Community Energy and Harvesting Systems with Integrated Geothermal Technologies

Energy Research Collaboration Opportunity

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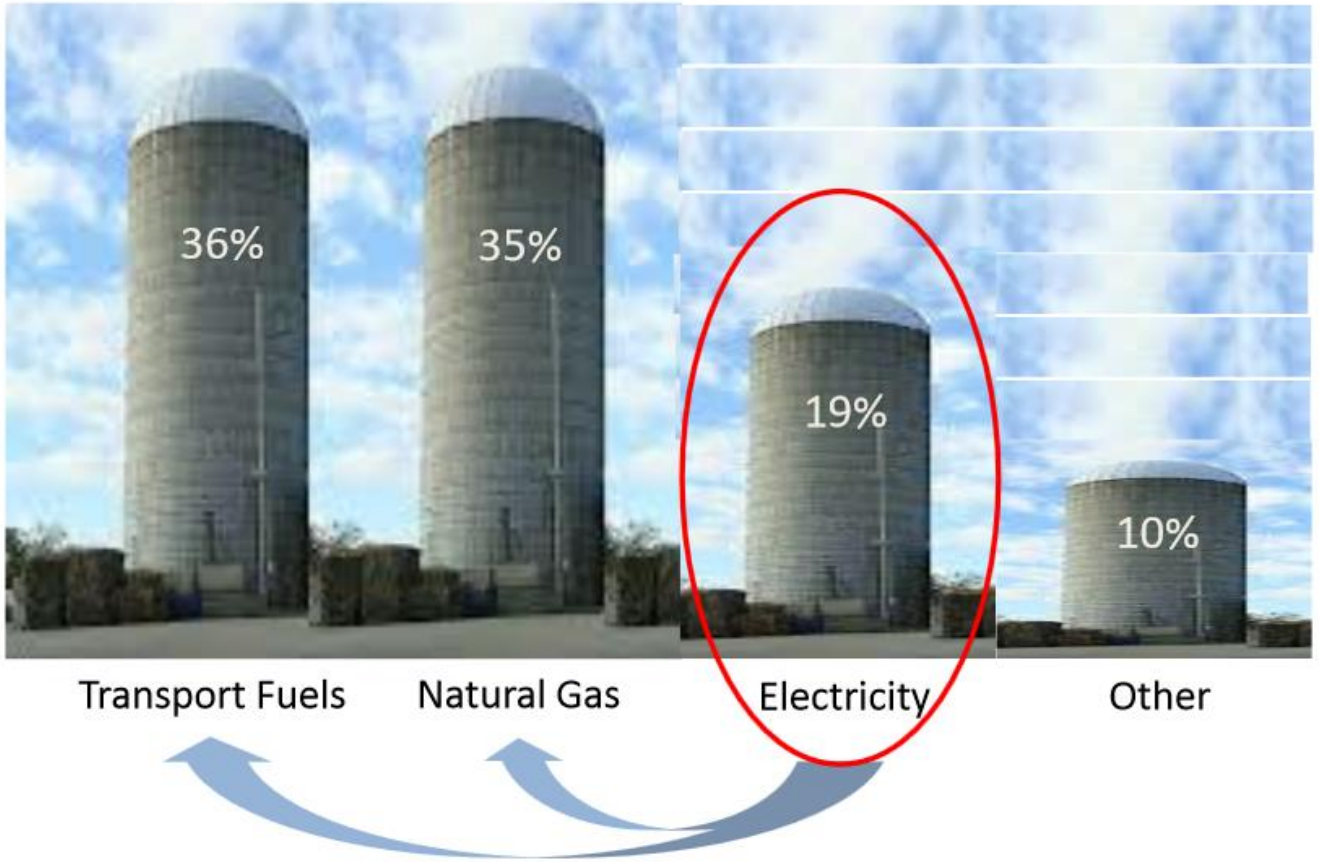
- McMaster University, 2007-
- Professor - Mechanical Engineering,
- Associate Director – McMaster Institute for Energy Studies

- Dana Canada Corporation, Long Manufacturing
- Research Supervisor- Heat Transfer & Analytical Development Team, 2003-2007
- Research Engineer- Heat Transfer Research, 2000-2003

Innovation Driven Research

- ✓ Heat transfer research
- ✓ Development of innovative energy harvesting systems
- ✓ Development of a thermal storage technologies that can store heat over short & long term periods

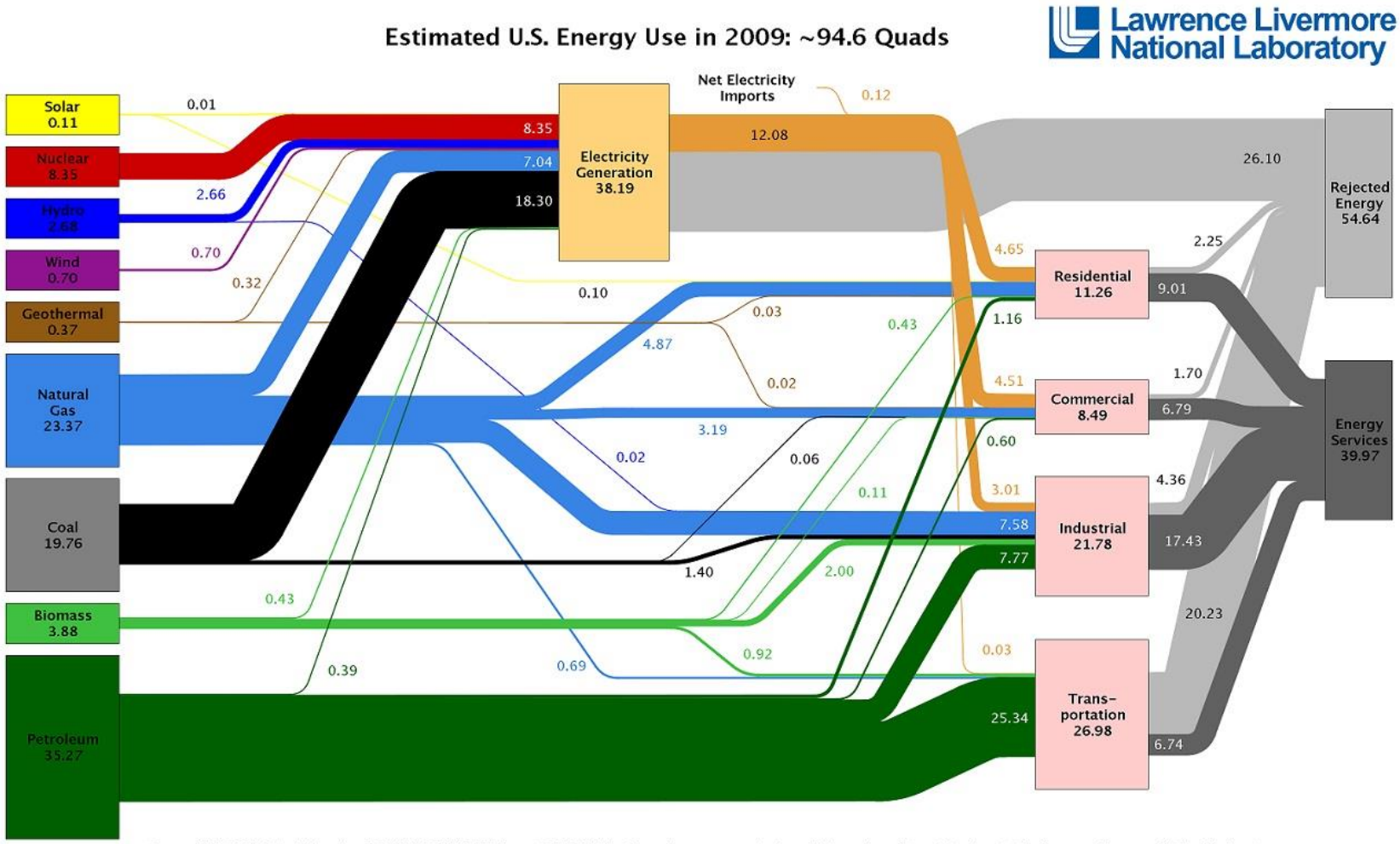
Ontario's Energy Silos



Source data: National Energy Board secondary energy demand forecast, Rethinking Energy Conservation in Ontario, May 2010 report

Source: Hydrogenics

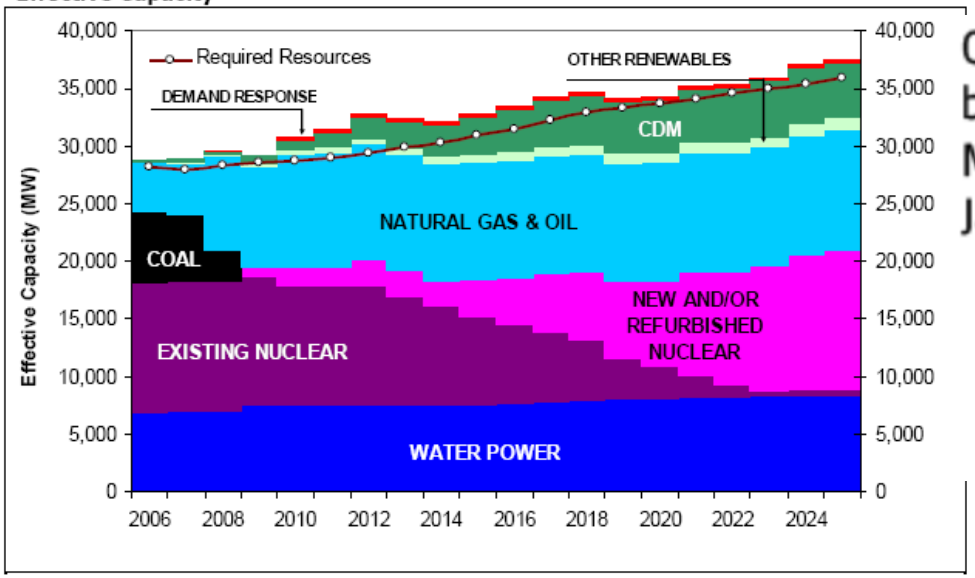
Silo Approach: More energy rejected than usefully used?



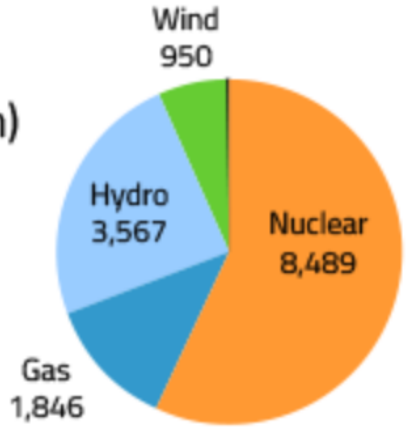
Source: LLNL 2010. Data is based on DOE/EIA-0384(2009), August 2010. If this information or a reproduction of it is used, credit must be given to the Lawrence Livermore National Laboratory and the Department of Energy, under whose auspices the work was performed. Distributed electricity represents only retail electricity sales and does not include self-generation. EIA reports flows for non-thermal resources (i.e., hydro, wind and solar) in BTU-equivalent values by assuming a typical fossil fuel plant "heat rate." The efficiency of electricity production is calculated as the total retail electricity delivered divided by the primary energy input into electricity generation. End use efficiency is estimated as 80% for the residential, commercial and industrial sectors, and as 25% for the transportation sector. Totals may not equal sum of components due to independent rounding. LLNL-MI-410527

Ontario's Electricity Generation Situation

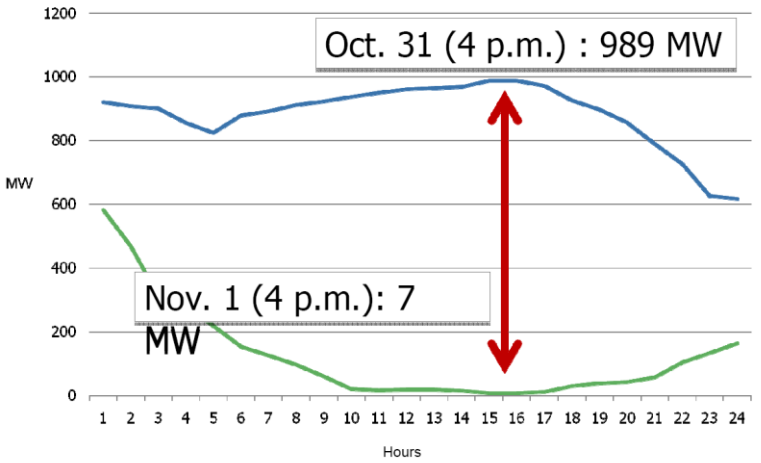
Figure 1.2.19: Scenario 5B – Higher Success In Harvesting Conservation Potential – Effective Capacity



Generator Output by Fuel Type Monthly Report (GWh) January 2015



- Aging Infrastructure
- Increasing cost of electricity
- Loss of load – surplus baseload
- Intermittent renewables
- We are terrible at planning



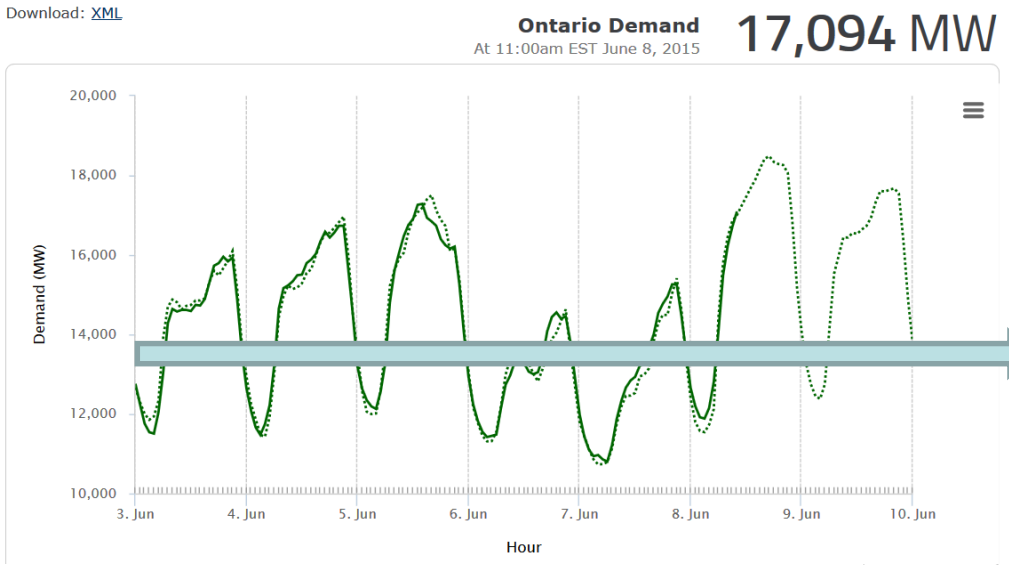
Source: OPA

Energy Harvesting Potential

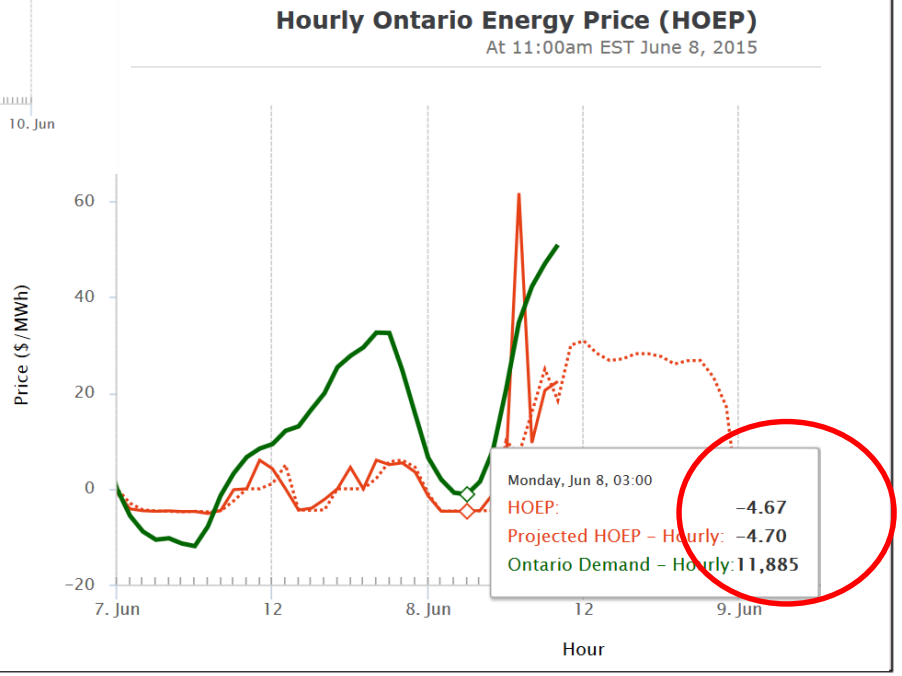
- Fossil fuels to generate electricity in Ontario over the past 5 years has been on average **24 TWh_e/year** or 16% of electricity generation

- At 30-40% efficient, almost **~40 TWh_t** enough energy to heat approximately 1.4 - 2.2 million homes or 30 - 45% of Ontario households - is simply lost

Ontario's Peaking vs Baseload Problems



Base Generation
Exceeds Demand



Solution: Sell to US for NEGATIVE -$$$

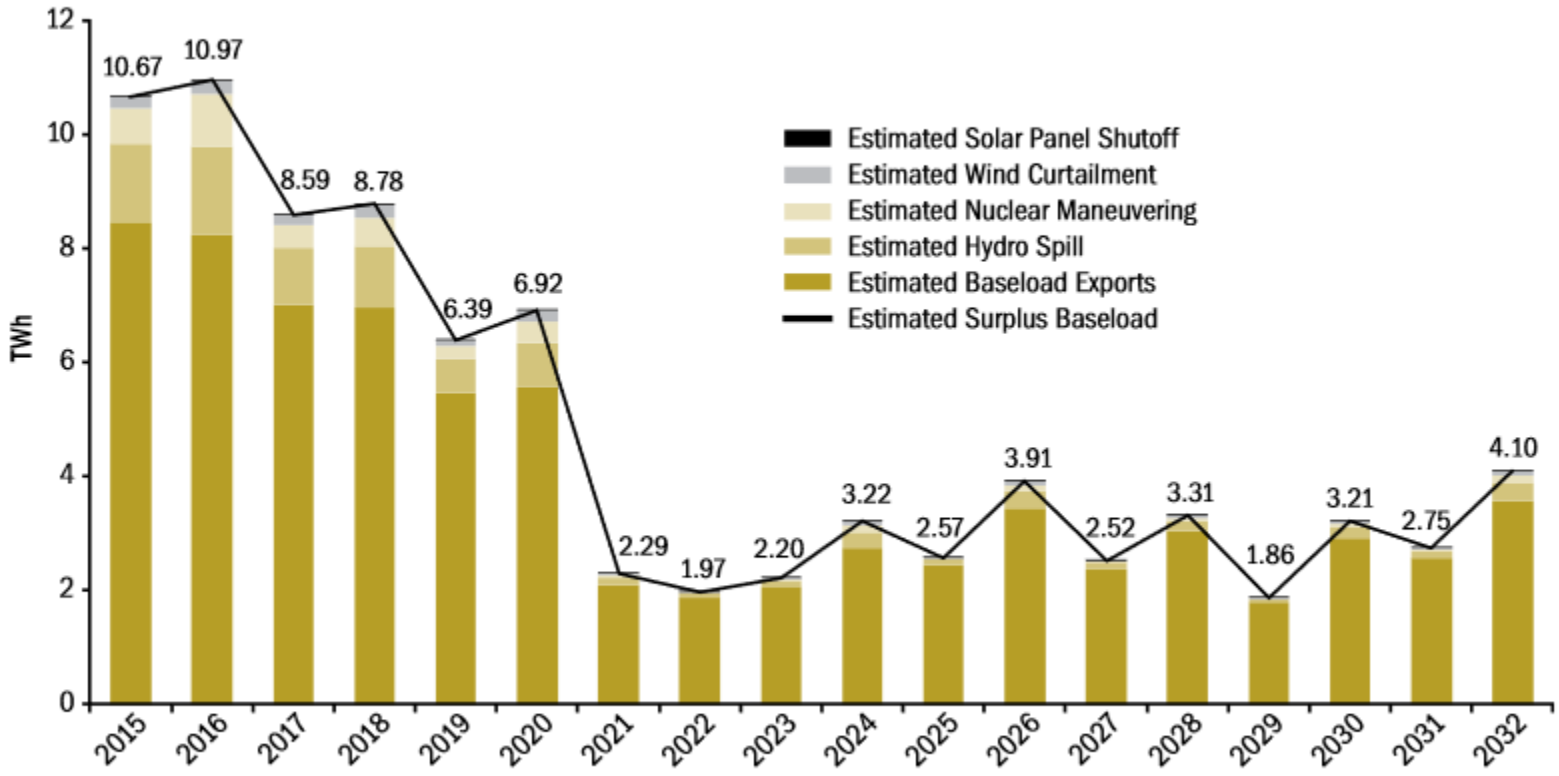
Source: IESO

Surplus Baseload Generation

An Opportunity for Geo - Thermal Storage?

Figure 11: IESO's Surplus Baseload Management Plan, 2015–2032

Source of data: Independent Electricity System Operator



Note: This graph shows Ontario's estimated surplus baseload from 2015 to 2032. IESO plans to manage this surplus by either exporting the excess power or requesting some generators (such as hydro, nuclear, wind or solar) to reduce production.

Integrated Community Energy and Harvesting Systems

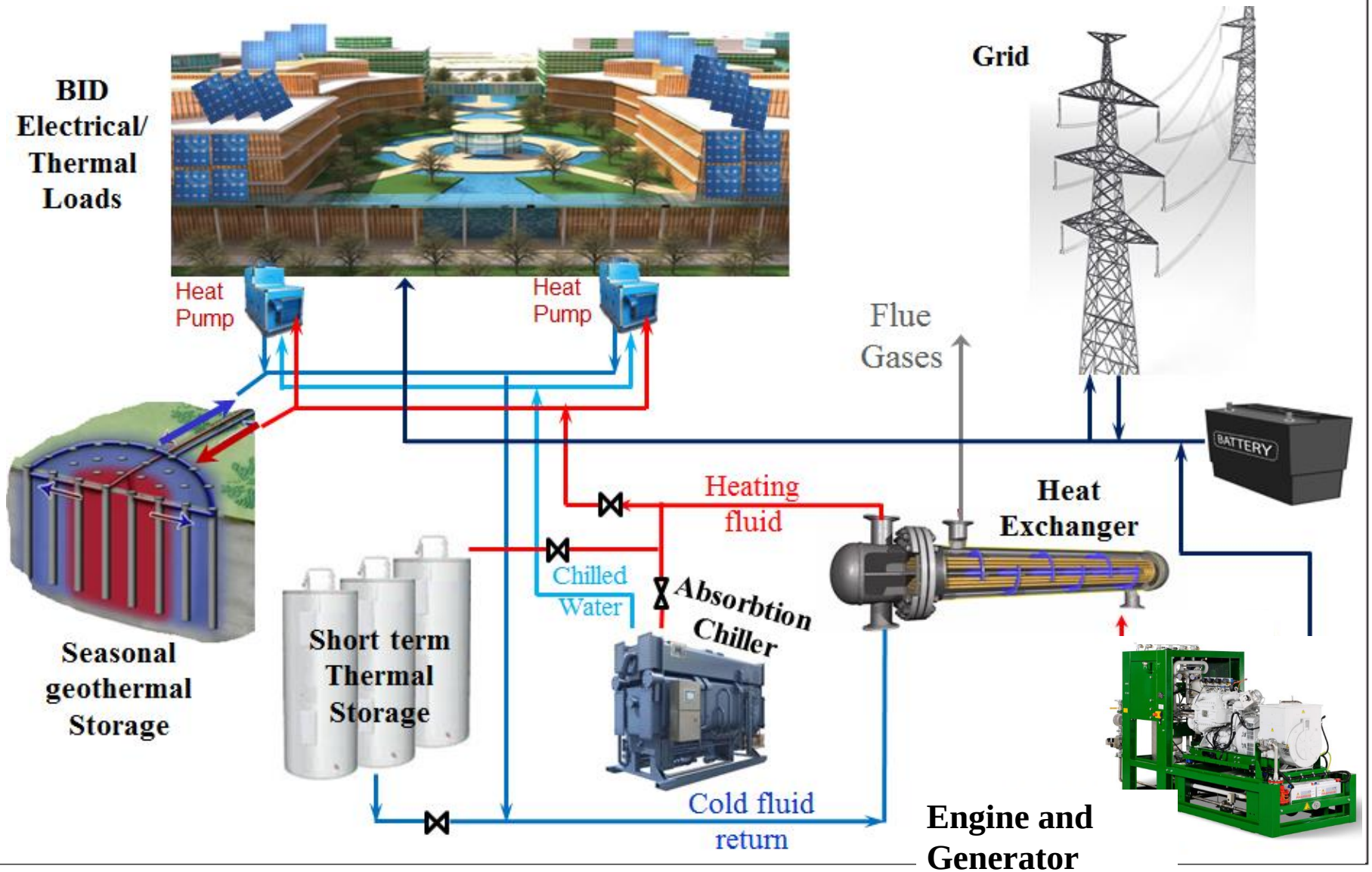
- ✓ Integrate Grid & Onsite Electricity Generation
- ✓ Thermal Energy Harvesting
- ✓ Electric & Thermal Storage

To deliver resiliency and a new low carbon energy based economic development ecosystem.

Community "Node-Based" Concept

- **Building Node:** local energy producing and energy consuming devices.
- **Neighborhood Node**: several building nodes are clustered together.
- **Community Node**: neighbourhood nodes will be clustered together.

Community Integrated Energy and Harvesting System

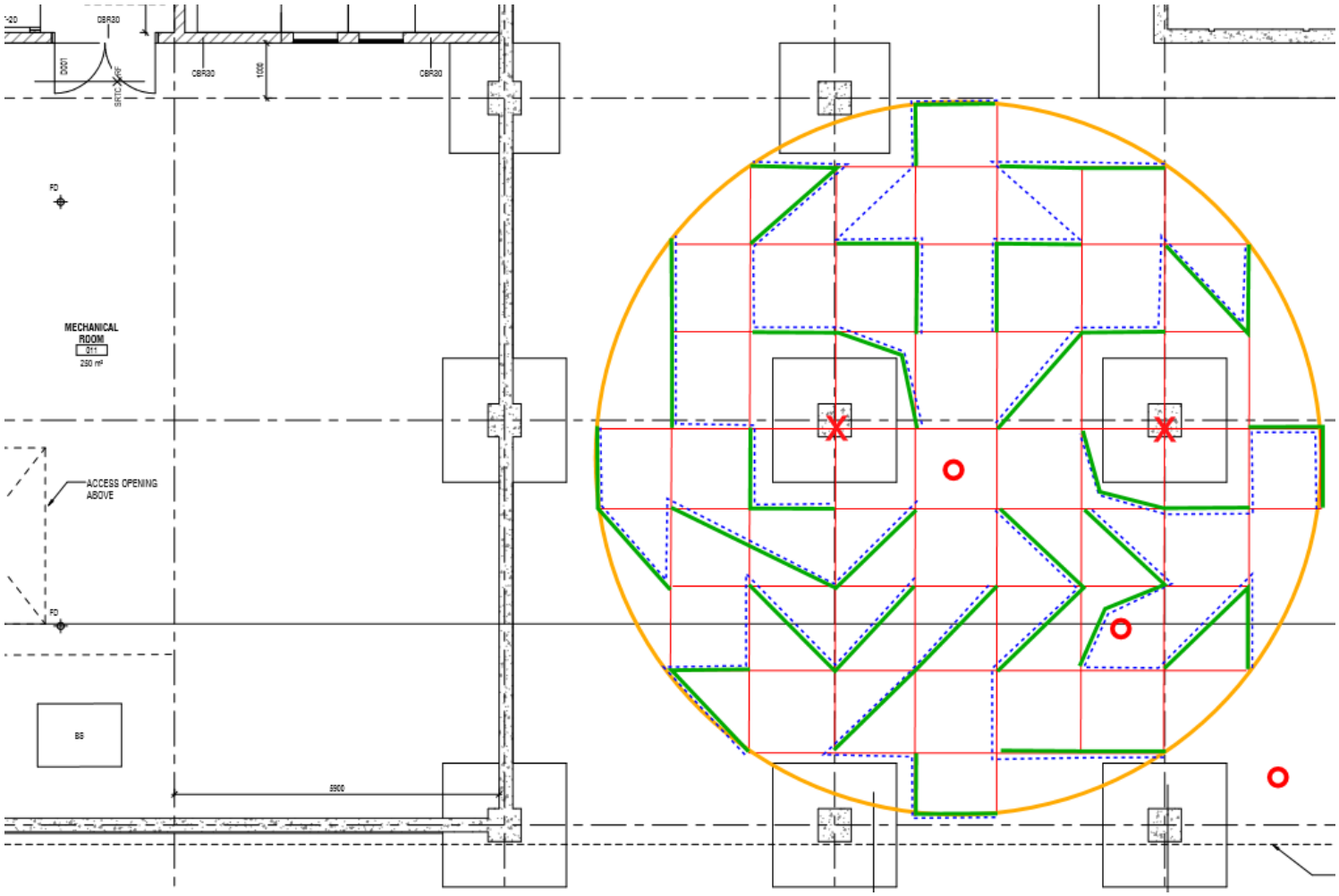


McMaster - Research Facility for Integrated Building Energy Harvesting Systems

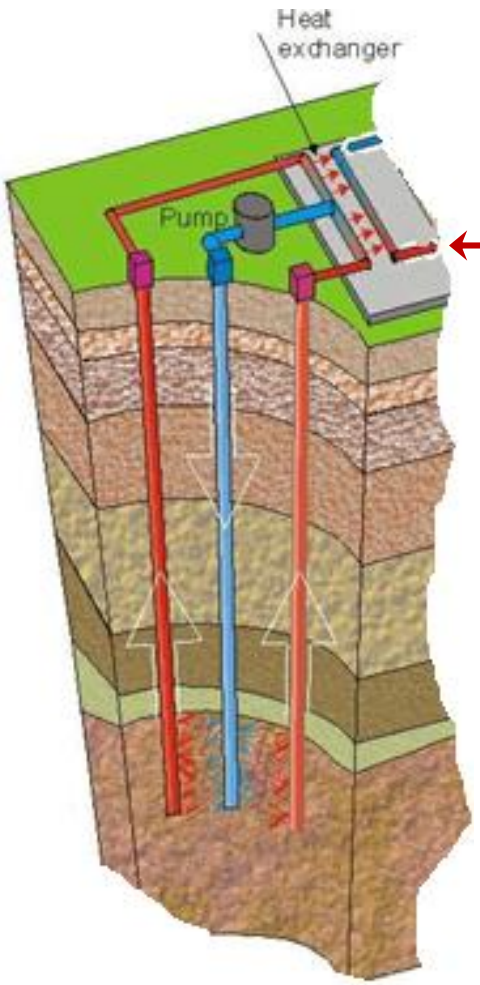
Equipment to be Integrated into Building

- Combined Heat and Power (80 kW_e, 125 kW_t)
- Renewables (Solar PV, Solar Thermal, Wind)
- Absorption Chiller (30 Ton)
- Geothermal - Water to Water Heat Pump
  - Seasonal Storage of Waste Heat
- Thermal Storage (Phase Change, Geothermal)
- Direct Current Micro Grid (AC&DC Distribution)
- Electrical Vehicle Charging (Bi-Directional)
- Electrical Storage (Battery)
- Energy Balance Sensor Array

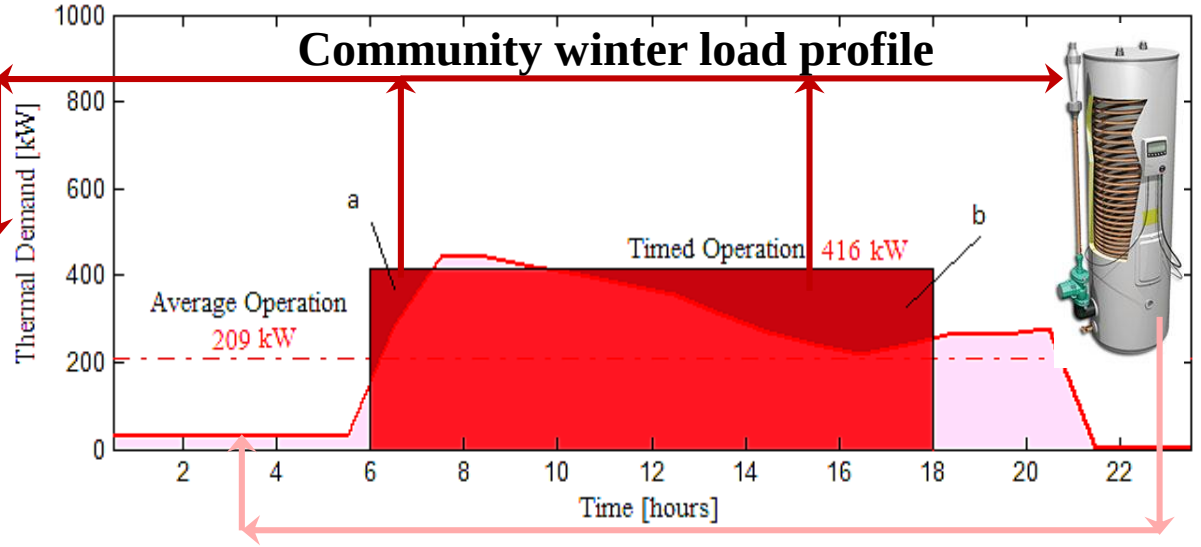
GeoSource Energy-Geothermal Seasonal Storage Field

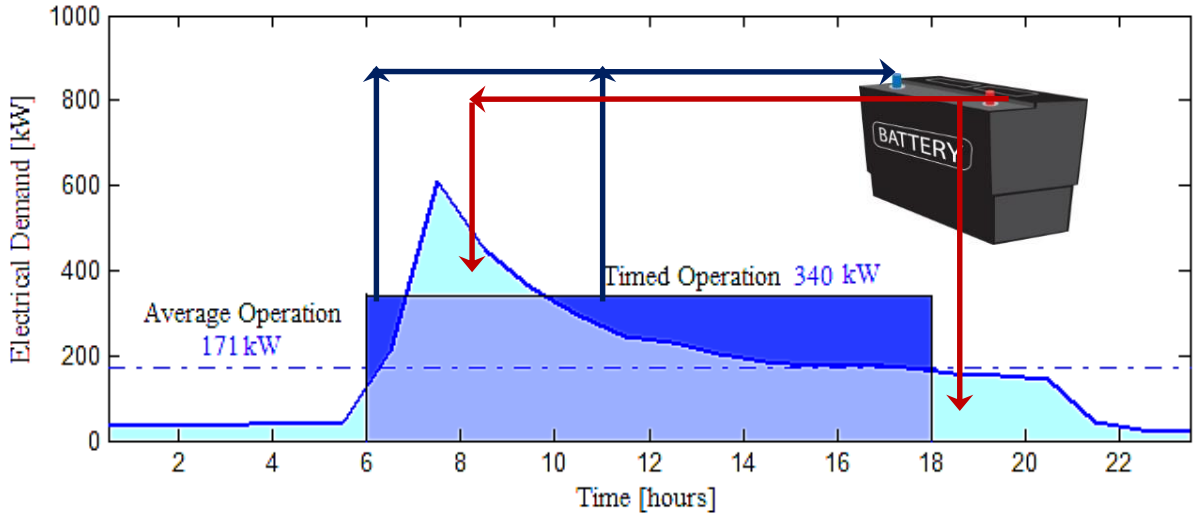


Simulations of System of Building Integrated Generation and Electrical/ Thermal Battery Storage on Peak Winter Day

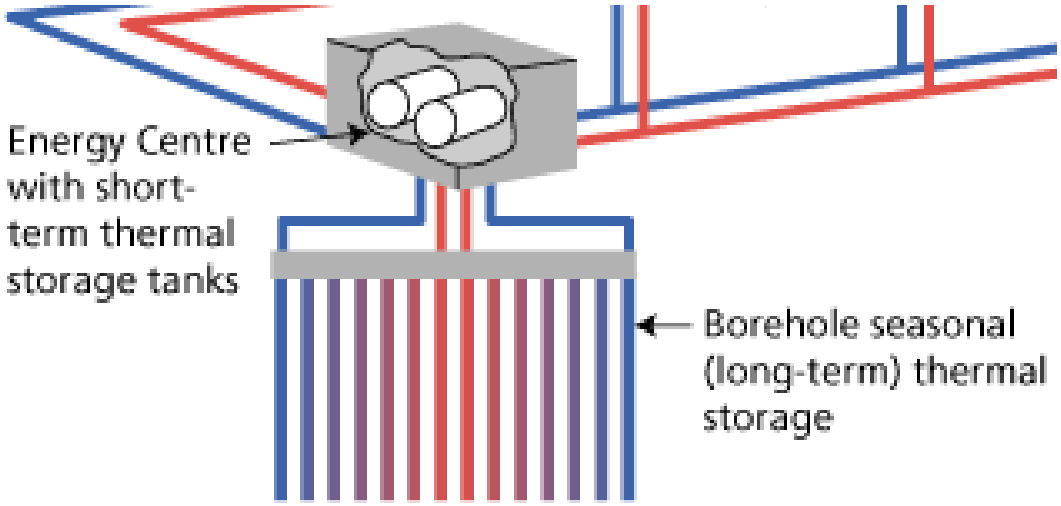


Geothermal Seasonal Energy Storage

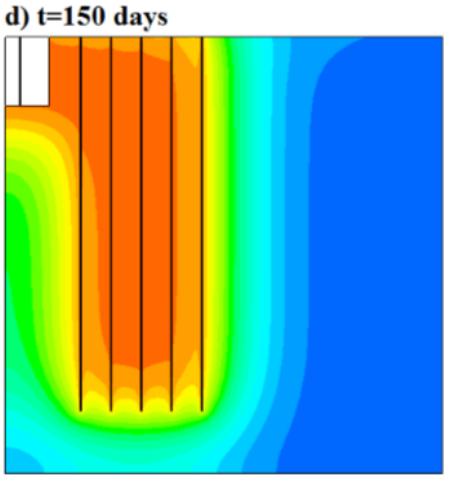


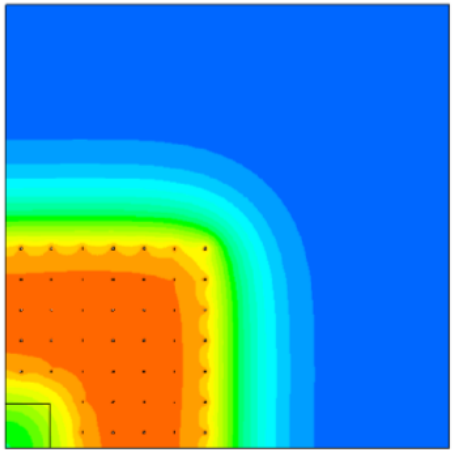


Borehole Seasonal Thermal Storage Research



* Image from Drakes Landing Solar Community, Okotoks Alberta





(Kandiah & Lightstone)

Geothermal Storage Research Challenges/Goals

- *Is there an optimum storage temperature?*

  - Higher storage temp, higher losses

  - Lower temperatures – larger field & require lower HVAC operating temperature equipment

- *Field design guidelines* - large fields are required to reduce losses. Not good fit for single house- *what is the 'right size' and best layout*.
- Long term balancing simulations and tools required.
- Demand respond vs seasonal storage optimization required.

Thank you

contact: cottonjs@mcmaster.ca

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