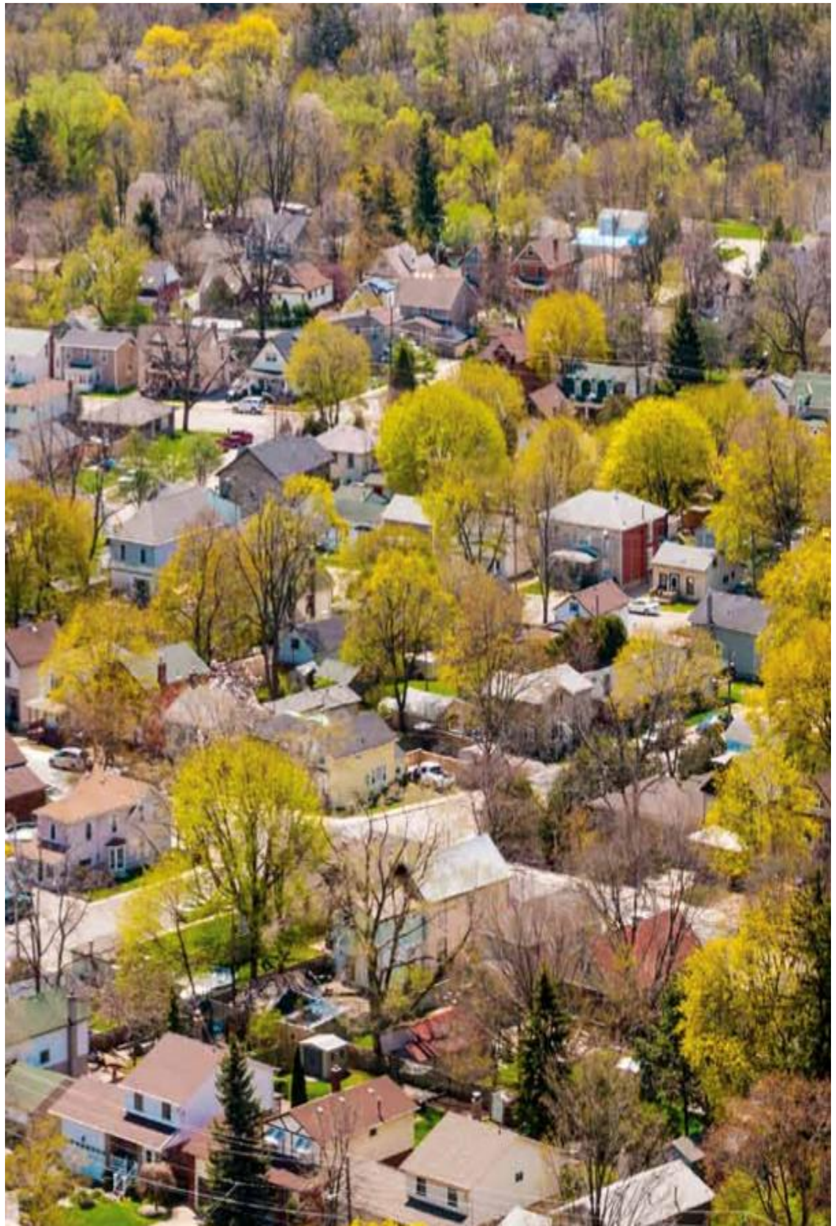
GROUND SOURCE HEAT PUMP SYSTEMS (geo-exchange)

SOLUTIONS FOR CANADIAN BUILDINGS



PRESENTED BY:

HRAI — YOUR ENVIRONMENT OUR EXPERTISE

OGA — Ontario Geothermal Association

Speaker Bios

Martin Luymes – is Vice-President Government and Stakeholder Relations, for the Heating, Refrigeration and Air Conditioning Institute of Canada (HRAI), where he has worked since 1995. Before starting at HRAI, Martin was Project Coordinator for the Social Investment Organization (SIO), Research Director for the Independent Power Producers Society of Ontario (IPPSO) and a Research Associate and Lecturer at the University of Toronto.

Jeff Hunter – is Vice-President of the Ontario Geothermal Association, an HVAC manufacturer representative with GPA Inc., and an instructor with Conestoga College in the Renewable Energy Techniques program. Jeff is actively involved in the Geothermal industry since 2005. As a Mechanical Technologist, Jeff has extensive experience in Residential and Commercial HVAC systems, specializing in Chilled water systems, Heat Pumps, Hydronics, and high-performance ventilation systems.

AGENDA

Quick Review: How Geothermal Works / System Overview

Residential Single Family

Multi-Family

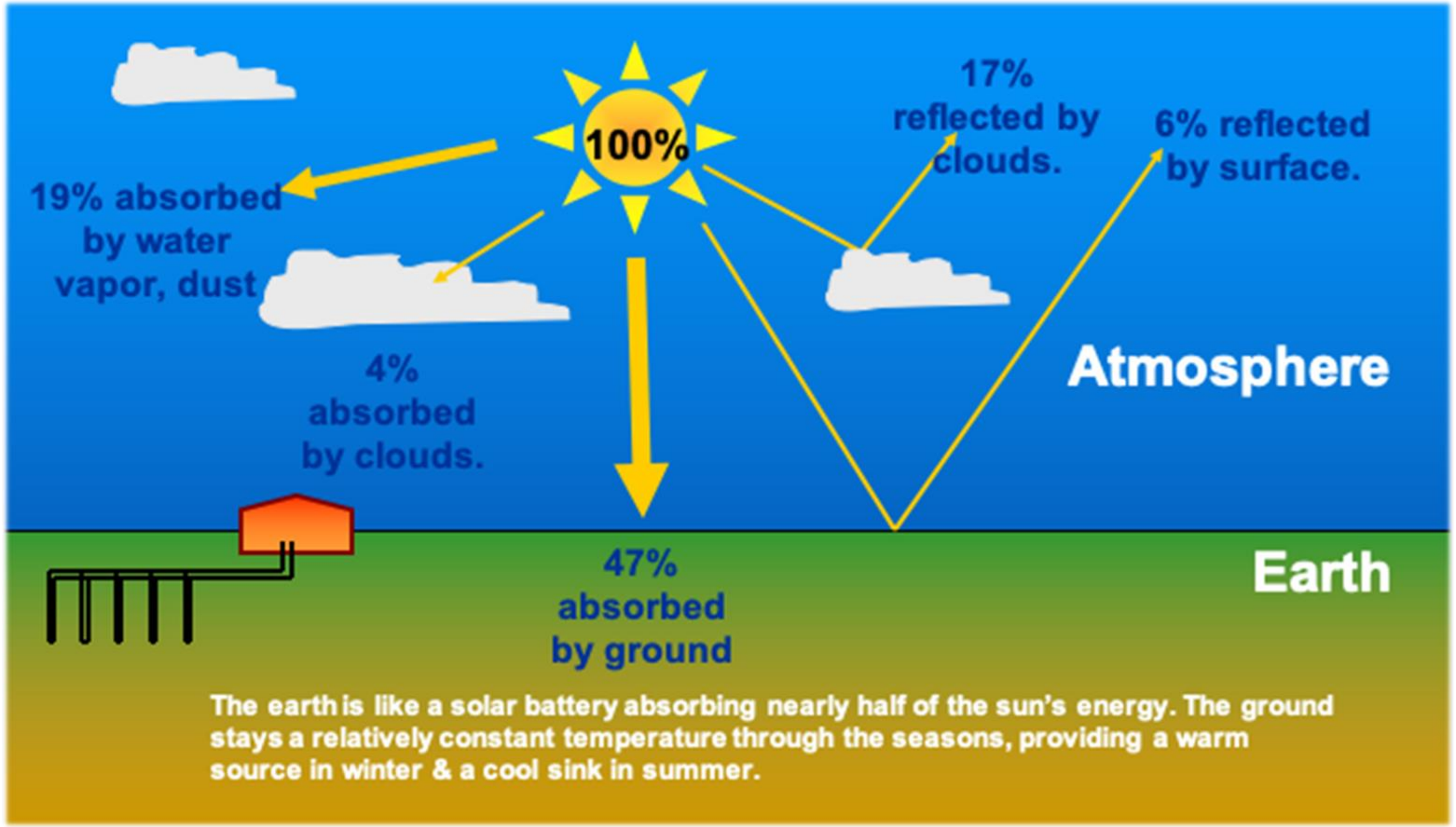
MUSH

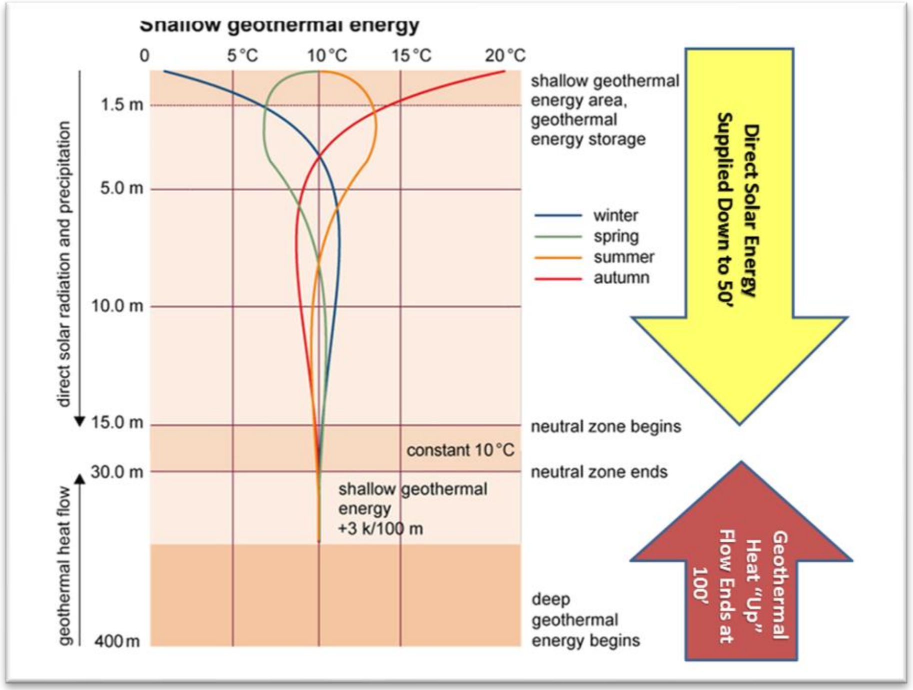
What about ASHP / cc-ASHP?

Canadian Context - Martin

GEOTHERMAL: WHERE DOES IT COME FROM?

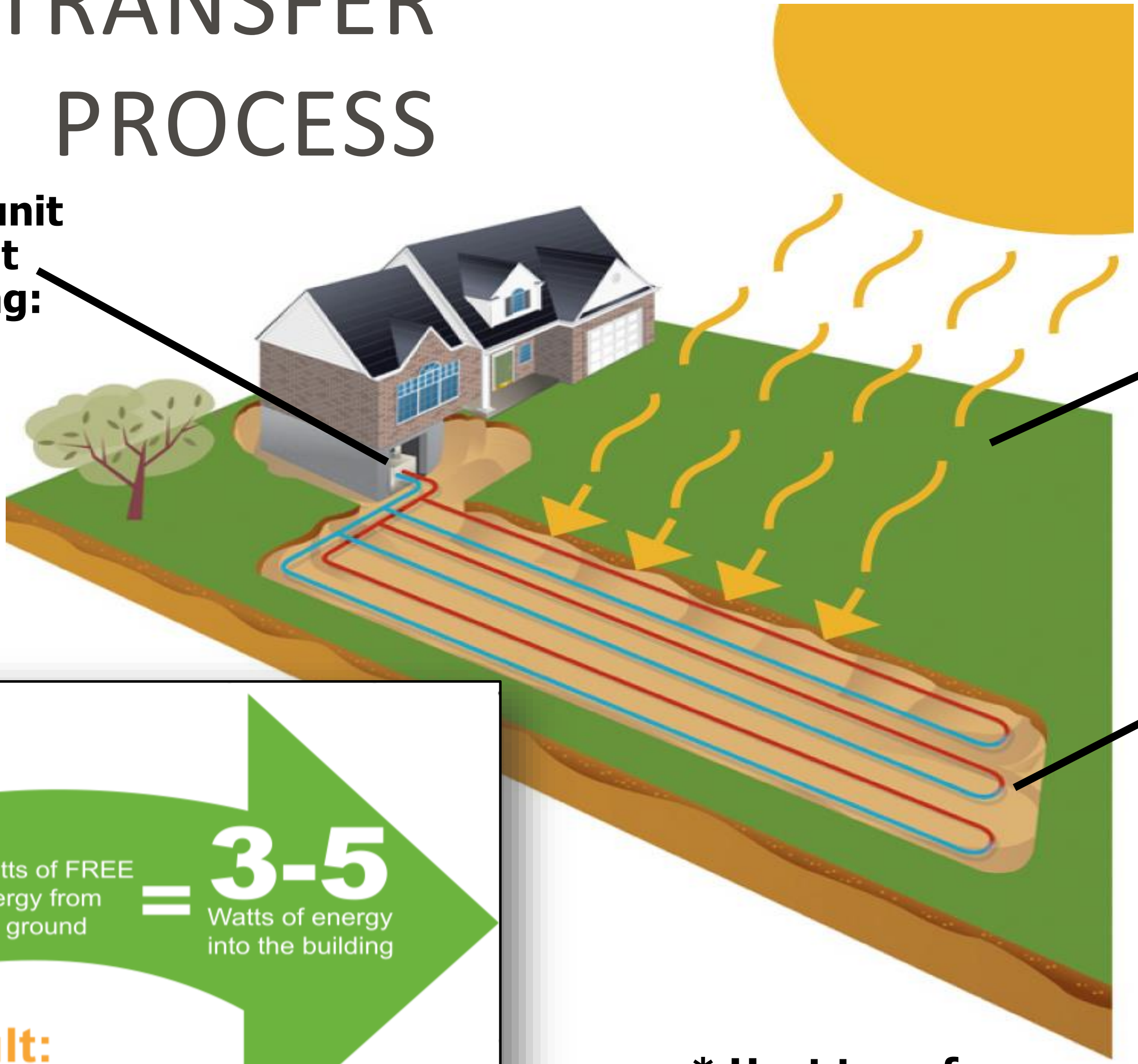
GSHP's USE STORED SOLAR ENERGY.





THE HEAT TRANSFER PROCESS

Geothermal unit transfers heat to the building: Forced Air or Hydronic



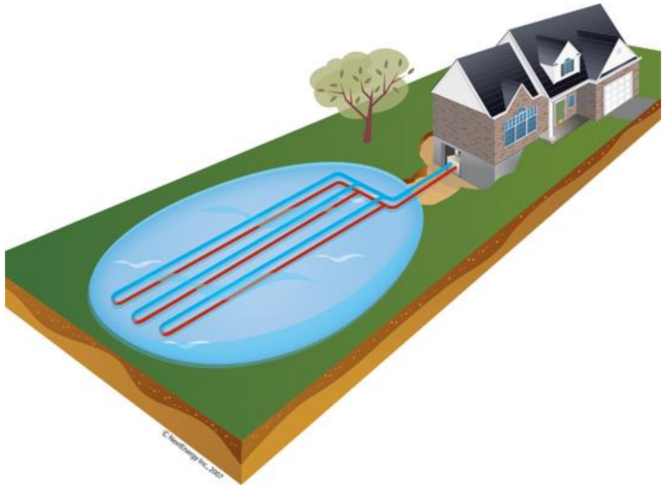
Energy of the sun warms the ground

Loop absorbs heat from ground

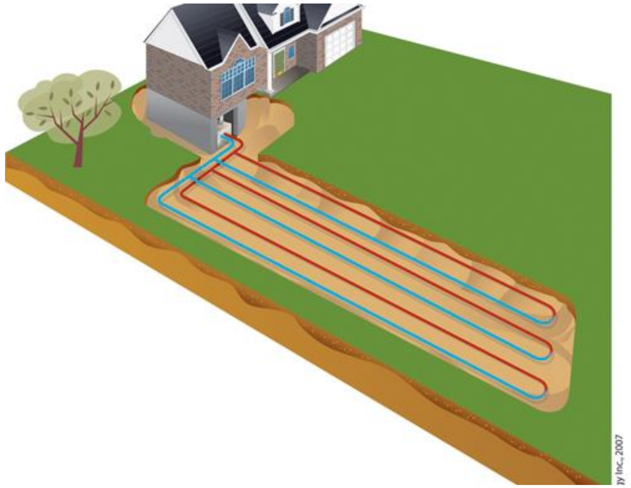
*** Heat transfer process is reversed for cooling**

GEOTHERMAL ”LOOPS”

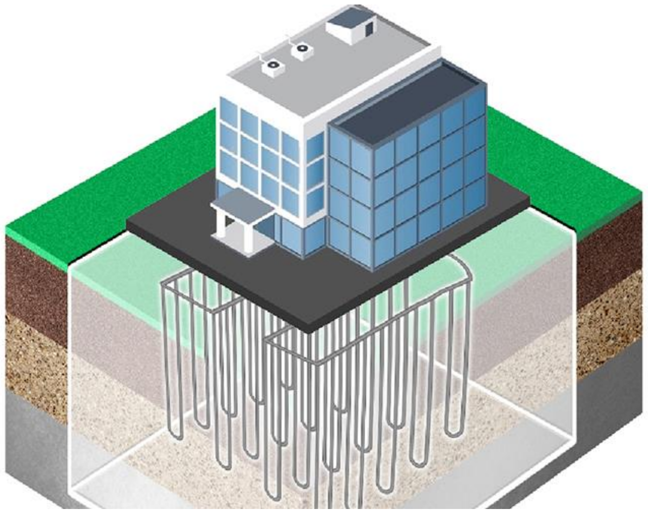
Vertical
Earth Loop



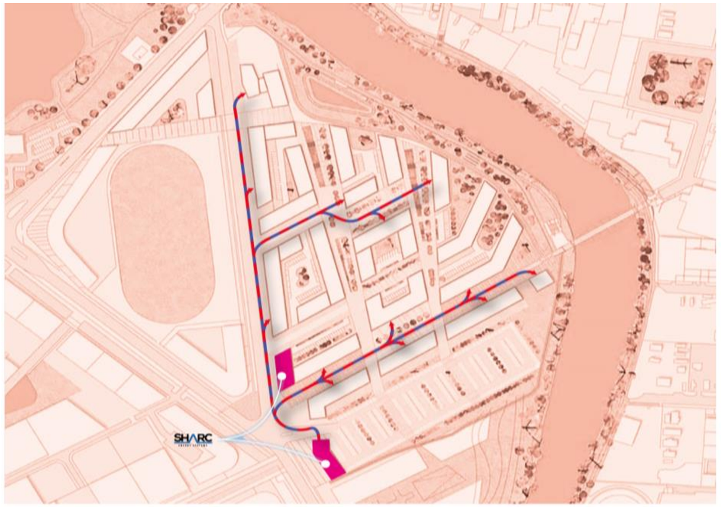
Pond or
Lake Loop



Horizontal
Earth Loop



Common Loop
Geo-Micro-District



Waste Water Heat Recovery

Single-Family 3 ton Vertical Real-time Data

Data from: Feb.28, 2019

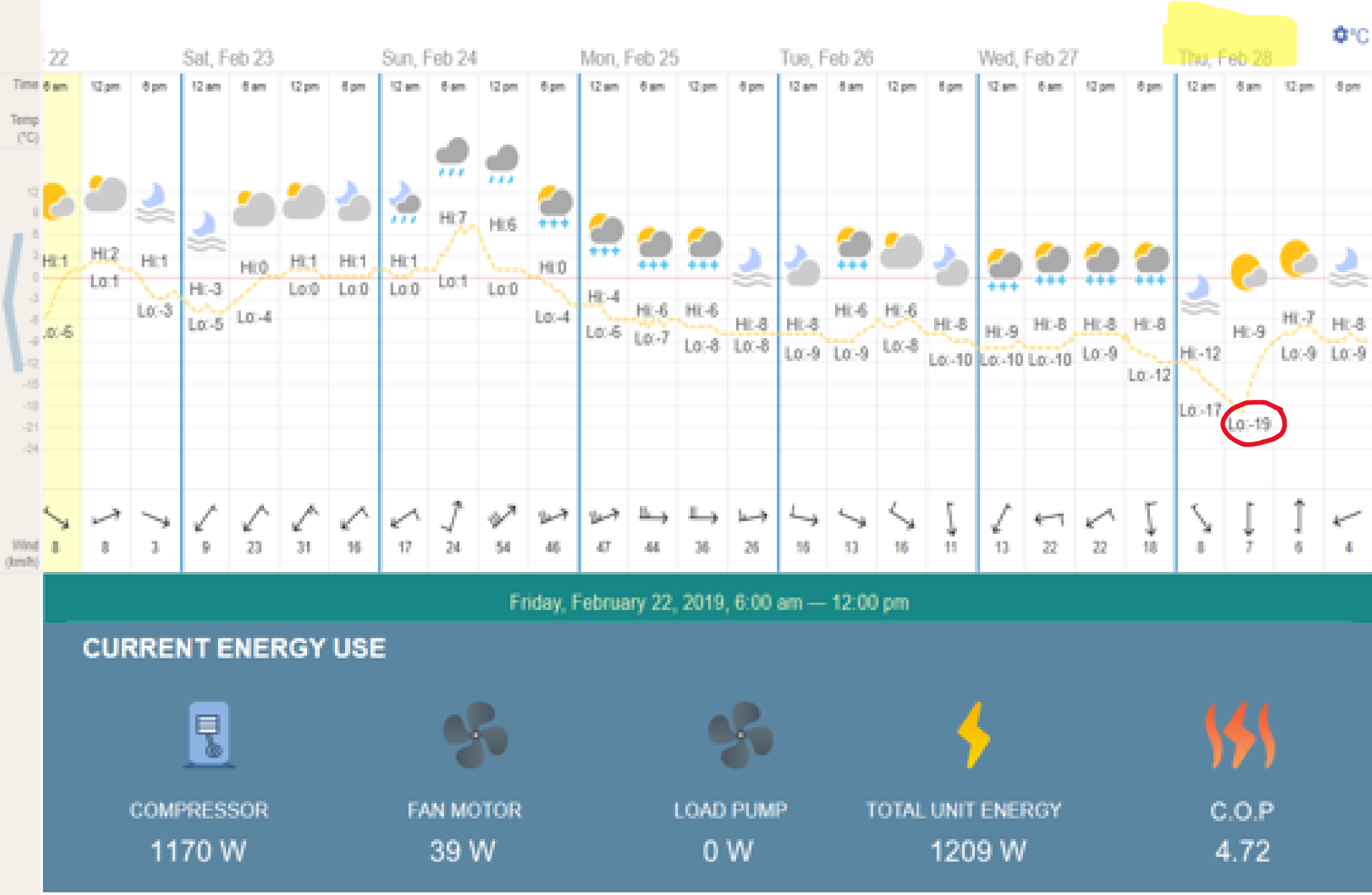
LOOP EWT (C): 3.1

LOOP LWT (C): 0.8

OA TEMP: -19C

TOTAL OUTPUT: 19,487 BTU/HR. (5711 W)

NDV038 (TWO-STAGE HEAT PUMP)



Single-Family
3 ton Vertical
Real-time Data

Data from July 16, 2019

LOOP EWT (C): 15.8

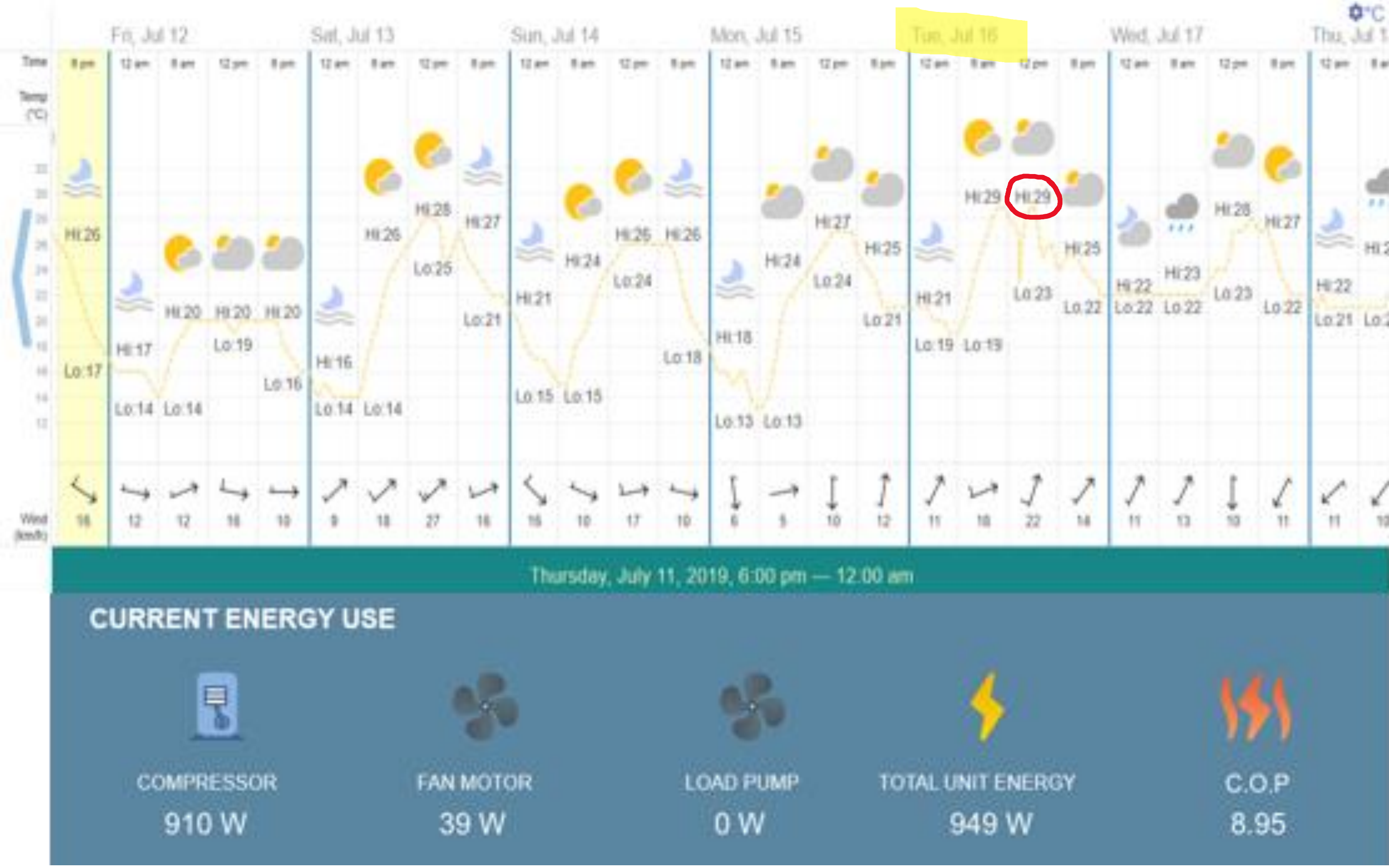
LOOP LWT (C): 19.1

OA TEMP: +29C

TOTAL OUTPUT: 28,975 BTU/HR. (8491 W)

Cooling EER: 30.5

NDV038 (TWO-STAGE HEAT PUMP)



Single-Family:
Geothermal Annual Energy Consumption

Heating		
Tranquility 30 - Digital		
Electrical Use:	5,363	kWh
Average Efficiency:	4.03	COP (W/W)
Annual Contribution:	99	%
Annual Cost:	992	CAD
Electric Resistance		
Electrical Use:	116	kWh
Average Efficiency:	100	%
Annual Contribution:	1	%
Annual Cost:	22	CAD
Annual Heating Cost:	1,014	CAD

Cooling		
Tranquility 30 - Digital		
Electrical Use:	753	kWh
Average Efficiency:	22.98	EER (Btu/W)
Annual Cooling Cost:	139	CAD

Water Heating		
Geothermal Hot Water Generator		
Electrical Use:	430	kWh
Average Efficiency:	4.75	COP (W/W)
Annual Contribution:	59	%
Annual Cost:	80	CAD
Electric Storage Water Heater		
Electrical Use:	1,605	kWh
Average Efficiency:	88	%
Annual Contribution:	41	%
Annual Cost:	297	CAD
Annual Water Heating Cost:	376	CAD

Utility Cost	CAD	Summer	Winter
Electric - Geothermal	per kWh	.185	.185
Electric - Heat Pump	per kWh	.185	.185
Electric - Furnace	per kWh	.185	.185
Natural Gas	per m3	0.45	0.45
Propane	per Litre	0.65	0.65
Fuel Oil	per Litre	0.90	0.90

3-ton Vertical

Single-Family: Conventional Annual Energy Consumption

Natural Gas

Heating		
Gas Furnace		
Fuel Use:	2,339	m3
Electrical Use:	915	kWh
Average Efficiency:	90	%
Annual Heating Cost:	1,222	CAD
Cooling		
Air Conditioner - Split		
Electrical Use:	1,715	kWh
Average Efficiency:	10.09	EER (Btu/W)
Annual Cooling Cost:	317	CAD
Water Heating		
Gas Storage Water Heater		
Fuel Use:	576	m3
Average Efficiency:	58	%
Annual Water Heating Cost:	259	CAD
Continuous Fan		
Electrical Use:	0	kWh
Annual Continuous Fan Cost:	0	CAD
Total Annual Operating Cost:	1,799	CAD

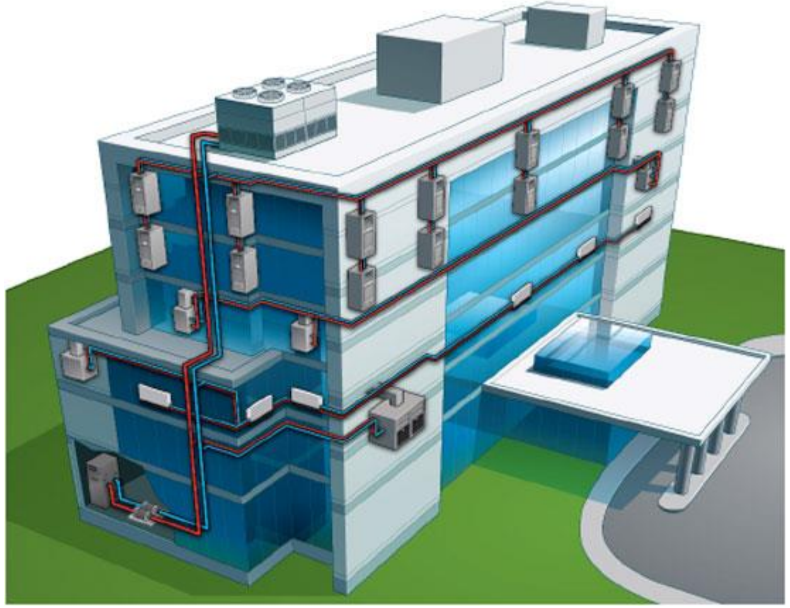
Propane

Heating		
Propane Furnace		
Fuel Use:	3,418	Litres
Electrical Use:	915	kWh
Average Efficiency:	90	%
Annual Heating Cost:	2,391	CAD
Cooling		
Air Conditioner - Split		
Electrical Use:	1,715	kWh
Average Efficiency:	10.09	EER (Btu/W)
Annual Cooling Cost:	317	CAD
Water Heating		
Propane Storage Water Heater		
Fuel Use:	841	Litres
Average Efficiency:	58	%
Annual Water Heating Cost:	547	CAD
Continuous Fan		
Electrical Use:	0	kWh
Annual Continuous Fan Cost:	0	CAD
Total Annual Operating Cost:	3,255	CAD

Oil

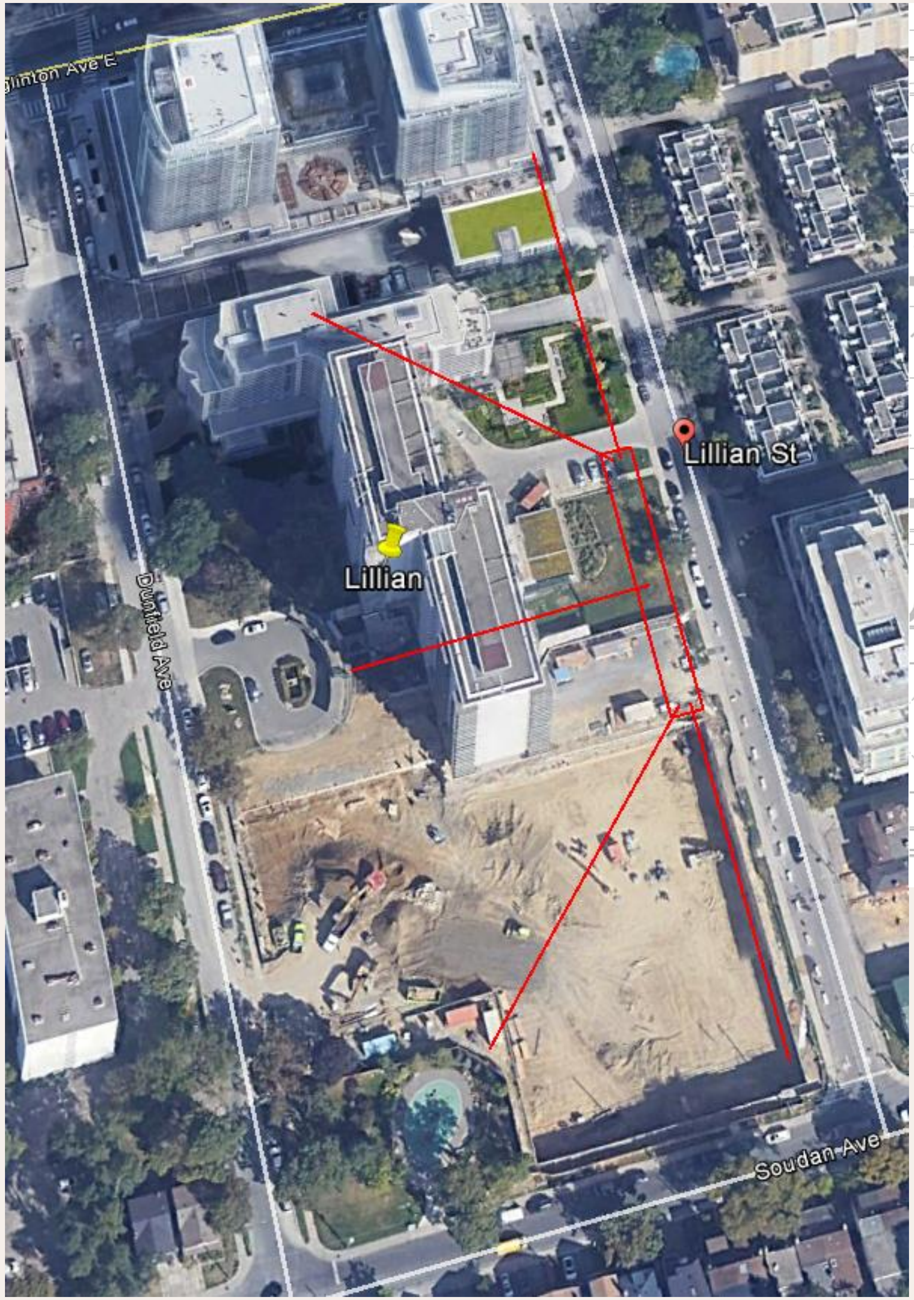
Heating		
Oil Furnace		
Fuel Use:	2,886	Litres
Electrical Use:	1,403	kWh
Average Efficiency:	70	%
Annual Heating Cost:	2,856	CAD
Cooling		
Air Conditioner - Split		
Electrical Use:	1,749	kWh
Average Efficiency:	9.90	EER (Btu/W)
Annual Cooling Cost:	323	CAD
Water Heating		
Oil Storage Water Heater		
Fuel Use:	539	Litres
Average Efficiency:	60	%
Annual Water Heating Cost:	485	CAD
Continuous Fan		
Electrical Use:	0	kWh
Annual Continuous Fan Cost:	0	CAD
Total Annual Operating Cost:	3,665	CAD

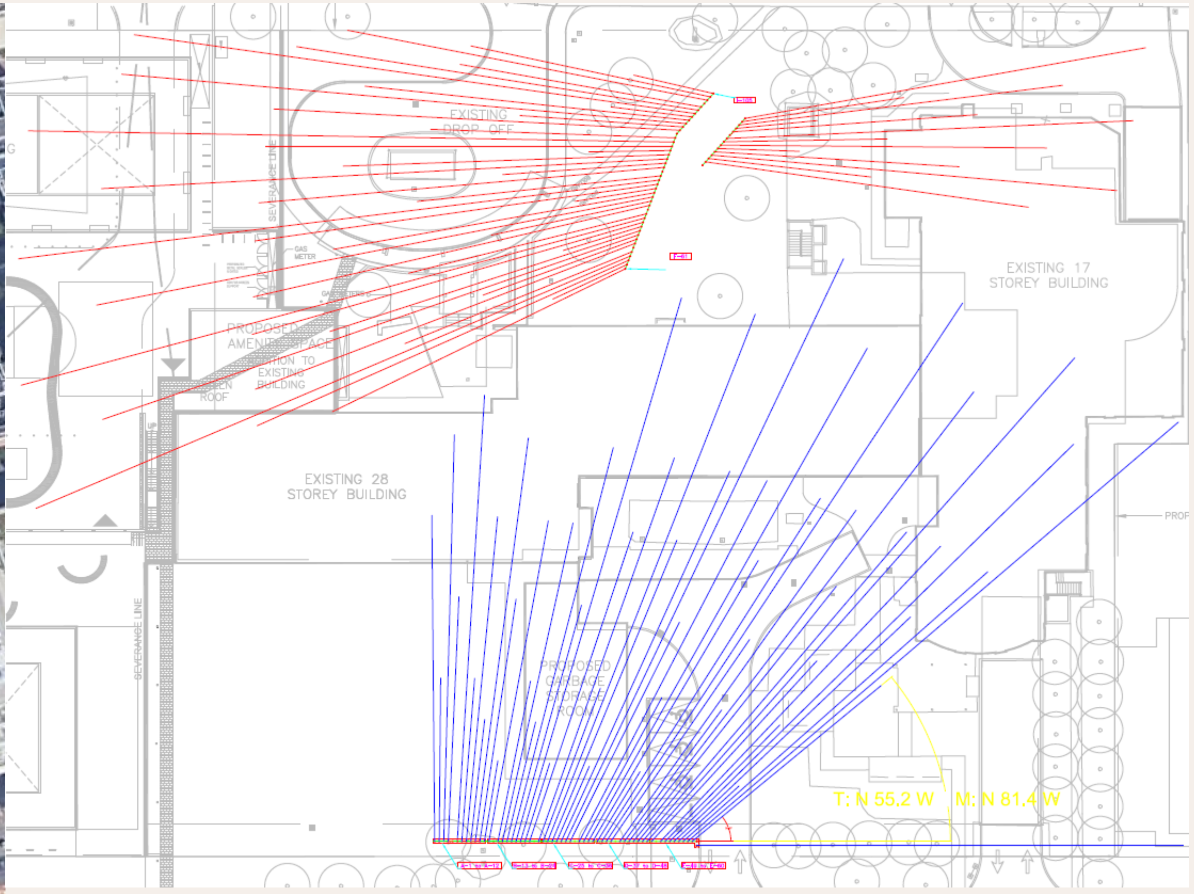
Commercial / Multi-Residential:



Water Source Heat Pump Loop, ClimateMaster Inc.

Ground Source HP Loop ClimateMaster Inc.





URBAN
NEW CONSTRUCTION

COOLING DOMINANT
APPLICATIONS PROVIDE
IMMEDIATE BENEFITS

14,000 sq m Multi-Family Building - Toronto, ON[9]

Feasibility Summary

geofease

Capital Costs			
Description	**Standard ASHRAE 90.1 Building**	**Optimized Building with Gas Heating**	**Optimized Building with GSHP**
Base System Cost[1]	$4,522,000	$4,522,000	$4,522,000
GHX System Cost[2]	---	---	$835,999
Exhaust Energy Recovery Cost[3]	---	$301,420	$301,420
Upgraded Glass Cost[4]	---	$112,980	$112,980
TOTAL COST	**$4,522,000**	**$4,936,400**	**$5,772,399**

Operation Costs			
Cooling Cost[5]	$54,170	$41,825	$29,412
Heating Cost[6]	$24,821	$7,245	$15,322
Total Heating and Cooling Cost	$78,991	$49,069	$44,734
ANNUAL COST SAVINGS	---	**$29,922**	**$34,257**

Summary			
Simple Payback[7]	---	**13.8 years**	**36.5 years**
Percent CO_2 Emissions Reduction[8]	---	**62%**	**85%**
Total Borehole Length	---	---	**12,740 m**

1 $323/square meter of building
2 $65.62/meter of bore
3 $21.53/square meter of building
4 $8.07/square meter of building
5 $0.175/kWh electricity cost
6 $0.450/Therm gas fuel cost
7 Investment Term: 20 years, Discount Rate: 2.5%, Electricity Inflation Rate: 2.0%, Fuel Inflation Rate: 2.0%
8 0.440 lbs/kWh, taken from https://www.eia.gov (US) or https://www.cer-rec.gc.ca/ (Canada)
9 The estimated building load calculations are based on weather data taken from Toronto, ON, Canada.

Multi-Residential

Project Financial Overview

Condo

Project Name:	Oakville Condo
Size (sq. ft.):	160,000

Project Benefits Summary									
Total Estimated Construction Savings								$	300,000
Expected Savings for Condo Corporation over 30 years								$	1,804,467
Condo Savings per sqft (Net Diverso Energy Charge)									
	Year 1		Year 5		Year 10		Year 20		Year 30
Annual	$ 0.08	$	0.13	$	0.21	$	0.45	$	0.86
Monthly	$ 0.01	$	0.01	$	0.02	$	0.04	$	0.07

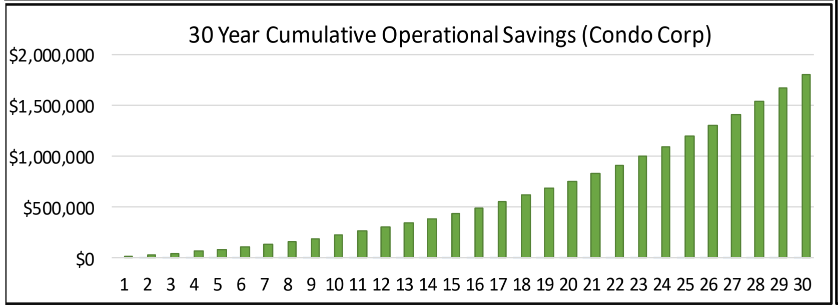
Sustainability Impact (Key Metrics)		
Annual HVAC Energy Saved	50 %	
Annual Emissions Reductions	190	tons CO^2
Annual Water Saved	2,200,000	litres

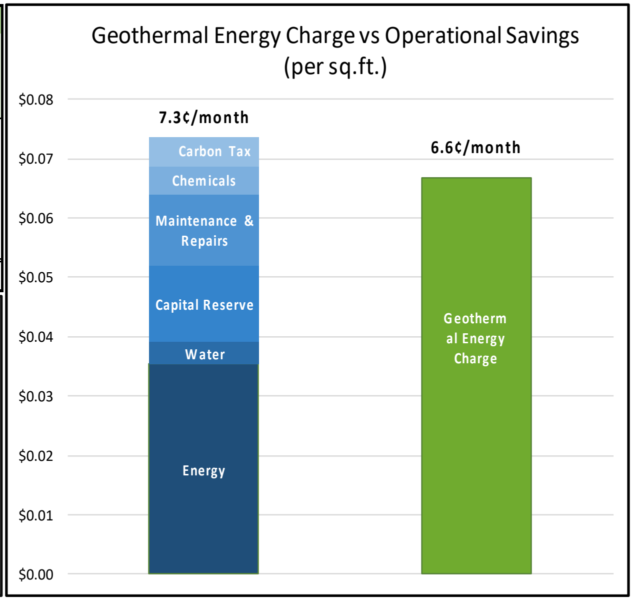
Construction Savings for Developer		
Diverso Energy Geothermal Cost to Developer	$	-
Estimated Savings from Displaced Equipment (Cooling tower, heating boilers, etc.)	$	300,000
Estimated Construction Savings (equipment avoided)	**$**	**300,000**
Developer's Contribution to Borefield Cost	$	-
Total Estimated Net Construction Savings	**$**	**300,000**

Financial Details		
Annual Energy (Electricity & Gas) Avoided Cost	*$*	*68,000*
Annual Water Avoided Cost	*$*	*7,000*
Annual Capital Reserve Avoided Cost	*$*	*25,000*
Annual Maintenance & Repairs Avoided Cost	*$*	*23,000*
Annual Chemicals Avoided Cost	*$*	*9,000*
Annual Carbon Tax ($50/Ton - 2022)	*$*	*9,500*
Total Expected Avoided Costs	***$***	***141,500***
Geothermal Energy Charge	*$*	*128,000*
Year 1 Net Savings to Condo Corporation	***$***	***13,500***
Charges will be inflated based on below annual indexation		
Expected Energy (Electricity & Gas) Inflation Rate		*4.0%*
Expected Water Inflation Rate		*5.0%*
Expected Capital Reserve Inflation Rate		*3.0%*
Expected Maintanance & Repairs Cost Inflation Rate		*4.0%*
Expected Chemicals Inflation Rate		*4.0%*
Expected Carbon Tax Inflation Rate		*5.0%*
Diverso Energy Inflation Adjustment		*3.0%*

Operational Cost Savings for Condo Corporation

Year	Energy & Gas Avoided Costs	Water & Chemicals Avoided Costs	Maintenance & Capital Reserve Avoided Costs	Carbon Tax Avoided Costs	Annual Net Savings
1	$ 68,000	$ 16,000	$ 48,000	$ 9,500	**$ 13,500**
5	$ 79,550	$ 19,037	$ 55,044	$ 11,547	**$ 21,114**
10	$ 96,785	$ 23,669	$ 65,356	$ 14,738	**$ 33,536**
20	$ 143,266	$ 36,650	$ 92,295	$ 24,006	**$ 71,768**
30	$ 212,068	$ 56,881	$ 130,643	$ 39,103	**$ 137,055**
TOTAL	$ 3,813,776	$ 969,836	$ 2,479,339	$ 504,764	**$ 1,804,467**



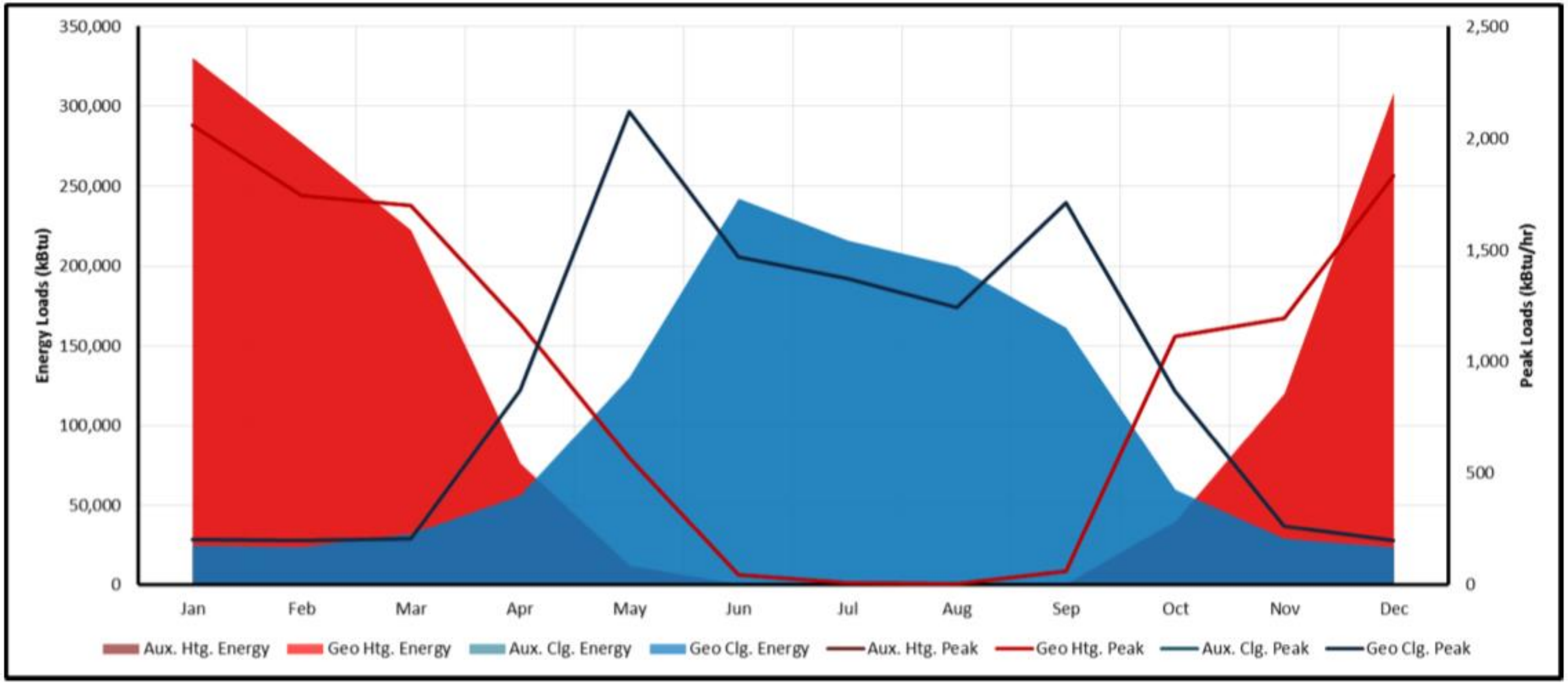


Multi-Residential

MUSH:

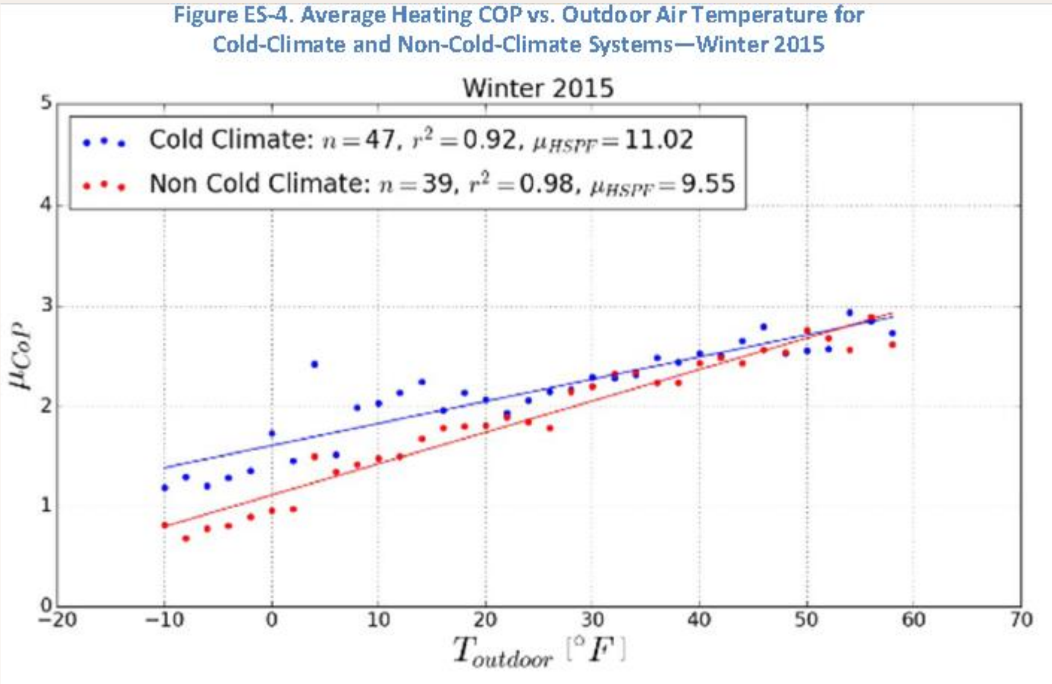
John Paul II Secondary – London, ON.

MUSH:

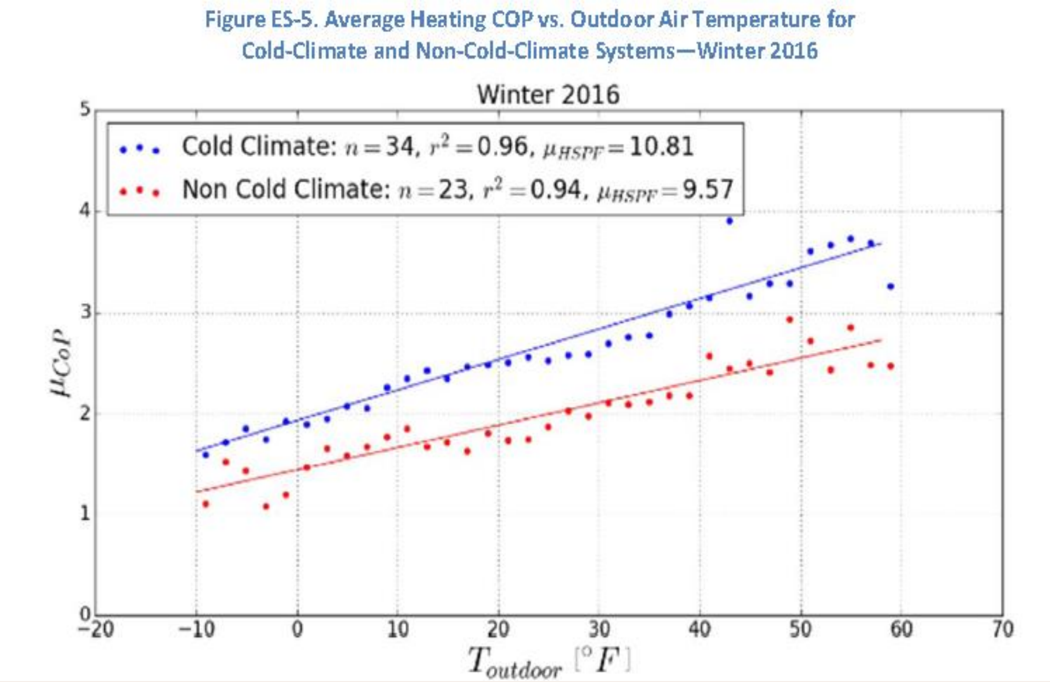


John Paul II Secondary – London, ON.

Air Source Performance Data

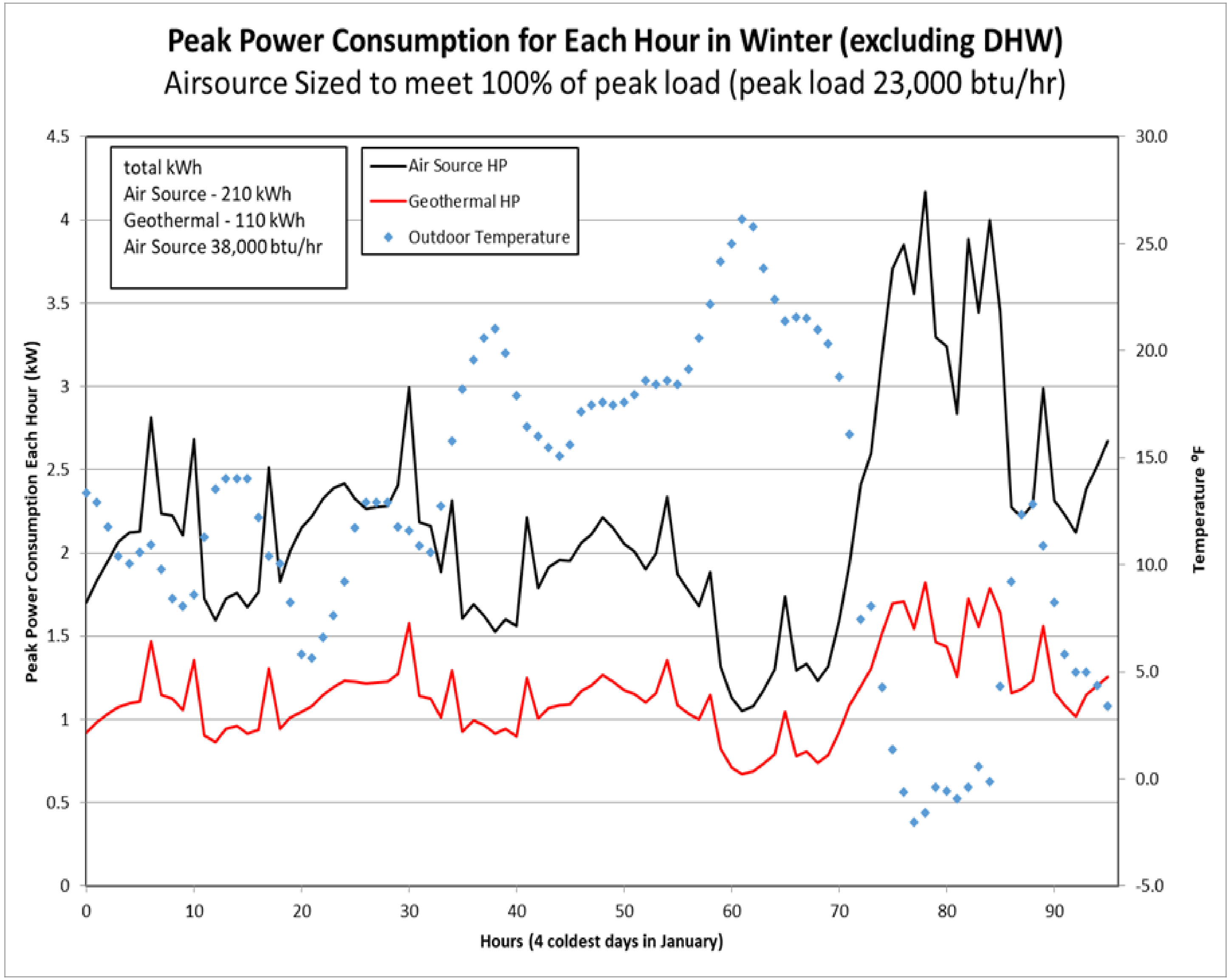


ccASHP + ASHP 2015



ccASHP + ASHP 2016

When demand is high, conservation is the most critical.



Canadian Context

Martin Luymes

SIZE OF MARKET

CANADA

- Few reliable statistics exist – and HRAI does not track shipments.
- National Energy Use Database (NEUD) says Heat Pumps were 5.1% of homes (“residential space heating”) in 2017 (no breakdown by type).

(NEUD Residential Sector Canada, Table 27: Heating System Stock by Building Type and Heating System Type).

- i.e. under 800,000 homes out of 15.5 million homes.
- ...but probably up since then (esp. on the coasts).
- Industry estimates suggest approximately 5,000 GSHPs sold in residential applications last year (60% of these in new construction).

- MUSH sector with both new and retrofit of universities, colleges, schools, community centres. Starting to see federal projects, district systems.
- Multi-residential growing rapidly. (Ontario / Lower BC)
- Beginnings of new community scale applications currently being tendered (Markham – 300 homes). More on horizon.
- Major push by several municipalities/cities to go low carbon, including: City of Toronto, Oakville, Peel Region, Halton Region, Kingston, Ottawa and Markham. Changes are happening quickly with whole developments either adopting or considering adopting district with geo and single geo installs for homes.

GSHP IN CANADA: REASON FOR OPTIMISM

dunsky

HRAI
YOUR ENVIRONMENT OUR EXPERTISE

Ontario Geothermal Association

The Economic Value of Ground Source Heat Pumps for Building Sector Decarbonization

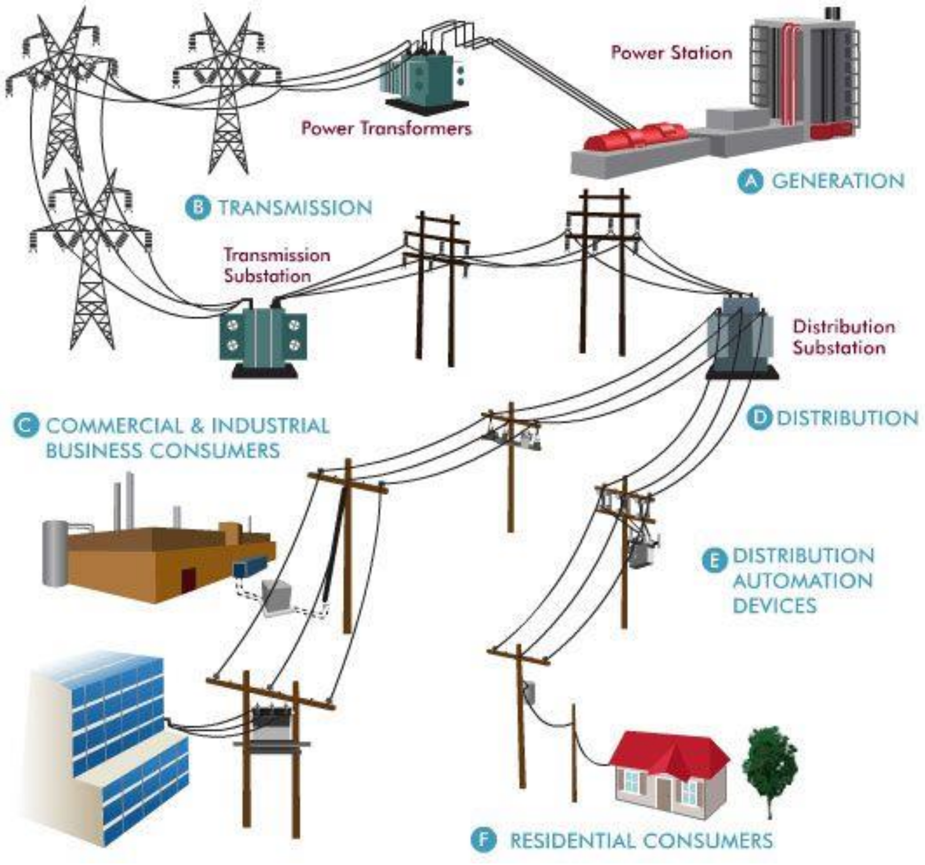
Review of a recent analysis estimating the costs of electrification in Canada

Introduction

Electrification of fossil-fuel consuming technologies is commonly recognized as one of the key tools to achieving Canada's GHG emission reduction targets.

Total cost of electrification in Canada could be exorbitant, as utilities and consumers are required to invest in infrastructure for power generation, transmission, distribution, building intake, and consumption.

GSHPs can play an important role in reducing the total costs of electrification, alongside other low-carbon technologies, by minimizing peak demand.



Approach

Review of a recent study[1] modeling the costs of electrifying Canadian buildings, industries and vehicles under different scenarios

Original study assumes all buildings are converted to ASHPs; GSHPs were excluded.

Detailed modelling of ASHP and GSHP costs and performance for different building archetypes and climates

Assessment of the **relative impact of GSHPs** on cost components for each electrification scenario in the original study

- *Equipment + fuel costs*
- *Utility costs*

[1] Canadian Gas Association, *Implications of Policy-Driven Electrification in Canada (October 2019). For purposes of this assessment, Dunsky assumed that all of the original study's inputs and assumptions are accurate. Any errors or omissions in the original study could impact the results presented herein.*

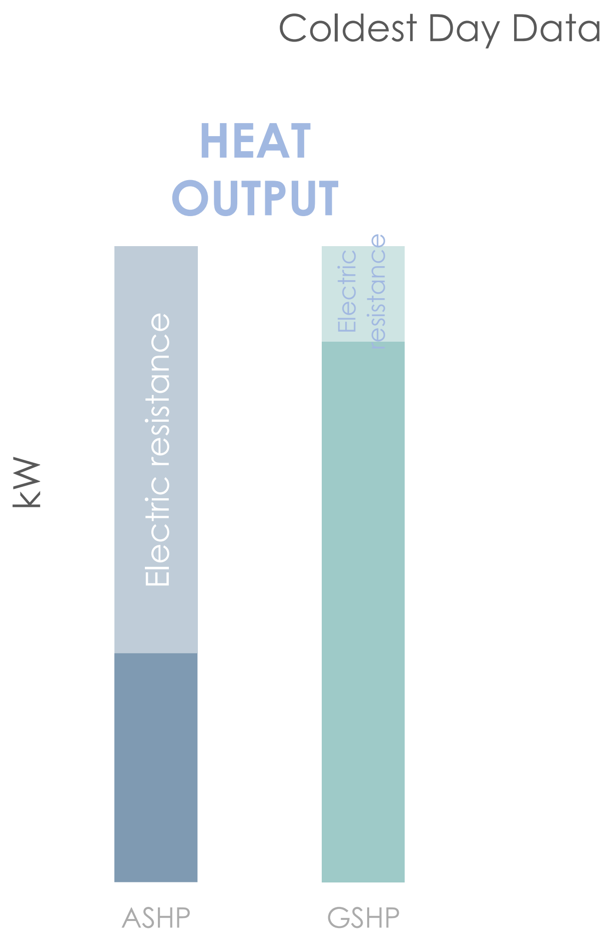
Different technologies yield different grid impacts

Original study: all buildings are assumed to use ASHPs with electric resistance back-up

- As temperatures drop, the capacity and performance of the ASHPs degrade, and the electric resistance has to provide more of the heating capacity

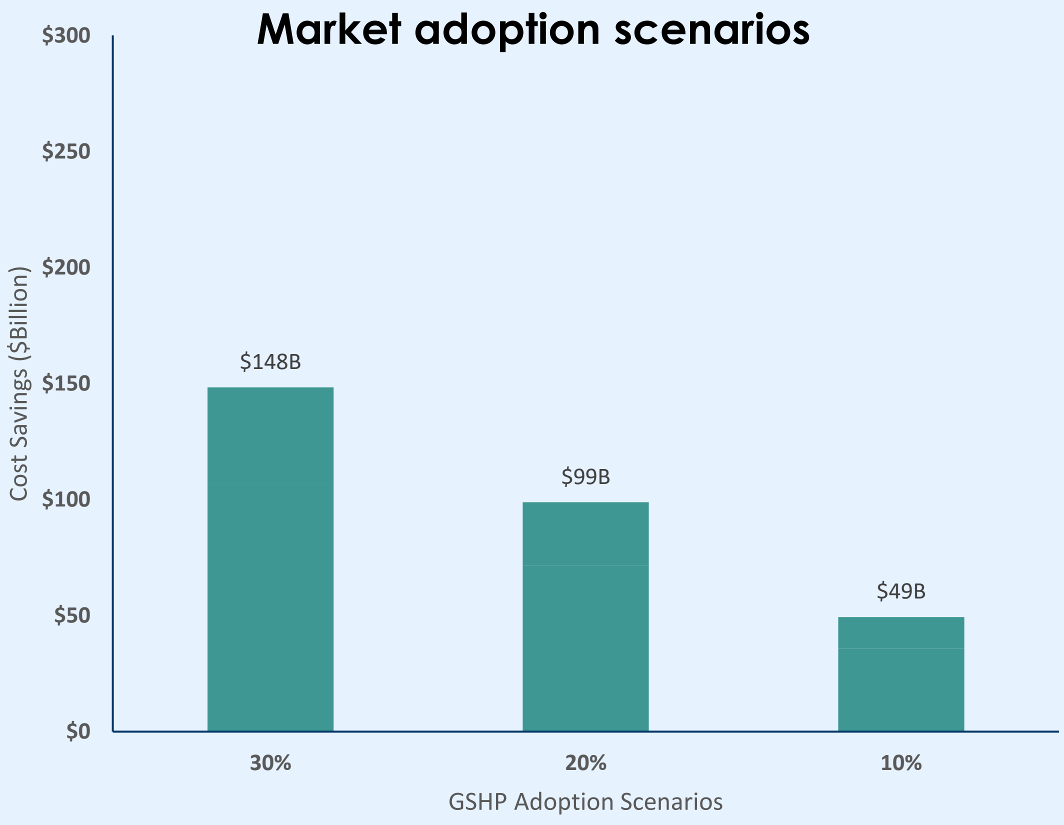
Our analysis: impact of using GSHPs with electric resistance back-up

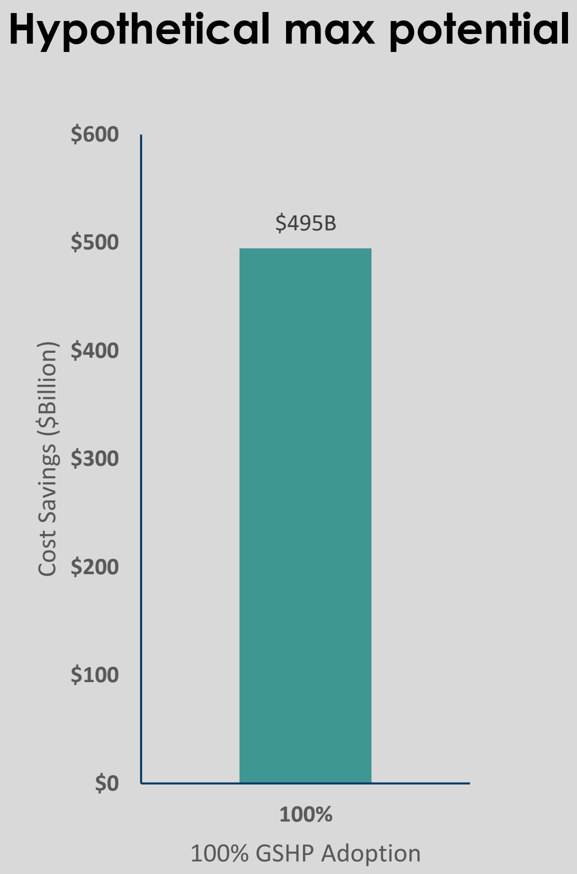
- GSHPs keep performing even during winter peaks; reducing how much energy is required from the electric resistance



Results

Under a scenario in which Canada moves to 100% carbon-free electricity generation by 2050, **aggressive promotion of GSHPs could save Canadians between $49 and $148 billion** relative to the original study's findings.





Results

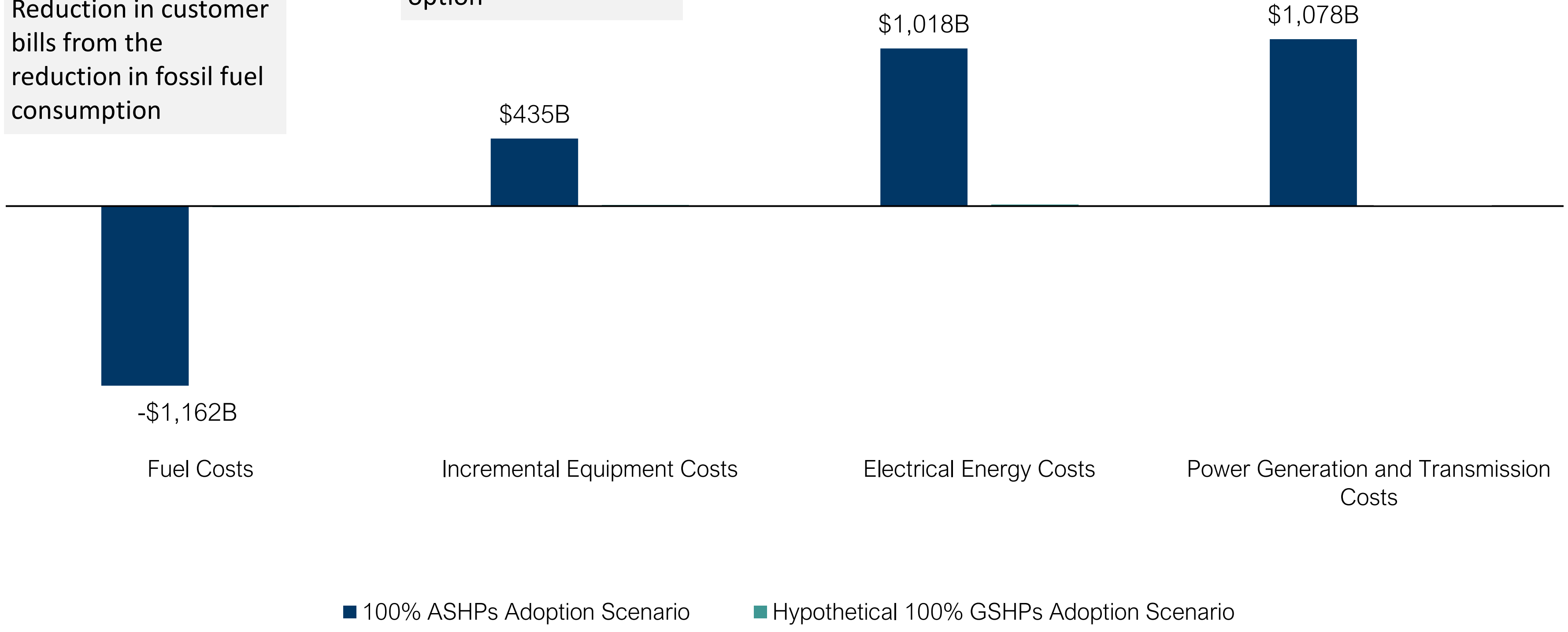
Costs components variation under a 100% ASHP adoption scenario
(compared to a BAU scenario)

Reduction in customer bills from the reduction in fossil fuel consumption

Additional costs of the electric technology relative to the conventional fossil fuel option

Increase in customer bills from the increase in electricity purchases

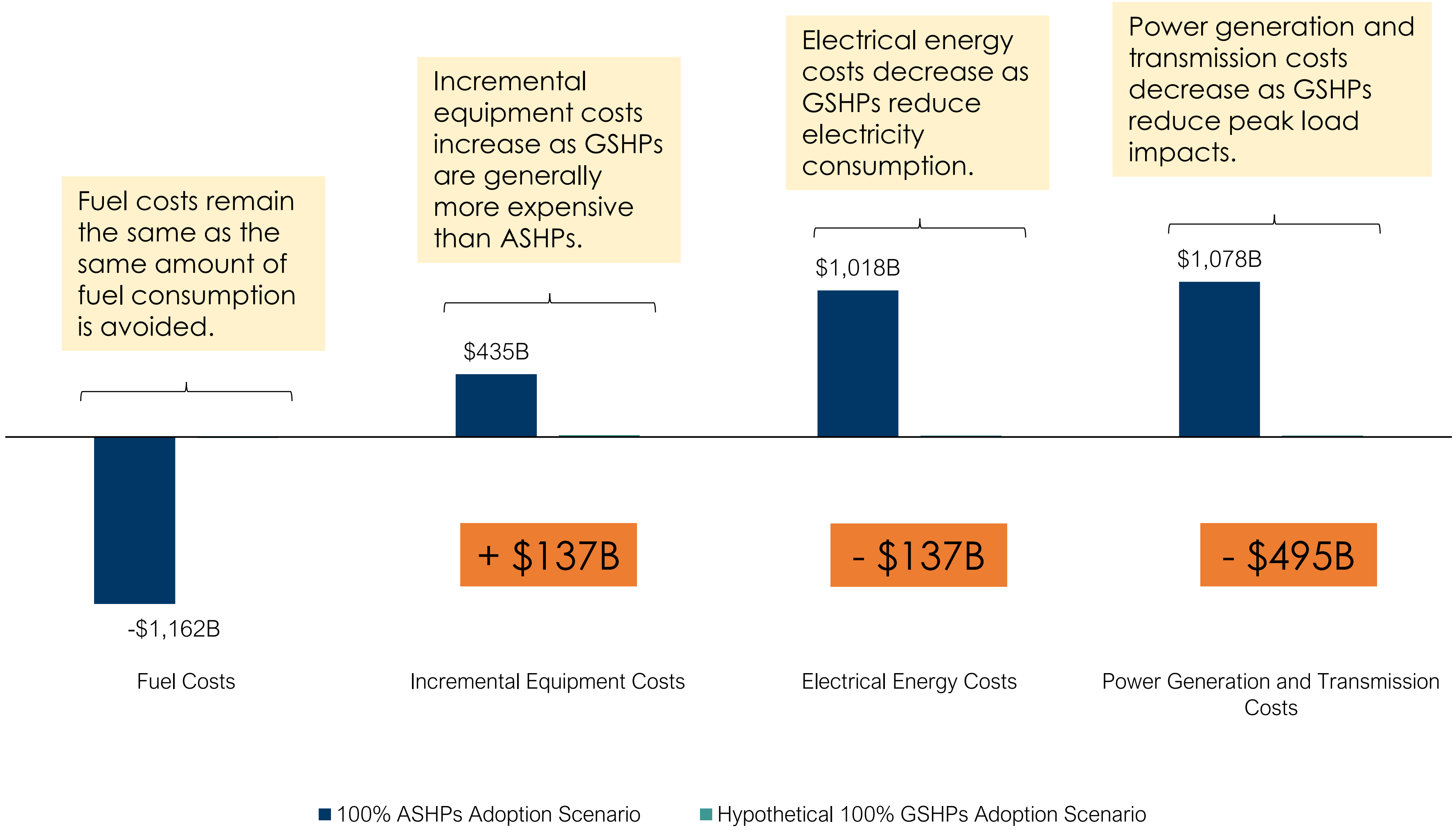
Increase in costs associated with the power generation required to serve the additional electric load and the transmission infrastructure to connect the additional power generation



Total: $1,369B

Results

Variation under a *hypothetical* 100% GSHP adoption scenario



Conclusion

GSHPs can significantly reduce the costs of widespread electrification in Canada

- Lower power generation and transmission costs
- Lower electricity costs for consumers
- Increased investment in buildings is more than offset by cost reductions

Benefits of GSHPs are highest in colder climates

- ASHPs must rely more heavily on electric resistance back-up
- In milder climates (e.g. Vancouver), GSHPs generate total costs reductions in larger buildings using hydronic heating systems, but not in smaller buildings using furnaces or rooftop units

GSHPs have an important role to play to decarbonize buildings in Canada

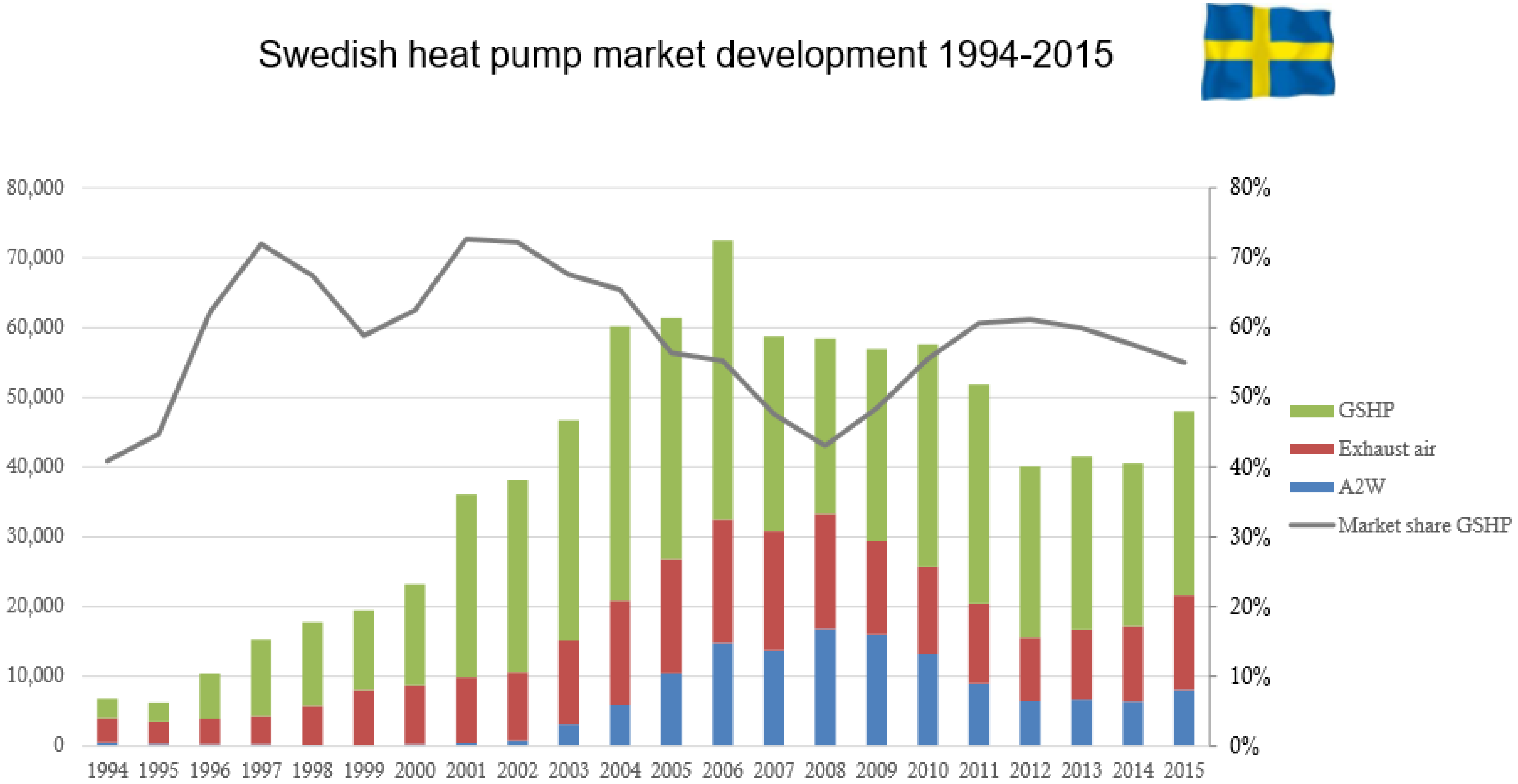
- GSHPs should be included in electrification policies, especially as we move towards renewables-based power generation
- However, numerous solutions will be required, in the near-term, to decarbonize Canada’s building sector, including ASHPs, GSHPs, and renewable gas.

Next steps

Phase 2 Study

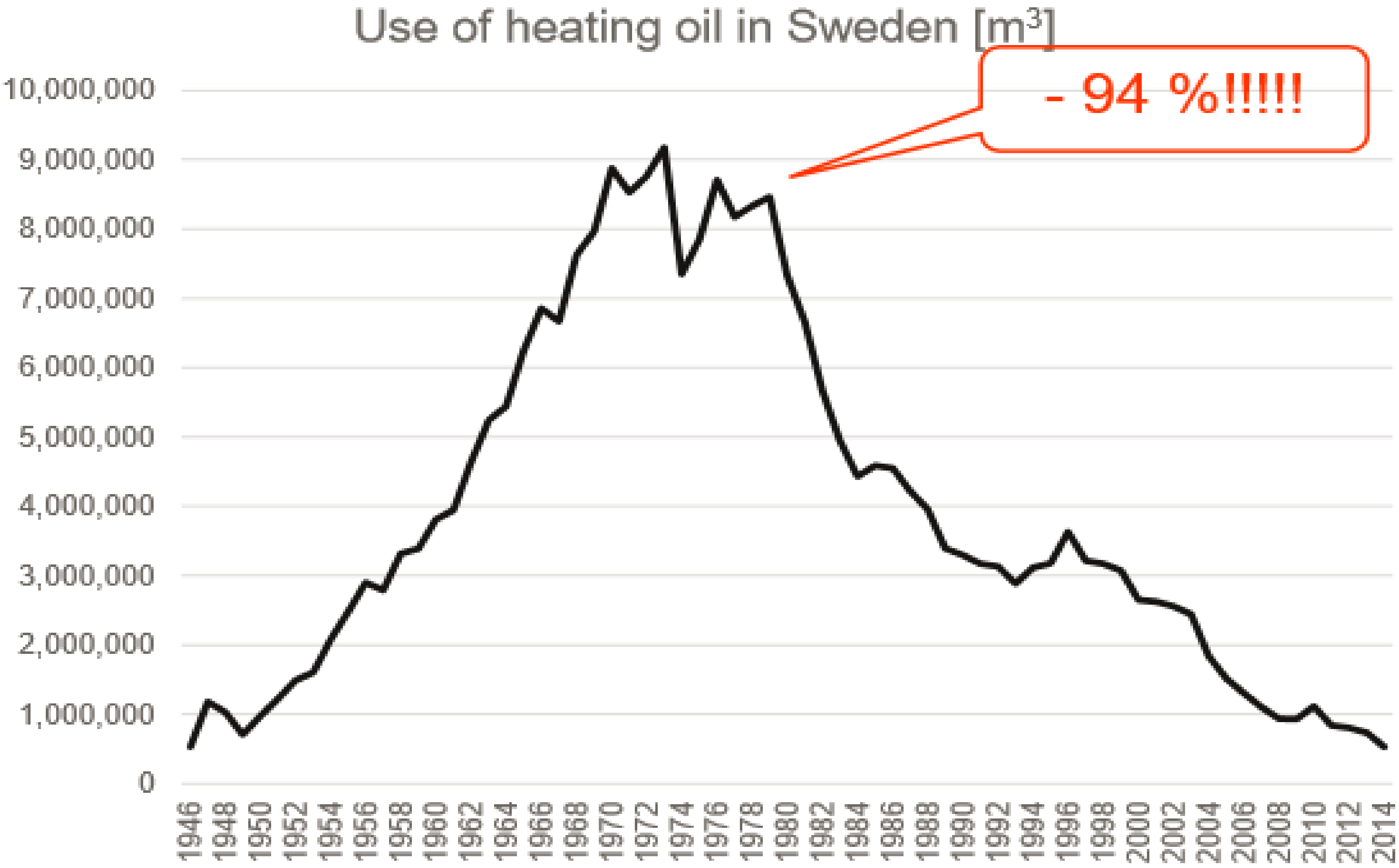
- Recommendations on **actionable policies and regulations** to increase the use of GSHPs in Canada
- **Learn from the best** around the world
- Adapt what we learn to the **Canadian context**

The Sweden Example...



The Sweden Example...

Vertical Geothermal Loops in Sundbyberg, a Residential Neighbourhood of Stockholm, Sweden


Use of heating oil in Sweden [m3]
- 94 %!!!!!
10,000,000
9,000,000
8,000,000
7,000,000
6,000,000
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4,000,000
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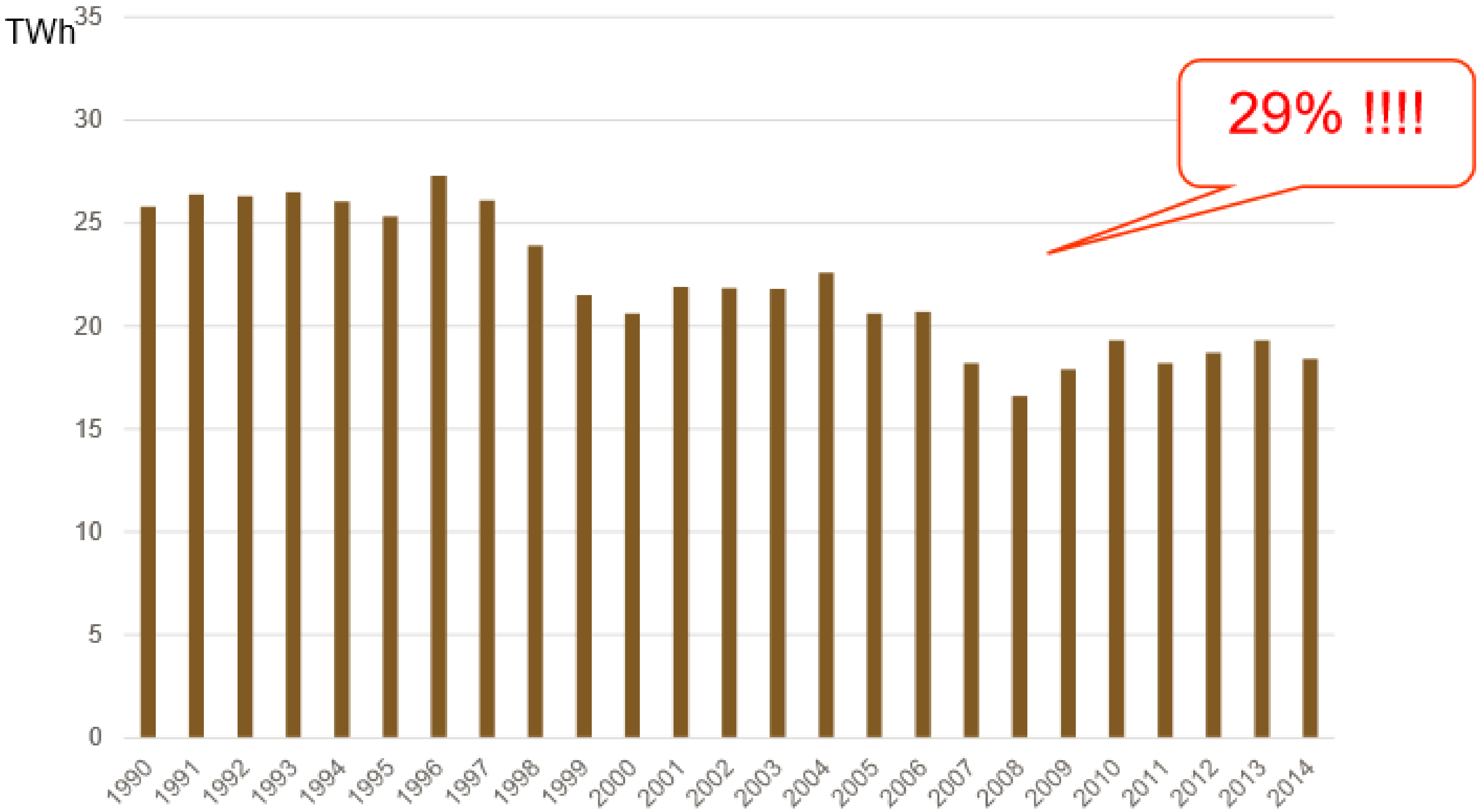
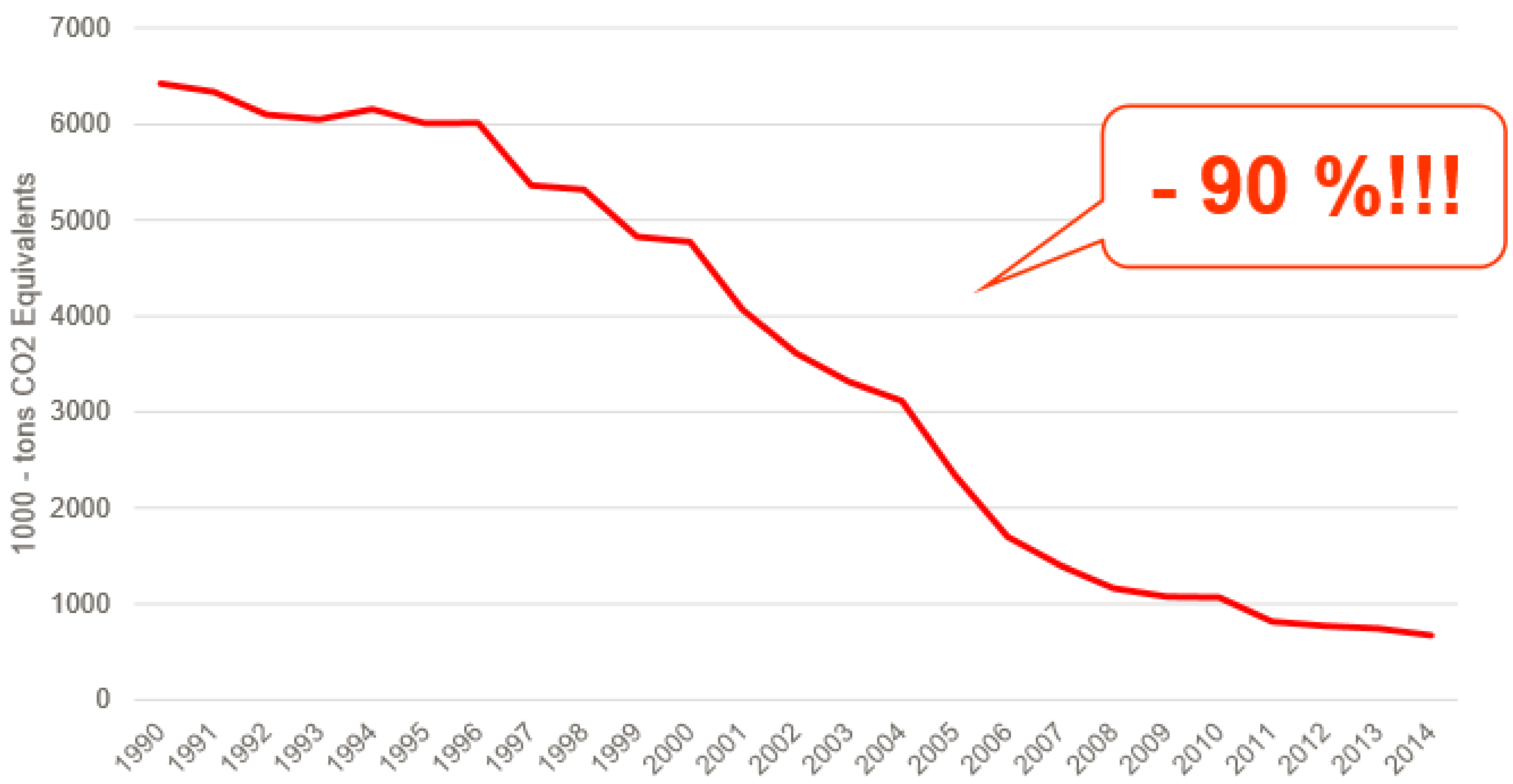
Use of electricity for heating purposes in Sweden



GHG-Emissions related to heating in buildings



Thank You

Q & A