Electric Vehicle Infrastructure Planning and Integrated Charging Strategy

Prepared for: THE BATTERY SHOW NORTH AMERICA

September 15, 2021

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<th>AGENDA</th>
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<td><strong>Ricardo introduction</strong></td>
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<td>• Critical challenges faced by EV fleets</td>
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<td>• EV fleet planning framework</td>
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<td>• Case study</td>
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RICARDO INTRODUCTION

Ricardo provides a unique combination of strategic collaboration with strong technical competencies.

**Strategic**
- Scenario Planning
- Disruptive Technologies
- Future Mobility
- M&A and Investor Support
- NPI and Supply Chain
- Operational Improvement
- Cost Reduction
- Business Transformation

**Technical**
- Engine/ Transmission/ Driveline
- Chassis Development
- Hybrid & Electric Vehicles
- Control & Electronics (HW and SW)
- Combustion/ Emissions/ Performance
- Prototype
- ADAS/ Autonomous Vehicle Technology
- Vehicle Software/ EE Architecture

**Combined Approach**
AGENDA

- Ricardo introduction
- Critical challenges faced by EV fleets
  - EV fleet planning framework
  - Case study
  - Q&A
CRITICAL CHALLENGES FACED BY EV FLEETS: CHARGING STRATEGY
Fleet operators struggle with developing and executing a cost-effective charging strategy

Charging Strategy

- Cost of electricity ($/mile) incurred by fleets is often higher or at par with conventional fuel
- Fleet operators need to consider complexities of utility tariffs to manage EV charging without compromising on operational needs
- Options in scheduling charging and distributing loads may be limited in high usage applications
- Load management with solar or stationary battery may be necessary to reduce cost
- These complexities and costs are expected to be concerning as EV adoption increases
- Certain utilities are offering temporary exemption from demand charges which is an immediate relief but not a long-term solution
- Charger selection is important to be able to execute charging strategy

Electricity and Fuel Cost ($/mile)
CRITICAL CHALLENGES FACED BY EV FLEETS: CHARGING INFRASTRUCTURE

Fleets need guidance for charging station deployment; lack of familiarity leads to significant delay

Charging Infrastructure Development

- 12–18-month lead time observed for infrastructure setup due to several steps:
  - Determine # of EV, chargers, kW
  - Communicate plan to local utility
  - Behind-the-meter design
  - Site survey
  - To-the-meter electrical upgrades
  - Approvals
  - Construction
  - Charger installation and test

- Fleets need guidance which either comes from OEM or Utility company

- Utility providers may need 5-year electrification plan to future proof electrical upgrades
  - Fleets struggle with developing a well-defined plan

Image Source: PG&E
Battery and charger sizing decisions are difficult for fleets and creates downstream operational challenges.

**Battery And Charger Selection**

- Fleets expect BEVs to attain OEM advertised range but have experience drop in range.
- Unanticipated range drop restricts deployment options and requires significant coordination on the part of fleet operators.
- Example issues:
  - Premature shift end and swap with ICE
  - On-route power loss
  - Towing BEVs last few miles
  - Operation without HVAC to extend range
- Impact of HVAC is an important consideration when assessing achievable range.
- Battery should be sized for long term needs of fleets.
- Charger kW and quantity should be based on fleet’s operational needs, charging opportunities and desired redundancy.

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**Electric Vehicle Range (miles)**

<table>
<thead>
<tr>
<th>Fleet</th>
<th>Range in Miles</th>
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<tbody>
<tr>
<td>#1</td>
<td>120</td>
</tr>
<tr>
<td>#2</td>
<td>160</td>
</tr>
<tr>
<td>#3</td>
<td>180</td>
</tr>
<tr>
<td>#4</td>
<td>140</td>
</tr>
<tr>
<td>#5</td>
<td>200</td>
</tr>
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- Estimated Range From Data Collected
- Fleet Expected Range
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- **EV fleet planning framework**
- Case study
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**EV Fleet Planning Framework**

Framework allows fleets to conduct internal due diligence during planning phase and reduces CAPEX and OPEX

<table>
<thead>
<tr>
<th>Inputs</th>
<th>Outputs</th>
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<tbody>
<tr>
<td>Vehicle operation schedule</td>
<td>Optimal kW and quantities of chargers</td>
</tr>
<tr>
<td>Database of electricity rates</td>
<td>Remaining Battery SOC and recommended kWh</td>
</tr>
<tr>
<td>EV fleet size and duty cycle</td>
<td>Cost impact of battery and charger selection</td>
</tr>
<tr>
<td>Vehicle battery pack kWh</td>
<td>Most economical tariff</td>
</tr>
<tr>
<td>Charger quantity and kW</td>
<td>Recommended charging schedule</td>
</tr>
<tr>
<td>Stationary Battery Capacity</td>
<td>Optimized cost of electricity</td>
</tr>
<tr>
<td>Solar Capacity</td>
<td>Cost-benefit of load management strategies</td>
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<tr>
<td>Credits and Subsidies</td>
<td>Relative impact of charge rate on battery degradation</td>
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**EV Fleet Planning Framework**

- Better understanding of battery and charger requirement for planning EV adoption
- Mitigate range anxiety with data driven planning of EV deployment
- Optimize investments in charging infrastructure and EV battery pack
- Identification of most suitable tariffs
- Develop charging strategy and improve cost of operation within the constraints of fleet operation schedule
- Explore cost-benefit and feasibility of stationary energy storage and solar power
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CASE STUDY: SCHOOL BUS APPLICATION

Maintaining operations and minimizing operating cost is most critical for School Bus fleets.

Fleet Information And Other Assumptions

**Base case:** 120 EV buses operating between 7 am to 9am, 10am to 12pm and 2pm to 4pm. Each bus has a dedicated charger and charges at the end of day.

**Optimal charging and shared charger:** Opportunities for mid-day charging and charger sharing between buses explored.

**Optimal charging with shared chargers and PV system:** Benefit of installing a 1MW PV system explored.

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**CapEx and OpEx Impact**

- **Base Case:** $2.04M
- **Optimal Charging with Shared Chargers:** $1.02M (50% reduction)
- **Optimal Charging with Shared Chargers and PV System:** $2.03M ($1.02M - 199%)

Shared chargers reduced CapEx by 50%; Optimized charging rate and schedule reduced OpEx by 65%.

Investing in PV system reduced OpEx by 39% and with payback period of 5yr*.

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Managed charging strategy reduces demand charge and energy costs by optimally spreading the load.
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QUESTIONS?

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