A Model for electric car usage in context with solar PV power and energy conservation

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Electric car use in Prince George

1. **Context of talk today**
   a) Forthcoming COP in Paris
   b) Much talk now about developing Canada-wide plans for climate change
   c) Meetings with Councillors Susan Scott, Albert Koehler

2. **General context for greenhouse gas emissions worldwide**
   a) Transportation sector
   b) Urban sources of carbon and particulate matter from tailpipes
   c) Health effects and global warming
Past and future CO₂ atmospheric concentrations

Ice core data
Direct measurements
Projections

Scenarios
- A1B
- A1T
- A1FI
- A2
- B1
- B2
- IS92a

ppm
Annual Greenhouse Gas Emissions by Sector

- Power stations: 21.3%
- Industrial processes: 16.8%
- Waste disposal and treatment: 3.4%
- Land use and biomass burning: 10.0%
- Residential, commercial, and other sources: 10.3%
- Transportation fuels: 14.0%
- Agricultural byproducts: 12.5%
- Fossil fuel retrieval, processing, and distribution: 11.3%

- Carbon Dioxide: 29.5% (99.4% of total)
- Methane: 40.0% (0.47% of total)
- Nitrous Oxide: 62.0% (0.084% of total)
Power stations 15.6%
Industrial processes 14.6%
Transportation fuels 22.7%
Agricultural byproducts 6.8%
Fossil fuel retrieval, processing and distribution 17.4%
Residential, commercial and other sources 9.7%
LULUCF 9.7%
Waste disposal 3.5%
Contribution of transportation to greenhouse gas emissions and climate change

- The greenhouse gas emissions resulting from energy production constitute a serious global environmental problem.

- Limiting global temperature rise to 2 degrees Celsius demands an 80% decline in carbon emissions in the industrial countries by 2050, assuming the population increases to 10 billion by then.

- Transportation will play a big role in achieving this goal, accounting for approximately 25% of world energy demand and more than 62% of all oil used per year.

- To reach the 2°C goal, energy efficiency must come first, followed by decarbonisation of electricity generation, then electrification of transportation and other sectors.

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1. Transportation plan involving electric car for Prince George
   a) Private ownership vs. commercial lease
   b) Annual lease option: participants & investors
   c) Getting electric car into public eye
   d) Fitting electric car with public transit system
   e) Electric car plan for small cities vs. larger cities

2. The next stage for electric car use in Prince George
   a) Pitfalls, suggestions, improvements upon stage I plan
   b) Working with original car share group to develop the next stage
      (UNBC, Northern Health, District, City of Prince George)
"We want to persuade people to shift from the concept of owning a car to that of using a car," Autolib General Manager Morald Chibout told Reuters news agency.
Electric cars

- All electric plug-in vehicle with 80 kW front-mounted AC synchronous electric motor; range, 160 km/charge based on EPA LA4 test cycle; 5-dr, hatchback.
- Starting at $38,395 before provincial incentives (BC, Ontario, Quebec); top speed, 145 kph; 24-kWh Li-ion rechargeable battery.

- All electric plug-in vehicle: 107 kW electric motor; range, 165 km/charge based on EPA LA4 2-phase test cycle; 5-dr, hatchback.
- Base price, $39,995; top speed, 135 kph; 23-kWh Li-ion rechargeable battery.
Electric cars

- All electric plug-in vehicle with 45 kW AC electric motor powered by a lithium polymer battery coupled to a supercapacitor; range, **250 km**/charge; 5-dr/3-dr hatchback.
  - Base price, **€12,000** (US$15,370); top speed, 130 kph; 30-kWh Li-ion-metal-polymer battery.

- All electric plug-in vehicle with 44 kW AC electric motor powered by a lithium ion battery; range, **170 km**/charge; 5-dr/2-dr van.
  - Base price, **€20,000** (US$25,600); top speed, 130 kph; 22-kWh Li-ion rechargeable battery.
Electric cars

**Tesla Roadster**
- All electric plug-in vehicle: 185 kW 3-phase 4-pole AC induction air-cooled electric motor with variable frequency drive; range, **394 km**/charge; 2-dr coupe.
- Base price, **$109,000**; top speed, 200 kph; production ended in 2012.

**Model S**
- All electric plug-in vehicle: 3 battery size options (40, 60 and 85 kWh); range, up to **483 km**/charge for the larger battery pack; 4-dr sedan.
- Base price, **$57,400**; top speed, 203 kph; 85-kWh Li-ion rechargeable battery. Model S and Model T to be available in 2013 and 2014 respectively.
Electric cars

• Greater use of electric vehicles in urban centers would reduce combustion products along with their deleterious health effects.

• When electric cars are recharged by means of renewable energy, atmospheric emission of greenhouse gases can be brought to near zero.

The Nissan LEAF™, with >47,400 units sold worldwide in 2013, followed by Chevy VOLT >28,200 units, Toyota Prius PHEV >23,000 units, and Tesla Model S, >22,100 units, were the world’s top four selling highway-capable electric cars through 2013.

(World Electrified Vehicle Sales, 2013 Report, EV Obsession)
Cost analysis of ICE vs. electric car

- Average annual driving distance: 21,700 km
- Average urban fuel efficiency: 11 L / 100 km
- Electric recharge requirement:
  25 kWh / 150 km  [Nissan LEAF]
  16 kWh / 64 km  [Chevy VOLT]

- 8.4 L / 100 km
- 1,820 L gasoline / yr
- 25 kWh / 150 km
- 3,600 kWh / yr

$2,005 / yr  $324 / yr
Carbon footprint of ICE vs. electric car

• Metric tons of CO$_2$e for ICE passenger vehicles + light trucks (EPA 2000): 5.50 / yr

• Average fuel efficiency:
  - passenger vehicles 10.9 L / 100 km
  - light trucks 13.7 L / 100 km

• Metric tons of CO$_2$e for electric power:
  - 0.027 / MWh [BC]
  - 0.915 / MWh [Alberta]
  - 0.844 / MWh [Saskatchewan]

• Metric tons of CO$_2$e for electric cars:
  - 0.097 / yr [BC]
  - 3.29 / yr [Alberta]
  - 3.03 / yr [Saskatchewan]
Hybrid cars

- Runs for 40 – 80 km on electric power alone, then switches to a 1.4L gasoline-powered generator to achieve extended range of 580 km; 5-dr, hatchback.

- Base price, $39,995; top speed, 150 kph; 16-kWh Li-ion rechargeable battery.

- Power-split or series-parallel (full) hybrid electric vehicle powered by an electric motor (sealed Ni-metal hydride battery) and ICE; range, ~870 km; 5-dr, hatchback.

- Base price, $26,100 (XW20, XW30); $32,000 (plug-in hybrid); top speed, 150 kph; 4-kWh Li-ion rechargeable battery in PHVs permits ~20 km without ICE.
Cost analysis of hybrid electric car

• Toyota Prius: first mass-produced hybrid vehicle (HV), appearing at dealerships in Japan in 1997.
• Global sales: 1 million by May 2008; 4.6 million (Oct, 2012)
• Hybrid Synergy Drive® (HSD) allows the car to run on the electric motor alone at low threshold speeds with a judicious right foot;
• The advance of a plug-in hybrid in 2012 allows the PHV to achieve and maintain speeds of up to 100 kph using electricity alone for ~20 km.

Standard Hybrid
• 3.3 L / 100 km
• 716 L gasoline / yr

Plug-in Hybrid (PHV)
• 2.1 L / 100 km
• 456 L gasoline / yr

$790 / yr

$618 / yr
Carbon footprint of hybrid electric car

- Metric tons of CO$_2$e for standard hybrid Prius (i.e., without reliance on exogenous electric power):
  
  \[
  1.65 / \text{yr}
  \]

- Average fuel efficiency:
  
  regular hybrid \quad 3.3 \text{ L / 100 km}

- Metric tons of CO$_2$e for electric power:
  
  \[
  \begin{align*}
  0.027 / \text{MWh} & \quad [\text{BC}] \\
  0.915 / \text{MWh} & \quad [\text{Alberta}] \\
  0.844 / \text{MWh} & \quad [\text{Saskatchewan}]
  \end{align*}
  \]

- Metric tons of CO$_2$e for hybrid PHV:
  
  \[
  \begin{align*}
  1.08 / \text{yr} & \quad [\text{BC}] \\
  2.25 / \text{yr} & \quad [\text{Alberta}] \\
  2.15 / \text{yr} & \quad [\text{Saskatchewan}]
  \end{align*}
  \]
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• Model energy requirements of electric car with solar PV car port installations.

• Develop electric car lease agreements and sales as a component of smart energy communities, promoting 5 – 12 cars to public attention in one integrated plan.

• Consider Vehicle-to-Grid (V2G) vehicle energy management for bidirectional flow on the grid.
• An **electric vehicle network** is a proposed infrastructure system of publicly accessible charging stations and battery swap stations to recharge electric vehicles. Government, car manufacturers, and charging infrastructure providers have entered into many agreements to create such networks.
This freeway could be anywhere in the World.

It epitomises what we are doing wrong in our world today.
Summary

Pilot programs to bring the electric car into the public eye are a necessary step to promote acceptance of this form of urban transportation. Efforts to design and retrofit buildings for energy savings on a community scale could be coupled to the promotion of electric cars with shared usage, lease and purchase plans. This ensures that electric re-charge stations are located with particular attention to the total energy profile of the community as it is being (re)-designed. It is compatible with the aims of urban planners in promoting the use of rapid transit and changing our cities for healthier air quality, reduced noise, wiser use of energy and reduction of GHG emissions.
Overpass

Jack Bishop