Can autonomous light vehicles be fully electric?

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Problem Statement

• Transport sector is the leading source of CO$_2$ emissions in the United States.
• Autonomous vehicles (AVs) promise less energy use and pollution via smoother driving and higher safety.
• If energy demands of autonomy significantly penalize electric vehicle range (EV) ⟹ first AVs might be gas-electric hybrids.
• Tradeoff between the gains in safety from automation and objective of reducing carbon emissions.

AV parameters & scenarios

Uncertainty about AV parameters propagated using Monte Carlo simulation - bounds based on literature and technical specifications.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Bounds</th>
<th>Mode</th>
<th>Distribution</th>
</tr>
</thead>
<tbody>
<tr>
<td>Increase in Drag</td>
<td>[0%,50%]</td>
<td>25%</td>
<td>Triangular</td>
</tr>
<tr>
<td>Energy Savings</td>
<td>[5%,20%]</td>
<td>10%</td>
<td>Triangular</td>
</tr>
<tr>
<td>Sensor Load (W)</td>
<td>[30,180]</td>
<td>80</td>
<td>Triangular</td>
</tr>
</tbody>
</table>

Comp. Load(W)=5*(Sen. Load)+100; Bounds [250,1000]

Methods

• Extended Sripad and Viswanathan’s (2) first principles based physics model for autonomous electric vehicles (AEVs).
• Model accounts for extra weight, aerodynamic losses from LiDAR dome, power demands of computing + sensors, and energy savings from smoother driving.

\[
F_{\text{total}} = F_{\text{drag}} + F_{\text{friction}} + F_{\text{inertia}} + F_{\text{gradient}}
\]

\[
P(t)_{\text{drag}} = (0.5 \ast p \ast C_d \ast v(t)^2) \ast v(t)
\]

\[
P(t)_{\text{friction}} = (\mu_r \ast \text{mass} \ast g) \ast v(t)
\]

\[
P(t)_{\text{inertia}} = (\text{mass} \ast \frac{dv}{dt}) \ast v(t)
\]

\[
P(t)_{\text{total}} = \frac{P(t)_{\text{drag}} + P(t)_{\text{friction}} + P(t)_{\text{inertia}}}{(\text{battery & drivetrain efficiency})} + \frac{P(t)_{\text{computation}}}{(\text{battery efficiency})} + \frac{P(t)_{\text{senser}}}{(\text{battery efficiency})}
\]

Our autonomous EV

Tesla Model 3 with 310 miles of range combined with technology for autonomous driving.

Physics Model

Autonomy likely more valuable than 10% loss in range

• Range valued at $100 per mile ⟹ 30 miles valued at $3000.
• We find negligible reduction in battery longevity.
• Taxi drivers earn $12 per hour; Americans drive 1 hour per day → driving time saved worth $12 per hour x 1 hour per day x 300 days / year = $3600 per year.

References


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