Electric Vehicles Cometh: Reality, Challenges and Opportunities

John Eichberger
Executive Director
The Fuels Institute

Fuels Institute
Today’s agenda

• Factors influencing future liquid fuel demand
• A profile of the electric vehicle market
• The business of providing charging services

Be thinking about:
• How will changes in fuel demand affect your business?
• How can you position your business to evolve with demand?
• What do you need to know before you consider EV charging?
Fuels Institute Board of Advisors

Disclaimer: The opinions and views expressed herein do not necessarily state or reflect those of the individuals on the Fuels Institute Board of Directors and the Fuels Institute Board of Advisors, or any contributing organization to the Fuels Institute. They are exclusively those of the speaker.
Demand Destruction: It’s not all about electrification
The U.S. fleet has improved MPG since 2000

Passenger cars are up 38% and light trucks are up 34%

**Average Fuel Efficiency of New Vehicles**

Source: U.S. Bureau of Transportation Statistics
Every single class has become cleaner

Change in CO2 Emissions and Miles per Gallon (2004 - 2018)

Source: U.S. Environmental Protection Agency
OEMs have achieved by adding technology

Manufacturers Use of Emerging Technologies

Efficiency affects fuel demand in the real world

2010 4dr SuperCrew 4WD
14 city/18 hwy (15 combined)
13,000 miles = 867 gallons
36 gal tank = 24 full tanks

2020 4dr SuperCrew 4WD
18 city/23 hwy (20 combined)
13,000 miles = 650 gallons
26 gal tank = 25 full tanks

In 2019, Ford sold 658,062 F150s.
The MPG improvement from 2010 – 2020 results in 143 million gallons of fuel saved from this 1 vehicle.
CAFE program forces more miles per gallon

Fleet projected to be 47% more efficient by 2040, even though model assumes no regulatory increase after 2025.

Light Duty Vehicle Fuel Efficiency

Source: U.S. Energy Information Administration AEO2020
2019 EIA had forecast big drop in demand

Based upon current CAFE program requirements established during Obama Administration.

Liquid Fuel Demand

- Gasoline: -23.6%
- Ethanol: -10.9%

Source: US Energy Information Administration
But crude oil prices make a big difference

2040 price projections range from $41.68 to $171.24, which affects all levers of demand
VMT projected to increase 7% - 20%

Number of licensed drivers also projected to increase approximately 12%

Project LDV Miles Traveled Per Year

Source: U.S. Energy Information Administration AEO2020
Latest AEO projects smaller drop in demand

Obama era-CAFE standards remain in place, offsetting more miles with greater efficiency.

---

**Liquid Fuel Demand**

- **-13% to -26%**
- **-3% to -15%**

Source: U.S. Energy Information Administration AEO2020
The U.S. is an important market, but it is not the only market automakers are serving. The global (and local) momentum for reducing carbon emissions from transportation is growing.
Global LDV Fuel Efficiency Improvement

Over 80% of the vehicle market already covered, will be 90% when planned policies are implemented in the next five years.

IEA World Energy Outlook 2018: “By 2040 there are no cars sold that have an efficiency worse than 6.5 liters/100 km.”

LDV=Passenger cars, light trucks and sport utility vehicles (SUVs)

Source: Compiled by Future Fuel Strategies citing numerous sources including “Global Fuel Economy An update for COP23,” Global Fuel Economy Initiative; September 2018
ICE bans seem to be popular...in some places

How many of these will actually be fully implemented and what impact on the global market might they have?

Table 2.3 • Announced sales bans for ICE vehicles

<table>
<thead>
<tr>
<th>Country</th>
<th>2025</th>
<th>2030</th>
<th>2032</th>
<th>2040</th>
<th>2045</th>
</tr>
</thead>
<tbody>
<tr>
<td>France</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ireland</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Netherlands</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Norway</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Slovenia</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sri Lanka</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sweden</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Scotland</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>United Kingdom</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- Green circle: ICE sales ban or 100% ZEV sales target
- Purple circle: Fleet without ICEs

Source: International Energy Agency, "Global EV Outlook 2018"
States Are Moving to Control Carbon in Fuels Either through LCFS Programs or Carbon Taxation

Key

- **LCFS Policy in Place**
- **LCFS Legislation Failed in 2019**
- **Midwest LCFS...Maybe?**
- **Considering carbon tax on fuel**
- **TCI States – Cap and Trade on Fuels**

Carbon tax measure failed in Maine last year

Source: Future Fuel Strategies, January 2020
Electric Vehicle Market Evolution
you must unlearn what you have learned
## New EVs fast and furious – but production volume?

![Image of new EVs](image)

### Table 2.5: OEM announcements related to electric cars

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>BMW</td>
<td>0.14</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>15-25%</td>
<td>25</td>
</tr>
<tr>
<td>BAIC</td>
<td>0.8</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>BYD</td>
<td>0.6</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dongfeng Motor Co</td>
<td></td>
<td>30%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ford</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>40</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Geely</td>
<td></td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>GM</td>
<td>2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>20</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Honda</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>15%</td>
</tr>
<tr>
<td>Hyundai-Kia</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mahindra &amp; Mahindra</td>
<td></td>
<td>0.036</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Maruti Suzuki</td>
<td></td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mazda</td>
<td></td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mercedes-Benz</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>15-25%</td>
</tr>
<tr>
<td>Other Chinese OEMs</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PSA</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.9</td>
<td></td>
<td>27</td>
<td></td>
</tr>
<tr>
<td>Renault-Nissan</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tesla</td>
<td>100%</td>
<td>0.5</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Toyota</td>
<td>10</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>25%</td>
<td>1</td>
</tr>
<tr>
<td>Volkswagen</td>
<td>0.4</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Volvo</td>
<td>1</td>
<td></td>
<td>5</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- **Number of sales millions**
- **% of electric sales**
- **Number of new EV models**
- **Share of models with an electric version**

*Source: International Energy Agency*
EV sales growth slowed in 2019...

BEVs up 17.1% while PHEVs down 30.6% in 2019 (In June BEVs were up 96%)
Gasoline-powered vehicles down just 1.6% of new LDVs sold in five years.

Share of Sales by Powertrain

- **Fuel Cell**
- **Hybrid**
- **PHEV**
- **Electric**
- **Diesel**
- **Gasoline**

Source: Wards Intelligence
...and plug-in vehicles totaled 1.9% - again.

BEVs gain 0.2% at the expense of PHEVs.

Share of Sales of Non-Gasoline Powertrains

Source: Wards intelligence
More than half of EVs are delivered to CA

**EVs STILL HAVE LIMITED AUDIENCE**
U.S. vehicle market is BIG!

*Images presented to scale

16.7 Million New ICE LDVs Sold in 2019

257.12 Million Registered LDVs in 2019

330,000 BEV+PHEV Sold in 2019

15.4 Million LDVs Retired in 2019

Source: Wards Intelligence, U.S. EIA
The market changes slowly.

New Vehicles as Share of Fleet on the Road

Data and Assumptions
- Source: U.S. EIA Annual Energy Outlook 2018
- EIA LDV Fleet Size - 243.8 million in 2018
- EIA LDV Sales Forecast - 16.1 million/year average

At least 9 Years for New Vehicles to Amass 50%
Sales take a long time to influence the fleet.

Even with aggressive sales growth, BEV & PHEV would combine for 10% of vehicles on road in 2035.

**Potential Growth of Battery Electric and Plug-In Hybrid Vehicles**

Assumptions:
- U.S. EIA Forecast LDV Fleet Size
- U.S. EIA Forecast LDV Sales
- Rate of Sales Growth BEV & PHEV = 26% 2017-2025
- Rate of Sales Growth BEV & PHEV = 20% 2026-2035

- 42.94% in 2035
- 10.36% in 2034
What does the EV market look like in the U.S.?
Model 3 represents 63.5% of BEV sales in U.S.

16 OEMs, 18 models, 244,217 units
PHEV market is more diverse, but smaller

18 OEMs, 32 models, 85,542 units
2020 Battery Electric Vehicles Gain Miles

16 models expected to be offered for sale in the beginning of 2020 with 11 boasting ranges of 200 miles+

Source: CNET.com
Range and price appear related
EV Sales Projection Benchmarking: FFS Compared to Other Analysts/Organizations

EVs as a Percentage of New LDV Sales—U.S. Only

Source: Compiled by Future Fuel Strategies citing data from these organizations updated July 2019. Pink diamond: My projection, which does not include hybrid electric vehicles. All projections focus on battery electric and plug-in hybrid electric vehicles. *The JP Morgan estimate does not include hybrid electric vehicles, which make up the bulk of its 2025 penetration estimate.
Charging Infrastructure
Charging has expanded, but DC Fast is slow

EV charging stations:
- 29,092 stations in US-Canada as of February 2020
- 4,131 DC Fast Chargers (14%)
- Fast chargers best match fuel retailer businesses

Source: U.S. Department of Energy
Opportunities for retailers?

Some advocates want chargers at gas stations
- This would reduce the amount of behavior change required when shifting to EV

Opportunities exist
- Partnerships are available to enter the business
- Financial programs are available to assist with installation

Challenges exist
- Siting regulations and requirements vary by jurisdiction
- Method of Sale is difficult
- Demand is very different from liquid fuel

Most charging will be done at home or work, but in-market charging will become more important as apartment dwellers purchase EVs.
Charger type is important:

**Level 1**
- AC Power, 120 V
- J1772 connector
- 2-5 miles/hour

**Level 2**
- AC power, 240 V
- J1772 connector
- 10-20 miles/hour

**DC Fast**
- DC power, 480V
- SAE, CHAdeMO, or Tesla connector
- Up to 240 miles/hour
## DC Fast Charger Options

<table>
<thead>
<tr>
<th>Charger Type</th>
<th>CCS</th>
<th>CHAdeMO</th>
<th>Tesla</th>
</tr>
</thead>
<tbody>
<tr>
<td>Max Power</td>
<td>350 KW</td>
<td>100 KW</td>
<td>250 KW</td>
</tr>
<tr>
<td>Time to 200 Miles</td>
<td>15 – 25 mins</td>
<td>35 – 70 mins</td>
<td>15 – 40 mins</td>
</tr>
<tr>
<td>Compatible EVs</td>
<td>20+</td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td>Automakers</td>
<td>GM, Ford, VW, Audi, <strong>Porsche</strong>, BMW, Mercedes, Jaguar, Hyundai, Honda, Harley</td>
<td>Nissan, Kia, Mitsubishi, Tesla (via adapter)</td>
<td><strong>Tesla</strong></td>
</tr>
</tbody>
</table>

Source: eMotive LLC
Installing DC fast chargers can be expensive

Requires about 1.6 parking spaces and $150,000 per charging unit

Capital and Space Requirements
(Your specific results will vary by location, utility, and permit authority)

<table>
<thead>
<tr>
<th>Component</th>
<th>Space (ft²)</th>
<th>Cost ($)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Parking</td>
<td>729 ft²</td>
<td></td>
</tr>
<tr>
<td>Chargers (4)</td>
<td>144 ft²</td>
<td>$320K</td>
</tr>
<tr>
<td>Switchgear (1)</td>
<td>108 ft²</td>
<td>$30K</td>
</tr>
<tr>
<td>Transformer (1)</td>
<td>54 ft²</td>
<td>$50K</td>
</tr>
<tr>
<td>Installation</td>
<td></td>
<td>$200K</td>
</tr>
<tr>
<td>Total</td>
<td>1035 ft²</td>
<td>$600K</td>
</tr>
</tbody>
</table>

4 “End-Zone” 150 kW charging spaces requires 4.5 parking spaces with ADA

Source: eMotive LLC
## Cost vary significantly

**EXHIBIT 1**
Cost ranges for charging infrastructure components.

<table>
<thead>
<tr>
<th>COST ELEMENT</th>
<th>LOWEST COST</th>
<th>HIGHEST COST</th>
</tr>
</thead>
<tbody>
<tr>
<td>Level 2 residential charger</td>
<td>$380 (2.9 kW)</td>
<td>$689 (7.7 kW)</td>
</tr>
<tr>
<td>Level 2 commercial charger</td>
<td>$2,500 (7.7 kW)</td>
<td>$4,900 (16.8 kW); outlier: $7,210 (14.4 kW)</td>
</tr>
<tr>
<td>DCFC (50 kW)</td>
<td>$20,000</td>
<td>$35,800</td>
</tr>
<tr>
<td>DCFC (150 kW)</td>
<td>$75,600</td>
<td>$100,000</td>
</tr>
<tr>
<td>DCFC (350 kW)</td>
<td>$128,000</td>
<td>$150,000</td>
</tr>
<tr>
<td>Transformer (150–300 kVA)</td>
<td>$35,000</td>
<td>$53,000</td>
</tr>
<tr>
<td>Transformer (500–750 kVA)</td>
<td>$44,000</td>
<td>$69,600</td>
</tr>
<tr>
<td>Transformer (1,000+ kVA)</td>
<td>$66,000</td>
<td>$173,000</td>
</tr>
<tr>
<td>Data contracts</td>
<td>$84/year/charger</td>
<td>$240/year/charger</td>
</tr>
<tr>
<td>Network contracts</td>
<td>$200/year/charger</td>
<td>$250/year/charger</td>
</tr>
<tr>
<td>Credit card reader</td>
<td>$325</td>
<td>$1,000</td>
</tr>
<tr>
<td>Cable cost</td>
<td>$1,500</td>
<td>$3,500</td>
</tr>
</tbody>
</table>

*Source: Rocky Mountain Institute*
Key Cost Drivers

2015 Dept of Energy study reaffirmed by RMI: “Installation costs, however, are highly variable and there is no consensus among industry stakeholders about the direction of future installation costs.”

Significant cost drivers found in “soft costs”
- Site acquisition
- Meeting local building codes
- Extended processes for obtaining utility interconnections, easements and local permits

Other drivers of procurement costs:
- Power rating of charger/total power requirements of site with multiple chargers
- Existing grid power capacity at the site
- Location of chargers within the site

Source: Rocky Mountain Institute
How much power should you offer?

Only 1 vehicle can use 350kw today – but it is important to consider future proofing your system.

EXHIBIT 6
Range of DC fast charger costs.

- 350 kW: $128,000–$150,000
- 150 kW: $75,600
- 50 kW: $20,000–$35,800

Source: Rocky Mountain Institute
Significant challenges to charger operations

“Electric Vehicle Charging Infrastructure: Current Challenges and Impacts on EV Adoption in the U.S.”
NextEnergy, September 2019:

Method of Sale:

It’s important to note that not being able to charge EV owners by the kilowatt hour, or pass the electricity costs directly to the EV owner, create inconsistent pricing models that lead to confusion and create risk for the EVSE network operator’s ability to be profitable. Furthermore, that profitability risk is impeding the creation of new private businesses focused on deploying EVSE networks, expanding access to EV owners, and creating more incentive for increased EV adoption.

Consumer Friction:

Another factor that has impeded EV adoption is the fragmentation of EVSE networks across the United States. An owner of a vehicle with an internal combustion engine can pull up to any gas station and refuel. Conversely, early EVSE network operators have tried to create loyalty and increase revenue by requiring memberships to access their network. Fortunately, there have been many recent announcements addressing these unwanted barriers, streamlining
How business is conducted today...

Three primary methods of delivering electrons to EVs:

- Free
- Pay-as-you-go: Payment collected at each recharging occasion based upon a variety of possible factors
- Monthly Subscriptions: Typically lowers cost of charging per session

Most current billing models are based on one or more of:

- Time of Use – access rates change based upon the cost of electricity as it varies throughout the day
- Duration – billing is based upon minutes spent connected to the charger
- Access – there is a fee assessed simply for connecting to the charger, which sometimes results in lower rate
- Parking – parking fees can be shared with the charging provider
- Idling – vehicles remaining at a charging station after being fully charged may be assessed a higher rate
• Launched January 2020
• Diverse coalition of stakeholders – OEMs, charging networks, utilities, retailers…
• Delivering value to the market through research:
  • Evaluating regulatory structures affecting siting, installation and operations of charging stations
  • Developing site host education materials
    • Decision tree
    • Best practices
    • Case studies
  • Studying consumer behavior and preferences
  • Helping stakeholders better understand and develop a legitimate business model
Takeaways

• Gallons will diminish due to efficiency gains, impact on trips unclear
• Global focus on carbon emissions will drive changes in transportation policies and influence the market
• Electrification stalled in 2019, but new models will spur growth
• It is time to consider potential opportunities for charging services
Q&A
Fuels Institute

John Eichberger
Executive Director
jeichberger@fuelsinstitute.org