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PATHWAYS FOR CANADA'S TRANSITION TOWARDS ELECTRIFICATION AND SUSTAINABLE TRANSPORTATION

Electrification and Electric Transportation

Sustainable Canada Dialogues

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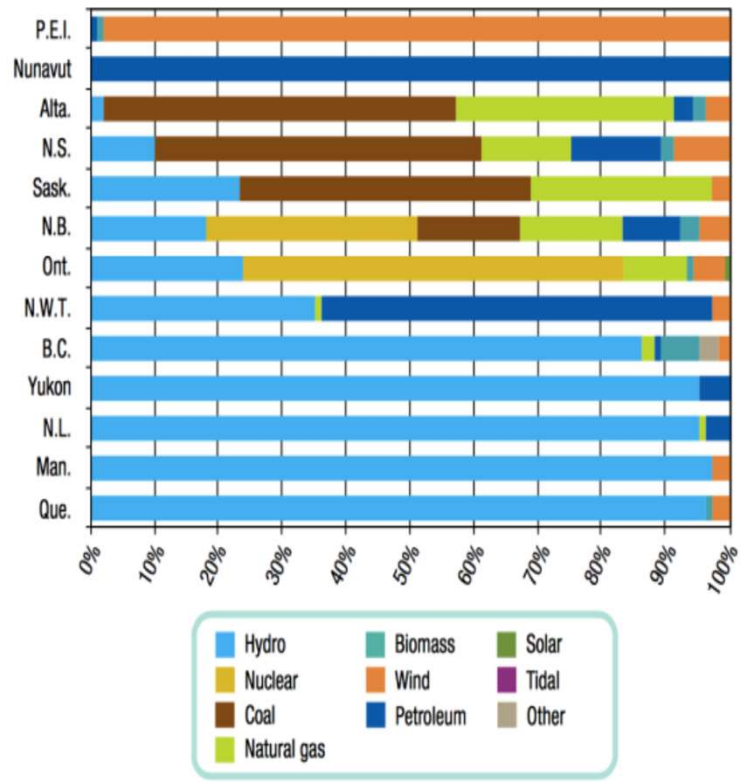
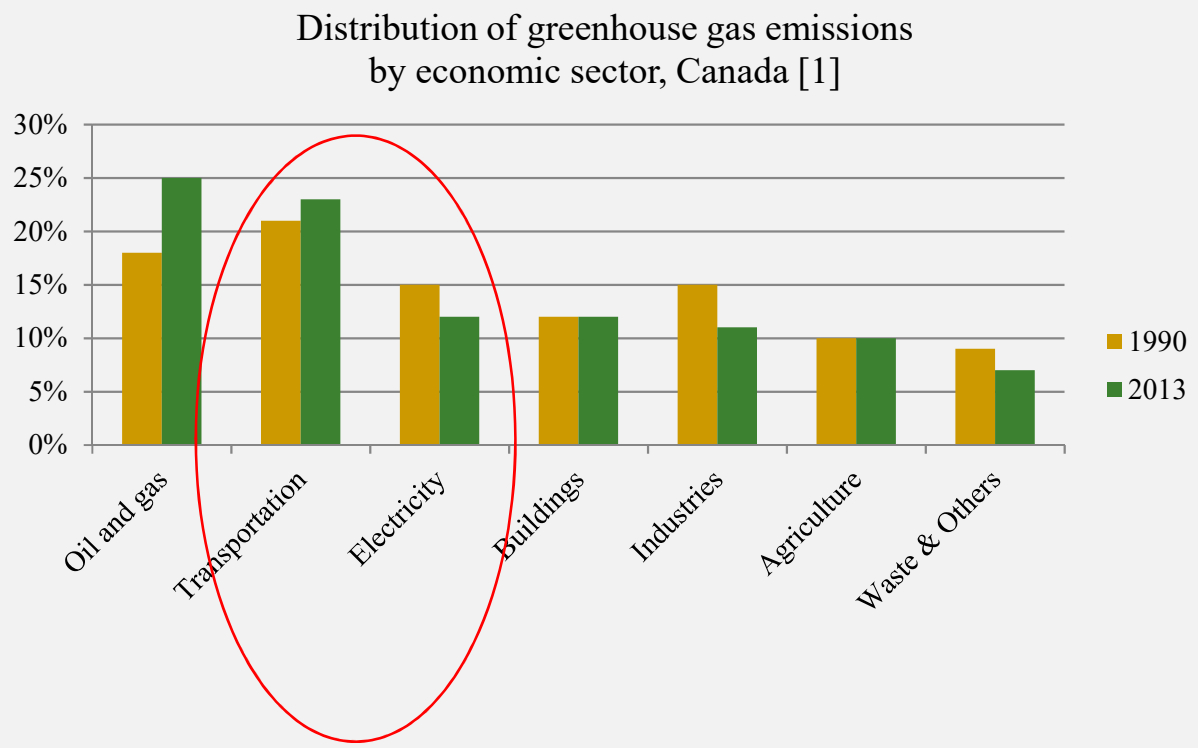
CANADA'S TRANSITION TO LOW CARBON ENERGY

- Sustainable Canada Dialogues is a group led by Prof. Catherine Potvin of some 80 scholars from across Canada who are collectively thinking about pathways to a sustainable society:
  - Canada is ready to transition its energy systems to low carbon
  - Canada already has 80% of its electricity being generated from non-GHG-emitting sources
  - Electrification will be a key component of our decarbonised energy future, while offering technologies and solutions to the world
  - Transport electrification will have a significant impact on GHG emissions



Energy Fact Book 2016–2017
http://www.nrcan.gc.ca/sites/www.nrcan.gc.ca/files/energy/pdf/EnergyFactBook_2016_17_En.pdf

TRANSPORT ELECTRIFICATION TO REDUCE GHG EMISSIONS



ELECTRIC VEHICLES

- In road transportation, there is a revolution of electric vehicles underway, with the number of EVs worldwide growing by approximately 50% annually (32% in Canada)
- The plunging cost of lithium-ion batteries, which leads to falling prices for EVs, as well as longer range, are the main drivers of the growth in EVs.
- Thanks to recent technological advances in lithium-ion batteries, electric cars, trucks and buses with over 500km range on a single charge are now available on the market.
- Big advantage of increased electrification of transport is that it uses electricity which can be produced renewably.

Tesla Model 3
~60kWh battery,
>350km range available
late 2017, $35,000USD

Tesla Model S
75kWh battery, 400km range
available now,
$90,000CAD

Chevrolet Bolt
60kWh battery, 383km range
available now,
$37,500USD

GREEN SMART GRID SUPPORTIN G ELECTRIC VEHICLES

- Local generation for EVs is now possible with the lower cost of PV panel and wind generator.
- Companie like Tesla offer complete solution with solar roof tiles producing electricity stored in home Li-ion batteries which can be used to recharge the household EVs.
- Utilities are starting pilot programs for vehicle-to-grid (V2G), vehicle-to-home (V2H) in order to use the EVs batteries as flexible capacity to meet peak demands which happen when people are back home with their vehicle connected for charging
- The distribution networks substation transformers typically already have enough capacity to recharge many EVs per neighborhood.
- Cities are starting to install charging stations in public locations and on street parking for people living in apartments or condos.

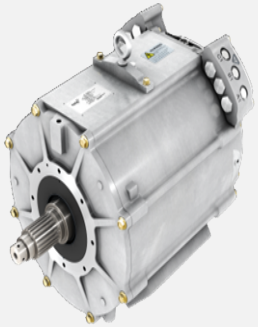
Tesla solar roof shingles

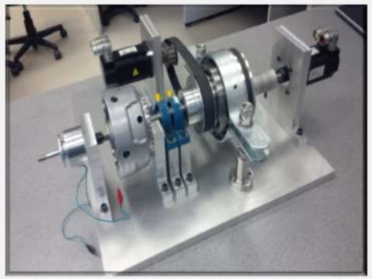
MCGILL APC ELECTRIC DRIVETRAIN PROJECT

10M$ Automotive Partnership Canada program, 7 McGill Engineering Professors, over 40 HQPs

Industrial partners: Linamar, TM4, Infolytica, Purolator

To develop high-performance, low-cost multispeed drivetrains for the international electric vehicle market





CAN TRUCKS AND BUSES BE ELECTRIFIED TOO?

- City Pollution is a Big Problem!

YES!

Lion electric school bus, 160km range, available now (St-Jérôme)

- Electric Foton Bus (China);
  Nova bus (St-Eustache)

The Foton and the Nova LFSe are powered by a TM4 **SUMO motor** highly efficient electric powertrain with a maximum torque reaching 3,500 Nm

PUROLATOR ELECTRIC TRUCK PROTOTYPE

- McGill – TM4 – Cummins – Purolator
- Will be tested on Montreal downtown route in summer 2017
- Developed for commercialization

CFI-9 INTELLIGENT TRANSPORTATION PLATFORMS FOR A SUSTAINABLE FUTURE

- Autonomous electric vehicles (terrestrial and aerial) for transportation and agriculture
- Artificial Intelligence for autonomous operation
- Fast charging integrating sustainable energy
- Mechatronics