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New Gas Technologies that Complement Low Energy/Carbon Homes

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ENBRIDGE

Outline

ENBRIDGE Life Takes Energy

1. Who we are.
2. Recent Residential Pilot Projects.
   a) Optimization of Electric Assets such as PV and Battery Storage.
   b) mCHP for Residential Homes- Three Demo Projects
   c) Lessons Learned to Date from mCHP Pilots
   d) Hybrid Heating Solution
   e) Smart Dual Fuel Control, and Preliminary Results

Enbridge in Ontario

Enbridge Gas Inc.

- Enbridge delivers about 37% of Ontario's total energy use each year.
- More than 100 years of experience in safe and reliable service.
- A new developer of electricity transmission.
- The Sarnia-area *Dawn Storage Hub* is Canada's largest and one of the top-5 natural gas trading hubs in North America.

Natural gas
3.7 M customers, heating >75% of Ontario homes.

DSM Programs
Saved customers ~20 billion cubic metres of natural gas.

Renewables
7 projects: wind, solar and hydroelectric (490 MW).

Liquids pipelines
3 pipelines which move 419,000 barrels per day.

Employment
~4,800 Ontario-based permanent and temporary staff.

Community investment
$6.6 M invested in community initiatives across Ontario in 2017.

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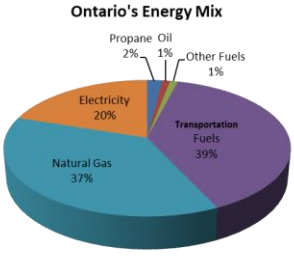
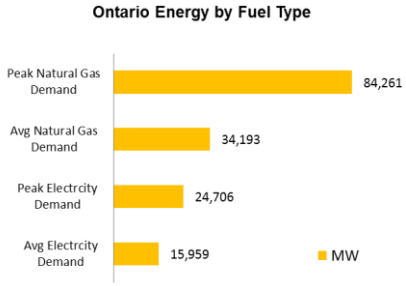
The Energy Landscape in Ontario

Natural gas plays a critical and cost effective role

Critical

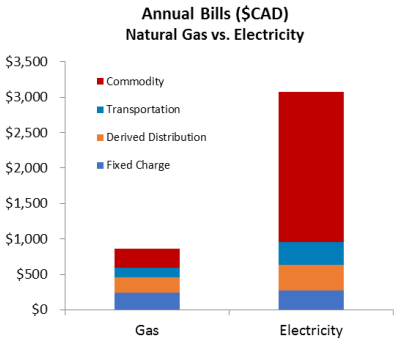


Reliable



Notes:
1. Ontario Peak natural gas demand is 6.9 bcf/day
2. Avg. natural gas demand includes refill of storage
3. Peak electricity demand recorded in Summer 2006 (IESO)

Inexpensive



Note: Does not include rate riders

Ontario's energy system reality: Electrifying the entire province would require a three-fold increase in Ontario's generation, transmission and distribution assets.**

*Environmental Commissioner's Annual Energy Conservation Report 2016-2017 (Volume 2)
**Enbridge's 2017 Ontario LTEP Submission.

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Pilot Projects

Optimization of Electric assets such as PV and Battery Storage
Integration of mCHP in homes

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Remarks on CHP

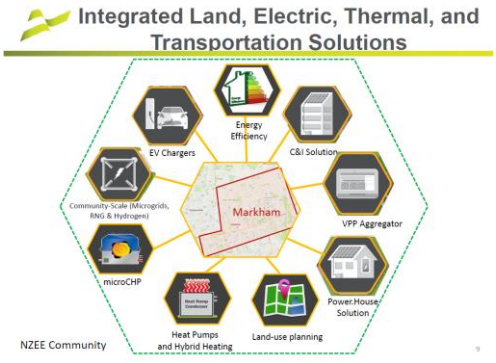
- CHP can help the Ontario Government with:
  - 31 TWh conservation target by 2035
  - 1400 – 3700 MW short fall anticipated by 2023 - 2025
  - Province wide GHG emission reduction by displacing generation from less efficient gas plants
  - Resiliency for sustained occupancy
- Integration of microCHP with PV and battery storage could optimize the operation of these assets
- CHP should be considered in future mix of electricity generation, just like other DG technologies

SLIDE 6

Optimization of Electric assets such as PV and Battery Storage

Pilot Project: Collaboration between gas and electric utilities and a municipality Moving Towards NZEE Communities

- Overall Objective:
  - Learn how the electric and thermal solutions can be integrated to:
    - provide for more grid flexibility
    - reduce GHG emissions
    - minimize operational costs to customers
  - Learnings from the in-depth M&V plan will help us to optimize the system configuration & design for future installations



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alectra
Discover the possibilities

MARKHAM

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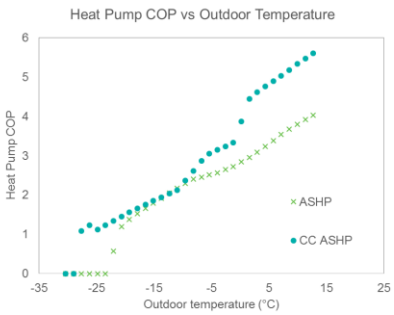
The Role of mCHP in Ontario NZEE Homes

Optimize, right size, reduce

1. Optimize electrical assets
   - Maximize use of battery storage
     - Solar harvest is low in winter
   - Right sizing of PV

2. Right sizing of ASHP
   - Avoid oversizing of ASHP to meet space heating loads (oversize air-conditioner)
   - ASHP performance drops significantly at low temperatures, acts like electric resistance heating

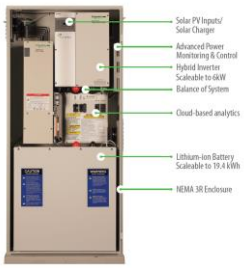


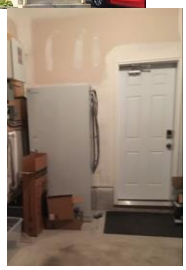
3. Reduce GHG emissions: (site vs. source)
   - Central gas plants are projected to run long hours due to nuclear refurbishment and electrification

Project Background

Current House Selected from Alectra's Power.House Program

- Alectra installed PV and Battery Storage at 20 retrofit homes through their Power.House Program (2015 – 2017)
- Current pilot is a house that participated in Power.House Program
- PV: 5 kW
- Solar storage: 11.4 kWh Lithium-ion battery
- Sunverge controller
- EV charger

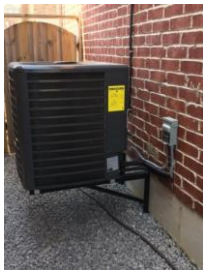




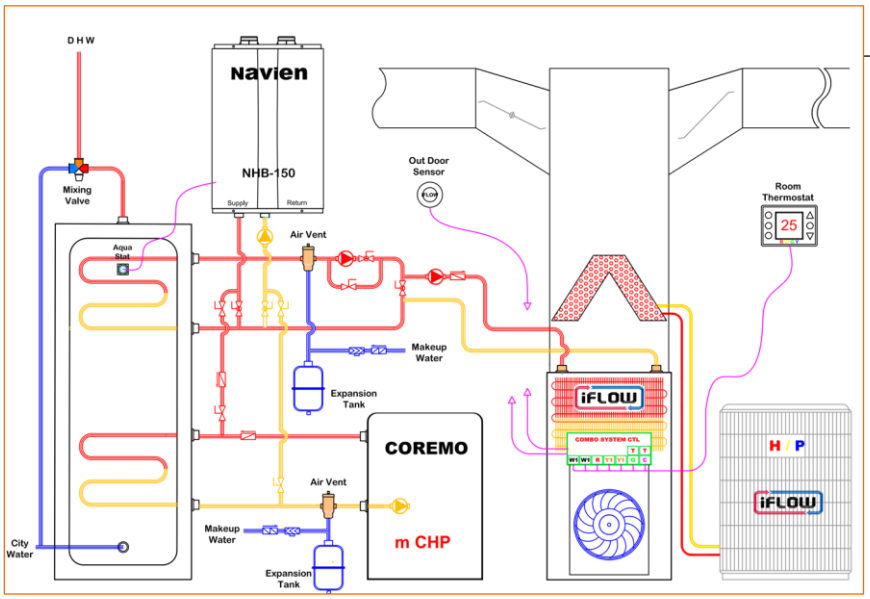
Enbridge Partnered to Install Hybrid Heating Equipment

Replaced gas furnace and DWH heater

- Aisin Coremo mCHP
  - Electrical output: 1.5 kW
  - Thermal output: 12,000 Btu/hr
  - First of its kind indoor installations in a residence
- Condensing Navien Gas Boiler
  - Input: 150,000 Btu/hr
- Air source heat pump
  - Goodman 3 Ton
- One smart air handler (iFLOW) for zone control
- Water storage tank
  - NTI 80 Gal



Heating Equipment Schematics



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mCHP Operating Strategy

Flexible GHG Reduction mode

- mCHP runs only when heat sink is available to achieve high CHP system efficiency
  - No heat dump
  - Hot water storage tank will act as a buffer to store mCHP waste heat
- mCHP would run based on bulk electricity grid *marginal emission factors* to ensure GHG savings are achieved:
  - GHG emissions are reduced by displacing on-site electrical and thermal loads
- Space heating priority: mCHP would run based on outside temp and ASHP coefficient of performance (cop)
  - Typically mCHP would run when ambient temperature drops below a predetermined temp.
- Navien boiler provides auxiliary heat and DWH
- Solar PV will never be curtailed

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Pilot Projects

mCHP- Aisin Coremo demonstration
Existing NZE home retrofit

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mCHP- Aisin Coremo demonstration
Existing NZE home retrofit - BK Cornerstone

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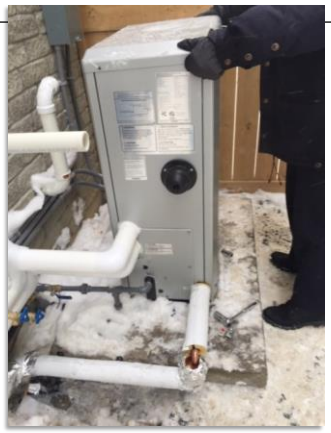
Aisin Coremo demonstration
Existing NZE home retrofit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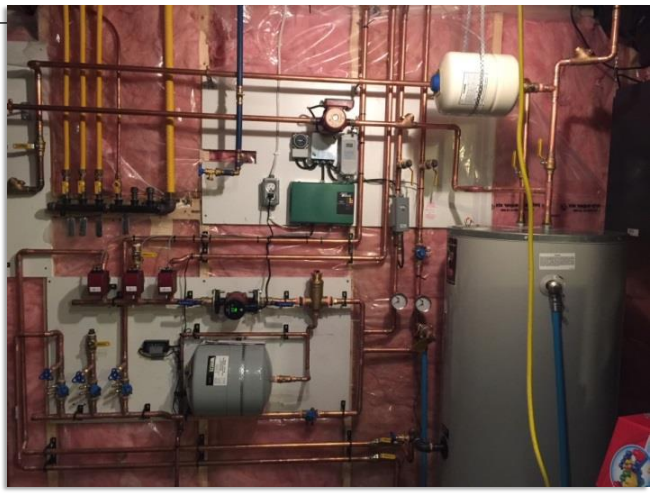
Aisin Coremo demonstration
Existing NZE home retrofit



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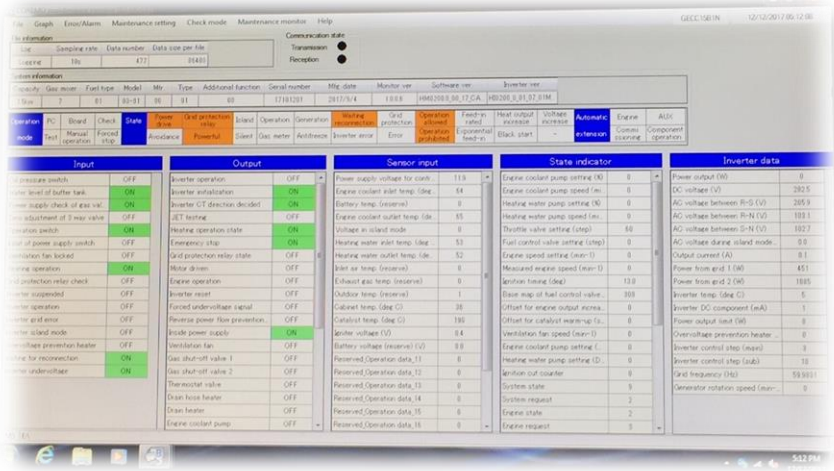
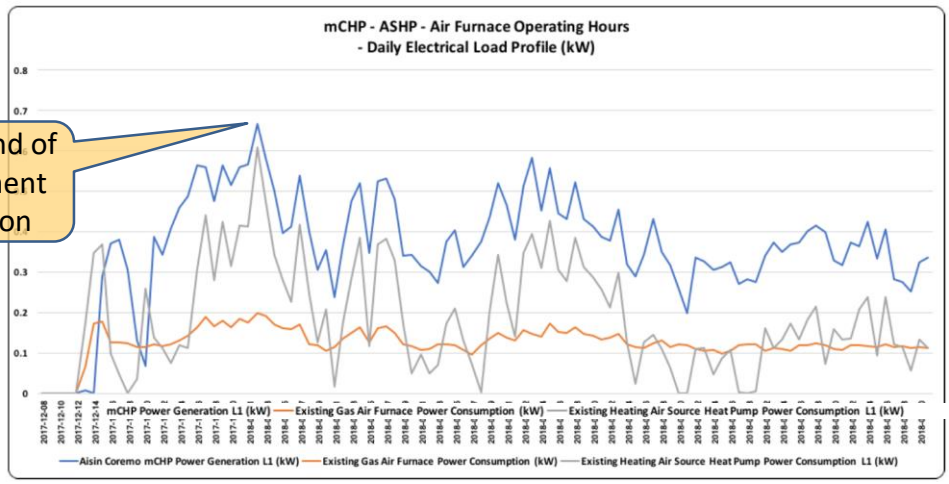
Aisin Coremo demonstration
Monitoring and tracking

Monitoring Platform



Aisin Coremo demonstration
Monitoring and tracking

mCHP following trend of mechanical equipment energy consumption



Pilot Projects

Aisin Coremo demonstration
Existing 1980's home retrofit

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Aisin Coremo demonstration
Existing 1980's home retrofit - Entegrus

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Aisin Coremo demonstration
Existing 1980's home retrofit



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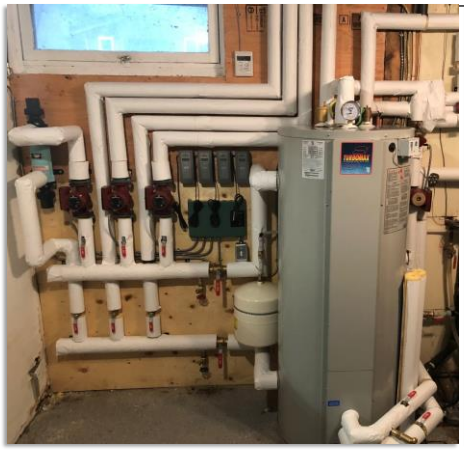
Aisin Coremo demonstration
Existing 1980's home retrofit

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Aisin Coremo demonstration

Black start opportunities

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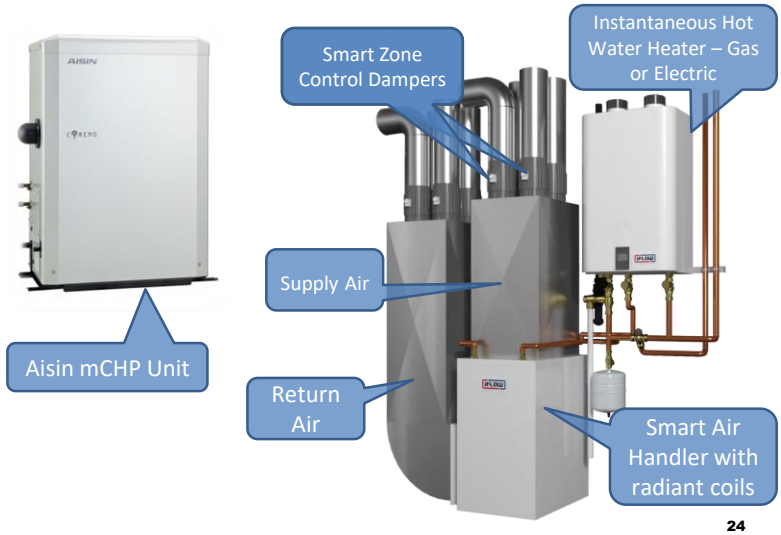
Aisin Coremo demonstration

New NZE home integration - Reids Heritage Homes

- mCHP integrated into new building systems.
- Radiant heating and cooling design.
- “Smart” Building Controls.



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Lessons learned
Aisin Coremo - Integration and Installation

- Minimal training for trades – plumbing, electrical, controls.
- Tools for identifying ideal homes.
  - Energy consumption, time of use.
  - Available heating loads.
- Involvement of certification bodies (TSSA) LDC's or authorities throughout.
- Controls are key – retrofit applications require integrated controls for mCHP.
- Outdoor Installation – easier but less efficient.
  - Size of equipment matters in retrofit (storage tanks etc.).
- Commissioning 2 ways:
  - "Start-up" Commissioning .
  - Operational Commissioning.

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Pilot Projects

Hybrid Heating Solution
Net Zero Energy Emission

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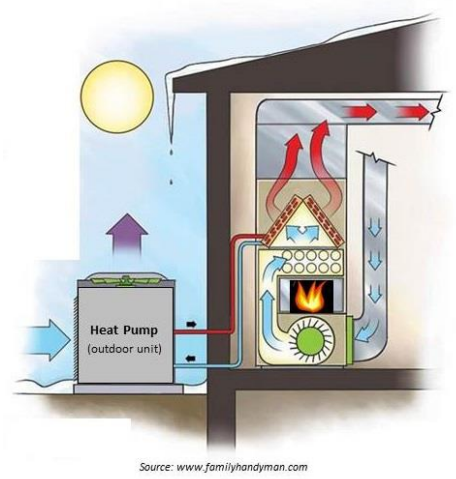
Hybrid Heating Solution:

Natural Resources Canada Has Identified This As Dual-Fuel Thermal Energy Supply Using Air Source Heat Pump (ASHP) and Natural Gas



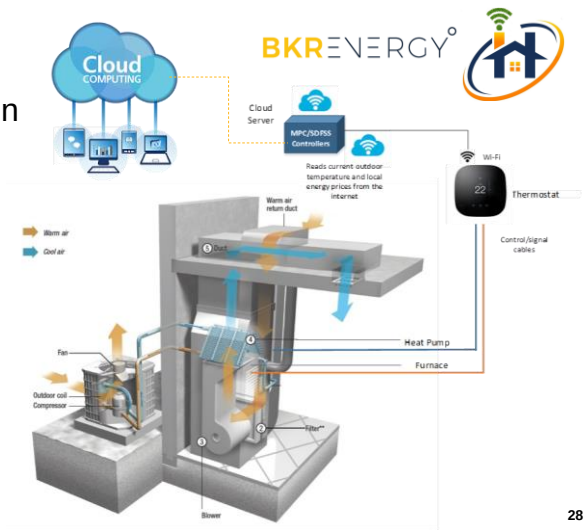
Source: www.familyhandyman.com

- ASHP When Bulk Power Grid Has Adequate Renewables
- Direct , High-Efficiency Natural Gas When Power Grid Has Peak Needs
- More Affordable GHG Reductions
- Energy Resiliency Greatly Improved

SLIDE **27**

Smart Fuel Switching Control (SFSC)

This cloud-based technology provides a flexible mechanism for residential houses to optimally share the heating load between furnace and ASHP.



Project Overview

- The purpose of the technology is to reduce energy cost of space heating and reduce GHG emissions.
- Provides cloud-based platform and user interface. The platform provides additional features to support the electrical utility to reduce the peak load.
- The ultimate outcome of this project would enable us to define a DSM program with technical and marketing supports.

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Smart Fuel Switching Control (SFSC)

Base Case vs. Efficient Upgrade Case

Base Case Residential Configuration:

Existing equipment includes:

- Natural gas furnace for space heating; and
- air conditioner (A/C) for space cooling

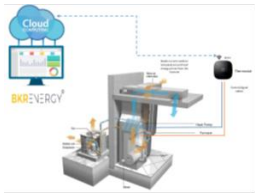
Efficient Upgrade Case:

Upgraded equipment includes:

- High efficiency natural gas furnace for space heating; and
- air source heat pump (ASHP) for space heating/cooling

Target market:
Residential retrofit installation; and expandable to the new construction

Upgrade Case feature:
Quick and cost effective installation
Remote monitoring



SFSC Pilot Demo Project

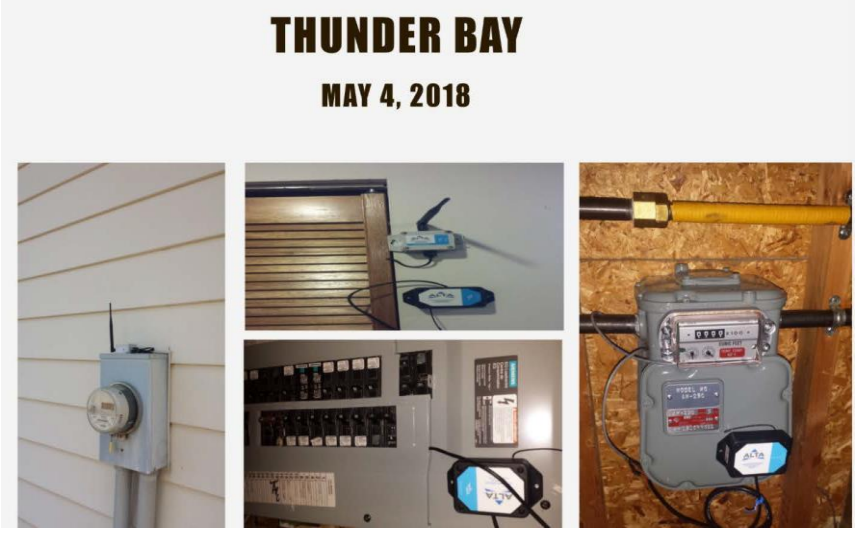
- Four pilot projects planned and have started in residential homes since early 2018
- Upgrading HVAC system and thermostat
- Install energy metering sensors
- Launch energy cloud server platform to monitor system functionality

Equipment
ASHP/Furnace: Rheem/Rheem – Lennox/Lennox – Bosch/Armstrong
Thermostat: Owon – Ecobee - iComfort

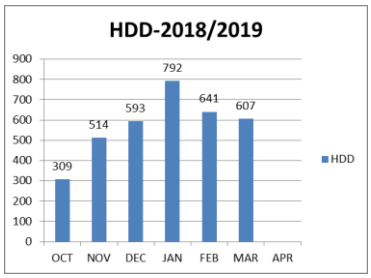
Home Location	Area (ft2)	Age	Type	Heating Load Cooling Load (kBtu)	NG Annual consumption (m3)
Enbridge - Vaughn	4,600	12 years	Detached	76.5 32.6	2197
Enbridge - Mississauga	3,800	10 years	Detached	76.7 49.5	2951
Union Gas - Chatham	2,800	11 years	Detached	63.8 37.2	2405
Union Gas – Thunder Bay	2,700	12 years	Detached	79.8 35.6	2587

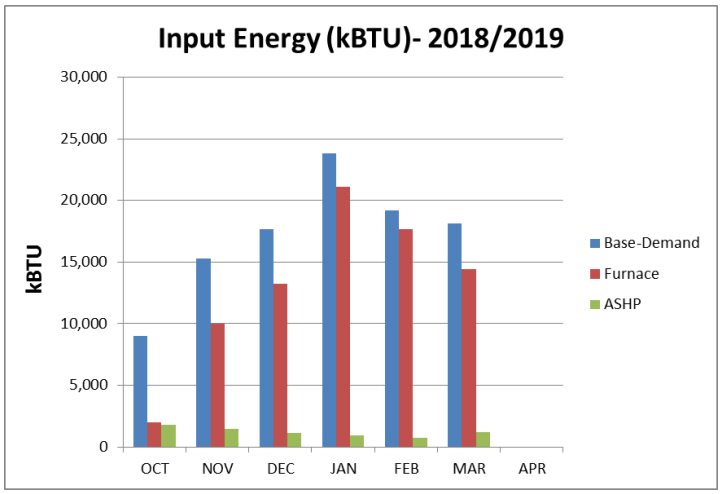
SFSC Pilot Demo Home Installation

SFSC Pilot Demo Home Installation

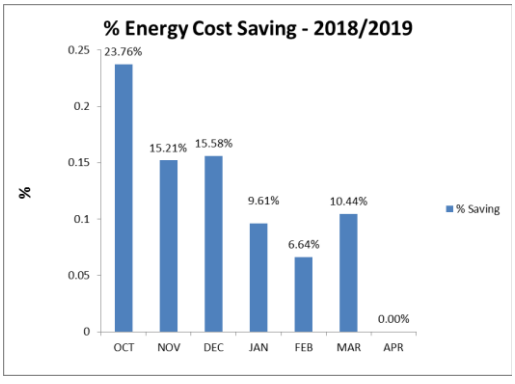


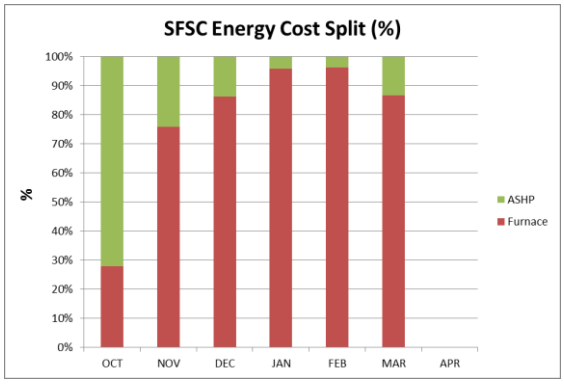
SFSC Pilot Demo-Preliminary Results at Vaughan





SFSC Pilot Demo-Preliminary Results at Vaughan





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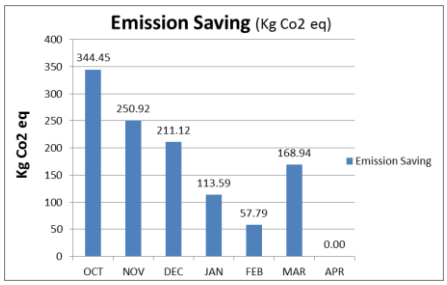

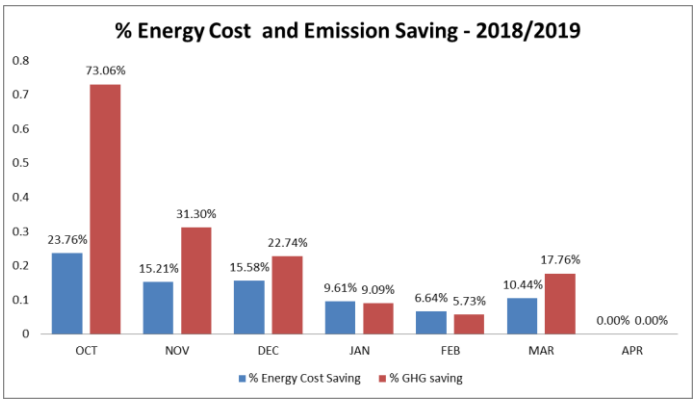

If three homes simultaneously install SFSC technology, the obtained GHG emission saving per year is equal to removing one car on the street.