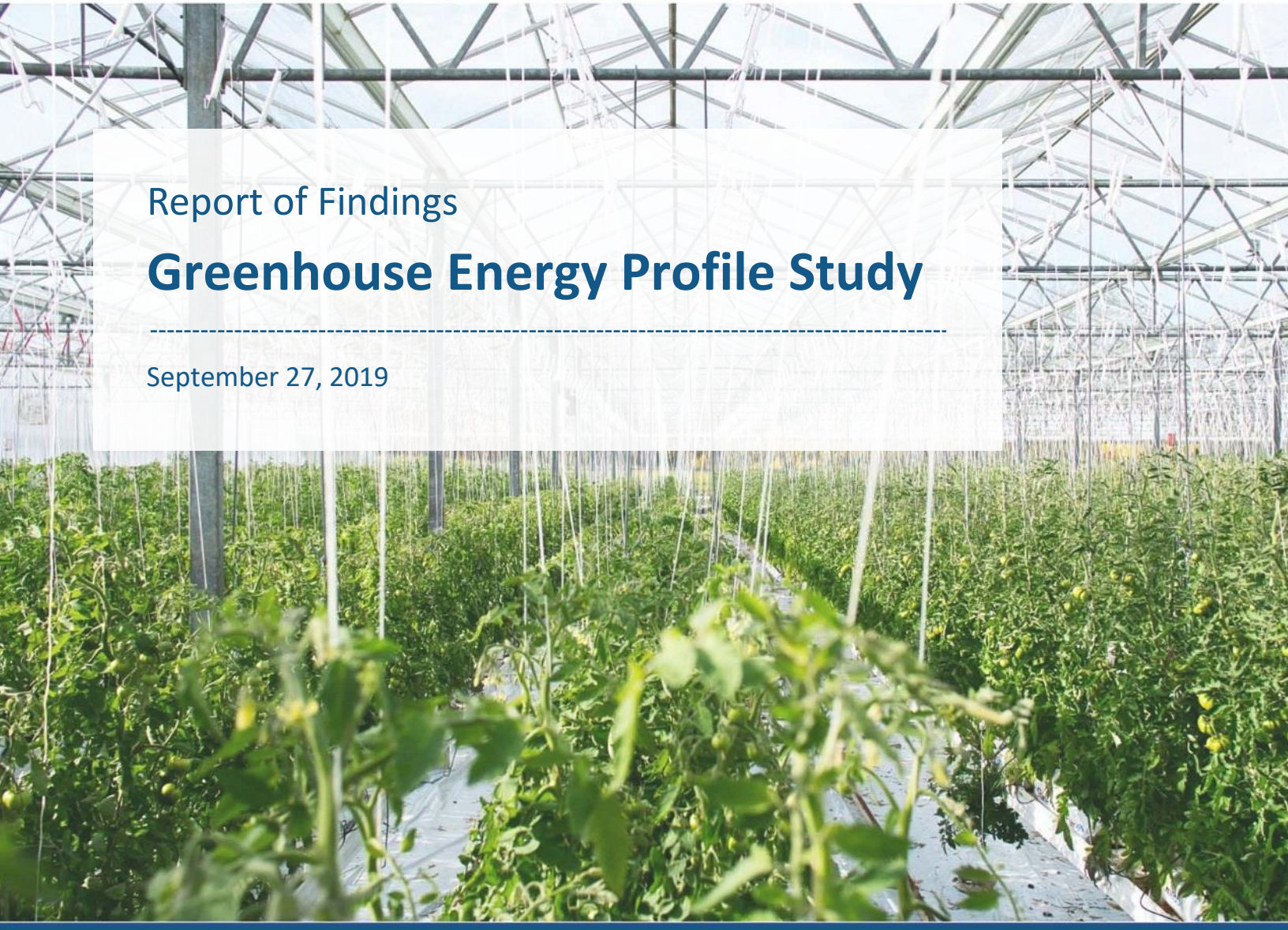


Report of Findings

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

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%

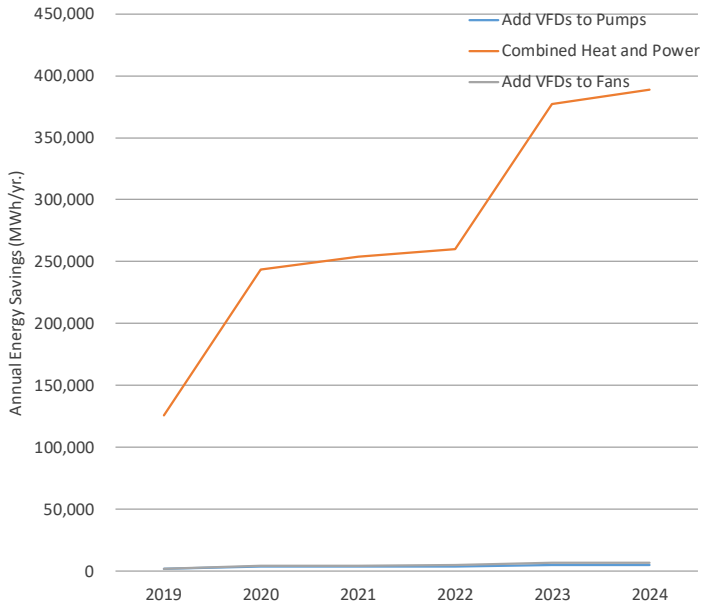
Measure Name	Measure Description	End Use [Fuel]	Sub-sector Applicability	% Energy Savings
			Cannabis Indoor & Vertical: n/a	
Integrated Environmental Controls	Integrated environmental controller to replace a stand-alone control system. Integrated controller applications include control of VFDs, staging 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

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