Benefits, Costs and Future of Electric Vehicles

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Photo: swirlspice via flickr
100 Years Ago

EV Advantages
• No vibration, smell, noise
• No gears to change
• No handcrank
• Quick start
• No backfiring
• Only good roads were in town. Range not an issue
1990 Low Emissions Vehicle (LEV-I) Program
• 2% ZEVs by 1998
• 5% ZEVs by 2001
• 10% ZEVs by 2003
Hybrids

1997 Toyota Prius

2005 Silverado

1999 Honda Insight

2012 Chevy Volt

- Honda civic, Chevy Silverado, Ford Escape, Honda Accord, Lexus RX 400h, Toyota Highlander, Lexus GS 450h, Toyota Camry, Mazda Tribute, Nissan Altima,
  - Saturn, Dodge, Mercedes, Hyundai, Lincoln, Volkswagen, BMW, Volvo, GM
Modern Electric Vehicles

Ford Focus Electric. Photo: inhabitat via flickr

Tesla Roadster. Photo: kenjonbro via flickr

Mitsubishi iMiEV. Photo: kenjonbro via Flickr

Coda Sedan. Photo: Mariordo via Wikipedia

Nissan Leaf. Photo: Tom Raftery via Flickr

Others:
• Bollore Bluecar (Ile de France only)
• Toyota Rav 4 EV
• Wheego Whip LiFe

Tesla Model S. Photo: Al Abut via Flickr

Honda Fit. Photo: autoblog.com
Planned EVs

BMW i3
Photo: autoviva.com via Flickr

Volkswagen Blue e-motion
Photo: pilot_micha via Flickr

Smart ED
Photo: Mariord via Flickr

Volvo C30 Electric
Photo: pvolvoankan via Flickr

Fiat 500e
Photo: Chrysler-Group via Flickr

Chevy Spark
Photo: inhabitat via Flickr
New PEV sales compared to HEV sales over their respective 24 month introductory periods

Source: US DOE – EV Everywhere
Tesla Motors

**Tesla Roadster**  Photo: kenjonbro via flickr
- 0-97km/h: 3.7s
- Range: 320km
- Seating Capacity: 2
- Base Price: $110,000 (no longer in production)

**Tesla Model S**  Photo: Al Abut via Flickr
- 0-97km/h: 4.2s
- Range: Up to 480km
- Seating Capacity: 5+2
- Price: $62,000 - $87,000
Energy

Photo: Claus Ablieter via wikipedia

Photo: Canadian Tire
Energy vs. Power

E.g., Running vs. Walking
Same distance = Same Energy

More Power

Less Power
Energy

- Kilowatt-hours (kWh)
- Joules
- Calories
- Litre of gas equivalent

Power

- Kilowatt (kW)
  - also megawatt, gigawatt
- Horsepower
  - About 0.746kW in 1HP
Quiz: Energy or Power?

1. 34.8 Megajoules per liter of gasoline
   1. 34.8MJ = 9.67 kWh

2. Max Output of Motor in the Tesla Roadster: 185kW

3. 24kWh battery pack in the Nissan Leaf

4. Honda Fit EV: 2 liters/100km

kWh → Energy  kW → Power
Electric Vehicles: Advantages
Electric Motors

Synchronous AC Motor
Animation: Zephyris via Wikipedia
Graph: Tesla Motors (www.teslamotors.com)
Efficiency

More than 90%

Less than 30%
Well to Wheel Efficiency

- Crude oil → refinery → pipeline → gas pump → gas tank → engine → wheels

- Water → turbine → transmission lines → plug → battery → wheels
Well to Wheel Efficiency

Notes:
• Based on Midsize 2012 Cars
• Gasoline data is based on Tar Sand source
• Electricity Source is California Average

Energy Content
- Gas: 9.67kWh/l
- Diesel: 9.96kWh/l
- Natural Gas: 7.03kWh/l
Greenhouse Gas Emissions

Notes:
• Based on Midsize 2012 Cars
• Gasoline data is based on Tar Sand source
• Electricity Source is California Average

Source: California Energy Commission
EV Greenhouse Gas Emissions

Gasoline Vehicle: ~310 g CO2/km

- 100% Coal: 417g CO₂/km
- Alberta: 335g CO₂/km (~79% Coal)
- Canada: 84g CO₂/km (~61% Hydro, 23% FF)
- BC: 7g CO₂/km (>90% Hydro)
- US: 250g CO₂/km (~50% Coal)
- Japan: 191g CO₂/km (~27% Coal)
- France: 34g CO₂/km (~75% Nuclear)
- Norway: 1g CO₂/km (~97% Hydro)
- Iceland: 0g CO₂/km (70% Hydro, 30% geothermal)

FF: Fossil Fuels

Source: RETScreen
Level 1 Chargers

- 120V, 12A
- ~1.5 kW
- 7-10km range/hr
- SAE J1772 plug to car
- Regular electrical plug to wall
Level 2 Chargers

- 208 – 240V, up to 32A
- Up to 7.2kW
- 30-60km range/hr
- NEMA Receptacle for residential stations

Photo: Rob St. Onge
DC Fast Charge

- 300-500V, 100-200A
- 30-100kW
- Up to 400km range/hr
- Not included in all vehicles
- Requires 3 Phase Wiring (not residential)
- CHAdeMO

Images: C-CarTom via Wikipedia
SAE J1772 Combo Plug
Residential (House)

- Easy Installation
  - Electrician recommended
- ~$900 for the charger
- $500 Rebate from Live Smart BC (until March 31, 2014 or money runs out)
Residential (Multi Unit)

- Vancouver: 20% of parking stalls wired 240V (since 2011)

Charging Station Maps

www.plugshare.com
Charging Station Maps

www.plugshare.com
Charging Station Maps

www.plugshare.com
## Electric Vehicle Comparison

<table>
<thead>
<tr>
<th>Make</th>
<th>Motor</th>
<th>Top Speed</th>
<th>Passengers</th>
<th>Battery</th>
<th>Range</th>
<th>Charge Time (240V/120V)</th>
<th>Base Price</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Ford Focus</strong></td>
<td>107kW</td>
<td>135km/h</td>
<td>5</td>
<td>23kWh</td>
<td>120km</td>
<td>4/20</td>
<td>$39,000</td>
</tr>
<tr>
<td><strong>Nissan Leaf</strong></td>
<td>80kW</td>
<td>144km/h</td>
<td>5</td>
<td>24kWh</td>
<td>117km</td>
<td>7/21</td>
<td>$38,000</td>
</tr>
<tr>
<td><strong>iMiEV</strong></td>
<td>49kW</td>
<td>130km/h</td>
<td>4</td>
<td>16kWh</td>
<td>100km</td>
<td>7/22</td>
<td>$30,000</td>
</tr>
<tr>
<td><strong>Toyota Prius (PHEV)</strong></td>
<td>100kW (75/25)</td>
<td>170km/h</td>
<td>5</td>
<td>4.4kWh</td>
<td>870km</td>
<td>3/1.5</td>
<td>$36,000</td>
</tr>
<tr>
<td><strong>Chevy Volt</strong></td>
<td>111kW</td>
<td>160km/h</td>
<td>5</td>
<td>16.5kWh</td>
<td>60/610km (electric/total)</td>
<td>5/10</td>
<td>$42,000</td>
</tr>
<tr>
<td><strong>Tesla Model S</strong></td>
<td>225kW</td>
<td>207km/h</td>
<td>5+2</td>
<td>85kWh</td>
<td>420km</td>
<td>5/?</td>
<td>$87,000</td>
</tr>
</tbody>
</table>
Driving Costs

**Nissan Leaf**
- Fuel Economy: 0.212 kWh/km
- Electricity: 12.9¢/kWh
- Cost Per Kilometer:
  \[
  0.212 \frac{kWh}{km} \times 12.9 \frac{¢}{kWh} = 2.74 \frac{¢}{km}
  \]

**Nissan Sentra**
- Fuel Economy: 4.9 liter/100km
- Gas: $1.35/litre
- Cost per km:
  \[
  4.9 \frac{l}{100km} \times \frac{$1.35}{l} = 6.6 \frac{¢}{km}
  \]

1. US. EPA (http://www.fueleconomy.gov/feg/Find.do?action=sbs&id=30979)
2. Fortis BC rates for usage above 1600 kWh/month
3. www.nissan.ca highway fuel efficiency
Assumptions:

- 50 km/day normal use (10% highway)
- 5400 km/year other use (80% highway)
- 90% Financed @ 6% over 5 years
- $1.30/l gas
- $0.10/kWh (elec)
- Vehicle prices and fuel economy from www.fueleconomy.gov (US)
- Clean Energy Vehicle Rebate not included
- Maintenance, tires, insurance included
- New battery purchases not included
- Discount Factor 2.3%
- No depreciation

Source: http://www.afdc.energy.gov/calc/
Cumulative Cost of Ownership by Year (Dollars)

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Source: http://www.afdc.energy.gov/calc/
- $5000 rebate for new electric vehicles
- $5000 rebate for fuel-cell vehicles
- $2500 rebate for plug-in hybrid vehicles
- $2500 rebate for CNG vehicles
- Deadline: March 31, 2014
  - Only $2.5M of remaining $4M was rolled over in March 31, 2013
Full Life Cycle Analysis of Environmental Impact of ICE vs. EV

Summary

• Very efficient
• Good for environment
• Long lasting
• Inexpensive
• Low total cost of ownership
• Long range

Working on it
Close
No
(Bright?) Future for EVs

- Prices will continue to come down
- EV compared to hybrid sales trends
- Education
- Car sharing programs
- Infrastructure growing
- Climate Change
- (Some) Government Support

Photo: Mariordo via wikipedia
Electrified vehicles' projected competitiveness with internal-combustion-engine (ICE) vehicles, based on total cost of ownership¹ (US example)

¹Assumes 240 watt hours per mile (as may be achieved with lightweight, efficient air conditioning) compared with today’s 305–322 watt hours per mile.
²Plug-in hybrid-electric vehicles.
New PEV sales compared to HEV sales over their respective 24 month introductory periods


Source: US DOE – EV Everywhere
Thank You!

Select Resources

• www.cevforbc.ca
• www.veva.bc.ca
• www.plugshare.com
• www.afdc.energy.gov/calc