NATURAL RESOURCES CANADA - INVENTIVE BY NATURE

# Heat Pumps for NZEB - Canada

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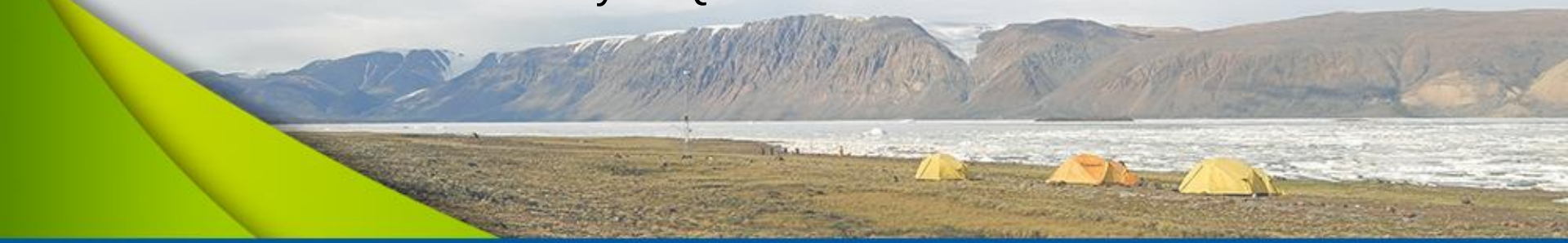


# Canadian Context

Image: Phoenix Real Estate 2014

- Canadian building sector
  - 31 % of secondary energy use
  - 28 % of GHG emissions

- Heating, cooling, and DHW
  - 82 % of energy use in residential sector
  - 61 % of energy use in commercial/institutional sector

# Our Vision for Nearly Zero Energy Buildings

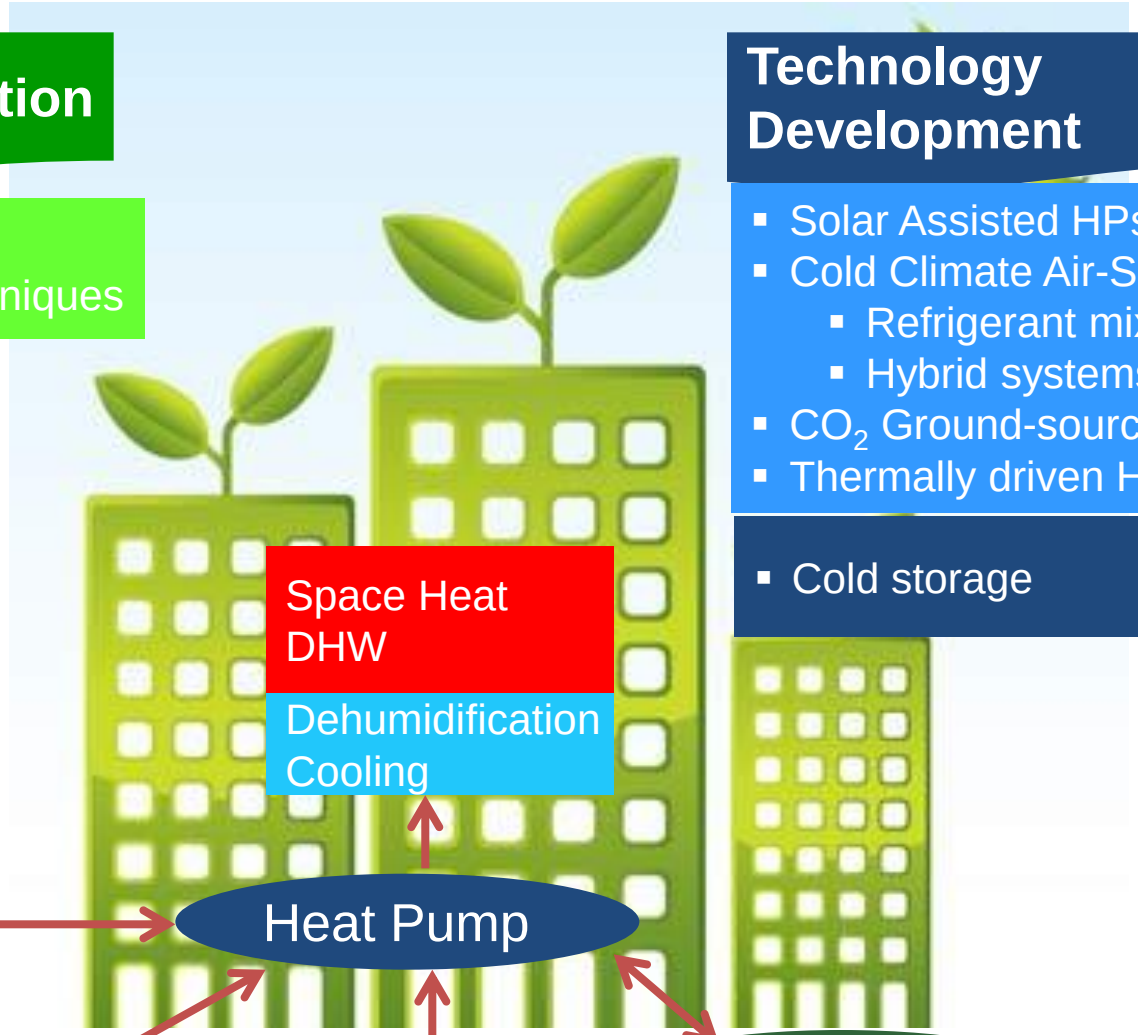
## Optimal Integration

- Simulation
- Optimization Techniques

## Technology Development

- Solar Assisted HPs
- Cold Climate Air-Source HP
  - Refrigerant mixtures
  - Hybrid systems
- $CO_2$ Ground-source HPs
- Thermally driven HPs

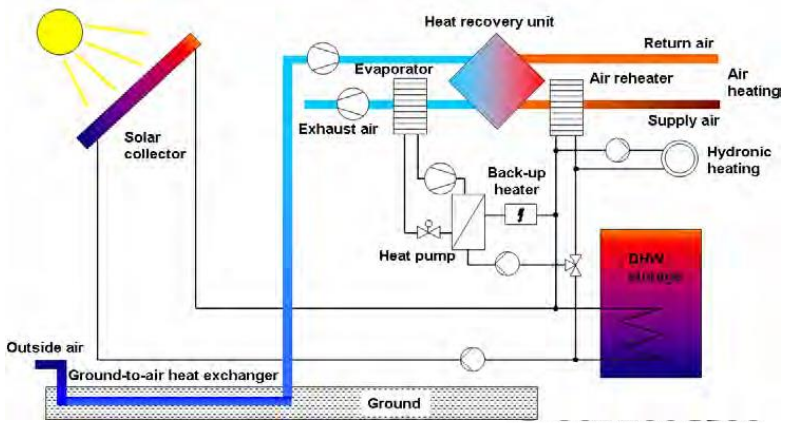
- Cold storage



# Optimal integration of HPs and renewables

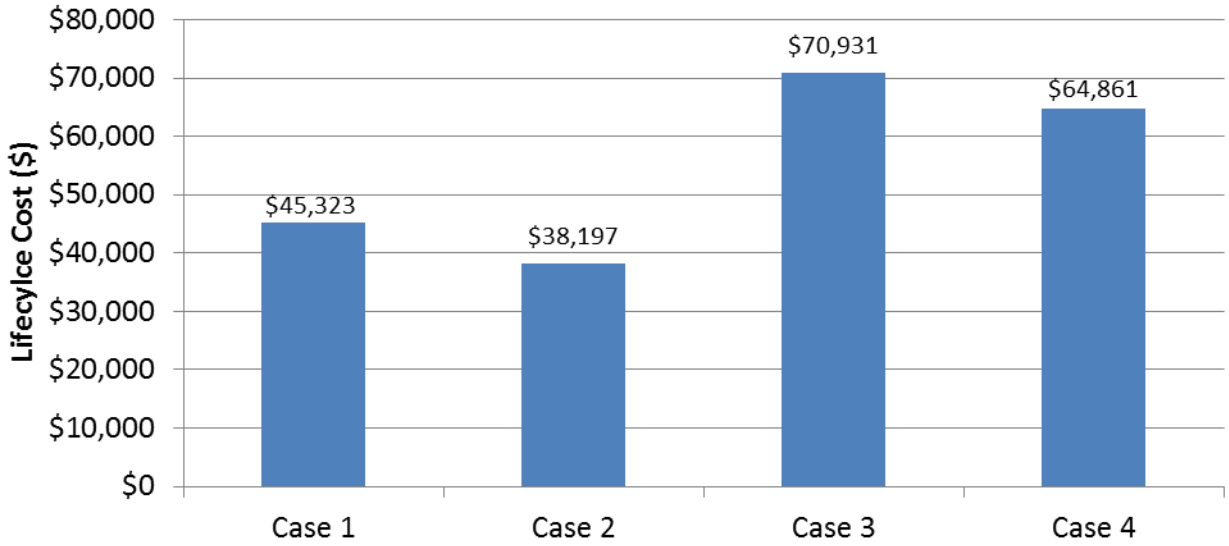
- A systematic optimization of integrated HPs and renewables:
  - 4 different houses (from the 70s, 80s, existing and low energy) and 6 climates in Canada
  - 3 different buildings (large office, school, and MURB) and 5 climates, including a northern community.

- HPs combined with one or more of the following systems:
  - Solar collectors
  - Cold and hot storages,
  - Heat recovery ventilators
  - Ground heat exchangers
  - Ground-to-air heat exchangers



# HPs in NZEB: Residential Sector

- Sample results for Montreal region




Case 1- Existing Envelop and systems

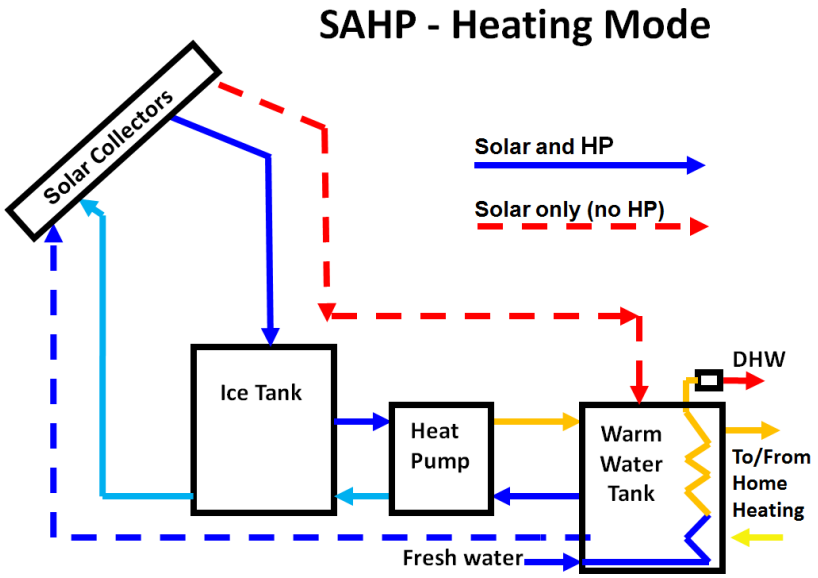
Case 2- Existing Envelope + GSHP

Case 3 - High Performance Building Envelope + existing systems

Case4 - Improved Envelope + ASHP

# Novel HP Systems: Solar Assisted HP

- New solar HP with ice storage
  - Smaller tank sizes
  - Improved collector efficiency
  - Strong energy savings potential

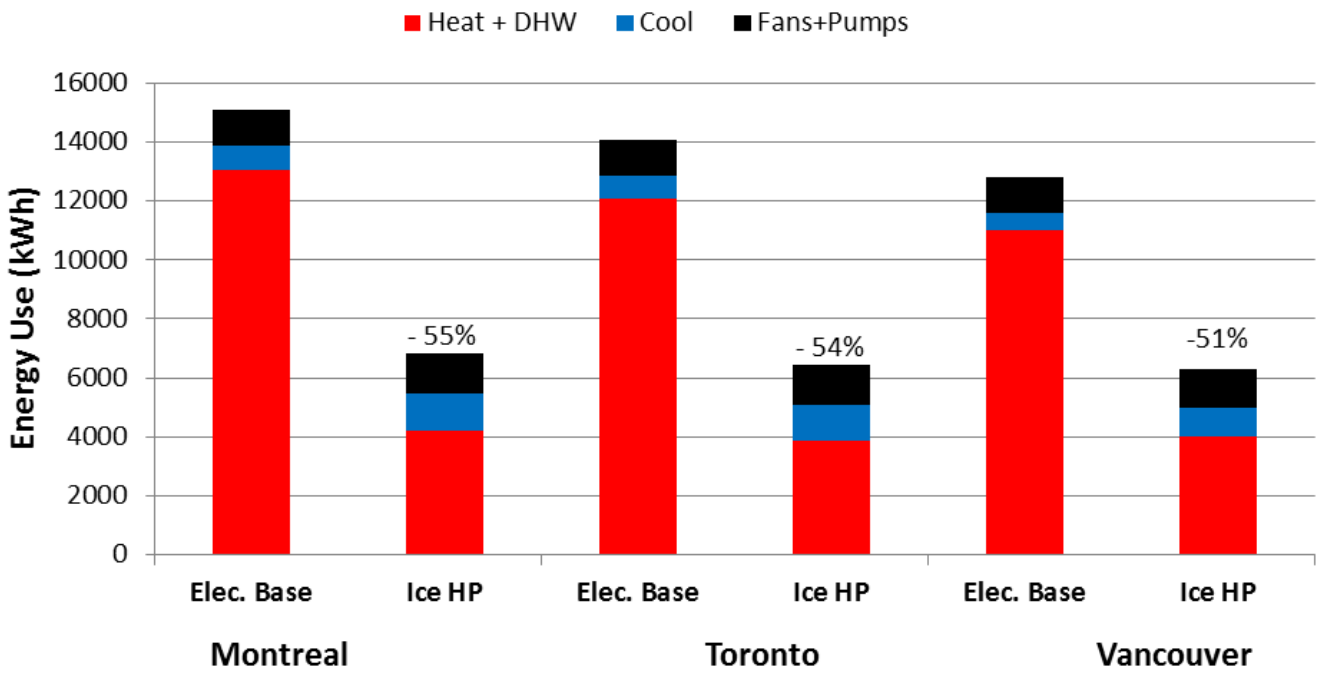



- Objective
  - Cost competitive integration for Canadian market

- Extensive development work
  - Energy modelling and simulation in Canadian homes
  - Test bench

# Ice Slurry SAHP: Energy Performance

- Strong energy savings across Canada



# Eco Terra demonstration house

Location: Québec (eastern Canada)

**2.84 kW Building-integrated photovoltaic-thermal (BIPV/T) system**

**Passive solar design**
Optimized triple glazed windows and thermal mass

**Ground-source heat pump**

# Eco Terra *net* annual electrical energy consumption

| Year | House status | Annual net electrical energy consumption | Energy consumption reduction vs. 26 700 kWh/year |
|---|---|---|---|
| - | - | kWh/year | % |
| 2010 | Occupied | 11 077 | 58.5 |
| 2011 | Occupied | 11 993 | 55.0 |
| 2012 | Occupied | 11 015 | 58.7 |
| 2013 | Occupied | 10 950 | 59.0 |
| 2014 | Occupied | 11 110 | 58.4 |

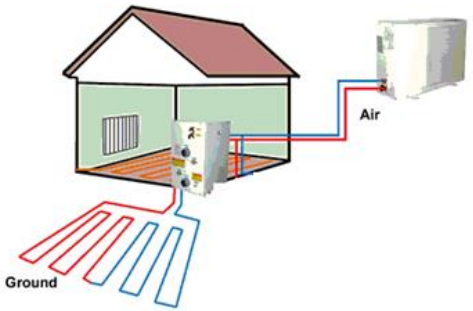
**Average energy consumption reduction: 57.9%**

Note: 26 700 kWh/year is the annual average energy consumption of electrically heated houses in Québec (eastern Canada)

# HP Grid Interaction

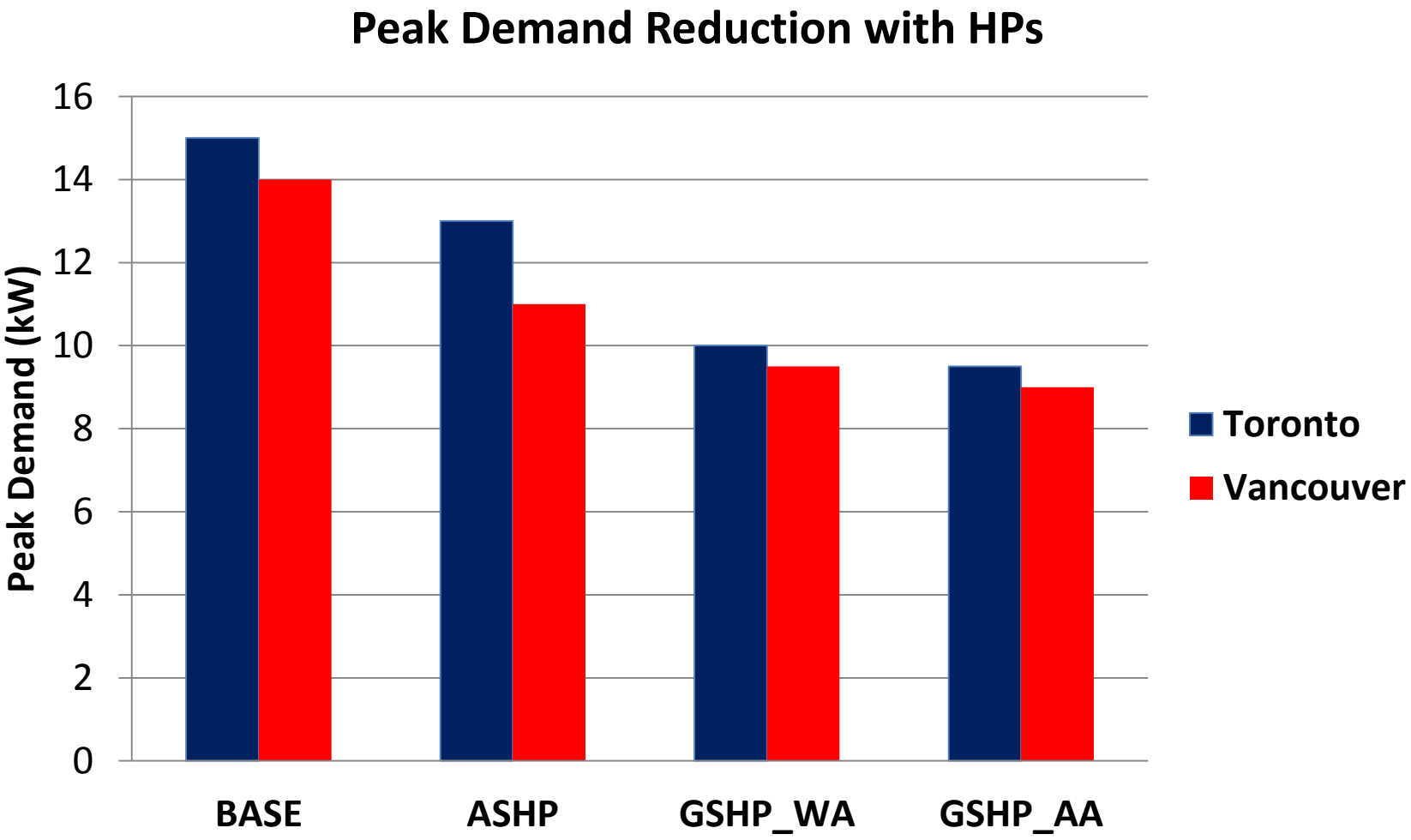
- **Objective**
  - How do HPs impact grid electrical loads?

- Focus: HP Systems in residential buildings
  - High performance housing in Toronto, Vancouver
    - PV system with 4 $kW_P$ capacity




- Four systems examined
  - Base case (electric heating and DHW)
  - Air-source heat pump (air distribution system)
  - Ground-source heat pump (air-distribution system)
  - Ground-source heat pump (hydronic distribution)

# HP Grid Interaction



# Conclusion

- Cost effective integration of renewable heating and cooling systems for nZEB

- Systematic HP system analysis
  - Residential and commercial buildings
  - Techno-economic framework

- Novel HP technology development
  - Solar HP with ice storage
  - Cold climate HP concepts (compressor/ejector ; refrigerant mixtures)
  - $CO_2$ GSHP