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

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California Energy Commission
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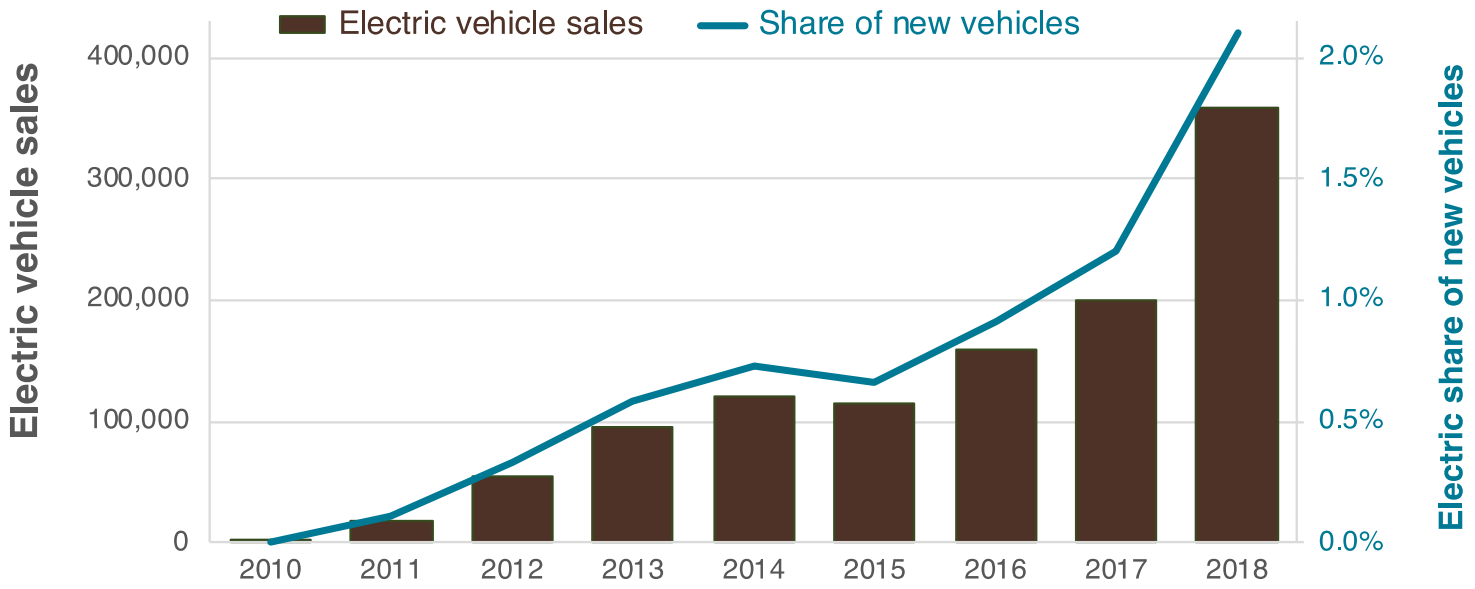
THE INTERNATIONAL COUNCIL ON CLEAN TRANSPORTATION

U.S. electric vehicle sales

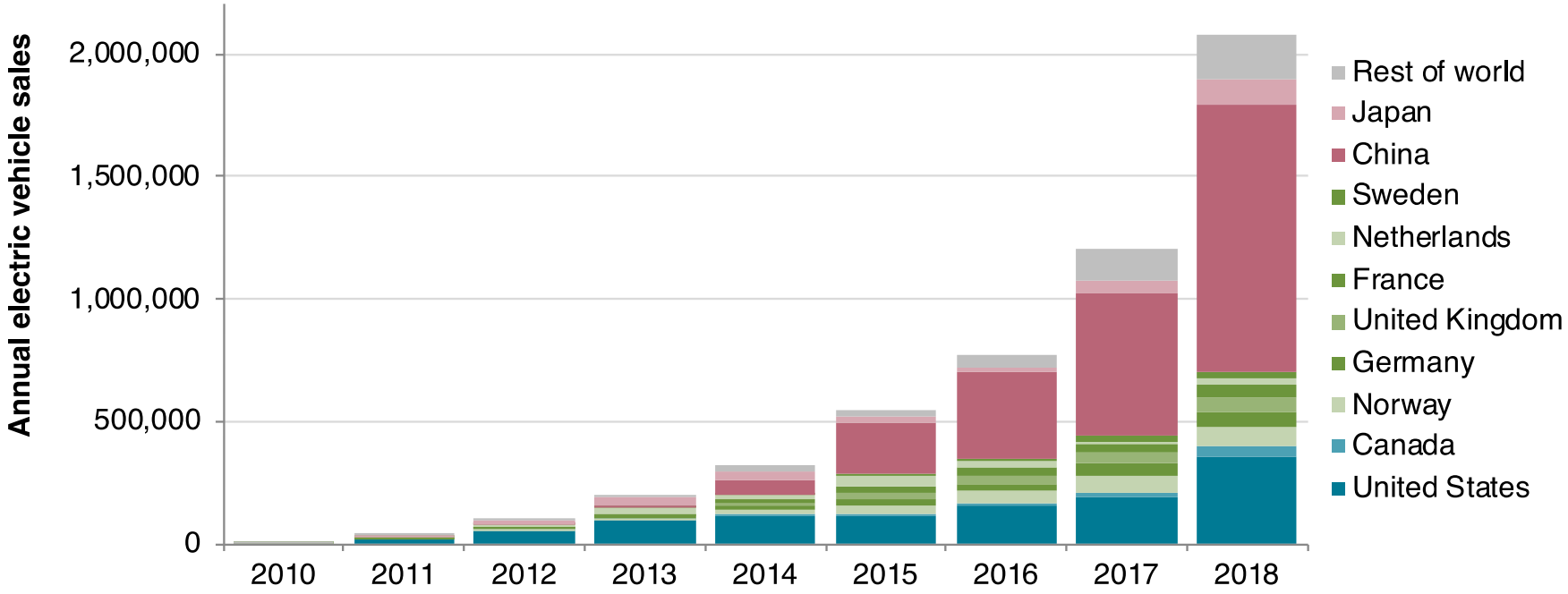
- Cumulative U.S. electric vehicle sales have passed 1 million
  - Mostly these EV sales are in markets with some combination of the following: ZEV regulation, incentives, extensive charging, city/utility promotions
  - Nearly two-thirds of EV sales are in ZEV regulation states (CA, OR, Northeast)



Source: www.EV-volumes.com

Global electric vehicle growth

- 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

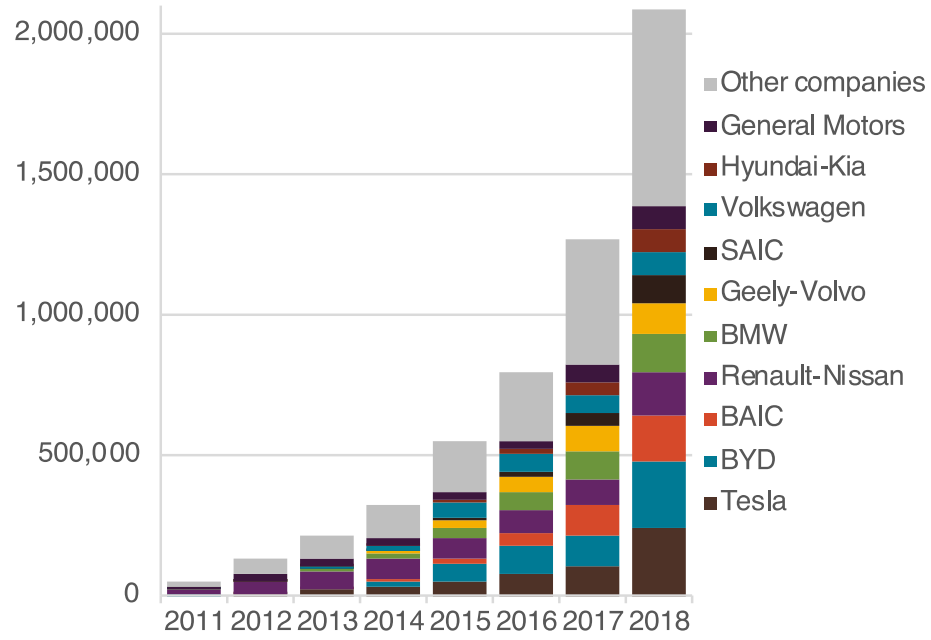


Source: www.EV-volumes.com

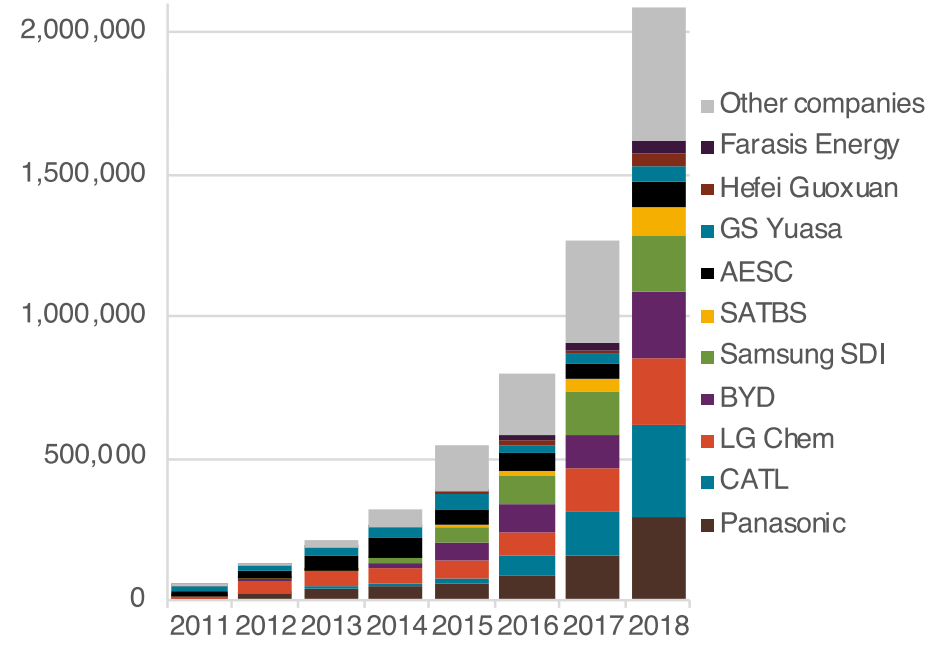
Global electric vehicle growth

- 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



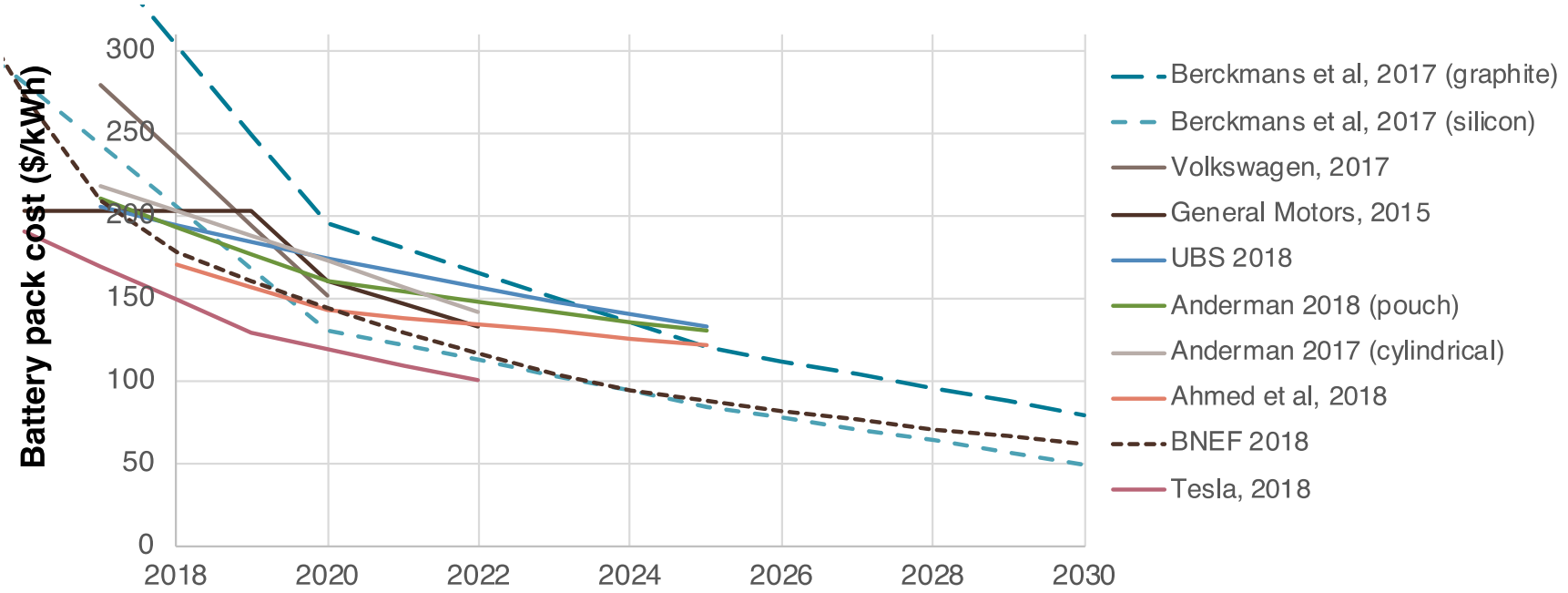
Electric vehicle sales by battery supplier



Source: www.EV-volumes.com

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



Source: ICCT, 2019. Update on electric vehicle costs in the United States through 2030.
https://www.theicct.org/publications/update-US-2030-electric-vehicle-cost

Automotive battery cost: Sources

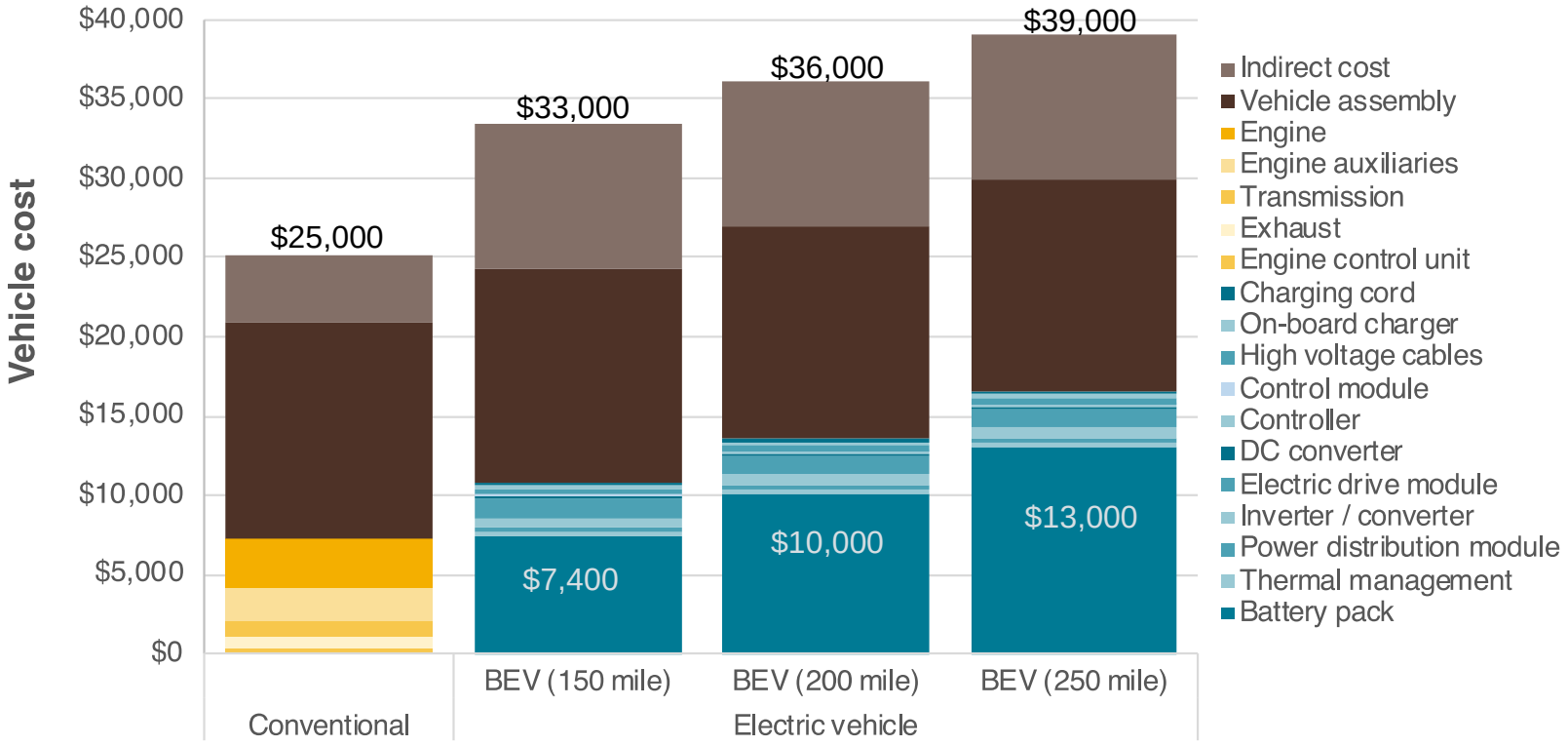
- State-of-the-art battery cost analyses include rigorous bottom-up analysis of assembly process, materials, volume
  - Technical studies below are largely corroborated by near-term auto statements

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

Source: ICCT, 2019. Update on electric vehicle costs in the United States through 2030. https://www.theicct.org/publications/update-US-2030-electric-vehicle-cost

Electric vehicle cost estimates: 2018

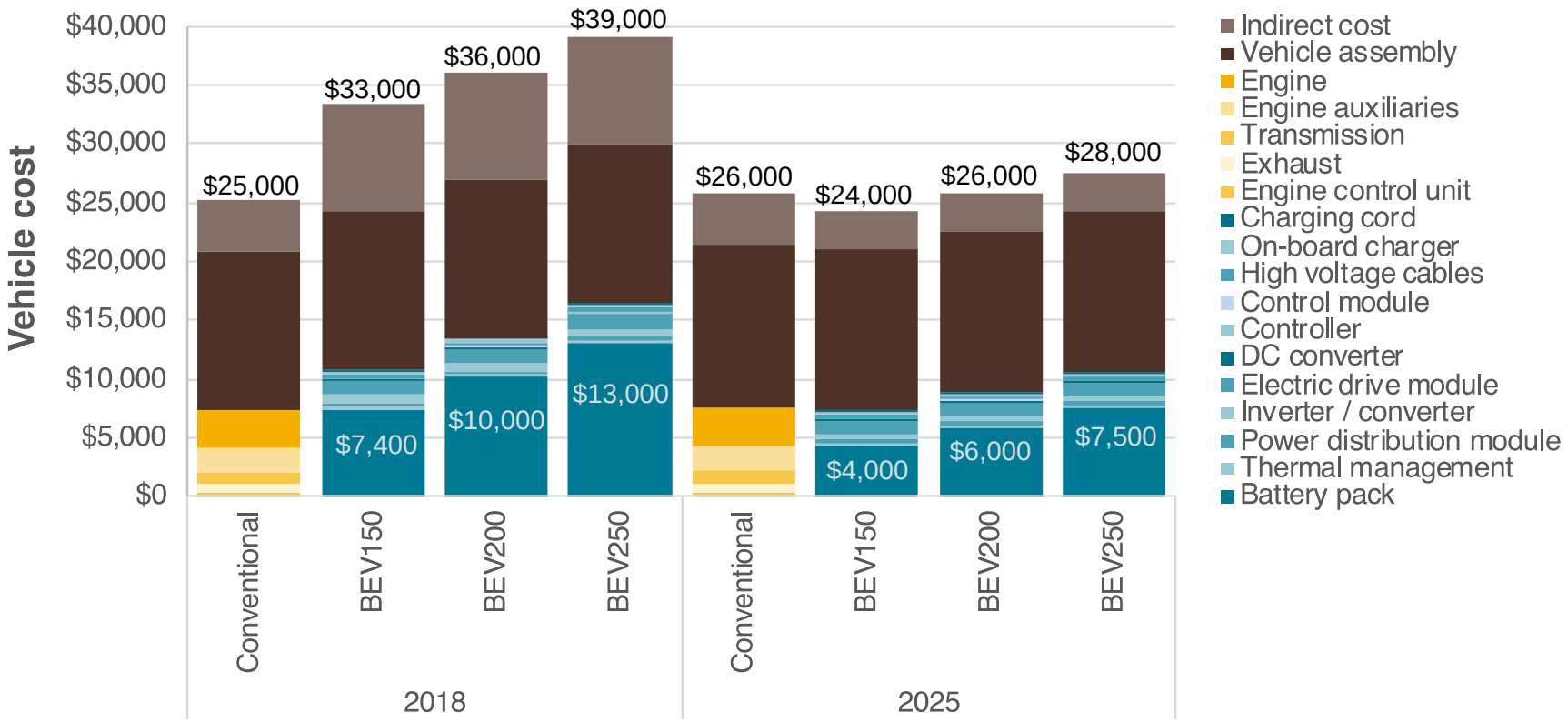
- Full engineering teardown analyses enable detailed cost estimates
  - Representative car costs: Conventional versus 150-250 mile electric
  - At $176/kWh, battery pack costs, are 22-34% of overall vehicle cost



Based on UBS. (2017). UBS evidence lab electric car teardown: Disruption ahead? https://neo.ubs.com/shared/d1ZTxnvF2k/ and Bloomberg New Energy Finance (2019) https://twitter.com/bloombergnef/status/1075410072283594753?lang=en

Electric vehicle cost estimates: 2018 and 2025

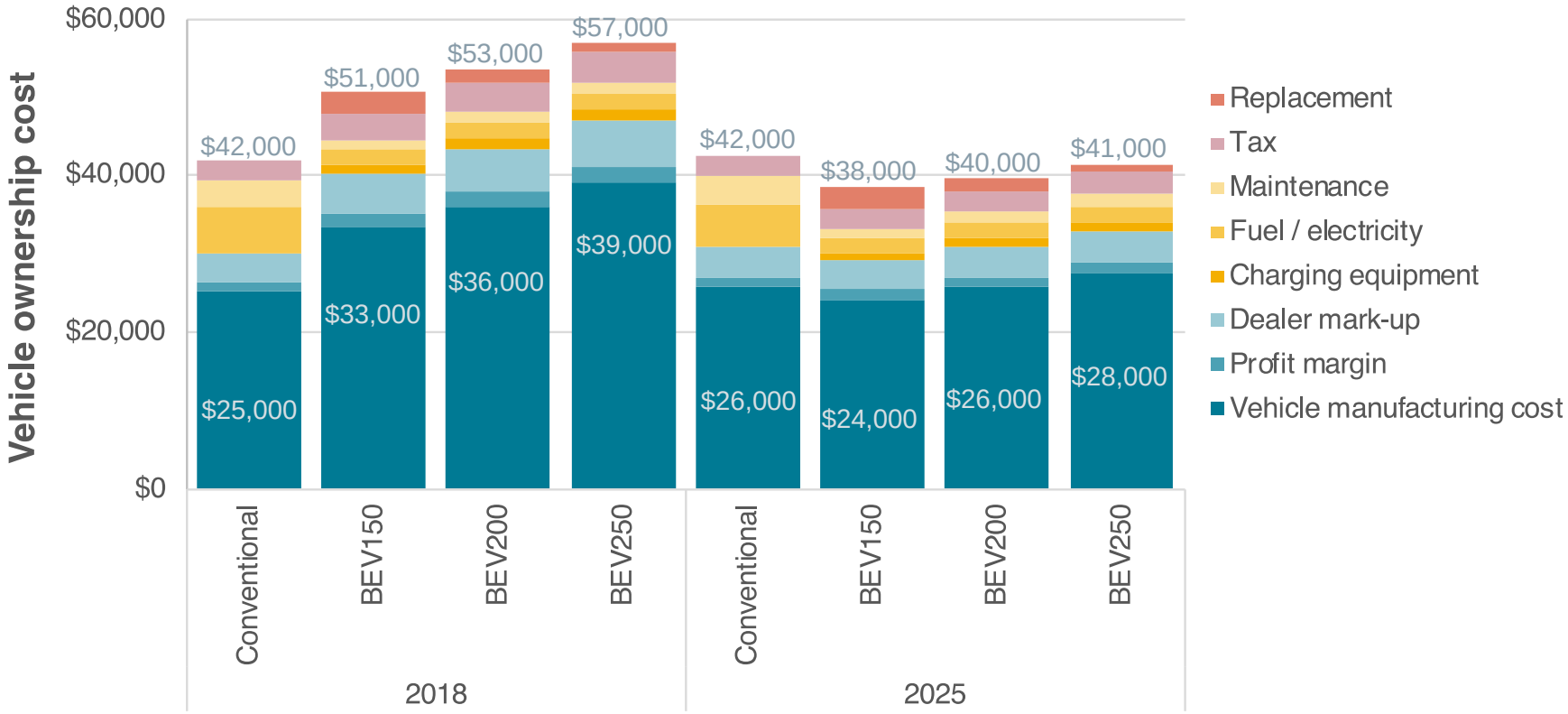
- Cost reductions allow EVs to approach cost parity with conventional cars
  - With 7%/year battery pack cost reduction ($105/kWh, 2025), EVs roughly at cost parity in 2025



Source: ICCT, 2019. Update on electric vehicle costs in the United States through 2030.
https://www.theicct.org/publications/update-US-2030-electric-vehicle-cost

Electric vehicle ownership: 2018 and 2025

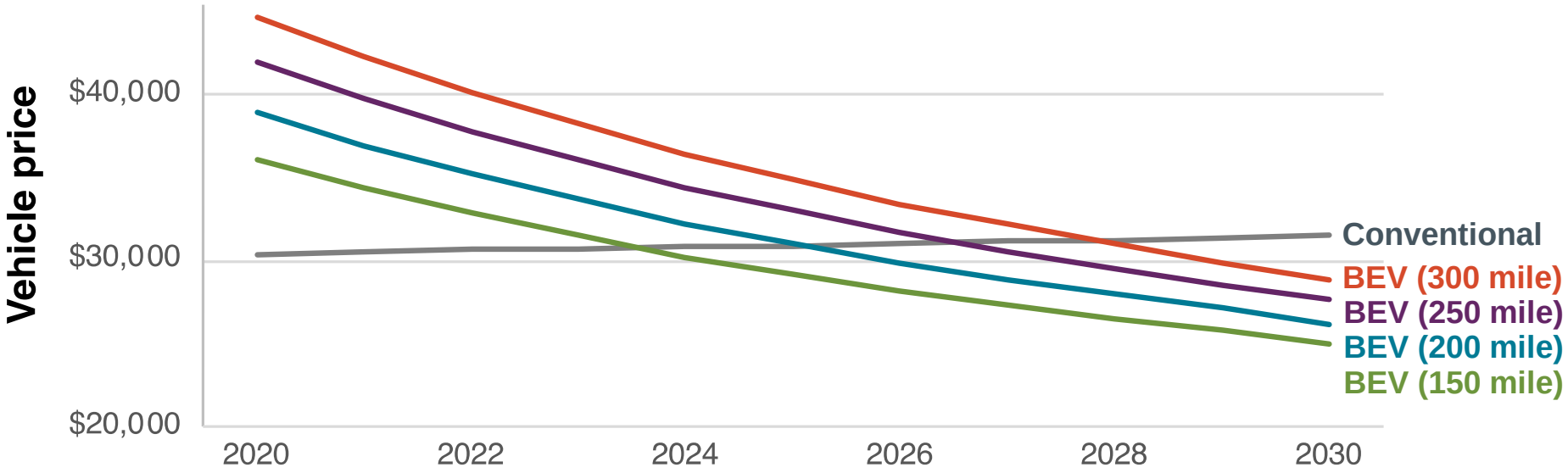
- Cost reductions allow EVs to reach ownership parity with conventional cars
  - With 7%/year battery pack cost reduction ($105/kWh, 2025), EVs roughly at cost parity in 2025



Source: ICCT, 2019. Update on electric vehicle costs in the United States through 2030.
https://www.theicct.org/publications/update-US-2030-electric-vehicle-cost

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



Based on ICCT, 2019. Update on electric vehicle costs in the United States through 2030.
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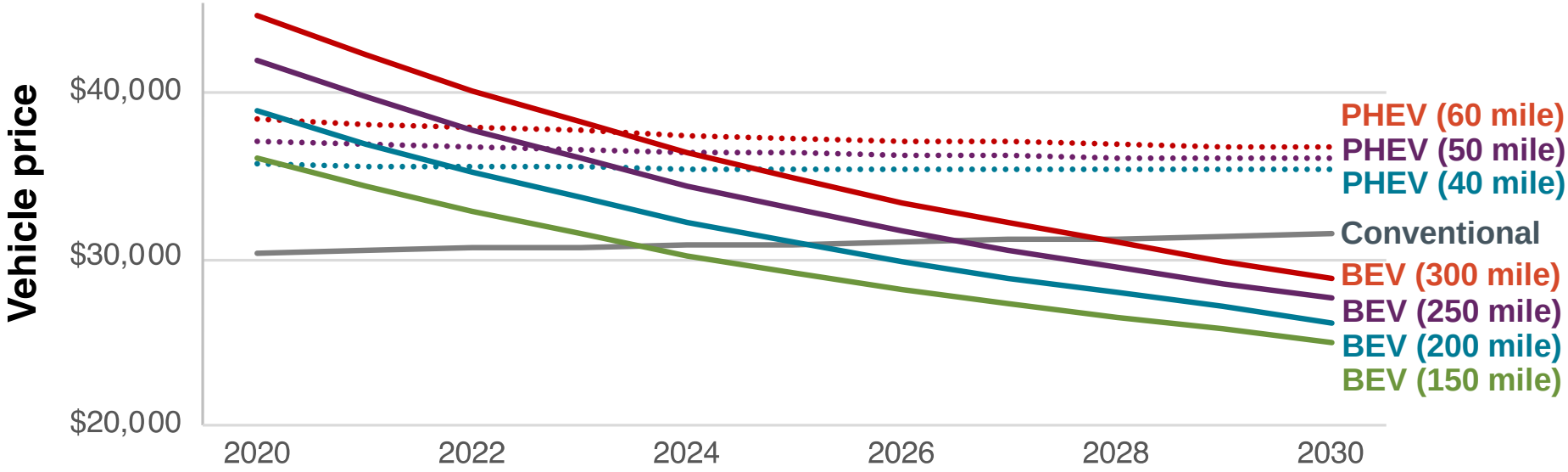
Results: Vehicle prices over 2020-2030

- 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)



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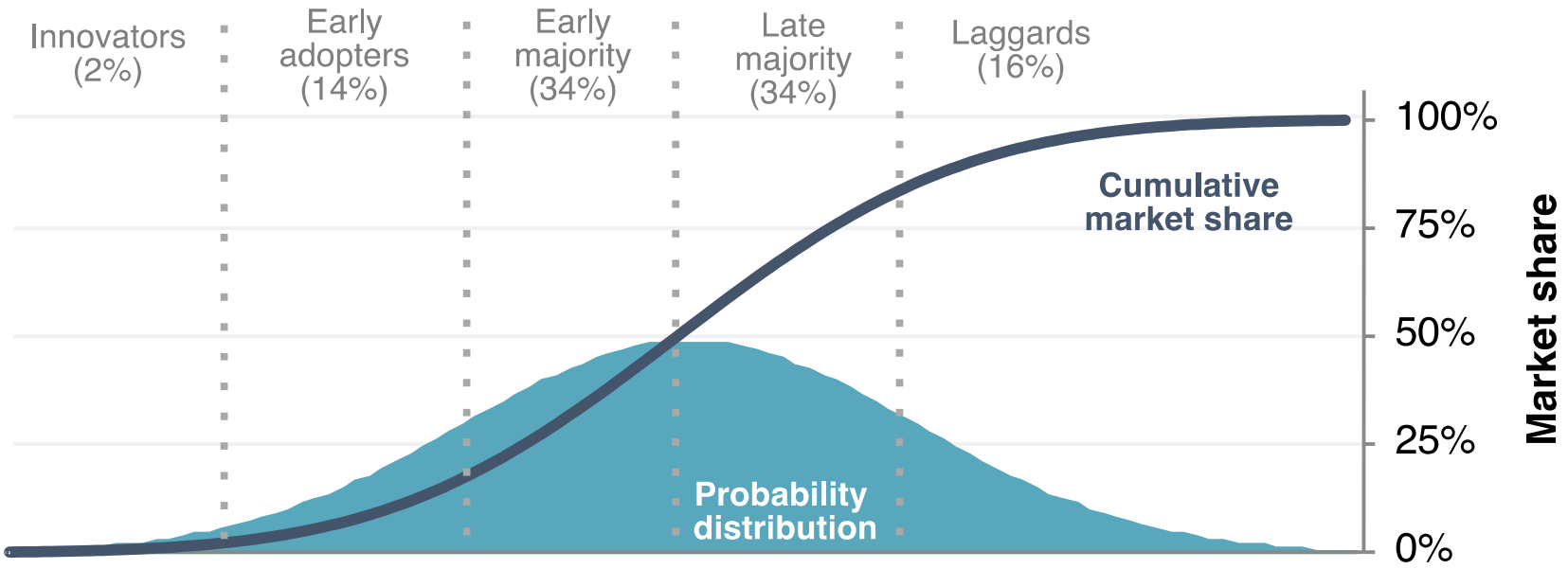
https://www.theicct.org/publications/update-US-2030-electric-vehicle-cost

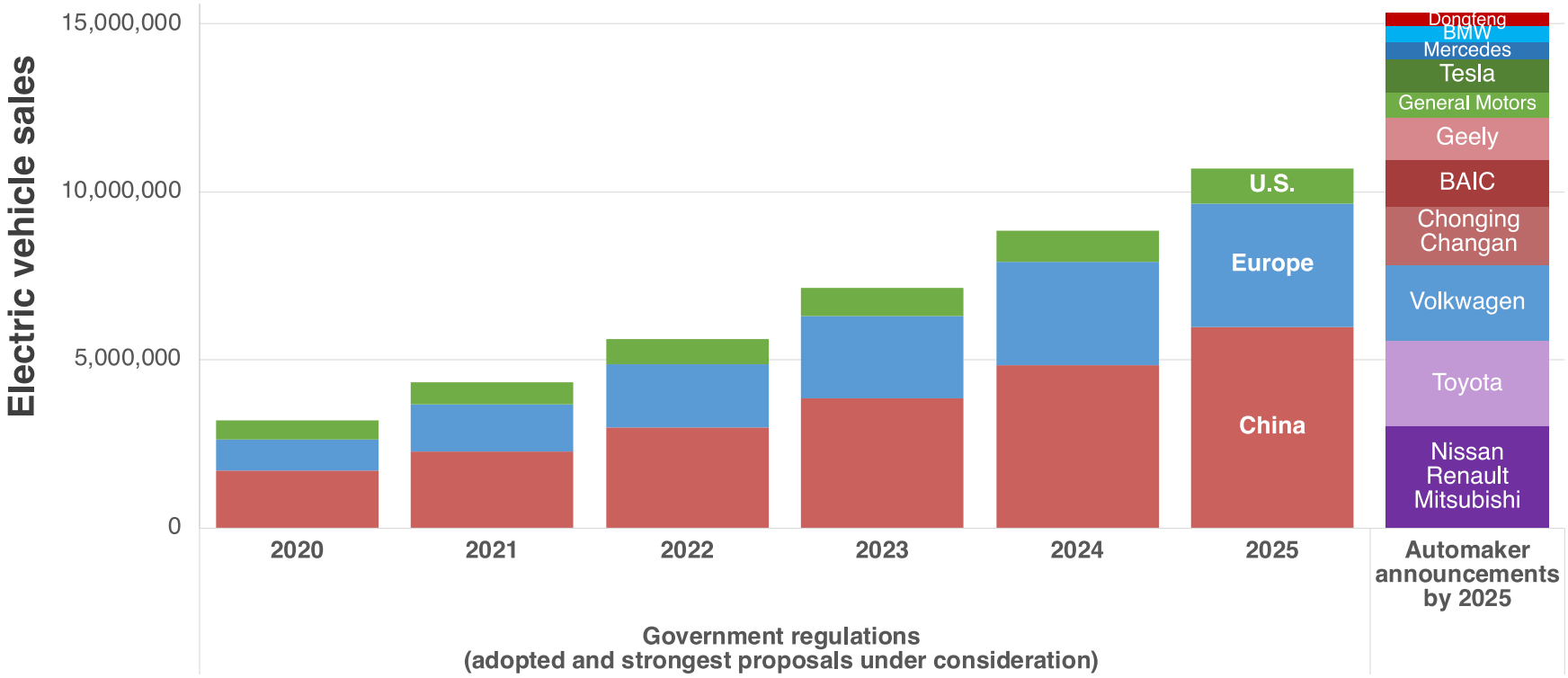
Broader perspective: Transition to mainstream market

- 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

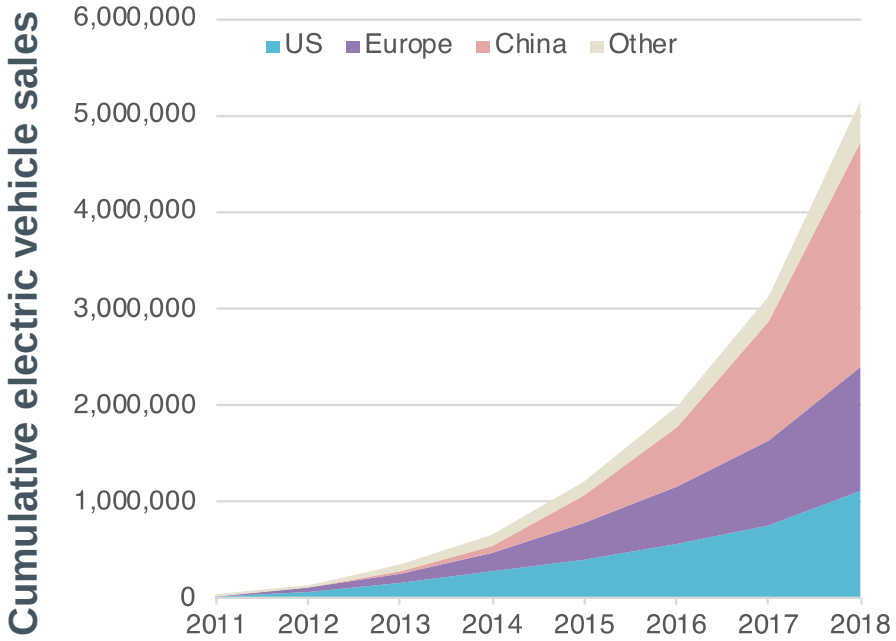
- Automaker announcements:
  - Hundreds of new EV models, over $200b in investments, and 15m EVs/year by 2025
  - Vehicle deployment would lead to higher volume than required by global regulations

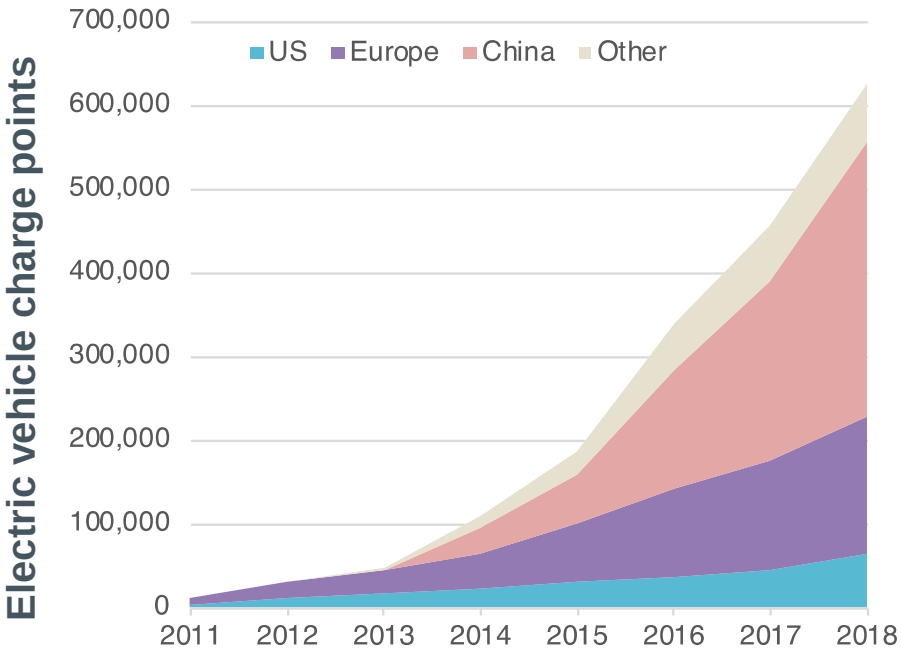


Based on company announcements for plug-in vehicles
See blog: https://www.theicct.org/blog/staff/future-is-electric-but-why-so-long
Report: https://www.theicct.org/publications/modernizing-regulations-electrification

Infrastructure: EV and public charging growth

- 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 CO_2 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:
http://www.theicct.org/publications/EV-capitals-of-the-world-2018

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:
https://www.theicct.org/publications/update-US-2030-electric-vehicle-cost

Acknowledgements

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