Intra-city EV charging optimization based on vehicle usage pattern and traffic congestion analysis

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Major Drivers for E-Mobility

15 of world’s top 20 polluted cities in India

High dependence on oil imports

India’s Second Biennial Update Report to the UNFCCC recognizes the path forward

“Transport is the second largest contributor to the country’s CO₂ emission and a major cause of air pollution”

“As vehicle ownership in India is set to rise substantially, an opportunity exists to diversify the transportation fuel mix to the benefit of the broader economy”
India is on-track to meet its emissions targets

India’s Nationally Determined Contribution (NDC)

<table>
<thead>
<tr>
<th>Year</th>
<th>MT CO₂ / $1000 GDP</th>
<th>Reduction in Emissions Intensity</th>
</tr>
</thead>
<tbody>
<tr>
<td>2005</td>
<td>0.47</td>
<td>33 - 35%</td>
</tr>
<tr>
<td>2030</td>
<td>0.31</td>
<td></td>
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Already reduced emissions intensity by 21% from 2005 -14
(India makes up 7% of the global CO₂ emissions as per a 2017 study)
Policies are being put in place to address Transport emissions

**National Mission on Electric Mobility Plan**

- **FAME I**
- **FAME II**

**2020 Targets**
- 6 - 7M elec. / hybrid vehicles
- 400K passenger BEVs

**2030 Ambition**
- > 30% electric vehicles

**National E-Mobility Programme**

**Niti Aayog Targets**

**Goals**
- 100% 3W by 2023
- 100% 2W <150cc by 2025
- 100% 4W by 2030
**Vehicle Usage Pattern**

### Vehicle and Battery Specifications

<table>
<thead>
<tr>
<th>Feature</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Battery Capacity</td>
<td>280 Ah</td>
</tr>
<tr>
<td>Technology</td>
<td>Lithium-ion</td>
</tr>
<tr>
<td>Battery on-board power</td>
<td>15.4 kWh</td>
</tr>
<tr>
<td>Driving Range</td>
<td>140 Km</td>
</tr>
</tbody>
</table>

### Key Points:
- Start the day of operation with 100% SoC
- Plug-in for charging at the end of operation
- Need to set SoC\text{min}
- Traffic congestion an important factor in deriving the vehicle range
Decision Tree

Start

Check $I_{SoC} > SoC_{min}$

Yes

Check $(I_{SoC_i} - SoC_{min}) \times (r * Tij) > x$

No

Locate nearest charger within radius of $[I_{SoC_i} \times (r * Ti)]$ using shortest path algorithm

No

Yes

Go for Trip
**Case study Analysis**

### General Assumptions

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<table>
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<tbody>
<tr>
<td>Average distance travelled over a day</td>
<td>200 Km</td>
</tr>
<tr>
<td>Hours of Operation</td>
<td>7 AM to 10 PM</td>
</tr>
<tr>
<td>SoC_{min}</td>
<td>5%</td>
</tr>
<tr>
<td>SoC_{max}</td>
<td>80%</td>
</tr>
<tr>
<td>Electric Peak Load Hours</td>
<td>6 AM to 10 AM &amp; 6 PM to 10 PM</td>
</tr>
</tbody>
</table>

### Key Points:

- Study is done for fixed route and flexible route fleet
- Vehicle charging pattern needs to be planned to avoid waiting time at charging station

![Traffic Congestion Coefficient](chart.png)
Fixed Route Fleet

Vehicle Charging pattern with 100% starting SoC

Vehicle Charging pattern with 70% starting SoC

Key Points:
• Partial number of vehicles in a fleet can start a day with lower SoC levels
• This will lead to non-coincidental charging patterns for vehicles in the fleet
• Trade off between waiting at charging station or losing business opportunity in terms of next trip
Flexible Route Fleet solution and future needs

A connective tissue that enables mobility stakeholders to transition to a connected drive future

- **EV Drivers**
  - Charging Station Availability
  - Charge Location
  - Eliminate Range Anxiety

- **OEMs**
  - Vehicle Usage Patterns
  - Battery Usage & Diagnostics
  - Vehicle Diagnostics

- **Utilities**
  - Billing & Collection
  - Demand Forecasting
  - Dynamic Energy Pricing

- **Car Sharing / Pay for Use**
  - Trip & route planning
  - Availability of parking

- **Charging Point Operator**
  - Billing & Collection
  - Localized Load Management
  - Consumption Information

- **Public Transportation**
  - Last mile connectivity to public transport
  - Single ePass / Ticketing

Telematics Platform
Fixed route EVs can start a day of operation with varying SOC levels

Trade off between waiting at charging station and having one more charging cycle over the operating day

Flexible fleets need to have a real time software platform for better fleet management

Fleet owners need to invest in charging infrastructure rather than relying on public charging stations

Waiting time at charging stations can be reduced by using combination of battery swapping and plug-in charging models
For more information; please contact

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