EV Everywhere Battery Workshop: Preliminary Target-Setting Framework

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For this Analysis, Three “EV” Scenarios

1. **PHEV40** – reduces battery size while removing range issues, but involves the higher cost of two powertrains

2. **AEV100** – minimizes vehicle purchase cost, but introduces range/vehicle use/infrastructure tradeoffs

3. **AEV300** – helps to address range issues, but large battery leads to high vehicle cost

*Vehicle-level analysis provides a starting point for setting EV Everywhere technical targets for these vehicles.*
Levelized Cost of Driving (LCD)

vehicle purchase price + fuel expenditure over 5 years, expressed per mile traveled

Analysis Assumptions: 2022 midsize vehicle, mid-case technology projection (with high and low technology sensitivities), EIA’s AEO11 “High Oil” fuel prices projections for 2022 = (Gasoline $5.12/gal, diesel $4.76/gal, Electricity $4.12/gge), 14.5k miles/year, 5-year analysis period, no discounting, retail markup over manufactured cost = +50%
**EV Everywhere Analysis Process Flow**

_in three steps...

1. **DOE experts define the bounds of technical possibility** for technology key metrics
   - 90% “low progress” scenario
   - 50% “mid case” scenario
   - 10% “high progress” scenario

2. **Define virtual vehicles** in Argonne National Lab’s *Autonomie* modeling and simulation software

3. **Compare vehicles in a 5-year simple payback framework** within bounds defined by experts
Comparing LCDs

Implications for 5-year payback—

<table>
<thead>
<tr>
<th>Vehicle</th>
<th>Payback (?)</th>
</tr>
</thead>
<tbody>
<tr>
<td>SI HEV</td>
<td>Yes, at mid technology case</td>
</tr>
<tr>
<td>SI PHEV10</td>
<td>Yes, between mid and high technology case</td>
</tr>
<tr>
<td>SI PHEV40</td>
<td>No, requires push just beyond high technology case</td>
</tr>
<tr>
<td>AEV100</td>
<td>Yes, even at “low” technology case</td>
</tr>
<tr>
<td>AEV300</td>
<td>No, requires aggressive push beyond high technology case</td>
</tr>
</tbody>
</table>

Levelized cost of driving, 2011$/mile

Adv SI “mid progress”
Adv SI “high progress”

(off chart: AEV300 costs range from 57-67 ¢/mi.)
Estimating 5-year LCD equivalents

How far beyond current stretch targets might we (should we?) push?

For this analysis, use the proportion the LCD has to be lowered as a starting point for technical targets.

This proportion can imply a full set of component-level technical targets for vehicles with a 5-year payback.
Setting Targets – how aggressive?

Vehicle architectures that are already LCD-competitive in the analysis framework at current targets (green dots) can still be cost competitive with a less aggressive push to the target:

- 90% ~“Low” Target
- 50% ~“Middle” Target
- 10% ~“Stretch” Target

Vehicle architectures that are not LCD-competitive in the analysis framework at current targets (yellow dots) can still be cost competitive with more aggressive push to the target:

Vehicle architectures that are not LCD-competitive even at the stretch target level (red dots) require an even more aggressive push beyond stretch targets:
Analysis: 2022 Midsize SI PHEV40

- **Power electronics and motor**: 
  - $/kW: 7, 10, 13

- **Energy Storage**: 
  - $/kWh: 200, 225, 250

- **Lightweighting**: 
  - % wt reduction: 27, 24, 7

- **Levelized Cost Per Mile ($/mi)**:
  - $0.45, $0.46, $0.47, $0.48, $0.49, $0.50

- **LCD-implied targets**:
  - $/kW: 5
  - $/kWh: 190
  - % wt: 29
Analysis: 2022 Midsize AEV100

- Power electronics and motor
  - $/kW: 7, 10, 13

- Energy Storage
  - $/kWh: 125, 175, 250

- Lightweighting
  - % wt reduction: 27, 24, 7

- LCD-implicitly
  - $/kW: 14
  - $/kWh: 300
  - % wt: 3

Levelized Cost Per Mile ($/mi)
Analysis: 2022 Midsize AEV300

<table>
<thead>
<tr>
<th>Component</th>
<th>$/kW</th>
<th>$/kWh</th>
<th>% wt reduction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Power electronics and motor</td>
<td>7</td>
<td>10</td>
<td>13</td>
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<tr>
<td>Energy Storage</td>
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<td></td>
<td>200</td>
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<tr>
<td>Lightweighting</td>
<td></td>
<td>225</td>
<td>7</td>
</tr>
<tr>
<td></td>
<td></td>
<td>250</td>
<td>30</td>
</tr>
</tbody>
</table>

LCD-implied targets

- $/kW: 4
- $/kWh: 110
- % wt: 30
### Target Implications Summary –

90% ~“Low” Target

50% ~“Middle” Target

10% ~“Stretch” Target

<table>
<thead>
<tr>
<th></th>
<th>Current Status</th>
<th>PHEV40</th>
<th>AEV100</th>
<th>AEV300</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Battery Cost</strong></td>
<td>$/kWh</td>
<td>~650</td>
<td>190</td>
<td>300</td>
</tr>
<tr>
<td><strong>Power electronics and motor</strong></td>
<td>$/kW</td>
<td>~20</td>
<td>5</td>
<td>14</td>
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<tr>
<td><strong>% Weight Removed</strong></td>
<td>%</td>
<td>n/a</td>
<td>29</td>
<td>3</td>
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<tr>
<td><strong>Charger Cost</strong></td>
<td>$</td>
<td>~150</td>
<td>35</td>
<td>140</td>
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</tbody>
</table>

*AEV100*