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Global light duty electric vehicle trends, costs of battery technologies, consumer prices, and implications for policy

California Energy Commission

May 2, 2019

Michael Nicholas
Cumulative U.S. electric vehicle sales have passed 1 million

- Mostly these EV sales are in markets with some combination of the following: ZEV regulation, incentives, extensive charging, city/utility promotions
- Nearly two-thirds of EV sales are in ZEV regulation states (CA, OR, Northeast)

Source: www.EV-volumes.com
Annual global EV sales surpassed 2 million/year in 2018 (5 million cumulative)
Mostly the sales are in China, Europe, and the U.S.
- These markets have policy, incentives, charging infrastructure, local action

Source: www.EV-volumes.com
Global electric vehicle growth

- Annual global EV production surpassed 2 million/year in 2018
- There are now 10 automaker groups selling over 80,000 EVs per year
  - Battery production: 4 companies supplying batteries for 230,000-320,000 EVs per year

**Electric vehicle sales by automaker**

**Electric vehicle sales by battery supplier**

Source: [www.EV-volumes.com](http://www.EV-volumes.com)
Automotive battery pack cost

The figure below depicts technical bottom-up battery cost analyses, statements by automakers, and prominent battery cost projections.

- Decline results from improved cathode chemistry, cell design for greater energy density, improved pack design for further density improvements, lower assembly costs from learning and volume

Automotive battery cost: Sources

- State-of-the-art battery cost analyses include rigorous bottom-up analysis of assembly process, materials, volume
  - Technical studies below are largely corroborated by near-term auto statements

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<th>Type</th>
<th>Source</th>
<th>Battery specifications and cost elements included</th>
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<tbody>
<tr>
<td>Technical reports</td>
<td>Ahmed et al, 2018</td>
<td>Pouch NMC 6,2,2-graphite, production volume-based; includes total cost to automaker for material, process, overhead, depreciation, warranty</td>
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<td>Anderman, 2017</td>
<td>Cylindrical 21700, NCA 83,13,4, production volume-based; includes cost of material, capital, pack integration, labor, overhead, depreciation, R&amp;D, admin., warranty, profit</td>
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<td>Anderman, 2018</td>
<td>Pouch NMC 8,1,1-graphite, production volume-based; includes cost of materials, capital, pack integration, labor, overhead, depreciation, R&amp;D, administration, warranty, profit</td>
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<td>Berckmans et al, 2017</td>
<td>Pouch NMC 6,2,2-graphite anode, production volume-based; includes material, process, labor, overhead, depreciation, profit</td>
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<td>Pouch NMC 6,2,2-silicon alloy anode, production volume-based; includes material, process, labor, overhead, depreciation, profit</td>
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<td>Automaker statements</td>
<td>UBS, 2017</td>
<td>Pouch NMC 6,2,2-graphite, production volume-based; includes material, process, labor, overhead, depreciation, profit</td>
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<td>Davies, 2017</td>
<td>Volkswagen statement. Associated with planned production volume of 100,000 per year by 2020 for I.D. series</td>
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<td>Lienert &amp; White, 2017</td>
<td>General Motors statement related to Chevrolet Bolt (NMC 6,2,2), associated timeframe for production volume has not been stated</td>
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<td>Tesla, 2018</td>
<td>Tesla statement related to Model 3 production volume of 500,000 with Panasonic battery production (cylindrical 21700, NCA 83,13,4) in Nevada by 2020</td>
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Electric vehicle cost estimates: 2018

- Full engineering teardown analyses enable detailed cost estimates
  - Representative car costs: Conventional versus 150-250 mile electric
  - At $176/kWh, battery pack costs are 22-34% of overall vehicle cost

Cost reductions allow EVs to approach cost parity with conventional cars

With 7%/year battery pack cost reduction ($105/kWh, 2025), EVs roughly at cost parity in 2025

Electric vehicle ownership: 2018 and 2025

- Cost reductions allow EVs to reach ownership parity with conventional cars
  - With 7%/year battery pack cost reduction ($105/kWh, 2025), EVs roughly at cost parity in 2025

Battery cost reductions enable electric vehicle cost parity

- Parity points for cars: 2024 to 2029 for 150-300-mile electric range
- Parity points for crossovers and SUVs tend to be several years later

Results: Vehicle prices over 2020-2030

- Battery cost reductions enable electric vehicle cost parity
  - Parity points for cars: 2024 to 2029 for 150-300-mile electric range
  - Parity points for crossovers and SUVs tend to be several years later
  - PHEVs do not reach parity (but do when vehicle lifetime savings included)

Based on ICCT, 2019. Update on electric vehicle costs in the United States through 2030. 
Broader perspective: Transition to mainstream market

- We are still just in the very beginning of the transition to electric vehicles
- We will need sustained support through the transition to tackle each barrier:
  - Cost (incentives); Convenience (infrastructure); Supply (regulation); Consumer understanding (campaigns)
Automakers increasingly share all-electric vision

- Automaker announcements:
  - Hundreds of new EV models, over $200b in investments, and 15m EVs/year by 2025
  - Vehicle deployment would lead to higher volume than required by global regulations

Based on company announcements for plug-in vehicles
See blog: https://www.theicct.org/blog/staff/future-is-electric-but-why-so-long
Report: https://www.theicct.org/publications/modernizing-regulations-electrification
End of 2018: About 5 million electric cars and 600,000 public charge points
Conclusions

- **Electric vehicle growth**
  - Growth: 60%+ annual growth rate, 2 million EVs per year and growing
  - Battery innovation and production scale is advancing rapidly, enabling mainstream market in years ahead – assuming continued policy support
  - Industry commitments show that order of magnitude higher ZEV production scale is on the way and the emergence of a shared all-electric zero-emission vision

- **Zero-emission vehicle policy**
  - Top EV markets around the world have a complete policy package
  - Policies will have to reduce new vehicle CO₂ emissions at triple the historical rate to decarbonize the transport sector
  - International collaboration greatly accelerates the shift to zero-emissions
  - Manufacturing cost parity could come as early as 2024 for lower-range cars and should come for most vehicle classes by 2030
  - Policy could shift from incentives to regulation as vehicles reach manufacturing cost parity - infrastructure incentives may be needed longer term
More info

ICCT electric vehicle page:
http://theicct.org/electric-vehicles

World electric vehicle capital report:

U.S. city electric vehicle report:
https://www.theicct.org/publications/continued-EV-transition-us-cities-2018

Update on electric vehicle costs in the United States through 2030:

Acknowledgements

Analysis and data collection by Dale Hall, Pete Slowik, Hongyang Cui, Mikhail Grant, Sandra Wappelhorst, Huan Zhou, Mike Nicholas, Nic Lutsey