The Pathway to Zero Emissions

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Agenda

- Examples of Zero Emissions Markets Already Developed
- Current Markets for EVs in North America
- Current Market Barriers
- Role of Industry Stakeholders
  - Manufacturers
  - Fleets
  - Utilities
  - Politicians
- Future Markets for EVs in North America
Why do we need Zero Emission Vehicles (ZEVs)?

* The IEA 6°C Scenario (6DS) is largely an extension of current trends and excludes the adoption of transformative policies of the energy system. By 2050, energy use almost doubles (compared with 2010) and total GHG emissions rise even more, leading to an average global temperature rise projected to be at least 6°C in the long term.

Note: GtCO₂ = gigatonnes of carbon dioxide.
Electric Buses in China

https://www.youtube.com/watch?v=sLo3Pn4KC3w
### Electric Buses in China

**100% Electric Bus Sales In China**

Fully electric bus sales in China from 2011–2016. #Winning

<table>
<thead>
<tr>
<th>Year</th>
<th>Sales</th>
</tr>
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<tbody>
<tr>
<td>2011</td>
<td>1,136</td>
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<td>2012</td>
<td>1,904</td>
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<td>2013</td>
<td>1,672</td>
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<td>2014</td>
<td>12,760</td>
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<td>2015</td>
<td>94,260</td>
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<td>2016</td>
<td>115,700</td>
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</table>

#### Brand Rankings 2016

<table>
<thead>
<tr>
<th>Rank</th>
<th>Brand</th>
<th>2016</th>
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<tbody>
<tr>
<td>1</td>
<td>Yutong</td>
<td>21,428</td>
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<td>2</td>
<td>BYD</td>
<td>14,903</td>
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<td>3</td>
<td>Nanjing</td>
<td>7,921</td>
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<td>4</td>
<td>Zuhai</td>
<td>6,000</td>
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<td>5</td>
<td>Hunan</td>
<td>3,410</td>
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Source: [CleanTechnica](Get the data)

- 2015: China had 98% of the global eBus market
- 2016: 20% of all bus sales in China were battery electric
- Expect all buses to be electric in 5-10 yrs
Why are Electric Bus Sales Growing in China?

- **Economics: incentives & lower total cost of ownership**
  - Previous Incentives: central government up to ~$80,000/bus in 2016 & generally matched by provincial governments up to 60% of purchase price; decreasing 20% in 2017-18 and 40% in 2019-20
  - New Incentives (effective Jan 1, 2017): central government incentive reduced to $43,000/bus and local subsidies capped at 50% of central government incentive

- **Politics**
  - Politicians involved in purchase decisions
  - Purchasing influenced by local economic impacts (e.g. Shenzhen converting 15,000 to BEVs)

- **General Economic Growth and Development in China: starting from scratch**
Growth of Electric Passenger Cars, 2010-2015

Note: the EV stock shown here is primarily estimated on the basis of cumulative sales since 2005.

BEV = battery electric vehicles; PHEV = plug-in hybrid vehicles, which typically have both an electric motor and a conventional engine.  (IEA, Global EV Outlook 2016)
Policy Drivers for EVs, 2015

(Tend to be from national or state level)
(Tend to be from local policies)

<table>
<thead>
<tr>
<th>Policy Driver</th>
<th>Canada</th>
<th>China</th>
<th>Denmark</th>
<th>France</th>
<th>Germany</th>
<th>India</th>
<th>Italy</th>
<th>Japan</th>
<th>Netherlands</th>
<th>Norway</th>
<th>Portugal</th>
<th>South Korea</th>
<th>Spain</th>
<th>Sweden</th>
<th>United Kingdom</th>
<th>United States</th>
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<td>EV purchase incentives</td>
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<td>Sales tax exemptions (incl. VAT)</td>
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<td>Waivers on fees (e.g. tolls, parking, ferries)</td>
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<td>Tailpipe emissions standards</td>
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<td>Fuel economy standards/regulations including elements</td>
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<td>Road vehicles tailpipe pollutant emissions standards</td>
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<td>Market share of electric cars in 2015</td>
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</table>

Legend:
- No policy
- Targeted policy
- Widespread policy
- National policy
- General fuel economy standard, indirectly favouring EV deployment
- Pollutant emissions standard in place in 2015

(IEA, Global EV Outlook 2016)
Why are EV Passenger Cars Growing in Norway?

- EVs exempt from value-added tax (VAT) @ 25% and purchase taxes
- EVs exempt from registration tax @ $12,000
- Total value of subsidies ~$13,500/yr
- Non-monetary: waivers toll roads & ferries, access to bus lanes
- Norway: diesel VW Golf $40k vs eGolf $33k
- Sweden: diesel VW Golf $30k vs eGolf $40k
Markets for EVs in North America

Criteria for Battery Electric Vehicles

1. Defined duty cycles
   i. <200 miles
   ii. >50 miles
   iii. No major variations

2. Customer appetite
   i. Intrinsic
      – Reduced Emissions
      – Noise Pollution
      – Rider Comfort
      – Productivity
      – Performance
      – Lower TCO
   ii. Forced
      – Regulation
      – Lease

3. Large Market to justify and amortize development costs

Potential Markets 2016

Light Duty
Consumer – commuting, general
Fleet – government, utilities
Rideshare

Medium & Heavy Duty
Bus & Coach
Delivery Trucks
Refuse Trucks
Off-Road Freight Vehicles
Current Market Barriers

1. Higher Capital Cost

<table>
<thead>
<tr>
<th>Gas Car Model</th>
<th>Price</th>
<th>Electric Car Model</th>
<th>Price</th>
<th>Price Delta</th>
<th>% Delta</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chevy Cruze</td>
<td>$17,000</td>
<td>Chevy Bolt, 238 mi, 60 kWh</td>
<td>$37,500</td>
<td>$20,500</td>
<td>121%</td>
</tr>
<tr>
<td>Nissan Versa</td>
<td>$12,000</td>
<td>Nissan Leaf, 107 mi, 30 kWh</td>
<td>$31,500</td>
<td>$19,500</td>
<td>163%</td>
</tr>
<tr>
<td>BMW 6 Series</td>
<td>$77,600</td>
<td>Tesla Model S, 210-315 mi, 60-100 kWh</td>
<td>$69,200-135,700</td>
<td>$29,250</td>
<td>38%</td>
</tr>
<tr>
<td>Audi A7</td>
<td>$68,800</td>
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</tr>
<tr>
<td>Porsche Cayenne</td>
<td>$59,600</td>
<td>Tesla Model X, 238-289 mi, 75-100 kWh</td>
<td>$90,000-140,000</td>
<td>$55,400</td>
<td>93%</td>
</tr>
<tr>
<td>BMW 3 Series</td>
<td>$33,400</td>
<td>BMW i3, 114 mi, 33 kWh</td>
<td>$43,400</td>
<td>$10,000</td>
<td>30%</td>
</tr>
<tr>
<td>Fiat 500</td>
<td>$15,000</td>
<td>Fiat 500e, 84 mi, 24 kWh</td>
<td>$32,800</td>
<td>$17,800</td>
<td>119%</td>
</tr>
<tr>
<td>Ford Focus</td>
<td>$16,800</td>
<td>Ford Focus Electric, 115 mi, 33.5 kWh</td>
<td>$30,000</td>
<td>$13,200</td>
<td>79%</td>
</tr>
<tr>
<td>Kia Soul</td>
<td>$16,100</td>
<td>Kia Soul EV, 93 mi, 27 kWh</td>
<td>$32,800</td>
<td>$16,700</td>
<td>104%</td>
</tr>
<tr>
<td>Mercedes Benz C Class</td>
<td>$34,400</td>
<td>Mercedes Benz B250e, 87 mi, 28 kWh</td>
<td>$40,800</td>
<td>$6,400</td>
<td>19%</td>
</tr>
</tbody>
</table>

2. Infrastructure
   - Availability
   - Speed
   - No standards for medium & heavy duty
   - Installation costs

3. Market Confidence

<table>
<thead>
<tr>
<th>Fuel Type</th>
<th>40’ Transit Bus</th>
<th>% Delta to Electric</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diesel</td>
<td>$450,000</td>
<td>67%</td>
</tr>
<tr>
<td>CNG</td>
<td>$550,000</td>
<td>36%</td>
</tr>
<tr>
<td>Electric</td>
<td>$750,000</td>
<td></td>
</tr>
</tbody>
</table>

Trucks 2-3x for electric vs conventional
Role of Industry Stakeholders: Manufacturers

Education & Marketing

Payback Period – 40’ Transit Bus

- LDV fuel cost: in USA EVs yield 50% savings, in Europe 80-85% savings

Improve Technology

- BYD 40’ Transit Bus: improved motors from 90 kWx2 (2013) to 150 kWx2 (present)
- BYD updating all on-board inverters for all MHD vehicles – improve efficiency from 95% to ~99%
- Batteries: industry investing billions (more on this on next slide)
- Charging
  - Fast rate
  - On route
  - Battery swaps

Assuming Product Performance Risk

- Long-term warranties: life of vehicle
  - Bus: lifetime warranty on batteries
  - Direct and prompt service
Role of Industry Stakeholders: Manufacturers

Reduce Cost – Mostly Batteries

2 Primary Drivers
1. R&D Investment → Improving Energy Density
2. Manufacturing Investment → Scale Economies

- Batteries represent 1/3 cost light duty (GM)
- Batteries represent 2/3 cost MHD (BYD)

Source: Data compiled by Bloomberg New Energy Finance
Reducing Battery Cost: R&D Investment

Notes: USD/kWh = United States dollars per kilowatt-hour; Wh/L = watt-hours per litre. PHEV battery cost and energy density data shown here are based on an observed industry-wide trend, include useful energy only, refer to battery packs and suppose an annual battery production of 100,000 units for each manufacturer.

Sources: US DOE (2015 and 2016) for PHEV battery cost and energy density estimates; EV Obsession (2015); and HybridCARS (2015).

- BYD: 7-8% yoy historical; forecasting 11%+
- BYD 12,000 patents
Reducing Battery Costs: Manufacturing Investment

### Capacity by Manufacturer (MWh)

- **LG Chem Ltd**: 36,000 MWh
- **Tesla Inc**: 35,000 MWh
- **BYD Co Ltd**: 34,000 MWh
- **Guoxuan High-Tech Co Ltd**: 25,000 MWh
- **Tianjin Lishen Battery Joint-Stock Co Ltd**: 20,000 MWh
- **Contemporary Amperex Technology Co Ltd**: 17,500 MWh
- **Panasonic Corp**: 13,500 MWh
- **Optimum Battery Co Ltd**: 10,520 MWh
- **Automotive Energy Supply Corp**: 8,400 MWh
- **Boston-Power Inc**: 8,000 MWh
- **Samsung SDI Co Ltd**: 7,650 MWh
- **CBAK Energy Technology Inc**: 6,000 MWh
- **Hengdian Group DMEGC Magnetics Co Ltd**: 6,000 MWh
- **SK Innovation Co Ltd**: 4,435 MWh
- **FDG Electric Vehicles Ltd**: 4,400 MWh

**Status**

- **Fully commissioned**
- **Under construction**
- **Announced**

Source: Bloomberg New Energy Finance
Role of Industry Stakeholders: Manufacturers

Creative Models

- Battery Leases
  - Sell electric same price as conventional
  - Monthly leases paid out of maintenance & fuel savings
- Manufactures retain ownership > customers pay monthly expense
  - Manufacturers guarantee uptime & pay for all costs
- Microgrids – control electricity costs

New Entrants

- Price Pressure
- Compete on technology
Role of Industry Stakeholders: Fleets

**Demonstrate and Deploy Early Generation Technology**

- Invest time and energy from operations, maintenance, drivers
- Provide early and constant feedback to manufacturers

**Leadership from Large Fleets**

- Pioneer fleets need to validate technology and lead transition
  - CNG: LA Metro, WM
  - EV: Major Transit Authorities, UPS, Ports of LA & LB

**Drive Demand**

- Be prepared to adopt technology aggressively once economics & performance proven
- LOIs and other commitments
- Aggregate purchases to create sizable market
  - EV RFI led by City of LA: 114,000 pieces of equipment

![Graph showing cost comparisons between diesel and electric power]

- Diesel Price 2016: $100,000
- Electric Price 2016: $239,000
- Battery Price Drop in 5 yrs: $64,000
- Scale Economies after 1k orders: $36,000
- Recoup Engineering Costs: $24,000
- 3 yr Maint & Fuel Savings: $42,000
- Electric Price in 5 yrs w/Savings: $74,000
- Diesel Price in 5 years: $104,000
- CNG Price in 5 years: $135,000
Role of Industry Stakeholders: Utilities

Rate Programs for EVs

- EV rates
  - EV6 SCE
- Considerations to address demand charges

New Models to Support EVs

- New policies for distribution line and service extensions for EVs
- Utilities pay for chargers to the stub; rate-base costs

Programs to Address Duck Curve

- Support use of EVs for smoothing grid
  - TOU pricing
Role of Industry Stakeholders: Government

**Regulation**
- Increased stringency levels for fuel economy and tailpipe emissions
- Manufacturer credit programs
  - CARB ZEV Regulation
- Weight exemptions
- Reducing fuel subsidies
- Exemptions from quotas

**Government Fleets**
- Purchase mandates
  - LA 50%
  - CAAP Ports of LA & LB

**Charging Standards**
- MHD: depot, overhead, inductive

**Financial Incentives**
- Rebates, credits, etc.
- Exemption from taxes & registration fees
- R&D, Demonstrations, Pilots, First Come/First Serve

**Non-Monetary Incentives**
- Traffic or access restrictions, HOV, preferential parking

**Leadership**
- Aggressive goals
  - EV Stock
  - GHG Emissions
Deployment Scenarios for Electric Cars to 2030

Note: 2DS = 2°C Scenario; 4DS = 4°C Scenario.

Sources: IEA analysis based on IEA (2016), UNFCCC (2015b), the EVI 2020 target and the country targets assessment made in Table 3.

(IEA, Global EV Outlook 2016)
Future Markets for EVs
Questions?

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