Electric Vehicles
Economic and Environmental Benefits
And Enjoyment!

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ICE = Internal Combustion Engine
BEV = Battery Electric Vehicle
Environmental Aspect of BEVs

• Advantages
  – Much lower operating and maintenance costs reduce environmental footprint compared to ICEs.
  – Reduction in pollutants
  – Reduction in carbon-dioxide emissions
  – Almost no noise pollution

• Disadvantages
  – Motors have some rare-earth and critical metals.
  – More carbon-dioxide emitted in manufacture.
  – Tires wear out quicker than for ICEs.
Electric Vehicles vs Gasoline Vehicles

GHG Emissions

2018 US average = 22 MPG

65 mpg ICE for Tesla Model 3 in zip 24060.

2018 data: 80 MPG
2015 data: 68 MPG

US Average (EV sales-weighted): 80 MPG
2018 US average = 22 MPG

Note: The MPG (miles per gallon) value listed for each region is the combined city/highway fuel economy rating of a gasoline vehicle that would have global warming emissions equivalent to driving an EV. Regional global warming emissions ratings are based on 2016 power plant data in the EPA's eGRID 2016 database (the most recent version). Comparisons include gasoline and electricity fuel production emissions estimates using Argonne National Laboratory's GREET 2017 model. The 60 MPG US average is a sales-weighted average based on where EVs were sold in 2011-2017.
BEV vs ICE Fuel Cost

- **2018 US average ICE MPG** = 22
- **2018 average BEV MPGe** = 102 = 3.03 miles/kWh
- **2019 US average $/gallon** = $2.49
- **2018 US average $/kWh** = $0.125
- ICE $/mile = $2.49/22 = $0.113
- BEV $/mile = $0.125/3.03 = $0.0413
- **ICE/BEV** = 2.74
- Electricity price is more stable than gasoline price.
Hyundai Ioniq Electric vs Prius Eco Fuel Cost

- Toyota Prius Eco (hybrid) MPG = 56
- Hyundai Ioniq Elect. MPGe = 136 = 4.04 miles/kWh
- 2019 US average $/gallon = $2.49
- 2018 US average $/kWh = $0.125
- ICE $/mile = $2.49/56 = $0.0445
- BEV $/mile = $0.125/4.04 = $0.0309
- ICE/BEV = 1.44
Most efficient: Hyundai IONIQ
248 Wh/mile = 4.03 miles/kWh = 136 MPGe.

Least efficient: Jaguar i-Pace
443 Wh/mile = 2.26 miles/kWh = 76 MPGe.

Tesla Model 3 Standard Range:
251 Wh/mile = 3.98 miles/kWh = 134 MPGe
What about BEV Batteries?

• BEV batteries are guaranteed for defects for 8 years and 100,000 miles. (Tesla Model 3 Long Range for 120,000 miles)

• Lithium-ion batteries lose capacity with time.

• **Tesla Model 3** has a 70% degradation warranty within 8 years. Most will degrade much less than that depending on how they are driven and charged.

• New batteries that will last longer and cost less are being developed.
Roper Electric Power (23.1 MW)

<table>
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<th></th>
<th>2018</th>
<th>Coal</th>
<th>Nat. Gas</th>
<th>Wind</th>
<th>Hydro</th>
<th>Solar</th>
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<td>APCO</td>
<td>78.5%</td>
<td>15.4%</td>
<td>3.6%</td>
<td>2.5%</td>
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<tr>
<td>Roper</td>
<td>39.2%</td>
<td>7.7%</td>
<td>1.8%</td>
<td>1.2%</td>
<td>50.1%</td>
<td></td>
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<tr>
<td>USA 2018</td>
<td>32.3%</td>
<td>31.0%</td>
<td>19.4%</td>
<td>9.6%</td>
<td>6.4%</td>
<td>0.6%</td>
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About 15% of total Roper electricity and about 50% of Roper solar electricity is used to charge the Roper Tesla Model 3 Long Range RWD BEV.
Maintenance

ICE maintenance not in a BEV
- Mechanical brakes used constantly
- Oil and oil-filter regular changes
- Transmission
- Mufflers and tail pipes
- Catalytic converters
- Belts
- Spark plugs
- Many moving parts to wear out

• BEV
- Mechanical brakes are used only in emergencies and at low speed. Otherwise electricity regeneration slows or stops BEV.
- Electric motors can run 24/7 for many years without repairs
- Solid-state electronics are very reliable
V2H and V2G

• **Vehicle-to-Home (V2H)**
  – Vehicle batteries can connect to house circuit to use as backup for grid failure and solar PV system. Not available yet, but being developed.

• **Vehicle-to-Grid (V2G)**
  – Vehicle batteries can connect to grid to supply electric power during low vehicle usage and high electricity demand. Not available yet, but being developed.
  – May be able to pay for BEV by providing high-demand power for grid.
Enjoyment!

• Very quiet.
• High acceleration.
• Most battery charging overnight at home.
  – No fumes or bad weather when charging.
• Much free < 10-kW charging.
• Low center of gravity enhances safety and performance.
• One-pedal driving.
Charging

• Most charging takes place overnight at home.
• Tesla has by far the most fast (Superchargers) and overnight charging stations for long trips.
• Electrify America is quickly building fast charging stations for all BEVs.
• Plugshare.com is the best web page for finding charging stations.
• ABetterRoutePlanner.com is an excellent program for planning BEV trips.
• Tesla has excellent navigation showing where Superchargers are and how long to charge there.
  – Shows number of charging stalls available at next SC.
Tesla Superchargers

On I-81:
Bristol TN,
Wytheville,
Lexington,
Staunton,
Mt. Jackson,
Strasburg,
Martinsburg WV
Hagerstown MD
Soon: Roanoke
Tesla Destination Chargers

At hotels, parks, businesses, multi-family complexes and workplaces. Usually there is no fee to use Destination Chargers.
Electrify America Chargers Plans

Two near Blacksburg:
I-81 exit 156 near Fincastle,
Wytheville Sheetz Station
Cycle 2 investments will be made in 18 metropolitan areas across the country.
Other U.S. Charging Networks

- Blink ~1680 sites
- Chargepoint ~6083 sites
- eVgo ~774 sites
- Greenlots ~392 sites
- Semaconnect ~1166 sites
- Webasto ~164 sites

Many < 10-kW chargers have no fee.