in Ontario, and typically occur on weekdays when businesses are operating.

There are three peak periods considered in this study, as follows:

Exhibit 21 – Peak Period Definitions

Peak Period	*Hours of the Day*	*Days of the Week*	*Months of the Year*
Summer	1pm to 7pm	weekdays	June, July and August
Winter	6pm to 8pm	weekdays	January, February and December
Greenhouse Peak Hour	Peak Hour Occurs in February. See definition below.		

For this study, we defined 'Greenhouse Peak Hour" as the hour with the highest predicted aggregate electricity use in Essex region's covered agriculture facilities; in other words, the one hour that uses more electricity than any of the other 8,759 hours in the year. The greenhouse peak hour is coincident with the peak lighting load at greenhouse facilities. In areas with high concentrations of greenhouses, this greenhouse peak hour is impacting local transformer stations.

Reference Case: The reference case forecast begins with the base year (2018) and then forecasts consumption under current "business as usual" conditions for the next six years (2019-2024). The reference case accounts for growth (both in terms of the number of greenhouses and their energy consumption), changing operations (e.g., adding grow lighting) and substitutions in energy sources (e.g., adding more behind the meter generation). Accounts are scaled to represent the forecast for regional energy footprints and profiles, as well as an aggregate profile for the province as a whole.

Overview of Ontario's Covered Agriculture Sector

1 Overview of Ontario's Covered Agriculture Sector

1.1 Introduction

In this study, the covered agriculture sector is defined as agricultural products produced in self-contained controlled environments [7]*. "Greenhouse" sector is used interchangeably with "covered agriculture" throughout this report; however indoor cannabis and vertical farming sub-sectors are also included.*

Since the 1990's, Canada has been the largest producer of greenhouse products in North America [1]. Ontario has the largest greenhouse sector in Canada relative to other provinces. In 2017, Ontario represented 60% of total national greenhouse area [2] and contributed 70% of farm gate value. The Essex region in south-western Ontario has the largest concentration of greenhouses in North America [13]. In 2016, the greenhouse sector supported $3.2 billion to GDP and over 80,000 jobs [3]. Due to the ability to control environmental conditions, greenhouses produce seven times higher yields compared to field production [14]. The industry is innovating, with research and development for the use of robotics and automation to make growing produce more efficient [14].

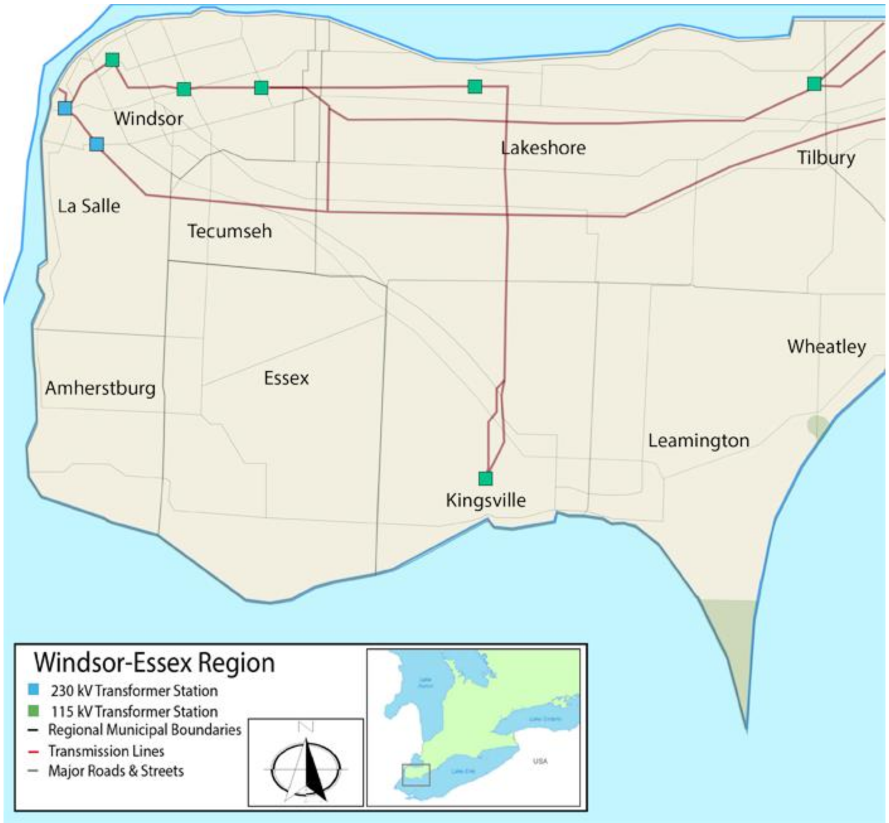
1.2 Key Regions

The study breaks the province into five regions due to their concentration of greenhouses and unique characteristics: Essex, Chatham-Kent, Haldimand–Norfolk-Haldimad, Niagara, and the Rest of Ontario. A brief description of each region in terms of location and their covered agriculture industry are provided below.

1.2.1 Essex

The Essex region is the most southern portion of the province, and includes the City of Windsor, the Municipality of Leamington, the Township of Pelee, and the towns of Kingsville, Essex, and LaSalle.

Exhibit 22 – Map of the Essex Region [15]



The Essex region was previously dominated by the manufacturing sector, particularly the automotive industry, which has declined since the recession in 2008. The region's rural areas are dominated by agriculture, particularly vegetables and fruits grown in greenhouses, with Essex County having the largest concentration of vegetable greenhouses in North America [4]. As the most southern region of the province, Essex has 212 growing days per year, which supports the $3 billion agricultural industry in the area [16]. This greenhouse industry is growing in the region, including the recent addition of cannabis facilities.

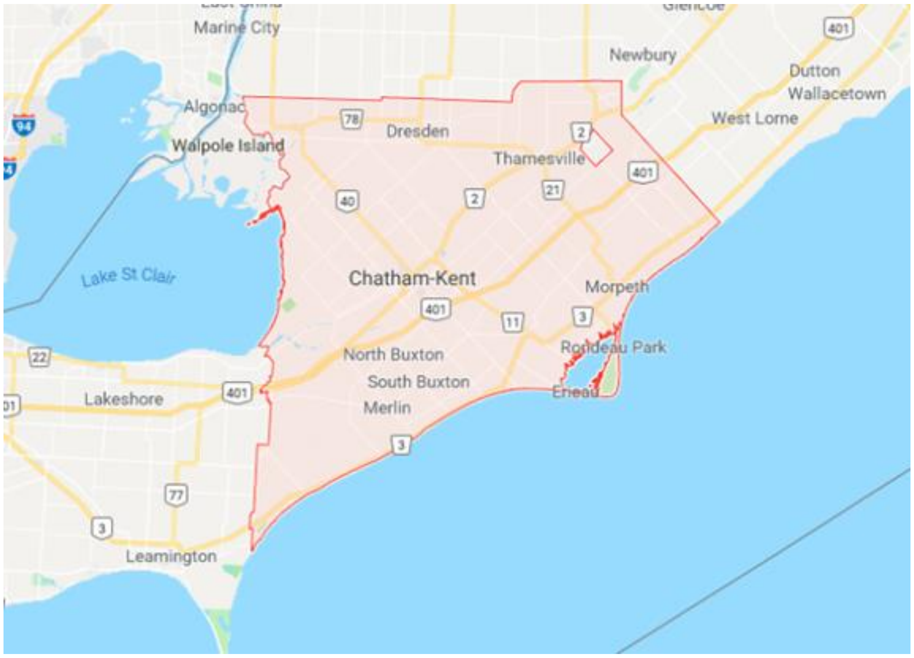
Essex County, the most southern part of the province, has the largest concentration of vegetable greenhouses in North America [4]. Ontario is the third largest producer of greenhouse-grown flower products in North America and is projected to be the largest cannabis market in Canada [6].

Seacliff Energy is an anaerobic digester facility in Leamington that recycles organic materials – including reject vegetables from local greenhouses - into renewable electricity and organic fertilizer. The facility generates 1.6 MW of electricity per hour and provides heat to the 7-acre greenhouse on site [17].

1.2.2 Chatham-Kent

The Chatham-Kent region is in south-western Ontario, as displayed in the map in Exhibit 23

Exhibit 23 – Map of the Chatham-Kent Region [18]



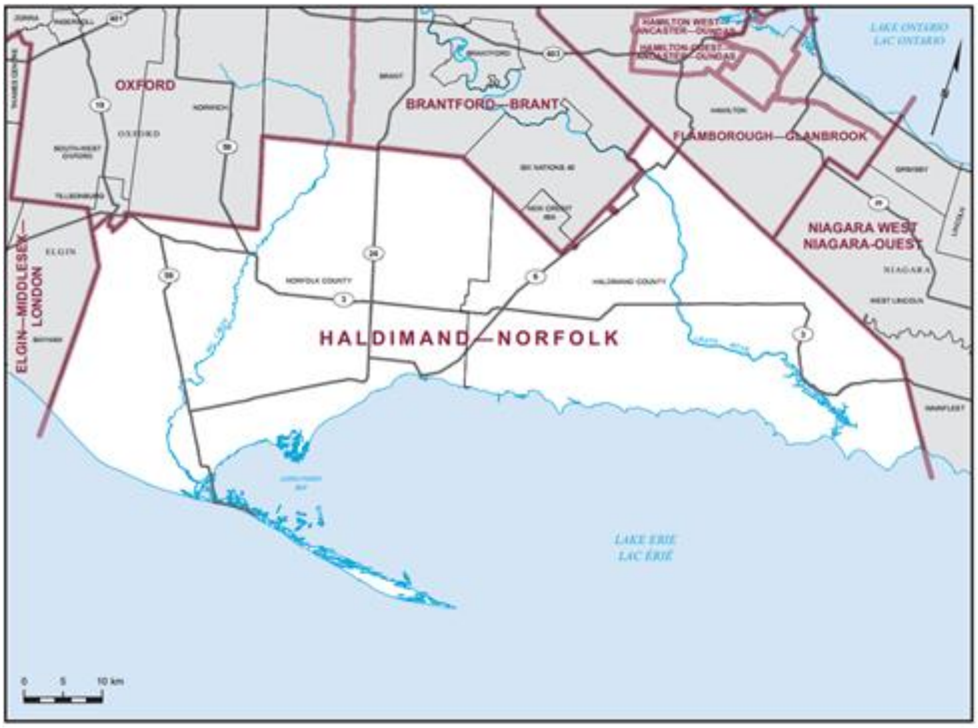
Chatham-Kent is a relatively rural region with a predominant agriculture sector. There are a significant number of greenhouses in the region growing over 70 types of crops, mainly vegetables and fruits. The greenhouse sector has been growing in the region over the last decade [19].

Enbridge is currently working on the Chatham-Kent Rural Pipeline Expansion project to provide more natural gas to the area, largely due to the growing greenhouse sector [20].

1.2.3 Haldimand–Haldimand–Norfolk Region

The Haldimand–Haldimand–Norfolk region is in southwestern Ontario on the north shore of Lake Erie, as displayed on the map below.

Exhibit 24 – Map of the Haldimand–Norfolk Region [21]

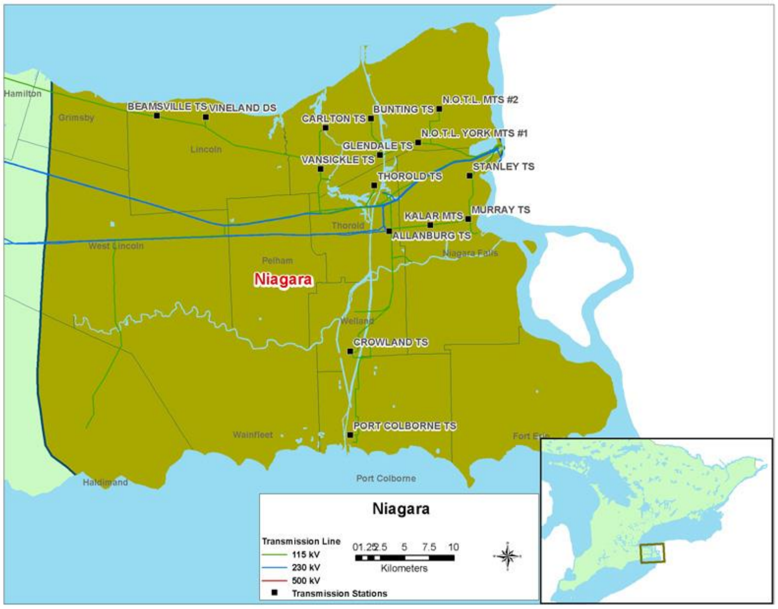


Haldimand–Haldimand–Norfolk has a dominated agriculture sector, including greenhouses growing flowers, and fruits [22].

1.2.4 Niagara

As displayed in the map below, the Niagara region is in southern Ontario in between Lake Ontario and Lake Erie and to the west of the Niagara River.

Exhibit 25 – Map of the Niagara Region [23]



Greenhouses in the Niagara region predominantly produce flowers and potted plants. The Niagara region is home to 50% of flower greenhouses and 60% of production area for flowers [5].

1.2.5 Rest of Ontario

The Rest of Ontario region includes all areas of the province excluding the other study regions already defined. The Rest of Ontario includes the northern areas of the province and the area east of the Niagara region.

1.3 The Sector in 2018

Exhibit 26 and Exhibit 27 show the number of greenhouse facilities and proportion of floor area by sub-sector, respectively. These exhibits illustrate that most greenhouses are in the flower and vegetable sub-sectors and most of the square footage of the sector is producing vegetables and fruits.

Exhibit 26 – 2018: Facilities by Sub-sector

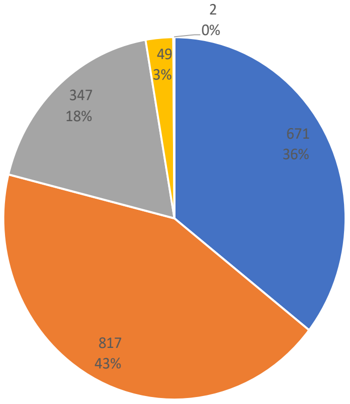


Exhibit 27 – 2018: Area (sq. ft.) by Sub-sector

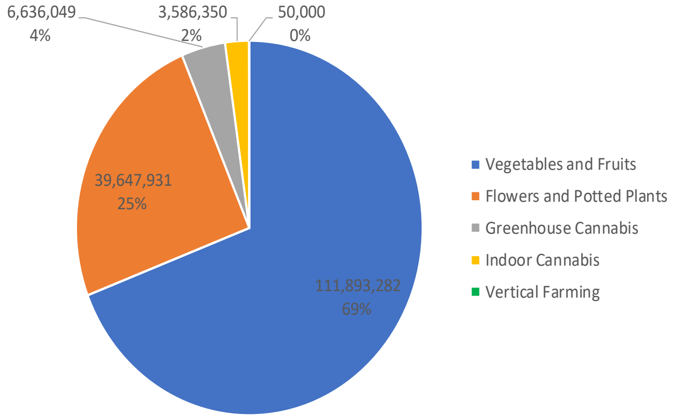


Exhibit 28 shows the number of facilities by region and Exhibit 29 shows the area (square feet) by region. While Exhibit 28 illustrates that the majority of facilities are located in the Rest of Ontario region, Exhibit 29 shows that most of the footprint of the sector is in the Essex Region.

Exhibit 28 – 2018: Facilities by Region

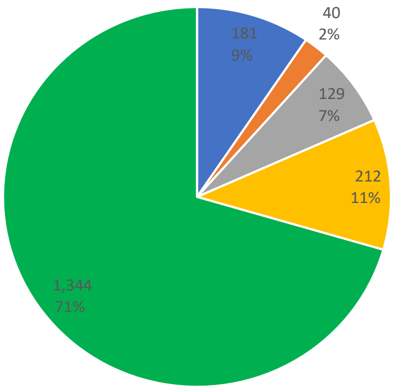


Exhibit 29 – 2018: Area (sq. ft.) by Region

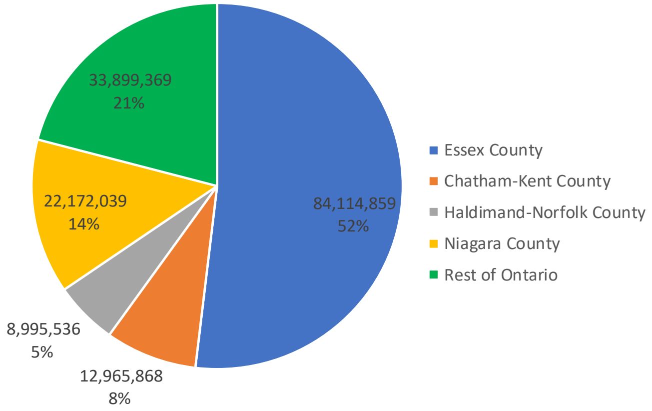


Exhibit 30 shows that most of the greenhouse floor area in Ontario is in Essex County. There is more floor area in Essex County (84,000,000 ft^2), than in the rest of Ontario combined (78,000,000 ft^2). Exhibit 30 also shows that most of the greenhouse floor area in Ontario in 2018 was used to grow vegetables, followed by flowers.

Exhibit 30 – 2018: Floor Area by Sub-sector and Region

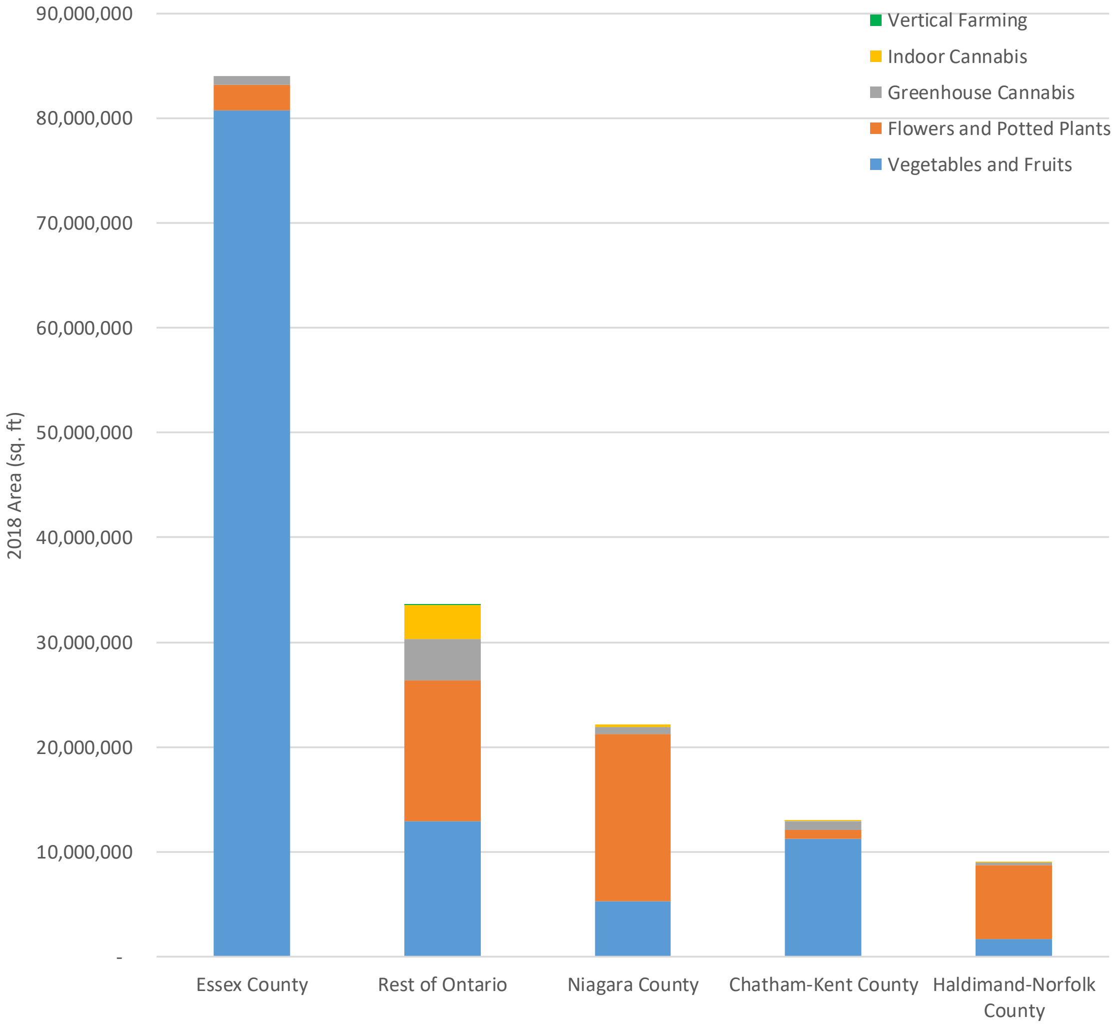


Exhibit 31 presents the 2018 electricity consumption (MWh) by fuel and sub-sector. Electricity generated on-site (by CHP units) is a very small portion of the supply. The Flowers sub-sector consumed the most electricity, as this sub-sector already had supplemental lighting while other sub-sectors did not in 2018.

Exhibit 31 – 2018: Electricity Consumption (MWh) by Fuel and Sub-sector

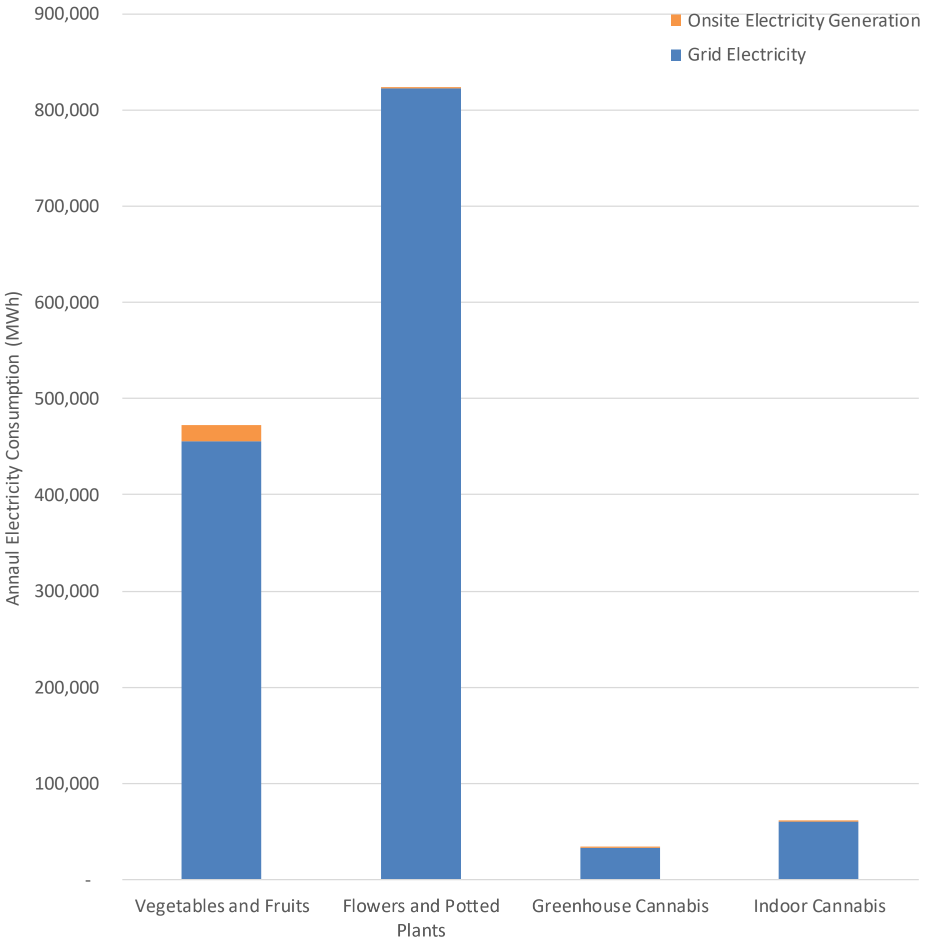


Exhibit 32 shows base year energy consumption by sub-sector and fuel. Onsite electricity generation represents electricity generated via behind the meter tri-generation units; cogeneration heat represents the natural gas heating displaced by the tri-generation units. Biomass and oil represent approximately 10% of the heating load in Ontario.

Exhibit 32 – 2018: Energy Consumption (MWh) by Fuel and Sub-sector

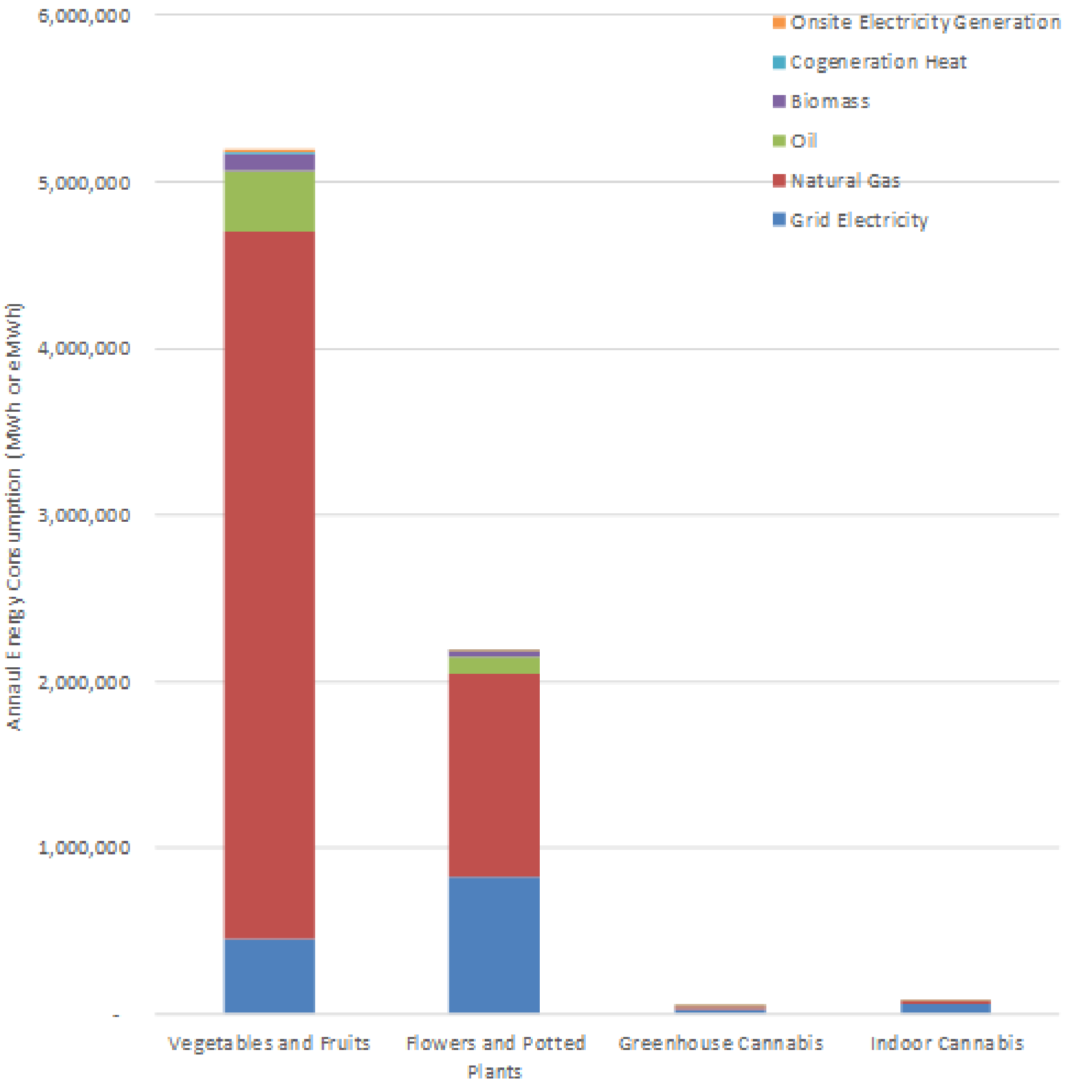


Exhibit 33 shows demand by peak period for the Chatham-Kent, Essex, Haldimand–Norfolk and Niagara regions for the base year. The exhibit illustrate that the greenhouse peak hour is not coincident with the provincial system summer or winter peaks. This is because the greenhouse peak hour aligns with the peak lighting load at greenhouse facilities. In areas with high concentrations of greenhouses, this greenhouse peak hour is impacting local transformer stations.

The Niagara region had the highest demand in 2018 due the high proportion of flower greenhouses in this region. Flower greenhouses had a relatively high adoption rate of horticulture grow lighting in 2018 (75% of the floor area is lit compared to only 4% for vegetable greenhouses).

Exhibit 33 – 2018: Demand by Peak Period and Region

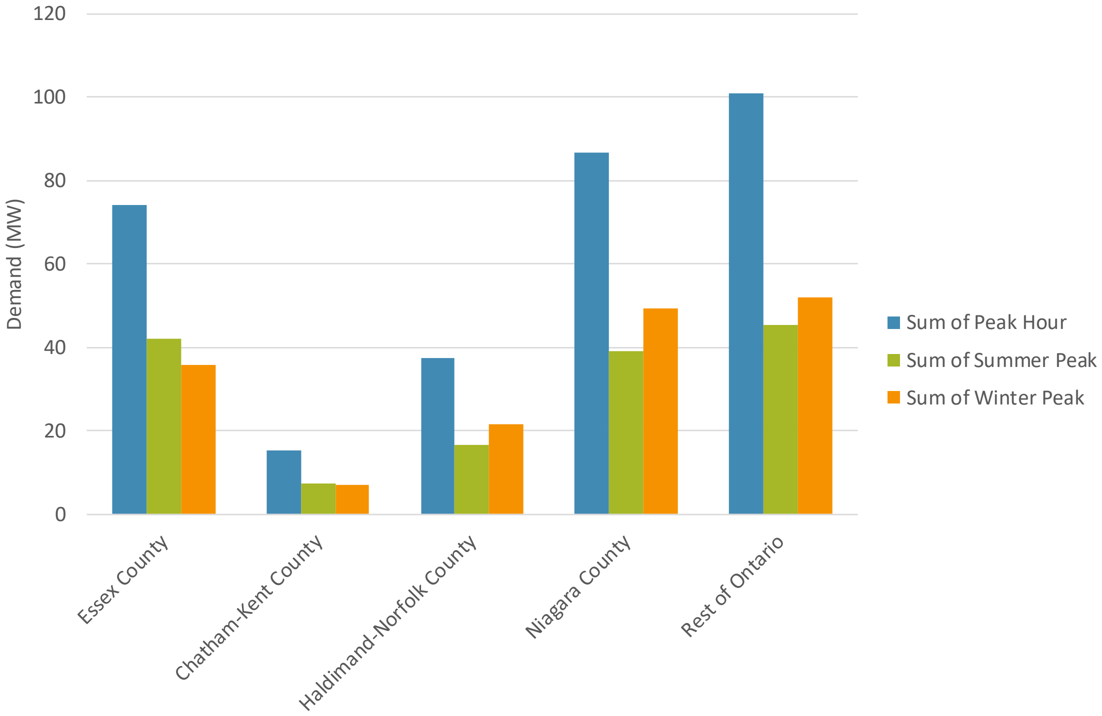


Exhibit 34 shows electricity consumption (grid electricity and on-site generation) by end-use and sub-sector for the base year. More electricity is consumed for lighting (752,000 MWh) than for the other electrical end-uses combined (637,000 MWh).

Exhibit 34 – 2018: Electricity Consumption (MWh/yr.) by End Use and Sub-sector

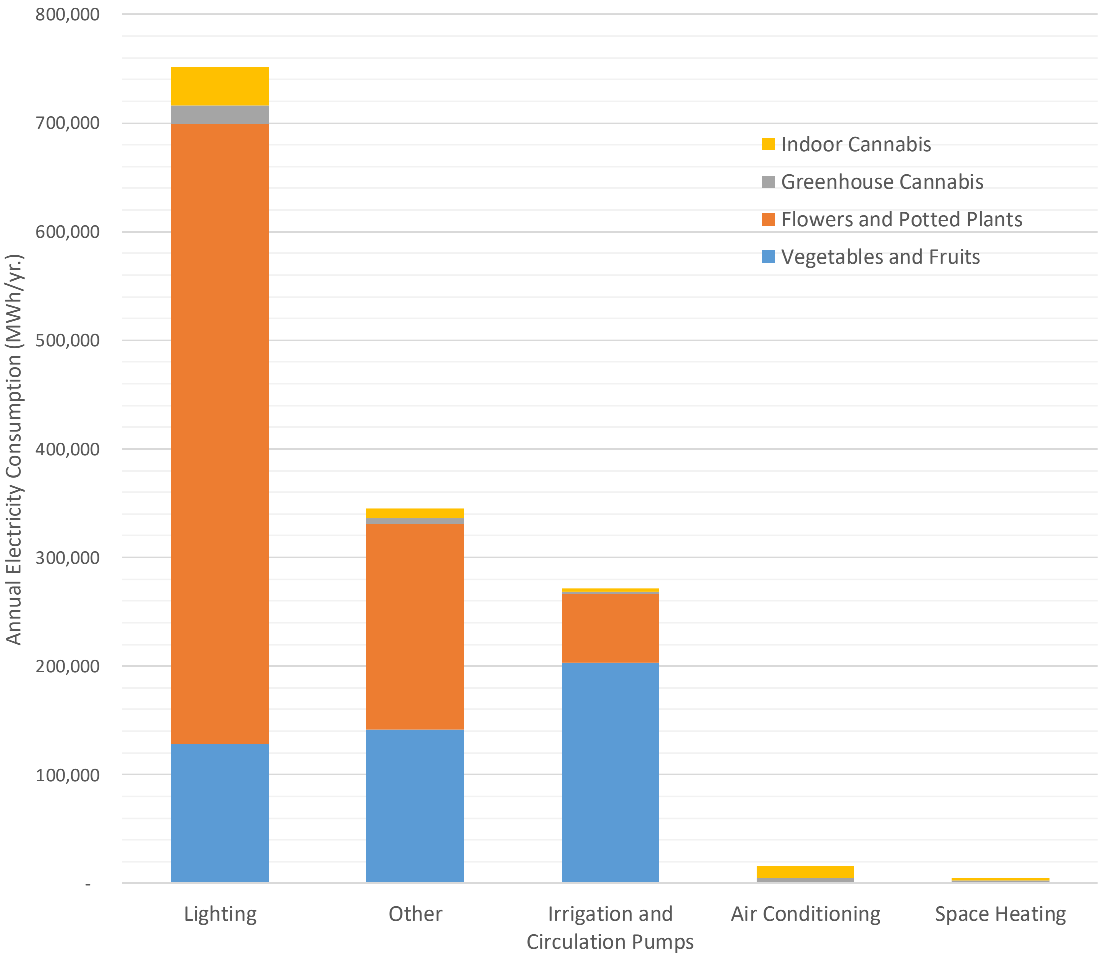
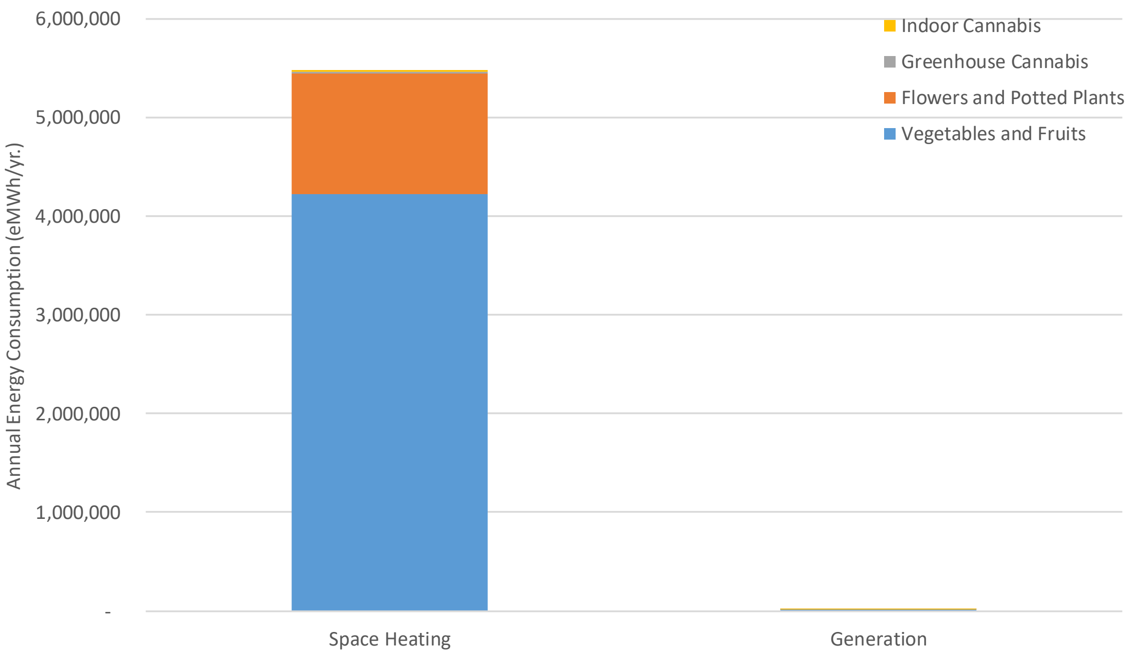


Exhibit 35 shows natural gas consumption by end use and sub-sector for the base year. The generation end use represents natural gas consumed by behind the meter tri-generation units.

Exhibit 35 – 2018: Natural Gas Consumption (eMWh) by End Use and Sub-sector



1.4 Growth and Opportunities

There are many factors contributing to the success of the greenhouse sector and many opportunities for continued growth in the province, including:

1.4.1 Strong exports

Ontario exports vegetables, fruits and flowers to international markets. About 70% of all greenhouse produce is exported to the U.S. [24]. Exports of greenhouse cucumbers to the U.S. increased by more than 50% from 2012 to 2017 [24].

1.4.2 Increased demand for local, healthy foods

Many consumers are increasingly preferring to buy healthy and/or local food [7] [25]. This trend has contributed to increased demand within Ontario for locally grown produce, which is often grown in greenhouses [26].

1.4.3 Support from government

Government has provided funding to support the success of Ontario’s greenhouse sector. Funding has come from municipal, provincial and federal government for initiatives that support innovation and economic growth. Examples of government support include:

- The Canadian Agricultural Partnership – a commitment from all levels of government to provide funds to support Canada’s agri-food and agri-products sector, including greenhouses in Ontario.
- The Greenhouse Competitiveness and Innovation Initiative – the Province of Ontario provided $19 million to support projects that develop and adapt technologies that help the competitiveness of Ontario’s commercial greenhouse sector. The Initiative is administered by the Agricultural Adaptation Council [27].

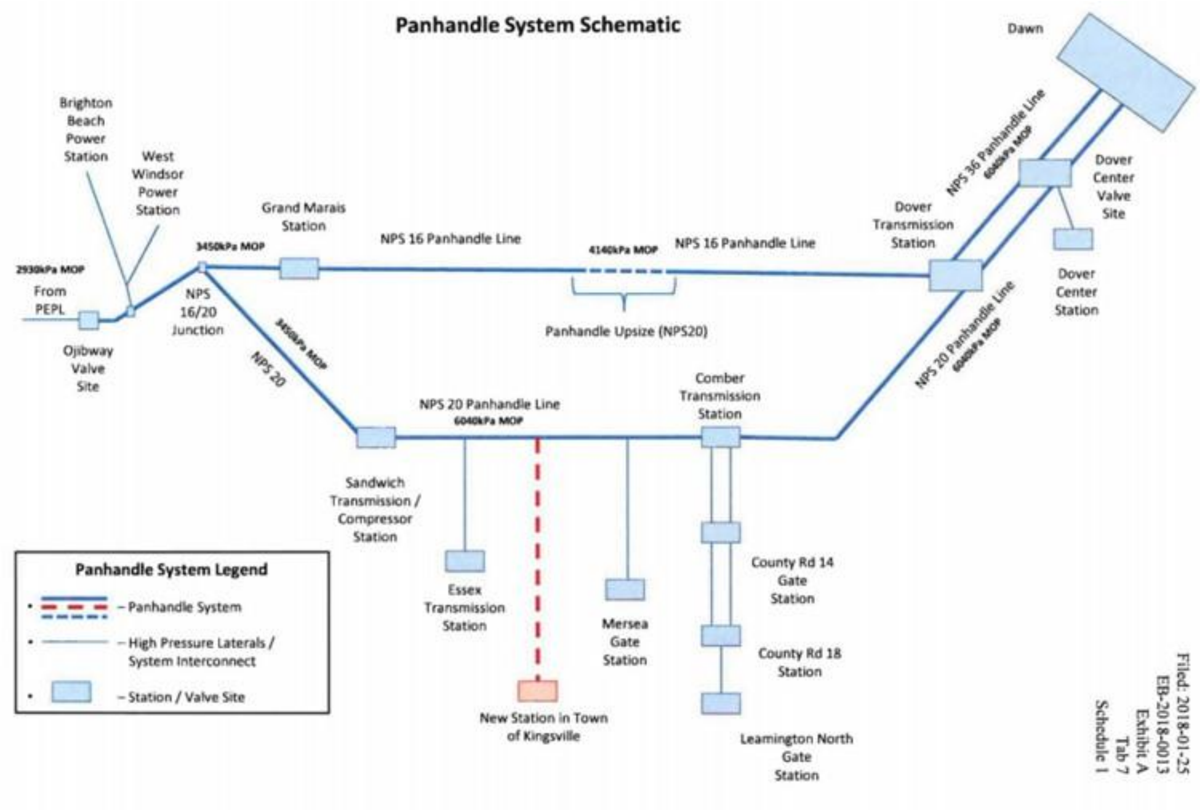
1.4.4 Expanded energy supply in respond from the growth in the greenhouse sector

Infrastructure for both electricity and natural gas have been expanded in recent years in response to growth in the greenhouse sector in the province. Section 1.5.1 discusses the challenges growers face when energy is limited.

Natural Gas

Natural gas pipeline has been expanded and reinforced in part to respond to the growing greenhouse sector in Ontario. Enbridge (and legacy Union Gas) invested almost $2 billion in infrastructure between 2015 and 2017, including a $265 million expansion of the Panhandle transmission system to meet in part the growing demand from the greenhouse sector in the Essex and Chatham-Kent regions [28]. The Ontario Energy Board (OEB) recently approved a reinforcement project to the Kingsville and Leamington area (the Kingsville Transmission Reinforcement Project), in part to support the increasing demand for gas from greenhouses [29].

Exhibit 36 – Panhandle Reinforcement & Kingsville Transmission Reinforcement Projects [30]



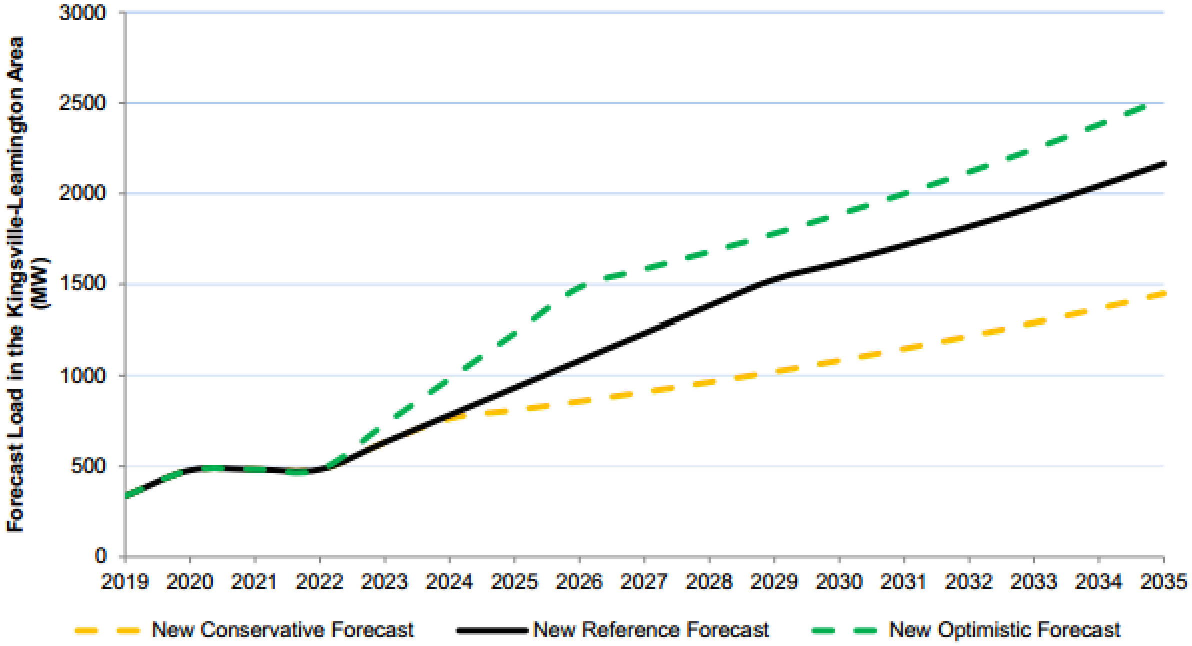
An application is also currently under review by the OEB to expand the Chatham-Kent Rural Pipeline; another region with a growing greenhouse sector [20] [31].

Electricity

The IESO reports "unprecedented growth in forecast electricity usage for the greenhouse sector in the Kingsville-Leamington area" in a June 2019 report that recommends installing new bulk system facilities to in part address the electricity needs of the sector; growth that is primarily from the introduction of supplemental grow lighting in the vegetable sub-sector, additional vegetable acreage, and the new cannabis sub-sector [32].

Hydro One received connection requests in excess of 1,000 MW for customers wishing to connect in the Leamington-Kingsville area [32].

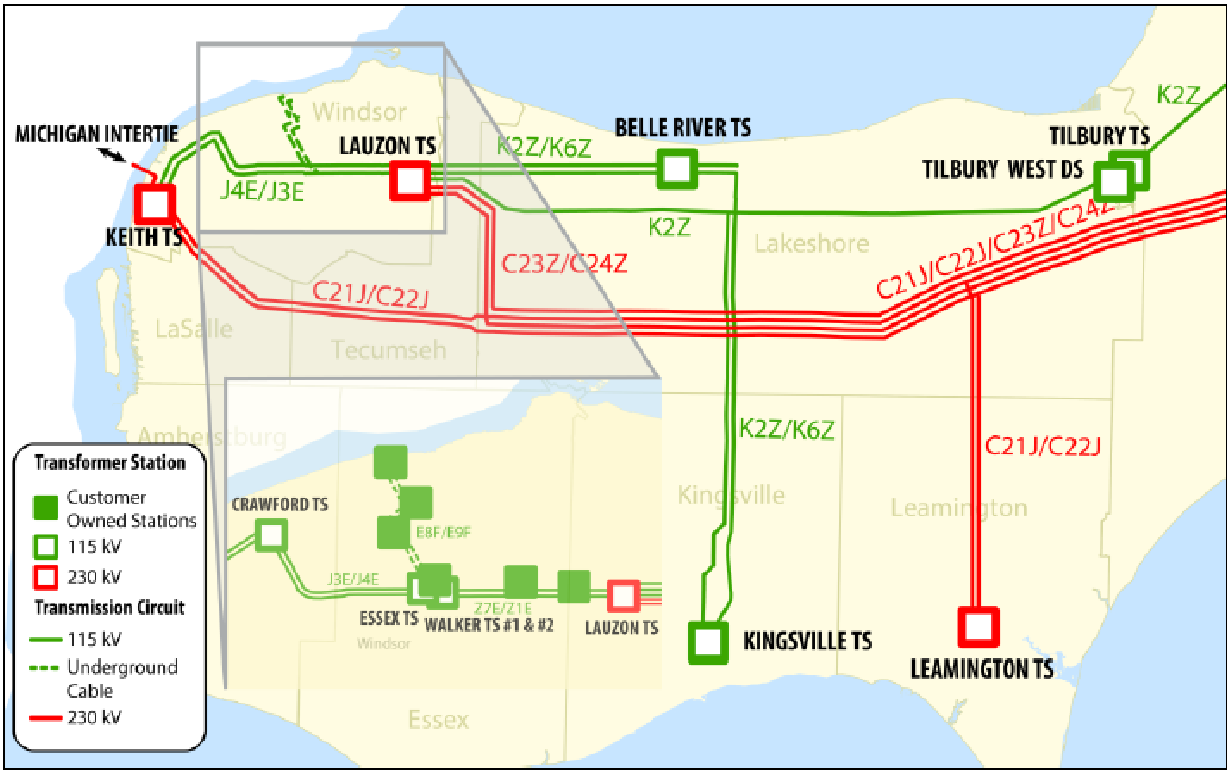
Exhibit 37 – Electricity Winter Peak Forecast Scenarios for Kingsville-Leamington [32]



The existing infrastructure was sized to support a winter peak load below 300 MW and was not able to support these requests, hence the IESO, Hydro One, and Local Distribution Companies are working to expand the system to meet the growing need for electricity in the region [33] [34] [35] [36].

The IESO convened a technical working group for the regional planning process in the Windsor-Essex region to discuss challenges and opportunities related to local electricity needs [36].

Exhibit 38 – Essex Region Electrical Single Line Diagram [34]



In response to connection requests in the Kingsville-Leamington area, mainly from large greenhouse customers, the following measures have been planned and will facilitate a significant increase in peak winter load capacity by 2026:

- Interim measures to enable a larger load meeting capability in the immediate term: in service starting in 2019. [36]
- Leamington Transformer Station upgrade: in service starting in 2020. [36]
- New switching station near Leamington (Lakeshore Transformer Station): in service starting 2023 and relieving need for interim measures. [37]
- New Chatham to Lakeshore transmission line: in service starting 2026. [38]

1.5 Constraints and Challenges

Profitability and growth of the greenhouse sector in Ontario faces constraints and challenges. Each sub-sector and region have different barriers and limitations, and these factors are in flux. The following section summarizes some of the key constraints faced by greenhouse operators in the province.

1.5.1 Limited Energy Supply

Some growers do not have access to enough energy - natural gas or electricity - to meet their production needs.

Natural Gas

Many greenhouse operators want “firm” natural gas service contracts so they can access a fixed volume of natural gas all year. However, many growers cannot have a firm contract due to limited natural gas infrastructure. Instead, they have interruptible contracts that require switching to other fuels for heating during periods of extreme cold [39, p. 18].

Electricity

As discussed in the previous section, there are significant infrastructure improvements planned in the Essex region to address forecasted growth constraints. Until the full scope of reinforcements are completed, growers in this region will continue to experience electricity connection constraints.

One of the indicators for additional electricity growth is the availability and ease of access to gas and water infrastructure. For example, if the OEB approves the Chatham-Kent Rural Pipeline expansion, the Chatham-Kent region could see an increase in electricity connection requests – similar to those being submitted in the Essex region after the after the Kingsville Transmission Reinforcement Project was approved. Already there are electricity constraints in the Chatham-Kent area, with a new 55MW cannabis facility that is able to connect 30MW in 2020, but must wait until 2023 to connect the rest of the facility. Niagara and Haldimand-Haldimand–Norfolk regions are also strong candidates for additional growth and constraints in future years.

To address local connection constraints, growers that need additional capacity (e.g., due to the introduction of year-round artificial crop lighting) are taking matters into their own hands and installing behind the meter tri-generation (also known as combined heat and power) units. These units are typically sized to offset lighting load and have the additional benefit of providing heat and CO_2 to the greenhouse.

Almost 70 MW of behind the meter generation is projected to be operational by the end of 2019; by 2024, this is expected to increase.

Exhibit 39 and Exhibit 40 show a small increase by 2024 is very likely (total of over 73 MW of behind the meter generation); however, a larger increase by 2024 is also possible (e.g., the total installed capacity could be greater than 100 MW by 2024).

Exhibit 39 – Forecasted Peak Capacity of Tri-gen/CHP by Region in 2024

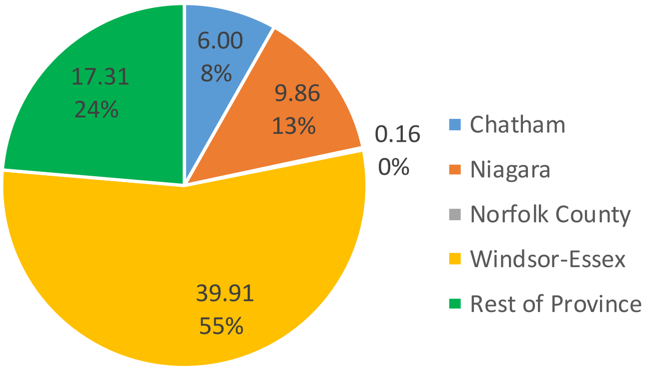
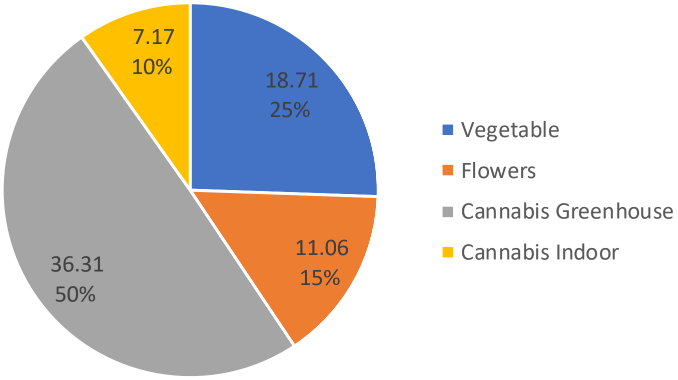


Exhibit 40 - Forecasted Peak Capacity of Tri-gen/CHP by Sub-sector in 2024



1.5.2 Increased Operating Costs

Many greenhouse operators are experiencing increased operating costs [40], mainly due to:

- Increased minimum wage – Ontario's minimum wage increased from $11.60/hour in 2017 to $14.00/hour in 2018. Most greenhouses employ people to perform many of the daily operating tasks, so the increase in minimum wage had a direct impact on operating costs.
- Price on carbon – the federal carbon price impacted some larger greenhouses which had to pay for GHG emissions if they were a large emitter.

1.5.3 Disruption from the New Legal Cannabis Market

The legalization of recreational cannabis in 2018 resulted in some existing greenhouse operators selling their facilities to cannabis producers. This new sector attracted labour and construction resources, in some cases limiting the availability of these resources to greenhouse operators in existing markets. As the recreational cannabis market is in its infancy in Canada, there is uncertainty about its future and impact on the existing greenhouse sector [41].

1.5.4 Uncertain Terms of Trade

Renegotiation of trade agreements and the use of tariffs for political purposes has created uncertainty for trade within North America [42], including for the greenhouse sector which exports a significant amount of produce and flowers south of Canada's border.

1.6 The Sector in the Future: 2019-2024 Forecast

Exhibit 41 shows the reference case (business as usual) energy consumption (all fuels) for each sub-sector over the study period.

Energy consumption is expected to increase across all sub-sectors, with the largest relative growth occurring in the greenhouse cannabis and indoor cannabis sub-sectors. Greenhouse cannabis consumption is forecasted to increase from 1% of sector energy consumption in 2018 to 7% by 2024, while indoor cannabis is expected to increase from 1% of consumption in 2018 to 6% of consumption by 2024. In both cases this is being driven largely by build-out of existing area. In 2018 only 1 million ft^2 of the total sub-sector area (10%) was planted and growing product.

The largest absolute growth is occurring in the vegetable sub-sector. Vegetable greenhouse energy consumption is forecasted to increase by 84% from 2018 to 2024; growth that is being driven by both increased greenhouse area, and a greater proportion of greenhouse area expected to be using grow lighting by 2024.

Exhibit 41 – Forecasted Annual Energy Consumption by Sub-sector

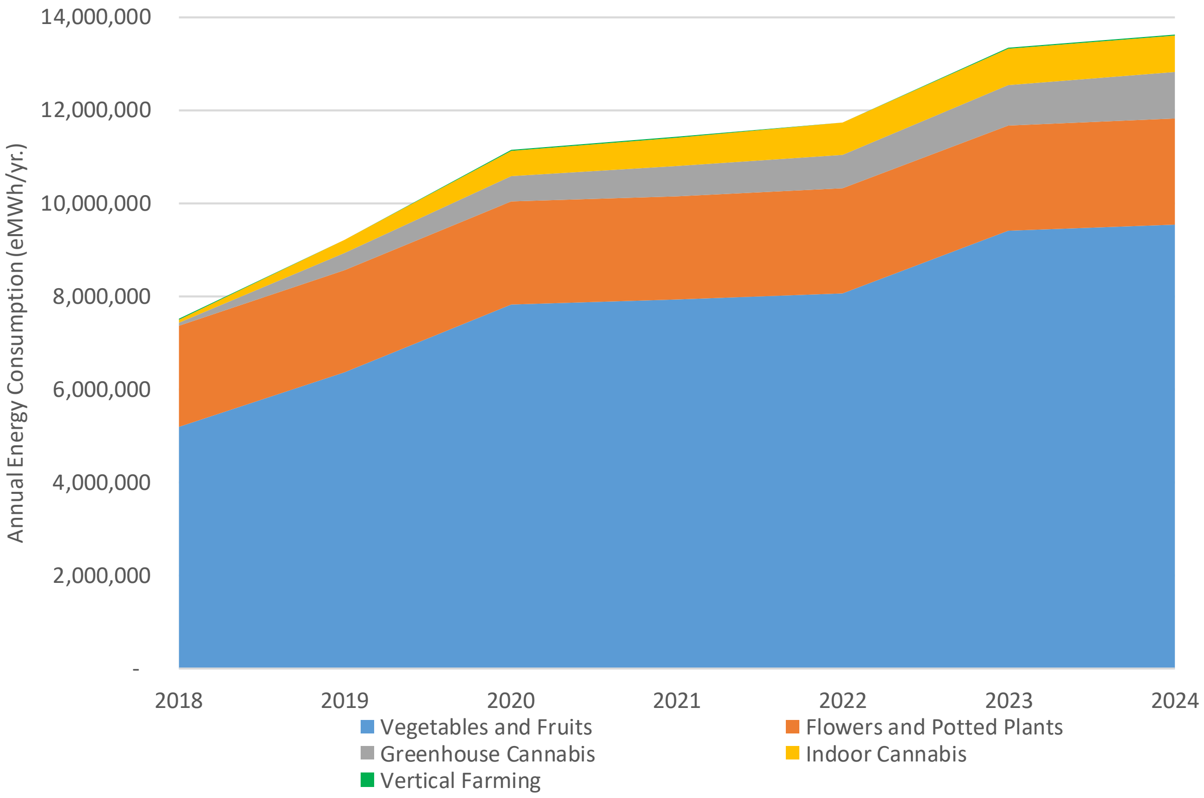


Exhibit 42 shows the projected annual electricity consumption (MWh) by sub-sector. In 2018, the sector consumed almost 1.4 TWh of electricity. It is forecasted that the sector will consume about 3.9 TWh of electricity in 2024. The vegetable sub-sector is expected to have a significant increase in electricity consumption. The Vegetable and Fruits sub-sector consumed about 473,000 MWh of electricity in 2018. Electricity consumption from this sub-sector is expected to increase by 282% in the next five years (to 1,808,000 MWh in 2024). This increase in electricity is driven by growth in square footage and the addition of supplemental lighting.

Exhibit 42 – Forecasted Annual Electricity Consumption (MWh) by Sub-sector

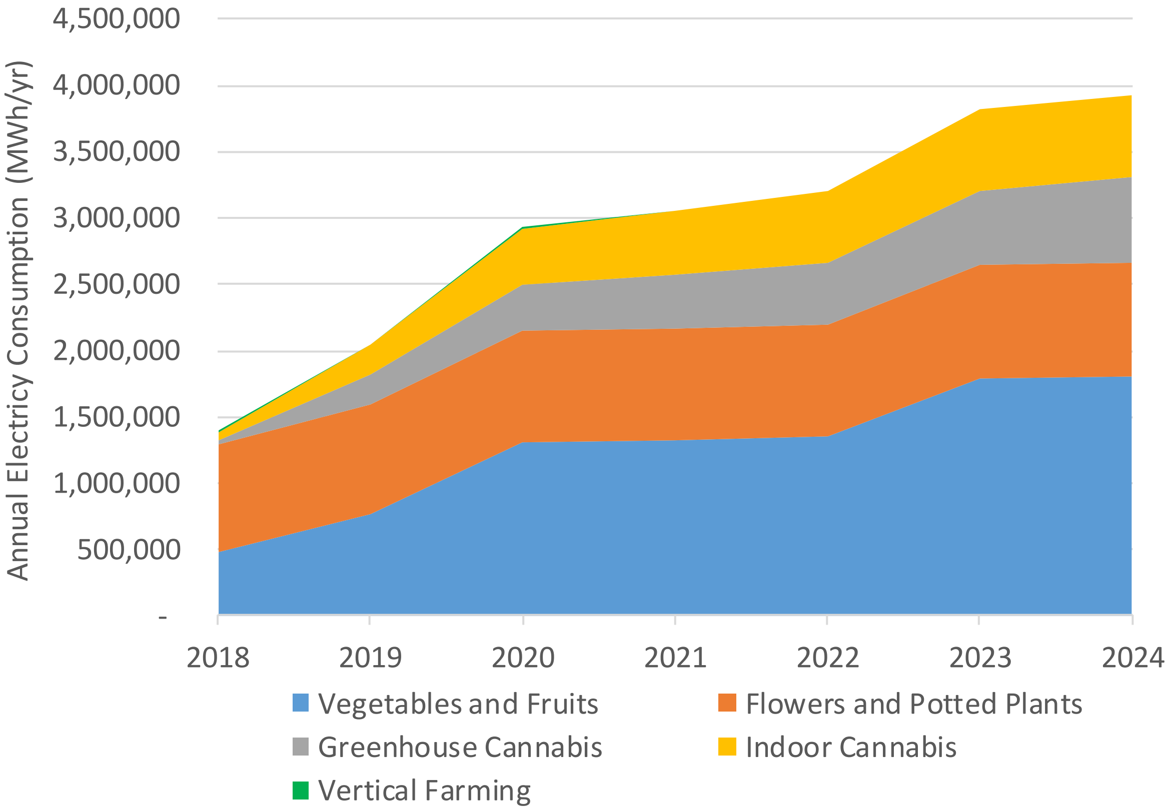


Exhibit 43 shows the reference case energy consumption (all fuels) by region during the study period. Consumption is projected to increase year over year in all regions.

Moderate growth is expected across most regions, but Essex and Chatham-Kent are exceptions.

- In Essex, the greenhouse cannabis and vegetable sub-sectors are expected to grow at an average of 9% year over year. Also, the lit portion of the vegetable sector is expected to increase from 4% in 2018 to 29% in 2024. This growth aligns with the IESO's electricity demand growth forecast and is based on Hydro One's backlog of connection requests and projected available capacity over the next 6 years.
- In Chatham-Kent, a large indoor cannabis facility is coming online in 2020 (55% of the load is coming online in 2020 and remaining part of the facility will come online in 2023).

Exhibit 43 – Forecasted Annual Energy Consumption (eMWh or MWh) by Region

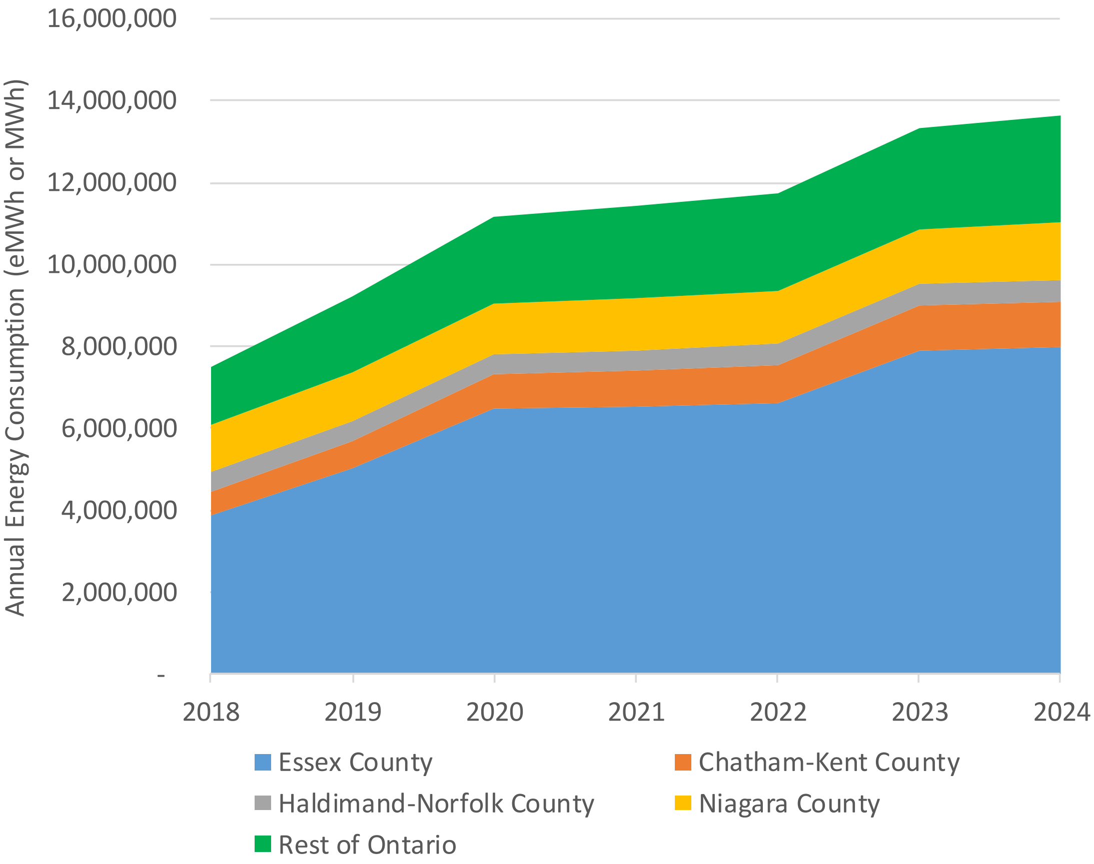


Exhibit 44 shows the forecast electricity consumption (MWh) by region. Electricity consumption is expected to rise in all regions however Essex is of particular interest: In 2018, the covered agriculture sector in Essex county consumed almost 0.4 TWh of electricity; it is forecasted to consume about 1.8 TWh of electricity in 2024, a 351% increase. This increase is driven by the growth in acreage and the addition of supplemental lighting in vegetable greenhouses. There is also a large increase in electricity consumption expected in the Chatham-Kent region: In 2018, the covered agriculture sector in Chatham-Kent county consumed more than 69 MWh of electricity; it is forecasted to consume more than 384 MWh of electricity in 2024, a 455% increase.

Exhibit 44 - Forecasted Electricity Consumption (MWh) by Region

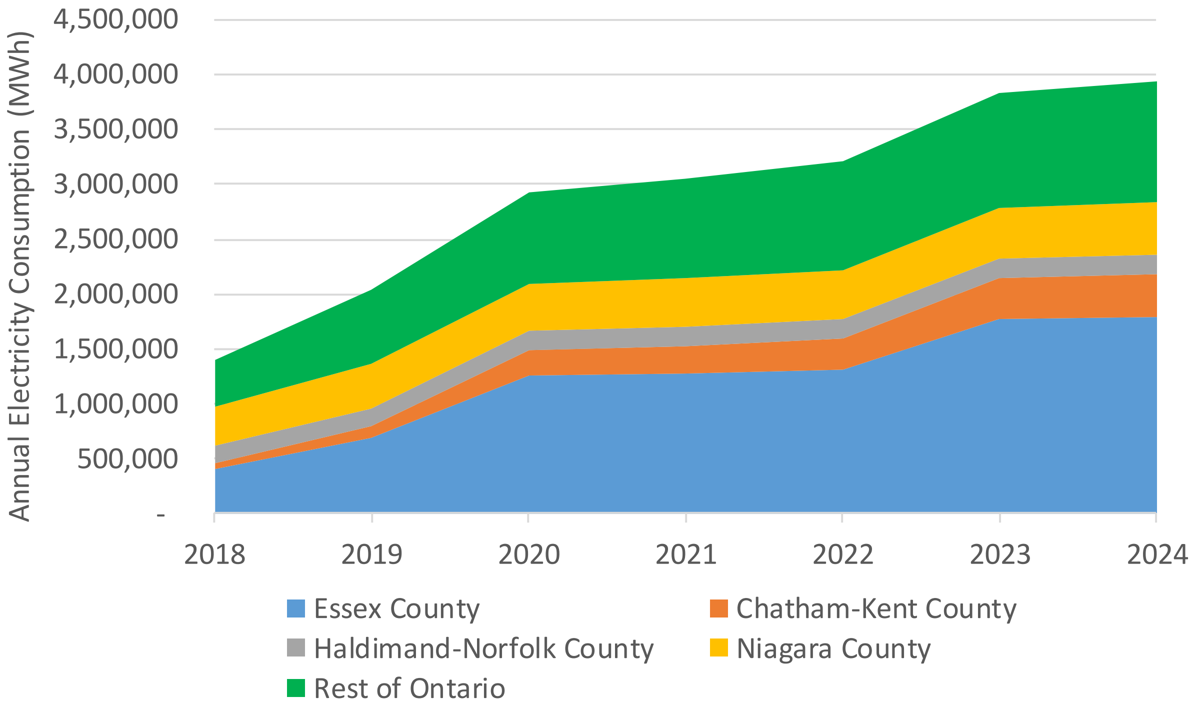


Exhibit 45 shows the reference case forecast for energy consumption by fuel. Consumption of electricity and natural gas are expected, as displayed in the exhibit below.

Exhibit 45 – Forecasted Energy Consumption by Fuel

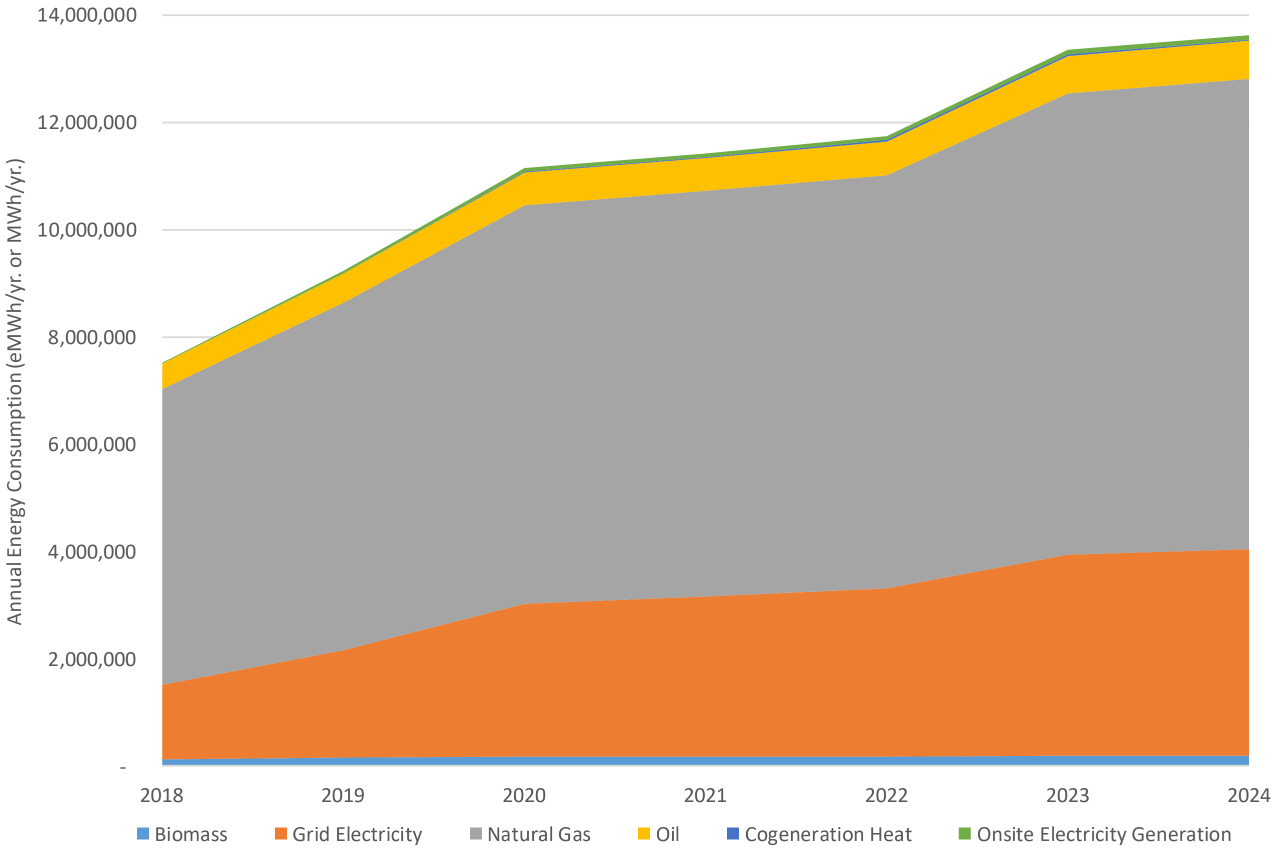
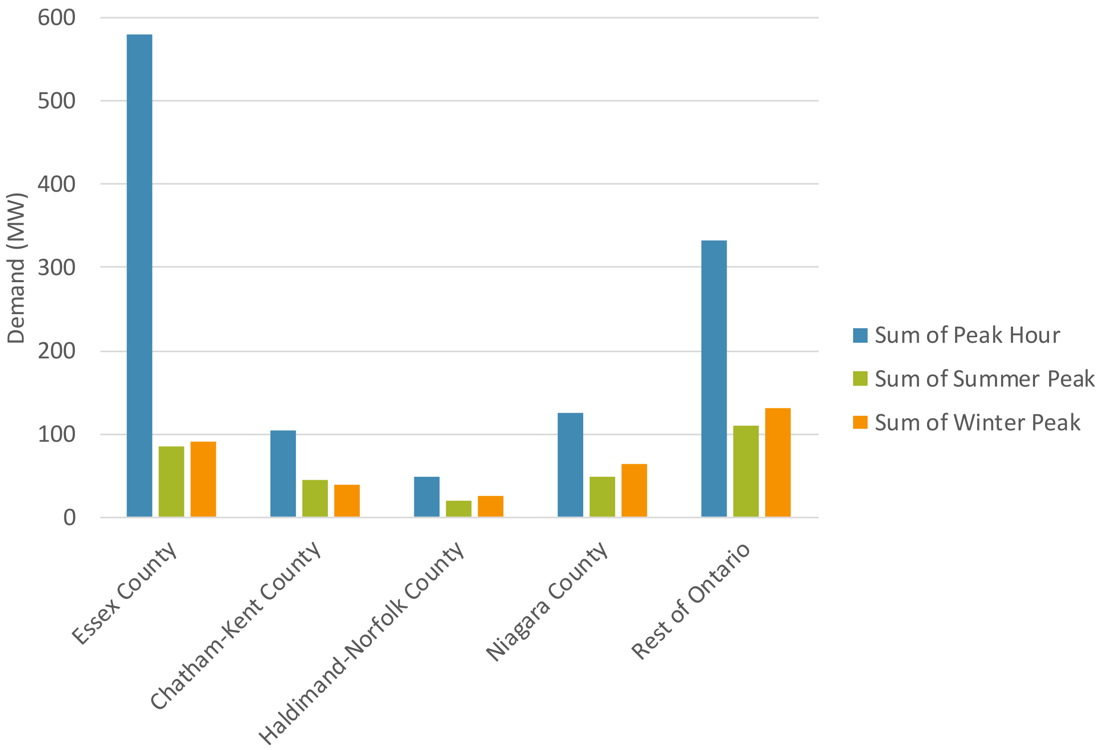


Exhibit 46 shows forecasted demand by peak period for the Chatham-Kent, Essex, Haldimand-Haldimand–Norfolk and Niagara regions in 2024. The exhibit illustrate that the greenhouse peak hour is not coincident with the provincial system summer or winter peaks. This is because the greenhouse peak hour aligns with the peak lighting load at greenhouse facilities. In areas with high concentrations of greenhouses, this greenhouse peak hour is impacting local transformer stations.

The Essex region is predicted to have the highest peak hour in 2024, largely due to an increase in grow lighting in the region’s vegetable sub-sector (from 4% of greenhouse area in 2018 to 29% of area in 2024).

Exhibit 46 – 2024: Demand by Peak Period and Region



Energy Savings Potential

2 Energy Savings Potential

2.1 Energy Saving Potential Development

The amount of energy that can be saved can be estimated in the following ways:

Technical Potential

Technical Potential is the theoretical maximum amount of energy use that could be displaced by the measures, only considering technical constraints. Non-technical constraints such as cost-effectiveness and the willingness of end-users to adopt the efficiency measures are not considered. *This study only reports technical potential for the LED measure scenarios.*

Economic Potential

Economic Potential is the subset of the Technical Potential that passes the Total Resource Cost (TRC) test. The participants' perspective is provided in the form of simple payback in years, but this calculation is not used for screening measures. *This study reports economic potential for all measures, except LEDs for which technical potential is estimated.*

Achievable Potential

Achievable Potential is the subset of Economic Potential that is realistically possible, considering market barriers to adopt energy efficiency measures. *This study does not estimate achievable potential.*

Peak Demand Savings

Electric peak demand savings from energy conservation measures are modelled by applying load shape assumptions to baseline sector consumption, as well as measure-level conservation potential.

There are three peak periods considered in this study, as follows:

Exhibit 47 – Peak Period Definitions

Peak Period	*Hours of the Day*	*Days of the Week*	*Months of the Year*
Summer	1pm to 7pm	weekdays	June, July and August
Winter	6pm to 8pm	weekdays	January, February and December
Greenhouse Peak Hour	Peak Hour Occurs in February. See definition below.		

For this study, we defined 'Greenhouse Peak Hour" as the hour with the highest predicted aggregate electricity use in Essex region's covered agriculture facilities; in other words, the one hour that uses more electricity than any of the other 8,759 hours in the year. The greenhouse peak hour is coincident with the peak lighting load at greenhouse facilities. In areas with high concentrations of greenhouses, this greenhouse peak hour is impacting local transformer stations.

2.2 Measures

The following table lists the energy saving measures considered in the analysis, including the applicable end use and fuels, which sub-sectors the measure applies to, and energy savings estimates.

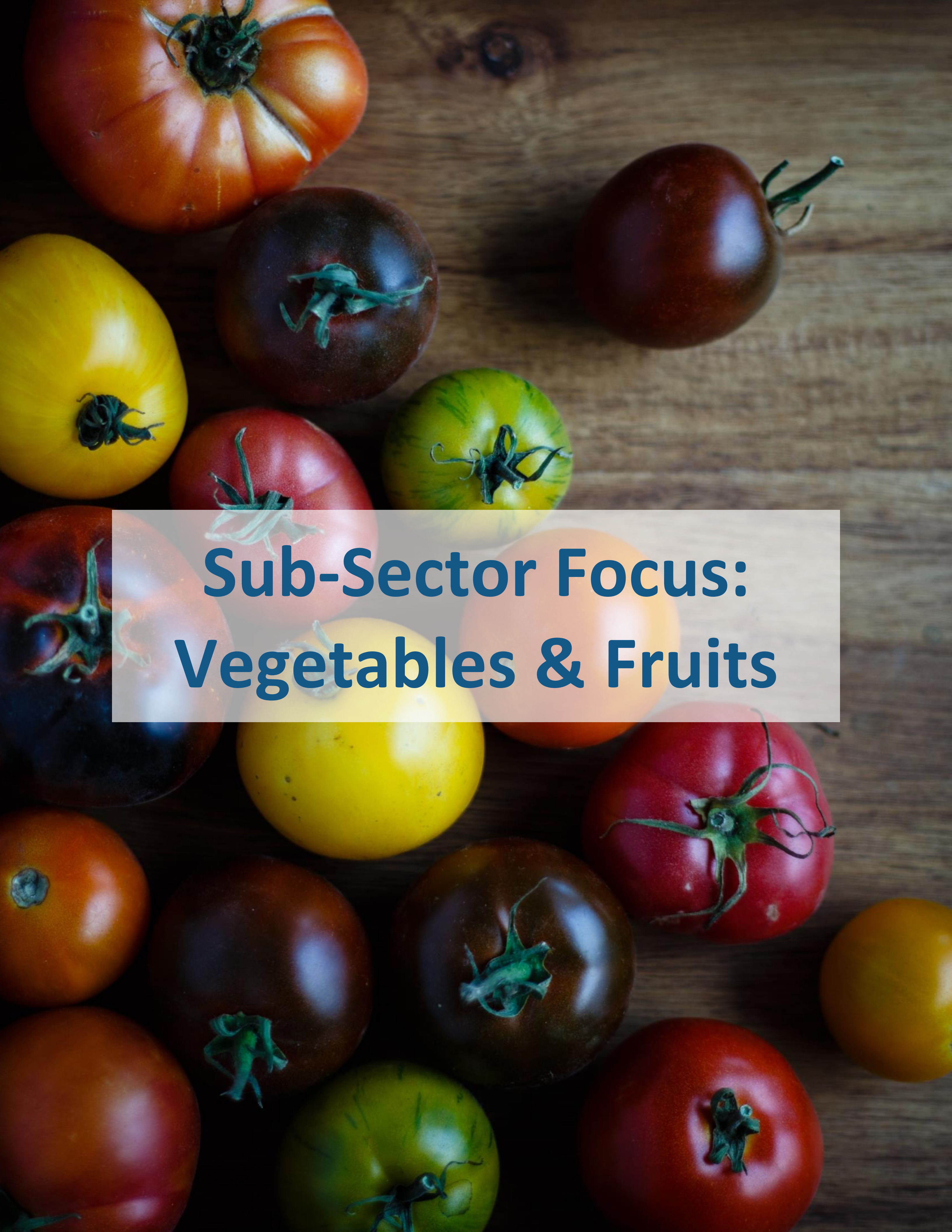
Exhibit 48 – Energy Efficiency Measures included in the Savings Potential Analysis

Measure Name	Measure Description	End Use [Fuel]	Sub-sector Applicability	% Energy Savings
LED Grow Lights	Light Emitting Diode (LED) are energy efficient indoor grow lights to replace high-pressure sodium (HPS) indoor grow lighting.	Lighting	All	35% - 55%
Energy Curtains	Energy curtains installed in a greenhouse where none existed. Energy curtains are retractable barriers that offer shading (in summer) and heat retention benefits thereby resulting in energy savings and better control of the greenhouse environment.	Space heating [Natural gas, biomass, oil]	All greenhouses (not indoor cannabis or vertical farms)	30%
Add VFDs to pumps	Variable frequency drive (VFD) added to existing pump to match motor output speed to the load requirement. The resulting benefit is a reduced power consumption when full flow operation is not required.	Pumping [Electricity]	All	12%
High efficiency pumps	High efficiency pump to replace an existing pump.	Pumping [Electricity]	All	43%
High efficiency condensing hot water boiler system	High efficiency condensing hot water boiler system replacing an existing non-condensing hot water boiler system. A high-efficiency condensing boiler has a heat exchanger to capture the latent heat of the flue gas and improve its overall combustion and thermal efficiency.	Space heating [Natural gas]	Vegetable: 100% of acreage Flowers: 85% of acreage (remaining 15% heat with unit heaters) Cannabis Greenhouse: 100% of acreage	8%

Measure Name	Measure Description	End Use [Fuel]	Sub-sector Applicability	% Energy Savings
			Cannabis Indoor & Vertical: n/a	
Integrated Environmental Controls	Integrated environmental controller to replace a stand-alone control system. Integrated controller applications include control of VFDs, staging and control of exhaust fan speed, control of shade/thermal curtain operation, control of heat buffering systems, managing climate including control of zone pumps, mixing valves, and heating & ventilation equipment, and managing irrigation.	Space heating, Pumping, Other [Natural gas, electricity]	Vegetable, Flowers, Vertical Farming	15%
Drip irrigation	Drip irrigation system to replace a standard irrigation system. Drip irrigation systems deliver water slowly to the roots of plants, minimizing evaporation compared to standard systems. In addition to energy savings, this measure is estimated to result in 40% water savings.	Pumping [Electricity]	All	3%
Envelope improvements	Envelope improvements to an in-situ greenhouse, including increasing air-tightness, applying insulation and using more energy efficient glazing material.	Space heating [Natural gas, biomass, oil]	All sectors	30%
Combined Heat and Power – Flower Greenhouses	Installation of a gas-fired turbine or reciprocating engine to generate electricity. This electricity can offset the lighting load in a flower greenhouse. Waste heat produced during the combustion process can offset the heating load, and CO_2 in the exhaust can be captured and injected into the growing area. This measure results in electricity savings, but a net increase in gas consumption.	Lighting, Space Heating [Electricity, natural gas]	Flowers	2.92 kWh/ft^2/yr; 0.0005 kW/ft^2; % heat displaced: 23%
Combined Heat and Power - Vegetable Greenhouses	Installation of a gas-fired turbine or reciprocating engine to generate electricity. This electricity can offset the lighting load in a vegetable greenhouse. Waste heat produced during the combustion process can offset the heating load, and CO_2 in the exhaust can be captured and	Lighting, Space Heating [Electricity, natural gas]	Vegetables	10.85 kWh/ft^2/yr;

Measure Name	Measure Description	End Use [Fuel]	Sub-sector Applicability	% Energy Savings
	injected into the growing area. This measure results in electricity savings, but a net increase in gas consumption.			0.0016 kW/ft^2; % heat displaced: 18%
Combined Heat and Power - Cannabis Indoor	Installation of a gas-fired turbine or reciprocating engine to generate electricity. This electricity can offset the lighting load in an indoor cannabis facility. Waste heat produced during the combustion process can offset the heating load, and CO2 in the exhaust can be captured and injected into the growing area. This measure results in electricity savings, but a net increase in gas consumption.	Lighting, Space Heating [Electricity, natural gas]	Cannabis Indoor	94.07 kWh/ft^2/yr; 0.0153 kW/ft^2; % heat displaced: 56%
Combined Heat and Power - Cannabis Greenhouses	Installation of a gas-fired turbine or reciprocating engine to generate electricity. This electricity can offset the lighting load in a cannabis greenhouse. Waste heat produced during the combustion process can offset the heating load, and CO2 in the exhaust can be captured and injected into the growing area. This measure results in electricity savings, but a net increase in gas consumption.	Lighting, Space Heating [Electricity, natural gas]	Cannabis Greenhouse	50.81 kWh/ft^2/yr; 0.0100 kW/ft^2; % heat displaced: 69%
Condensing Unit Heater	Condensing unit heater to replace a non-condensing unit heater. Condensing unit heaters have two heat exchangers: a primary non-condensing heat exchanger, and a secondary heat exchanger where waste heat from flue gases is recovered.	Space heating [natural gas]	Flowers: 15% of acreage Vegetable, Cannabis (Indoor & Greenhouse), Vertical: n/a	11%

Measure Name	Measure Description	End Use [Fuel]	Sub-sector Applicability	% Energy Savings
High Efficiency Circulation Fans	High efficiency circulation fan to replace a standard efficiency fan. High efficiency circulation fans have higher cfm/watt ratings (Ventilating Efficiency Ratio or VER) compared to standard efficiency fans.	Other [Electricity]	All	13%
VFD equipped exhaust fans	Variable frequency drive (VFD) added to existing exhaust fan to match motor output speed to the load requirement. VFD allows fan to operate at variable loads instead of at full power all the time.	Other [Electricity]	All	12%
Docking Seals	Docking seals are fabric-covered foam pads that reduce heat loss from greenhouse or indoor cannabis facility loading areas. The foam pads compress when a trailer backs into them, which creates a tight seal around the sides of the trailer and closes the gaps between the trailer's door hinges.	Space heating, Air Conditioning [Natural gas, biomass, oil, electricity]	All (space heating) Cannabis Indoor (air conditioning)	2% space heating; 0.5% air conditioning
Optimizing HVAC for Cannabis	This measure has been developed as a proxy to highlight the magnitude of the of HVAC retrofit opportunity for cannabis facilities. These facilities each have unique HVAC characteristics, and require a bespoke approach to optimize, re-design, or enhance existing systems. Cooling, heating, and dehumidification requirements vary significantly across growth stages, and differ notably compared to vegetable and flower operations. Equipment set-up and selection also differs significantly. This measure represents opportunity for improved design and operation of HVAC equipment.	Space heating, air conditioning [Natural gas, electricity]	Cannabis Greenhouse Cannabis Indoor	10% space heating; 30% air conditioning



Sub-Sector Focus: Vegetables & Fruits

3 Sub-Sector Focus: Vegetables & Fruits

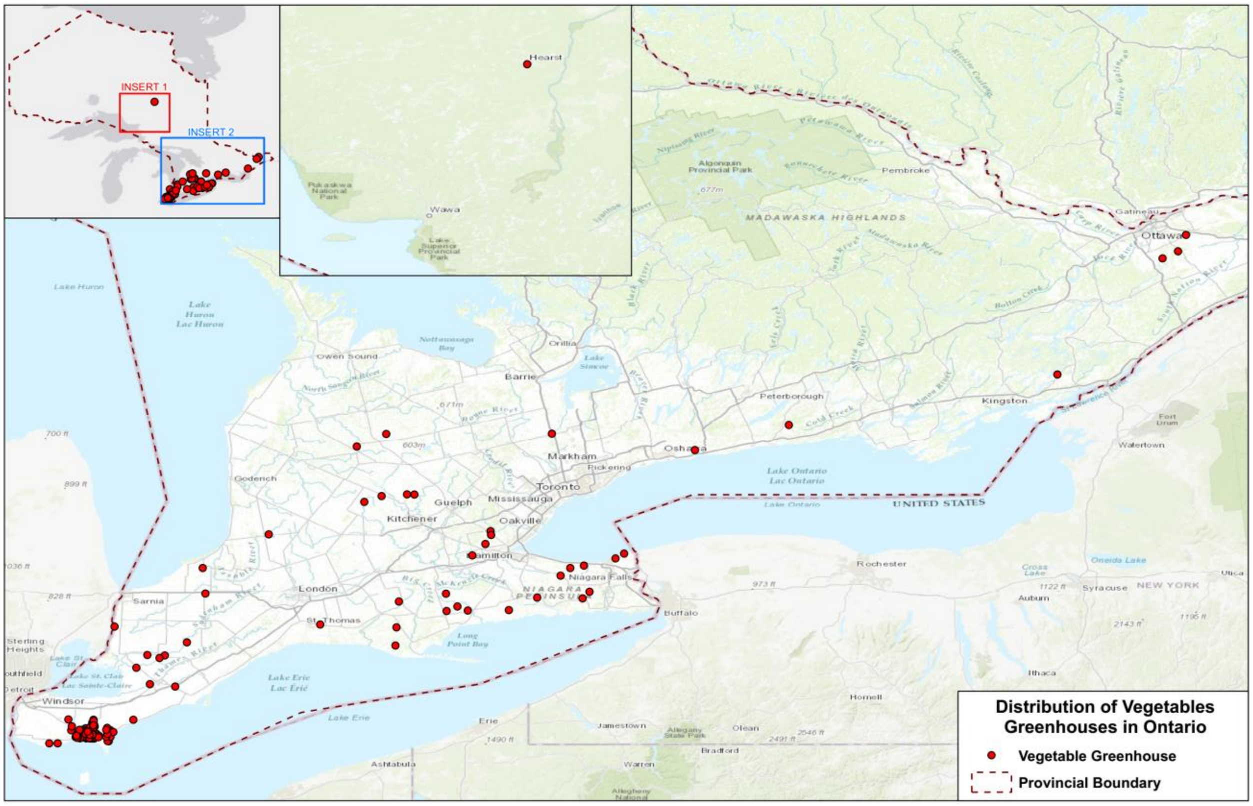
3.1 Sub-sector Description

Vegetable and fruit greenhouses (referred to as the 'vegetable' sub-sector in this report) is the largest and fastest growing sub-sector of the horticulture sector in Canada [7]. As of 2017, most of the greenhouse acreage in Ontario produced vegetables. The main vegetable crops are tomatoes, peppers and cucumbers which account for almost 98% of total vegetable harvest, with each accounting for about one-third of vegetable production [8]. Other vegetable crops include lettuce, eggplant and herbs. Some fruits are produced in greenhouses, including a variety of berries [9].

The 2018 farm gate value from greenhouse vegetables was $947 million [43], with more than 70% of produce exported to the U.S. [8]. In 2016, the export value of greenhouse vegetables was the highest of all fresh produce exports, accounting for about 40% of all fresh produce exports from Canada [7].

This sub-sector is concentrated in the Essex region. Of the 224 members of the Ontario Greenhouse Vegetable Grower (OGVG) association, 85% are located in the Essex region [10]. Greenhouses are concentrated in this area in part due to the warm climate (relative to the rest of Canada) and close proximity to the U.S. [10].

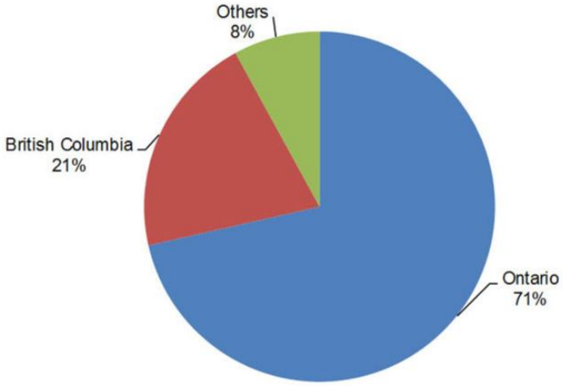
Exhibit 49 – Map of Vegetable Greenhouse Concentration by Region [44]



Greenhouses used for these crops tend to have glass or polyethylene roofing, use energy screen systems, and heat with centralized steam or hot water systems, including after-market condenser systems. Ventilation is commonly done by opening the roof or sidewall vents and complemented with fans [45]. Climate control is managed through integrated computer-controlled systems [46]. These greenhouses are large natural gas consumers with their major end-uses being space heating.

In the past, vegetable greenhouses typically did not use supplemental grow lighting, but this is beginning to change with growers looking to increase production to meet increasing demand. Lit vegetable greenhouses tend to consume a significant amount of electricity, and existing greenhouses introducing grow lighting is expected to be a significant driver of electricity growth in this sector over the next six years.

Exhibit 50 – Share of Greenhouse Vegetable Production by Province (2015) [47]



3.2 Base Year (2018) Results

Exhibit 51 shows the proportion of base year floor area by region for the vegetable sub-sector. In 2018 there was 111.9 million ft^2 (2,570 acres) of vegetable greenhouses, with the majority located in Essex County. The average vegetable greenhouse in Essex and Chatham-Kent is 9 times larger than the average in the rest of the province.

Exhibit 51 – 2018: Vegetable Sub-Sector Area by Region (%)

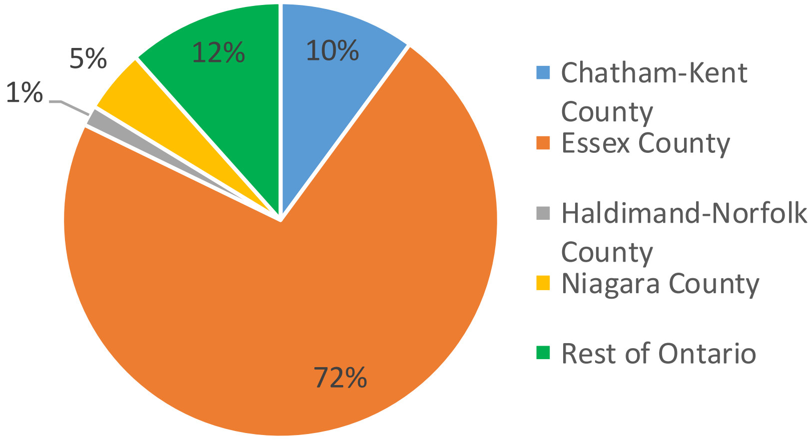


Exhibit 52 shows the number of lit and unlit facilities by region for the vegetable and fruit sub-sector in the base year. Only 4% of the vegetable greenhouse area in 2018 had grow lighting.

Exhibit 52 – 2018: Number of Vegetable Greenhouses by Region and Lighting Status

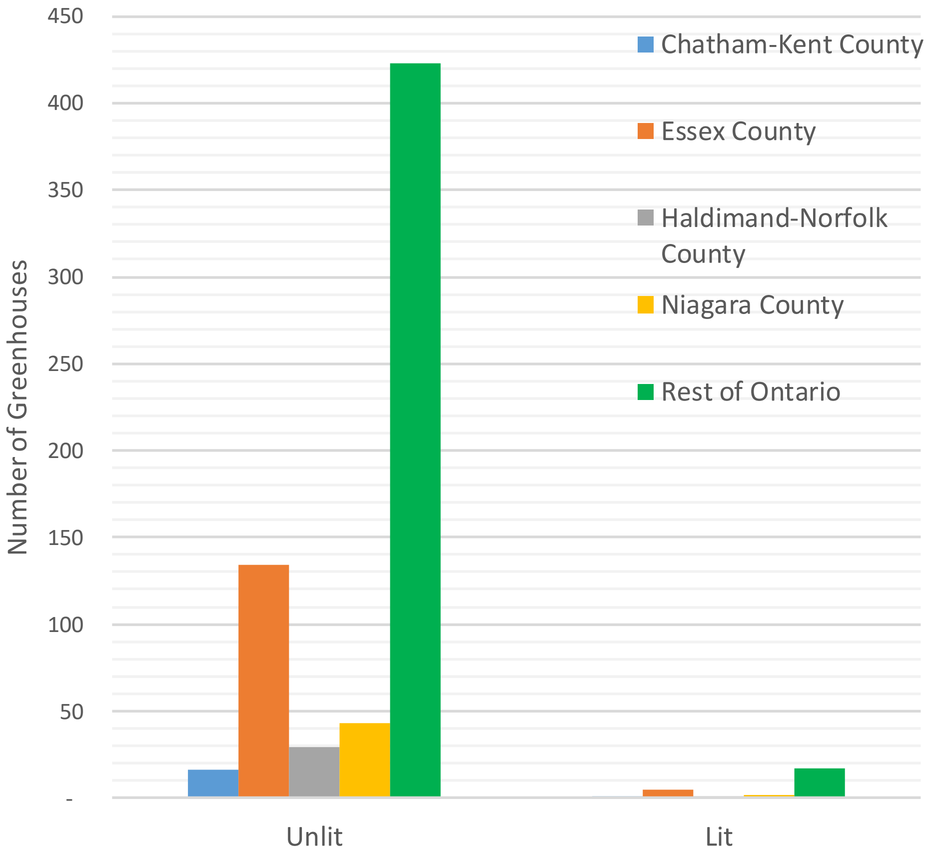


Exhibit 53 shows annual energy consumption (unit energy consumption or UEC) by end use for a typical lit vegetable greenhouse and unlit vegetable greenhouse. A lit vegetable greenhouse consumes ten times as much electricity as an unlit vegetable greenhouse (30.94 ekWh/ft^2 vs. 3.18 ekWh/ft^2) with essentially all the additional electricity used for lighting.

Exhibit 53 – UEC Values by End Use and Lighting Status

	UEC Value (ekWh/ft^2)	
End Use	**Lit Vegetable/Fruit Greenhouse**	**Unlit Vegetable/Fruit Greenhouse**
Heating	42.01	42.01
Lighting	27.86	0.10
Pumping	1.82	1.82
Other	1.26	1.26

Exhibit 54 shows base year energy consumption by region and fuel for the vegetable and fruit sub-sector. It is estimated 4 MW of behind the meter tri-generation is installed in Essex County (the only region with tri-generation in the base year).

Exhibit 54 – 2018: Vegetable Sub-Sector Annual Energy Consumption by Region and Fuel

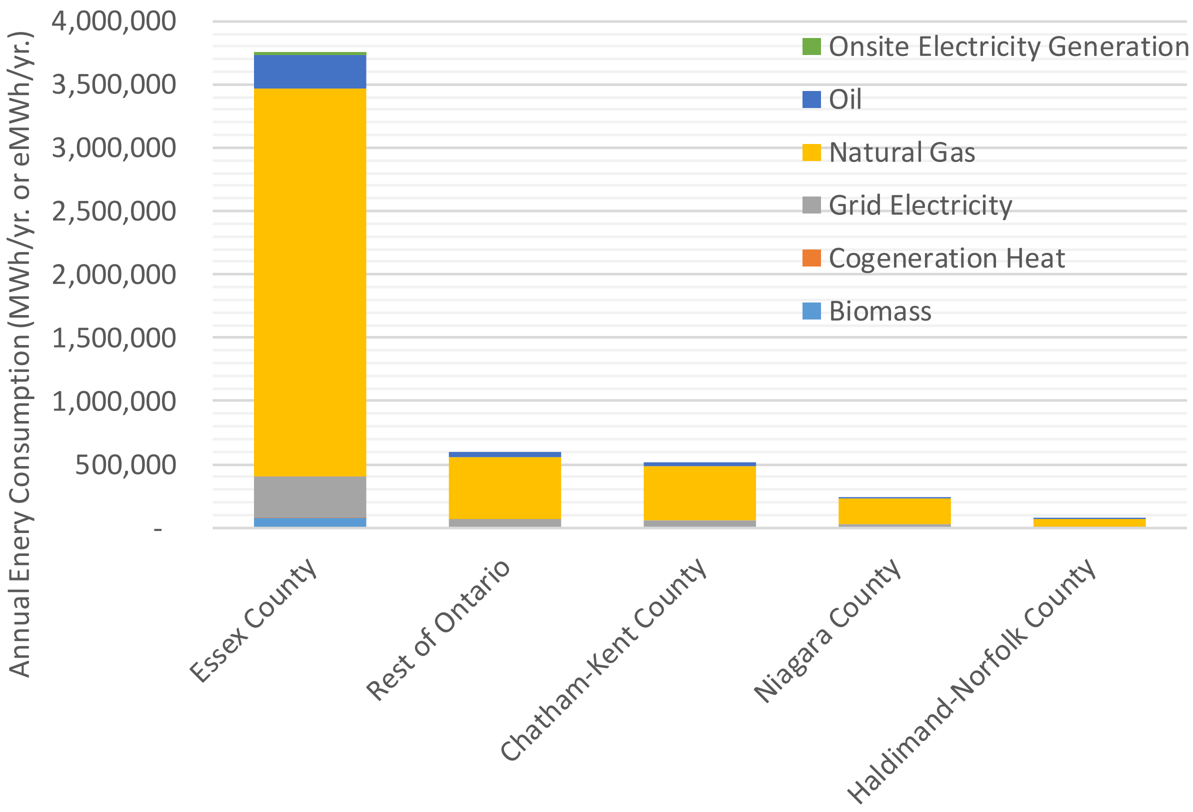
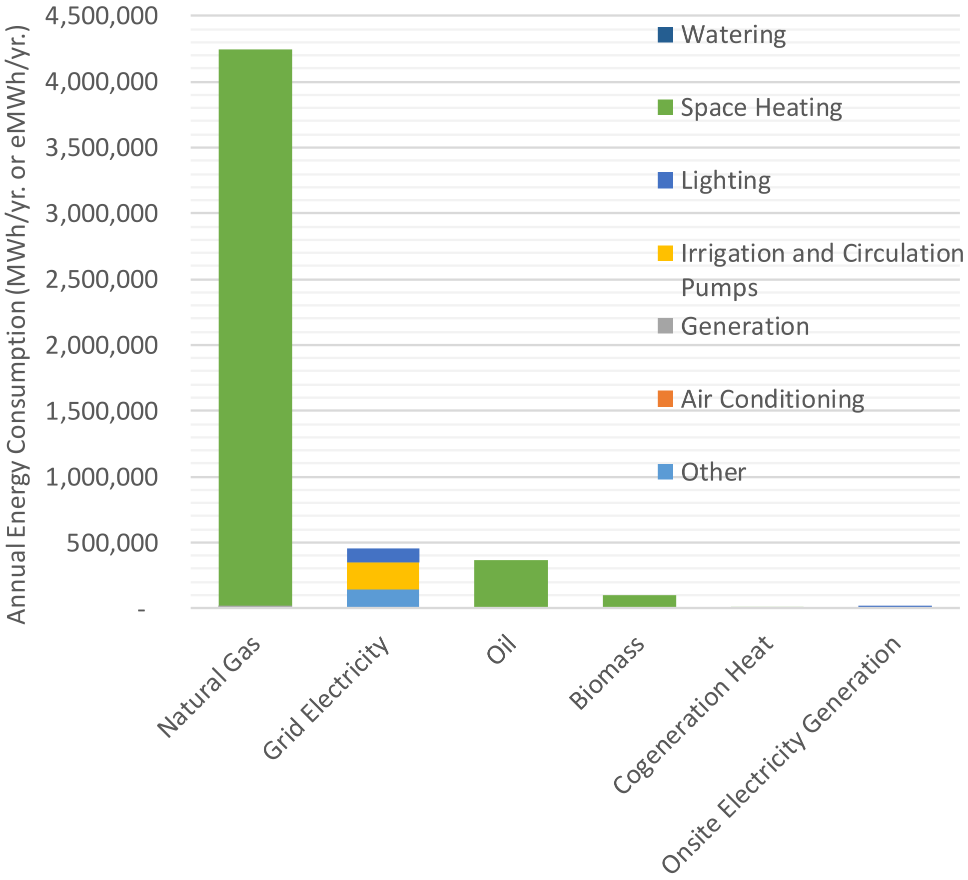


Exhibit 55 shows the base year energy consumption by end-use and fuel for the vegetable and fruit sub-sector.

Exhibit 55 – 2018: Vegetable Sub-sector Energy Consumption by End-Use and Fuel



3.2.1 Load Profiles

Load profiles for vegetable greenhouses were developed by the study team using the following data sources:

- Hourly electricity consumption data for 326 greenhouse customers for 2016 and 2017 provided by Hydro One
- Hourly gas consumption data for 125 greenhouse customers for 2017 provided by Enbridge Gas
- The load shape of a lit greenhouse was provided by the IESO based on hourly data from four lit vegetable greenhouses.

Based on these data sources, the load profiles presented below represent a "typical" load profile based on the data sources. Load profiles for specific facilities may differ[3].

---

[3] The study team recommends that a sample of greenhouses be sub-metered to capture end-use specific load shapes, particularly for lighting, to make the load profile analysis more accurate in the future.

Lit Vegetable Greenhouse Load Profiles

Exhibit 56 displays the load profile of monthly electricity consumption in a lit, vegetable greenhouse as a percentage of annual consumption. January is the month with the highest electricity consumption while the summer months have the lowest.

Exhibit 56 – Electricity Monthly Load Profile (% of annual) for Lit Vegetable Greenhouse

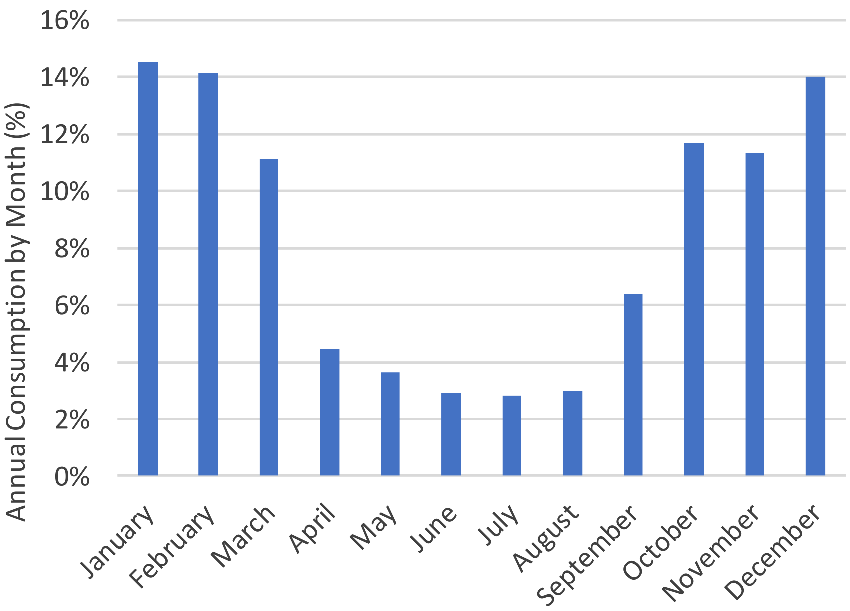


Exhibit 57 shows the load profile of daily electricity consumption for a lit vegetable greenhouse as a percentage of daily consumption.

Exhibit 57 – Electricity Hourly (% of day) Load Profile for Lit Vegetable Greenhouse

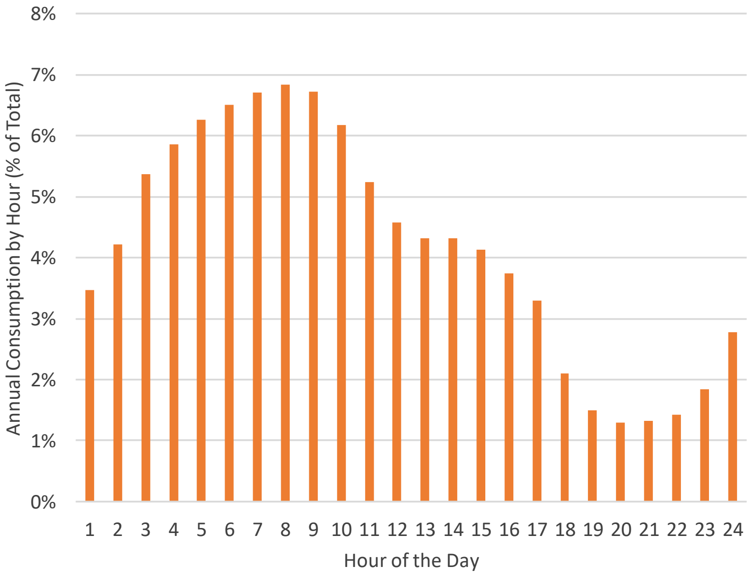
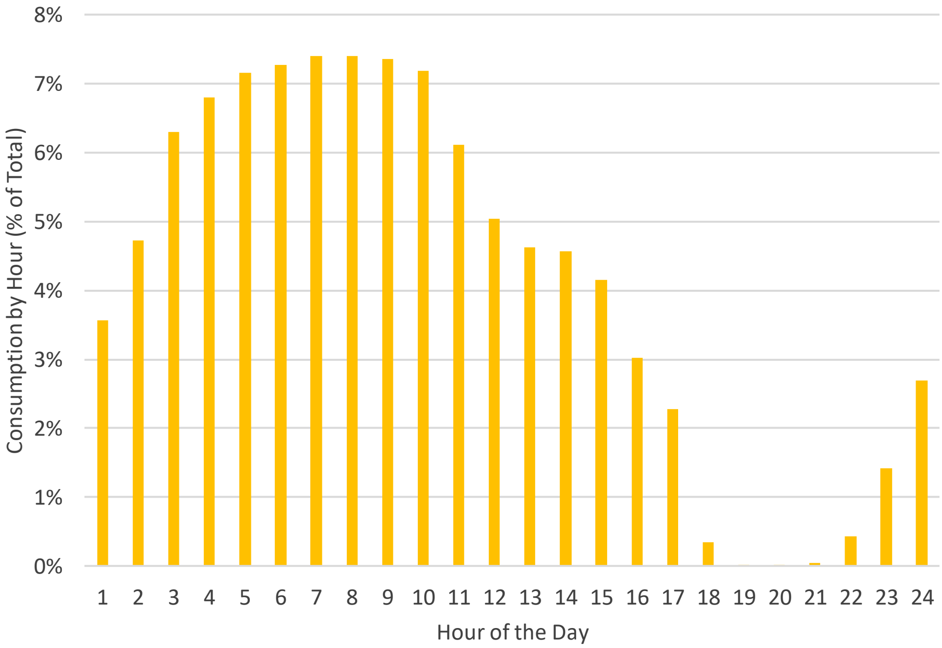


Exhibit 58 illustrates the hourly lighting end-use load profile as a percentage of daily consumption. The lighting load peaks in the morning.

Exhibit 58 – Lighting Hourly (% of day) Load Profile for Lit Vegetable Greenhouse



Unlit Vegetable Greenhouse Load Profiles

Exhibit 59 provides the load profile for an unlit vegetable greenhouse of monthly electricity consumption as a percentage of annual electricity consumption. August has the highest relative consumption of electricity.

Exhibit 59 – Electricity Monthly Load Profile (% of annual) for Unlit Vegetable Greenhouse

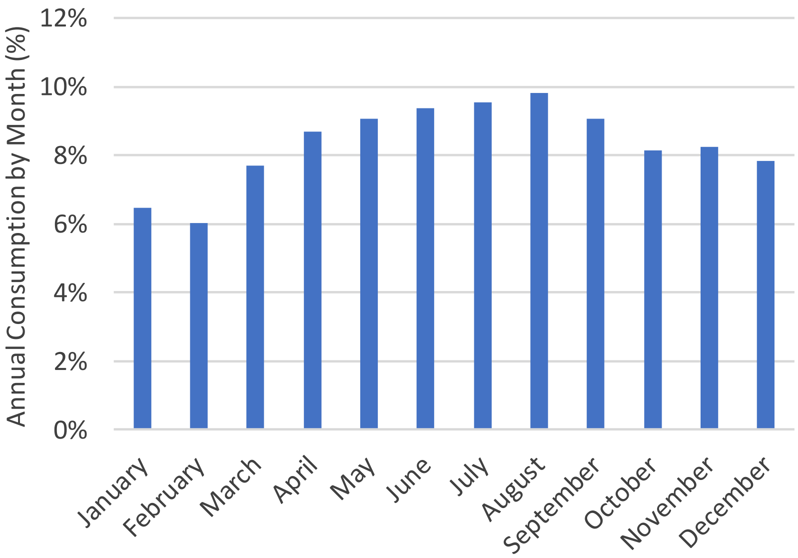
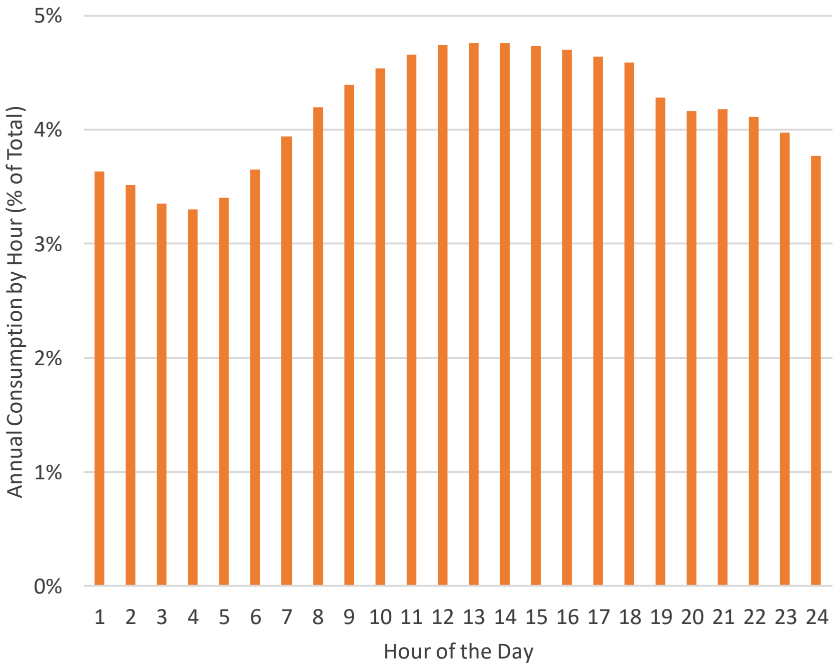


Exhibit 60 shows the load profile of daily electricity consumption for an unlit vegetable greenhouse as a percentage of daily consumption.

Exhibit 60 – Electricity Hourly (% of day) Load Profile for Unlit Vegetable Greenhouse



3.3 Reference Case (2019-2024) Forecast Results

Exhibit 61 shows the reference case floor area forecast by region for the vegetable sub-sector. The vegetable sub-sector is forecast to grow by 5% per year for all regions over the next six years (1% of this is expected to be new account growth and the other 4% is expansions of existing facilities).

Essex County is an exception, growing at an average of 9% year over year during the reference period. Due to a high number of connection requests in the area, growth is expected to follow the IESO's electricity demand growth forecast.

Exhibit 61 – Vegetable Sub-Sector: Forecasted Total Area (sq. ft.) By Region

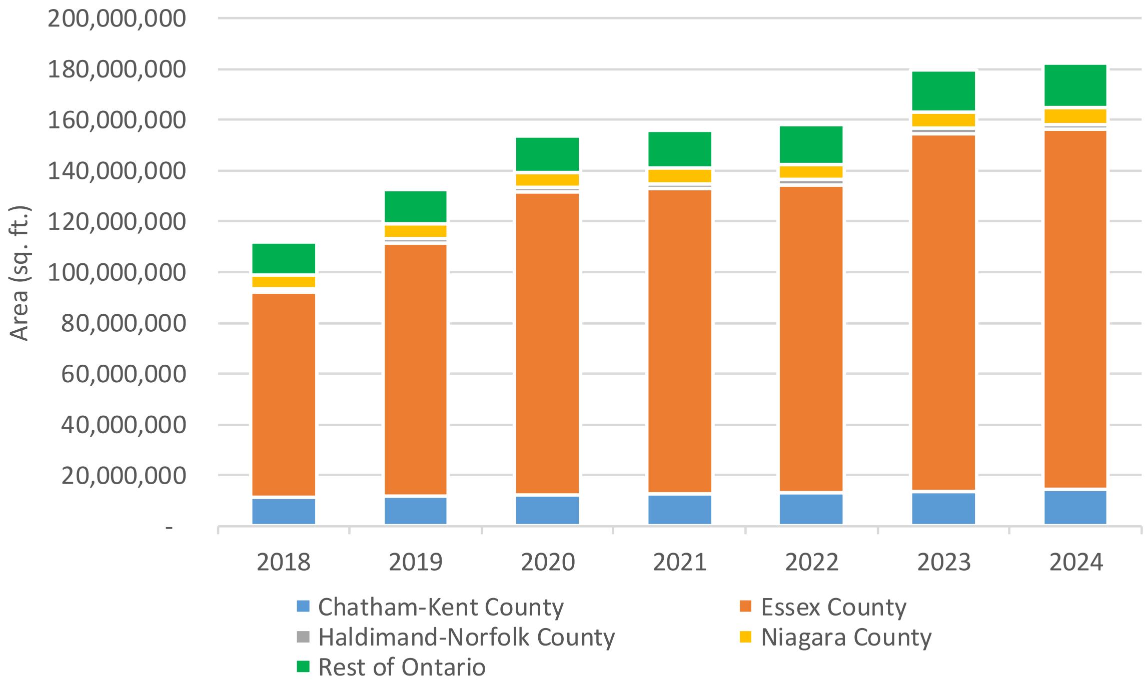


Exhibit 62 shows the reference case forecast for the number of lit and unlit facilities by region in the vegetable and fruit sub-sector. The lit portion is expected to increase from 4% in 2018 to 8% by 2020 in all regions except Essex, where the lit percentage increases to 29% by 2024 (existing growers adding grow lighting is a significant contributor to the electricity demand forecast in the region).

Exhibit 62 – Vegetable Sub-Sector: Forecasted Number of Facilities by Region and Lighting Status

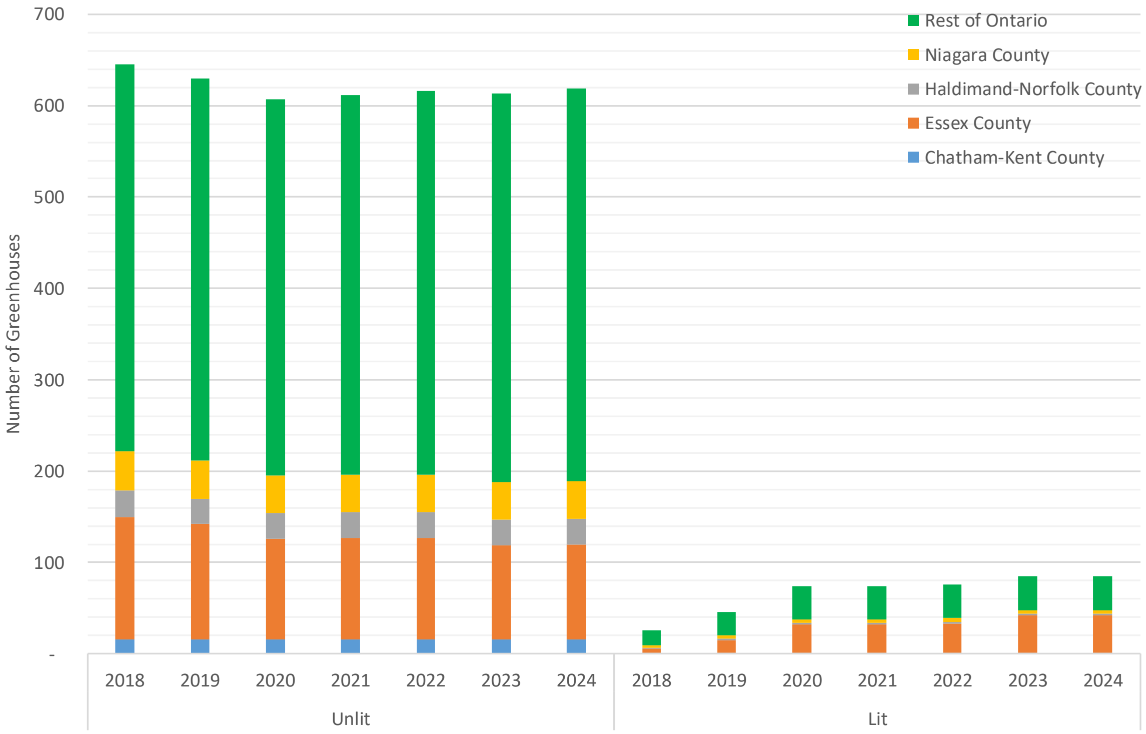


Exhibit 63 shows the reference case energy consumption forecast by fuel for the vegetable and fruit sub-sector. Total behind the meter tri-generation installed by end of reference case (2024) is expected to be 17 MW.

Exhibit 63 – Vegetable Sub-Sector: Forecasted Annual Consumption by Fuel

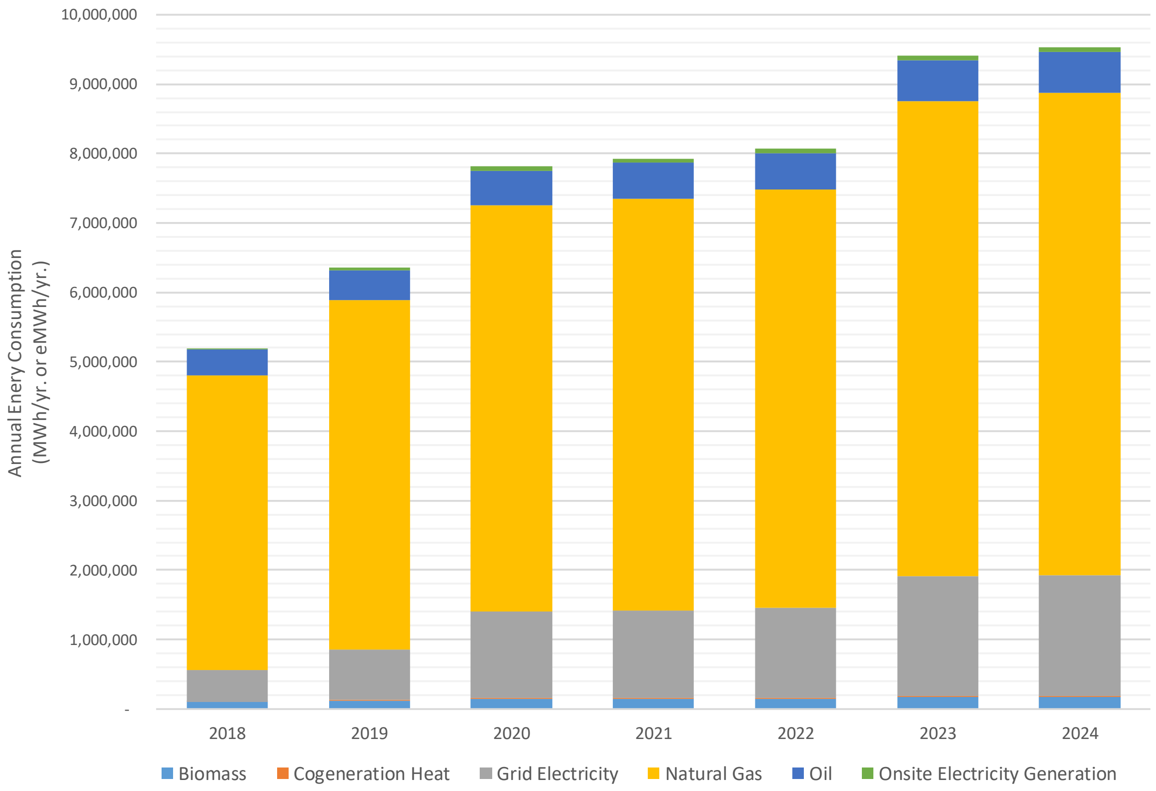


Exhibit 64 shows the reference case energy consumption forecast by region for the vegetable sub-sector.

Exhibit 64 – Vegetable Sub-Sector: Forecasted Annual Consumption by Region

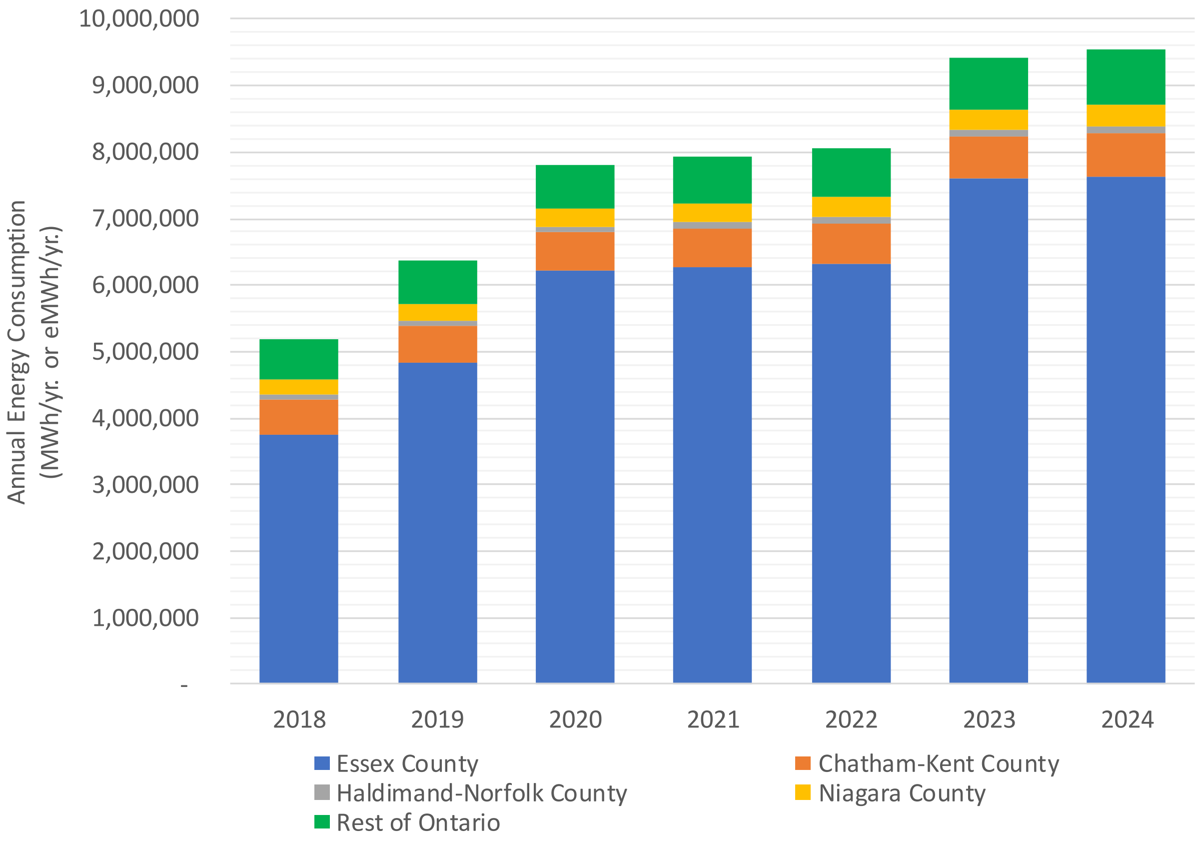


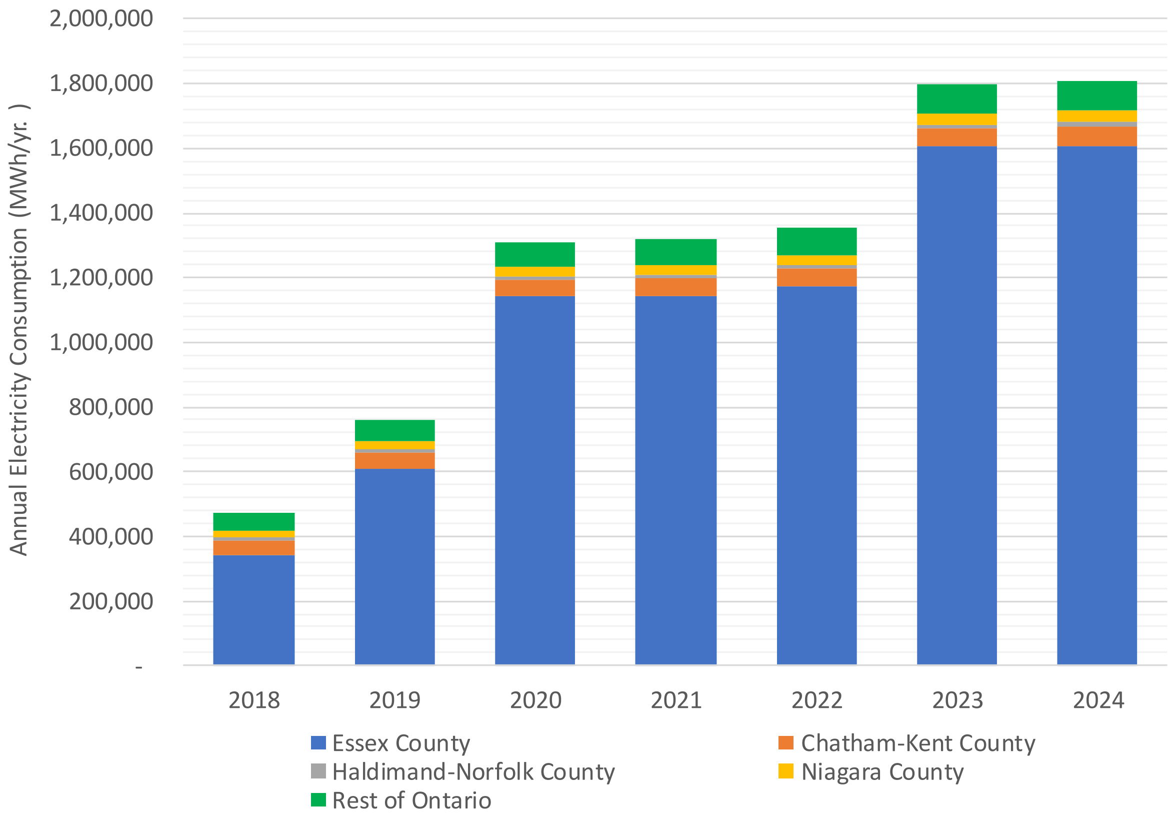
Exhibit 65 shows the forecasted electricity (MWh) consumption by region for the vegetable sub-sector.

The Vegetable and Fruits sub-sector consumed about 473,000 MWh of electricity in 2018. Electricity consumption from this sub-sector is expected to increase by 282% in the next five years (to 1,808,000 MWh in 2024). This increase in electricity is driven by growth in square footage and the addition of supplemental lighting.

Significant growth is electricity consumption is expected, notably:

- In 2018, the covered agriculture sector in Essex county consumed almost 0.4 TWh of electricity; it is forecasted to consume about 1.8 TWh of electricity in 2024, a 351% increase.
- In 2018, the covered agriculture sector in Chatham-Kent county consumed more than 69 MWh of electricity; it is forecasted to consume more than 384 MWh of electricity in 2024, a 455% increase.

Exhibit 65 - Vegetable Sub-Sector: Forecasted Electricity Consumption by Region



3.4 Energy Saving Opportunities

Opportunity for LED Grow Lights

[Please see Section 11.1 for a more fulsome discussion of LED Grow Lights and the sensitivity analysis that was performed for this study.]

LED grow lights offer electricity savings potential when they replace HPS lights. Despite the energy saving potential, LED grow lights currently have a small saturation in the Ontario covered agriculture sector. Growers are hesitant to adopt LEDs due to:

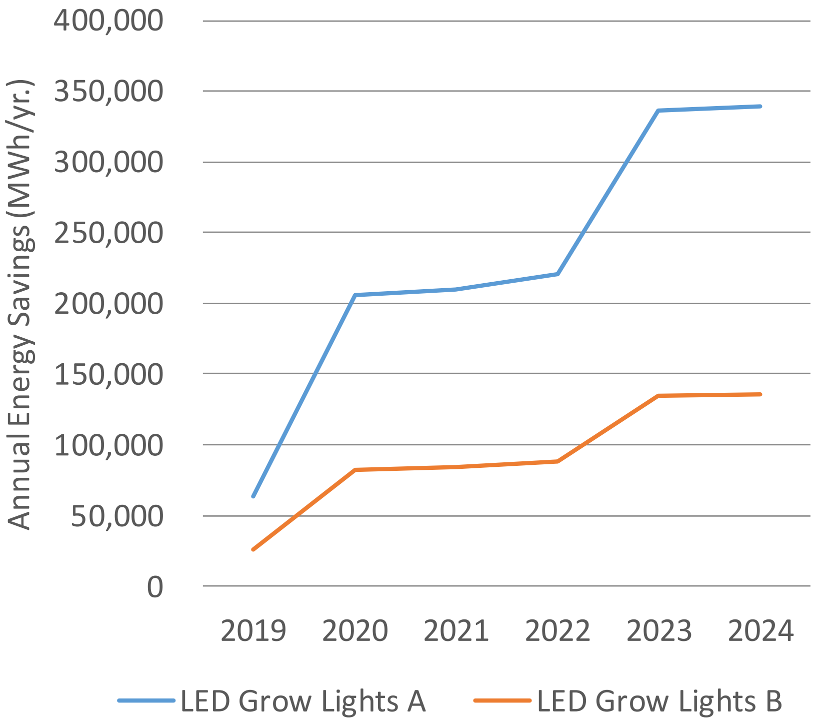
- Uncertainty over savings – savings claims being made by lighting suppliers have been at odds with published research [48] [49]
- Higher upfront costs -- the cost of agricultural LED products still varies widely and is expected to come down in the coming years as the technology continues to mature [48].
- Risk of impacting yield -- there is a learning curve required for growers to switch from HPS to LED, creating a barrier that growers tend not be willing to accept given the relative immaturity of the technology [50]

To illustrate the potential savings if/when LEDs are more widely adopted by the industry, two LED measure scenarios were modelled relative to the reference case:

a) “LED Grow Lights A” -- 55% savings at a cost point of $1.25/installed LED watt (a mid-range cost value) [48]
b) “LED Grow Lights B” -- 35% savings at a cost point of $0.75/installed LED watt (the lowest cost point reported in Ontario to date) [48]

The **technical energy savings potential**[4] results for the vegetables sub-sector are presented in Exhibit 66.

Exhibit 66 – Vegetable Sub-sector: Technical Energy Savings Potential from LED Measure Scenarios



Non-Lighting Electricity Savings Potential

Exhibit 67 shows the electricity savings potential for non-lighting measures that passed the economic screen that apply to the vegetable greenhouse sub-sector (lit and unlit). Adding variable frequency drives (VFDs) to fans is the measure that offers the most electricity savings potential, followed by adding VFDs to pumps.

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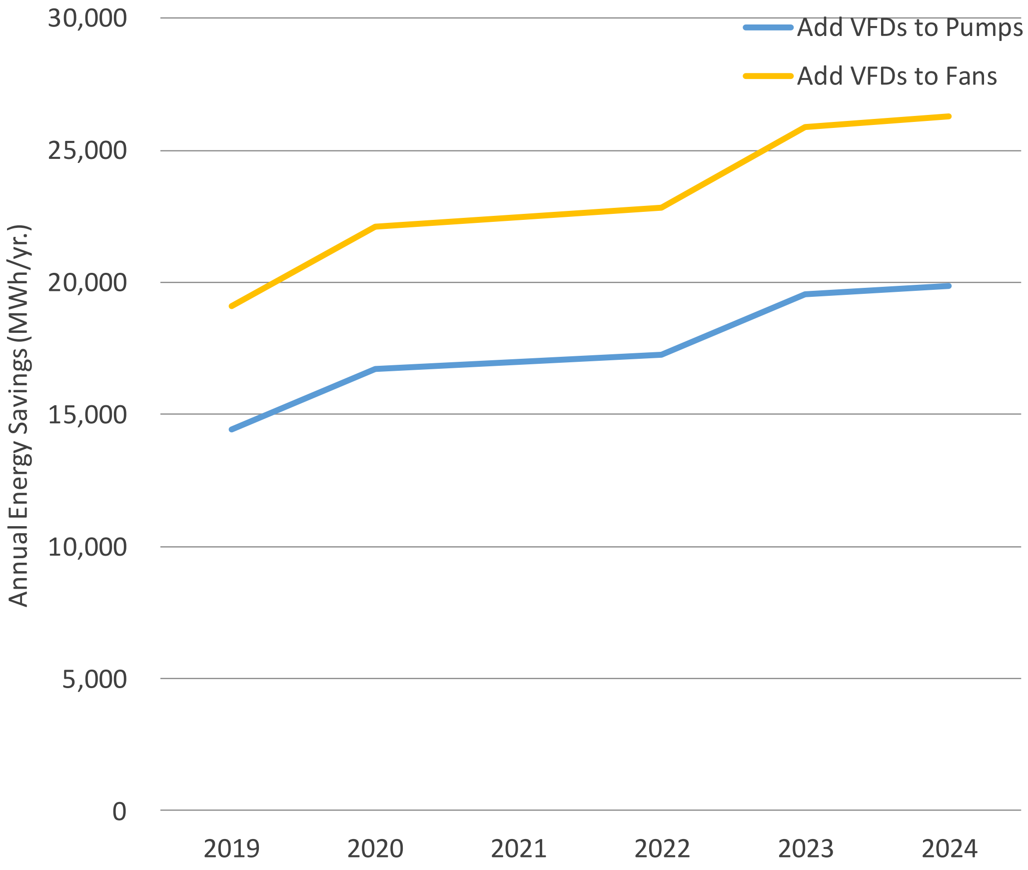
[4] Technical Potential is the theoretical maximum amount of energy use that could be displaced by the measures, only considering technical constraints. Non-technical constraints such as cost-effectiveness and the willingness of end-users to adopt the efficiency measures are not considered.

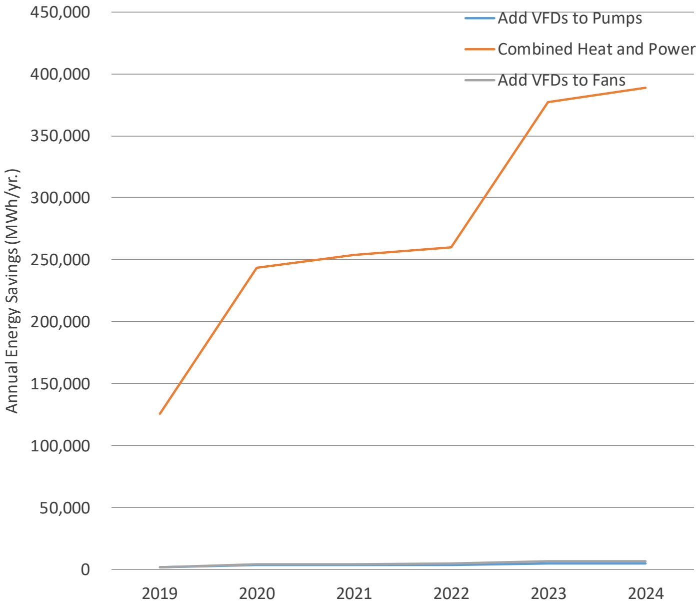
Exhibit 67 – Vegetable Sub-Sector: Electricity Savings Potential by Measure (lit and unlit greenhouses)



The Vineland Research and Innovation Centre has a Collaborative Greenhouse Technology Centre – a 40,000 square foot greenhouse dedicated to horticulture research. The Centre is researching how to use robotics and automation technologies to handle and pack produce, conduct irrigation and detect disease [51].

Exhibit 68 shows the electricity savings potential for lit vegetable greenhouses. In addition to adding VFDs to pumps and fans, the CHP measure passes the economic screen for this segment of the greenhouse sector due to the relatively high EUI for lighting in the lit vegetable greenhouse segment. This is the only segment when CHP offers economic electricity savings potential (i.e., passes the TRC).

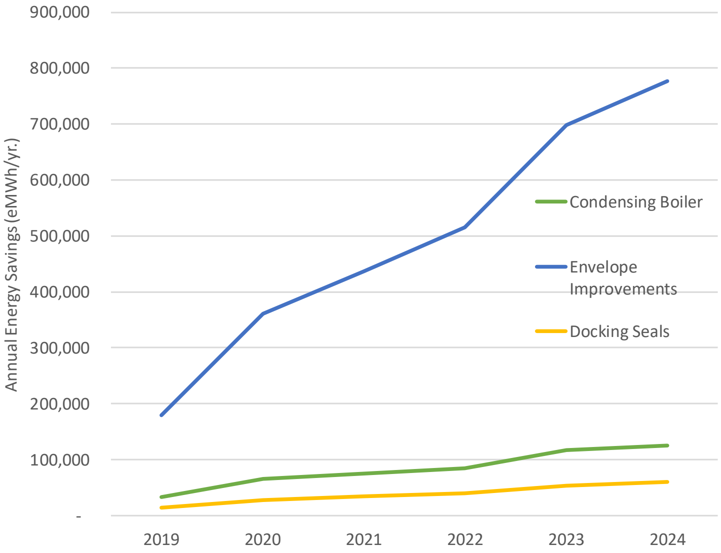
Exhibit 68 – Electricity Savings Potential by Measure for Lit Vegetable Greenhouses



Natural Gas Savings Potential

Exhibit 69 shows the savings potential for natural gas for the vegetable greenhouse sub-sector. Envelope improvements offers the greatest economic savings potential, followed by condensing boilers and docking deals.

Exhibit 69 – Natural Gas Savings Potential by Measure for Vegetable Greenhouse Sub-Sector



Sub-Sector Focus: Flowers & Potted Plants

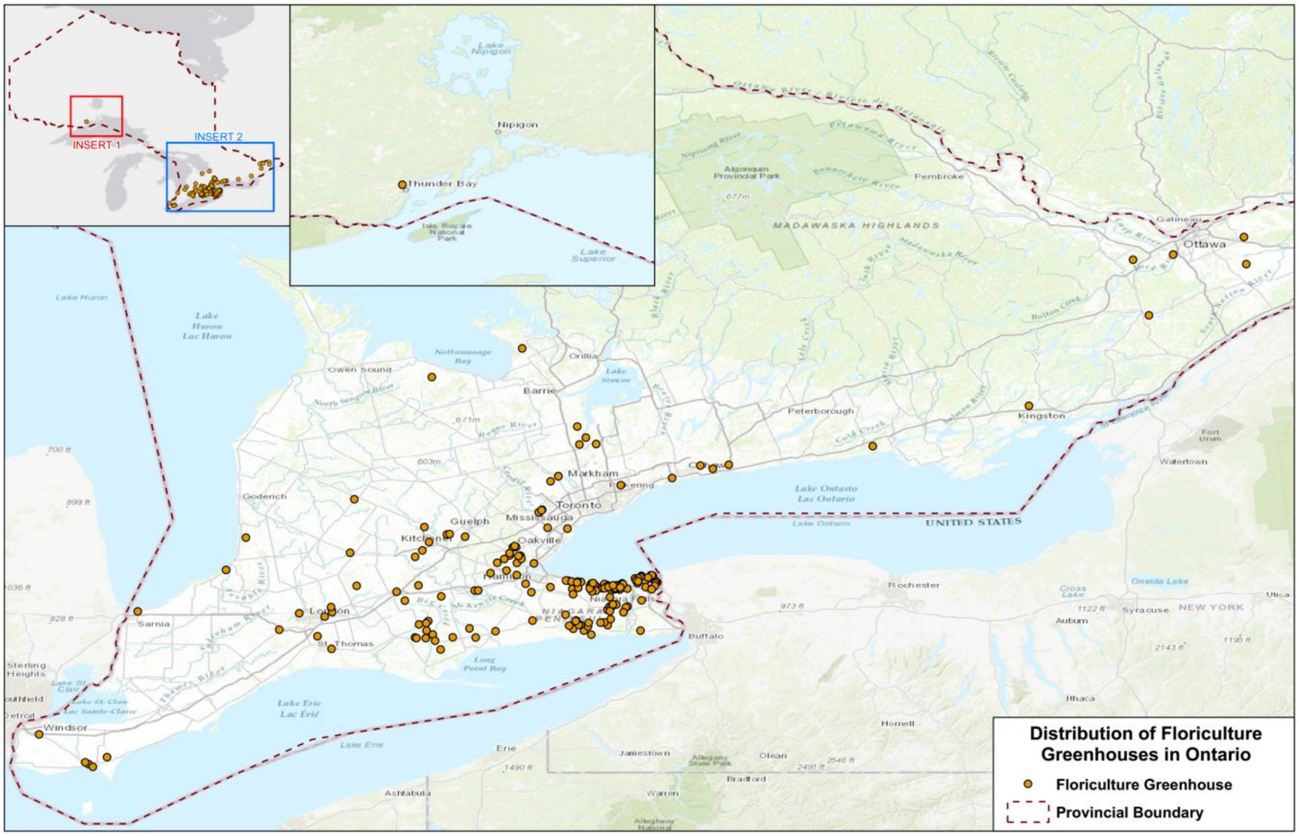
4 Sub-Sector Focus: Flowers & Potted Plants

4.1 Sub-sector Description

The flower and potted plant sub-sector (referred to as the ‘flowers’ sub-sector in this report) grows flowering potted plants, cut flowers, and bedding plants in greenhouses and hoop houses [5]. Ontario is the third largest producer of greenhouse-grown flower products in North America, with a farm gate value of $1.4 billion in 2012. The sub-sector in Ontario is concentrated in the Niagara region with a mixture of large wholesale growers and smaller retail-oriented growers. Many flower growers only operate 7.5 months of the year as winter offers lower consumer demand and higher energy costs [5].

Flowers greenhouses tend to be small operations (below the provincial average of 2 acres). Structures typically have double layer polyethylene roofing, heat with gas-fired unit heaters and ventilate using horizontal fans [46].

Exhibit 70 – Map of Flower and Potted Plant Greenhouses [52]



The flowers sub-sector has declined in recent years, both in terms of number of growers and total acreage. The shrinkage in the sector is in part due to conversions of greenhouses to produce vegetables or cannabis, fewer exports to the US [5], and changing consumer preferences [11] [53]. Sales of greenhouse flowers and plants declined by about 2% between 2016 and 2017 in Ontario [1].

4.2 Base Year (2018) Results

Exhibit 71 shows the proportion of base year floor area by region for the flowers sub-sector. In 2018 there was 39.6 million ft^2 (910 acres) of flower greenhouses, with the Niagara region having the highest concentration. The average flower greenhouse in Niagara and Haldimand-Haldimand–Norfolk is 2 times larger than the average in the rest of the province.

Exhibit 71 – 2018: Flowers Sub-Sector Area by Region (%)

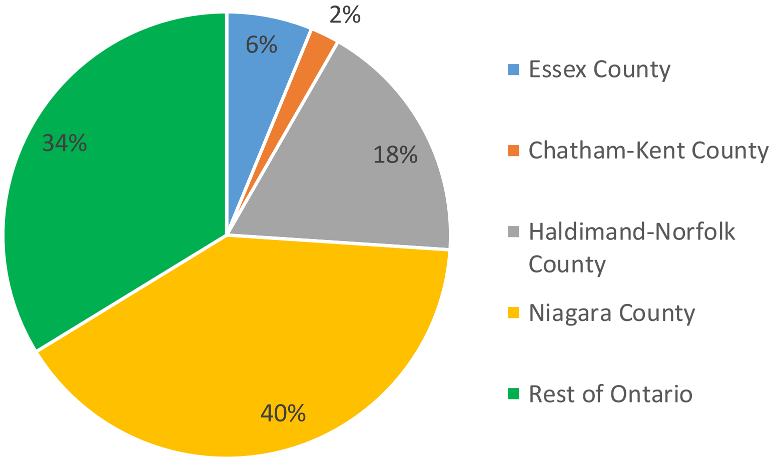


Exhibit 72 shows the number of lit and unlit facilities by region for the flowers sub-sector in the base year. 75% of the greenhouse area in 2018 had grow lighting.

Exhibit 72 – 2018: Flowers Sub-Sector Number of Greenhouses by Region and Lighting Status

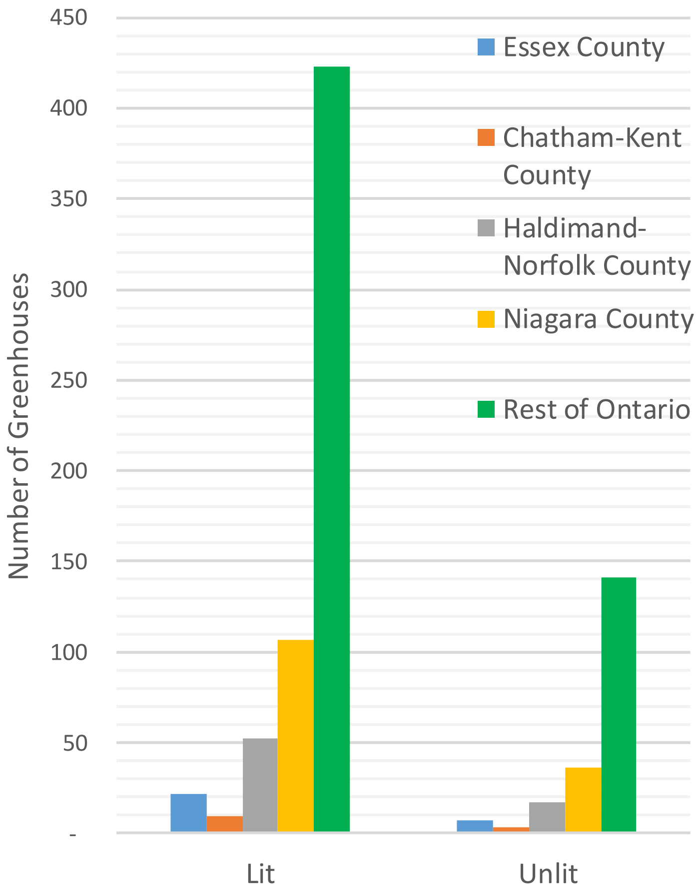


Exhibit 73 shows annual energy consumption (unit energy consumption or UEC) by end use for a typical lit flowers greenhouse and unlit flowers greenhouse. A lit flowers greenhouse consumes four times as much electricity as an unlit vegetable greenhouse (25.52 ekWh/ft^2 vs. 6.19 eKWh/ft^2) with essentially all the additional electricity used for lighting.

Exhibit 73 – UEC Values by End Use and Lighting Status

	UEC Value (ekWh/ft²)	
End Use	**Lit Flower Greenhouse**	**Unlit Flower Greenhouse**
Heating	34.21	34.21
Lighting	19.15	0.15
Pumping	1.60	1.60
Other	4.77	4.77

Exhibit 74 shows base year energy consumption by region and fuel for the flowers sub-sector. It is estimated 0.15 MW of behind the meter tri-generation is installed in the Niagara region (the only region with tri-generation in the base year).

Exhibit 74 – 2018: Flowers Sub-Sector Energy Consumption by Region and Fuel

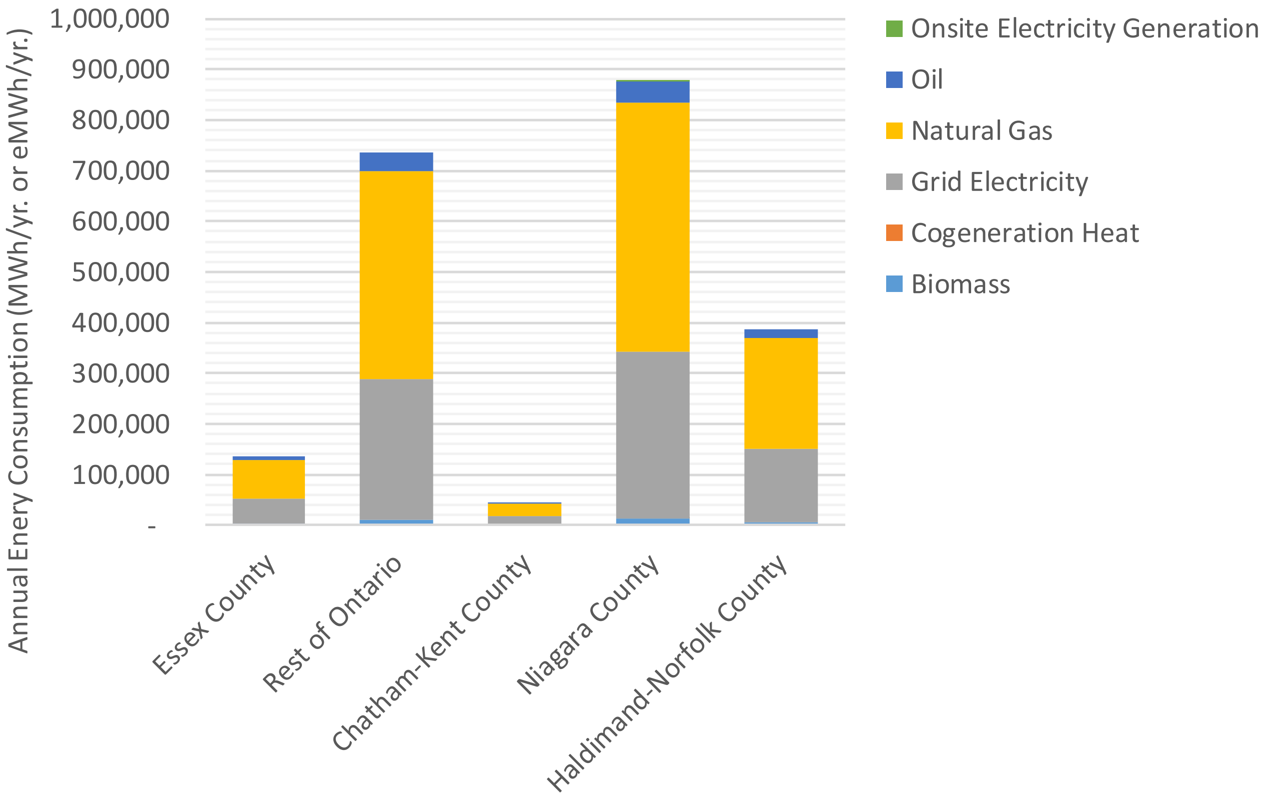
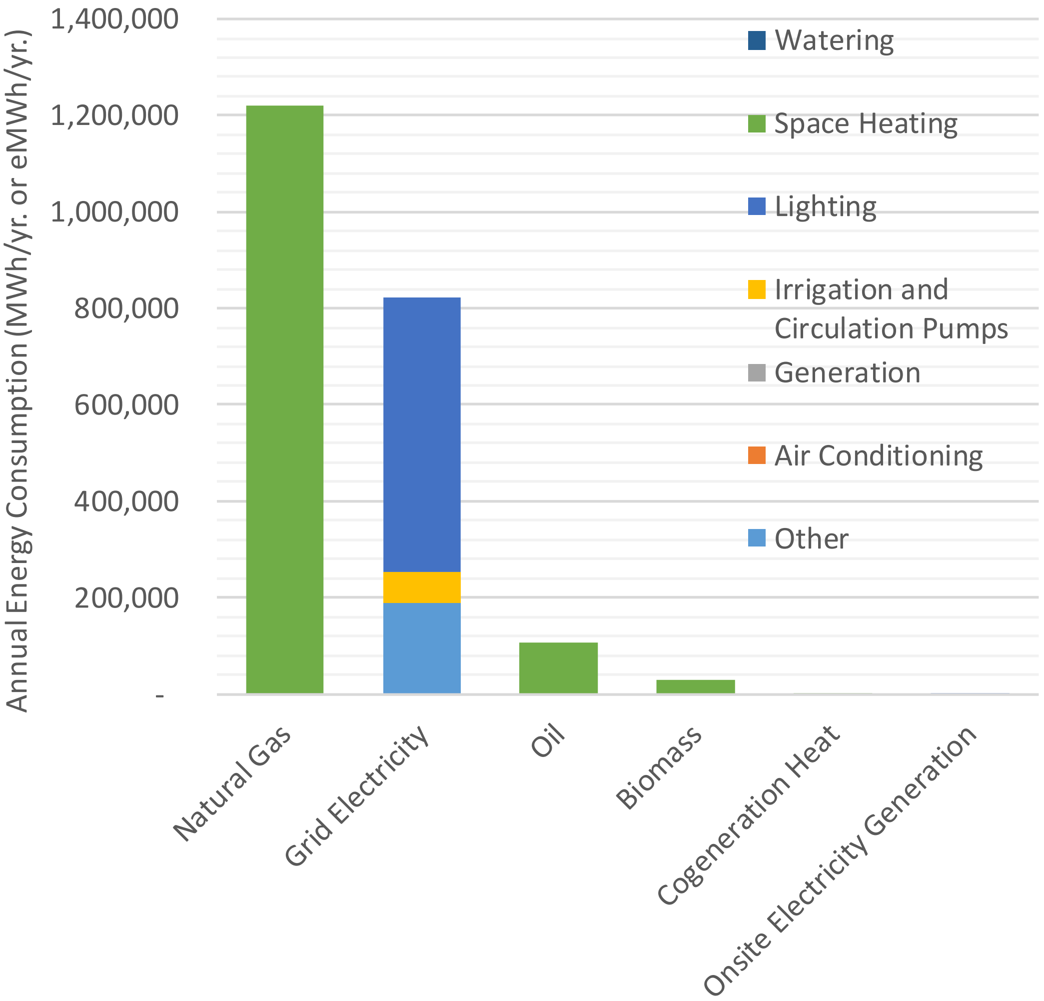


Exhibit 75 shows the base year energy consumption by end-use and fuel for the flowers sub-sector.

Exhibit 75 – 2018: Flowers Energy Consumption by End Use and Fuel



4.2.1 Load Profiles

Load profiles for flower greenhouses were developed by the study team using the following data sources:

- Hourly electricity consumption data for two flower greenhouses for 2018 provided by Flowers Canada Ontario.
- Hourly gas consumption data for 125 greenhouse customers for 2017 provided by Enbridge Gas.
- We used an equation to subtract a lit load shape from an unlit load shape to estimate the shape of lighting. This was done using the data from Hydro One for the unlit shape and the data from Flowers Canada for the lit shape[5].

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[5] The study team recommends sub-metering to capture the end-use load shape, particularly for lighting, to make the load profile analysis more accurate in the future.

The sample size to develop the load profiles for flower greenhouses was small and therefore these profiles may not be representative of the sub-sector in general.

Lit Flower Greenhouse Load Profiles

Exhibit 76 shows the load profile of electricity consumption by month as a percent of annual total for a lit flower greenhouse. March has the most consumption and June the least.

Exhibit 76 – Electricity Monthly Load Profile (% of annual) for Lit Flower Greenhouse

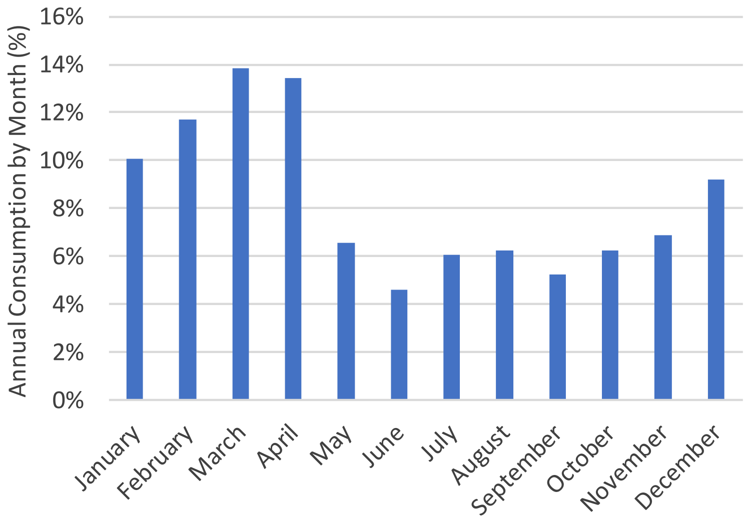


Exhibit 77 displays the load profile of hourly electricity consumption as a percentage of the daily total for a lit flower greenhouse.

Exhibit 77 – Electricity Hourly (% of day) Load Profile for Lit Flower Greenhouse

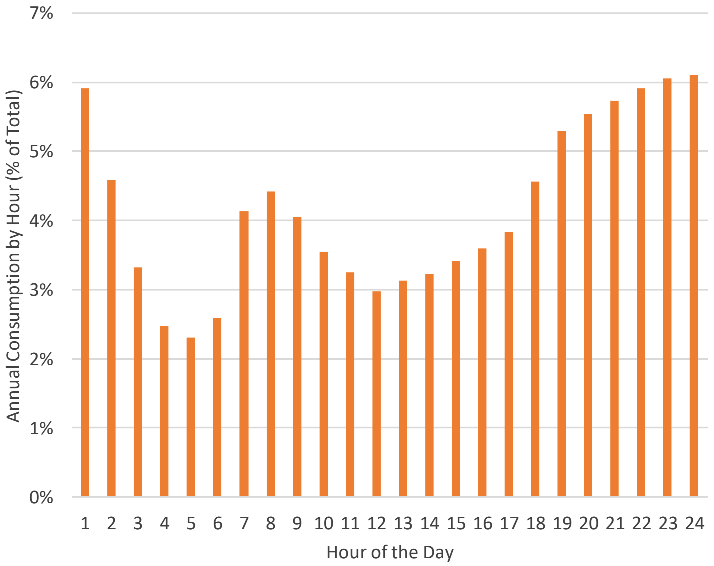
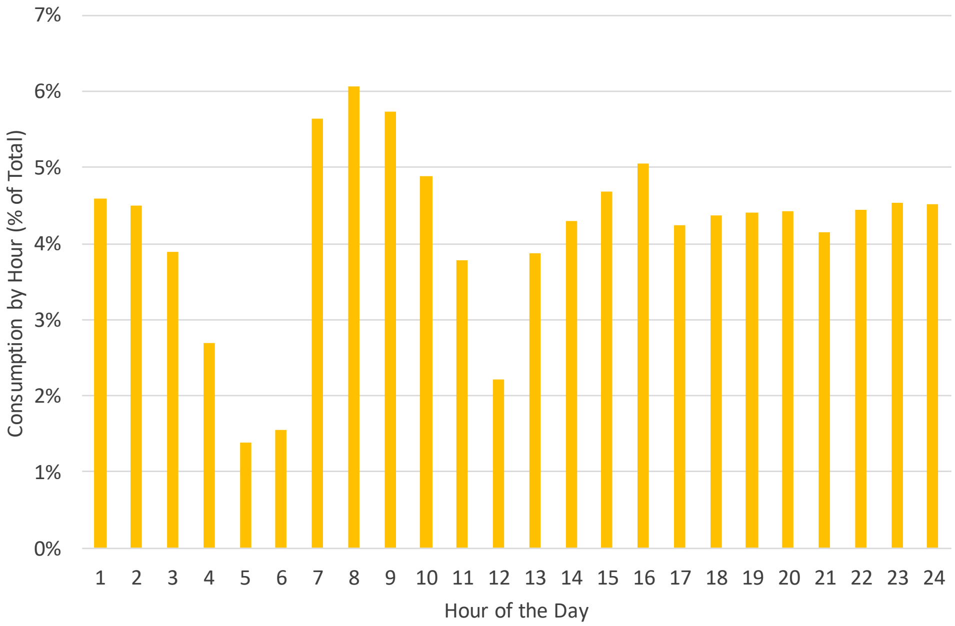


Exhibit 78 shows the hourly lighting end-use load profile as a percentage of daily consumption for a lit flower greenhouse.

Exhibit 78 – Lighting Hourly (% of day) Load Profile for Lit Flower Greenhouse



Unlit Flower Greenhouse Load Profiles

Exhibit 79 shows the load profile of electricity consumption by month as a percent of annual total for an unlit flower greenhouse. This load profile is flatter than the same load profile for a lit flower greenhouse.

Exhibit 79 – Electricity Monthly Load Profile (% of annual) for Unlit Flower Greenhouse

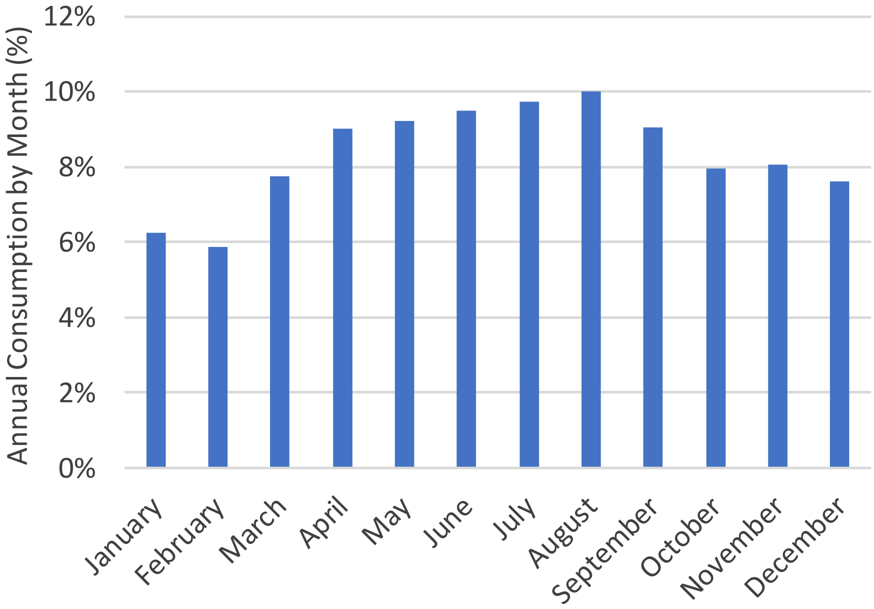
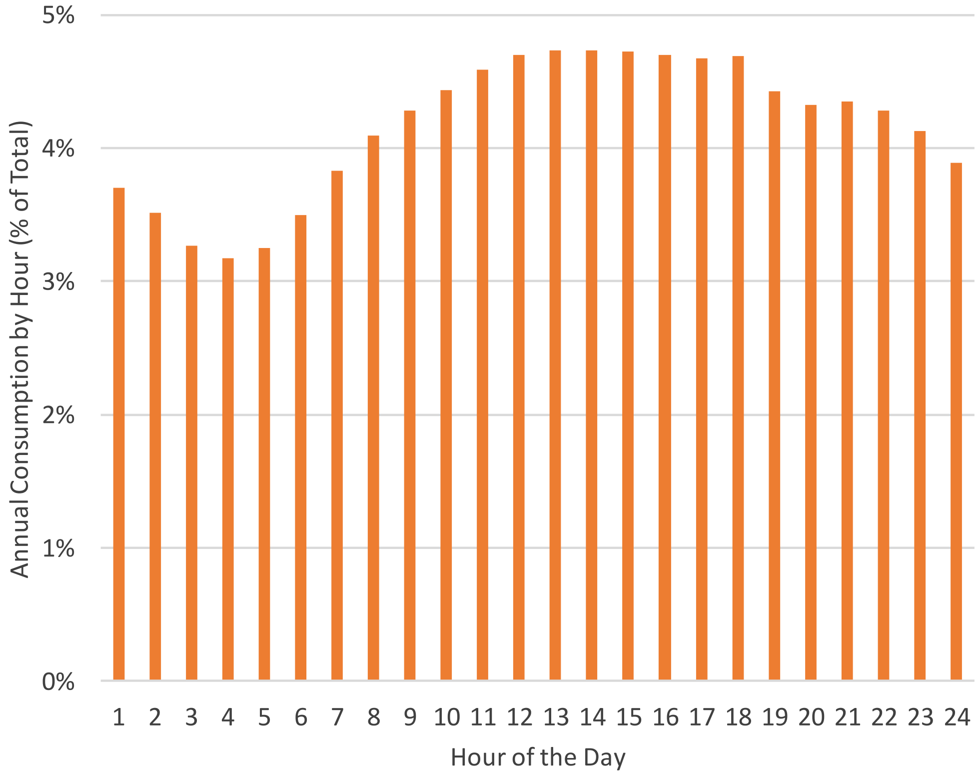


Exhibit 80 displays the load profile of hourly electricity consumption as a percentage of the daily total for an unlit flower greenhouse. This load profile is flatter relative to the same load profile for a lit flower greenhouse.

Exhibit 80 – Electricity Hourly (% of day) Load Profile for Unlit Flower Greenhouse



4.3 Reference Case (2019-2024) Forecast Results

Exhibit 81 shows the reference case floor area forecast by region for the flowers sub-sector. The flowers sector is forecasted to grow by increasing the size of existing facilities by 1% per year in Niagara region and 0.5% per year for all other regions.

Exhibit 81 – Flowers Sub-Sector: Forecasted Total Area (sq. ft.) by Region

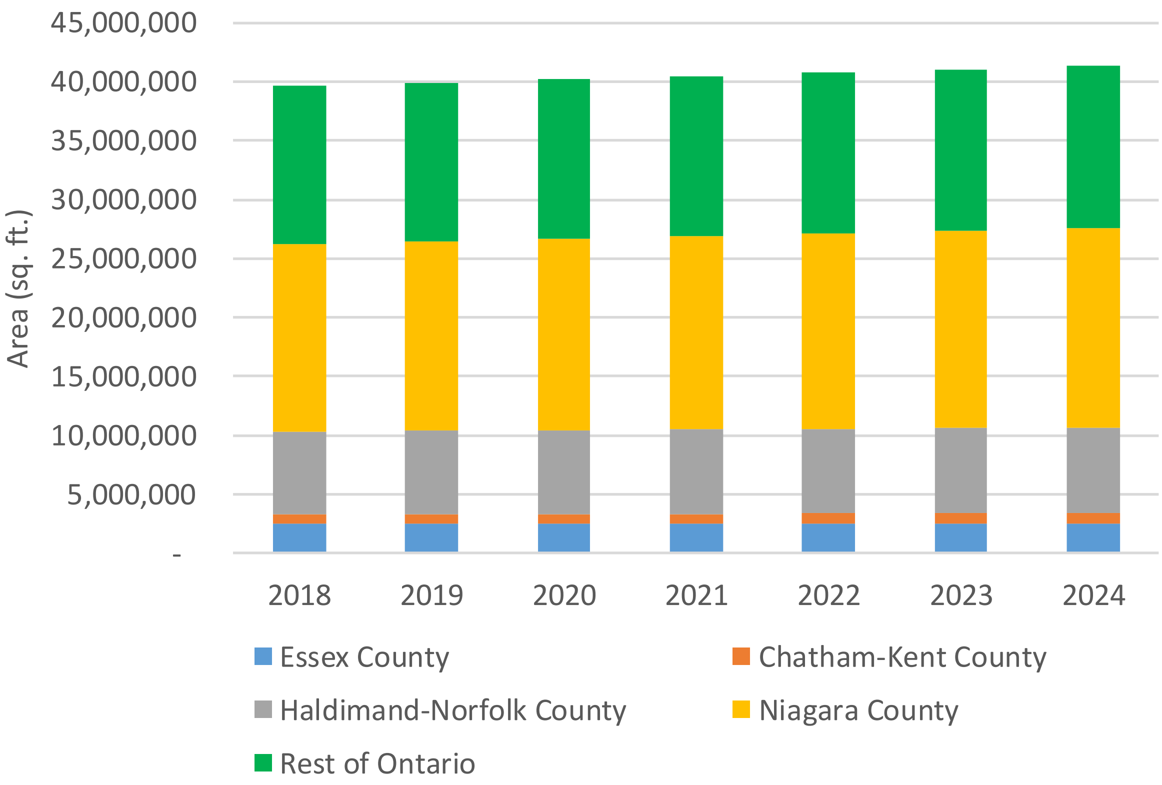


Exhibit 82 shows the reference case forecast for the number of lit and unlit facilities by region in the flowers sub-sector. The lit portion is expected to remain the same at 75% over the next six years.

Exhibit 82 – Flowers Sub-Sector: Forecasted Number of Greenhouses by Region and Lighting Status

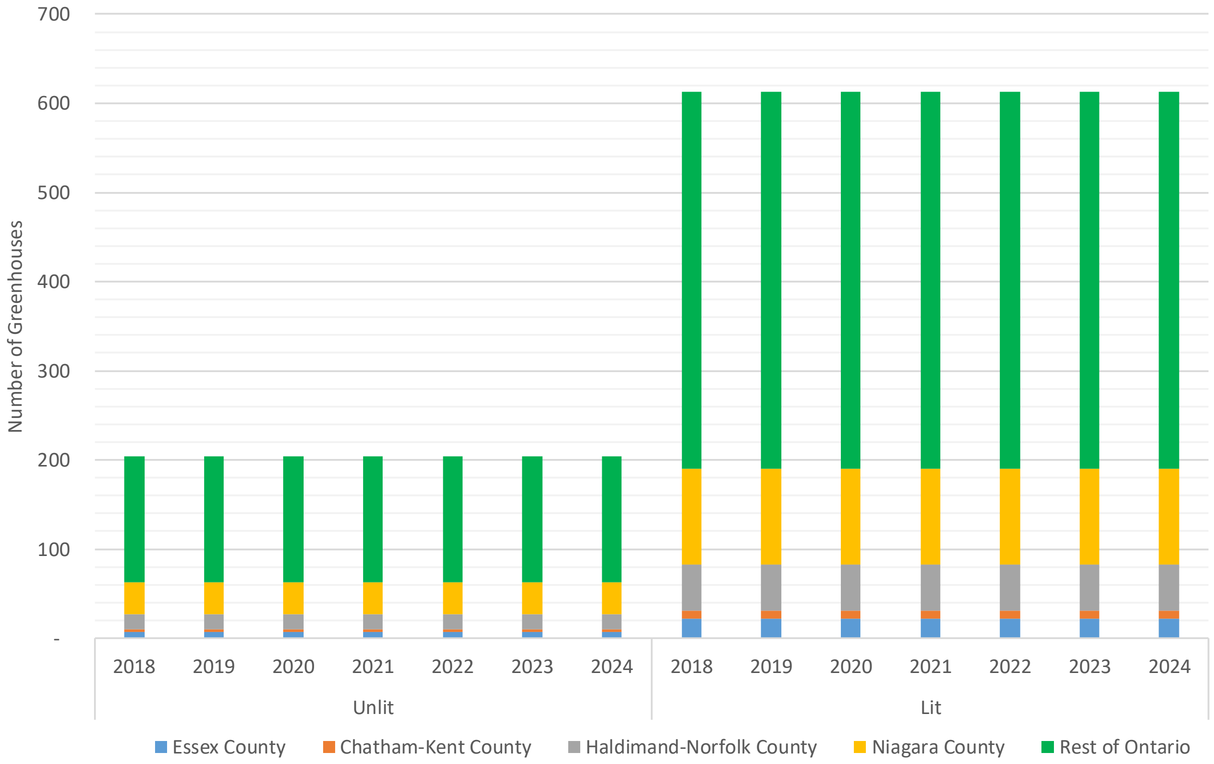


Exhibit 83 shows the reference case annual energy consumption forecast by fuel for the flowers sub-sector. Total behind the meter tri-generation installed by end of reference case (2024) is expected to be 11 MW.

Exhibit 83 – Flowers Sub-Sector: Forecasted Annual Consumption by Fuel

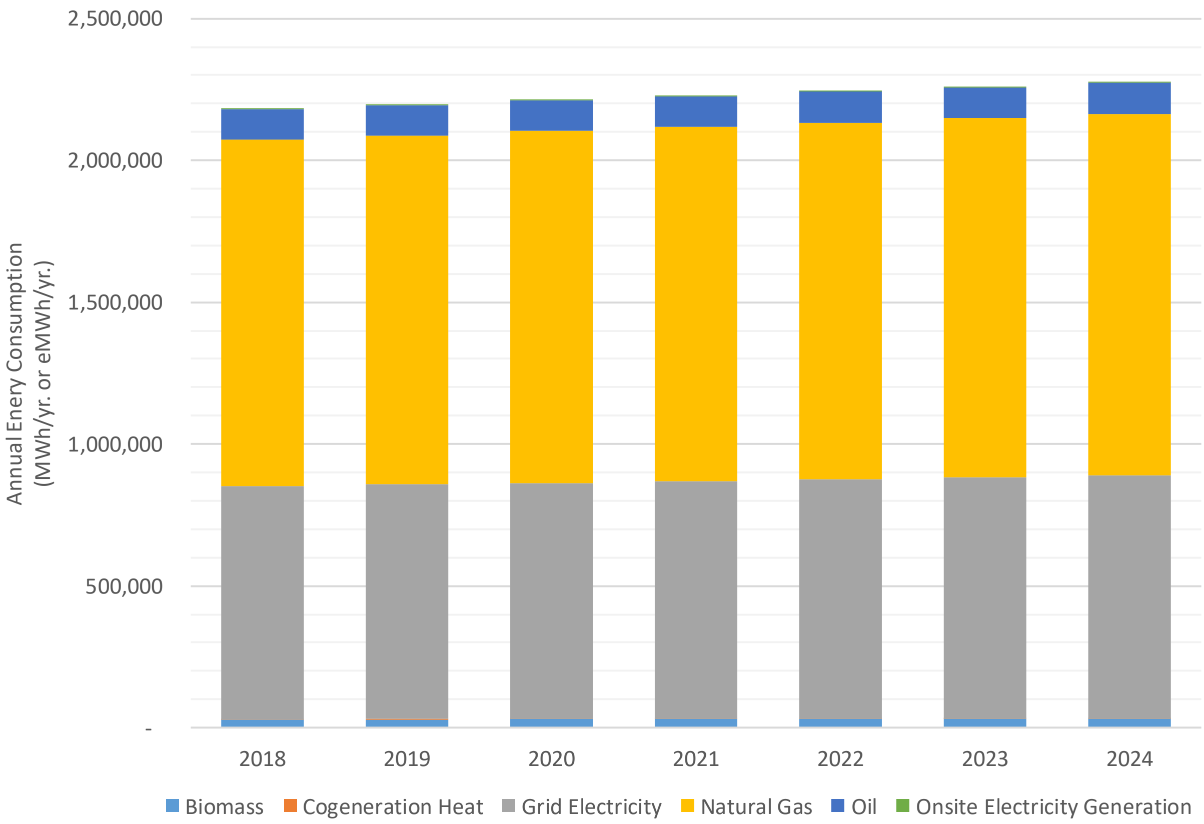


Exhibit 84 shows the reference case energy consumption forecast by region for the flowers sub-sector.

Exhibit 84 – Flowers Sub-Sector: Forecasted Energy Consumption by Region

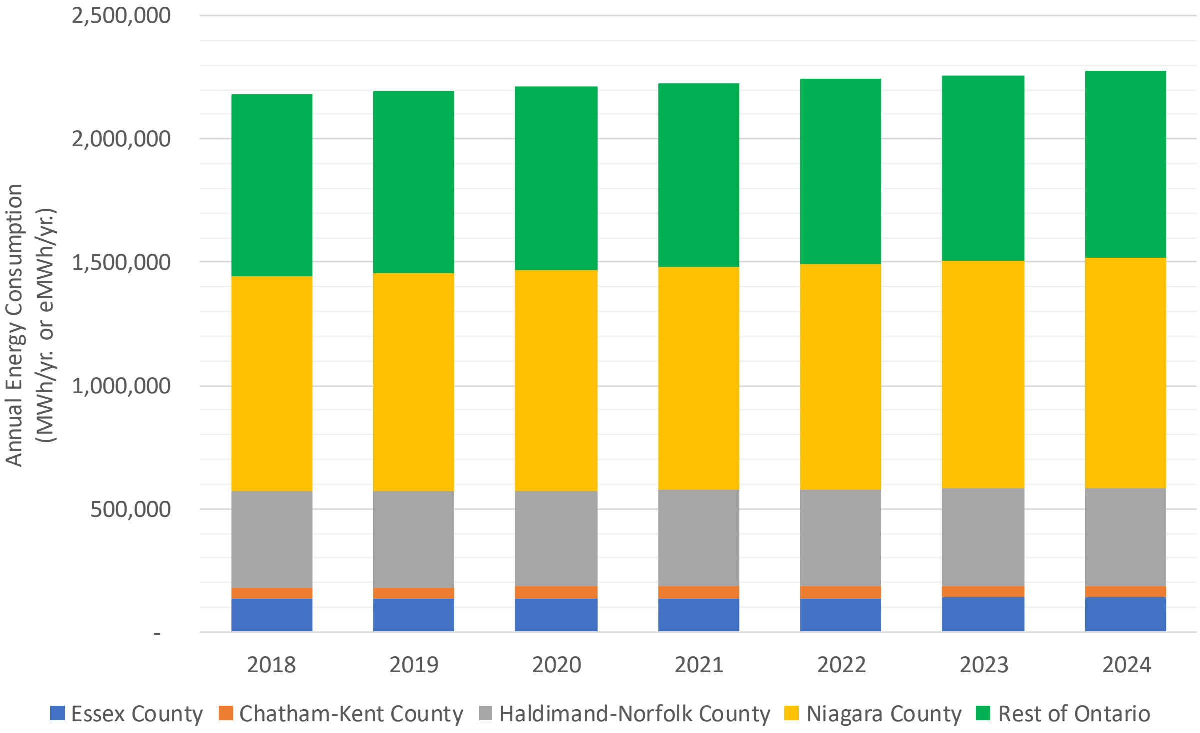
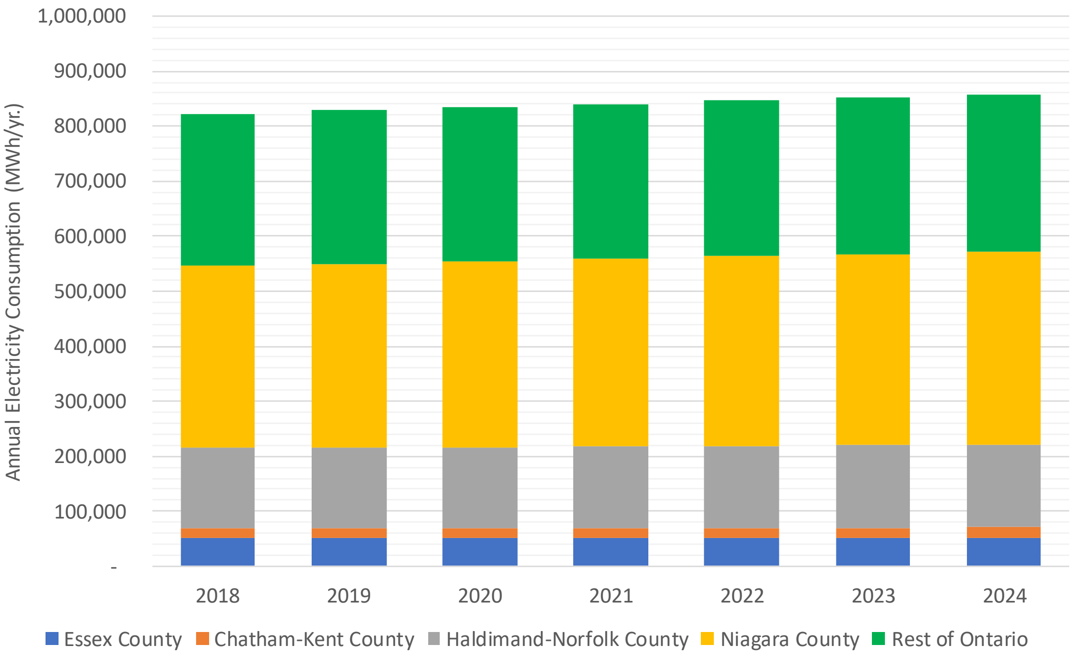


Exhibit 85 presents the forecast in electricity consumption (MWh) for the flowers sub-sector by region.

Exhibit 85 – Flowers Sub-sector: Forecasted Electricity Consumption by Region



4.4 Energy Saving Opportunities

Opportunity for LED Grow Lights

[Please see Section 11.1 for a more fulsome discussion of LED Grow Lights and the sensitivity analysis that was performed for this study.]

LED grow lights offer electricity savings potential when they replace HPS lights. Despite the energy saving potential, LED grow lights currently have a small saturation in the Ontario covered agriculture sector. Growers are hesitant to adopt LEDs due to:

- Uncertainty over savings – savings claims being made by lighting suppliers have been at odds with published research [48] [49]
- Higher upfront costs -- the cost of agricultural LED products still varies widely and is expected to come down in the coming years as the technology continues to mature [48].
- Risk of impacting yield -- there is a learning curve required for growers to switch from HPS to LED, creating a barrier that growers tend not be willing to accept given the relative immaturity of the technology [50]

To illustrate the potential savings if/when LEDs are more widely adopted by the industry, two LED measure scenarios were modelled relative to the reference case:

a) "LED Grow Lights A" -- 55% savings at a cost point of $1.25/installed LED watt (a mid-range cost value) [48]
b) "LED Grow Lights B" -- 35% savings at a cost point of $0.75/installed LED watt (the lowest cost point reported in Ontario to date) [48]

The **technical energy savings potential**[6] results for the flowers sub-sector are presented in Exhibit 86.

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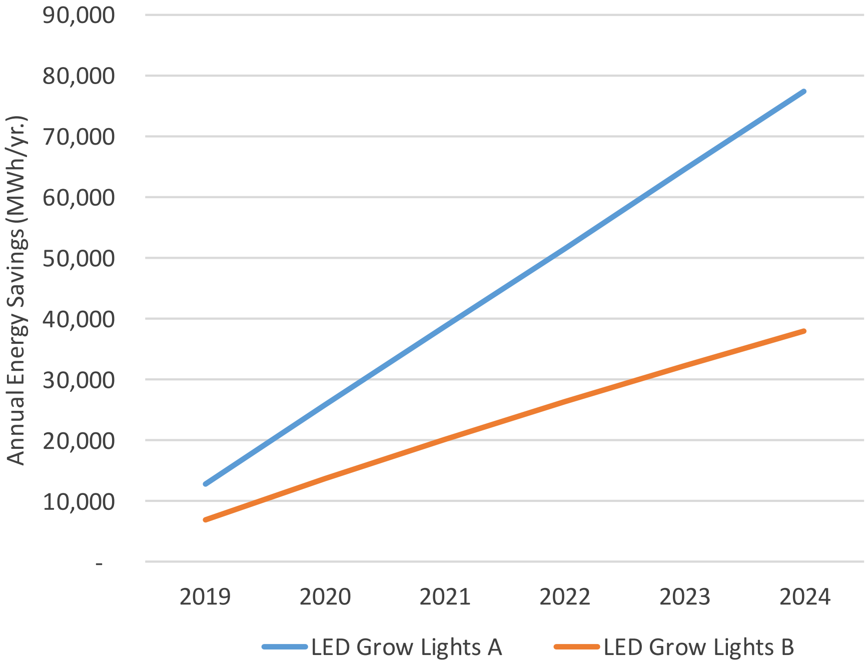
[6] Technical Potential is the theoretical maximum amount of energy use that could be displaced by the measures, only considering technical constraints. Non-technical constraints such as cost-effectiveness and the willingness of end-users to adopt the efficiency measures are not considered.

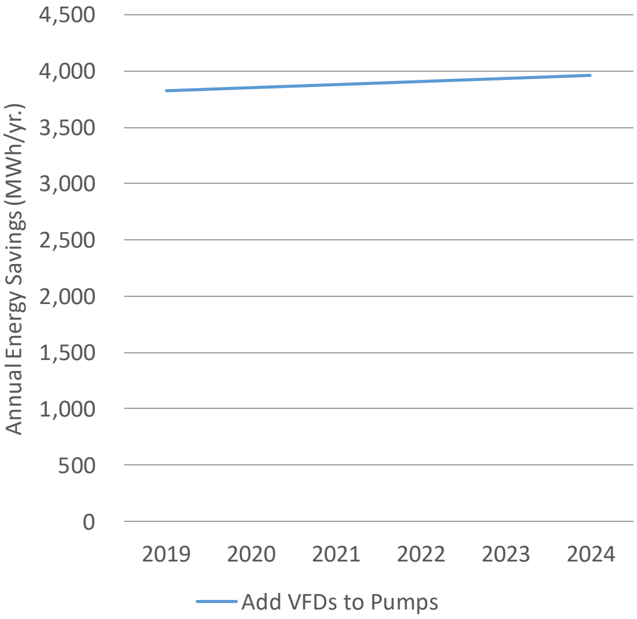
Exhibit 86 – Flowers Sub-Sector: Technical Energy Savings Potential from LED Measure Scenarios



Non-Lighting Electricity Savings Potential

Exhibit 87 shows the economic savings potential for electricity non-lighting measures for the flower greenhouse sub-sector. Adding VFDs to pumps was the only measure that passed the economic screen for this sub-sector.

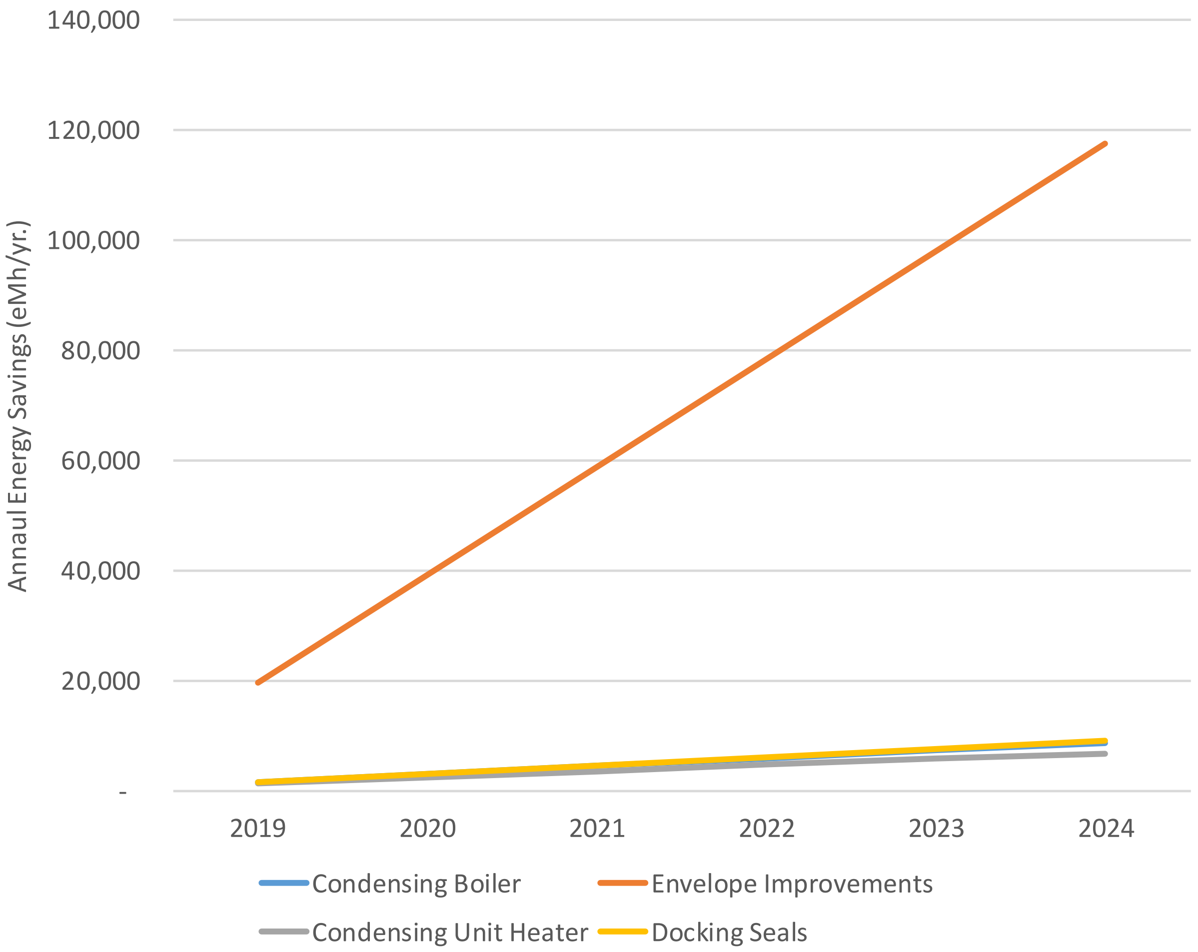
Exhibit 87 – Flower Sub-Sector: Electricity Savings Potential by Measure



Natural Gas Savings Potential

Exhibit 88 displays the economic savings potential for natural gas for the flower greenhouse sub-sector by measure. Similar to vegetable greenhouses, envelope improvements offer the most economic savings, followed by condensing boiler, condensing unit heater and docking seals.

Exhibit 88 – Flowers Sub-Sector: Natural Gas Savings Potential by Measure



Cannabis Sector

5 Cannabis Sector

5.1 Cannabis in Canada

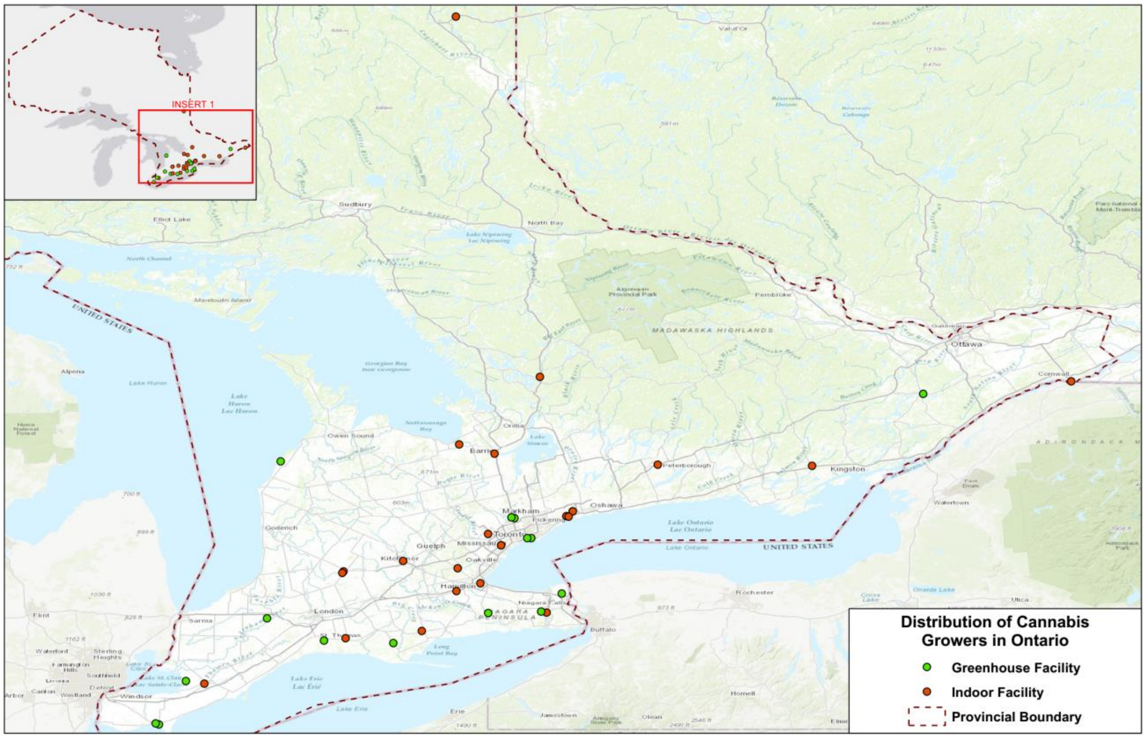
Producers licensed by Health Canada have been able to grow marijuana for medicinal purposes since 2014 in Canada. Cannabis was federally legalized for recreational use in the fall of 2018, thereby enabling a new market of legal cannabis production across Canada. Currently, dried and fresh cannabis, cannabis oils, and cannabis seeds are legal for purchase. Edibles, topicals and extract products are set to be legally available in the fall of 2019 [55]. The edible market is expected to be significant, with estimates that six out of ten cannabis users will choose edible products once they are legal [55, p. 18].

Niagara College now offers a Commercial Cannabis Production program through their school of Environment and Horticulture. The one-year program provides "training in the biology and cultural practices of cannabis production including plant nutrition, environment, lighting, climate control, pest control and cultivar selection." [54]

5.2 Cannabis in Ontario

Sales of recreational cannabis in the province are projected to be $930 million in 2019 and go up to $2.38 billion in 2021 [56]. Currently, the Ontario cannabis market supports about 5,700 jobs, of which 58% are in the agricultural sector [55, p. 15]. Although supply was unable to meet demand when the online legal market was launched, the sector is expected to be able to meet demand by 2020 [6] and Ontario is projected to be the largest cannabis market in Canada [6].

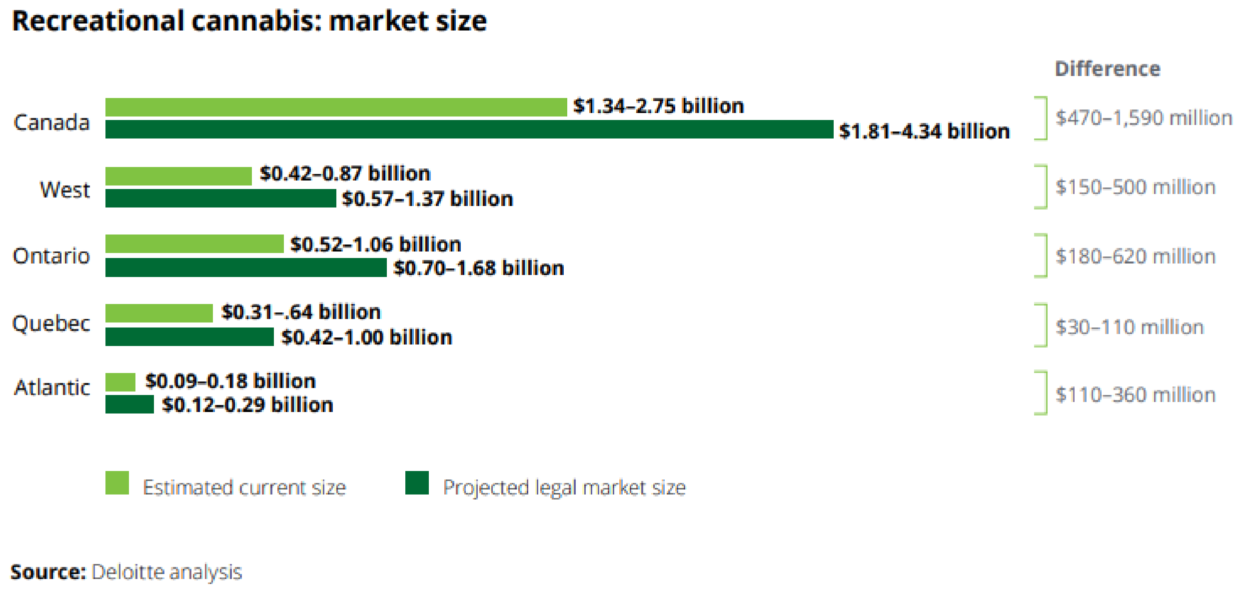
Exhibit 89 – Map of Cannabis Facilities (Greenhouse and Indoor) in Ontario [57]



Field production (i.e., cannabis grown outdoors) is currently rare in Ontario and therefore excluded from this study. However, field operations are expected to develop in the province.

Outdoor cultivation of cannabis is currently limited in Ontario but is expected to increase in the province as it is now legal, and licenses have been distributed. Outdoor farming offers lower production costs to growers, however, presents greater risks from an uncontrolled environment. The cost of cannabis is projected to fall in Ontario as the market matures and outdoor operations are expected to increase to provide a lower cost per gram of production [58].

Exhibit 90 – Canada's Recreational Cannabis Market Sales [59, p. 5]


Recreational cannabis: market size

Source: Deloitte analysis

The Atmospheric Fund (TAF) created the Low Carbon Cannabis Canada initiative in April of 2018. The initiative engages provincial governments across Canada, growers and former police chiefs to help the industry lower GHG emissions from cannabis cultivation [60].

5.2.1 Base Year (2018) Results

Exhibit 91 displays the breakdown of area (square feet) of the cannabis sector between greenhouse and indoor facilities. The majority of area for cannabis production in 2018 is in greenhouses (65%) compared to indoor facilities (35%).

Exhibit 91 – 2018: Cannabis Area (sq. ft.) by Sub-sector

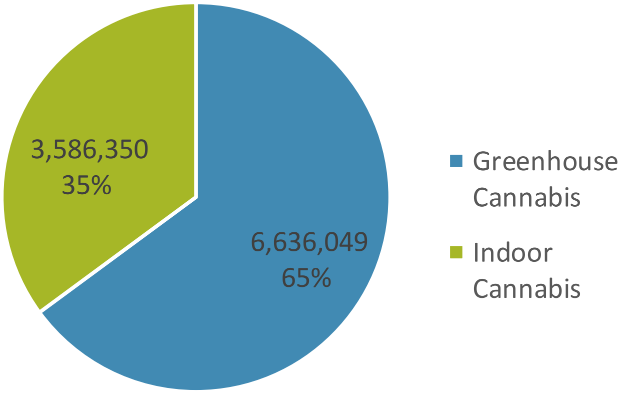


Exhibit 92 shows that in 2018, there are significantly more greenhouses producing cannabis than indoor facilities.

Exhibit 92 – 2018: Number of Cannabis Facilities by Sub-sector

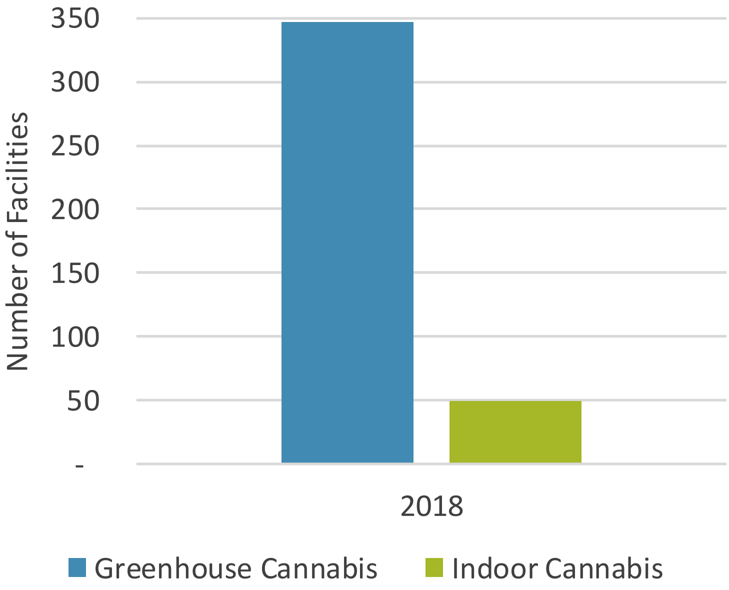


Exhibit 93 shows the area of the cannabis sector (square feet) by region, for greenhouse cannabis and indoor cannabis. Aside from the Rest of Ontario, most of the greenhouse cannabis are in Chatham-Kent and Essex regions, while the majority of area of indoor cannabis is in Niagara County.

Exhibit 93 – 2018: Cannabis Area (sq. ft.) by Region

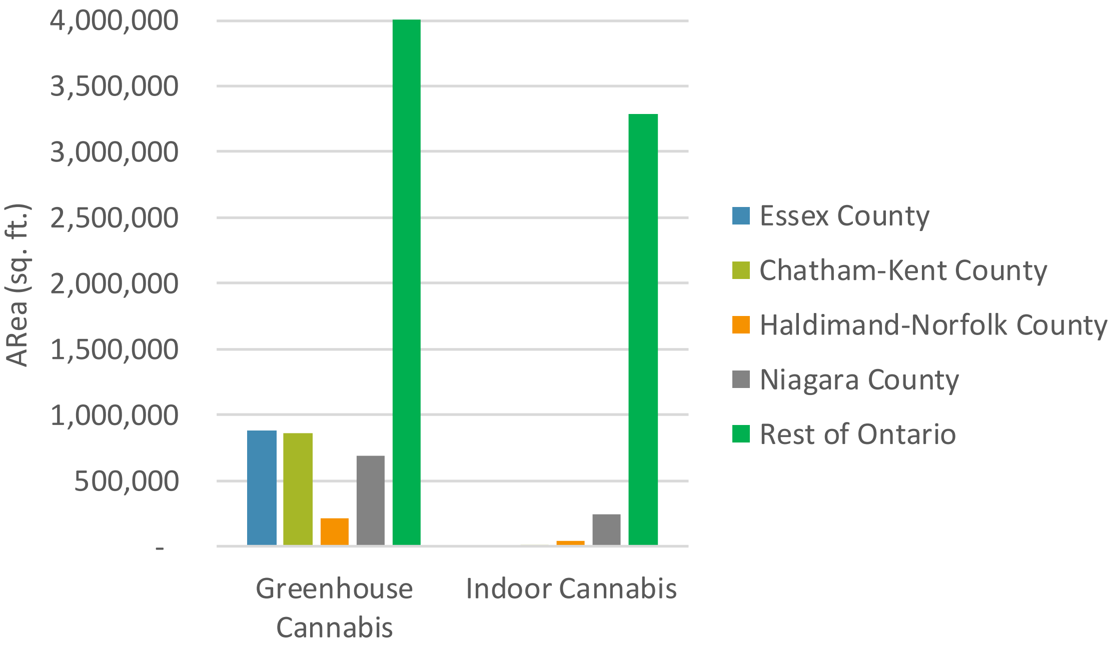
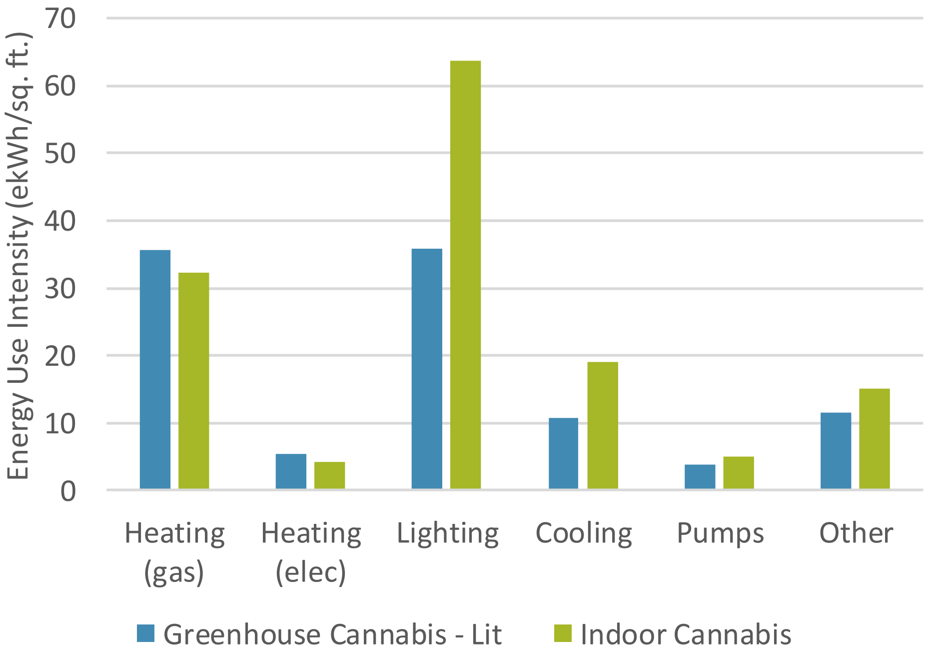


Exhibit 94 presents the end use breakdown estimated for the base year for the cannabis sector. Lighting consumes the most energy relative to other end uses in indoor cannabis facilities. Heating (gas) is the most energy intensive end use compared to other end uses in greenhouse cannabis facilities.

Exhibit 94 – 2018: End Use Breakdown by Cannabis Sub-sector



5.2.2 Reference Case (2019-2024) Forecast

Exhibit 95 shows the projected increase in total area (square footage) of the cannabis sector during the reference case. The total area for the cannabis sector is projected to increase by almost 50% during the forecast period. In 2018 approximately 10% of the cannabis facility area was planted and growing product; the portion of facility space under production increases to 100% by 2023.

Exhibit 95 – 2018-2024: Total Area (sq. ft.) and % Under Production of the Cannabis Sector

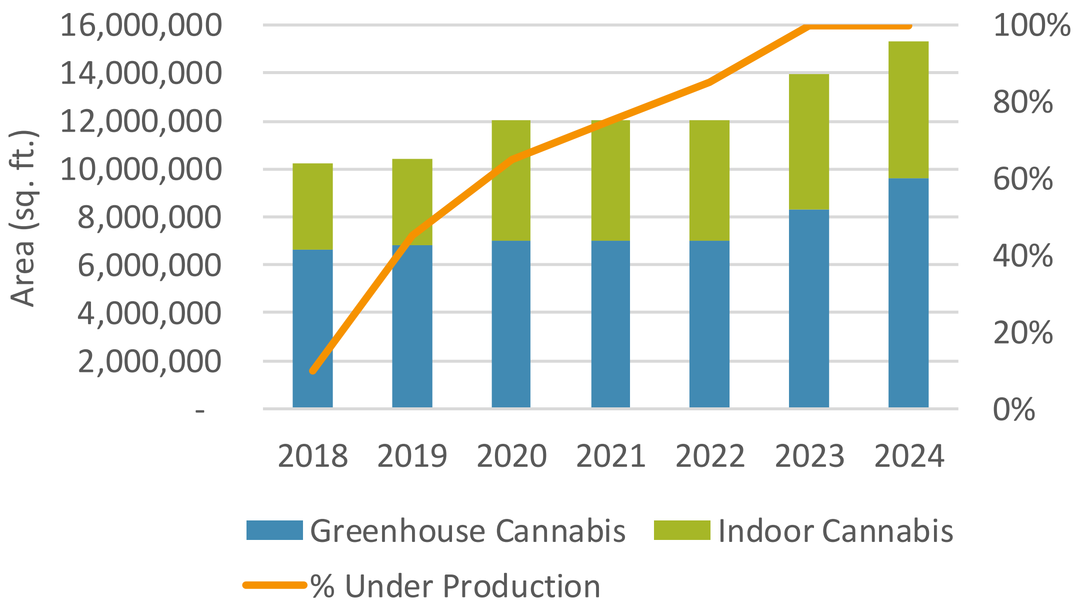


Exhibit 96 shows the projected increase in total area (square footage) of the cannabis sector by region. The Chatham-Kent region has the highest relative growth.

Exhibit 96 – 2018-2024: Total Area (sq. ft.) of the Cannabis Sector by Region

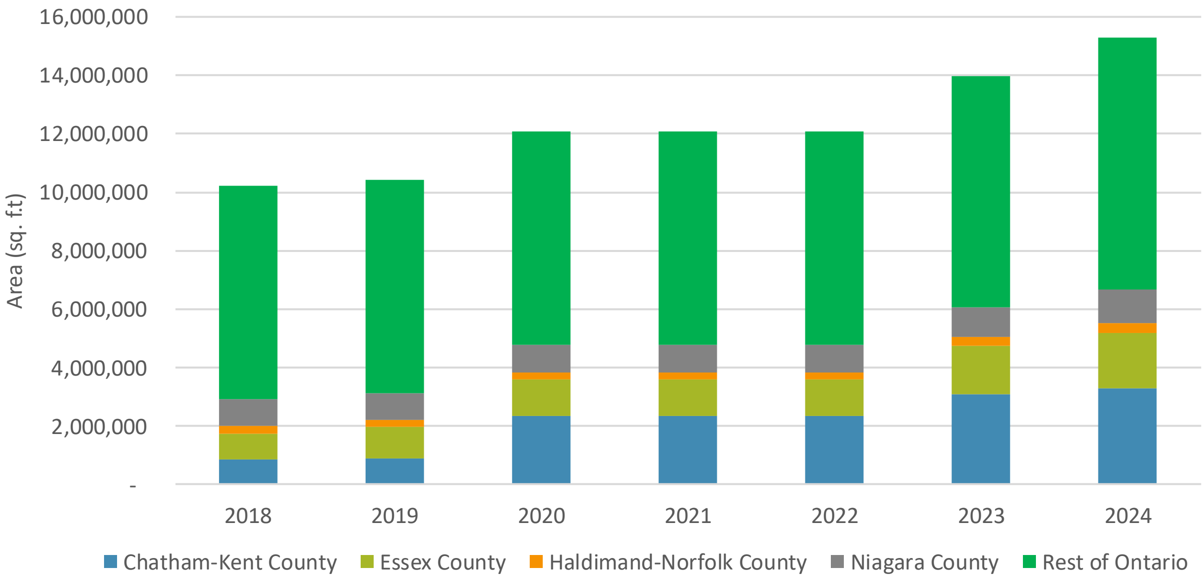


Exhibit 97 shows the projected increase in the number of facilities that produce cannabis. The number of greenhouses producing cannabis is expecting to increase during the forecast period. There is only one projected new indoor cannabis facility.

Exhibit 97 – 2018-2024: Number of Cannabis Facilities by Sub-sector

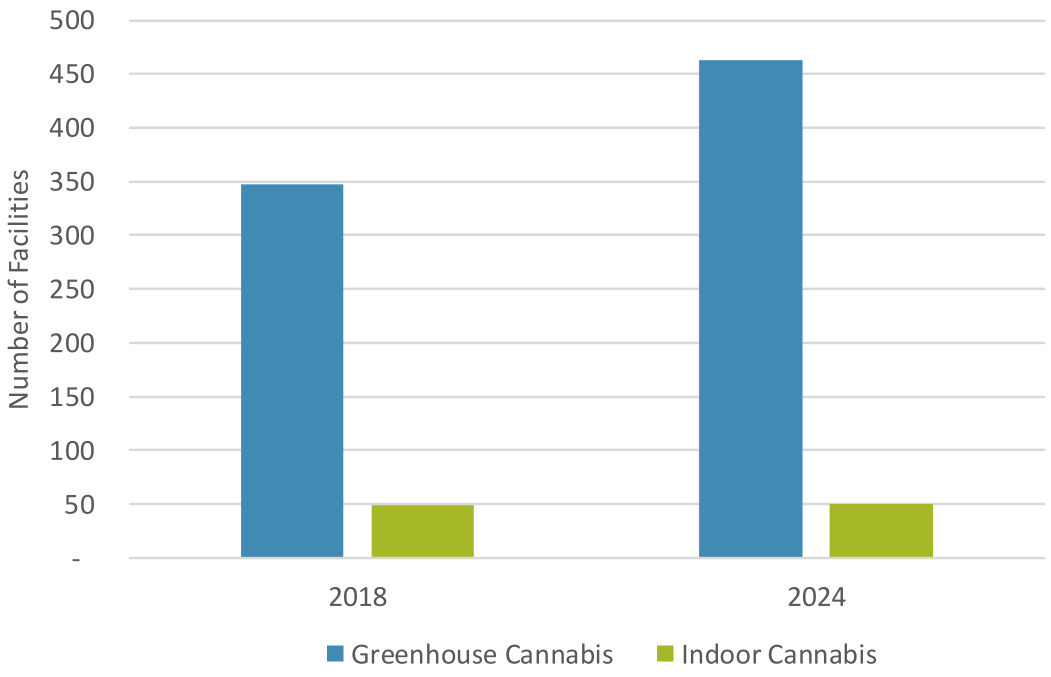


Exhibit 98 displays the projected annual energy consumption (eMWh/yr.) for the cannabis sector. This exhibit includes energy consumption from all fuels but excludes water consumption.

Exhibit 98 – 2019-2024: Annual Energy Consumption (eMWh/yr.) for the Cannabis Sector

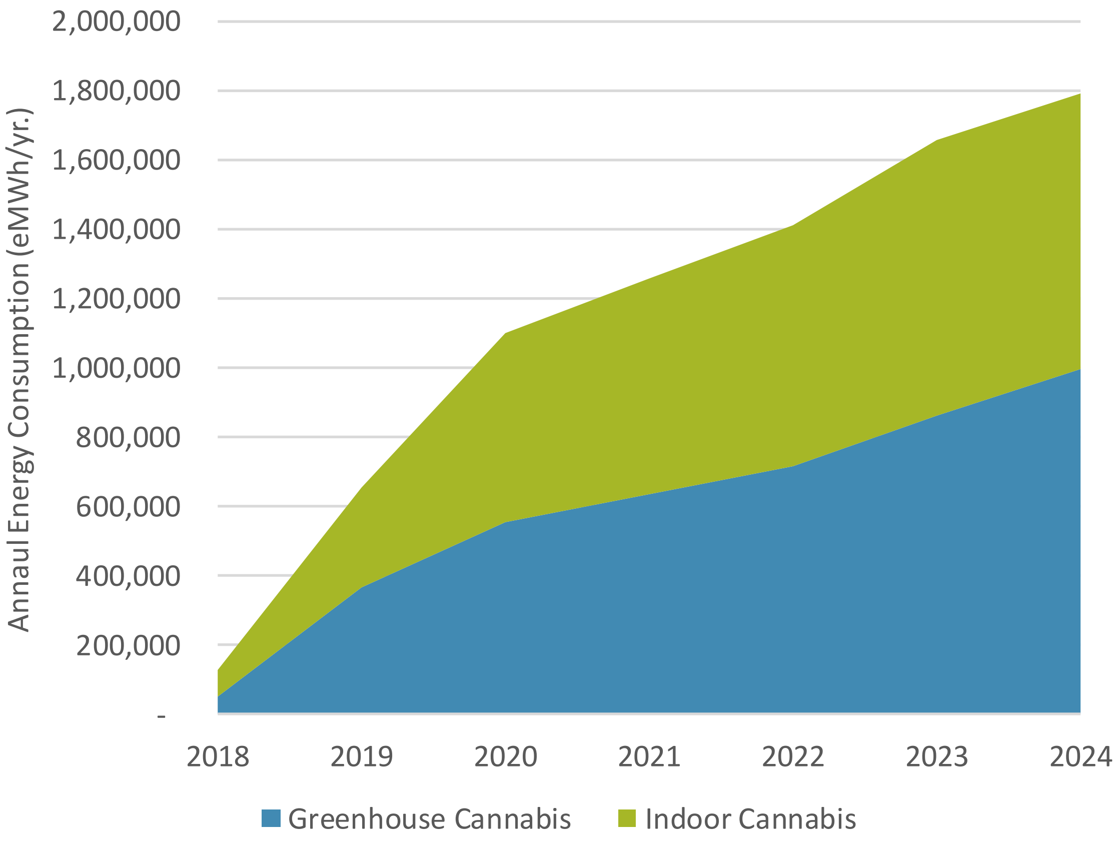
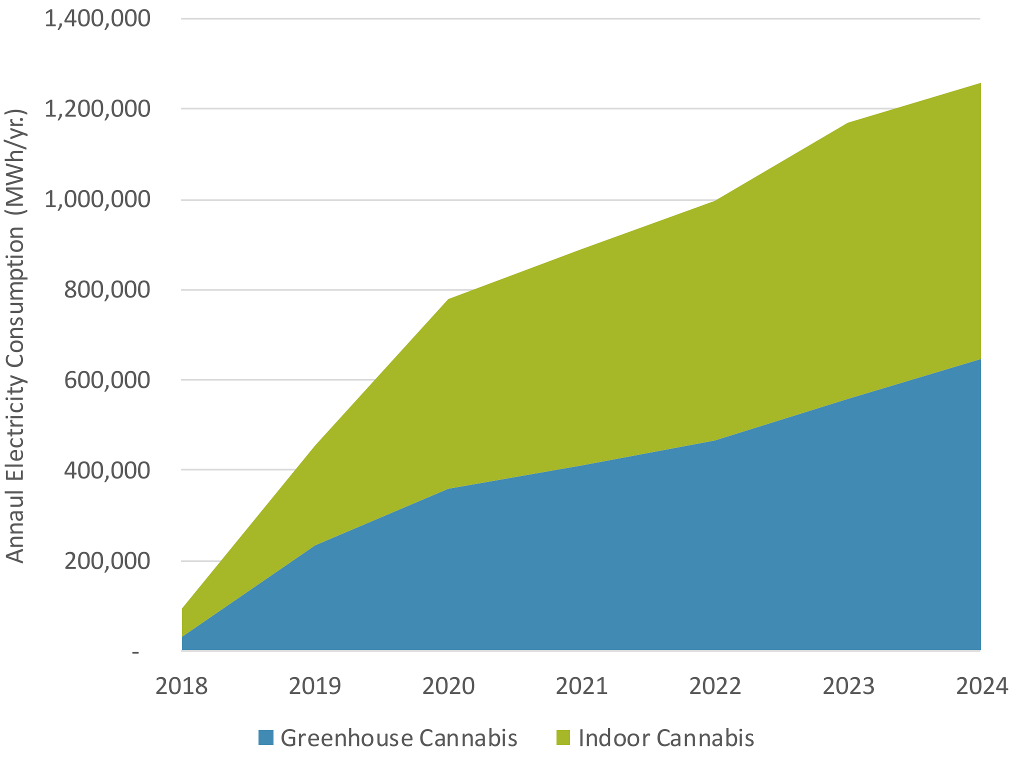


Exhibit 99 shows the forecasted electricity consumption for the cannabis sector. The Cannabis sub-sector (greenhouse and indoor facilities) consumed 93,000 MWh of electricity in 2018. In 2024, the sub-sector is expected to consume 1,258,000 MWh of electricity – a 1253% increase. This is large increase in consumption is because in 2018, only 10% of facility space was being used to produce cannabis. The remaining square footage is assumed to be dormant as other products cannot be grown due to risk of cross-contamination. The portion of facilities used for production is expected to ramp up quickly, reaching 100% by 2023.

Exhibit 99- 2019-2024: Annual Electricity Consumption (MWh/yr.) for the Cannabis Sector



Sub-sector focused results are presented in the following two sections of the report.

Sub-Sector Focus: Greenhouse Cannabis

6 Sub-Sector Focus: Greenhouse Cannabis

Cannabis production in Ontario is split into two sub-sectors: greenhouse and indoor. This section discusses cannabis grown in greenhouses and Section 7 focuses on cannabis grown indoors (i.e., warehouse).

6.1 Greenhouse Cannabis Sub-Sector Description

The legalization of recreational cannabis in the fall of 2018 enabled a new market of legal cannabis production across Canada, including in Ontario. For the legal medicinal market, cannabis was typically grown indoors. For the recreational market, many growers are choosing greenhouses instead. Cannabis grown in greenhouses consume 37% less electricity than cannabis grown indoors, offering producers cost savings. Greenhouses reduce the need for supplemental lighting and air conditioning – both of which are required for indoor operations and are costly. As the price of legal cannabis declines, producers will need to reduce operating costs to stay competitive [12]. Many greenhouse cannabis producers purchased existing greenhouses – often growing flowers - and converted them to their specific growing needs [50].

Ontario's capabilities and expertise in the greenhouse agriculture sector represent a unique opportunity for the Province to export skills and knowledge to the cannabis sector in other regions across Canada and the U.S.

6.2 Base Year (2018) Results

Exhibit 100 shows the proportion of base year floor area by region for the cannabis greenhouse sub-sector. In 2018 there was 6.6 million ft^2 (910 acres) of cannabis greenhouses, with the Rest of Ontario region having the highest concentration. The average cannabis greenhouse in Essex and Chatham-Kent is 4.5 times larger than the average in the rest of the province.

Exhibit 100 – 2018: Greenhouse Cannabis Area by Region (%)

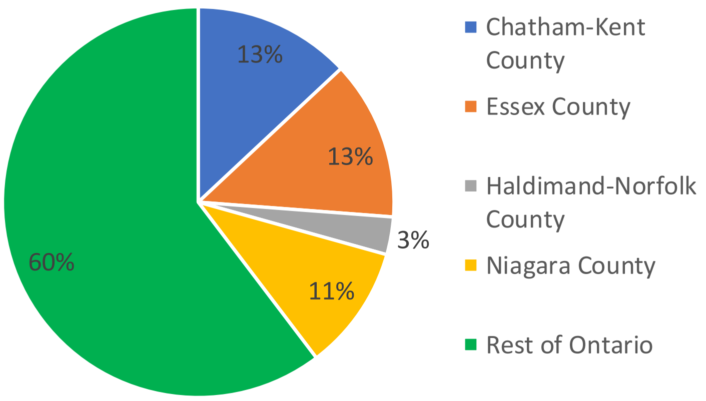


Exhibit 101 shows the number of lit and unlit facilities by region for the greenhouse cannabis sub-sector in the base year. 90% of the greenhouse area in 2018 had grow lighting.

Exhibit 101 – 2018: Greenhouse Cannabis - Number of Facilities by Region and Lighting Status

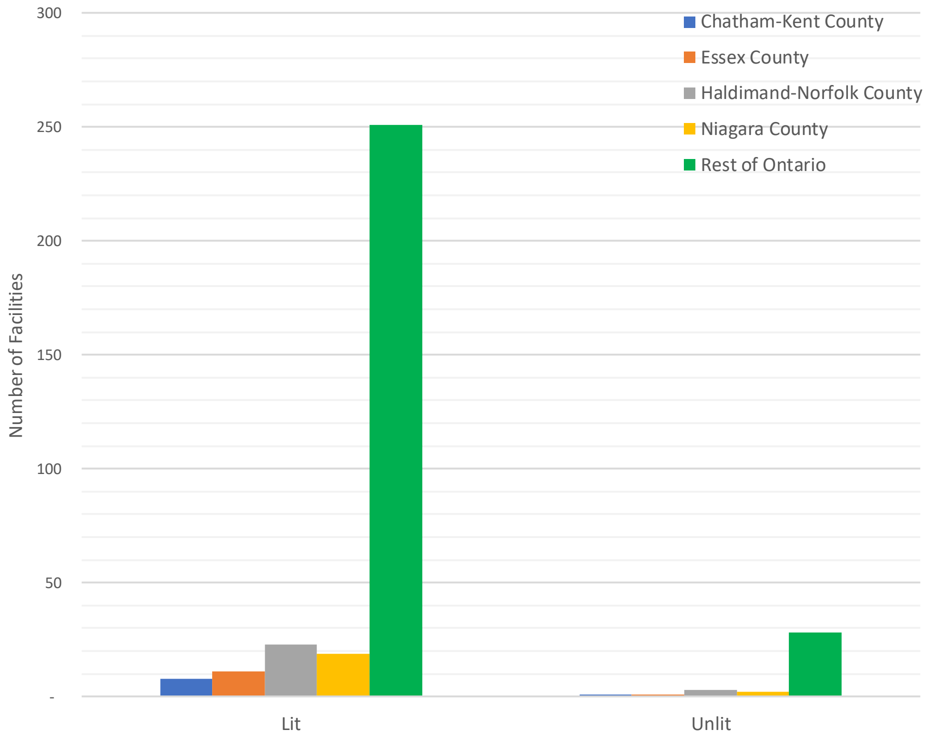


Exhibit 102 shows annual energy consumption (unit energy consumption or UEC) by end use for a typical greenhouse cannabis facility:

Exhibit 102 – UEC Values by End Use (ekWh/ft2)

End Use	*Greenhouse Cannabis - Lit*
Heating (gas)	35.71
Heating (elec)	5.36
Lighting	35.79
Cooling	10.74
Pumps	3.88
Other	11.60

The Cannabis PowerScore is an online energy benchmarking tool designed for cannabis producers. Cultivators enter data online via a short survey and are compared to the national average within the cultivation method. The free tool is offered by the Resource Innovation Institute [61].

Exhibit 103 shows base year energy consumption by region and fuel for the greenhouse cannabis sub-sector. It is estimated 6 MW of behind the meter tri-generation is installed in the Essex, Haldimand–Norfolk and the Rest of Ontario regions.

Exhibit 103 – 2018: Greenhouse Cannabis Energy Consumption by Region and Fuel

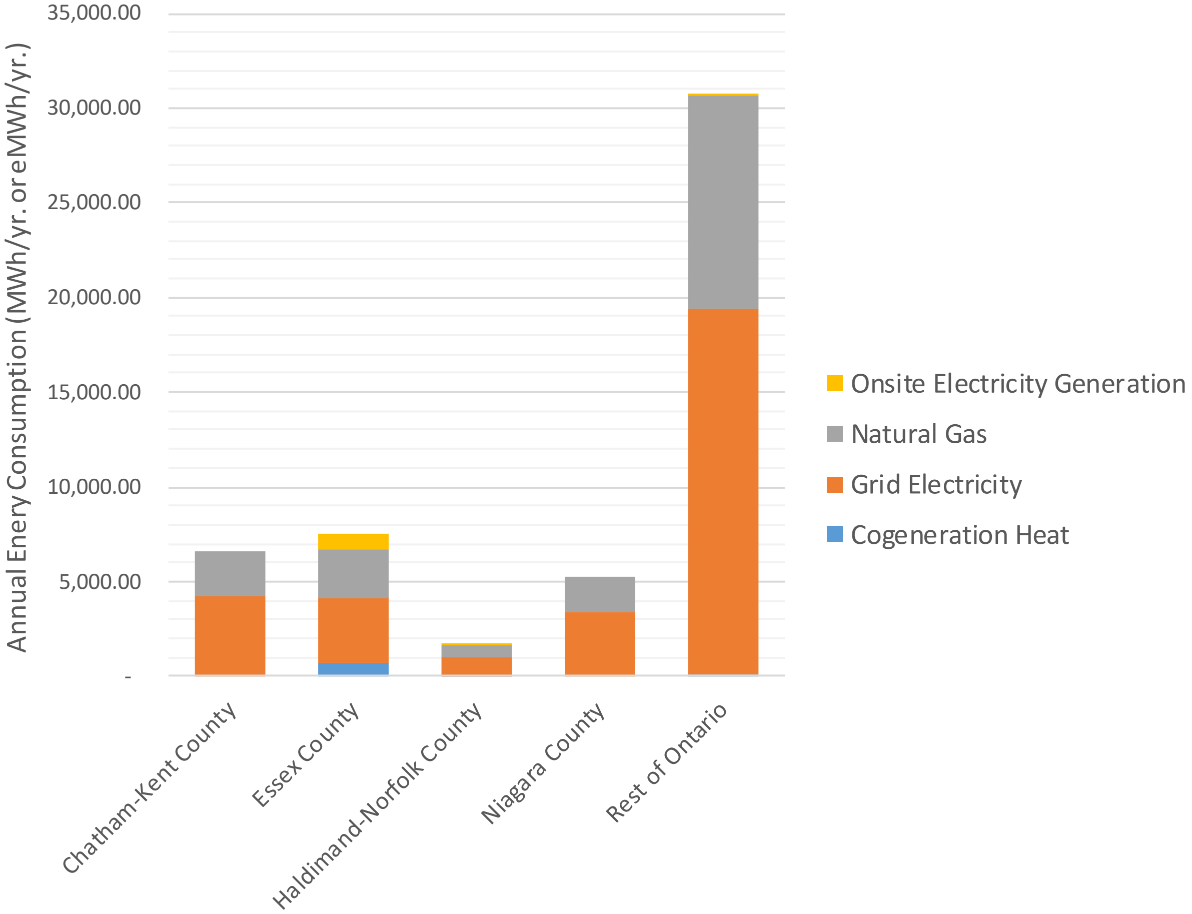
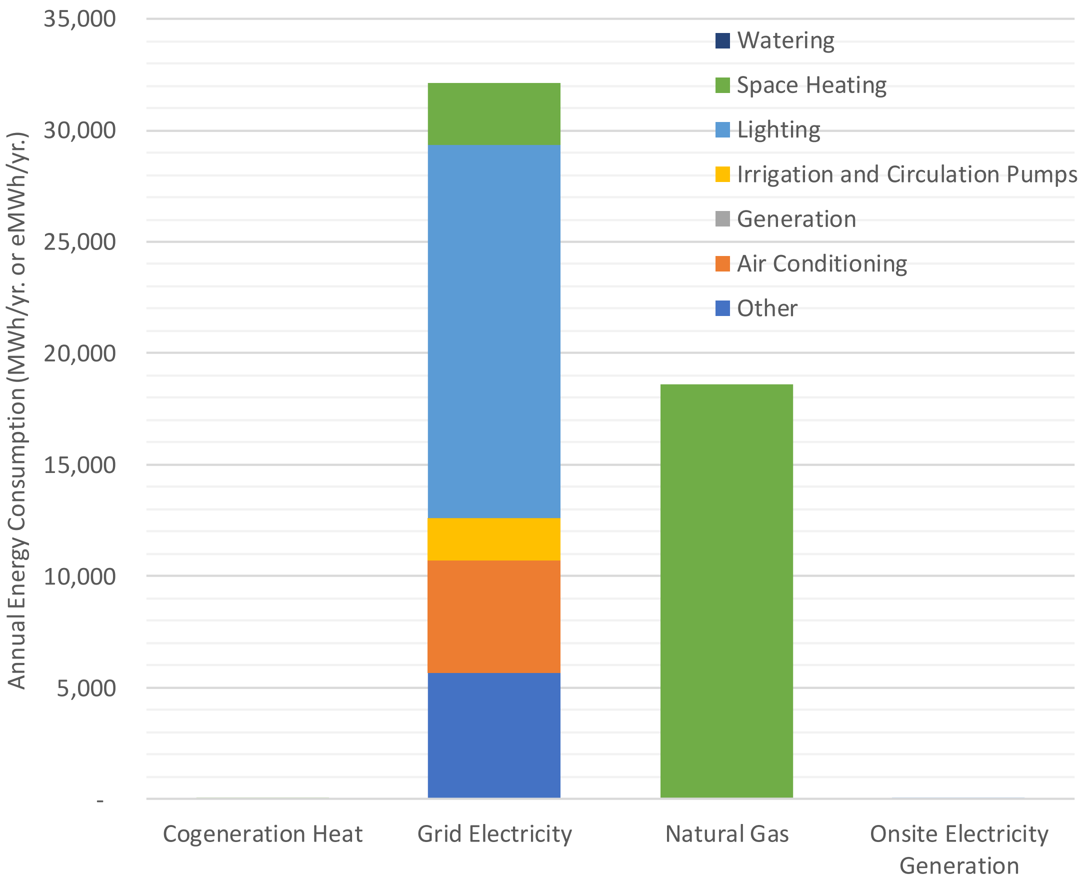


Exhibit 104 shows the base year energy consumption by end-use and fuel for the greenhouse cannabis sub-sector. In 2018 approximately 8% of this greenhouse cannabis facility area is planted and growing product. No production of other products occurs in the empty portions of those facilities, because of the risk of contamination.

Exhibit 104 – 2018: Greenhouse Cannabis Energy Consumption by Fuel and End Use



6.2.1 Load Profiles

Load profiles for greenhouse cannabis were developed by the study team using the following data sources:

- Hourly electricity consumption data for 326 greenhouse customers for 2016 and 2017 provided by Hydro One
- Hourly gas consumption data for 125 greenhouse customers for 2017 provided by Enbridge Gas
- The load shape of a lit cannabis greenhouse was provided by the IESO based on daily load shape derived from conversations with cannabis growers about their operations. Note that the lighting load profile of a specific facility may vary from the one presented in this report as lighting strategies may vary.

Exhibit 105 shows the load profile of monthly electricity consumption in a Cannabis greenhouse as a percentage of annual consumption. Electricity consumption is highest in the winter months and lowest in the summer.

Exhibit 105 – Electricity Monthly Load Profile (% of Annual) for Cannabis Greenhouse

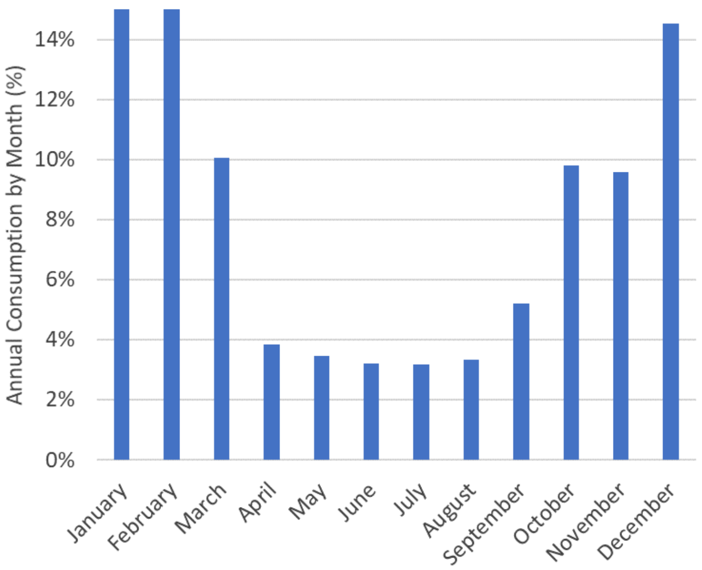


Exhibit 106 shows the load profile of hourly electricity consumption for cannabis greenhouse as a percentage of daily consumption. The electricity load is the highest in the middle of the day.

Exhibit 106 – Electricity Hourly (% of day) Load Profile for Cannabis Greenhouse

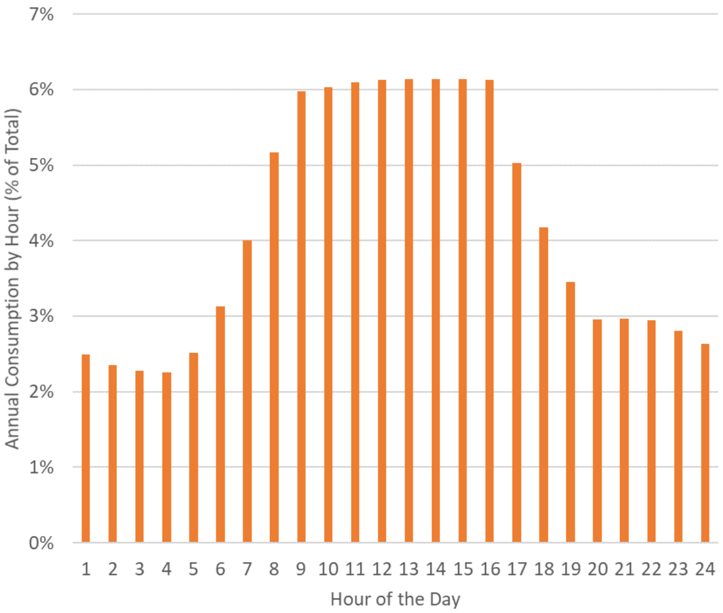
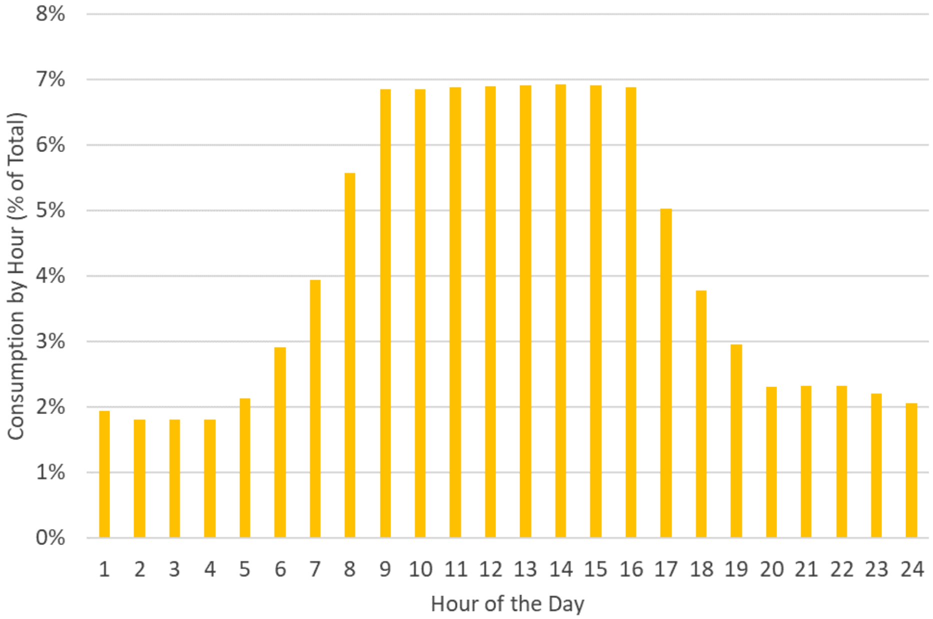


Exhibit 107 displays the hourly lighting end-use load profile as a percentage of daily consumption for a cannabis greenhouse. Unlike lit vegetable greenhouses, this load profile shows the majority of the lighting load occurring during the day, from late morning to mid-afternoon.

Exhibit 107 – Lighting Hourly (% of day) Load Profile for Cannabis Greenhouse



6.3 Reference Case (2019-2024) Forecast Results

Essex County is an exception, growing at an average of 9% year over year during the reference period. Due to a high number of connection requests in the area, growth is expected to follow the IESO's electricity demand growth forecast.

Exhibit 108 shows the reference case floor area forecast by region for the greenhouse cannabis sub-sector. Starting at 8% in 2018, the facility area that is planted and growing product is expected to be built out quickly, with 100% being built out by 2023. In addition to this, the sub-sector is projected to add another million ft^2 a year in 2023 and 2024.

Essex County is an exception, growing at an average of 9% year over year during the reference period. Due to a high number of connection requests in the area, growth is expected to follow the IESO's electricity demand growth forecast.

Exhibit 108 – Greenhouse Cannabis: Forecasted Total Area (ft^2) by Region

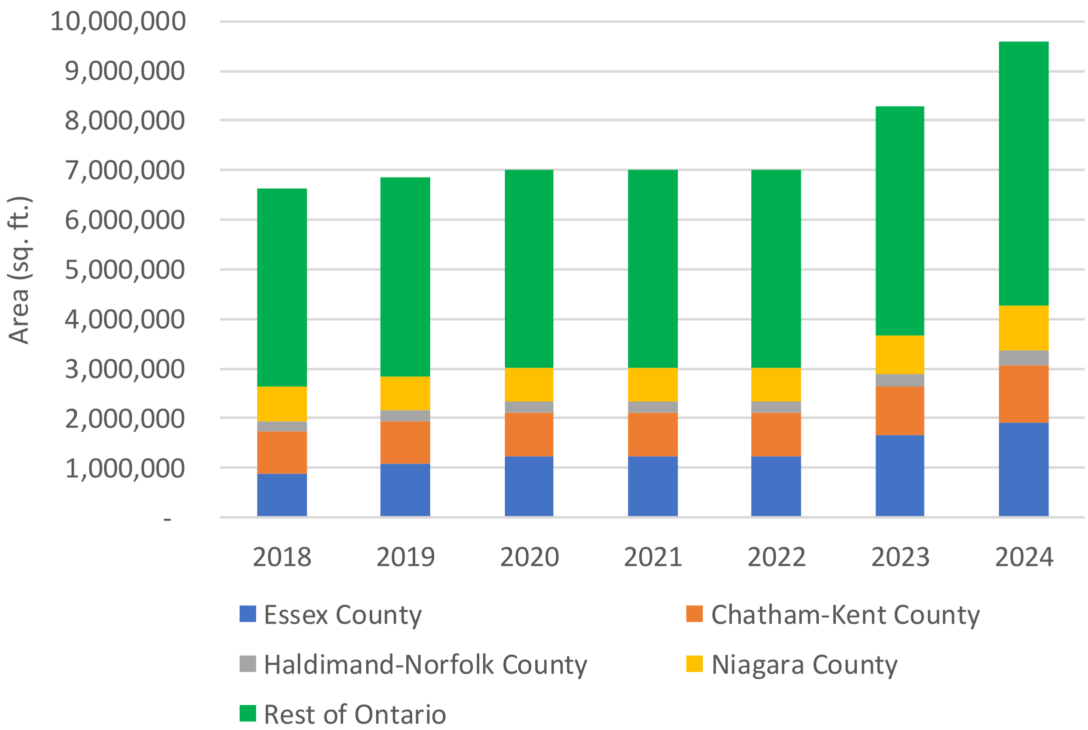


Exhibit 109 shows the reference case forecast for the number of lit and unlit facilities by region in the greenhouse cannabis sub-sector. The lit portion is expected to increase from 90% in 2018 to 100% by 2020 in all regions.

Exhibit 109 – Greenhouse Cannabis: Forecasted Number of Facilities by Region and Lighting Status

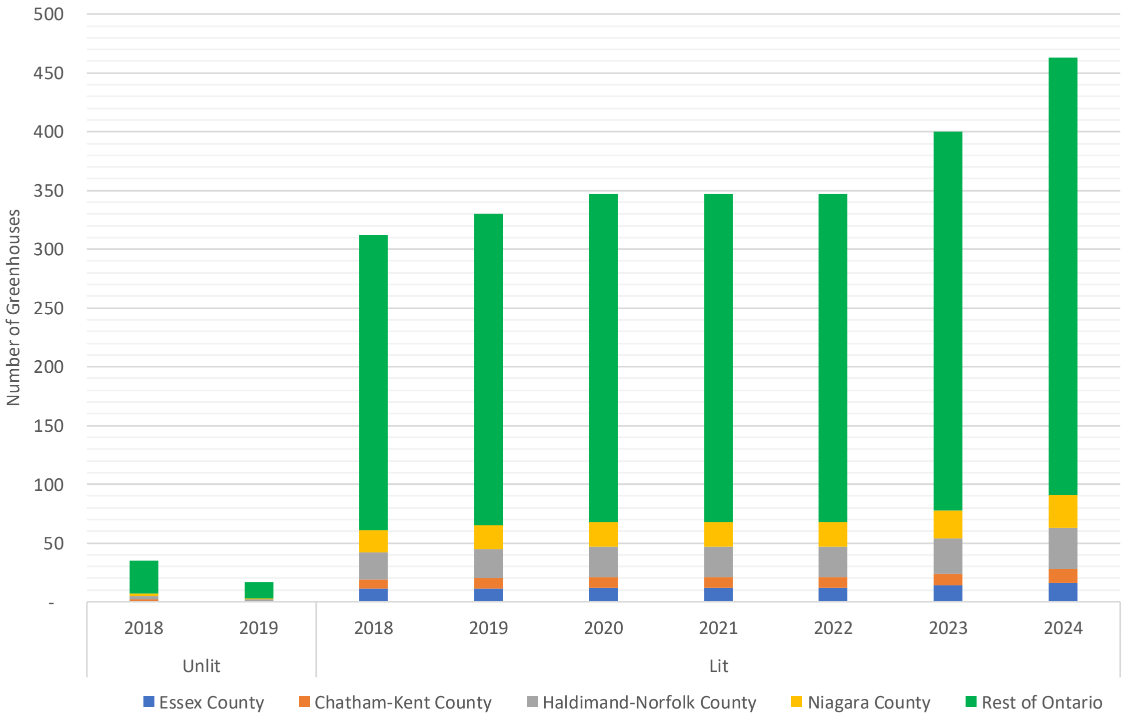


Exhibit 110 shows the reference case energy consumption forecast by fuel for the greenhouse cannabis sub-sector. Total behind the meter tri-generation installed by end of reference case (2024) is expected to be 36 MW.

Exhibit 110 – Greenhouse Cannabis: Forecasted Annual Consumption by Fuel

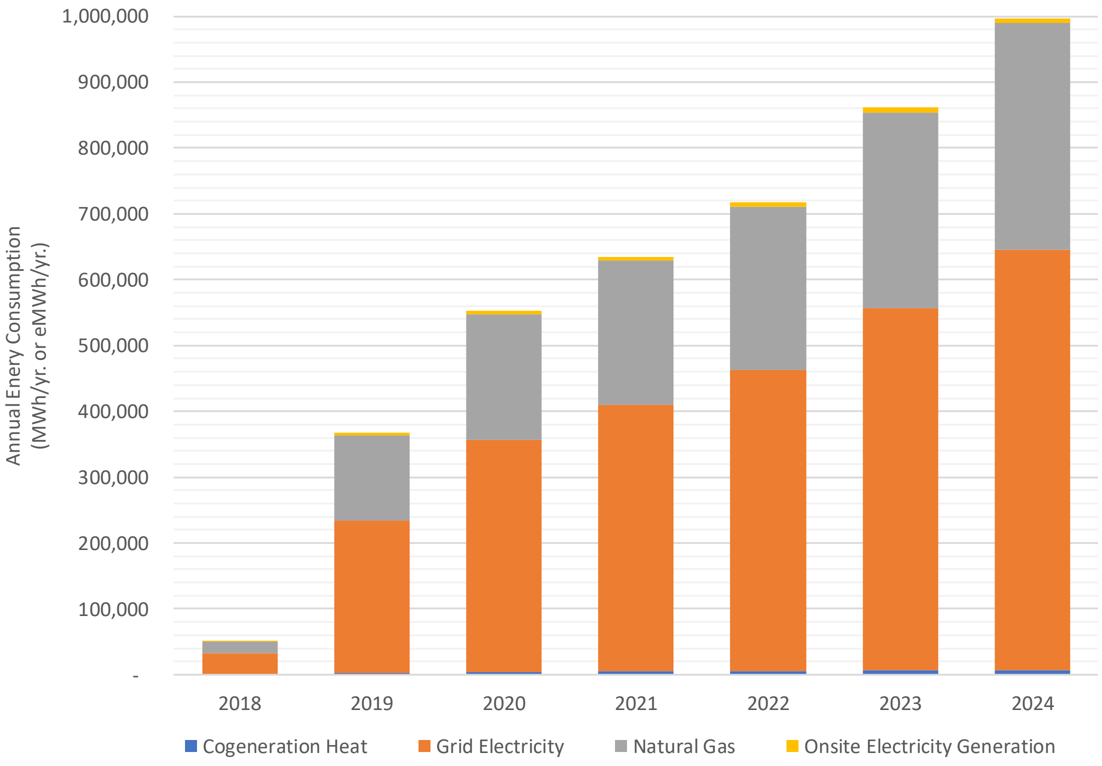


Exhibit 111 shows the reference case energy consumption forecast by region for the greenhouse cannabis sub-sector. Starting at 8% in 2018, the existing facility area that is planted and growing product is expected to be built out quickly, with 45% built out in 2019, 65% by 2020, 75% by 2021, 85% by 2022 and 100% by 2023.

Exhibit 111 – Greenhouse Cannabis: Forecasted Annual Energy Consumption by Region

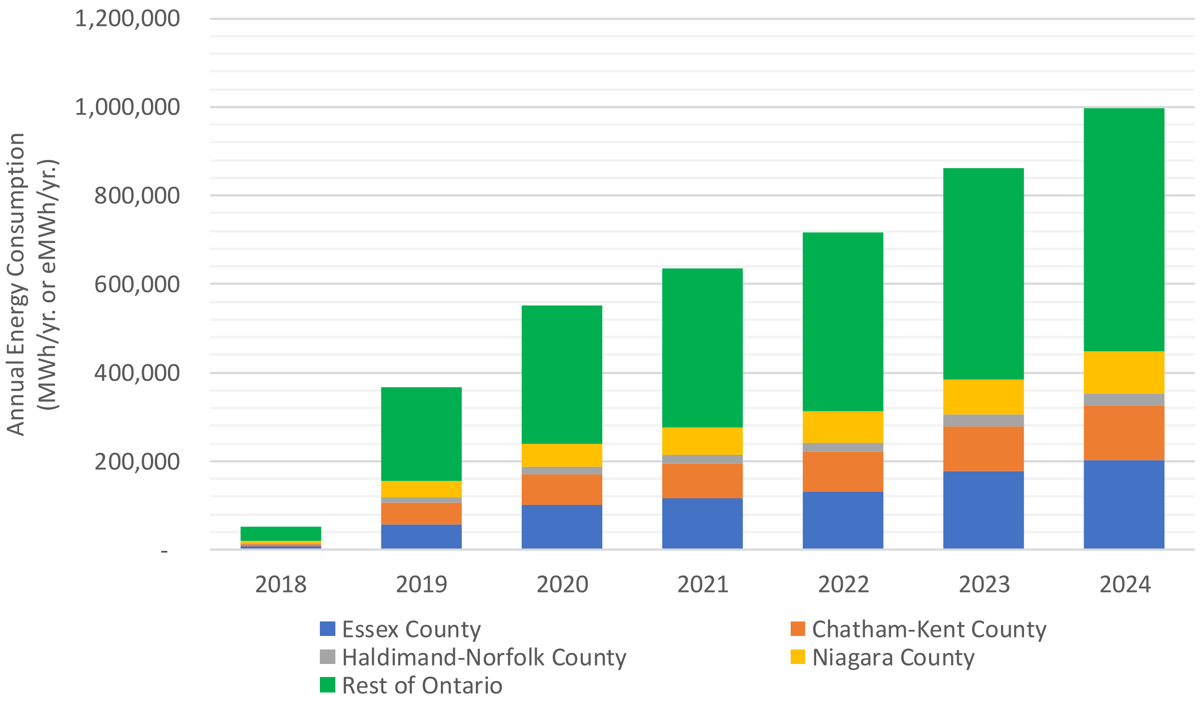
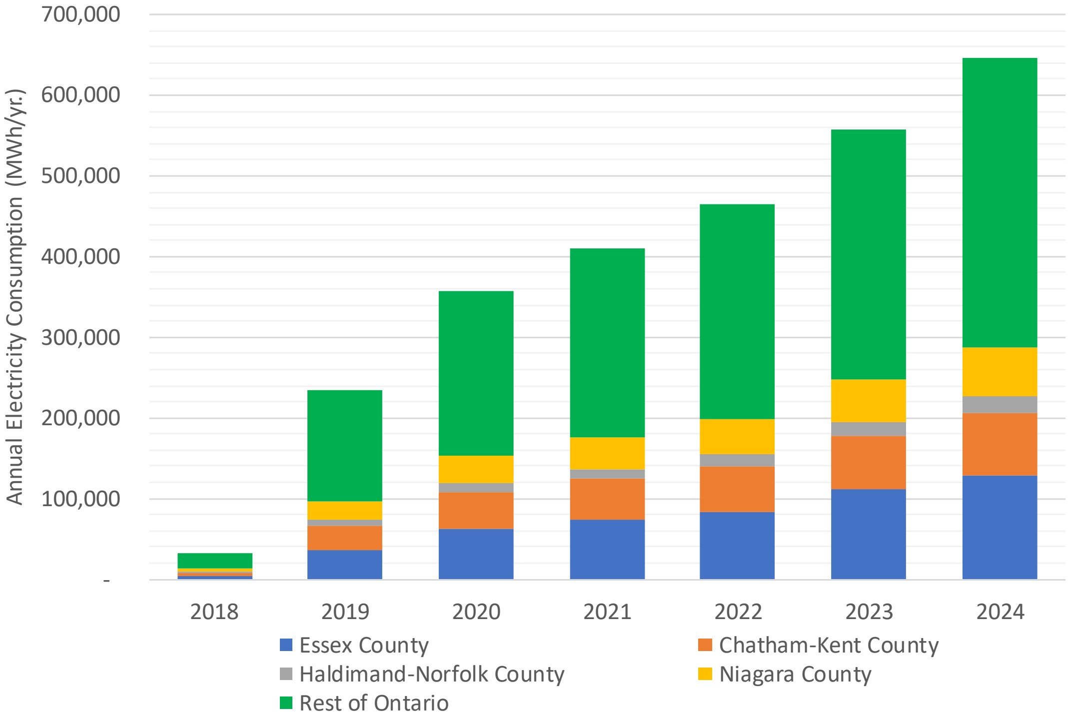


Exhibit 112 shows the projected annual electricity consumption (MWh/year) for the greenhouse cannabis sub-sector. As explained above, the increase in electricity consumption is expected due to the rapid ramp up of production in existing facilities such that all area is being used for production.

Exhibit 112 - Greenhouse Cannabis: Forecasted Annual Electricity Consumption by Region



6.4 Energy Saving Opportunities

Opportunity for LED Grow Lights

[Please see Section 11.1 for a more fulsome discussion of LED Grow Lights and the sensitivity analysis that was performed for this study.]

LED grow lights offer electricity savings potential when they replace HPS lights. Despite the energy saving potential, LED grow lights currently have a small saturation in the Ontario covered agriculture sector. Growers are hesitant to adopt LEDs due to:

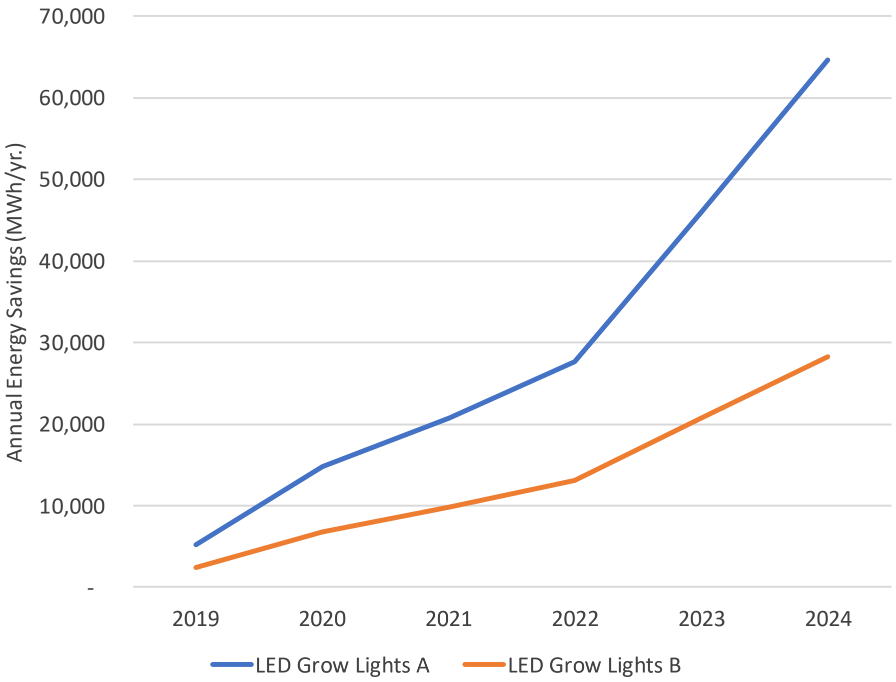
- Uncertainty over savings – savings claims being made by lighting suppliers have been at odds with published research [48] [49].
- Higher upfront costs -- the cost of agricultural LED products still varies widely and is expected to come down in the coming years as the technology continues to mature [48].
- Risk of impacting yield -- there is a learning curve required for growers to switch from HPS to LED, creating a barrier that growers tend not be willing to accept given the relative immaturity of the technology [50].

To illustrate the potential savings if/when LEDs are more widely adopted by the industry, two LED measure scenarios were modelled relative to the reference case:

a) "LED Grow Lights A" -- 55% savings at a cost point of $1.25/installed LED watt (a mid-range cost value) [48]
b) "LED Grow Lights B" -- 35% savings at a cost point of $0.75/installed LED watt (the lowest cost point reported in Ontario to date) [48]

The **technical energy savings potential**[7] results for the greenhouse cannabis sub-sector are presented in Exhibit 113.

Exhibit 113 – Greenhouse Cannabis: Technical Energy Savings Potential from LED Measure Scenarios



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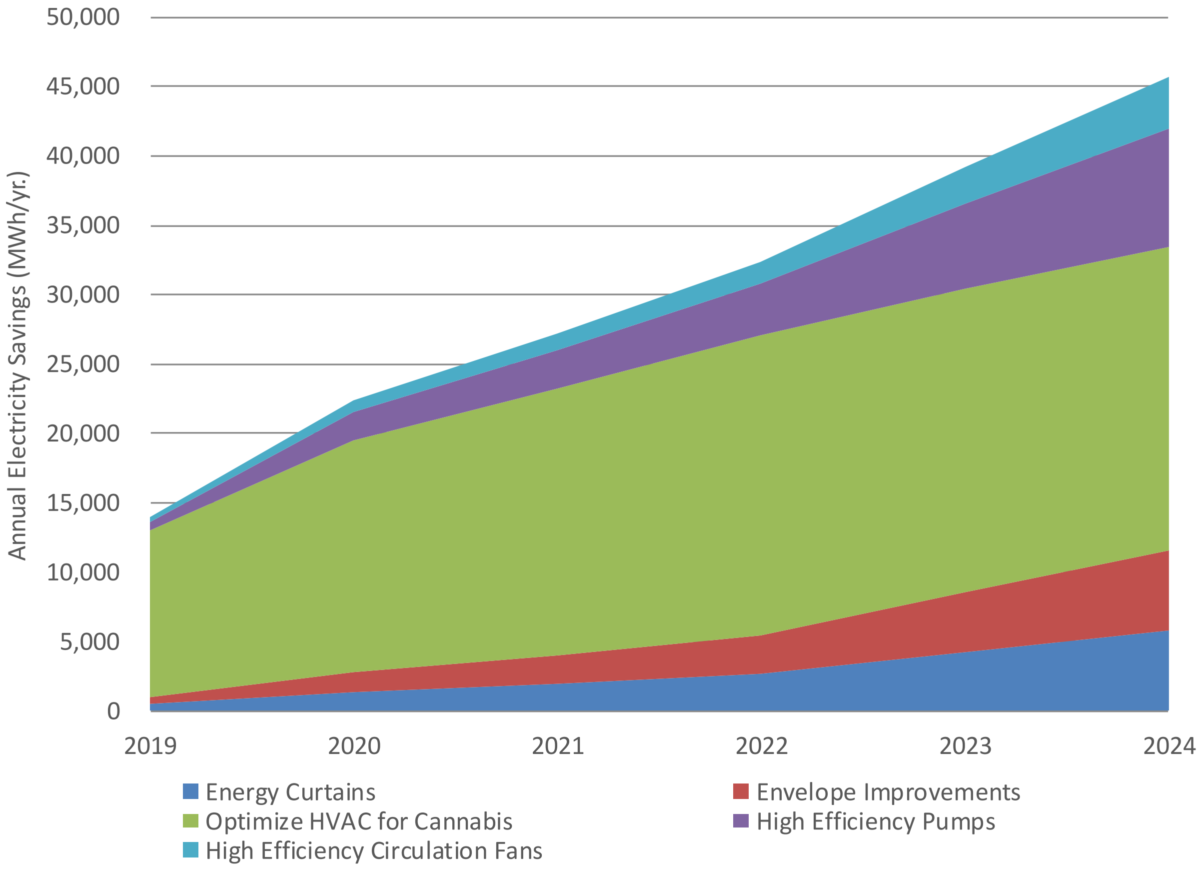
[7] Technical Potential is the theoretical maximum amount of energy use that could be displaced by the measures, only considering technical constraints. Non-technical constraints such as cost-effectiveness and the willingness of end-users to adopt the efficiency measures are not considered.

Non-Lighting Electricity Savings Potential

Exhibit 114 displays the economic savings potential for electricity non-lighting measures for the greenhouse cannabis sub-sector. The optimize HVAC for cannabis measure offers the most potential, followed by high efficiency pumps, envelope improvements, energy curtains and high efficiency circulation fans.

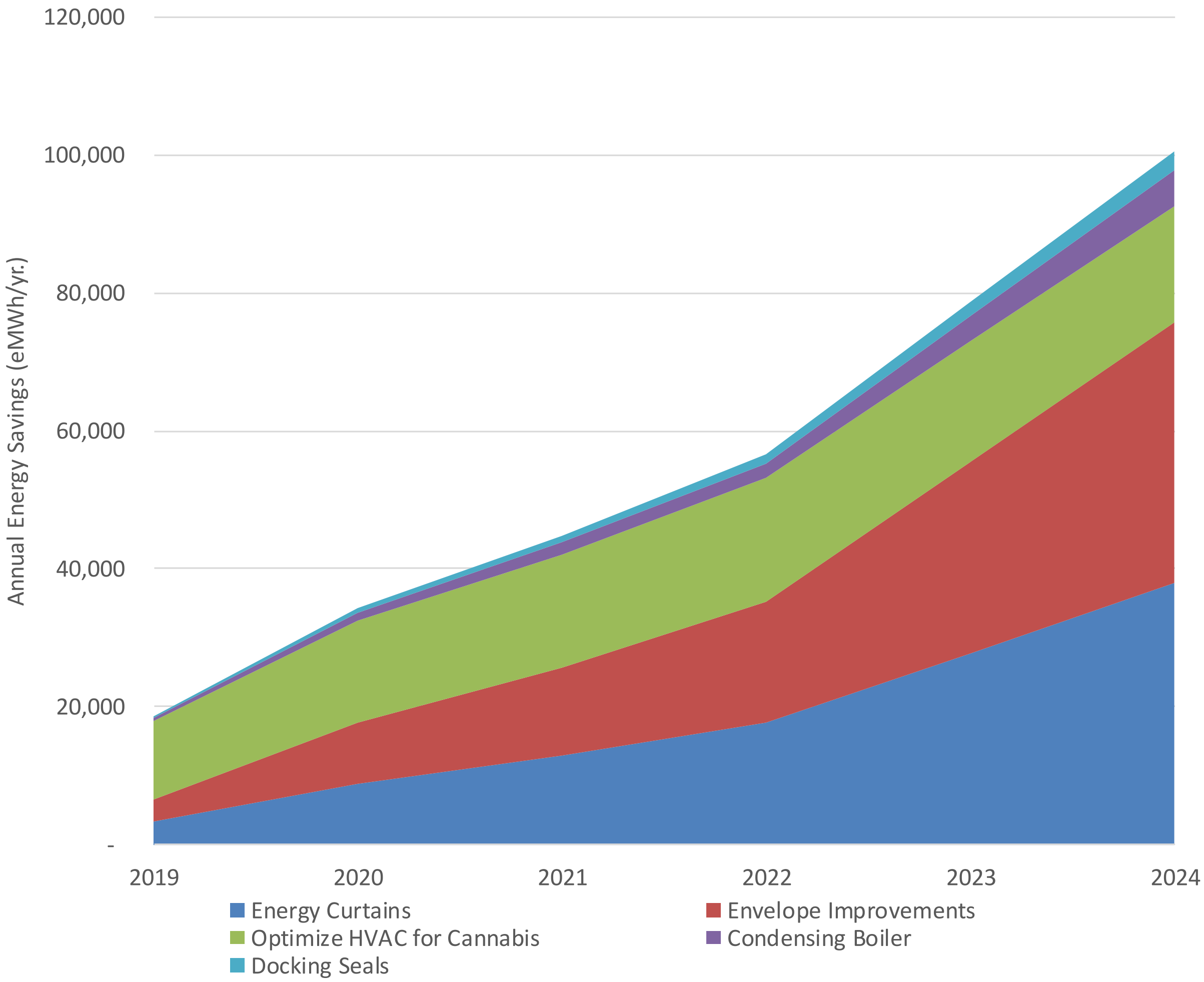
Exhibit 114 – Greenhouse Cannabis: Electricity Savings Potential by Measure



Natural Gas Savings Potential

Exhibit 115 displays the economic savings potential for natural gas for the greenhouse cannabis sub-sector for the top five measures. Envelope improvements is the measure that offers the most savings potential by 2024, followed by energy curtains and optimize HVAC for cannabis.

Exhibit 115 – Natural Gas Savings Potential by Measure for the Greenhouse Cannabis Sub-sector



Sub-Sector Focus: Indoor Cannabis

7 Sub-Sector Focus: Indoor Cannabis

7.1 Sub-sector Description

Ontario's cannabis cultivation industry consists of both *indoor* and *greenhouse* operations. In its infancy, Ontario's industry consisted exclusively of indoor operations serving the medical market. Greenhouse operations are a more recent development in Ontario; however, they have been part of the industry's progression in other jurisdictions with legal recreational markets. Ontario's cannabis sector is rapidly growing and is expected to continue to expand as the legal cannabis market matures.

Relative to greenhouse operations, indoor facilities provide a high degree of environmental control: grow rooms are sealed from the outdoor environment with artificial light, heat and dehumidification providing the optimal growing conditions. Indoor facilities tend to have high construction and operating costs relative to greenhouse operations [62].

Energy use for indoor and greenhouse cannabis cultivation varies, however the same basic end uses are common to both approaches. Major end-uses include space heating, dehumidification (broadly applicable in indoor operations, usually limited to drying rooms in greenhouse operations) and grow lighting. Compared to the vegetable sub-sector, cannabis operations use significantly more electricity (e.g., indoor cannabis facilities use more almost 3.5 times more electricity per square foot than lit vegetable greenhouses), with some facilities that have electricity demand peaks in excess of 10MW.

7.2 Base Year (2018) Results

Exhibit 116 shows the proportion of base year floor area by region for the indoor cannabis sub-sector. In 2018 there was 3.6 million ft^2 (82 acres) of indoor cannabis, with the Rest of Ontario region having the highest concentration. The average indoor cannabis facility in Niagara is 3.5 times larger than the average in the rest of the province.

Exhibit 116 – 2018: Indoor Cannabis Area (%.) by Region

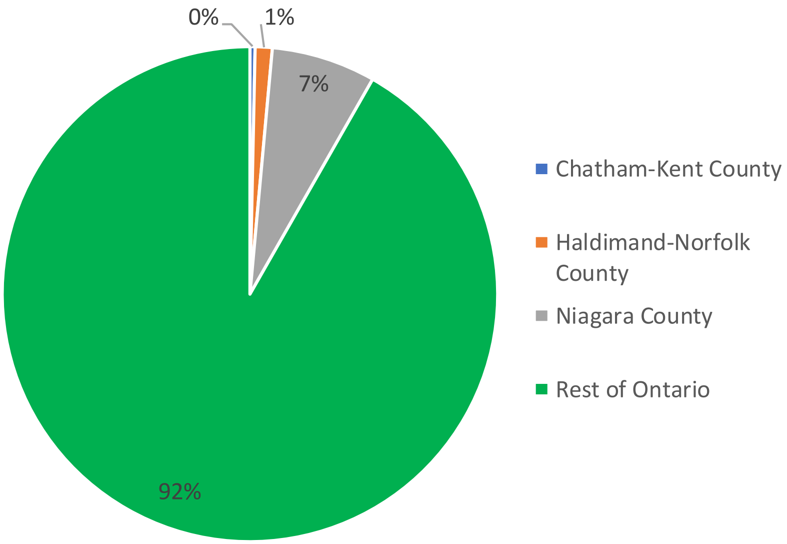


Exhibit 117 shows the number of indoor cannabis facilities by region. Only 6 (or 12%) of facilities are in Chatham-Kent, Haldimand–Norfolk and Niagara regions.

Exhibit 117 – 2018: Indoor Cannabis Facilities by Region

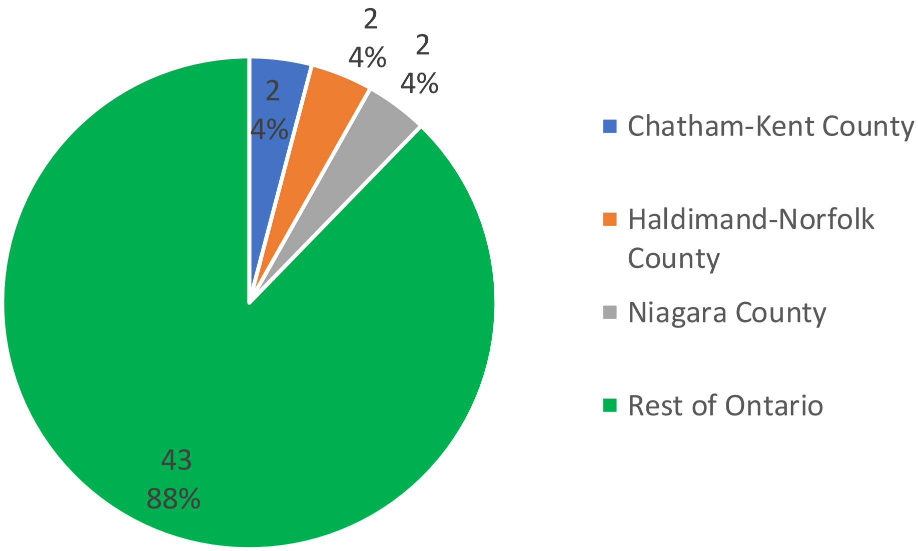


Exhibit 118 shows annual energy consumption (unit energy consumption or UEC) by end use for a typical indoor cannabis facility:

Exhibit 118 – UEC Values by End Use (ekWh/ft2)

End Use	*Indoor Cannabis*
Heating (gas)	32.29
Heating (elec)	4.20
Lighting	63.72
Cooling	19.12
Pumps	5.05
Other	15.11

Exhibit 119 shows base year energy consumption by region and fuel for the indoor cannabis sub-sector. It is estimated 1.17 MW of behind the meter tri-generation is installed in the Rest of Ontario region (the only region with tri-generation in the base year).

Exhibit 119 – 2018: Indoor Cannabis Energy Consumption by Region and Fuel

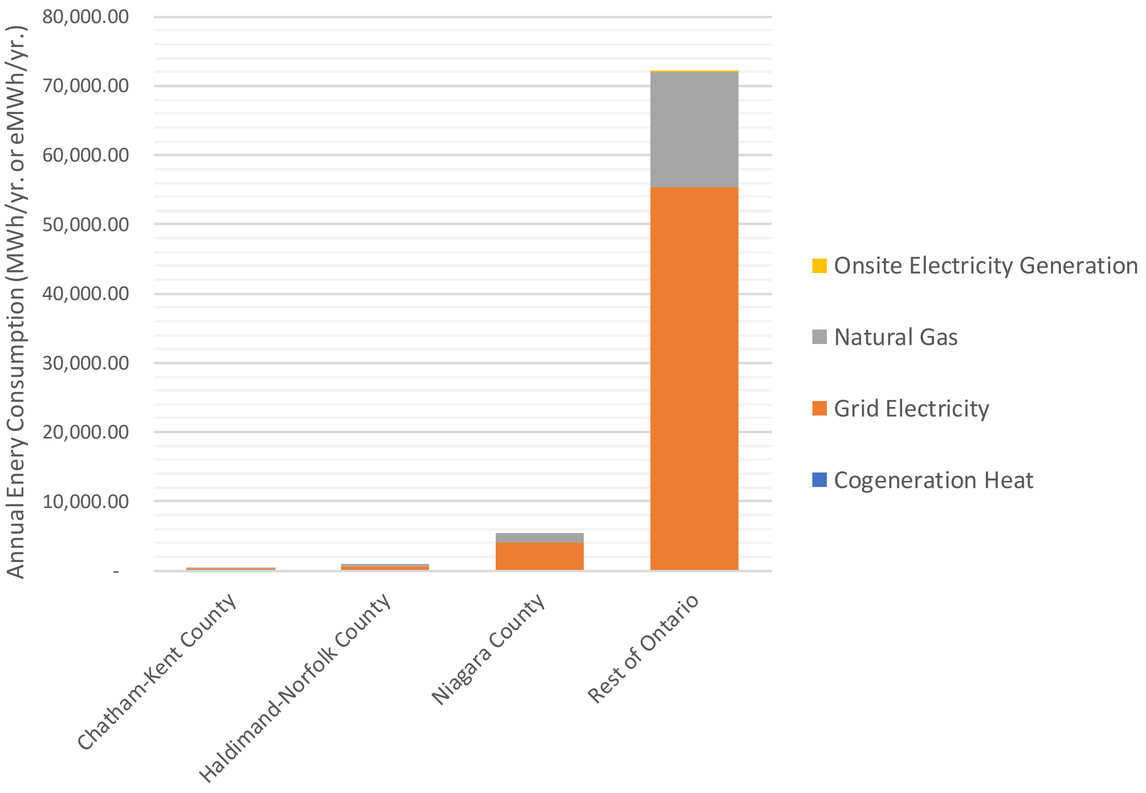
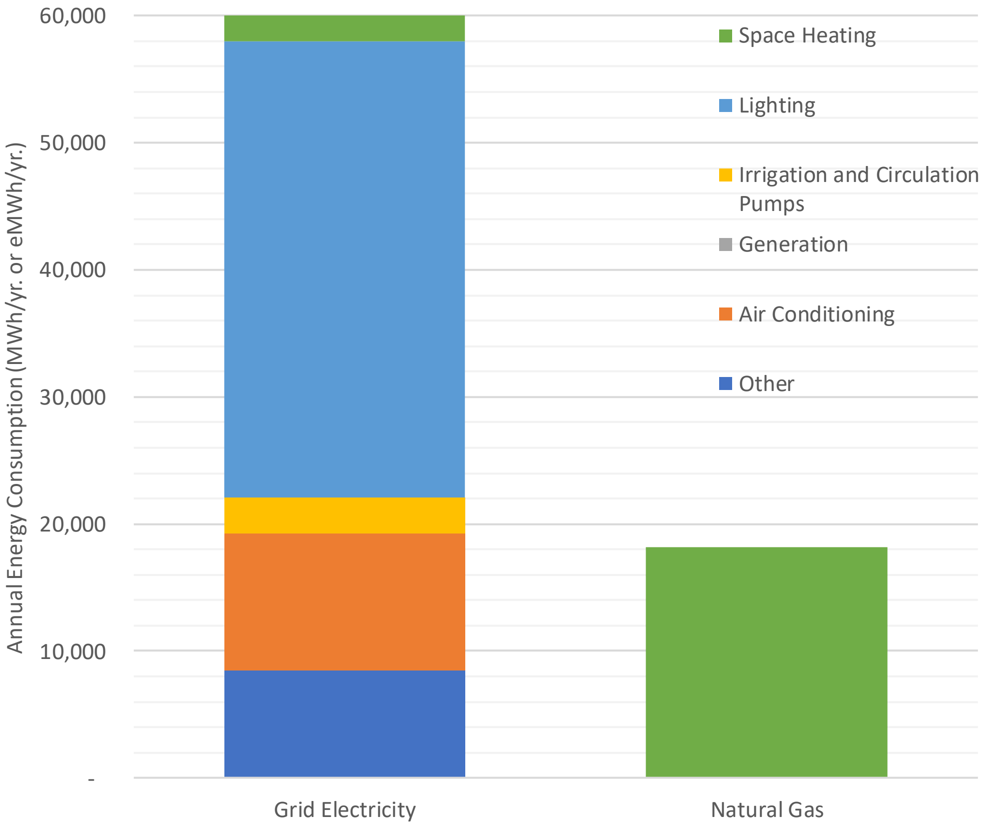


Exhibit 120 shows base year energy consumption by fuel and end-use for the indoor cannabis sub-sector. In 2018 approximately 16% of the indoor cannabis facility area was planted and growing product. No production of other products occurred in the empty portions of those facilities, because of the risk of contamination.

Exhibit 120 – 2018: Indoor Cannabis Energy Consumption by Fuel and End Use



7.2.1 Load Profiles

Load profiles for indoor cannabis were developed by the study team using the following method:

- We assumed an indoor cannabis facility had the same daily profile as a cannabis greenhouse and the greenhouse winter profile was used for every month of the year. The cannabis greenhouse load profile was provided by the IESO.

Note that the lighting load profile of a specific facility may vary from the one presented in this report as lighting strategies may vary.

Exhibit 121 displays the load profile of monthly electricity consumption for an indoor cannabis facility as a percentage of annual consumption. This load profile is relatively flat, as lighting is used year-round.

Exhibit 121 – Electricity Monthly Load Profile (% of Annual) for Indoor Cannabis

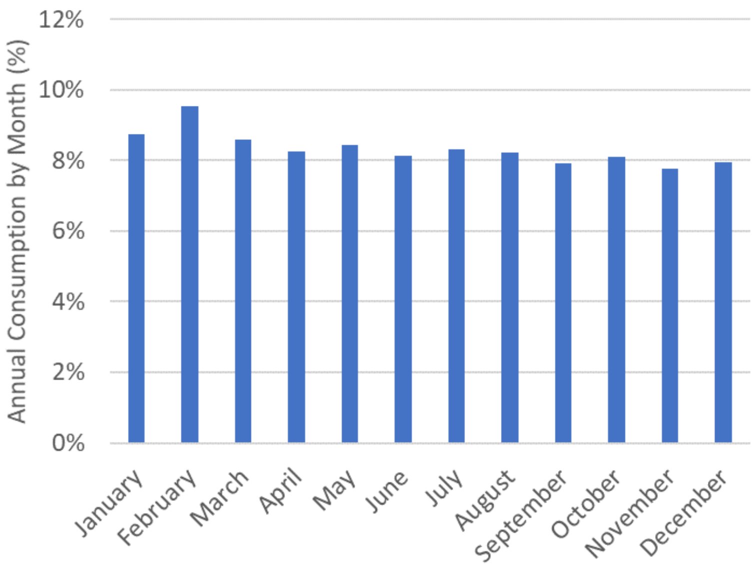


Exhibit 122 shows the load profile of hourly electricity consumption as a percentage of daily consumption for an indoor cannabis facility. Similar to cannabis greenhouse, the electricity consumption peaks during the day.

Exhibit 122 - Electricity Hourly (% of day) Load Profile for Indoor Cannabis

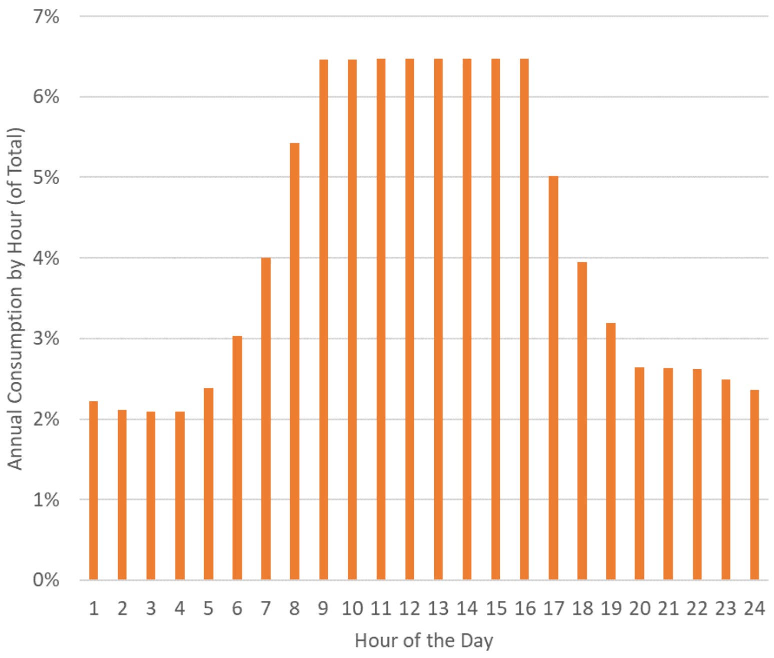
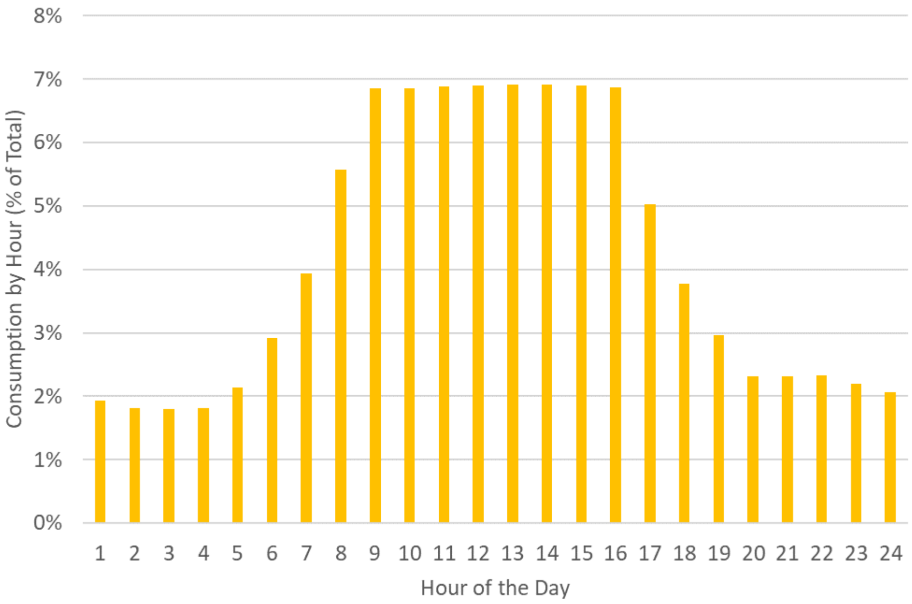


Exhibit 123 illustrates the hourly lighting end-use load profile as a percentage of daily consumption for an indoor cannabis facility. The lighting load peaks during the day.

Exhibit 123 – Lighting Hourly (% of day) Load Profile for Indoor Cannabis



7.3 Reference Case (2019-2024) Forecast Results

Exhibit 124 shows the reference case floor area forecast by region for the indoor cannabis sub-sector. The proportion of area used for production was 16% in 2018. It is expected production will ramp up quickly, with 100% of area being used for production by 2023. Beyond the growth in area used for production, no new indoor cannabis facilities are expected to be constructed, except for the Chatham-Kent region where a large indoor cannabis facility is coming online in 2020 (55% of the load is coming online in 2020 and remaining part of the facility will come online in 2023).

Exhibit 124 – 2018-2024: Indoor Cannabis Total Area (sq. ft.) by Region

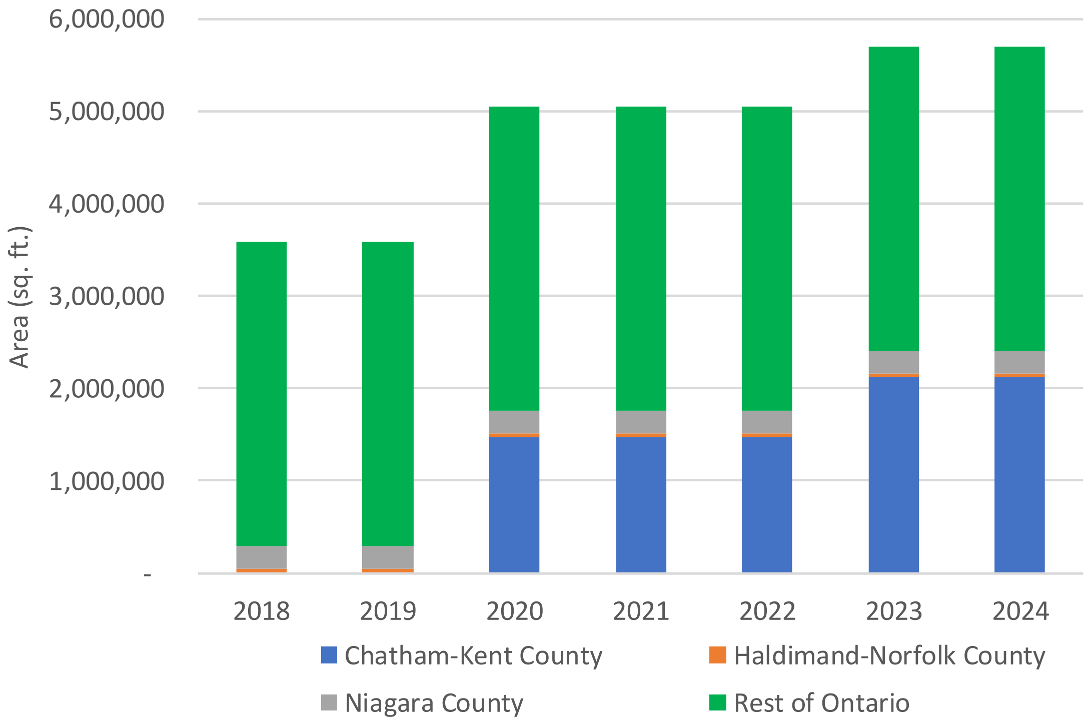


Exhibit 125 shows the reference case energy consumption forecast by fuel for the indoor cannabis sub-sector. Total behind the meter tri-generation installed by end of reference case (2024) is expected to be 6 MW.

Exhibit 125 – Indoor Cannabis Forecasted Energy Consumption by Fuel

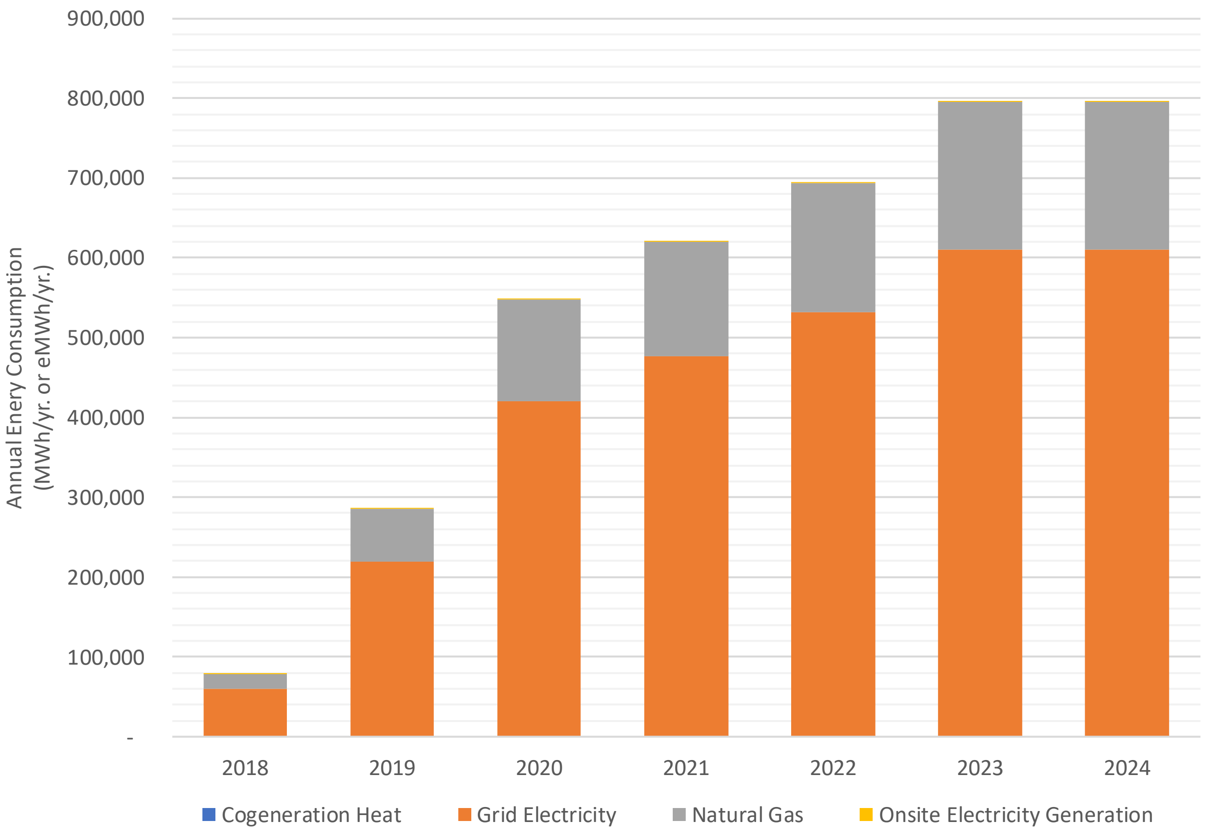


Exhibit 126 shows the reference case energy consumption forecast by region for the indoor cannabis sub-sector. The existing facility area that is planted and growing product is expected to be built out quickly, with 45% built out in 2019, 65% by 2020, 75% by 2021, 85% by 2022 and 100% by 2023.

Exhibit 126 – 2018-2024: Indoor Cannabis Annual Energy Consumption by Region

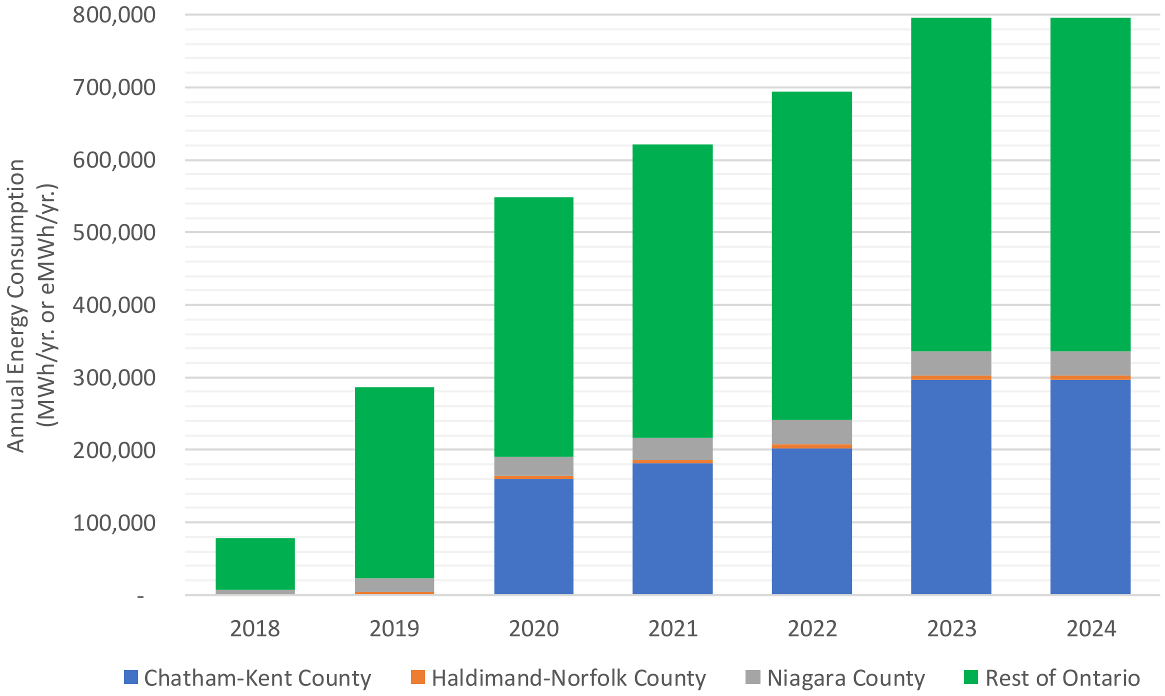
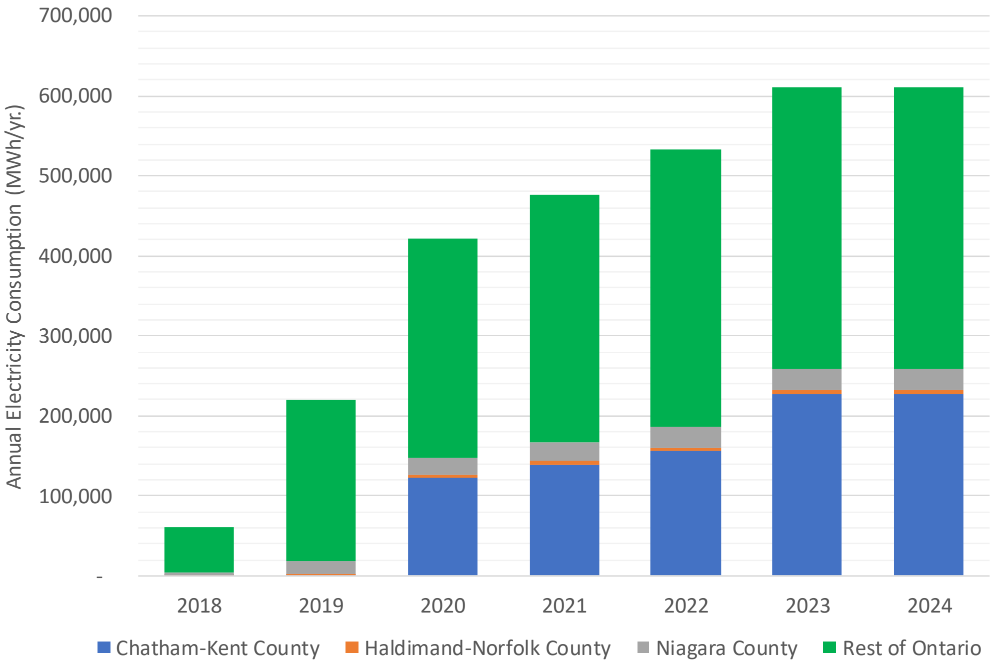


Exhibit 127 provides the forecasted annual electricity consumption by region for the indoor cannabis sub-sector.

Exhibit 127– 2018-2024: Indoor Cannabis Annual Electricity Consumption by Region



7.4 Energy Saving Opportunities

Opportunity for LED Grow Lights

[Please see Section 11.1 for a more fulsome discussion of LED Grow Lights and the sensitivity analysis that was performed for this study.]

LED grow lights offer electricity savings potential when they replace HPS lights. Despite the energy saving potential, LED grow lights currently have a small saturation in the Ontario covered agriculture sector. Growers are hesitant to adopt LEDs due to:

- Uncertainty over savings – savings claims being made by lighting suppliers have been at odds with published research [48] [49]
- Higher upfront costs -- the cost of agricultural LED products still varies widely and is expected to come down in the coming years as the technology continues to mature [48].
- Risk of impacting yield -- there is a learning curve required for growers to switch from HPS to LED, creating a barrier that growers tend not be willing to accept given the relative immaturity of the technology [50]

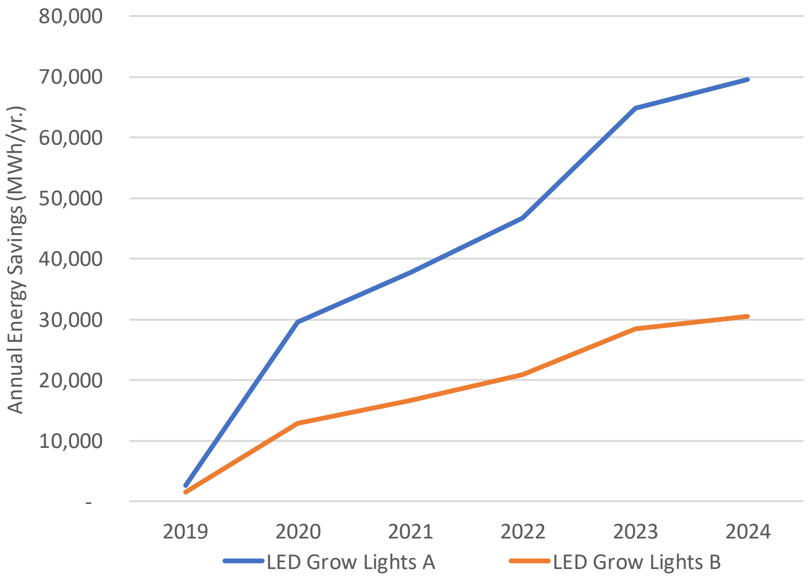
To illustrate the potential savings if/when LEDs are more widely adopted by the industry, two LED measure scenarios were modelled relative to the reference case:

a) “LED Grow Lights A” -- 55% savings at a cost point of $1.25/installed LED watt (a mid-range cost value) [48]

b) "LED Grow Lights B" -- 35% savings at a cost point of $0.75/installed LED watt (the lowest cost point reported in Ontario to date) [48]

The **technical energy savings potential**[8] results for the indoor cannabis sub-sector are presented in Exhibit 128.

Exhibit 128 – Indoor Cannabis: Technical Energy Savings Potential from LED Measure Scenarios



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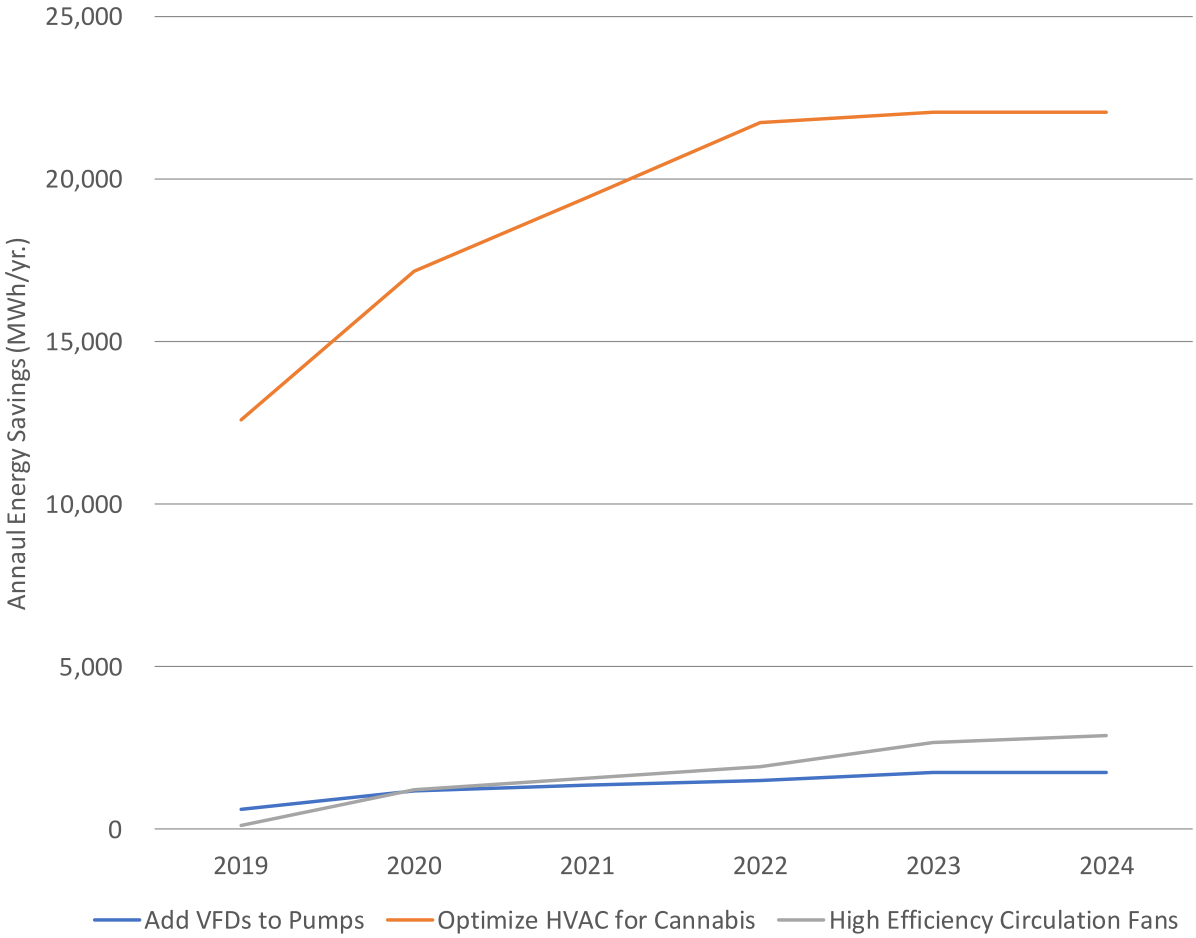
[8] Technical Potential is the theoretical maximum amount of energy use that could be displaced by the measures, only considering technical constraints. Non-technical constraints such as cost-effectiveness and the willingness of end-users to adopt the efficiency measures are not considered.

Non-Lighting Electricity Savings Potential

Exhibit 129 shows the economic savings potential for electricity non-lighting measures for the indoor cannabis sub-sector. The optimize HVAC for cannabis measure offers for greatest electricity savings, followed by high efficiency circulation fans and adding VFDs to pumps.

Exhibit 129 – Electricity Savings Potential by Measure for Indoor Cannabis Sub-Sector

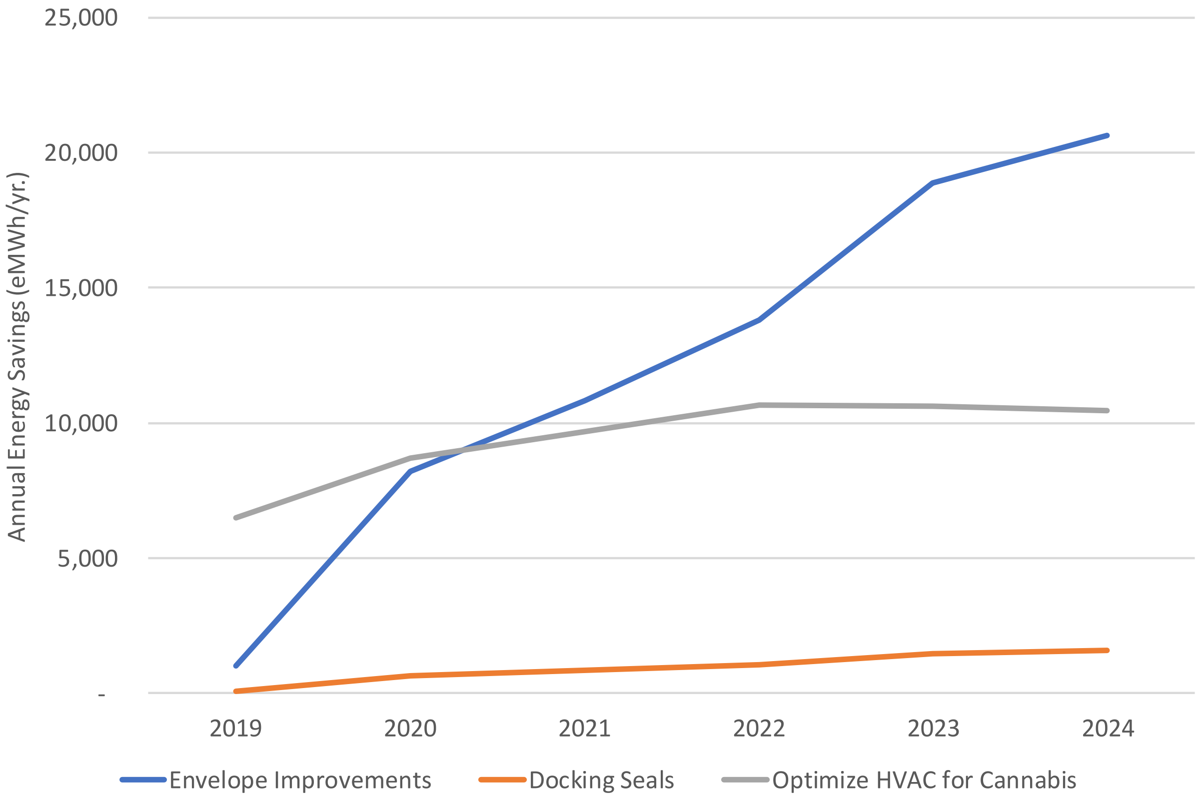


Canopy Growth expected to need an additional powerline to expand their indoor cannabis growing and processing facility in Smiths Falls. However, energy savings from efficiency measures enabled the facility to proceed with the available grid capacity [63] [64].

Natural Gas Savings Potential

Exhibit 130 displays the economic savings potential for natural gas for the indoor cannabis sub-sector by measure. Similar to the greenhouse cannabis sub-sector, envelope improvements offers the most savings potential by 2024 relative to other measures. Optimize HVAC for cannabis and docking seals are the other measures that offer economic natural gas savings potential.

Exhibit 130 – Natural Gas Savings Potential by Measure for Indoor Cannabis Sub-Sector



Sub-Sector Focus: Vertical Farming & Other Covered Agriculture

8 Sub-Sector Focus: Vertical Farming & Other Covered Agriculture

8.1 Sub-sector Description

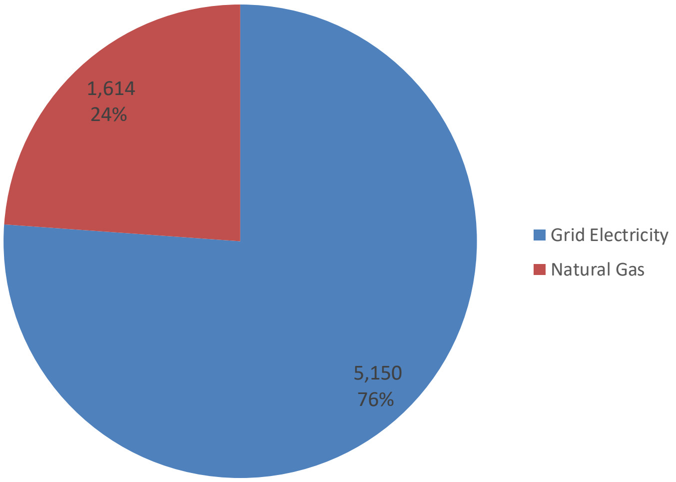
Vertical farming is an indoor, closed production system where plants are grown vertically up the indoor walls of the structure. Some vertical farms are in shipping containers, existing warehouses and other commercial spaces. Indoor vertical farms use controlled environmental agriculture (CEA) systems to grow high value crops such as leafy greens and herbs [65]. Vertical farms are often located in or nearer to urban areas compared to greenhouses as their smaller size and controlled indoor environments free them from geographic constraints. This sub-sector is currently small and still developing, and there is some skepticism about the commercial viability of vertical farms[9].

As vertical farms - like other indoor operations - are self-contained, closed systems, they require energy to produce light and heat, making them energy intensive operations [66]. A 2017 US indoor farming market report indicated its surveyed growers reported running their lights 16 hours per day, 7 days per week, all year round. This compared to 9 hours per day in the winter for greenhouse growers [67, p. 24].

8.2 Base Year (2018) & Reference Case (2019-2024) Results

Exhibit 131 shows base year energy consumption by fuel for the vertical farming sub-sector. In 2018 there were only two vertical farm facilities representing a total area of 50 thousand ft^2 (1.1 acres). Both these facilities are located in the Rest of Ontario region. The number of facilities and footprint of the vertical farming sub-sector is not expected to change notably over the next six years.

Exhibit 131 – 2018: Vertical Farming Annual Consumption by Fuel (MWh/yr. or eMWh/yr.)



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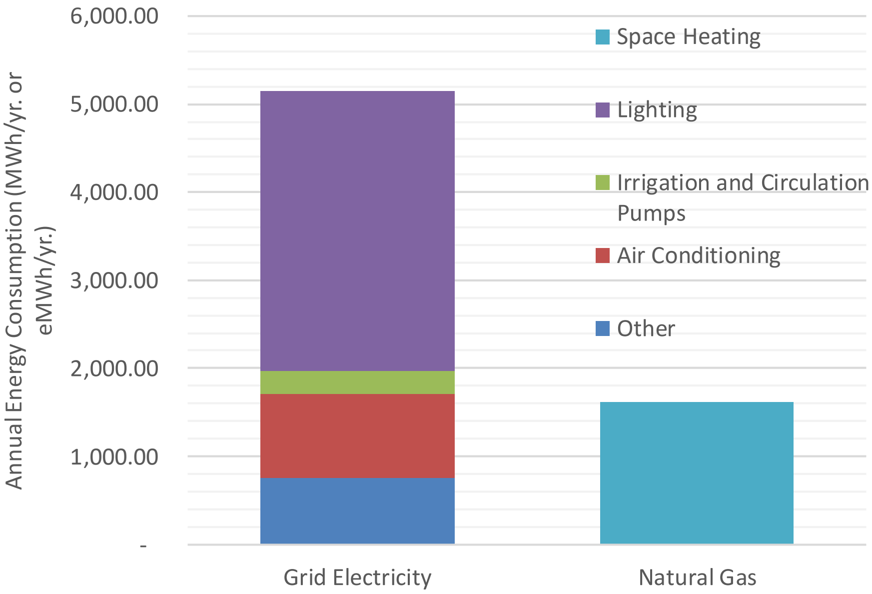
[9] For a discussion of the potential for vertical farms, see, IEEE Spectrum, June 2018: *The Green Promise of Vertical Farms* (https://spectrum.ieee.org/energy/environment/the-green-promise-of-vertical-farms) and The Guardian, 10 April 2015: *The buzz around indoor farms and artificial lighting makes no sense* (https://www.theguardian.com/sustainable-business/2015/apr/10/indoor-farming-makes-no-economic-environmental-sense)

Exhibit 132 shows the base year energy consumption by end-use and fuel for the vertical farming sub-sector. The energy profile of the vertical farming sub-sector is not expected to change notably over the next six years.

Exhibit 132 – 2018: Vertical Farming Energy Consumption by Fuel and End Use



8.3 Energy Saving Opportunities

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- Uncertainty over savings – savings claims being made by lighting suppliers have been at odds with published research [48] [49]
- Higher upfront costs -- the cost of agricultural LED products still varies widely and is expected to come down in the coming years as the technology continues to mature [48].
- Risk of impacting yield -- there is a learning curve required for growers to switch from HPS to LED, creating a barrier that growers tend not be willing to accept given the relative immaturity of the technology [50]

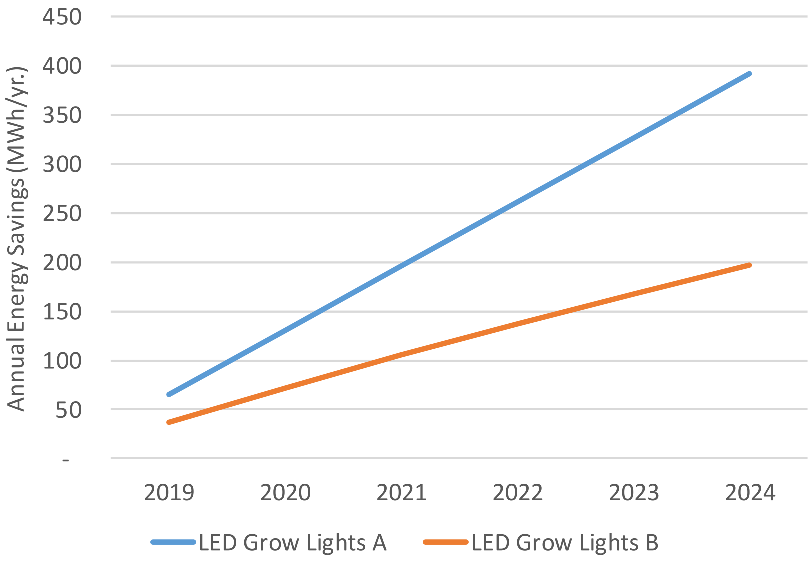
To illustrate the potential savings if/when LEDs are more widely adopted by the industry, two LED measure scenarios were modelled relative to the reference case:

a) "LED Grow Lights A" -- 55% savings at a cost point of $1.25/installed LED watt (a mid-range cost value) [48]

b) “LED Grow Lights B” -- 35% savings at a cost point of $0.75/installed LED watt (the lowest cost point reported in Ontario to date) [48]

The **technical energy savings potential**[10] results for the Vertical Farming sub-sector are presented in Exhibit 133.

Exhibit 133 – Vertical Farming: Technical Energy Savings Potential from LED Measure Scenarios



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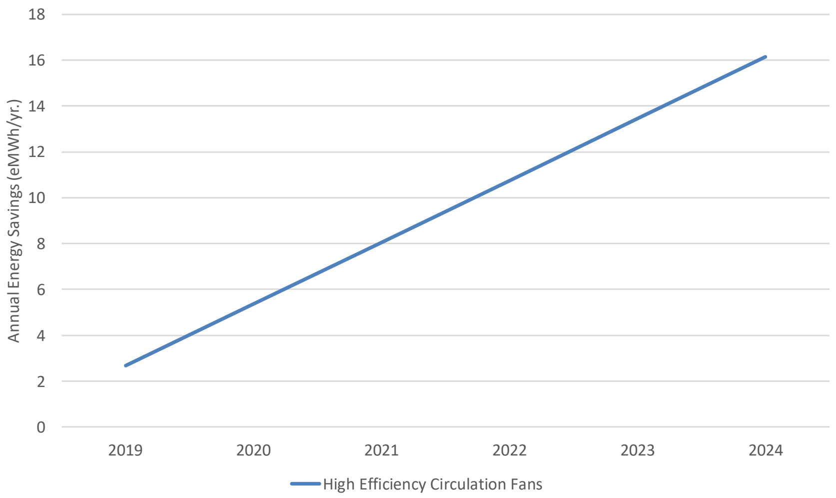
[10] Technical Potential is the theoretical maximum amount of energy use that could be displaced by the measures, only considering technical constraints. Non-technical constraints such as cost-effectiveness and the willingness of end-users to adopt the efficiency measures are not considered.

Non-Lighting Electricity Savings Potential

Exhibit 134 shows the electricity savings potential for vertical farming non-lighting measures, with high efficiency circulation fans being the only measure offering economic savings potential for this sub-sector.

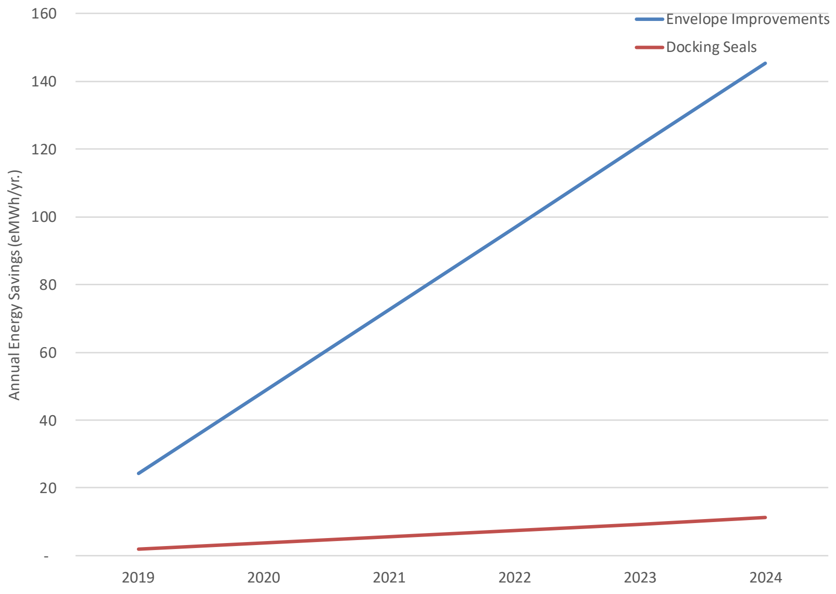
Exhibit 134 – Electricity Savings Potential by Measure for Vertical Farming Sub-Sector



Natural Gas Savings Potential

Exhibit 135 displays the economic savings potential for natural gas for the vertical farming sub-sector by measure. Envelope improvements and docking seals offer the greatest savings potential for this sub-sector.

Exhibit 135 – Natural Gas Savings Potential by Measure for Vertical Farming Sub-Sector



Energy Saving Incentive Programs

9 Energy Saving Incentive Programs

The provincial government discontinued the Conservation First Framework in March 2019 and replaced it with a new framework that has the IESO centrally delivering energy efficiency programs across Ontario. As a result of this change, some Save on Energy programs were cancelled, and some programs historically delivered by LDCs were centralized and are now administered by the IESO. The 2019-2020 interim framework offers the following programs via the IESO: the Retrofit Program, Small Business Lighting, the Energy Manager Program, Process and System Upgrades, Energy Performance Program, Home Assistance Program and energy-efficiency programming for Indigenous communities [68].

The following section provides an overview of the incentive programs applicable to the covered agricultural sector. The section also presents a high-level analysis of historic participation from the greenhouse sector under the recently superseded Conservation First Framework.

9.1 Existing Incentive Programs

Exhibit 136 summarizes the existing incentive programs that greenhouse/indoor agriculture facilities may be eligible to receive.

Exhibit 136 – Incentive Programs Relevant to the Covered Agriculture Sector

Program Name & Description	Administered (Funded) by	Program Type & Incentives	Eligible Sectors	Eligible Projects and Applicants
Process & Systems Upgrade Program (PSUP) The PSUP is designed to help organizations with complex systems and processes identify, implement, and validate energy efficiency projects from start to finish.	Save on Energy (IESO)	• Project incentive: the lesser of up to 70% of project costs, or; $200 per MWh of annual electricity savings	Industrial and Commercial	• Incentives available for implementing energy efficiency and electricity generation projects that are capital intensive. Incentives are also available for engineering feasibility studies once opportunities and costs have been identified. • Must be a single facility connected to a local hydro company distribution network. • The project must be in service before December 31, 2020

Program Name & Description	Administered (Funded) by	Program Type & Incentives	Eligible Sectors	Eligible Projects and Applicants
				and provide annualized electricity savings of at least 300 MWh
Retrofit Program Incentives available for energy saving equipment.	Save on Energy (IESO)	• Retrofit program: up to 50% of project costs for customer projects, or; fixed incentive levels for prescriptive projects • Prescriptive track: per unit incentives • Custom track: Incentives are based on energy savings over pre-project baselines.	Commercial, Industrial, Agricultural, or Institutional Facilities	• Must provide sustainable, measurable and verifiable reductions in electric peak demand and/or electricity consumption. • Prescriptive track: incentives available per unit of product; projects must be pre-approved; small projects must be worth a minimum incentive of a $500. • Custom track: incentive amount based on energy savings compared to pre-project baseline & capped at 50% of project cost; minimum incentive of $1,500. • Projects must deliver energy savings for at least 48 months.
Industrial Conservation Initiative The ICI is a demand response program that allows participating customers to manage their global adjustment (GA) costs by reducing	IESO	Customers who participate pay GA based on their percentage contribution to the top five peak Ontario demand hours over a 12-month base period.	Customers must have an average monthly peak demand greater than 500kW during an annual base period from May 1 to April 30; customers with an average peak demand above 5 MW automatically qualify as Class A customers (can opt out by June 15 of each year).	NA

Program Name & Description	Administered (Funded) by	Program Type & Incentives	Eligible Sectors	Eligible Projects and Applicants
electric peak demand during peak periods.				
Energy Manager Program Incentives to help bring an energy manager onto a team.	Save on Energy (IESO)	Incentive depends on the eligible organization	Industrial and Commercial	Incentive to hire a Certified Energy Manager, and further leverage incentive programs.

9.1.1 Other Energy Efficiency Support Programs

Energy Training and Support programs

Industry can receive training and support for energy management through a number of third-party training offerings, including the Dollars to $ense Energy Management Workshop and Certified Energy Manager training. In some cases, eligible individuals and organizations can apply for funding through Save on Energy to participate in these training and support programs [70].

Incentives to Reduce Natural Gas Consumption

Incentives are available from Enbridge to reduce natural gas consumption from space and water heating. Incentives are also available for engineering feasibility and process improvement studies [71]. Covered agriculture facilities are able to access these incentives to lower their natural gas consumption and associated costs.

Boulder County, Colorado has a Marijuana Energy Impact Offset Fund to help local cannabis producers to reduce the environmental impact of their operations. Commercial growers can offset their electricity use with local renewable energy or be required to pay a fee per kWh. The fee is put into the Offset Fund to help growers understand their energy use and find ways to reduce their consumption, including from more efficient lighting and ventilation systems [69].

9.2 Program Participation

Data from the IESO was analyzed to determine how many greenhouse operators participated in programs and for what types of projects. The following subsections provide details of participation in the PSUP and Retrofit program.

9.2.1 PSUP Program Participation

The following analysis is based on PSUP applications specifically from the agricultural sector as of January 22, 2019.

Twelve projects in covered agriculture facilities from nine companies in sub-sectors in scope for this study[11] are actively[12] participating in the PSUP program. Of these twelve projects, seven are in the cannabis sub-sector. All projects were for tri-generation systems, except for one ventilation and dehumidification upgrade project. The average estimated savings for the projects is 15,835 MWh, with 76,473 MWh being the highest estimated saving and 188 MWh being the smallest estimated savings. The average incentive amount is $3,754,740 with $14,780,000 being the highest incentive provided and $37,600 being the lowest incentive offered.

9.2.2 Retrofit Program Participation

The following analysis is based on Retrofit program applications specifically from the agricultural sector as of November 15, 2018.

In 2017, 42 applications were submitted to the Retrofit program for greenhouse[13] buildings and accepted.[14] In terms of measures, 60% of all projects were for lighting. In terms of project type, 88% of all projects were for equipment efficiency upgrades.

---

[11] Mushroom facilities were excluded from the application analyzed.

[12] Applications were filtered for “active” or “in-service” activity type. “Inactive” and “potentially inactive” were excluded.

[13] The study team filtered for ‘greenhouse’ under building type; all others were excluded.

[14] The study team filtered ‘In Quarterly Reporting’ for ‘Savings’ and excluded ‘rejected’ and ‘pipeline’.

Innovative & Emerging Technologies

10 Innovative & Emerging Technologies

Beyond the DSM opportunities discussed and analysed in detail in this study, there are several promising innovative solutions Ontario's covered agriculture sector and energy supply planners will be paying close attention to in the coming years. Technological advances, as well as advances in customization of technology for the covered agriculture sector, are being looked at to answer increasing energy demand in high density growing regions like Essex County by applying innovative solutions for improved flexibility, efficiency and reliability.

Covered agriculture growers have a long history of adoption of innovative practices and technologies and will continue to assess and adopt new solutions when sound business cases can be substantiated. Exploration of a number of promising technologies and energy solutions over the next six years through increased research and pilot testing will be important to build credible business cases for DSM, to enable cost reduction and increased competitiveness, and ensure energy reliability and resilience.

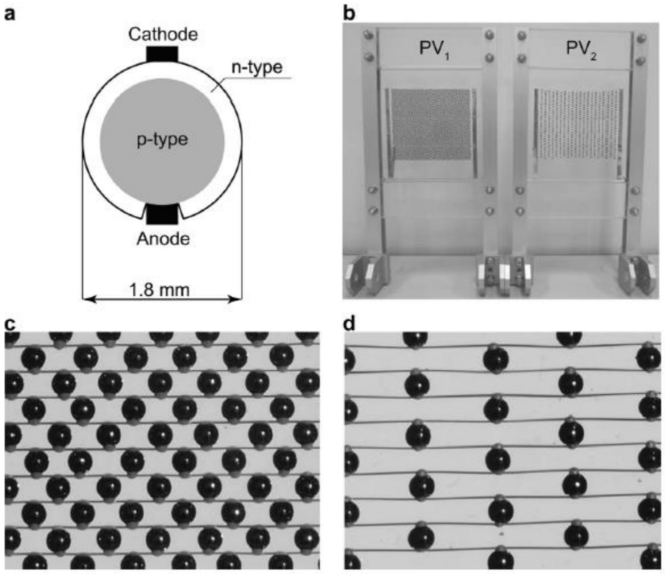
In 2012, Truly Green Farms began a project to build a greenhouse to produce tomatoes in Chatham-Kent. The greenhouse will be built out in phases over ten years, eventually reaching 90 acres of production area. This greenhouse will use waste heat and carbon dioxide from the nearby GreenField Ethanol plant, thereby lowering heating costs by 40-50% while increasing production by 5%. The provincial government provided $3.2 million to help support the costs of this innovative project – the first of its kind in North America [72] [73] [74].

Greenhouse-integrated semi-transparent solar photovoltaics

Although this technology is not yet widely used in Ontario, research and testing is underway in other countries including China [75], Japan [76] and Europe [77] to explore integrating solar photovoltaics into roof and shade screen [78] applications.

Here in Ontario, Ecohive is working with Soliculture and Heliene to provide bifacial solar cell technology to commercial greenhouses. Their "Greenhouse Integrated Photovoltaic Panels" are "designed to co-utilize the greenhouse roof for both positive crop growth and clean solar power production" [79].

Exhibit 137 – Cross-Sectional Structure of Typical Solar PV Panel Compared to Semi-Transparent Panel [76]

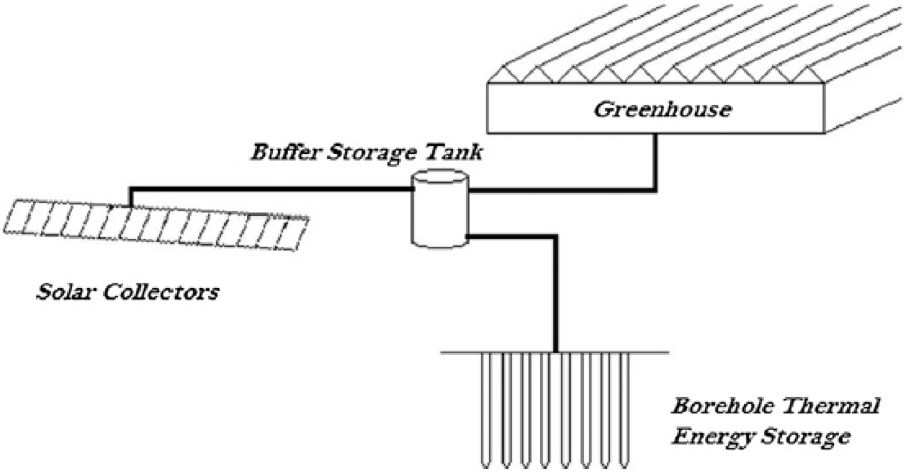


Seasonal thermal energy storage assisted ground-source heat pump

Solar assisted ground-source heat pumps (SAGSHP) systems look to have promising potential for the Ontario greenhouse sector in the future based on recent research undertaken by the University of Windsor.

"In heating dominated buildings utilizing a ground-source system, annual heat abstraction exceeding heat injection can lead to a decrease in mean ground temperature over time and decreased system coefficient of performance. With a solar-assisted system, solar energy harvested is used for ground recharge and increasing the source fluid temperature entering the heat pump." [80]

Exhibit 138 – SAGSHP System [80]



'Nextgen' control systems leveraging advanced sensors and artificial intelligence

Research currently underway in Ontario is expected to lead to more advanced sensor technology and integrated control platforms for optimizing grower operations.

In 2018, the Ministry of Agriculture and AgriFood announced "a federal investment of up to $5 million to the Automation Cluster under the Canadian Agricultural Partnership. The Cluster will be led by [Ontario's] Vineland Research and Innovation Centre Inc." and will focus on areas including "developing smart, wireless irrigation technologies for potted flowers and vegetables; and developing state-of-the-art sensors that will help detect and monitor moisture levels in the soil and air." [81]

At GreenTech 2018 in Amsterdam a new robotic scouting system was unveiled that "uses sensor technology, machine learning, and artificial intelligence to detect diseases, insect pests, deficiencies, and other plant abnormalities early on, allowing for a quick response before they become a serious problem. In addition to recognition of crop stress as the robot passes through the greenhouse, sensors also measure humidity, ambient temperature, CO_2, plant temperature, and photosynthetic ambient radiation." [82]

Hybrid generation & storage

Ontario growers are already very familiar with the advantages tri-generation systems offer (as discussed elsewhere in this study). Advances in battery system technology, combined with other renewable generation technology (e.g., solar photovoltaic), mean there will be more beneficial opportunities for growers to explore in the coming years. System planners will also have a keen interest in how the combination of generation and storage can be used to defer system upgrades and enhance regional reliability.

For example, the Arizona Public Service (APS) recently commissioned a battery energy storage system (BESS) as a solution to defer the need for a new distribution feeder due to load growth that was outstripping existing grid capabilities in a community outside Phoenix. APS considered several alternatives, including a traditional line upgrade and diesel gensets. The 2MW, 8 MWh BESS provided the least-cost option and is expected to provide the needed capacity for the community over the next 5 to 10 years [83].

Exhibit 139 – BESS commissioned by Arizona Public Service [83]

Microgrids and asset networking

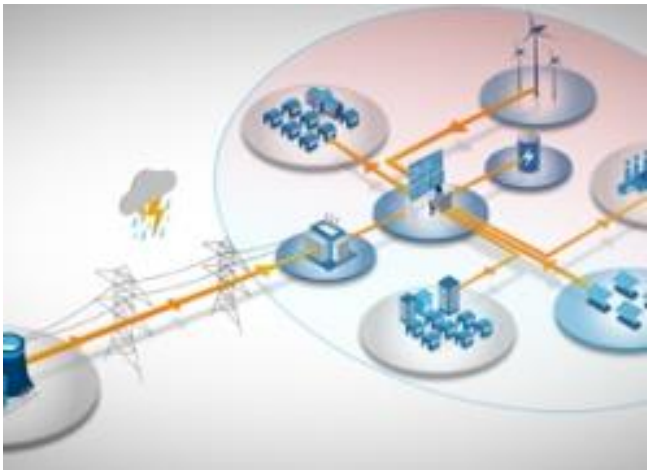
Growers in Essex County have already started installing behind the meter generation and there are plans for this to continue to enable expansion plans and the adoption of grow lighting in the region given the shortage of grid supplied electricity in the short-term. In this region, and in others if similar grid constraints are encountered in the future, there is a unique opportunity to explore microgrid opportunities, nested microgrids (interconnection of multiple microgrids on a single network) and peer-to-peer networking across generation assets.

Progress assessing a solution like this is already underway in other part of North America, including Texas, California, North Carolina, and Illinois. In Texas, Oncor, S&C Electric and Schneider Electric built a four-part microgrid on the backbone of an energy storage system:

> *"The grid-tied system consists of four interconnected microgrids and nine different distributed generation resources: two solar PV arrays, a microturbine, two energy storage units, and four generators. The system has a total peak capacity of 900 kilowatts but could theoretically scale to meet just about any need."* [84]

Another example is the Penetanguishene MiDAS Microgrid project. In June 2016, Alectra Utilities and Korea Electric Power Corporation commissioned a microgrid that features a 750 kVA Power Conversion System, 500 kWh battery and autonomous microgrid controller [85].

Exhibit 140 – Alectra Utilities' Microgrid Solution [85]



The University of Windsor's Environmental Energy Institute has two projects focused on energy use in greenhouses. The Greenhouse Solar Energy System to Reduce Carbon and Grid Dependency is researching the optimal solar energy system for Ontario greenhouses to reduce GHG emissions, grid reliance, energy costs and capital investment. This project is being funded by the Greenhouse Renewable Energy Technologies R&D Initiative [86]. The University is also working on the Greener Greenhouses project which seeks to reduce GHG emissions from greenhouses by using a solar thermal, photovoltaic and geo-seasonal thermal storage technologies [87].

Next Steps: Demand Side Management Priorities

11 Next Steps: Demand Side Management Priorities

This section presents a discussion about where energy supply planners, growers and covered agriculture stakeholders should be focusing their attention in the short term so that research and funding efforts can be applied judiciously to have the largest impact on supporting grid reliability through demand side management.

11.1 LED Grow Lighting

The predominant lighting technology in the horticulture sector continues to be high-intensity discharge (HID) lighting, with double-ended high-pressure sodium (DE-HPS) grow lights being used in a typical covered agriculture facility. Although there is a lot of discussion in the covered agriculture sector about light-emitting diode (LED) grow lights, it is not yet widely accepted as a viable replacement option for several reasons all related to maturity risk:

- Savings claims being made by lighting suppliers have been at odds with published research [48] [49].
- The cost of agricultural LED products still varies widely and is expected to come down in the coming years as the technology continues to mature. This means technology improvement in the near future will likely outperform any LED technology installed today at a lower cost [48].
- There is a learning curve required for growers to switch from DE-HPS to LED, creating a barrier that growers tend not be willing to accept given the relative immaturity of the technology [50].

In Ontario, adoption in the vegetable and flower sub-sectors continues to be minimal [50], while some growers in the cannabis sub-sector have shown a greater willingness to test and adopt the new technology [50]. Until very recently no clear horticulture lighting standards existed for manufacturers; growers are skeptical of performance of LED with claims ranging from 20-60% energy savings [48] [49] [50] and costs in the range of a four to five fold increase compared to DE-HPS fixtures [88].

LED in the Near Future

In response to the increasing interest in LED lighting in plant growth applications, The American Society of Agricultural and Biological Engineers (ASABE) has developed new horticulture lighting standards. In the coming years these lighting standards should pave the way to build trust between growers and lighting manufactures and suppliers regarding performance information as LED technology continues to mature.

The following section, excerpted from ASABE documents, describes the context that drove the development of new lighting standards for the horticulture sector [89]:

> *"Currently, device energy performance metrics commonly utilize the human eye response to visible radiation (light); common practice is to measure or calculate luminous efficacy (lumen per watt). This is not applicable to plant growth in the horticultural industry, in which the radiant flux or photon flux is a more significant value than lumen output to accurately predict plant response. Furthermore, studies have demonstrated that different plant species respond to*

> *radiation wavelength distributions differently. Thus, the device performance characteristics may need to be defined for varied horticultural applications. Such characteristics include but are not limited to the spectral content, intensity, flux density, and uniformity."*

Two ASABE standards, in a three-part series of horticulture lighting standards, have already been released. The published ASABE standards are[15]:

- ANSI/ASABE Standard S640 titled "Quantities and Units of Electromagnetic Radiation for Plants (Photosynthetic Organisms)" – This standard establishes units of measure to describe horticulture lighting.
- ANSI/ASABE S642 titled "Recommended Methods for Measurement and Testing of LED Products for Plant Growth and Development" – This standard provides guidance to LED manufacturers on the recommended testing methods for publishing performance specifications.
- The third and final ASABE standard in the series is expected to cover performance criteria requirements for horticulture lighting.

The DesignLights Consortium (DLC) has also recently developed a new performance standard for LED products used in horticulture applications. Besides specifying technical requirements for various light output characteristics, such as Photosynthetic Photon Flux (PPF), testing and reporting of lamp efficacy, represented by Photosynthetic Photon Efficacy (PPE), is also mandated by the standard. Manufacturers will be eligible to list qualified products on DLC's new Horticultural Qualified Products List (QPL) [90].[16]

LED Measure Sensitivity Analysis

The heat map below shows TRC based on avoided electricity consumption costs[17]. As shown, for an LED measure to be TRC positive for a consumption-based program, unit costs need to be in the range of $0.25-$1.00/installed LED watt for retrofit scenarios ranging from 80-25% of baseline wattage (20-75% savings).

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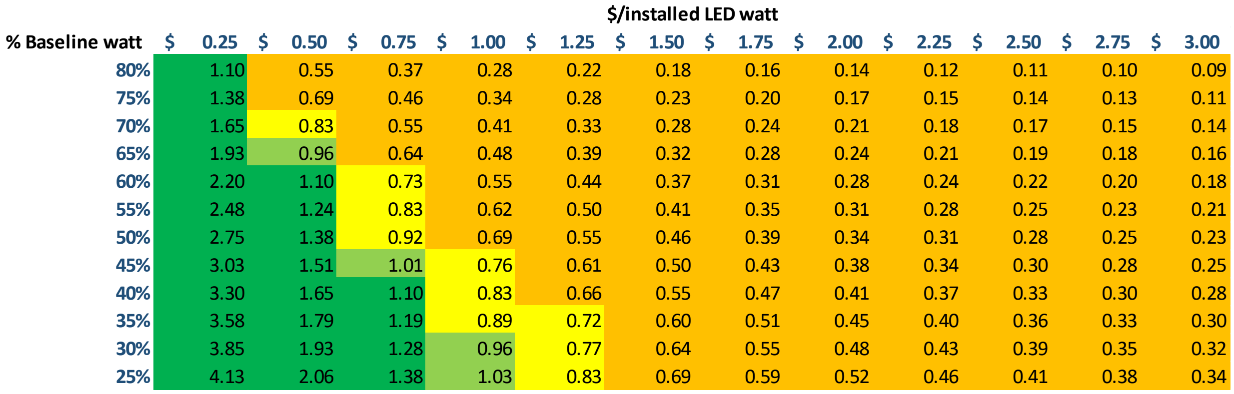
[15] Available here from ASABE technical library: https://elibrary.asabe.org/default.asp

[16] Further details on DLC's technical requirements for their new standard is available at: https://www.designlights.org/horticultural-lighting/technical-requirements/

[17] Avoided capacity costs are ignored to simplify the analysis because greenhouse lighting doesn't have a significant impact on the provincial summer peak

Exhibit 141 – TRC Heat Map: Avoided Electricity Consumption

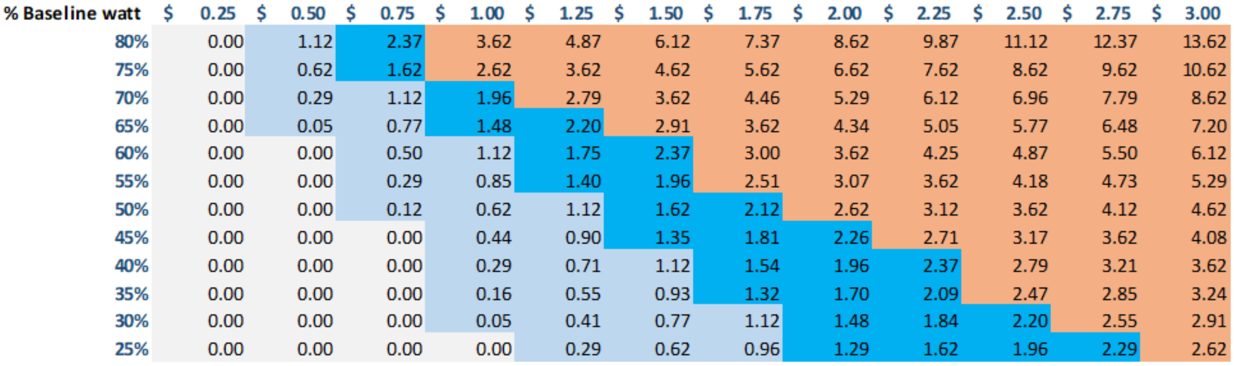


	$/installed LED watt											
% Baseline watt	$ 0.25	$ 0.50	$ 0.75	$ 1.00	$ 1.25	$ 1.50	$ 1.75	$ 2.00	$ 2.25	$ 2.50	$ 2.75	$ 3.00
80%	1.10	0.55	0.37	0.28	0.22	0.18	0.16	0.14	0.12	0.11	0.10	0.09
75%	1.38	0.69	0.46	0.34	0.28	0.23	0.20	0.17	0.15	0.14	0.13	0.11
70%	1.65	0.83	0.55	0.41	0.33	0.28	0.24	0.21	0.18	0.17	0.15	0.14
65%	1.93	0.96	0.64	0.48	0.39	0.32	0.28	0.24	0.21	0.19	0.18	0.16
60%	2.20	1.10	0.73	0.55	0.44	0.37	0.31	0.28	0.24	0.22	0.20	0.18
55%	2.48	1.24	0.83	0.62	0.50	0.41	0.35	0.31	0.28	0.25	0.23	0.21
50%	2.75	1.38	0.92	0.69	0.55	0.46	0.39	0.34	0.31	0.28	0.25	0.23
45%	3.03	1.51	1.01	0.76	0.61	0.50	0.43	0.38	0.34	0.30	0.28	0.25
40%	3.30	1.65	1.10	0.83	0.66	0.55	0.47	0.41	0.37	0.33	0.30	0.28
35%	3.58	1.79	1.19	0.89	0.72	0.60	0.51	0.45	0.40	0.36	0.33	0.30
30%	3.85	1.93	1.28	0.96	0.77	0.64	0.55	0.48	0.43	0.39	0.35	0.32
25%	4.13	2.06	1.38	1.03	0.83	0.69	0.59	0.52	0.46	0.41	0.38	0.34

The next heat map examines what local avoided capacity cost (net present value in dollars per watt) would be required to achieve a TRC of 1; avoided consumption costs are included in the analysis:

- Grey cells show unit cost and baseline wattage ranges where TRC is positive without the addition of local avoided capacity costs.
- Light blue cells show unit cost and baseline wattage ranges where local avoided capacity cost ranges between $0 - 1.20/W. For reference, the net present value of provincial system avoided capacity costs is $1.20/W.
- Dark blue cells show unit cost and baseline wattage ranges where local avoided capacity cost ranges between $1.20-2.40/W.

Exhibit 142 – Local Avoided Capacity Cost Heat Map: Net Present Value $/W



% Baseline watt	$ 0.25	$ 0.50	$ 0.75	$ 1.00	$ 1.25	$ 1.50	$ 1.75	$ 2.00	$ 2.25	$ 2.50	$ 2.75	$ 3.00
80%	0.00	1.12	2.37	3.62	4.87	6.12	7.37	8.62	9.87	11.12	12.37	13.62
75%	0.00	0.62	1.62	2.62	3.62	4.62	5.62	6.62	7.62	8.62	9.62	10.62
70%	0.00	0.29	1.12	1.96	2.79	3.62	4.46	5.29	6.12	6.96	7.79	8.62
65%	0.00	0.05	0.77	1.48	2.20	2.91	3.62	4.34	5.05	5.77	6.48	7.20
60%	0.00	0.00	0.50	1.12	1.75	2.37	3.00	3.62	4.25	4.87	5.50	6.12
55%	0.00	0.00	0.29	0.85	1.40	1.96	2.51	3.07	3.62	4.18	4.73	5.29
50%	0.00	0.00	0.12	0.62	1.12	1.62	2.12	2.62	3.12	3.62	4.12	4.62
45%	0.00	0.00	0.00	0.44	0.90	1.35	1.81	2.26	2.71	3.17	3.62	4.08
40%	0.00	0.00	0.00	0.29	0.71	1.12	1.54	1.96	2.37	2.79	3.21	3.62
35%	0.00	0.00	0.00	0.16	0.55	0.93	1.32	1.70	2.09	2.47	2.85	3.24
30%	0.00	0.00	0.00	0.05	0.41	0.77	1.12	1.48	1.84	2.20	2.55	2.91
25%	0.00	0.00	0.00	0.00	0.29	0.62	0.96	1.29	1.62	1.96	2.29	2.62

To put this further into perspective, the heat map below shows simple payback (without program incentives) across the same range of cost and performance data

Exhibit 143 – Simple Payback Heat Map

	$/installed LED watt											
% Baseline watt	$ 0.25	$ 0.50	$ 0.75	$ 1.00	$ 1.25	$ 1.50	$ 1.75	$ 2.00	$ 2.25	$ 2.50	$ 2.75	$ 3.00
80%	2.10	4.19	6.29	8.39	10.49	12.58	14.68	16.78	18.88	20.97	23.07	25.17
75%	1.68	3.36	5.03	6.71	8.39	10.07	11.75	13.42	15.10	16.78	18.46	20.13
70%	1.40	2.80	4.19	5.59	6.99	8.39	9.79	11.19	12.58	13.98	15.38	16.78
65%	1.20	2.40	3.60	4.79	5.99	7.19	8.39	9.59	10.79	11.98	13.18	14.38
60%	1.05	2.10	3.15	4.19	5.24	6.29	7.34	8.39	9.44	10.49	11.54	12.58
55%	0.93	1.86	2.80	3.73	4.66	5.59	6.53	7.46	8.39	9.32	10.25	11.19
50%	0.84	1.68	2.52	3.36	4.19	5.03	5.87	6.71	7.55	8.39	9.23	10.07
45%	0.76	1.53	2.29	3.05	3.81	4.58	5.34	6.10	6.86	7.63	8.39	9.15
40%	0.70	1.40	2.10	2.80	3.50	4.19	4.89	5.59	6.29	6.99	7.69	8.39
35%	0.65	1.29	1.94	2.58	3.23	3.87	4.52	5.16	5.81	6.45	7.10	7.74
30%	0.60	1.20	1.80	2.40	3.00	3.60	4.19	4.79	5.39	5.99	6.59	7.19
25%	0.56	1.12	1.68	2.24	2.80	3.36	3.92	4.47	5.03	5.59	6.15	6.71

In the absence of program incentives, growers typically want to see a payback of 2 years or less for a measure like LED lighting due to its relatively unproven status [50]. As shown, for an LED measure to have a payback under 2 years, unit costs need to be in the range of $0.25-$0.75/installed LED watt for retrofit scenarios ranging from 75-25% of baseline wattage (25-75% savings). To date, LED costs in horticulture lighting applications in Ontario have all been higher than $0.75/installed LED watt [48].

LED Advantages & Potential Impact to the Sector

LED lighting offers two important advantages that have the potential to have a major impact on the sector as the technology matures and as growers begin to trust manufacturer and lighting supplier information [91]:

1) LEDs are a point light source with directional output, where HPS lamps emit light in a 360-degree sphere. In other words, LEDs mean more light can be transferred to the plant canopy.
2) LED manufacturers can tune the light output to specific parts of the lighting spectrum, enabling greater transfer of photons within the optimum spectrum to the plant canopy.

To illustrate the magnitude of the savings potential that will be possible in the future once LED becomes more widely accepted as a legitimate replacement option, two TRC positive[18] savings scenarios have been modelled relative to the reference case:

a) "LED Grow Lights A" -- 55% savings at a cost point of $1.25/installed LED watt (a mid-range cost value) [48]
b) "LED Grow Lights B" -- 35% savings at a cost point of $0.75/installed LED watt (the lowest cost point reported in Ontario to date) [48]

Exhibit 144 shows the energy savings potential for the two variations on the LED measure.

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[18] From a demand savings perspective.

Exhibit 144 – Hypothetical Consumption Savings Potential for 2 LED Scenarios

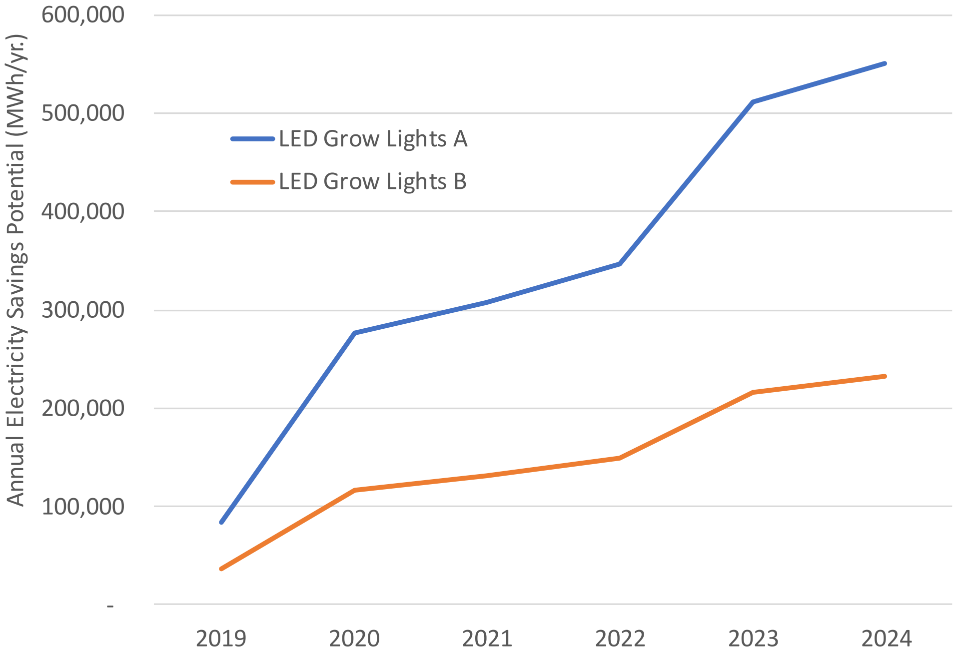
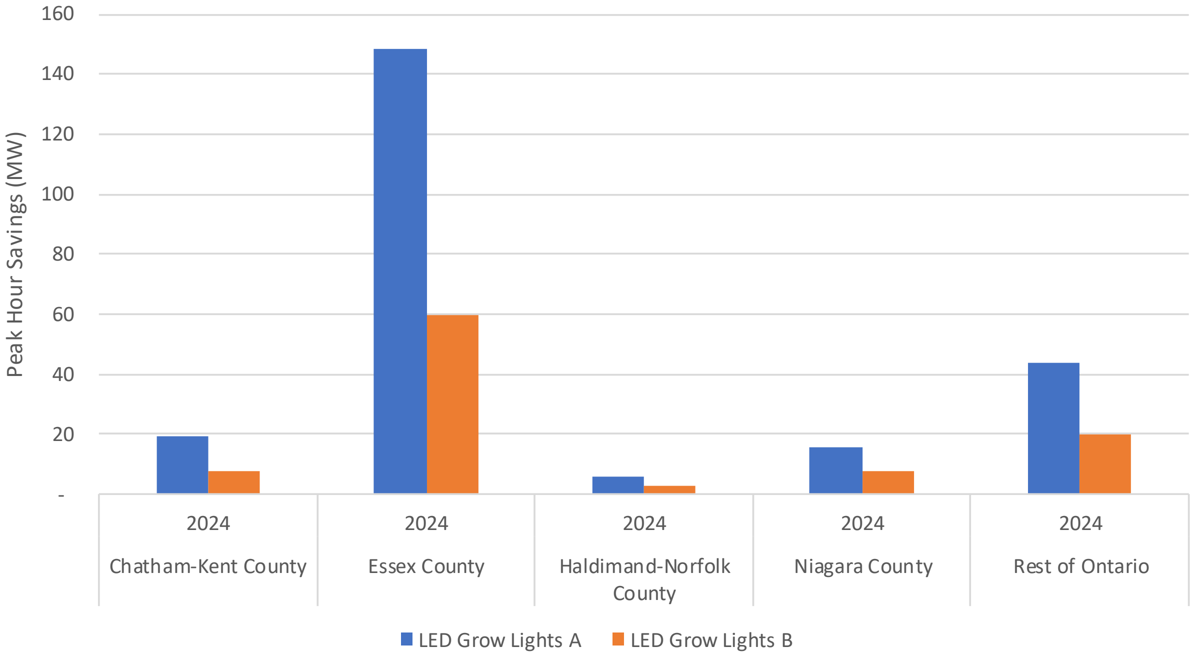


Exhibit 145 – Hypothetical Greenhouse Peak Demand Savings Potential by Region for 2 LED Scenarios



As shown, LED lighting could have an impact between 230 GWh/year and 550 GWh/year by 2024. In Essex, for example, LED lighting could have a greenhouse peak hour impact in the range of about 60 to 150 MW by 2024.

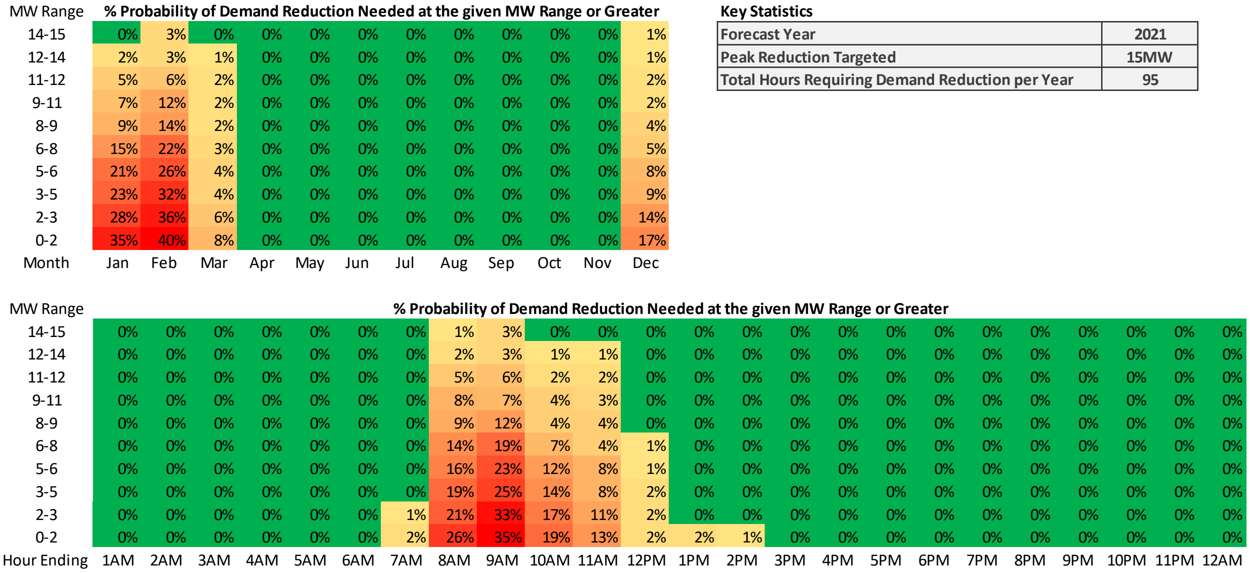
11.2 Lighting Load Demand Response

“Demand response is a dispatchable solution involving loads that can be reduced or avoided during hours when the need occurs.” [88] Because grow lighting is a significant contributor to greenhouse peak hour in regions with high concentrations of greenhouses (e.g. Essex, Niagara), demand response targeting lighting schedules could have a notable impact on peak reductions. In practice, this load could be shed by:

- Turning-off lighting (or reducing lighting levels) when the local grid is projected to peak
- Staggering light cycles [92]
- Potentially leveraging other technologies that could achieve the same impact (e.g., storage, behind the meter generation)

Per the Windsor-Essex Integrated Regional Resource Plan (IRRP) Report, “the magnitude of the desired peak reduction will determine the duration and frequency of the need. The relationship between these variables is inherently probabilistic since the load profile varies daily and seasonally. As an example, [Exhibit 146 below] visualizes the duration and frequency requirement for a desired peak reduction of 15 MW in 2021 using a heat map which shows the probability that a need may arise in a given time of year and hour of day.”

Exhibit 146 – Heat Map of Need for 15 MW Reduction



MW Range	% Probability of Demand Reduction Needed at the given MW Range or Greater											
14-15	0%	3%	0%	0%	0%	0%	0%	0%	0%	0%	0%	1%
12-14	2%	3%	1%	0%	0%	0%	0%	0%	0%	0%	0%	1%
11-12	5%	6%	2%	0%	0%	0%	0%	0%	0%	0%	0%	2%
9-11	7%	12%	2%	0%	0%	0%	0%	0%	0%	0%	0%	2%
8-9	9%	14%	2%	0%	0%	0%	0%	0%	0%	0%	0%	4%
6-8	15%	22%	3%	0%	0%	0%	0%	0%	0%	0%	0%	5%
5-6	21%	26%	4%	0%	0%	0%	0%	0%	0%	0%	0%	8%
3-5	23%	32%	4%	0%	0%	0%	0%	0%	0%	0%	0%	9%
2-3	28%	36%	6%	0%	0%	0%	0%	0%	0%	0%	0%	14%
0-2	35%	40%	8%	0%	0%	0%	0%	0%	0%	0%	0%	17%
Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec

Key Statistics

Forecast Year	2021
Peak Reduction Targeted	15MW
Total Hours Requiring Demand Reduction per Year	95

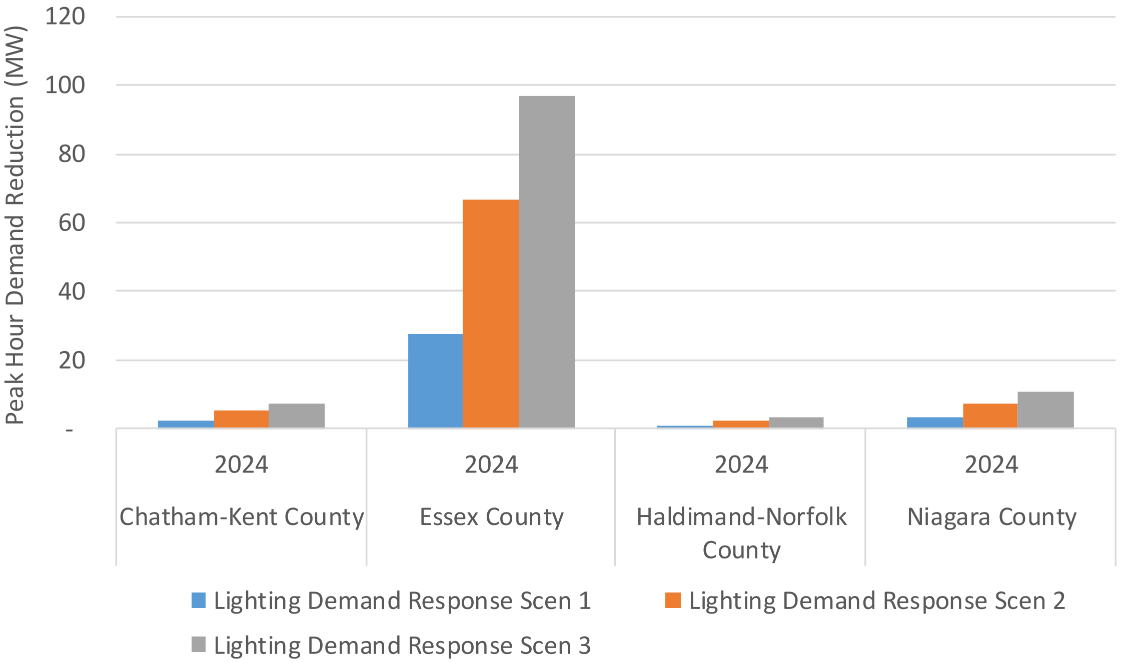
MW Range	% Probability of Demand Reduction Needed at the given MW Range or Greater																							
14-15	0%	0%	0%	0%	0%	0%	0%	1%	3%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
12-14	0%	0%	0%	0%	0%	0%	0%	2%	3%	1%	1%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
11-12	0%	0%	0%	0%	0%	0%	0%	5%	6%	2%	2%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
9-11	0%	0%	0%	0%	0%	0%	0%	8%	7%	4%	3%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
8-9	0%	0%	0%	0%	0%	0%	0%	9%	12%	4%	4%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
6-8	0%	0%	0%	0%	0%	0%	0%	14%	19%	7%	4%	1%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
5-6	0%	0%	0%	0%	0%	0%	0%	16%	23%	12%	8%	1%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
3-5	0%	0%	0%	0%	0%	0%	0%	19%	25%	14%	8%	2%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
2-3	0%	0%	0%	0%	0%	0%	1%	21%	33%	17%	11%	2%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
0-2	0%	0%	0%	0%	0%	0%	2%	26%	35%	19%	13%	2%	2%	1%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Hour Ending	1AM	2AM	3AM	4AM	5AM	6AM	7AM	8AM	9AM	10AM	11AM	12PM	1PM	2PM	3PM	4PM	5PM	6PM	7PM	8PM	9PM	10PM	11PM	12AM

For consistency with the analysis explored by the IESO as part of the Essex Region IRRP process [88], three different measure scenarios have been modelled to explore the range of potential load reduction impacts:

- Scenario 1: 30% demand reduction for 4 hours(5am-9am)
- Scenario 2: 60% demand reduction for 2 hours(6am-8am)
- Scenario 3: 85% demand reduction for 3 hours (5am-8am)

Exhibit 147 shows the hypothetical greenhouse peak hour impact in 2024 by region for each of the three scenarios.

Exhibit 147 – Demand Response Potential in 2024 by Region for the 3 Load Reduction Scenarios



One of the key market barriers identified during the Essex Region IRRP process was the uncertainty about whether growers would be able to meet the frequency and duration of curtailment that would be required if a demand response program was being relied on as a dependable non-wires solution. For example, it is not clear [88]:

- What the maximum acceptable duration of lighting curtailment will be for growers, and what growers will consider an acceptable frequency during a growing season;
- What associated costs of taking demand response actions are for growers, including what type of impacts they have on crop productivity; and
- Whether there are variations between crop types that would impact the answers to any of the above uncertainties.

The good news is that demand response in the greenhouse sector has been around for a long time; in the 1980's well known methods for demand response were implemented in the covered agriculture sector by Ontario Hydro and other North American utilities [93]. Today in Colorado, Xcel Energy's Peak Partner Awards program is open to any customer that is "able to shed 25 kW or more on call (called events) in the summer months (June through September) during peak hours (between 2 pm and 6 pm):

> "*The customer commits to the level of capacity they are willing to reduce (which is decided on a monthly basis) for which they are awarded $2/kW per month for that commitment. If an event is called, the customer is also eligible for an additional credit of $0.70/kWh throughout the duration of the event*" [94] [92].

Demand response aggregators may also be a helpful ally. In the U.S., aggregators use cloud-based platforms that connect greenhouse energy assets, such as lighting and climate control, to a management control system. A typical covered agriculture customer in Colorado earns money each year for helping to balance the grid, typically be reducing their lighting for less than one hour a week [92].

There is also an opportunity to leverage existing research and tool development and deploy or test it here in Ontario:

- As published in a 2015 research paper, a European company has developed a software tool specifically designed to dynamically control supplemental lighting in greenhouses. "The software uses weather forecasts and electricity prices together with a photosynthesis model to compute energy and cost-efficient supplemental light plans, which fulfills the productivity goal defined by the grower." Research findings show that although not all plants are able to cope with irregular light environments across all growth phases, some plants can without noticeable effects. The researchers "were able to reallocate between 7.8% and 10.6% of the light hours used for supplemental lighting," decreasing peak energy demand and energy costs "without noticeable effect on the plant quality" [95].
- Similar research by the University of Waterloo presents a control approach based on novel optimization models to "optimize temperature, humidity, CO2 concentration, and lighting levels" to "minimize total energy costs and demand charges" [96].

11.3 Energy Supply Planning Focus: Regions with High Greenhouse Concentrations

One of the indicators for additional electricity growth in the greenhouse sector is the availability and ease of access to gas and water infrastructure. Planners have already been paying close attention to the Essex region and there are already significant infrastructure improvements planned to address forecasted growth constraints being driven by the growing greenhouse sector.

Over the next six years, electricity supply planning will focus more closely on other regions with high greenhouse concentrations. For example, if the OEB approves the Chatham-Kent Rural Pipeline expansion, the Chatham-Kent region could see an increase in electricity connection requests – similar to those being submitted in the Essex region after the after the Kingsville Transmission Reinforcement Project was approved. Already there are electricity constraints in the Chatham-Kent area, with a new 55MW cannabis facility that is able to connect 30MW in 2020, but must wait until 2023 to connect the rest of the facility. Niagara and Haldimand–Norfolk regions are also strong candidates for additional growth and constraints in future years.

11.4 Deeper Research in the Cannabis Sub-sector

CEATI International is launching a study in Q4 2019 to profile the indoor and greenhouse cannabis sector in more detail. The objectives of the study are twofold: to assess and document baseline consumption of electricity and natural gas, and to document best practices, available technologies, and implementation costs for saving energy. The outcome of this work will enhance the Ontario cannabis sector research presented in this study and will enable comparison of Ontario's sector to sectors in other North American jurisdictions. Results are expected early 2020.

11.5 Energy Efficiency as a Resource: Targeted Call for Pilot Programs

"Through its Grid Innovation Fund, the IESO is issuing a call for novel projects focused on reducing electricity demand from indoor agriculture during local and bulk system peak periods. The IESO will accept proposals from November 18, 2019 – February 14, 2020 and award up to $2.5 million for approved projects. Special consideration will be made for projects located in areas with identified or anticipated electricity infrastructure challenges related to indoor agriculture expansion."

"This target call aims to:

- Accelerate the adoption of cost-effective demand-side solutions by greenhouse growers,
- Demonstrate the efficacy of demand-side options to address local transmission and distribution infrastructure capacity need(s), and
- Explore unknowns in the operationalization of demand-side options and the impact on greenhouse productivity" [97]

Energy supply planners, growers and covered agriculture stakeholders can reference findings from this study to hone their focus and set priorities for the pilot programs. Areas for opportunity include:

- The DSM measures with the greatest potential for consumption and demand savings (see Sections 2, 3.4, 4.4, 6.4 and 7.4),
- LED and demand response opportunities (see subsections above), and
- Innovative and emerging technologies (see Section 10).

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Appendix A Project Overview

Study Team and Advisory Committee

The study team is comprised of individuals from Posterity Group Consulting Inc. (“Posterity Group”) and Wood Environment & Infrastructure Solutions (“Wood”).

The IESO was the main client for this study. Enbridge and Ontario Greenhouse Vegetable Growers (OGVG) also contributed financial resources to the study.

The study was also supported by an Advisory Committee whose role was to provide input and guidance to the study ensuring study findings are comprehensive and broadly applicable. The group includes representatives from the IESO, electric local distribution companies, Enbridge, commodity group associations (OGVG, Flowers Canada, and the Cannabis Council of Canada), the Ontario Federation of Agriculture (OFA) and the Ontario Ministry of Agriculture, Food and Rural Affairs (OMAFRA).

Data Collection Activities and Information Sources

The study team collected data and information from a variety of sources to develop the base year, reference case assumptions, concepts for the scenarios, and measures to include in the energy savings potential analysis.

The main data collection activities, information sources and research included:

1. Focus group sessions with growers

Two focus group sessions were conducted: one with flower growers and one with vegetable growers. We were unable to conduct a focus group session with cannabis growers as no growers volunteered to participate, due to privacy concerns and a lack of availability due to priorities associated with the newly developing cannabis market in Ontario.

The following topics were discussed in the flower and vegetable sessions:

- Future growth and expansion: plans and barriers
- On-site power generation opportunities and demand response measures
- Uptake of energy efficiency measures
- General trends and issues in the industry

2. Survey of Growers

A survey was distributed to the growers that participated in the focus group sessions. The survey focused on detailed site consumption data and energy efficiency measures growers currently use and are considering for the future. Responses were received from a total of 13 growers (10 vegetable growers and 3 flower growers).

3. Facility walk-throughs

The study team visited two greenhouses – one growing flowers and the other growing vegetables – to obtain the following data:

- Energy load center details (number of pieces and types of energy using equipment)
- Estimated energy consumption by end use between the site energy load centers

4. Interviews with market actors

The study team interviewed select market actors, including energy managers and organizations that manufacture greenhouses and/or supply equipment to greenhouse operations. Topics discussed included:

- Current state of the greenhouse sector and energy use
- Differences between newly constructed greenhouses and expanded facilities
- Expectations for the future
- Market interest in energy efficiency measures and local generation

5. Data requests to utilities and local distribution companies

The study team requested hourly consumption data for greenhouse customers from Enbridge and local distribution companies. The following anonymized data was provided:

- Hydro One: hourly electricity consumption data for 326 greenhouse customers for 2016 and 2017, and annual consumption data for an additional 311 greenhouse customers
- Enbridge Gas (legacy Union): hourly gas consumption data for 125 greenhouse customers for 2017

6. Provincial Data on the Greenhouse Sector

Provincial-level data on the greenhouse and cannabis sectors was obtained from OMAFRA and Statistics Canada, specifically:

- OMAFRA: regional and county profiles: agriculture, food, and business. Provincial-level information about biomass used for heating in greenhouses.
- Statistics Canada: greenhouse products and mushrooms (Table 32-10-0420-01)

7. Research of secondary resources

The study team conducted extensive research on existing literature of energy use and production of greenhouses and the indoor cannabis sub-sector. Please see the Bibliography for sources used to develop this study.

Appendix B Model Structure

Energy and water use, and GHG emissions were estimated using Posterity Group's Navigator Energy and Emissions Simulation Suite. The model was created to reflect the unique needs of this project, as described below. This information is here to provide context for the information provided throughout the study report.

Model Parameters

The model is structured on five parameters. Exhibit 148 defines each parameter for this study and what metric is used to express the parameter.

Exhibit 148 – Model Parameters

Parameter	Definition	Expressed As
Accounts	Number of facilities	# of facilities
Units	Total square footage of facilities	sq. ft.
Size	Size of a facility (Units/Accounts)	sq. ft.
Area Built Out and Operating (%)	Primarily used for cannabis facilities, this parameter indicates the amount of square footage in an existing facility that is fully operational, as opposed to square footage that is currently not being used for production	%
Lit Portion	The portion of units that have supplemental lighting	%
Fuel Share	The percentage of the energy end-use that is supplied by each fuel	%
Unit Energy Consumption (UEC)	The amount of energy used by each end-use per unit	$\frac{eMWh}{sq.ft.}$

Data is added to the model based on this structure to calculate energy consumption, as well as hourly energy demand.

Model Segments

For this study, energy consumption and demand are segmented in the following ways:

Exhibit 149 – Model Segments

Regions

- Niagara
- Essex
- Chatham-Kent
- Haldimand-Haldimand–Norfolk
- Rest of Ontario

Sub-Sectors

- Vegetables & Fruits (lit/unlit)
- Flowers & Potted Plants (lit/unlit)
- Cannabis - Greenhouse (lit/unlit)
- Cannabis - Indoor
- Vertical Farming

End Uses

- Lighting
- Space Heating
- Air Conditioning
- Irrigation and Circulation Pumps
- Other (ventilation, CO_2 injection, drying, etc.)

Fuels

- Natural gas
- Grid electricity
- Onsite electricity generation
- Oil
- Biomass
- Cogeneration heat
- Water

Appendix C Sector Scenarios

Scenarios were modelled to illustrate potential futures of the covered agriculture sector. Adjustments are made to model parameters to show deviations from the reference case. The concepts for these scenarios are based on input from key stakeholders and the assumptions are based on the study's research sources.

Two scenarios were developed for this study to show potential deviations from the reference case: a high growth scenario and a low growth scenario. A brief description of each scenario is provided below.

High Growth Scenario

The high growth scenario models what the sector would look like if there is significant growth in the greenhouse industry across all regions of the province. Factors that could cause/contribute to high growth in the sector include:

- High commodity prices (e.g., under supply of cannabis)
- Low (or consistent long-term) energy prices relative to current prices and other jurisdictions
- Adequate supply of natural gas and electricity
- Favourable trade conditions with the U.S. and Mexico

High Growth Scenario Modelling

The high growth scenario was modelled using the following assumptions:

- Number of accounts grows by 2% per year (1% was used in the reference case) in the vegetable and flowers sub-sectors.
- Number of greenhouse cannabis accounts are doubled compared to the reference case
- Size of vegetable facilities grows by 8% per year (4% was used in the reference case) for all regions, except:
  - Growth in the Essex region for the vegetable and greenhouse cannabis sub-sectors follows the reference case due to the known energy supply constraints in the Essex region.
- Size of flower greenhouses grows by 3% per year in all regions.
- Growth in Chatham for indoor cannabis follows the reference case, which reflects a new large facility coming online in 2020.
- Sub-sectors that do not grow in the reference case (indoor cannabis, and vertical farms) do not grow in the high growth scenario.
- All other model parameters follow the reference case.

Low Growth Scenario

The low growth scenario models what the sector would look like if growth aligns with the reference case in 2019 and 2020 (assume investment decisions made in the base year and 2019 will be carried out), but flatlines afterwards as growth-perverse economic conditions persist. The following factors could cause or contribute to this:

- Reduced investment by vegetable & fruit, and/or flower & potted plant growers in Ontario because of:
  - High energy costs relative to other jurisdictions, including in the U.S.
  - Low commodity prices
  - Inability of greenhouse operators to secure enough electricity/natural gas to meet growth requirements
  - Unfavourable or uncertain terms of trade with the U.S. and Mexico

Low Growth Scenario Modelling

The low growth scenario was modelled by following the account growth assumptions used in the reference case until 2020 and having no growth until 2024. Specifically:

- Number of accounts grow by 1% per year in 2019 and 2020, per the reference case, and then remain constant until 2024. This assumption applies to all the sub-sectors and regions except for the Flowers sub-sector, which does not experience any growth in the number of accounts in 2019 and 2020 in the reference case.
- The growth in size of facilities follows the reference case assumptions.

Scenario Results

Exhibit 150 shows the annual consumption under the high growth and low growth scenarios relative to the reference case. As the low growth scenario follows the reference case growth until 2020, consumption only declines for the last four years of the forecast period. Annual energy consumption in this exhibit is composed of grid electricity, natural gas, biomass, and oil (onsite electricity generation, cogeneration heat, and water are excluded).

Exhibit 150 – Scenario Comparison of Annual Energy Consumption (eMWh/yr.)

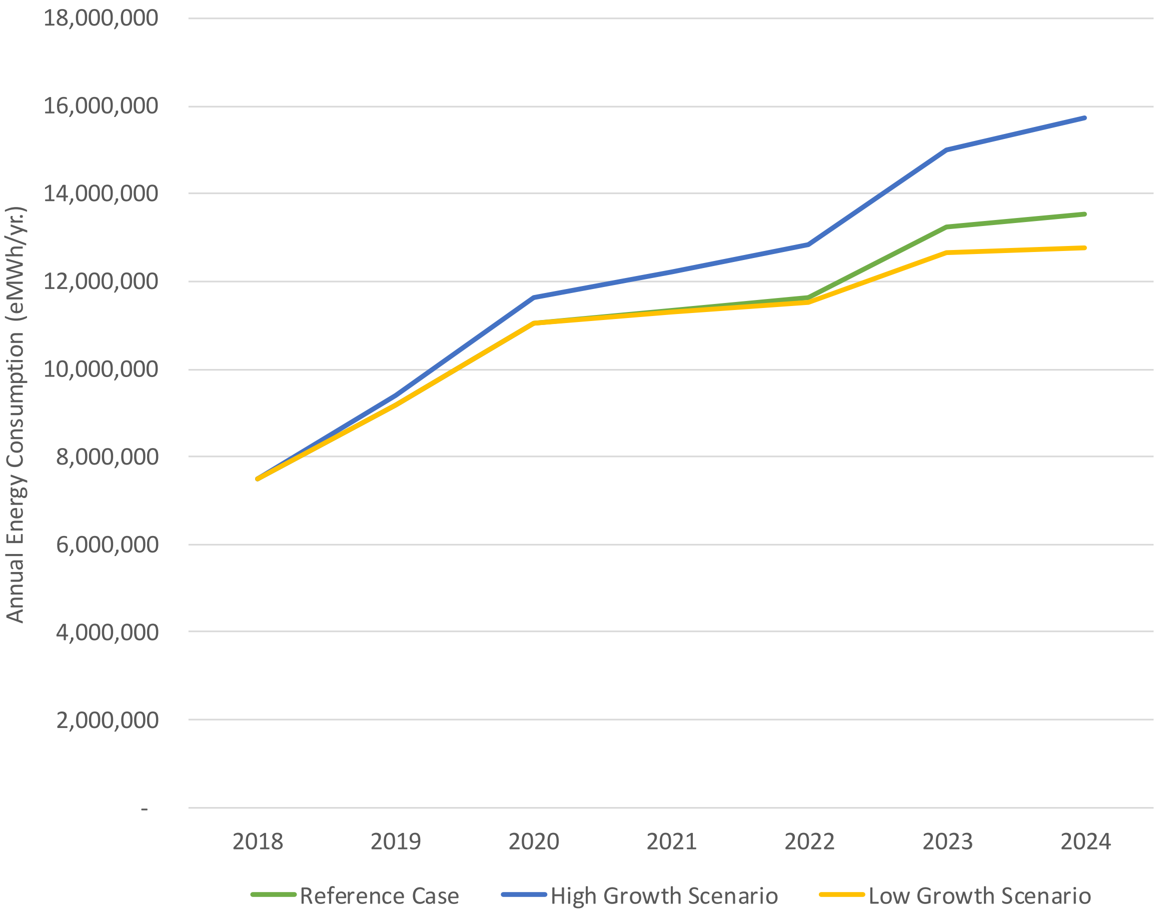

Exhibit 151 illustrates how the footprint of the sector changes in each scenario relative to the reference case. The total square footage is displayed and includes all regions and sub-sectors.

Exhibit 151 – Scenario Comparison of Total Units (sq. ft)