ZEV Technology Incremental Cost

February 10, 2022
Approach to ZEV Cost Analysis

- Modeling 2026 to 2035 Model Years

**Add:** ZEV Component Costs

**Subtract:** Internal Combustion Engine (ICE) Vehicle Component Costs

= Incremental Direct Manufacturing Cost
ZEV Technology Incremental Cost Categories

**Battery Electric Vehicle (BEV)**
- Battery Cost
- Non-Battery Component Cost
- Engine Removal & Delete Costs
- ZEV Assembly Cost Reductions

**Fuel Cell Electric Vehicle (FCEV)**
- Battery Cost
- Non-Battery Component Cost
- Fuel Cell System and Tank Costs
- Engine Removal & Delete Costs
- ZEV Assembly Cost Reductions

**Plug-in Hybrid Electric Vehicle (PHEV)**
- Battery Cost
- Non-Battery Component Cost
- GHG Technology Delete Cost
Modeling the California Fleet

- Small Car: 26%
- Med/Lg Car: 16%
- Small SUV: 35%
- Med/Lg SUV: 10%
- Pickup: 13%

Model Year 2019 - California Sales

<table>
<thead>
<tr>
<th>Technology</th>
<th>Range (mi)*</th>
</tr>
</thead>
<tbody>
<tr>
<td>BEV</td>
<td>300</td>
</tr>
<tr>
<td>Longer Range BEV</td>
<td>400</td>
</tr>
<tr>
<td>PHEV</td>
<td>50</td>
</tr>
<tr>
<td>FCEV</td>
<td>320</td>
</tr>
</tbody>
</table>

*Modeled ranges are EPA label all-electric-range equivalent
Battery Pack Costs

![Graph showing the cost of battery packs from 2025 to 2035 for BEV and PHEV. The cost decreases over time, with predictions for 2026 ($95), 2030 ($73), and 2035 ($56).]
Non-Battery Component Cost Projections

- **Method:**
  - Near-term costs estimated from numerous teardowns and vehicle comparison reports
  - Additional 1% per year cost reduction projected for future years

- **Example Cost:**
  - 300-mile BEV Medium/Large SUV non-battery component costs start at ~$3,700 in 2026 and decrease to ~$3,300 in 2035

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**Non-Battery Components:**
- Motor and gearbox
- Inverter
- DC-DC converter
- HV cabling
- HV control unit
- On-board charger
- Convenience cord
Fuel Cell and Hydrogen Storage Costs Projected to Fall with Technology Improvement and Manufacturing Scale

- US DOE funds evaluation of FCEV system costs
  - Strategic Analysis: Cost models of state-of-the-art technology at several production volumes
  - ANL: Cost estimates for future vehicles at high production volume with assumptions of future technology advancement
- CARB staff combined the data sources for ACC II evaluations
FCEV Cost Examples

- **Medium SUV**: $11,567 in 2025, $9,421 in 2027, $7,607 in 2029, $5,883 in 2031, $4,951 in 2033, $3,891 in 2035
- **Small Car**: $8,000 in 2025, $6,750 in 2027, $5,500 in 2029, $4,250 in 2031, $3,100 in 2033, $2,150 in 2035
How to Get From Cost to Consumer Price

Add: ZEV Component Costs

Subtract: ICE Vehicle Component Costs

Retail Price × Markup (1.5) = Incremental ZEV Price

**Total cost of operation (TCO) analysis not considered – no fuel, maintenance, other operational costs included**
# 2026 Model Year Incremental Cost and Price for a Medium SUV

<table>
<thead>
<tr>
<th>Cost Category</th>
<th>BEV 300</th>
<th>BEV 400</th>
<th>PHEV</th>
<th>FCEV</th>
</tr>
</thead>
<tbody>
<tr>
<td>Battery Cost</td>
<td>$8,896</td>
<td>$12,460</td>
<td>$3,015</td>
<td>$1,614</td>
</tr>
<tr>
<td>Non-Battery Cost</td>
<td>$4,767</td>
<td>$5,310</td>
<td>$2,656</td>
<td>$2,728</td>
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<tr>
<td>Fuel Cell Stack &amp; Tank Cost</td>
<td>$0</td>
<td>$0</td>
<td>$0</td>
<td>$13,916</td>
</tr>
<tr>
<td>Delete Costs</td>
<td>-$7,610</td>
<td>-$8,110</td>
<td>-$965</td>
<td>-$8,110</td>
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<tr>
<td>ZEV Assembly Cost Reductions</td>
<td>-$1,600</td>
<td>-$1,600</td>
<td>$0</td>
<td>-$800</td>
</tr>
<tr>
<td><strong>Total Incremental Vehicle Cost</strong></td>
<td><strong>$4,453</strong></td>
<td><strong>$8,060</strong></td>
<td><strong>$4,706</strong></td>
<td><strong>$9,348</strong></td>
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<tr>
<td><strong>Retail Price Equivalent / Incremental Price (x1.5)</strong></td>
<td><strong>$6,680</strong></td>
<td><strong>$12,090</strong></td>
<td><strong>$7,059</strong></td>
<td><strong>$14,022</strong></td>
</tr>
</tbody>
</table>
Fuel Cell Electric Vehicles Become Cost Competitive With Longer Range BEVs in 2033 – Both Are Cheaper Than PHEVs
Small Car 300-mile BEVs See Price Parity With Conventional Cars in 2035

Small Car Incremental Vehicle Price by ZEV Technology Type

- BEV300
- BEV400
- PHEV50
- FCEV320
Thank You!

Advanced Clean Cars II
Advanced Clean Cars II SRIA
Advanced Clean Cars II ZEV Cost Workbook
Additional Material
Fuel Cell Electric Vehicle Overview

• FCEV systems have been in development for several decades
• Cost, durability, and performance continue to improve
• Durability and cost remain the largest challenges
• Costs still have substantial room for improvement with economies of scale