Impact of Electric Vehicle (EV) Charging on the Local Grid

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Speakers

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PRDC

Moderator

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WRI India
## Electric Vehicle Charging Technologies

<table>
<thead>
<tr>
<th>Charging level</th>
<th>Voltage</th>
<th>Charging mode</th>
<th>Typical power</th>
<th>Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>Level 1</td>
<td>120 V AC</td>
<td>-</td>
<td>1.2-1.8 kW AC</td>
<td>Primarily residential in North America</td>
</tr>
<tr>
<td>Level 2</td>
<td>200-240 V AC</td>
<td>Mode 1</td>
<td>3.6-11 kW AC</td>
<td>Wall socket in Europe; Primarily for 2 &amp; 3 Wheelers</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Mode 2</td>
<td>3.6-22 kW AC</td>
<td>Home and workplace with cable or basic station</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Mode 3</td>
<td>3.6-22 kW AC</td>
<td>Home, workplace and public with hardwired station</td>
</tr>
<tr>
<td>Fast</td>
<td>400-1000 V DC</td>
<td>Mode 4</td>
<td>50 kW or more</td>
<td>Public, frequently intercity</td>
</tr>
</tbody>
</table>

**Notes:** V=Volts; AC= alternating current; DC= direct current; kW=kilowatt
Mitigation of Impacts of Electric Vehicle Charging

The smart charging strategy

Uncontrolled charging

Total demand of multiple households, MW

Smart charging

Total demand of multiple households, MW

Uncontrolled EV charging can exacerbate the peak load problem, with all users charging in the evening upon return from work.

Smart control systems could coordinate the timing of the charging of individual EVs (with user consent), potentially balancing the load and offsetting peaks.

Ref: Tom Buck, e-Mobility The charging infrastructure landscape, a UKEVSE perspective
### Simulation Methodology – Data collection, feeder selection criteria

12 Feeders shortlisted by BYPL before the site visit by project team

<table>
<thead>
<tr>
<th>Arya samaj road nalha</th>
<th>Criteria For Selection Of Feeders</th>
</tr>
</thead>
<tbody>
<tr>
<td>DDA flats pocket B</td>
<td>EV charging stations already exist in the feeder</td>
</tr>
<tr>
<td>DSR Mill</td>
<td>Solar roof top penetration</td>
</tr>
<tr>
<td>E block Vikas Marg</td>
<td>Loading of the feeder</td>
</tr>
<tr>
<td>Janta Colony</td>
<td>Priority for Level 2 chargers and DC Fast Charging</td>
</tr>
<tr>
<td>Karkardoma Court</td>
<td>DT loading in the feeder</td>
</tr>
<tr>
<td>Karol Bagh - 2</td>
<td>Voltage profile of the feeder</td>
</tr>
<tr>
<td>Parade ground</td>
<td>Consumer mix in the feeder</td>
</tr>
<tr>
<td>District Center EROS Hotel</td>
<td>Monthly energy consumption in the feeder</td>
</tr>
<tr>
<td>Vikas Bhawan</td>
<td></td>
</tr>
<tr>
<td>IHBAS Mental hospital</td>
<td></td>
</tr>
<tr>
<td>Marjinal Bandh</td>
<td></td>
</tr>
</tbody>
</table>
Simulation Methodology – Data collection, feeder selection criteria

Data Collected

- Feeder data
- DT data
- Rooftop PV data
- EV connections data
- Shape file
- Rooftop PV Generation details
  - Connection details
  - Generation profile
- Feeder data
  - Load profile
  - Voltage profile
  - Power Factor
  - Consumer mix
- EV connection details
  - No. of connections
  - Location
  - Capacity

Impact of Electric Vehicle (EV) Charging on the Local Grid
Simulation Studies for Sample Feeders
Simulation Study: Modeling

- Network modelling
- Feeder loading
- EV modelling
- PV modelling
- Analysis

- Load Flow Analysis
- Dynamic Analysis
- Harmonic Studies
Simulation Studies for Sample Feeders

EV Modeling – MiPower Model
Simulation Studies for Sample Feeders

System-wide EV charging demand estimation

- Travel pattern model
- Energy consumption model
- Power consumption model
- EV Penetration Levels
- EV Charging Strategy

Charger locations

- Home charging
- Office/Work charging
- Public charging Station
- Mall/ Parking charging
- Private dedicated charging
- Battery swapping

Table 8.1.10: % EV sales assumed for each vehicle category for future years

<table>
<thead>
<tr>
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</tr>
</thead>
<tbody>
<tr>
<td>2W</td>
<td>1%</td>
<td>3%</td>
<td>5%</td>
<td>10%</td>
<td>15%</td>
<td>25%</td>
<td>27%</td>
<td>30%</td>
<td>33%</td>
<td>35%</td>
<td>37%</td>
<td>40%</td>
<td>40%</td>
</tr>
<tr>
<td>3W - PV</td>
<td>5%</td>
<td>10%</td>
<td>15%</td>
<td>20%</td>
<td>25%</td>
<td>25%</td>
<td>30%</td>
<td>40%</td>
<td>50%</td>
<td>60%</td>
<td>70%</td>
<td>80%</td>
<td>100%</td>
</tr>
<tr>
<td>3W - CV</td>
<td>0%</td>
<td>3%</td>
<td>5%</td>
<td>10%</td>
<td>15%</td>
<td>25%</td>
<td>30%</td>
<td>35%</td>
<td>40%</td>
<td>45%</td>
<td>50%</td>
<td>60%</td>
<td>70%</td>
</tr>
<tr>
<td>4W - PV</td>
<td>1%</td>
<td>1%</td>
<td>5%</td>
<td>10%</td>
<td>15%</td>
<td>25%</td>
<td>25%</td>
<td>25%</td>
<td>25%</td>
<td>26%</td>
<td>27%</td>
<td>28%</td>
<td>29%</td>
</tr>
<tr>
<td>4W - CV</td>
<td>1%</td>
<td>5%</td>
<td>10%</td>
<td>15%</td>
<td>20%</td>
<td>25%</td>
<td>30%</td>
<td>40%</td>
<td>50%</td>
<td>60%</td>
<td>70%</td>
<td>80%</td>
<td>100%</td>
</tr>
<tr>
<td>Bus</td>
<td>0%</td>
<td>5%</td>
<td>10%</td>
<td>15%</td>
<td>20%</td>
<td>50%</td>
<td>55%</td>
<td>60%</td>
<td>65%</td>
<td>70%</td>
<td>80%</td>
<td>90%</td>
<td>100%</td>
</tr>
</tbody>
</table>

*1% of all 2W sales in 2018 are considered as 2W EV, similarly for all vehicle categories for future years

As per Niti Ayog and GoI targets
Simulation Studies for Sample Feeders

CASES

- Base case
- Case 1: EV penetration with high battery capacity with SoC of 25%
  - Case 1A: EV penetration with initial SOC of 60% considered for vehicles
- Case 2A: EV penetration with typical solar generation profile
- Case 2B: EV penetration with varying solar generation profile
- Case 3: EV penetration with one public charger in the feeder
- Case 4: EV penetration 100% more than anticipated
- Case 5: EV penetration with Public charger (EV 100% more than anticipated)
- Case 6: EV penetration with Public charger (EV 100% more than anticipated) with TOU
- Case 7: EV penetration with grid storage system
- Case 8: EV penetration with EV battery capacity as per existing trends in India
Simulation Studies for Sample Feeders

Projected EV’s

<table>
<thead>
<tr>
<th>Feeder-1</th>
<th>2019</th>
<th>2023</th>
<th>2030</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Feeder-2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Feeder-3</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Simulation Studies for Sample Feeders**

**Projected EV’s**

**Feeder-1**
- 2019: 118, 45, 1, 18
- 2023: 129, 198, 5, 1
- 2030: 1,109, 203, 40, 8

**Feeder-2**
- 2019: 156, 60, 2, 24
- 2023: 262, 112, 7, 1
- 2030: 1,465, 525, 19, 53

**Feeder-3**
- 2019: 64, 24, 1, 10
- 2023: 107, 46, 1, 3
- 2030: 597, 214, 8, 22
Simulation Results – Sample Feeders

Typical day Feeder Load Profile

TRF-2: R.K. DASS-1/2 K. BAGH- LT bus (415 V)

- Basecase voltage in pu
- Max voltage limit in pu
- Min voltage limit in pu

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Simulation Results – Sample Feeders

![Graph showing percentage of vehicles plugged in at different times of the day for different charging types: Home charging, Office/Work charging, Mall/Parking charging, and Public charging.]

**Vehicle Category** | **Battery Capacity (kWh)** | **No. of charges per year per vehicle (with SoC of 25%)**
---|---|---
2W | 4 | 65
3W - PV | 7 | 487
3W - CV | 9 | 389
4W - PV | 80 | 48
4W - CV | 80 | 292
Bus | 250 | 389
Simulation Results – Sample Feeders

Feeder Load Profile with EV load

Feeder Load Profile with EV and solar penetration

Simulation Results – Sample Feeders

Impact of Electric Vehicle (EV) Charging on the Local Grid
Simulation Results – Sample Feeders

<table>
<thead>
<tr>
<th>Name of the DT</th>
<th>No of EV's charged with public charging</th>
<th>Cumulative battery capacity (kWh)</th>
</tr>
</thead>
<tbody>
<tr>
<td>DT-Public Charging (Capacity: 800 kVA)</td>
<td>96</td>
<td>2167</td>
</tr>
</tbody>
</table>

Feeder Load Profile with Public Charger

- **Load (MW)**
- **Hours**
- **Case3**
- **Basecase**
- **EV load**

Impact of Electric Vehicle (EV) Charging on the Local Grid

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Simulation Results – Sample Feeders

Plug-in time slot distribution with TOU during roof-top solar generation

- Home charging
- Office/Work charging
- Mall/ Parking charging
- Public charging
Simulation Results – Sample Feeders

Feeder Load Profile with EV Load, Public Charger and Solar Generation (TOU)

Load (MW)

0.00 1.00 2.00 3.00 4.00 5.00

00:00 00:45 01:30 02:15 03:00 03:45 04:30 05:15 06:00 06:45 07:30 08:15 09:00 09:45 10:30 11:15 12:00 12:45 13:30 14:15 15:00 15:45 16:30 17:15 18:00 18:45 19:30 20:15 21:00 21:45 22:30 23:15

Case6  Basecase  EV load  Solar Generation

Impact of Electric Vehicle (EV) Charging on the Local Grid
Conclusions & Recommendation

Extrapolation of the Results to the Entire DISCOM for the Year 2030

Energy and Peak demand requirement for EV charging for the year 2030

<table>
<thead>
<tr>
<th>EV type</th>
<th>Battery Capacity</th>
<th>EV charging Energy per charge in kWh</th>
<th>No of EVs</th>
<th>No of Charges per EV per year</th>
<th>EV charging Energy in MU</th>
</tr>
</thead>
<tbody>
<tr>
<td>2W</td>
<td>4</td>
<td>3</td>
<td>509281</td>
<td>65</td>
<td>99</td>
</tr>
<tr>
<td>3W - PV</td>
<td>7</td>
<td>5.25</td>
<td>93083</td>
<td>594</td>
<td>290</td>
</tr>
<tr>
<td>3W - CV</td>
<td>9</td>
<td>6.75</td>
<td>6571</td>
<td>441</td>
<td>20</td>
</tr>
<tr>
<td>4W - PV</td>
<td>80</td>
<td>60</td>
<td>182467</td>
<td>48</td>
<td>526</td>
</tr>
<tr>
<td>4W - CV</td>
<td>80</td>
<td>60</td>
<td>18478</td>
<td>292</td>
<td>324</td>
</tr>
<tr>
<td>Bus</td>
<td>250</td>
<td>187.5</td>
<td>3547</td>
<td>389</td>
<td>259</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td></td>
<td><strong>3547</strong></td>
<td><strong>389</strong></td>
<td><strong>1517 MU</strong></td>
</tr>
</tbody>
</table>
## Conclusions & Recommendation

**Summary Of EV Penetration Impact DISCOM system**

<table>
<thead>
<tr>
<th>Description</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Projected Energy requirement for year 2019-20 without losses, projected by DISCOM</td>
<td>6925 MU</td>
</tr>
<tr>
<td>Energy projection by 2030 without EV and without losses considering growth rate of 4.76%</td>
<td>11022 MU</td>
</tr>
<tr>
<td>Projected Peak demand for the year 2019-20 by DISCOM</td>
<td>1640 MW</td>
</tr>
<tr>
<td>Projected Peak demand for the year 2029-30 by CAGR of 6% as per historical growth without EVs</td>
<td>2943 MW</td>
</tr>
<tr>
<td>Additional energy requirement with EV penetration for the year 2030</td>
<td>1517 MU</td>
</tr>
<tr>
<td>% Energy consumption by EV for the year 2030 with reference to energy sales without EVs</td>
<td>13.8%</td>
</tr>
<tr>
<td>Energy requirement of DISCOM with EV penetration for the year 2030</td>
<td>12539 MU</td>
</tr>
<tr>
<td>Peak demand contribution of EVs as per the DISCOM current load factor of 0.48</td>
<td>361 MW</td>
</tr>
<tr>
<td>% peak demand consumption by EV for the year 2030 with reference to peak demand without EVs in the system</td>
<td>12.3%</td>
</tr>
</tbody>
</table>
Conclusions & Recommendation

From the simulations, **peak load** coming from EV charging may not pose a significant toll on the existing business-as-usual infrastructure upgradation plan.

As per the EV projections and EV charging patterns presented in the methodology, un-controlled EV charging will contribute around 13.8% of energy sales for the year 2030.

Similarly, un-controlled EV charging will contribute around 12.3% of peak demand for the year 2030.

It is recommended to adopt controlled charging and/or Time of day or Time of Usage tariff to minimize the impact on peak load. This will minimize the grid infrastructure cost considerably.

The impact of EVs on local grid needs to be studies for each system considering the existing infrastructure loading, load profile and solar roof-top PV generation and expected EV profile.
Thank you