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Wind-dominated System where Thermal Storage has been a Key Enabling Technology

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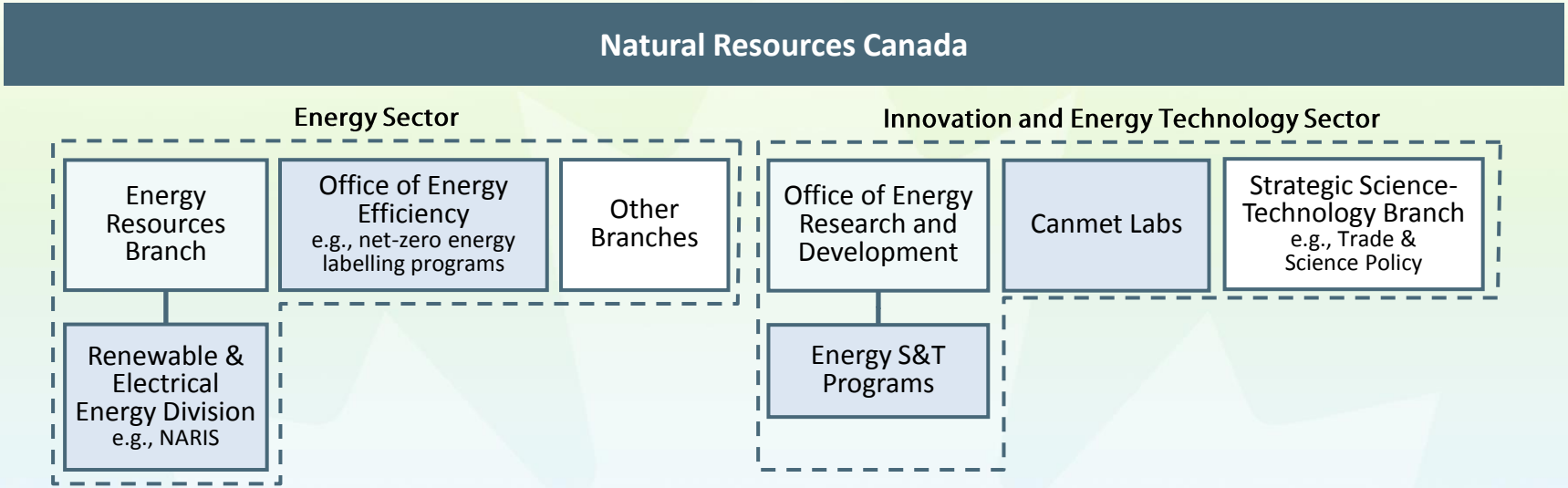
2018 International conference on
Integration of Renewable and Distributed Energy Resources(IRED)
Vienna, Austria

Canada

Federal Government and the Smart Grid

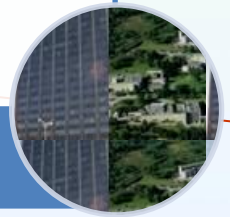


Canmet Laboratories Across Canada

- Oil sands & heavy oil

Devon

- Buildings & communities
- Industrial processes
- Clean electricity
- Bioenergy
- Renewables
- Transportation



Ottawa

- Buildings
- Industrial processes
- **Renewable energy integration**
- RETScreen International

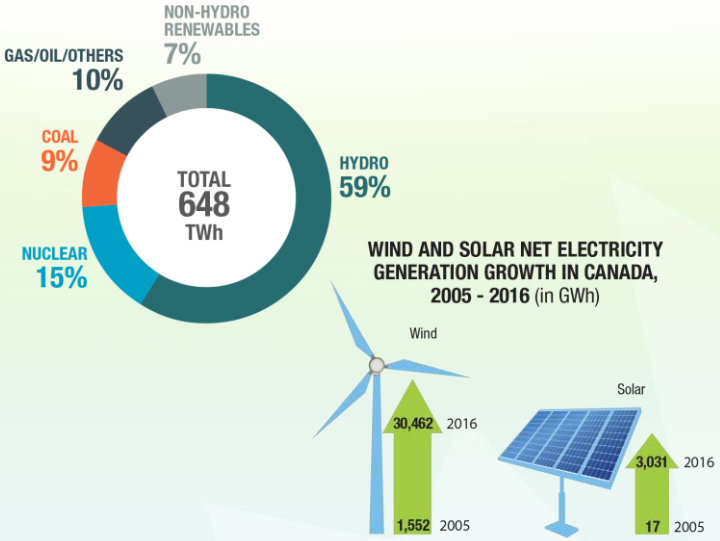
Varennes

- Transportation (materials)
- Pipelines
- Manufacturing

Hamilton

Smart Grid Deployment Metrics in Canada 2018

GENERATION BY SOURCE, 2016



In 2016, **81%** of electricity in Canada came from **non-GHG emitting sources**

SOLAR PV
2.10 GW_{AC} distributed out of
2.48 GW_{AC} installed grid-connected capacity
Data as of December 31, 2017

EV
72.8 k BEVs and PHEVs on road
>5.8 k Level 2 charging outlets
>850 Level 3 charging outlets
Data as of July 31, 2018

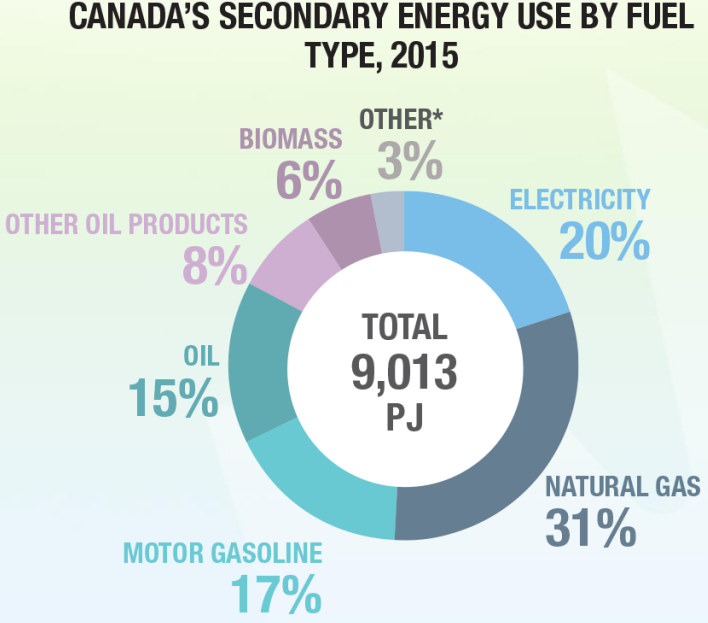
SMART METER
>81% of meters are smart
Data as of August 17, 2018

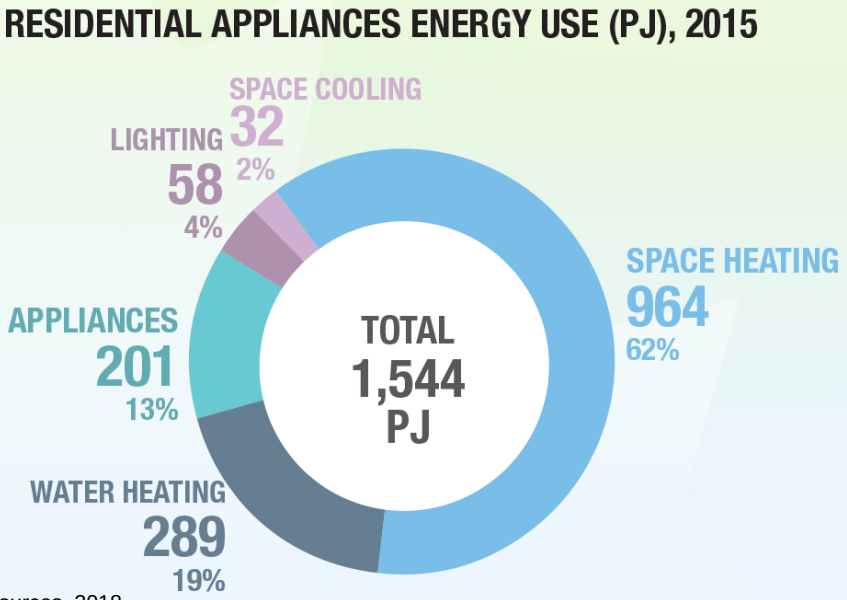
WIND
0.96 GW_{AC} distributed* out of
12.70 GW_{AC} installed capacity
*assuming all wind capacity below 20 MW is distribution connected
Data as of July 1, 2018

Decarbonization and Electrification

Residential energy use

81% of residential energy consumption is used for space and water heating

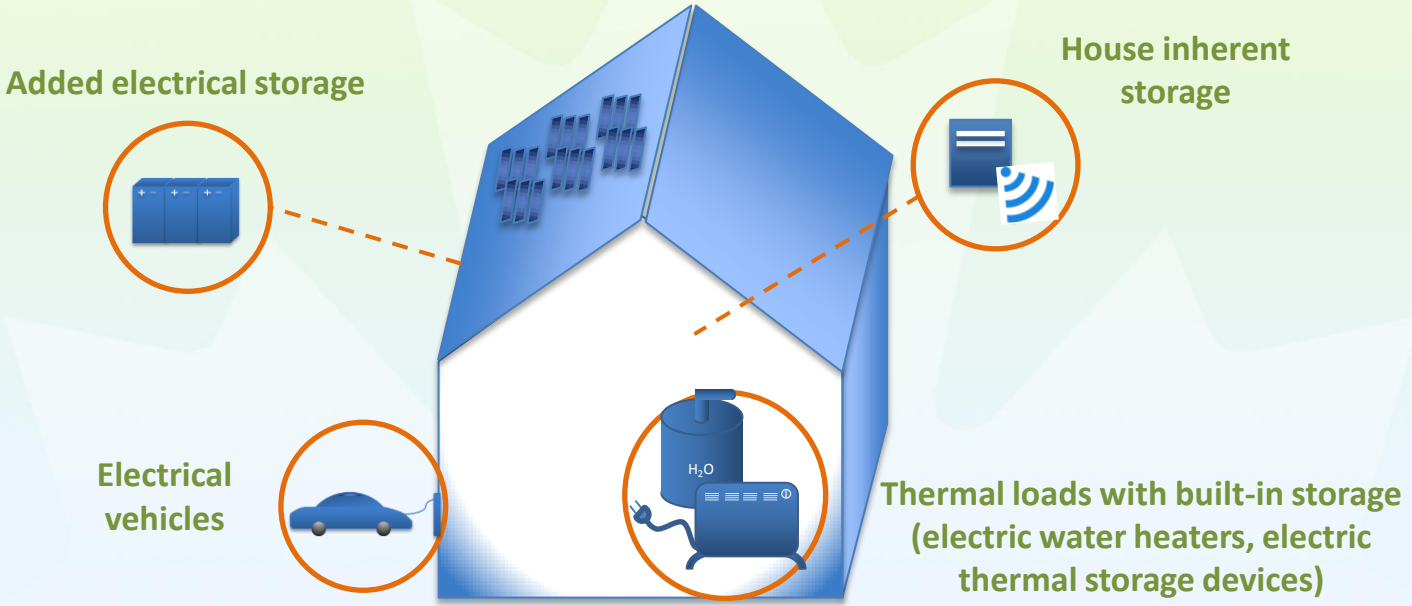




Summerside Electric Case Study

Flexible Loads = Integrate Renewable

Residential Sector Example



Canada's DR potential

Total residential DR potential in Canada is 39 GW/ 85 GWh

		BC	AB	SK	MB	ON	QC	NB	NS	PE	NL	Total
Space Heating	Peak Load (GW)	3.6	0.58	0.25	1.2	6.1	13	1.1	0.68	0.02	0.93	27
	Thermal Storage Capacity (GWh)	7.2	1.2	4.9	2.4	12	25	2.2	1.4	0.05	1.9	58
Space Cooling	No. Homes with Central AC (k)	198	221	194	271	3110	524	52	18.0	0.5	4.8	4593
Water Heating	Peak Load (GW)	0.73	0.12	0.08	0.27	1.3	3.6	3.3	2.3	0.01	0.23	12
	Thermal Storage Capacity (GWh)	2.8	0.46	0.30	1.0	5.2	14	1.3	0.91	0.05	0.88	27

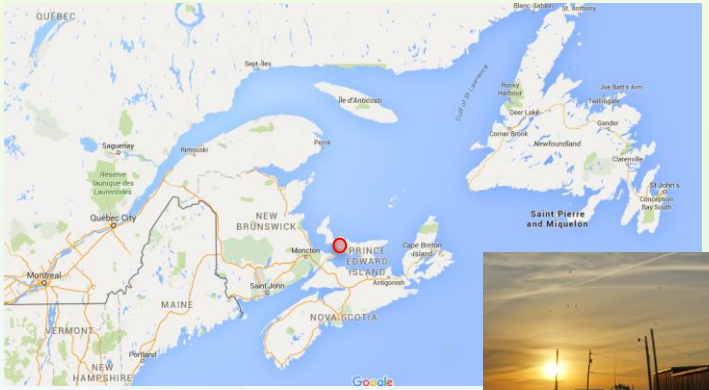
- With minimal/no comfort impact
- Without storage addition

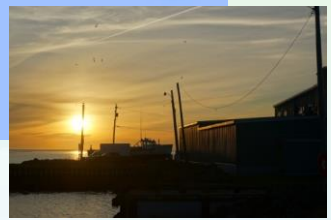
Steven Wong, Canadian Residential Demand Response and Ancillary Service Market Opportunities, CanmetENERGY, Varennes Research Centre, Natural Resources Canada, Report No. 2015-022 (RP-TEC), April 2015

Summerside Smart Grid Project for Wind Integration

Summerside, Prince Edward Island

- 15,000 inhabitants
- 27 MW peak
- 130 GWh annual energy consumption





Electric utility

- Municipally-owned
- 21 MW wind generation (owned/contracted) (supplies 40-50% energy)
- Interconnected with New Brunswick Power

City of Summerside
Prince Edward Island

S. Wong, G. Gaudet and L. P. Proulx, "Capturing Wind with Thermal Energy Storage – Summerside's Smart Grid Approach," in *IEEE Power and Energy Technology Systems Journal*, In Press. doi: 10.1109/JPETS.2017.2754139

Wind Integration Challenge

- Mismatch between wind and load means that energy must often be exported to bulk grid
- Consequences:
  - Lost GHG reduction potential with clean energy not being used locally
  - Missed economic gains by exporting the wind energy at less than value

Solution

Solution:

- A *smart grid* program increasing local utilization of wind generation

Since wind cannot be controlled (without losing energy), solution must be on the load side

Approach:

- Increase electric heat load
- Enable flexibility in heat load through utility managed heat energy storage
- Use wind energy to heat or to charge energy storage appliances for space/water heating

High temperature electric water heater with thermostatic valve

Program

Consumer-side Program:

- Encourage replacement of oil-fired equipment with
  - Electric thermal storage (ETS) space heating units
  - High capacity/temperature electric water heaters

  by offering discounted rates
  - Offsetting customer-borne capital costs
  - Bucket at 8¢ vs 12¢ per kWh for appliance energy demand
- Appliance load management options
  - Smart (dynamically)
  - Time-of-use

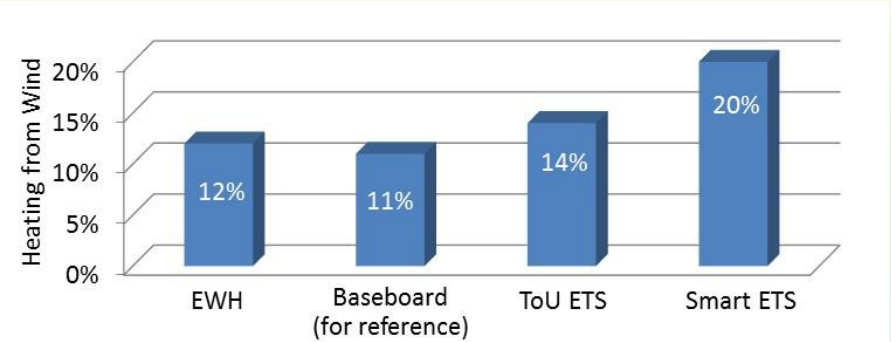
Total device uptake, to 2015

Device	No.	Total Charging Capacity (kW)	Total Storage Capacity (kWh)	Estimated Energy Use (MWh)
Room ETS	120	642	3240	1436
House ETS	45	1244	6618	2153
Thermal Electric Large ETS	6	480	2280	2997
Water Heater	140	630	849	n/a

Total of 3 MW and 13.5 MWh of available storage

Results

- Additional 621 MWh (24% of surplus) of wind locally consumed



Portion of energy use supplied by wind, per device

- 400 t CO_2eq GHG avoidance

ToU ETS (small home)	Smart ETS (small home)	ToU EWH
2.4 t CO_2eq/y/appliance	2.9 t CO_2eq/y/appliance	0.3 t CO_2eq/y/appliance

Conclusion

- Decarbonization, electrification, clean electricity
- Flexibility from the demand side = enabler for renewables
- Smart grid technologies deployed in Summerside to use wind surpluses for clean heating
- Now studying future control options using AI techniques to improve prediction and control

Questions

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