BUSINESS OF CHARGING INFRASTRUCTURE FOR ELECTRIC VEHICLES & ENERGY STORAGE AND ITS IMPACT ON POWER MARKET

IIT, Kanpur
27.07.2019
Powering an Energy-Rich Future

Capacity: 55,126 MW
No. of assets: 52
Capacity under construction: 19,856 MW
Coal Mines under development: 100 + MMT
Employee strength: 20,600+
Revenues for FY 17-18: 85,208 Cr.
PAT for FY 17-18: 9,780 Cr.
Fuel Mix: Coal, Gas, Solar, Wind, Hydro
Other Business Areas:
- Power trading, Consultancy services, Training & development,
- Electric Vehicle Charging Infrastructure, Waste to energy

#1 Independent Power Producer & Trader - 2018, Platts
E-MOBILITY: INTRODUCTION AND MARKET SCENARIO
Electric Mobility-Definitions

- Vehicles powered by an Electric Motor which draws current from a rechargeable battery are termed as Electric Vehicles.

- IC Engines replaced by Electric Motor & rechargeable Batteries
**Type of Electric Vehicles**

**Hybrid Electric Vehicles:** IC Engines with small battery
- Battery charged during coasting & braking
- Provides additional Power in accelerating or climbing hills (mild hybrids)
- Power during low speed conditions
- Auto off/ start during idling conditions (micro-hybrids)

**Plug in Hybrid Electric Vehicles:** IC Engines with larger battery
- Battery recharged by EVSE
- Allows to drive extended distances
- Switches to IC engine when low on battery
- No tailpipe emission when run on battery
- Economic on fuel consumption

**Battery Electric Vehicles:** No IC Engines with larger battery
- Battery recharged by EVSE
- Zero tailpipe emissions
- Current range more than 500 Kms in single charge
Electric Mobility Drivers

- Battery prices have fallen down to ~250 USD in 2017.
- Expected to hit a lower than 100 USD mark around 2025 and reach 74USD/KWhr by 2030
- Expected to reach price parity by 2025
- Parity may be achieved sooner with higher range batteries

Source: BNEF report 2017
Electric Vehicles Stock (Passenger Cars)

Passenger electric car stock in main markets and the top-ten EVI countries

Other includes Australia, Brazil, Chile, India, Japan, Korea, Malaysia, Mexico, New Zealand, South Africa and Thailand.

There were 5.1 million electric passenger cars on the road worldwide by the end of 2018, of which 45% were in China.
Electric Vehicles Stock (Electric Buses)

- With a total of 460,000 Nos., the global stock of electric buses increased by 25% in 2018 relative to 2017.

- China accounts for 99% of the global market for electric buses.

- Outside of China, about 900 electric buses were registered in 2018, mostly in Europe.
Electric Mobility Drivers – Indian Perspective

- Energy Efficiency (Low TCOs)
- Reduction in GHG Emissions
- Energy Security
- Air Pollution
- Noise Reduction
Electric Mobility For India

Most Polluted Cities of World 2018

- 07 Indian cities in Worst 10, and 22 of the Worst 30.
- In Gurugram, average air pollution levels in 2018 were more than 13 times the level permitted under WHO guidelines.

Source: IQAir AirVisual 2018 World Air Quality report and Greenpeace
India’s reliance on Crude Oil continues to increase and pose a threat to Energy Security
## Indian Automobile Sector

- There are more than 1.2 billion vehicles world-wide; 2 billion by 2035
- Indian automobile industry is 3rd largest in the world

### Total number of Registered motor vehicles in India:

<table>
<thead>
<tr>
<th>YEAR</th>
<th>2-Wheelers</th>
<th>Car, Jeeps and Taxis</th>
<th>Buses</th>
<th>Goods Vehicles</th>
<th>Others*</th>
</tr>
</thead>
<tbody>
<tr>
<td>2015</td>
<td>154</td>
<td>29</td>
<td>2</td>
<td>9</td>
<td>16</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Total-210</td>
</tr>
<tr>
<td>2030</td>
<td>738</td>
<td>104</td>
<td>10</td>
<td>29</td>
<td>46</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Total-927</td>
</tr>
</tbody>
</table>

*CAGR*  

*Includes tractors, trailers, 3 wheelers/LMV which is otherwise not classified*

Source: Report on Automobiles published by India Brand Equity Foundation (IBEF) in April'17
## India - Electric Vehicle Scenario

### Expected EV sales in India

<table>
<thead>
<tr>
<th>Year</th>
<th>e-2-wheelers</th>
<th>e-3-wheelers</th>
<th>e-4-wheelers</th>
<th>e-Buses (*)</th>
<th>Total</th>
<th>Energy Requirement</th>
<th>Approximate MW capacity required</th>
</tr>
</thead>
<tbody>
<tr>
<td>2020</td>
<td>73.52 lakhs</td>
<td>6.46 lakhs</td>
<td>0.26 lakhs</td>
<td>3500</td>
<td>~80 lakhs</td>
<td>6372 MU</td>
<td>1275</td>
</tr>
<tr>
<td>2025</td>
<td>140.35 lakhs</td>
<td>23.64 lakhs</td>
<td>15.92 lakhs</td>
<td>15000</td>
<td>~180 lakhs</td>
<td>20000 MU</td>
<td>4000</td>
</tr>
<tr>
<td>2030</td>
<td>265.14 lakhs</td>
<td>40.72 lakhs</td>
<td>159.11 lakhs</td>
<td>50000</td>
<td>~465 lakhs</td>
<td>87500 MU</td>
<td>17500</td>
</tr>
</tbody>
</table>

As per Niti Aayog and RMI Report  

(*) As per NTPC estimate
E-Mobility Challenges: Nascent stage of adoption

- Consumer Acceptability
  - Higher Capital Cost of Vehicles
  - Limited vehicle variants
  - Vehicle Performance

- Technical know how in Customers- Turn-key solutions required

- Lack of Charging Infrastructure- Range Anxiety

- Standardisation of Charging infrastructure

- Business viability for Charging Infrastructure Business

- Higher Charging times
CHARGING METHODOLOGIES

- **On Board Charger (AC Charger)**
  - Slow Charging
  - Overnight Charging

- **Off Board Charger (DC Charger)**
  - Fast Charging

- **Swapping (Battery Swapping)**
  - Requirement of Standardisation
  - Size, Rating, Communication Protocols
AC & DC Charging

**AC charging**
- Limited power, slow charging.

**DC charging**
- Infrastructure investment is shared among hundreds of users.
- Large power rating, fast charging.
- Capable of integration with renewable resources.

Diagram:
- On-board charger
- BMS
- Battery
- DC fast-charging station
- Grid, solar energy
Electric Vehicle Supply Equipment (EV Charger): Equipment which supplies Electrical Energy to recharge the battery of vehicles

- AC Charger (220 V/415 V, 15 A - 80 A supply) - 3.3 KW to 44 KW
- DC Charger (higher voltage & Current) - 15 KW to 350 KW

Type of Charging:
- Level 1 (120 V AC, standard house outlet) - Overnight charging
- Level 2 (240 V AC, Household appliances) - 4 to 6 hours
- Level 3 (500 V - 1000 V DC Charging) - 20 to 30 mins

Fast Charging Standards
- CCS (Combined Charging Standard) - Europe & US
- ChaDemo (Japan)
- GB/T (China)
- Bharat DC -001 (India) up to 100 V
# Global DC Charging Systems

## IEC DC Charging Systems

<table>
<thead>
<tr>
<th></th>
<th>System A</th>
<th>System B</th>
<th>System C</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>CHAdeMO (Japan)</td>
<td>GB/T (PRC)</td>
<td>COMBO1 (US)</td>
</tr>
<tr>
<td><strong>Connector</strong></td>
<td>![Connector A]</td>
<td>![Connector B]</td>
<td>![Connector C]</td>
</tr>
<tr>
<td><strong>Vehicle Inlet</strong></td>
<td>![Vehicle Inlet A]</td>
<td>![Vehicle Inlet B]</td>
<td>![Vehicle Inlet C]</td>
</tr>
<tr>
<td><strong>Communication Protocol</strong></td>
<td>CAN</td>
<td>PLC</td>
<td></td>
</tr>
</tbody>
</table>
Charging Infrastructure for Passenger Cars - Global Stock 2018

Publicly Accessible Slow Chargers

- Total 3,95,000

Publicly Accessible Fast Chargers

- Total 1,44,000

Copyright © 2017 NTPC Limited All Rights Reserved.
Charging Infrastructure Business

Electric Vehicle Supply Equipment (Chargers)

Electrical Infrastructure

Payment Gateways, Mobile App

Cloud Solutions

Input Supply from Discom

PSS

Cloud Data Management

EV User

Charging Stations

CMS

Payment Gateways, Mobile App

Cloud Solutions

Charging Stations

Input Supply from Discom

PSS

Cloud Data Management

EV User

Charging Stations

Copyright © 2017 NTPC Limited All Rights Reserved.
Charging Infrastructure: Financials

- **Cost of EVSE**
  - Fast DC Charger – 15 KW to 150 KW (Rs 2 Lac to Rs 20 Lac)
  - Slow AC Charger- 3.3 KW to 22 KW (Rs. 0.40 Lac to Rs. 5 Lac)

- **AMC Charges**

- **System Strengthening cost**

- **Charger Integration Charges, Mobile App, Payment gateways**

- **Operational expenses**
Charging Infrastructure: Challenges

- High Capital Expenditure with no returns during initial years
- Real estate / location of charging stations - Big challenge (Parking Issues)
- Most of the charging sessions expected at homes, offices
- Vehicles are expected to lag behind the Charging Infrastructure
- Substantial numbers of Chargers may attract EV adoption by public at large
- Too many players
Charging Network by-Tesla

1,255 Supercharger Stations with 9,955 Superchargers

Source: Tesla Website
EV MARKET IN INDIA
e-Vehicle Segment Analysis

3-Wheelers: e-rickshaws & e-autos

Luggage Carriers

4-Wheelers: Private & Passenger fleet

Electric Buses
## Analysis of E-Vehicle Segments

### 3 Wheeler: e-Rickshaws and e-Autos

**Opportunities:**
- Most common source of last mile connectivity
- Expected presence in large volumes
- May work best with Battery Swapping option
- Ownership of Li-Ion batteries
- Storage solutions in future during Li-Ion battery’s second life

**Challenges:**
- Unorganized market
- Currently, Lead acid batteries being used
- Security of Advanced batteries

### 4 Wheeler: Fleets & Private cars

**Opportunities:**
- Increased usage pattern of hail taxis in recent years
- Major cab aggregators like Ola, Uber, zoom car etc plan to add Electric Cars to their fleet
- Tighter regulations and emission norms may result in adoption of private cars in coming years

**Challenges:**
- Limited choice of vehicles at present
- Charging times do not meet user expectations (As of now)
- Market growth of this segment expected in 4-5 years time

### Large Public Transportation: E-Buses

**Opportunities:**
- This segment is expected to have maximum adoption all across India
- Most STU’s looking to convert their existing fleets to Electric
- They expect a Turn-key solution

**Challenges:**
- Large initial Capex
E-Mobility: Rest of World v/s India

**Tesla Model S**
- Battery size: 85 kWh
- Voltage: 375 V
- Range: 426 Kms
- 0-60 mph: 2.8 Sec
- Top Speed: 241 kmph
- Motor Power: 397 KW
- Price: ~ Rs. 49 Lac

**Tesla Super Charger**
- Capacity: 120 KW
- Charging time: 20 mins for 50%, 40 mins for 80% charge and 75 mins for 100% charge

**Mahindra e-Verito**
- Battery size: 18 kWh
- Voltage: 72 V
- Range: 140 Kms
- Motor Power: 31 KW
- Price: ~ Rs. 12 Lac

**Bharat DC-001**
- Capacity: 15 KW
- Charging time: 100 mins to full charge

**Hyundai Kona**
- Battery size: 40 kWh
- Voltage: 327 V
- Range: 450 Kms
- Price: ~ Rs. 26 Lac

**CCS Charger**
- Capacity: 50 KW
- Charging time: 60 mins to 80% charge
E-Mobility: Rest of World v/s India

Electric Buses/ Transport Vehicles:
1. Europe: OppCharge (with small battery pack)
E-Mobility: Rest of World v/s India

2. China: Depot Charging with large battery pack / Battery Swapping
E-Mobility: Rest of World v/s India

3. India : Depot Charging with medium/ large battery pack
BATTERY STORAGE
Energy Storage

India’s Target
By 2030

Reduction in emissions by 35% from 2005 level

40% non-fossil based electricity generation

Energy Storage
Power Scenario 2029-30

**INSTALLED CAPACITY**
- Wind, 140,000, 17%
- Solar, 300,000, 36%
- Nuclear, 16,880, 2%
- Gas, 24,350, 3%
- Biomass, 10,000, 1%
- Hydro, 73,445, 9%
- Coal, 266,827, 32%

**TOTAL** – 831 GW

**GENERATION**
- Coal, 50%
- Solar, 23%
- Wind, 12%
- Hydro, 8%
- Biomass, 1%
- Gas, 2%
- Nuclear, 4%

**TOTAL** – 2508 BU
Energy Storage

Means of Energy Storage

• Batteries
• Super Capacitors
• Compressed Air Energy Storage System
• Fly Wheels
• Pumped hydro storage plants

Battery Storage- preferred way!
• Fast pace of developments taking place in the battery technologies
• Price Competitiveness
### Storage Estimations

#### REQUIREMENT FOR GRID STORAGE

<table>
<thead>
<tr>
<th>Estimated Generation (GW)</th>
<th>2018-19</th>
<th>2022</th>
<th>2027</th>
<th>2032</th>
</tr>
</thead>
<tbody>
<tr>
<td>Solar</td>
<td>26</td>
<td>109</td>
<td>251</td>
<td>359</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Estimated Storage Requirement (MWh)</th>
<th>2018-19</th>
<th>2022</th>
<th>2027</th>
<th>2032</th>
</tr>
</thead>
<tbody>
<tr>
<td>Battery for LV Grid</td>
<td>209</td>
<td>6000</td>
<td>15220</td>
<td>22294</td>
</tr>
<tr>
<td>Battery for MV Grid</td>
<td>1050</td>
<td>3645</td>
<td>8793</td>
<td>12095</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>1259</strong></td>
<td><strong>9645</strong></td>
<td><strong>24013</strong></td>
<td><strong>34389</strong></td>
</tr>
</tbody>
</table>
Energy Storage with Electric Vehicles

Electric Vehicles to become competitive for all segments- 2W, 3W, 4W and Buses

<table>
<thead>
<tr>
<th>Application</th>
<th>Energy Storage Requirement (GWh)</th>
<th>2019-22</th>
<th>2022-27</th>
<th>2027-32</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electric Vehicles</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2W</td>
<td></td>
<td>4</td>
<td>55</td>
<td>496</td>
<td>555</td>
</tr>
<tr>
<td>3W</td>
<td></td>
<td>26</td>
<td>69</td>
<td>136</td>
<td>231</td>
</tr>
<tr>
<td>4W</td>
<td></td>
<td>8</td>
<td>110</td>
<td>725</td>
<td>843</td>
</tr>
<tr>
<td>Electric Bus</td>
<td></td>
<td>2</td>
<td>13</td>
<td>57</td>
<td>72</td>
</tr>
<tr>
<td>Total Electric Vehicles</td>
<td></td>
<td><strong>40</strong></td>
<td><strong>247</strong></td>
<td><strong>1414</strong></td>
<td><strong>1701</strong></td>
</tr>
</tbody>
</table>
IMPACT ON POWER MARKET
Power Market

- Renewable Power Concentration – Requirement of Transmission networks
- Centralised Power to Distributed Generation
  - Reverse Power flow
  - Increased fault currents
  - Phase imbalance
  - Redesigning of Network Protection System
Power Market: Challenges for Grid Operator

- High solar adoption creates a challenge for utilities to balance supply and demand on the grid.
- PV to produce more energy than can be used at one time, called over-generation.
- System operators to curtail PV generation, reducing its economic and environmental benefits.

The Duck Curve
Power Market: Impact of EVs

- Mass adoption of EVs is a near future reality

- EVs may be considered as active loads
  - Increasing the demand on the network during charging
  - Generating when operating in regeneration mode

- Schedule/Incentivize the charging times to flatten the load curve

- Example: Unplanned scenario
  - Users will tend to plug their vehicles into the charging outlets, as soon as they get home from work - at approximately 6:00-7:00 p.m.
  - EV charging adds to the pre-existing peak load and gives an even larger peak
  - Studies shows an increase of about 18% in maximum demand results from every 10% increase in houses with EVs
Power Market: Impact of EVs

- Reduction in Solar Power curtailment could be achieved by charging EVs during daytime.

- With appropriate control and communication with the grid, EVs could be designed to operate as part of a ‘Smart grid’
  - Providing ancillary services such as supply/demand matching and voltage/frequency control.
NTPC IN E-MOBILITY
Electric Mobility Ecosystem: NTPC’s Presence

- **Investment in Batteries for vehicles operating on Battery swapping**
- **Investment in Electric Buses for market development & creating initial critical demand**

Diagram:
- Batteries
- Electric Vehicles
- Charging Services
- Connected Services
NTPC offering for States

<table>
<thead>
<tr>
<th>Vehicle Segment</th>
<th>Vehicle Ownership</th>
<th>Charging Infra by NTPC</th>
</tr>
</thead>
<tbody>
<tr>
<td>E-Bus</td>
<td>STU/CTU</td>
<td>Off-Board Charging (Depot Charging + Top up Charging)</td>
</tr>
<tr>
<td>E-4-wheelers</td>
<td>Private Owners/ Government Offices/ Private Aggregators</td>
<td>Off-Board Charging</td>
</tr>
<tr>
<td>E-3- wheeler/ E-2Wheeler</td>
<td>Private Owners/Aggregators</td>
<td>Battery Swapping Model (Batteries owned by NTPC)</td>
</tr>
</tbody>
</table>
NTPC as EV Charging Solutions Provider

NTPC aims to provide complete energy solutions for the Electric Mobility Market
E-mobility projects under Implementation/Consideration

Installation of Charging Stations at all NTPC Projects & Offices across India

Faridabad 3-W Battery Swapping Pilot Project (50 E-Rickshaws) - Operational by Jul’19

Creating network of Charging Stations in Delhi-NCR, Hyderabad, Bengaluru, Pune, Bhopal, Indore
- Purchase Orders placed for 400 Nos. Bharat Chargers
- Tenders floated for 50 KW/120 KW Fast Chargers (Expected Award-Jul’19)

Development of Electric Highways (Delhi-Jaipur / Delhi-Agra/ Delhi-Chandigarh / Mumbai-Pune)

Charging Infrastructure creation for Goa, Guwahati and Tripura

E-Bus Solution for STUs
- Demand Aggregation & Tender for 500 Nos. electric buses (Technical Bid under Evaluation)
What NTPC offers in E-Mobility

- Supporting GoI initiatives for faster adoption of E-Mobility
- Synergic with its current business and provide opportunities for diversification

<table>
<thead>
<tr>
<th>Challenge</th>
<th>NTPC’s Role</th>
</tr>
</thead>
<tbody>
<tr>
<td>Higher Cost of EVs</td>
<td>Optimised Battery Size matching Operational requirements – (Average Daily Run -200 Kms.)</td>
</tr>
<tr>
<td>Optimised System Cost</td>
<td>Vehicle and Charging Infra Interoperability</td>
</tr>
<tr>
<td>Financial Support</td>
<td>Initial Capital Investment for Vehicles in public transport</td>
</tr>
<tr>
<td>Range Anxiety</td>
<td>Creation and Maintenance of Charging Infrastructure on Build Own and Operate basis</td>
</tr>
</tbody>
</table>
| Technology and Customer Support | • Necessary tie-ups with Bus Manufacturer for Maintenance  
|                             | • Training for end-customers                                                  |
## E-Bus Solutions for STU’s/CTU’s

<table>
<thead>
<tr>
<th></th>
<th>Dry Lease Model (e-Bus Provider)</th>
<th>Turnkey Solution</th>
</tr>
</thead>
<tbody>
<tr>
<td>Supply</td>
<td>NTPC</td>
<td>NTPC</td>
</tr>
<tr>
<td>Finance</td>
<td>NTPC</td>
<td>NTPC</td>
</tr>
<tr>
<td>Charging Solutions</td>
<td>NTPC</td>
<td>NTPC</td>
</tr>
<tr>
<td>Operations</td>
<td>STU</td>
<td>NTPC(through sub-contract)</td>
</tr>
<tr>
<td>Maintenance</td>
<td>NTPC (through OEM)</td>
<td>NTPC (through OEM)</td>
</tr>
<tr>
<td>Revenue Collection</td>
<td>STU</td>
<td>STU</td>
</tr>
</tbody>
</table>

*The Buses are provided by NTPC on a monthly rental depending upon the extent of investment done by NTPC. All subsidies/incentives provided by GoI/State Government are suitably adjusted.*
Advantages to STU’s/CTU’s

- Advantage of Demand Aggregation transparently passed to end-customer

- 'Pay as You Go Model' - No upfront investments required for
  - Bus procurement
  - Creation of Charging Infrastructure

- Advantage of NTPC’s low cost of borrowing

- Utilization of existing staff for operations – Customer Training integral part

- No Technology risk

- Transparent price discovery through competitive bidding amongst OEMs
Proposal for E-Car Charging Infrastructure

- Creation of Public Charging Infrastructure
  - Airports
  - Metro stations
  - Railway Station
  - Public Parking Lots

- Investments in Charging Infrastructure by NTPC

- Locations for setting up Charging Infrastructure in consultation with State administration

- Support for securing power from DISCOM
THANK YOU