National Energy Board
Office national de l'énergie

Electric Vehicle Battery Cost Assessment Model

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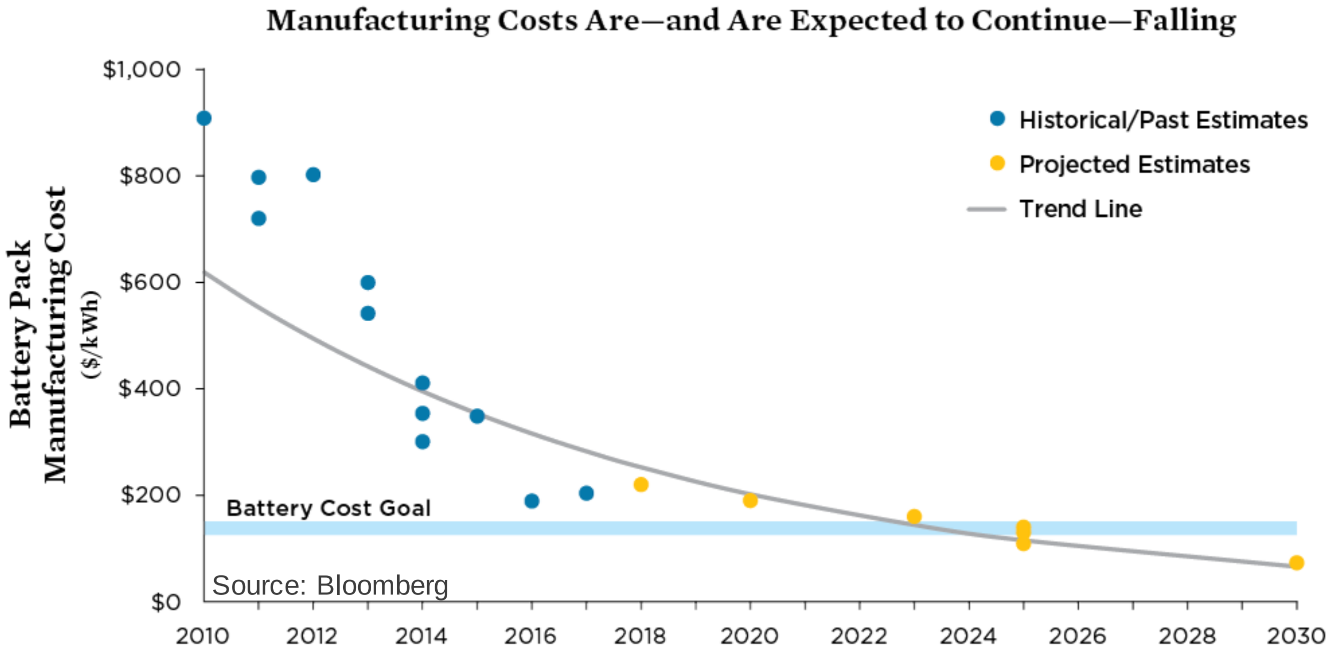
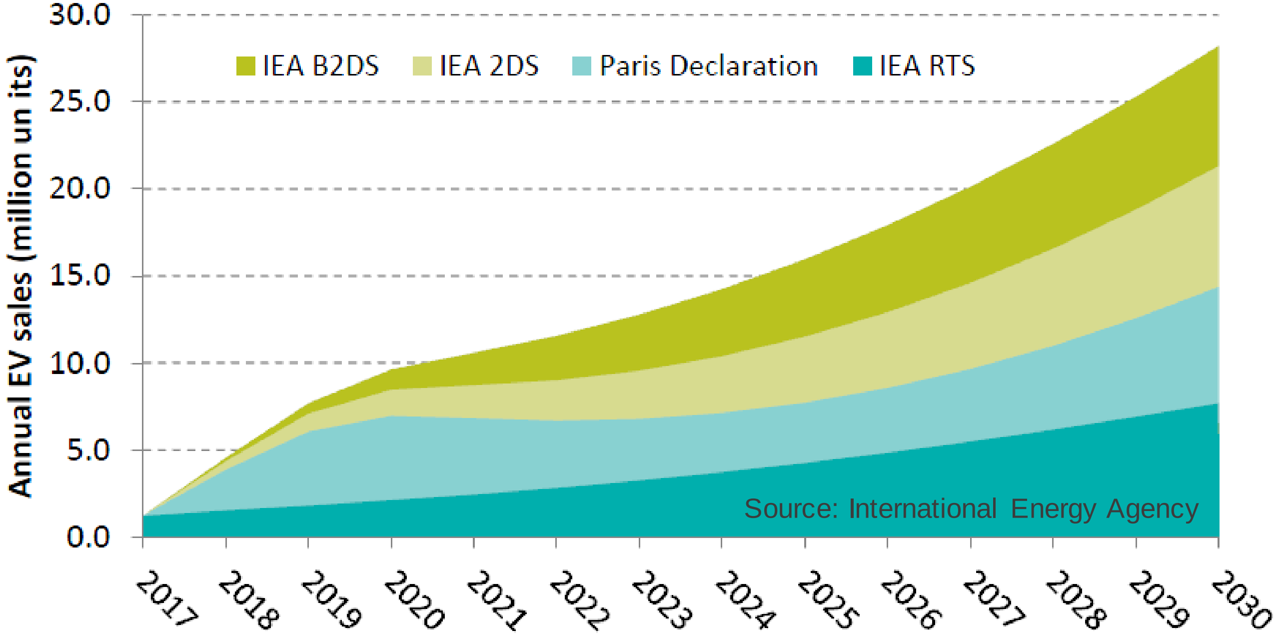
Context

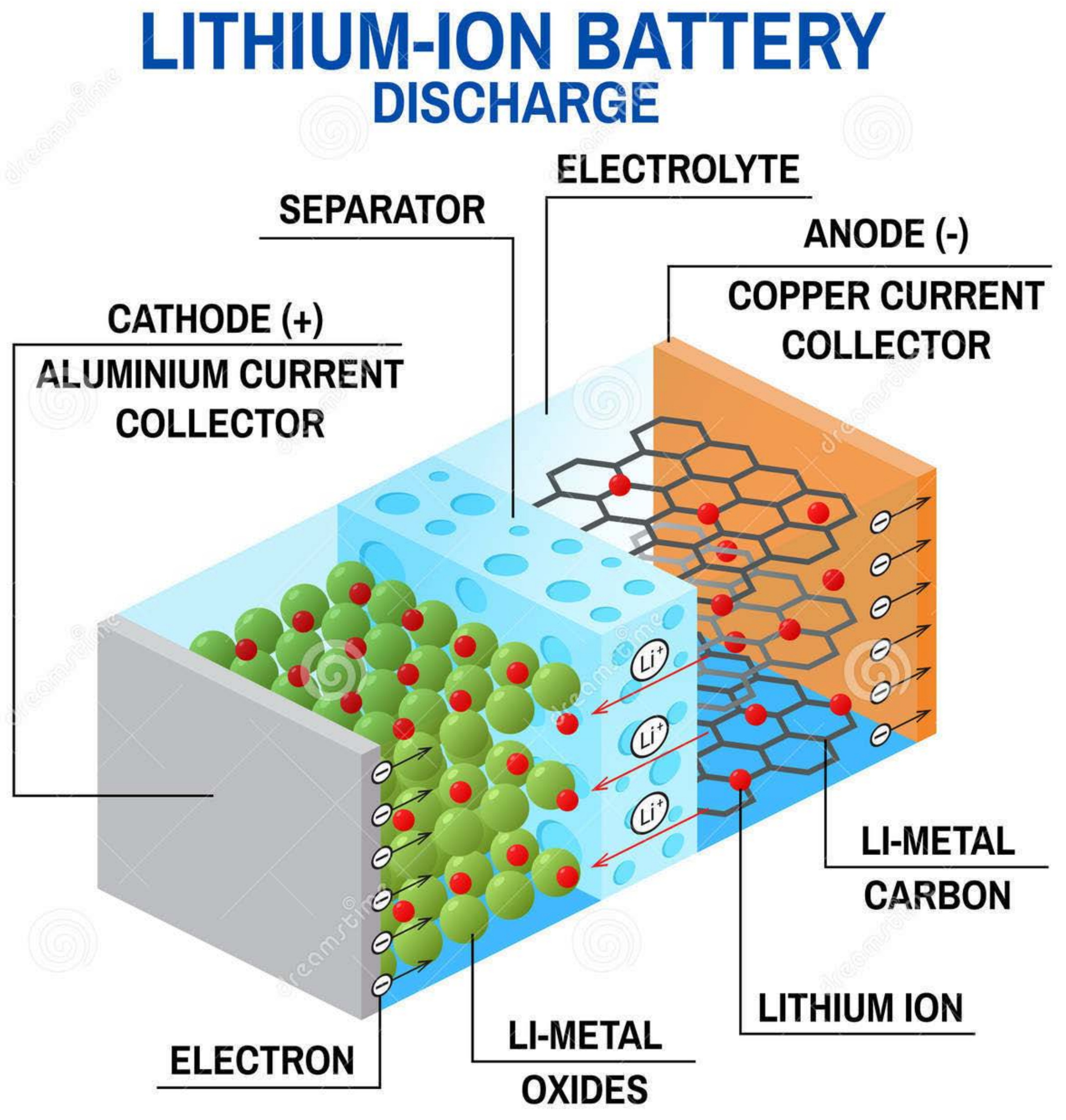
- In many outlooks that see the decrease of global CO2 emissions, EV sales dramatically increase as they replace ICE vehicles on the road
- In order for this increase to occur the costs of EVs are assumed to fall so they become comparable to ICE vehicles
- According to history, batteries appear to have room for cost improvement





Batteries 101

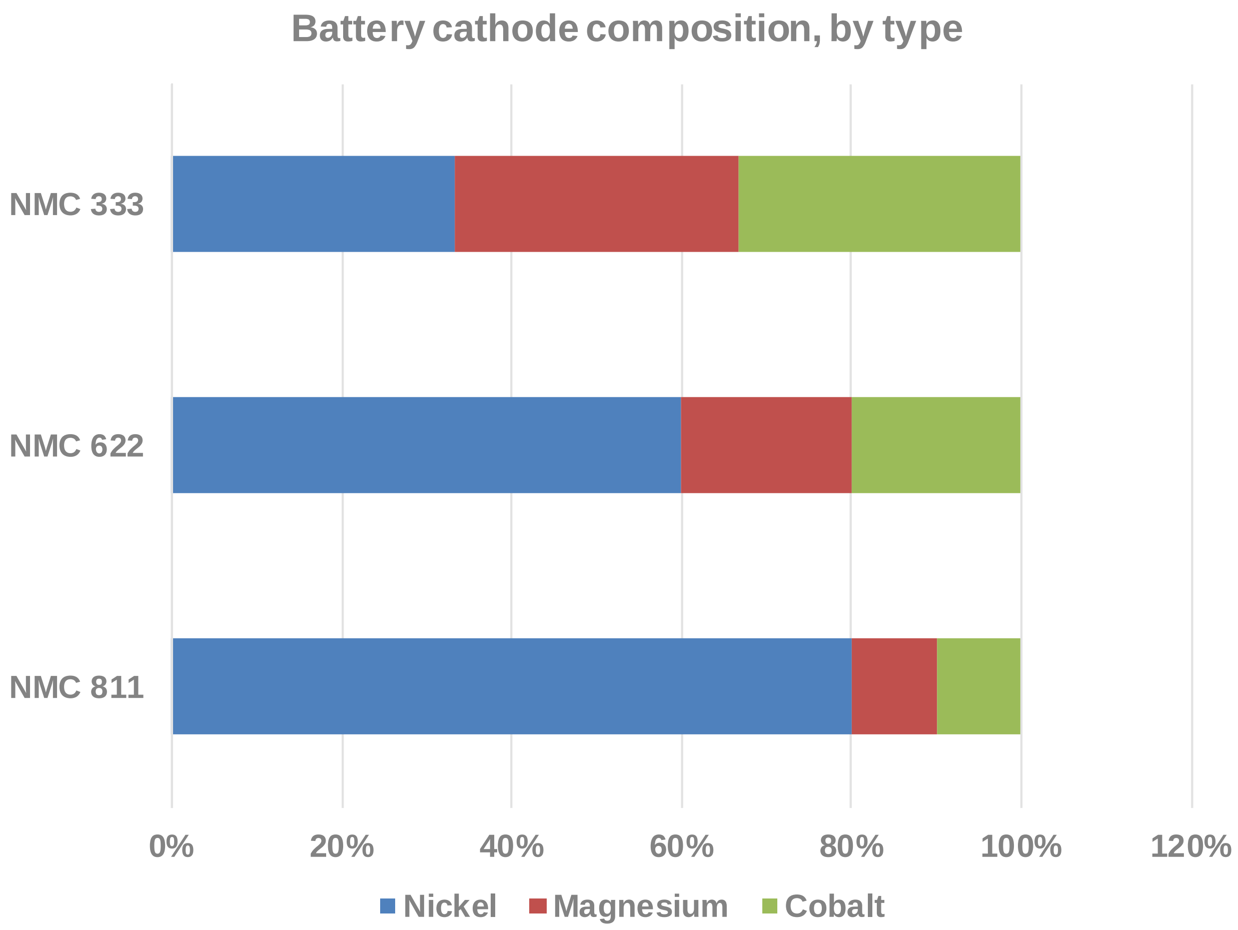
- Batteries have 3 main components: anode, cathode, and an electrolyte
- Currently our model focuses on lithium ion batteries with cathodes composed of Nickel, Magnesium and Cobalt (NMC)
- NMC 622 is 6 parts nickel, 2 parts magnesium and 2 parts cobalt



Source: https://www.dreamstime.com/stock-illustration-li-ion-battery-diagram-vector-illustration-rechargeable-which-lithium-ions-move-negative-electrode-to-image97122319

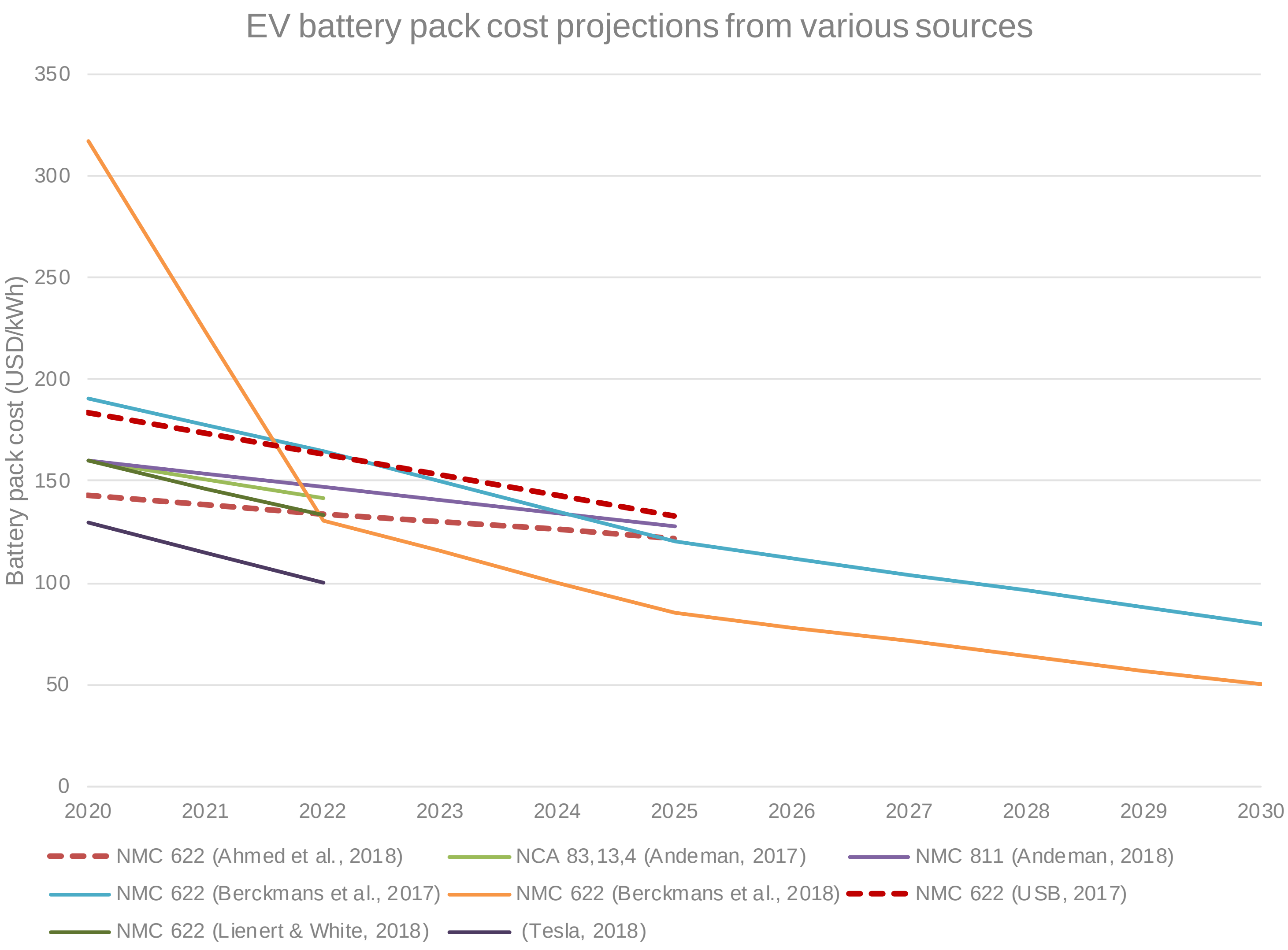
Batteries modeled

- NMC (333)
  - Cathode is equal parts nickel, magnesium and cobalt
  - Currently the main EV battery chemistry
- NMC (622)
  - Gaining market share
  - More nickel = longer range + lower material cost, BUT lower battery stability
- NMC (811)
  - Future/near-term
  - Production challenges, very unstable
  - Has potential to dramatically lower costs
- Plan to incorporate anode materials and different battery types
  - Lithium, copper etc.
  - Solid state (long term)

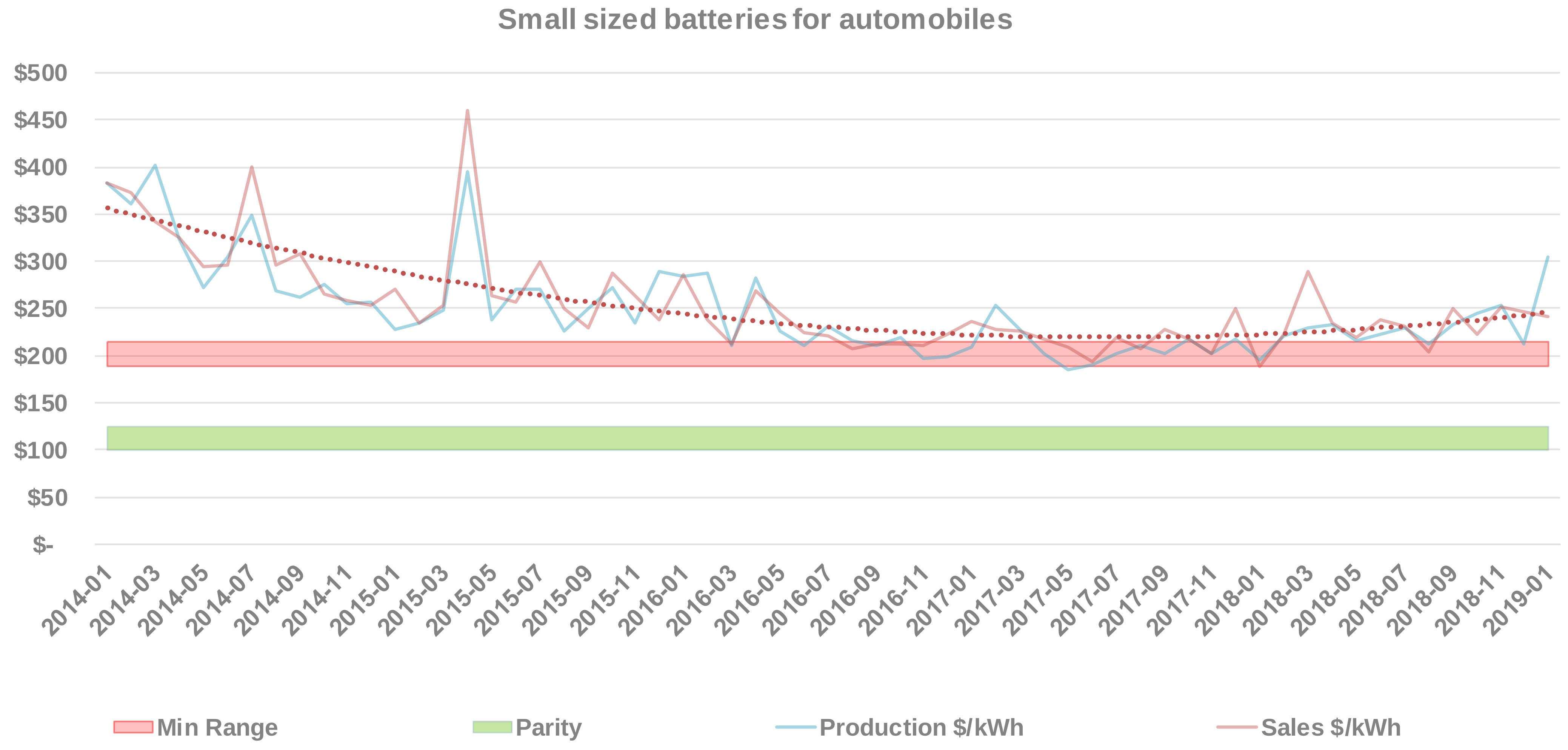


Information gap

- Wide range in estimated current costs and projections
  - It is difficult to determine how authors generate their cost declines
  - Some models simply project cost declines forward
  - Others have vested interest in projecting large cost reductions



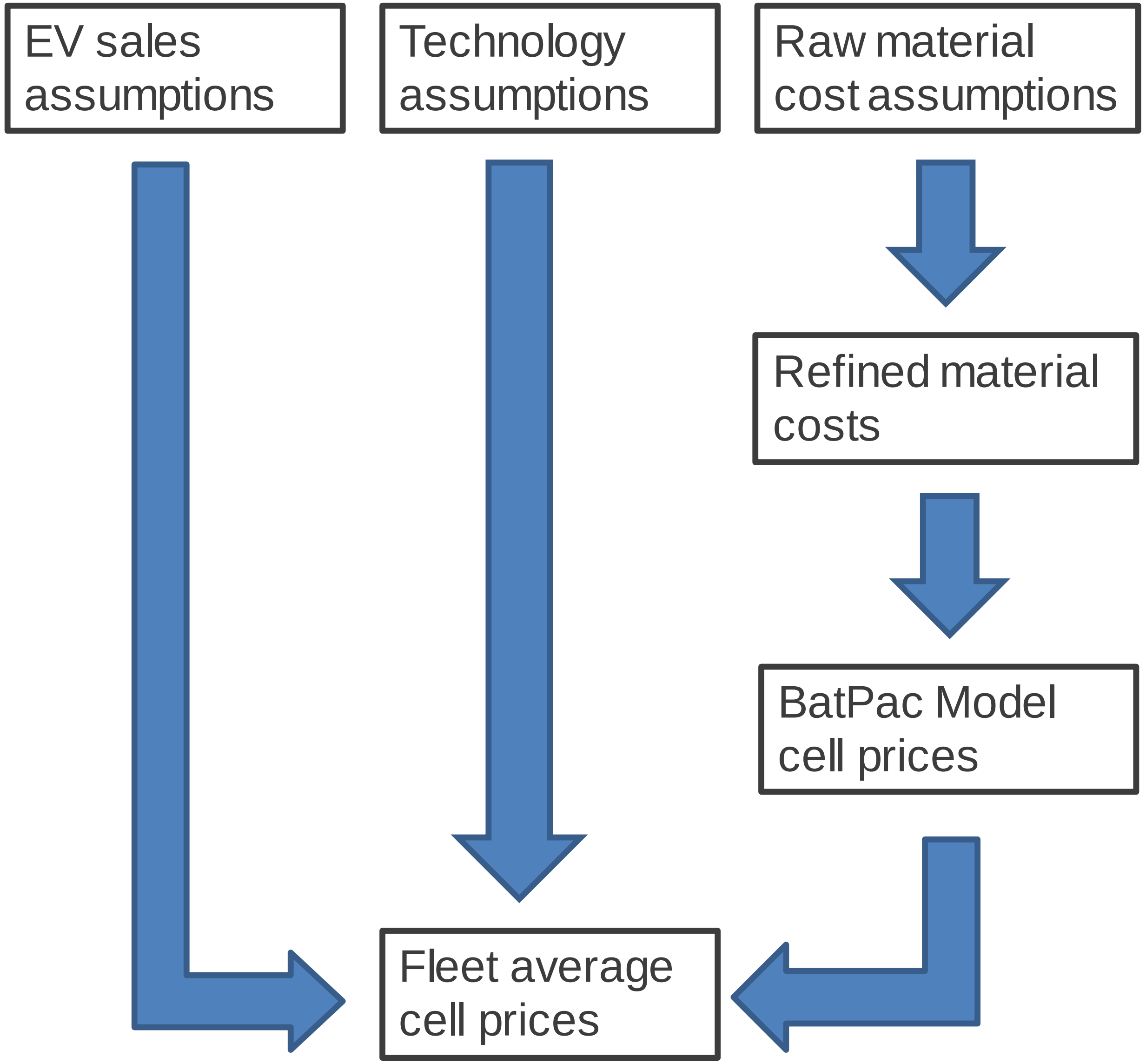
Recent data on NMC batteries



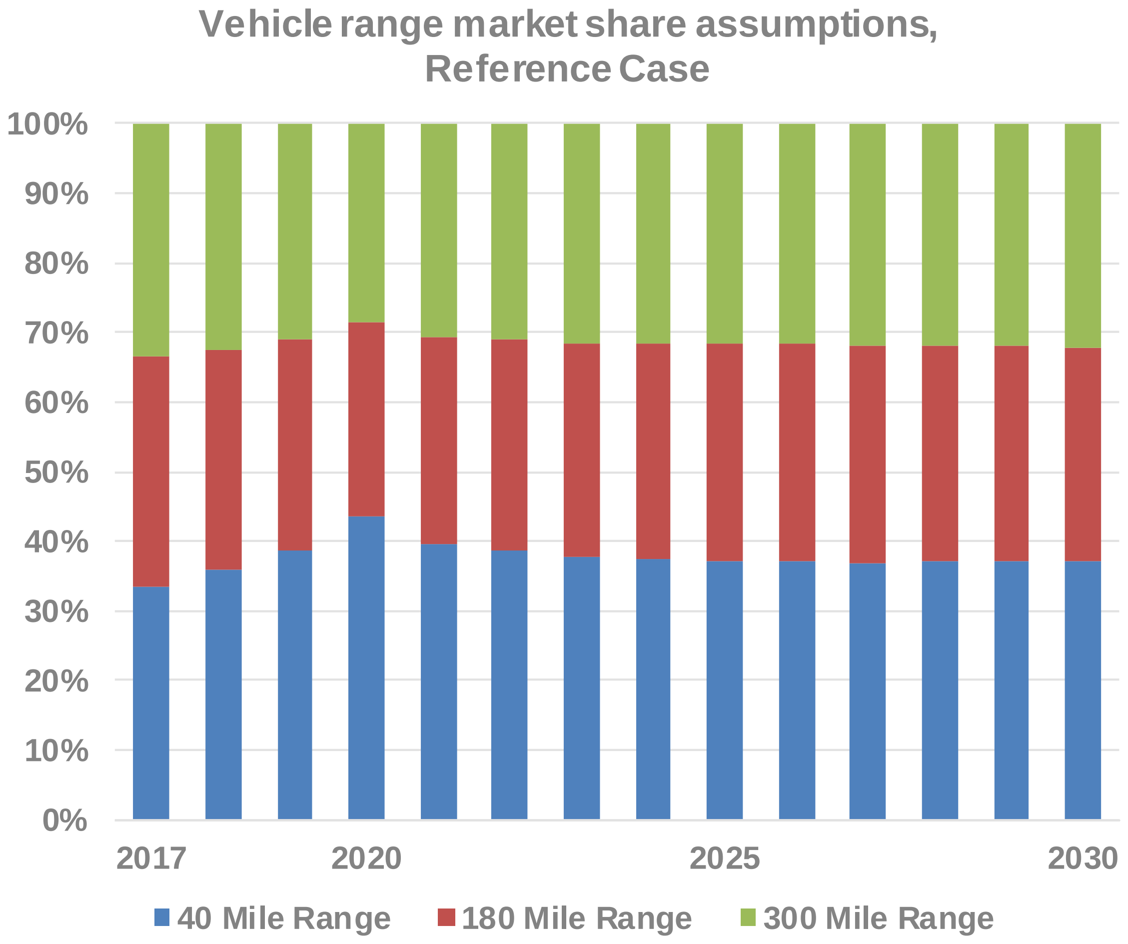
Data: Ministry of Economy, Trade and Industry of Japan

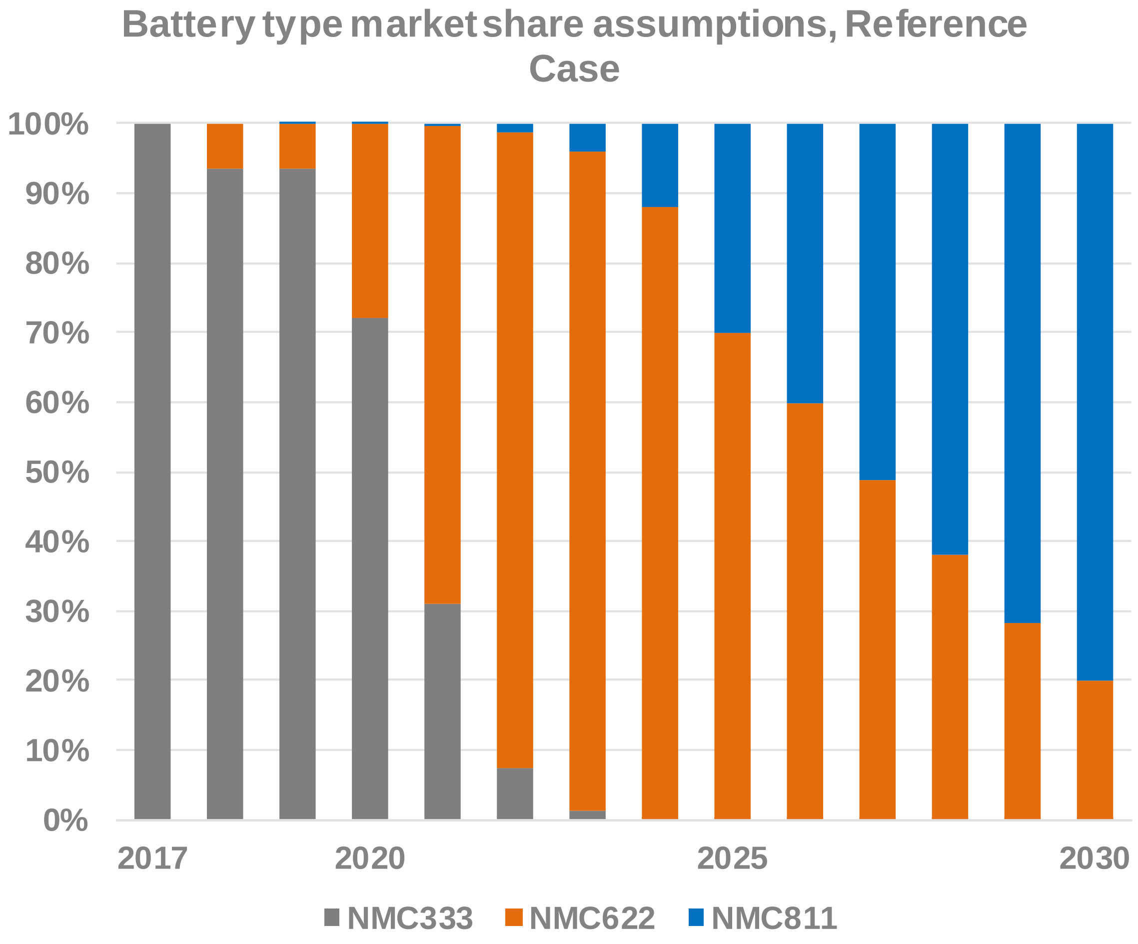
Our Process

- Forecasting battery costs is challenging, but our model can show us how prices may change with under a range of assumptions
- We have a good idea of what technologies will be available through 2030 (NMC 333, 622 and 811) and can make assumptions on their market shares
  - For the purpose of this presentation we limited battery chemistries to the NMC cathode, but the model can incorporate others – e.g. NCA, LMO, LFP



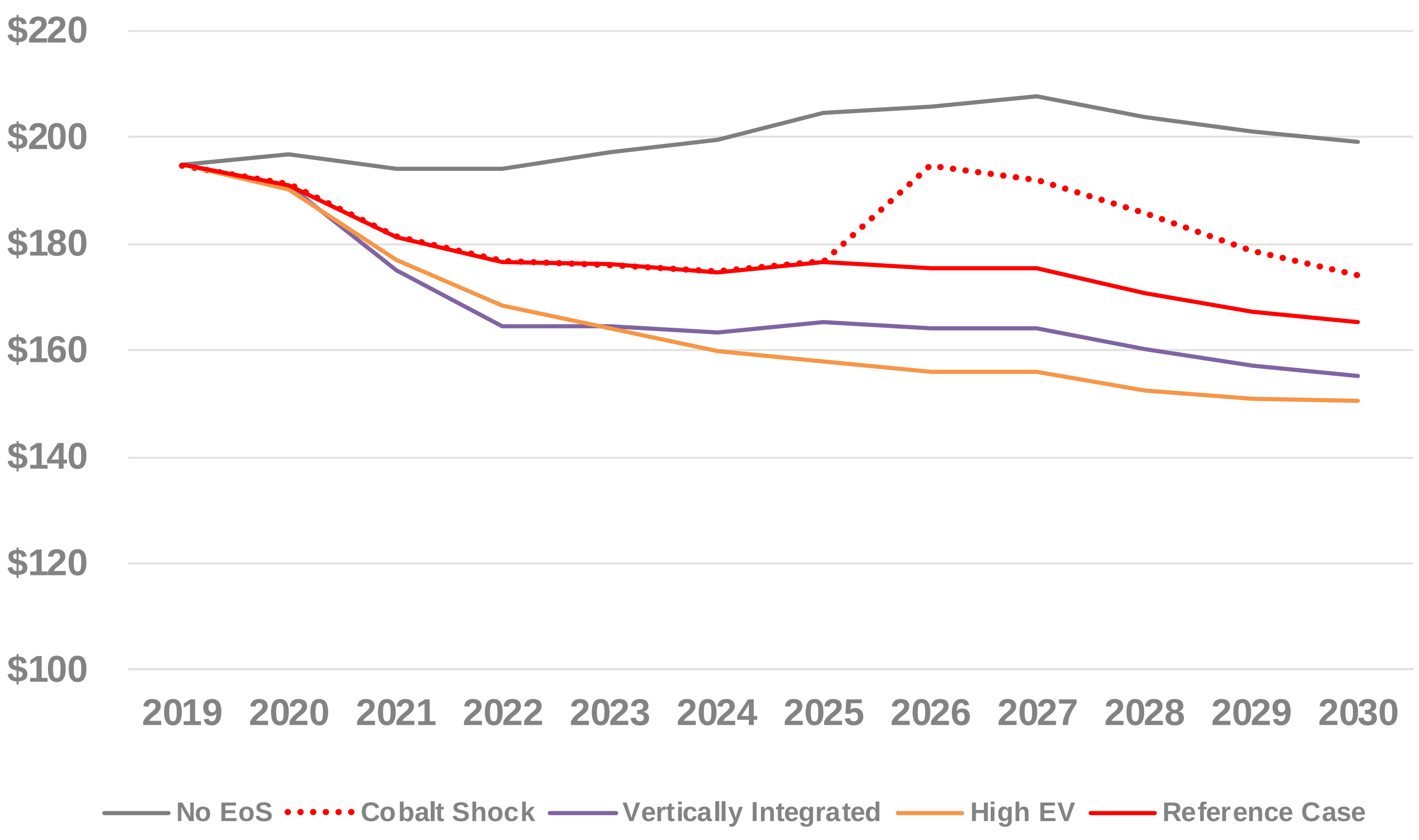
Assumptions



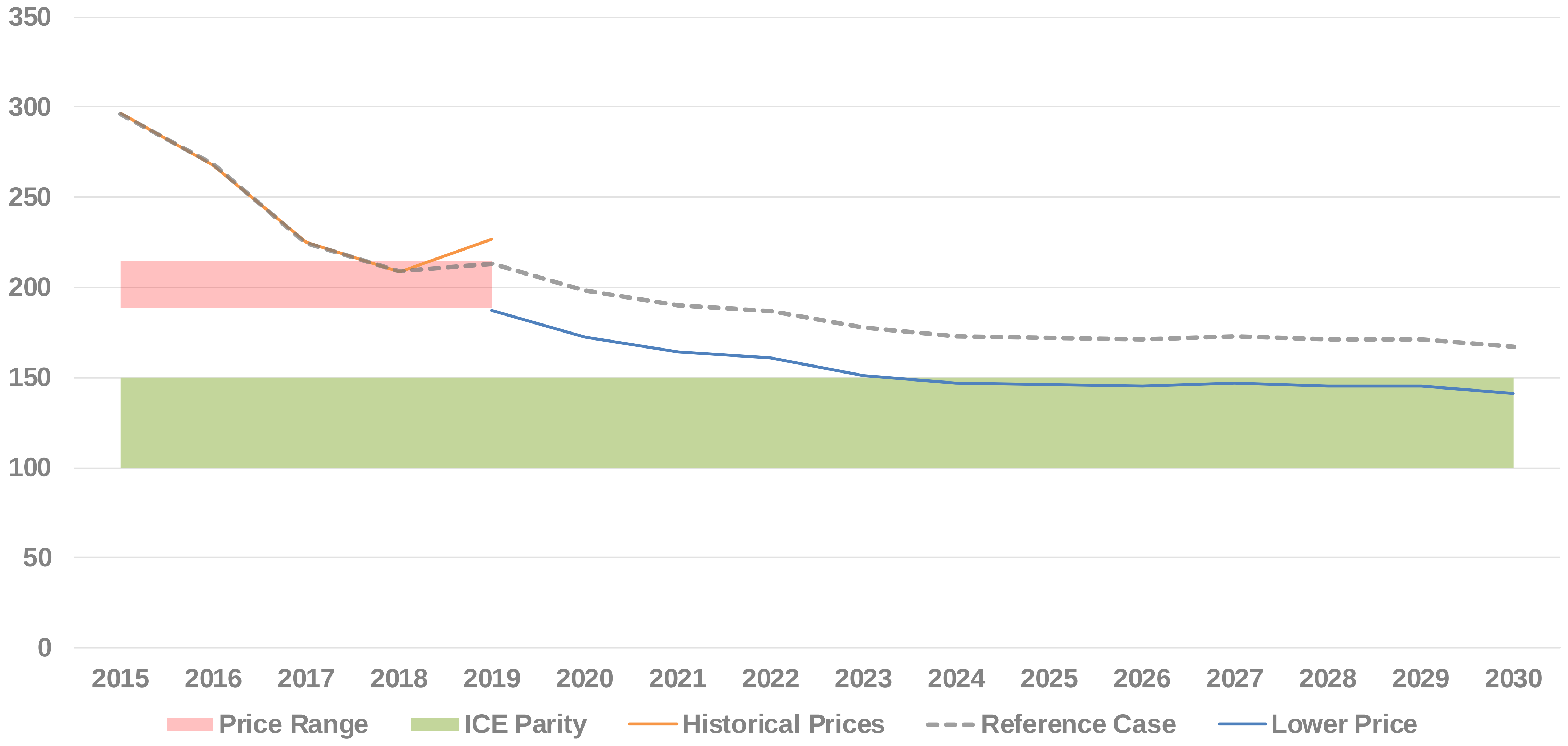


Cost of average EV battery ($/kWh)

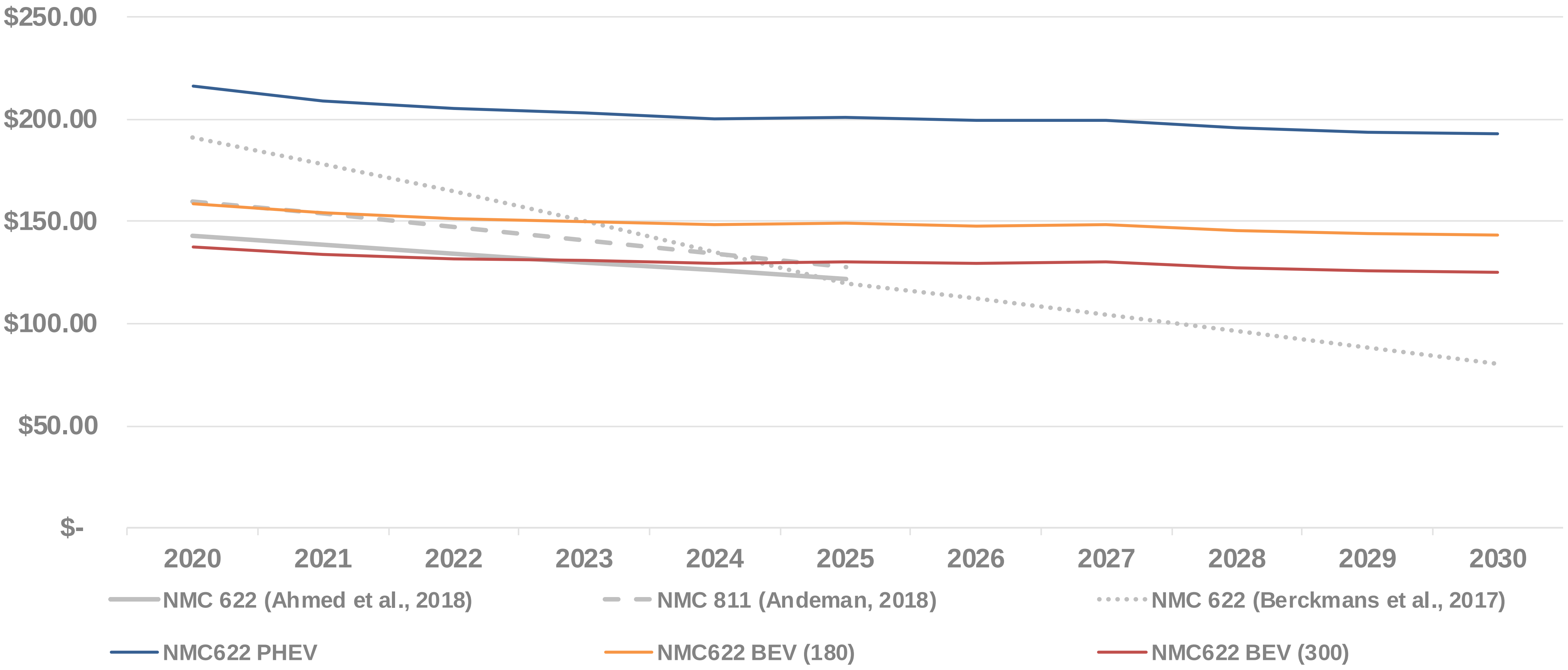
Scenario	Description
No Economies of Scale (EoS)	No cost decreases due to greater production capacity
Cobalt Shock	2026 cobalt price spike
Vertically Integrated	Increased supply chain vertical integration
High EV	Higher EV sales and preference for long range units
Reference	Our base case assumptions



Reference Case estimate with historical METI data, $/kWh



NMC 622 results comparison, Reference Case (in colour)



Key Findings

- Data uncertainty and opacity of markets makes determining exact prices difficult
- Improving technology and supply chains can be used to lower battery prices and help EVs achieve parity ICE vehicles
- Material costs are an important component factor in battery prices
    - Some studies hold input costs constant over short time scales

Future Developments and Key Scenarios

- Still need to incorporate other key minerals/metals
  - Lithium, copper, iron (for LFP batteries)…etc.

- Various other uncertainties provide interesting scenario analysis
  - Battery degradation from use in colder climates
  - Further supply chain issues
    - Cobalt: - ~90% mined as a byproduct, other potential concerns = geopolitical + concentration + humanitarian
    - Lithium shock
    - Nickel market bifurcation → prices for higher grade nickel could increase insignificantly

- Study impact of removal of Chinese subsidies on battery prices at the end of 2020
  - Dig further into historical $/kWh price reduction…