

एनटीपीसी NTPC
A Maharatna Company

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

एनटीपीसी NTPC
Powering e-Mobility!

IIT, Kanpur
27.07.2019



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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
9,790 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

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Electric Mobility-Definitions

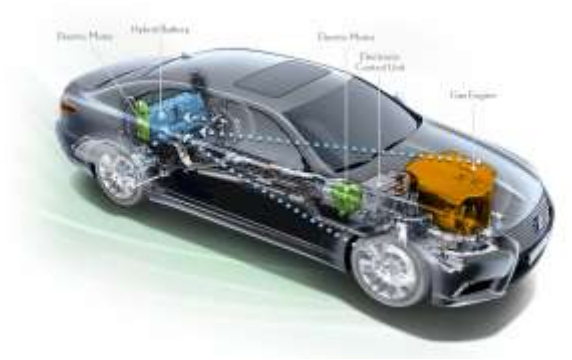
- Vehicles powered by an Electric Motor which draws current from a rechargeable battery are termed as Electric Vehicles.

- IC Engines replaced by Electric Motor & rechargeable Batteries

Type of Electric Vehicles

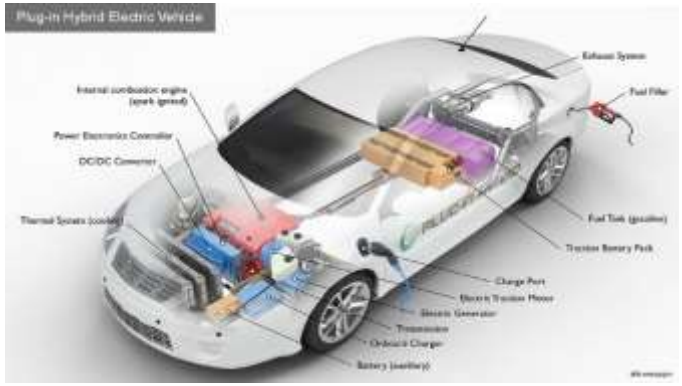
Hybrid Electric Vehicles: IC Engines with small battery

- 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

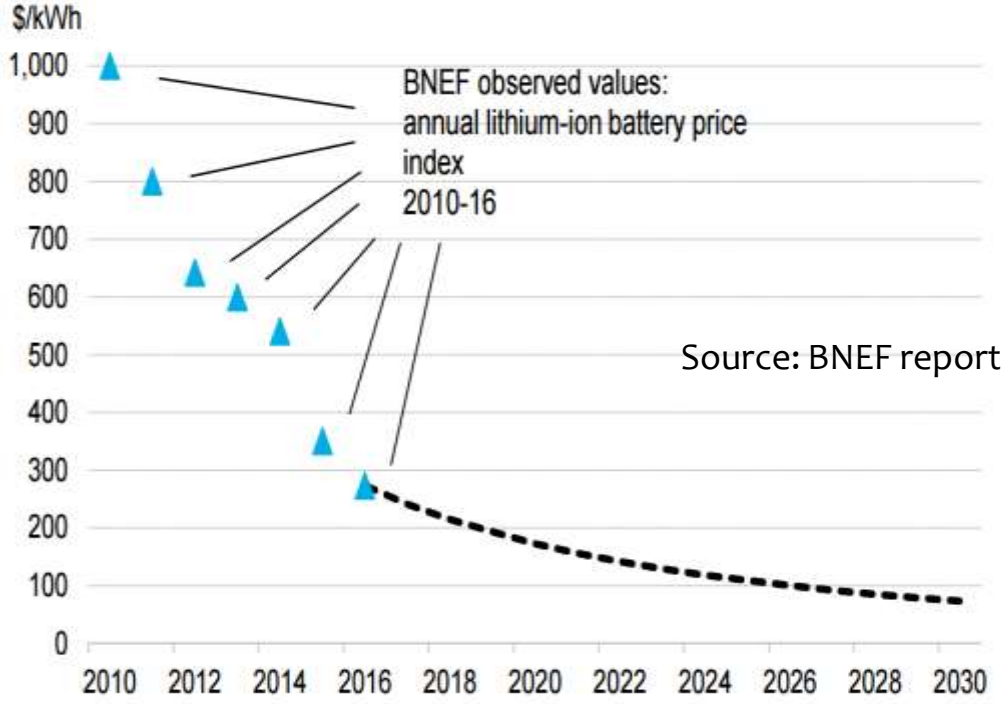


Battery Electric Vehicles: No IC Engines with larger battery

- Battery recharged by EVSE
- Zero tailpipe emissions
- Current range more than 500 Kms in single charge

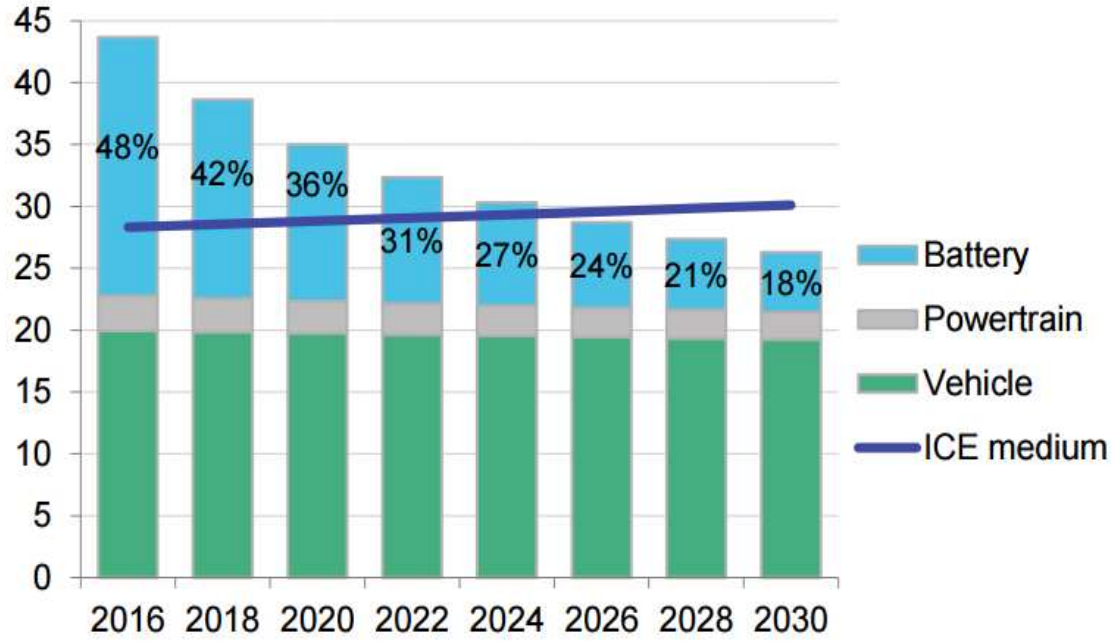
Electric Mobility Drivers

- 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



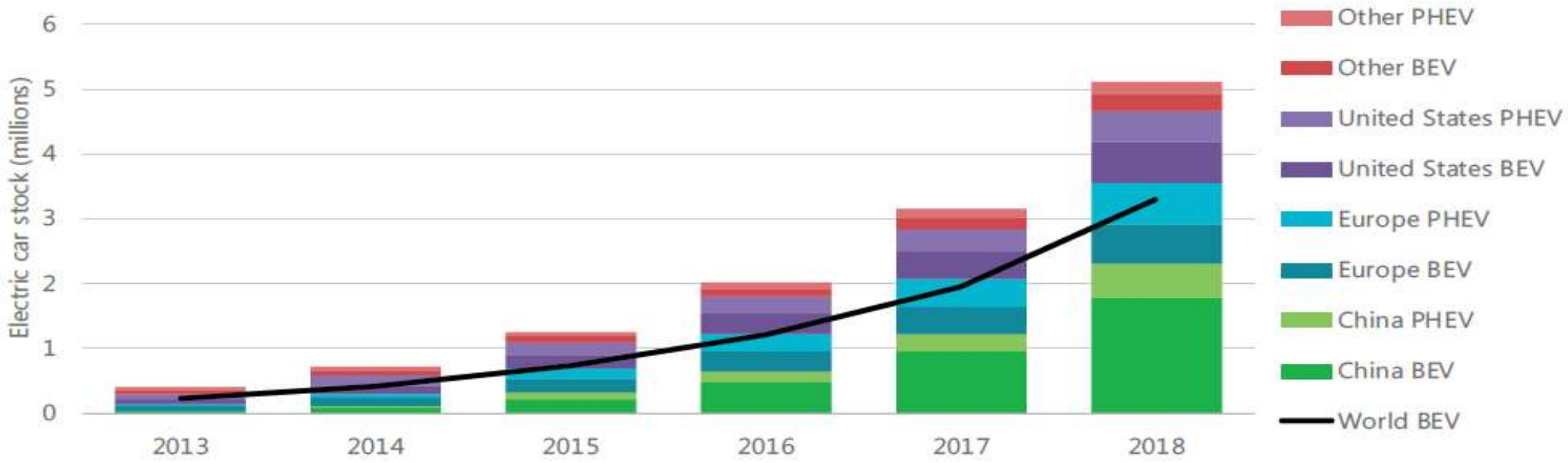
Source: BNEF report 2017

- Expected to reach price parity by 2025
- Parity may be achieved sooner with higher range batteries



Electric Vehicles Stock (Passenger Cars)

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



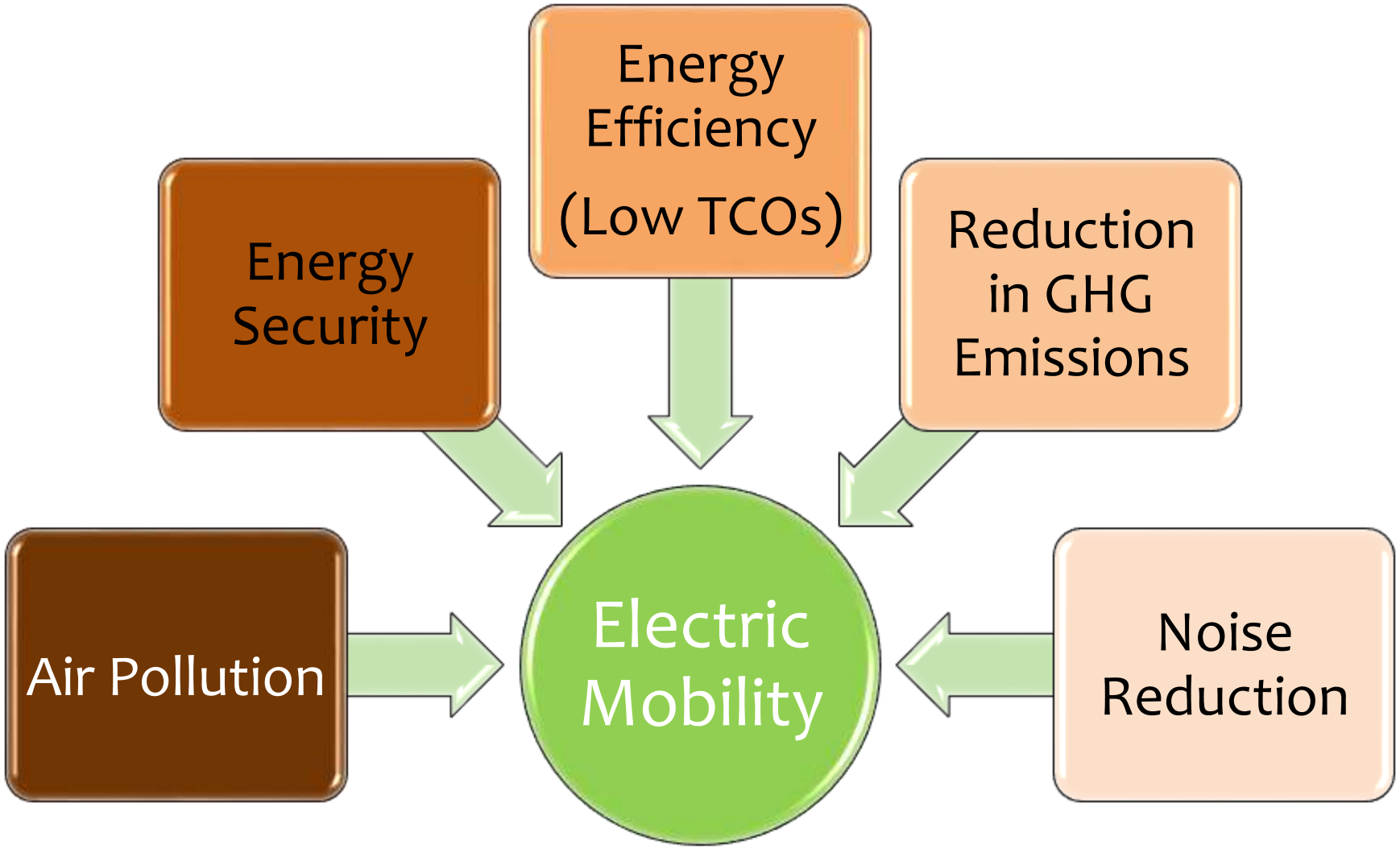
Other includes Australia, Brazil, Chile, India, Japan, Korea, Malaysia, Mexico, New Zealand, South Africa and Thailand.

There were 5.1 million electric passenger cars on the road worldwide by the end of 2018, of which 45% were in China

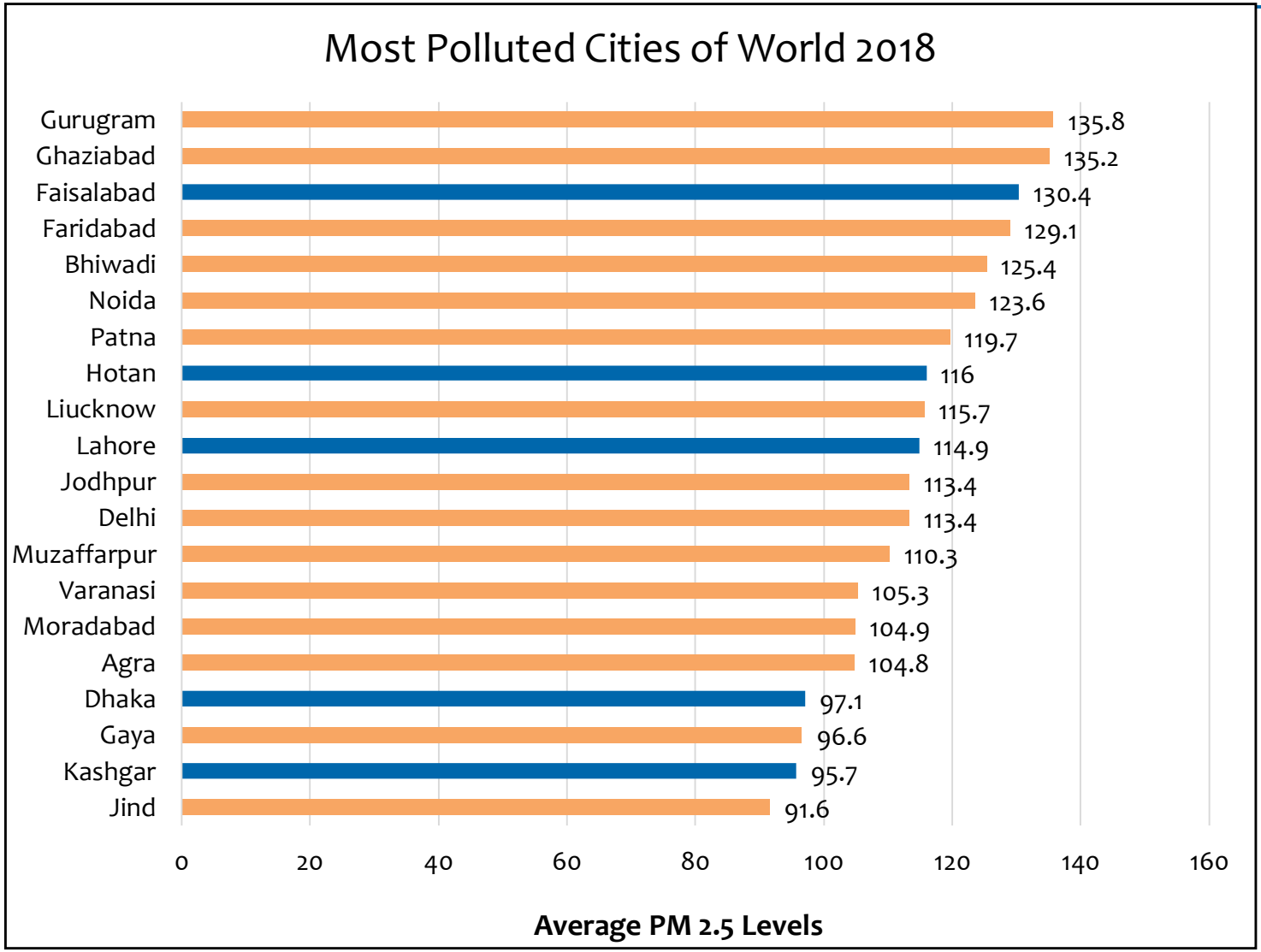
Electric Vehicles Stock (Electric Buses)

- 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



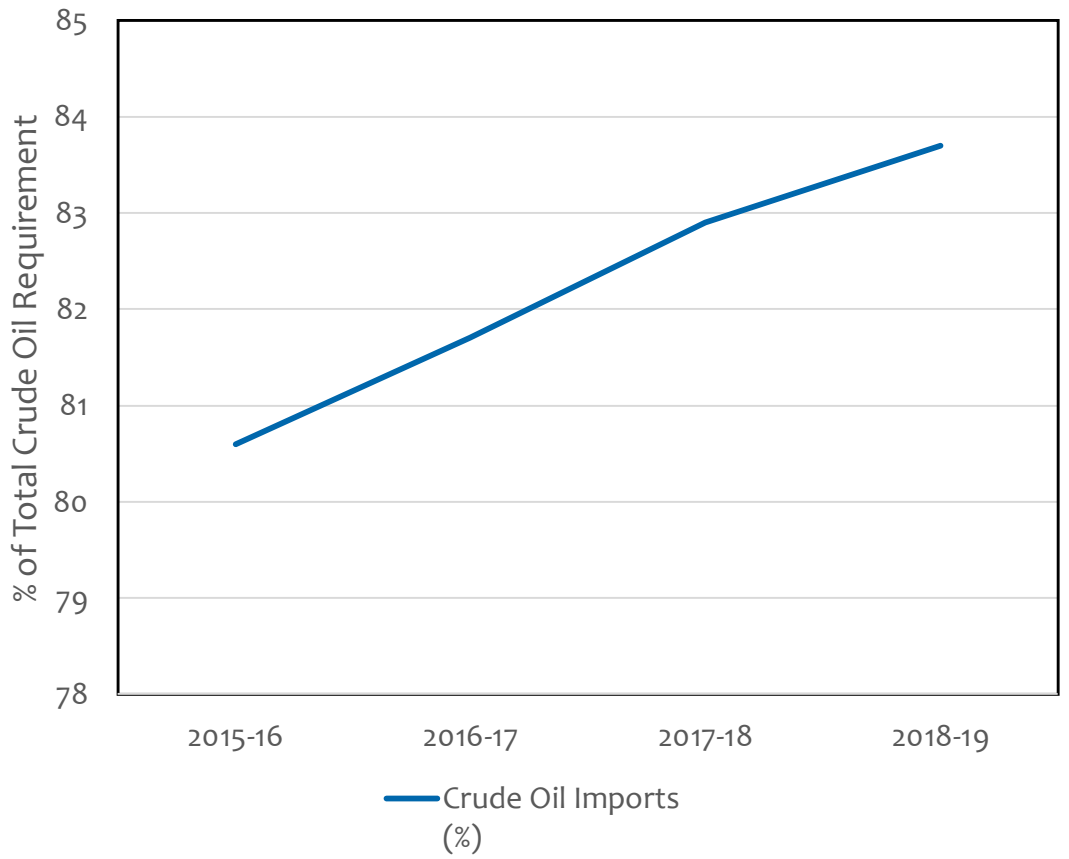
Electric Mobility For India

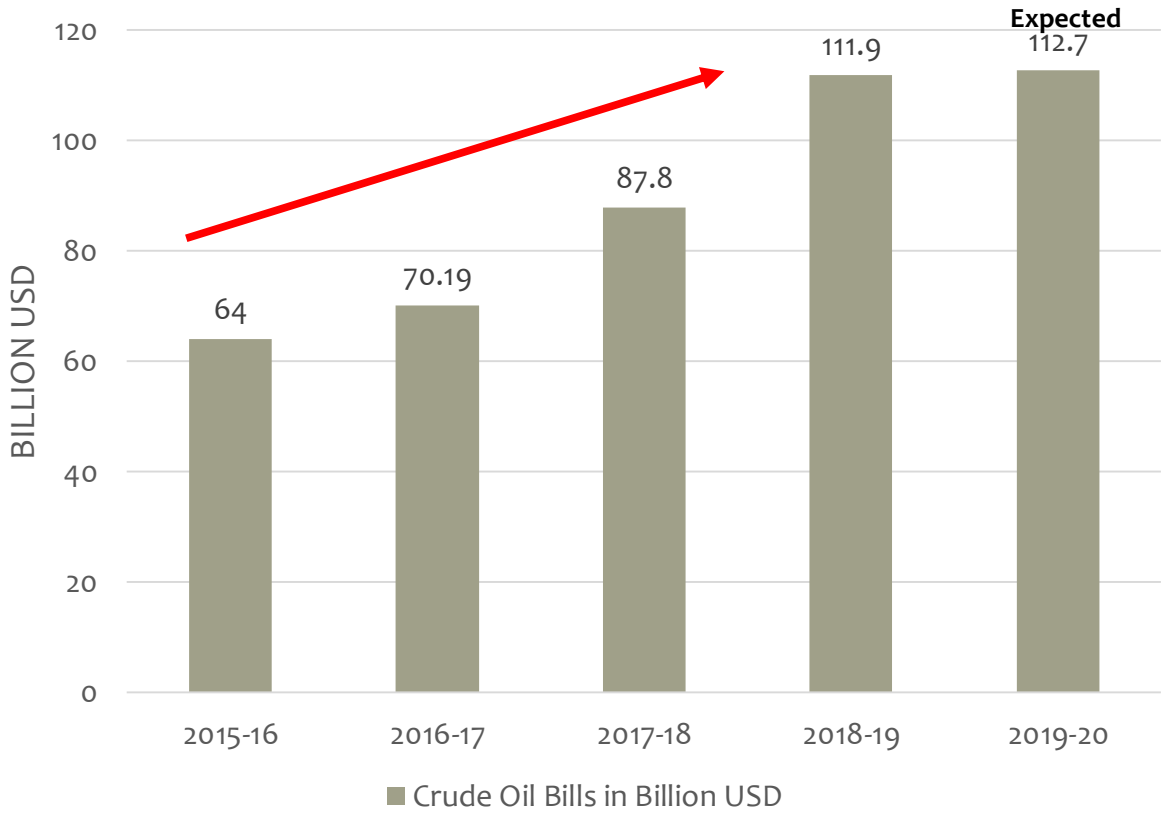


- 07 Indian cities in Worst 10, and 22 of the Worst 30.
- **In Gurugram, average air pollution levels in 2018 were more than 13 times the level permitted under WHO guidelines**

Source: IQAir AirVisual 2018 World Air Quality report and Greenpeace

Electric Mobility For India





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 :

(In millions)

YEAR	2-Wheelers	Car, Jeeps and Taxis	Buses	Goods Vehicles	Others*	
2015	154	29	2	9	16	Total-210
CAGR	**11%**	**9%**	**12%**	**8%**	**7.5%**	
2030	738	104	10	29	46	Total-927

* 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

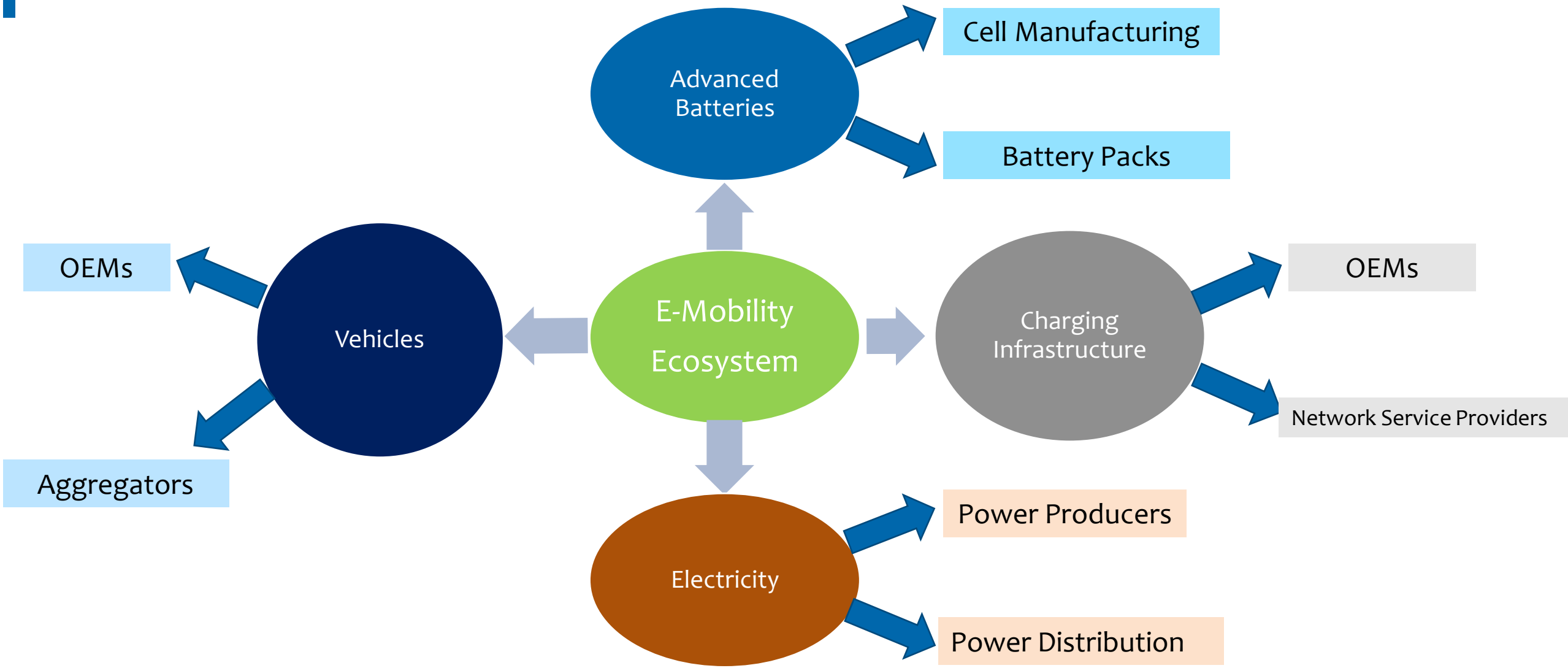
Expected EV sales in India

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

As per Niti Aayog and RMI Report

(*) As per NTPC estimate

Electric Mobility Ecosystem: Business Opportunities



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 INFRASTRUCTURE

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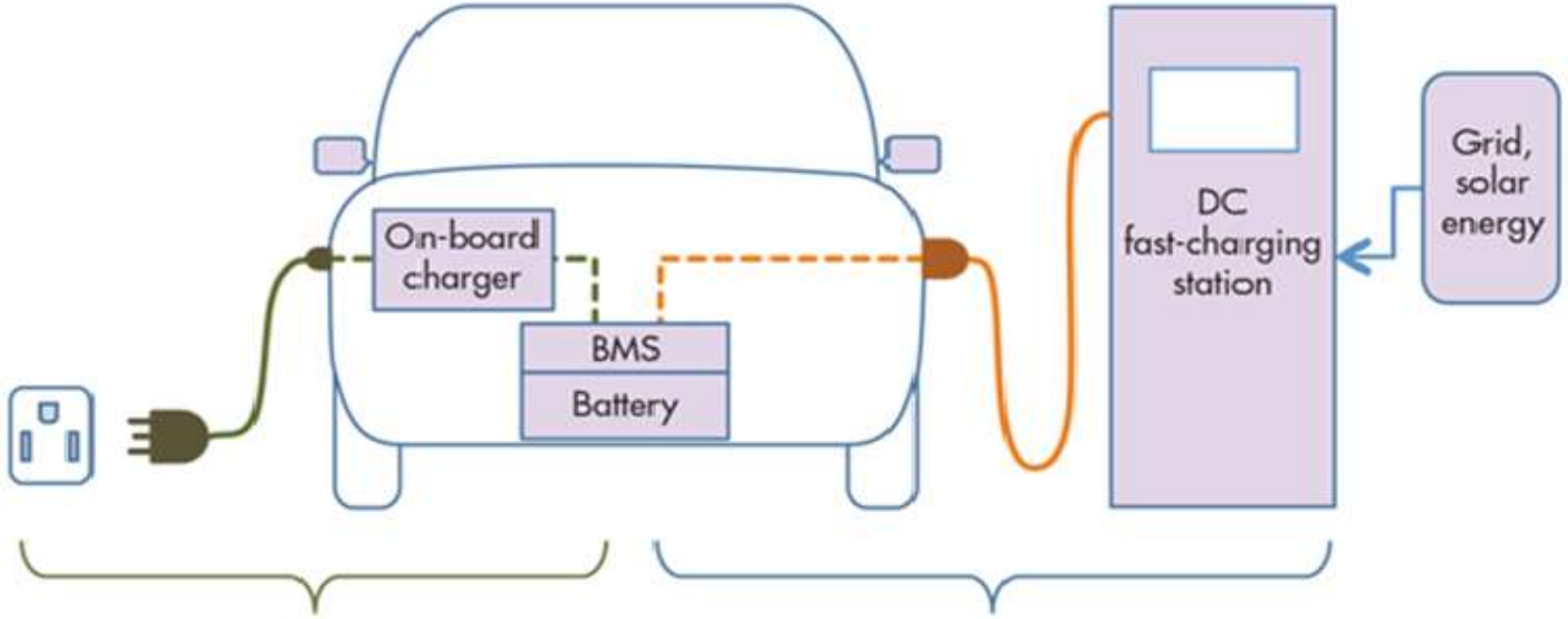
CHARGING METHODOLOGIES

- 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.

EV Chargers & Type of Charging

- 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

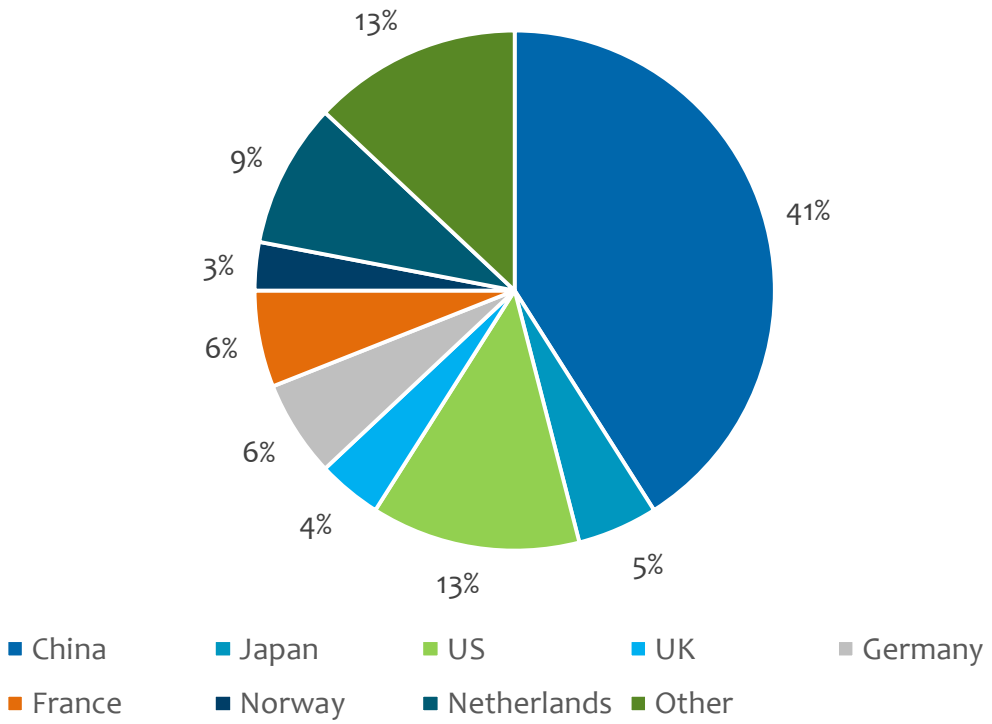
Global DC Charging Systems

IEC DC Charging Systems

	System A	System B	System C	
	CHAdeMO (Japan)	GB/T (PRC)	COMBO1 (US)	COMBO2 (DE)
Connector				
Vehicle Inlet				
Communication Protocol	CAN		PLC	

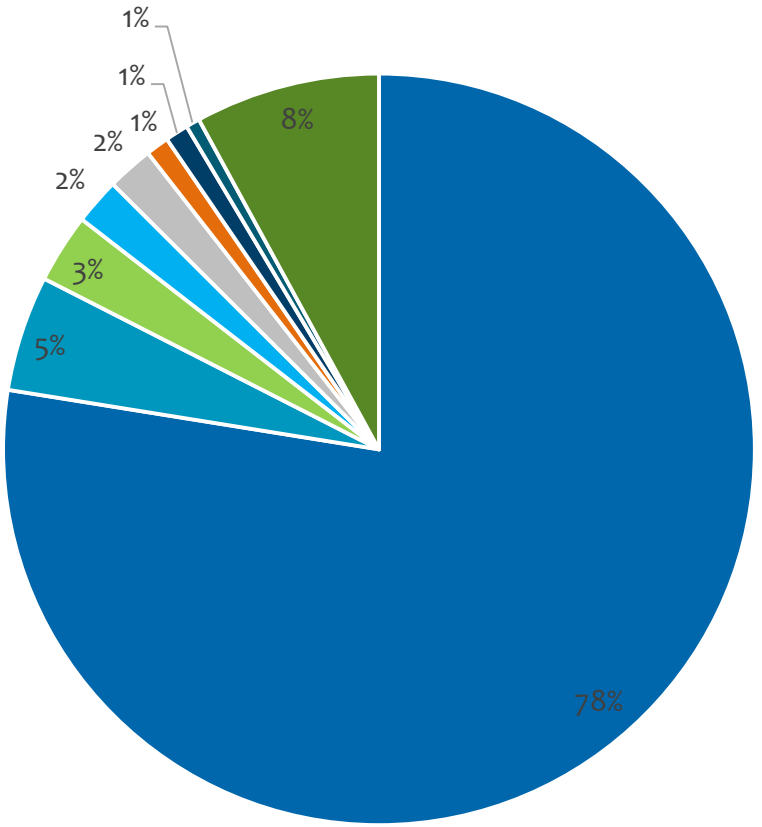
Charging Infrastructure for Passenger Cars -Global Stock 2018

Publicly Accessible Slow Chargers



Total 3,95,000

Publicly Accessible Fast Chargers



Total 1,44,000

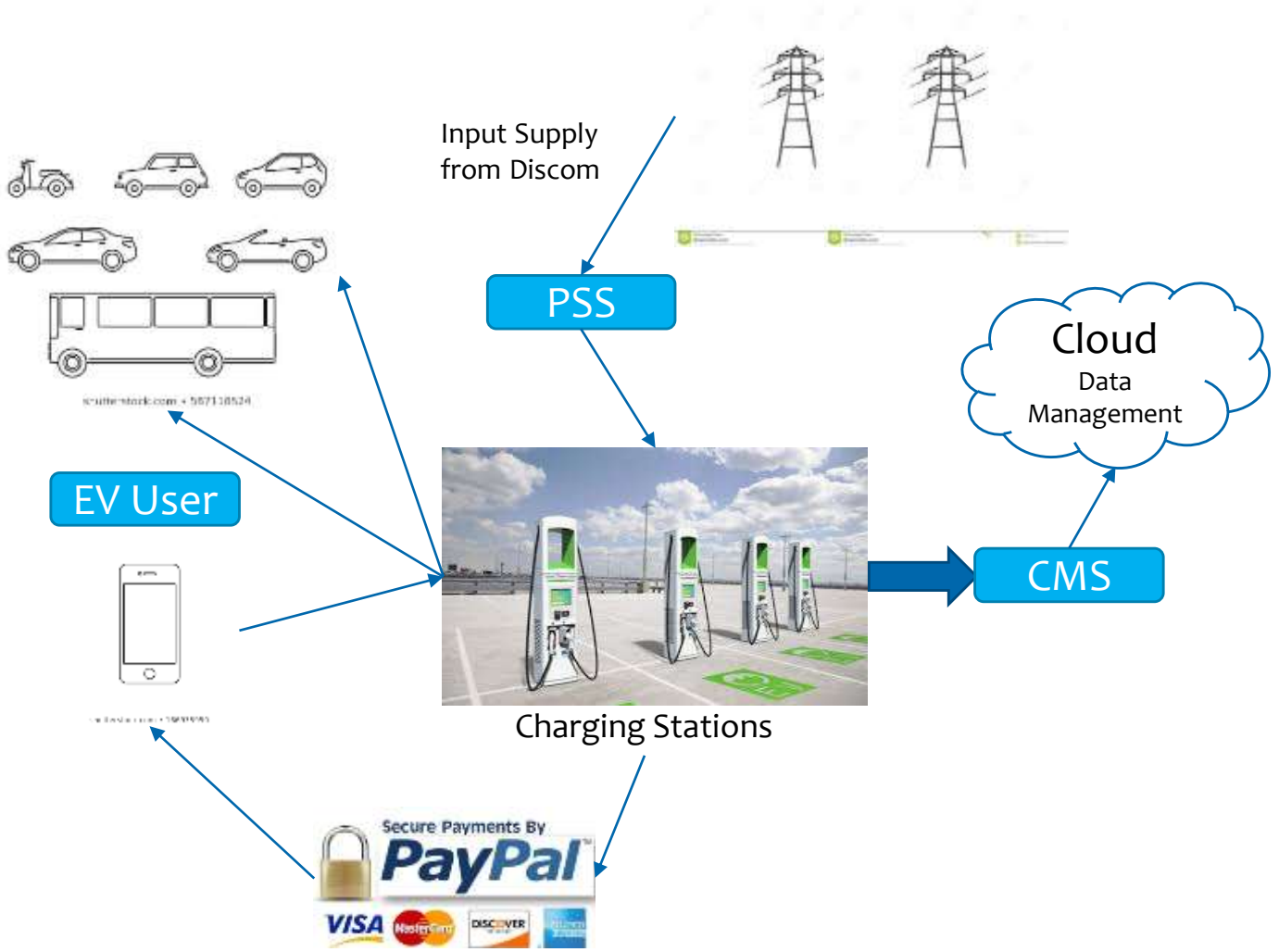
Charging Infrastructure Business

Electric Vehicle Supply Equipment (Chargers)

Electrical Infrastructure

Payment Gateways, Mobile App

Cloud Solutions



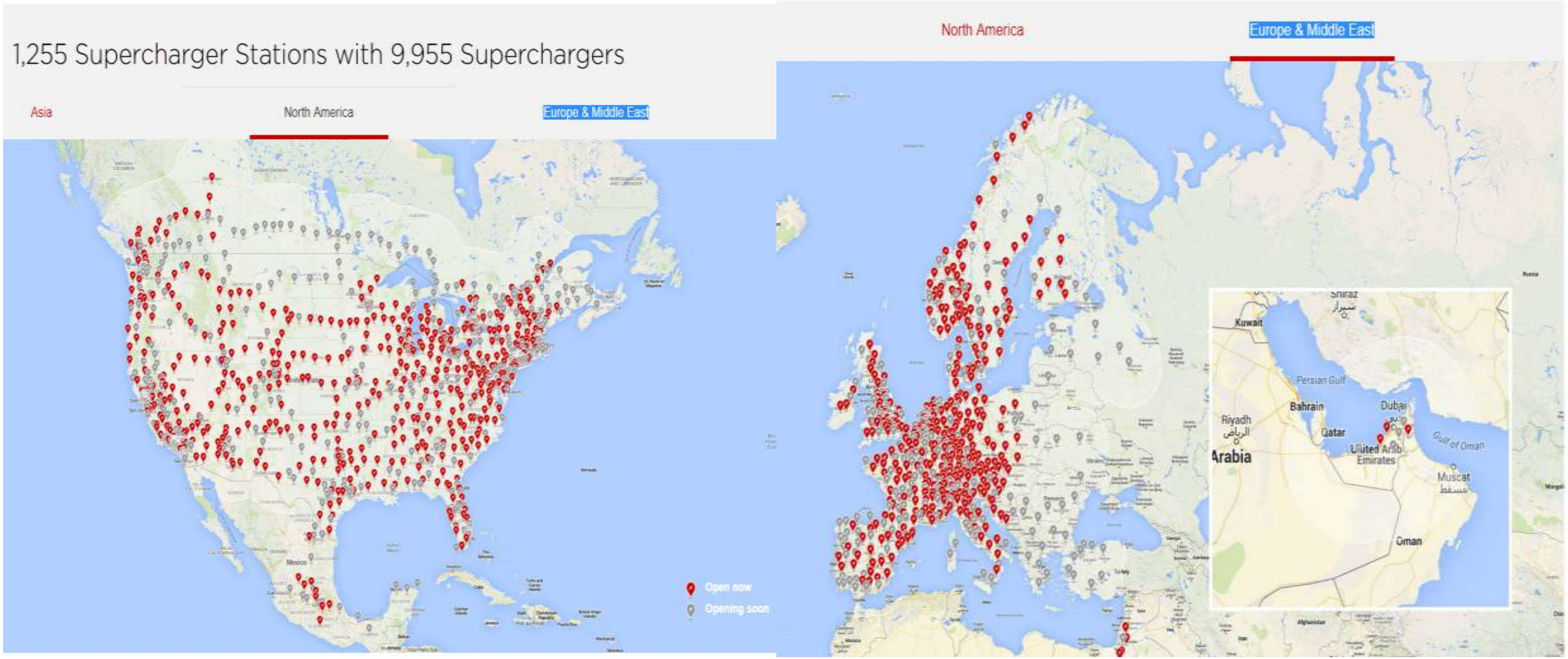
Charging Infrastructure: Financials

- 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



Source: Tesla Website

EV MARKET IN INDIA

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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

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

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

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

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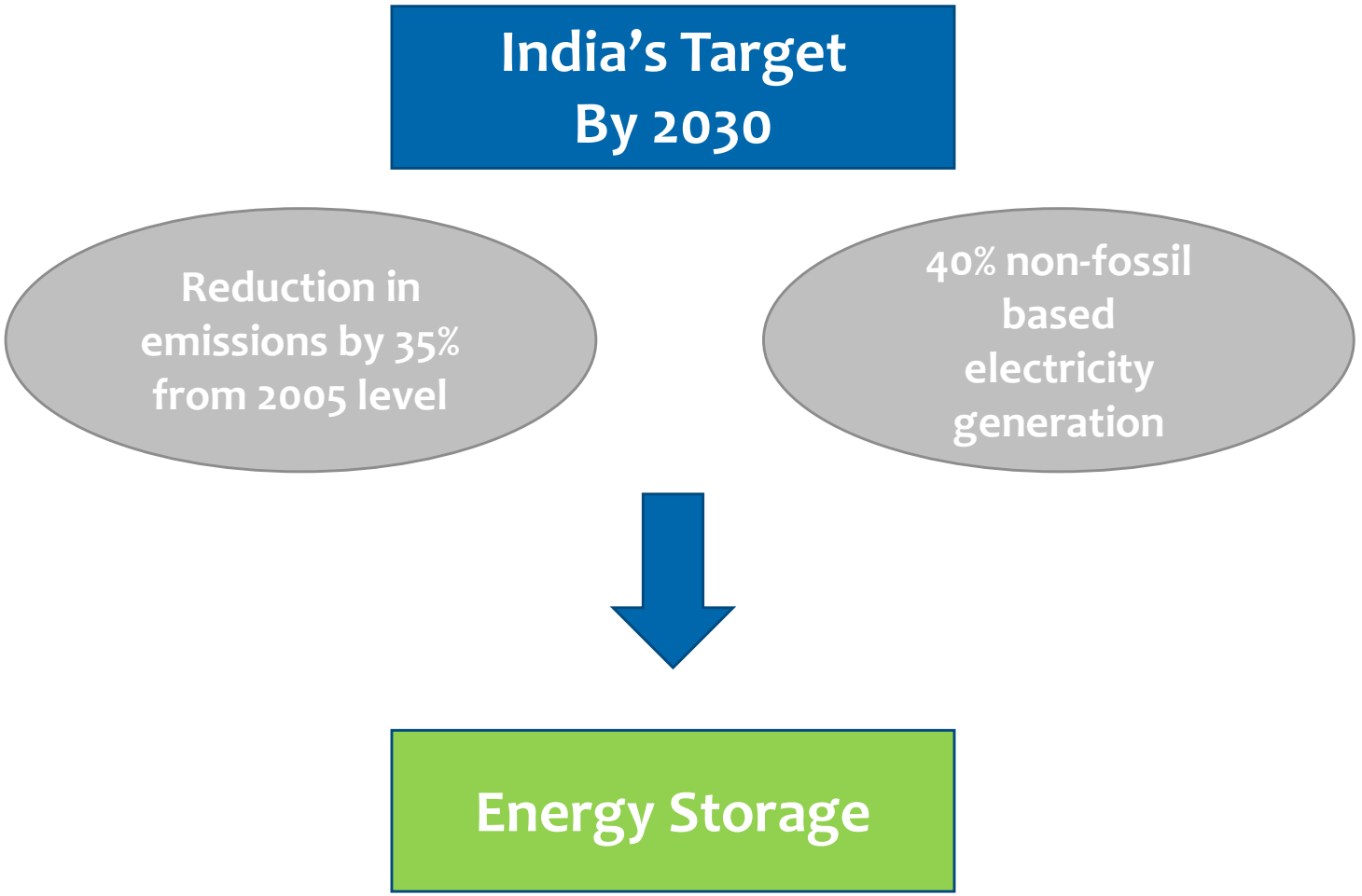
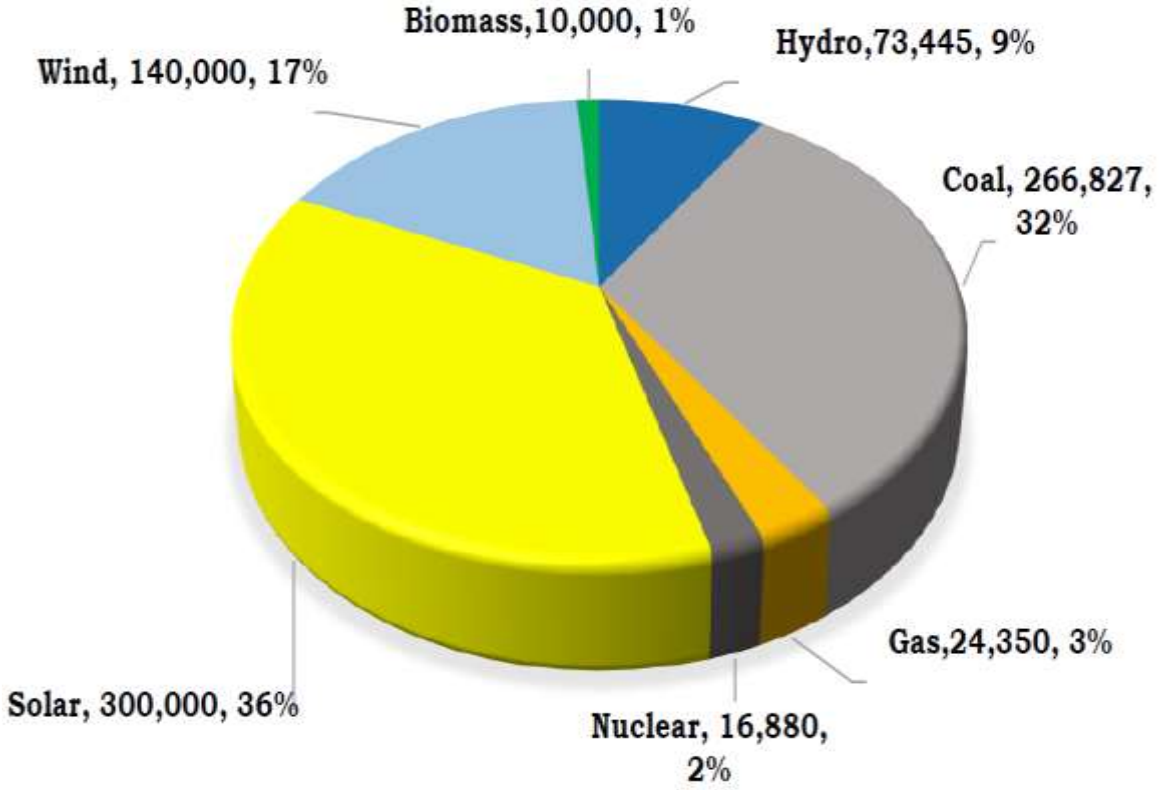
Energy Storage



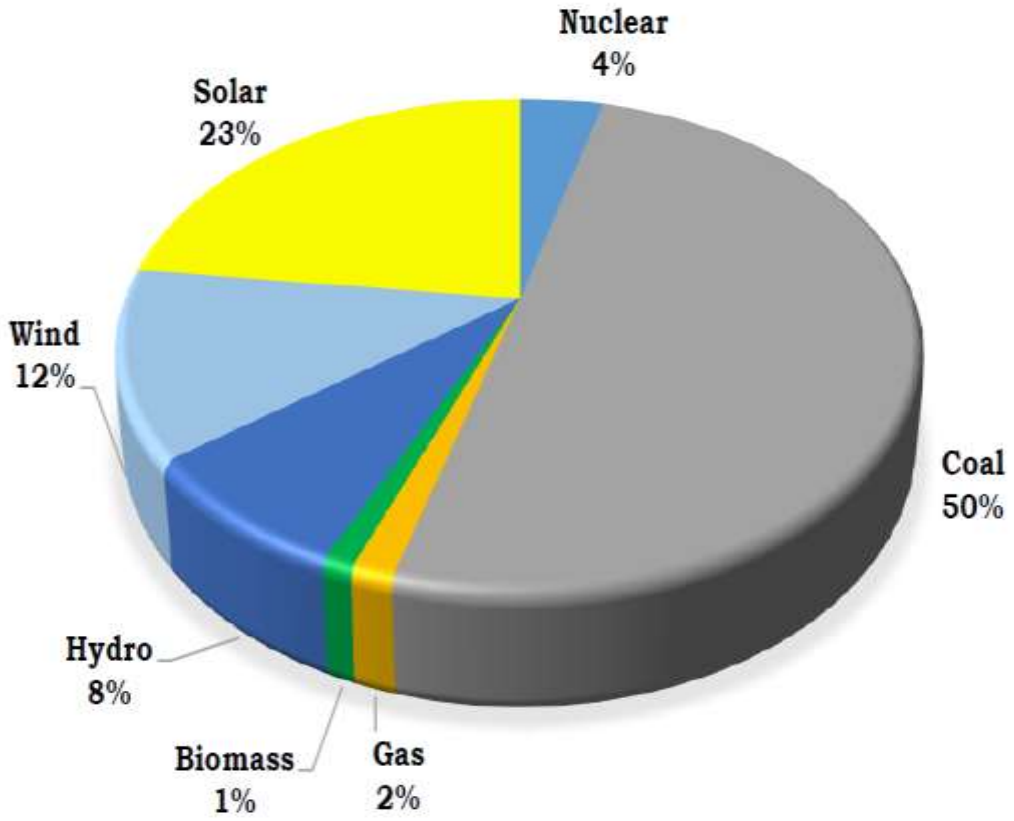
Power Scenario 2029-30

INSTALLED CAPACITY



TOTAL – 831 GW

GENERATION



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 Competiveness

Storage Estimations

REQUIRMENT FOR GRID STORAGE

Estimated Generation (GW)	2018-19	2022	2027	2032
Solar	26	109	251	359

Estimated Storage Requirement (MWh)	2018-19	2022	2027	2032
Battery for LV Grid	209	6000	15220	22294
Battery for MV Grid	1050	3645	8793	12095
Total	**1259**	**9645**	**24013**	**34389**

Energy Storage with Electric Vehicles

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

Application	Energy Storage Requirement (GWh)			
	2019-22	**2022-27**	**2027-32**	**Total**
Electric Vehicles				
2W	4	55	496	555
3W	26	69	136	231
4W	8	110	725	843
Electric Bus	2	13	57	72
Total Electric Vehicles	**40**	**247**	**1414**	**1701**

IMPACT ON POWER MARKET

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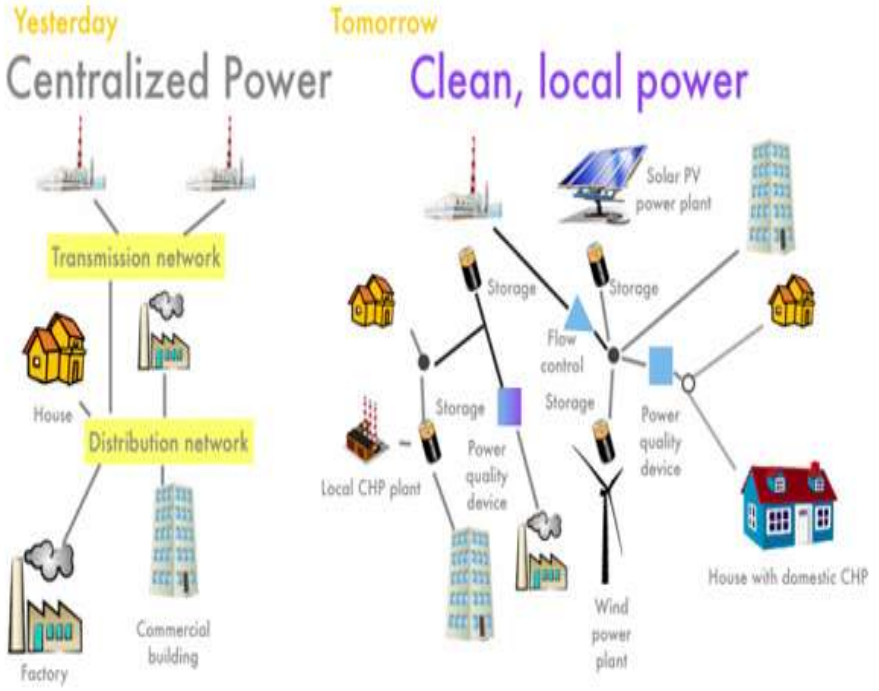
Power Market

- Renewable Power Concentration –

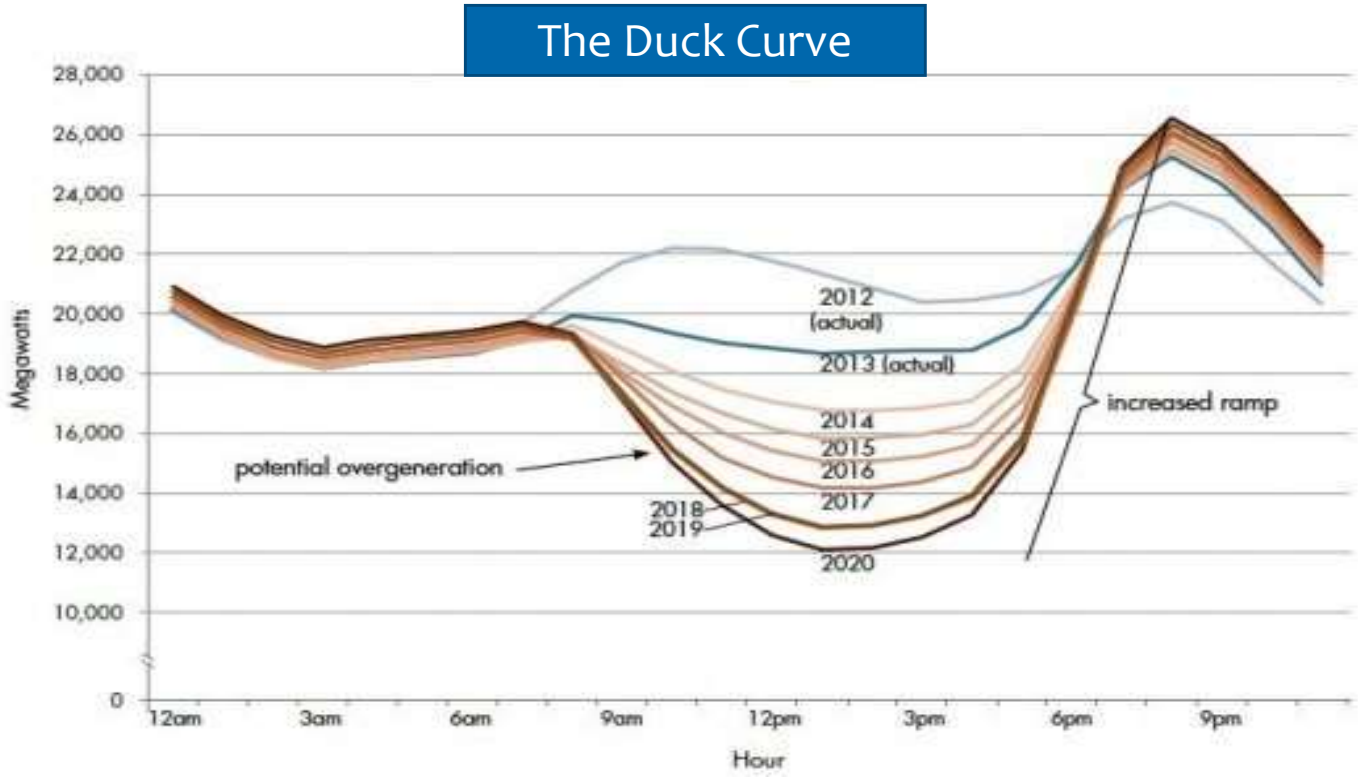
  Requirement of Transmission networks

- 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



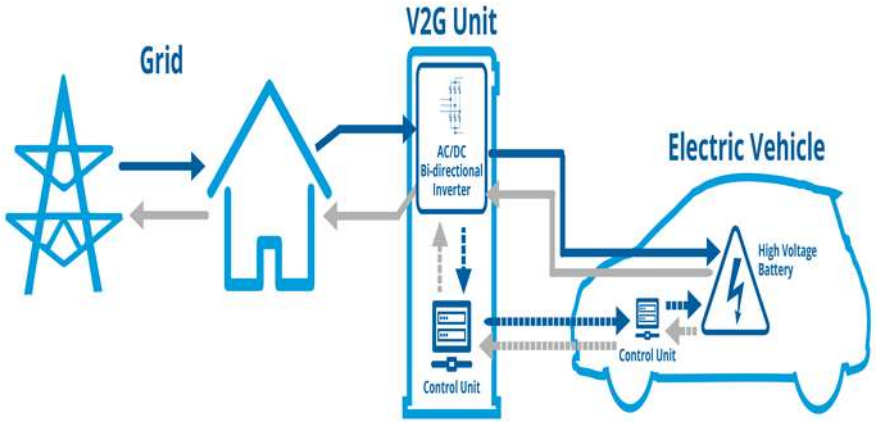
Power Market: Impact of EVs

- 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

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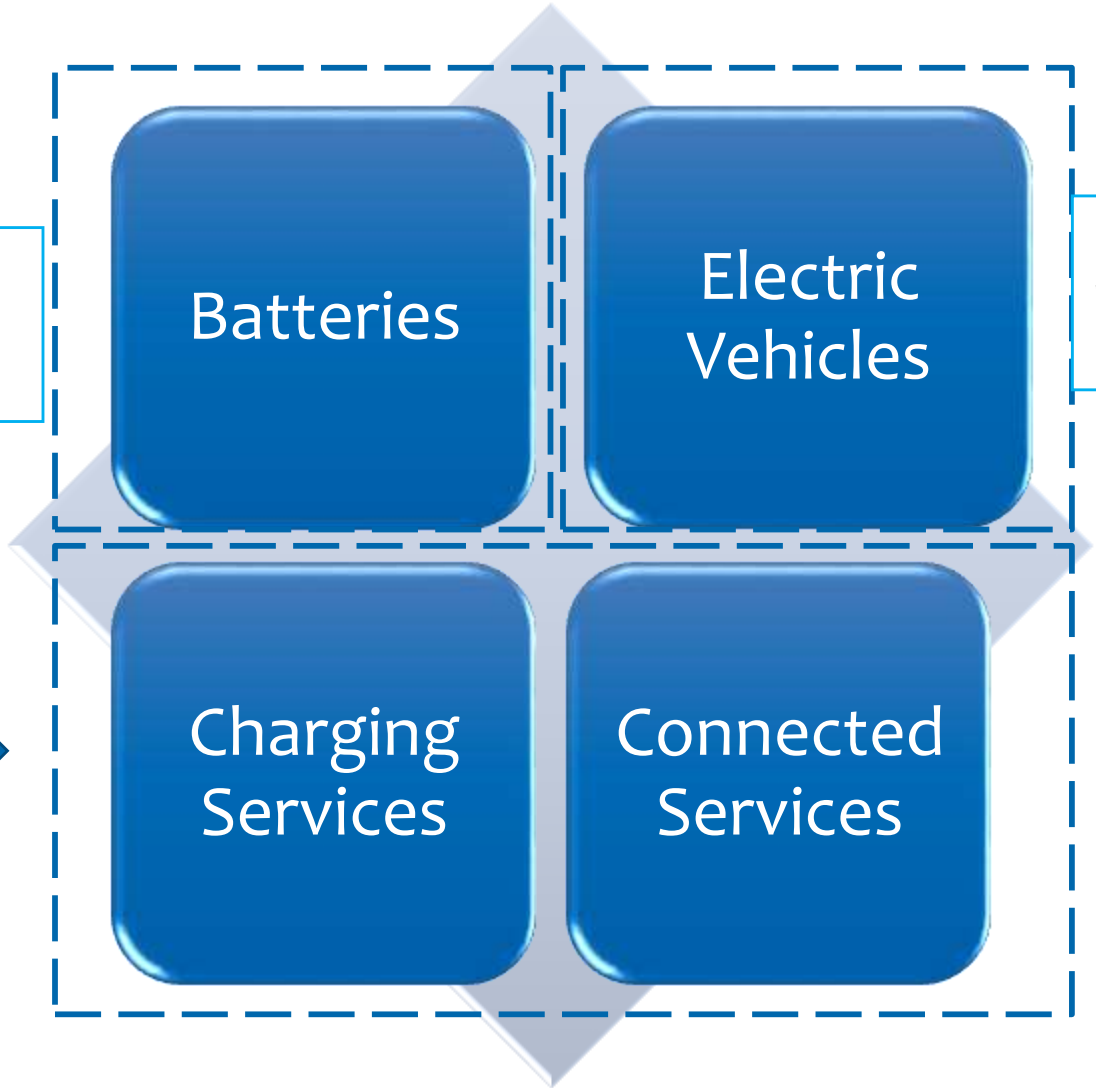
Electric Mobility Ecosystem: NTPC's Presence

Investment in Batteries for vehicles operating on Battery swapping

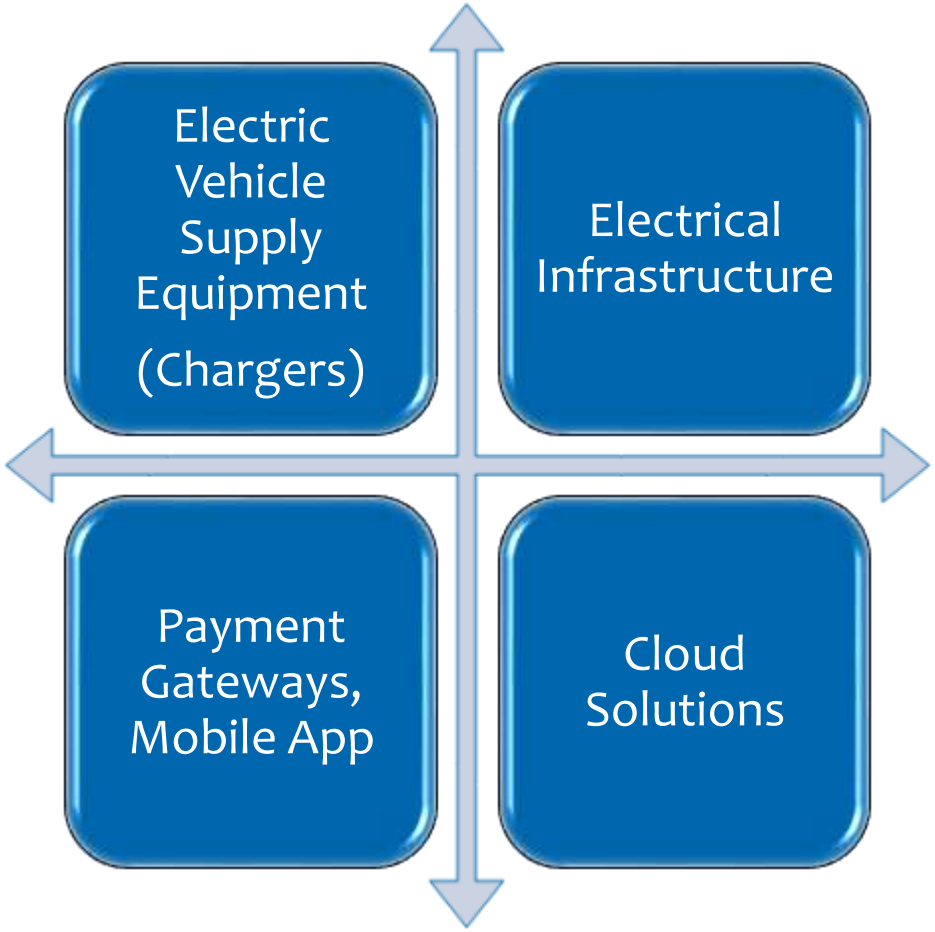


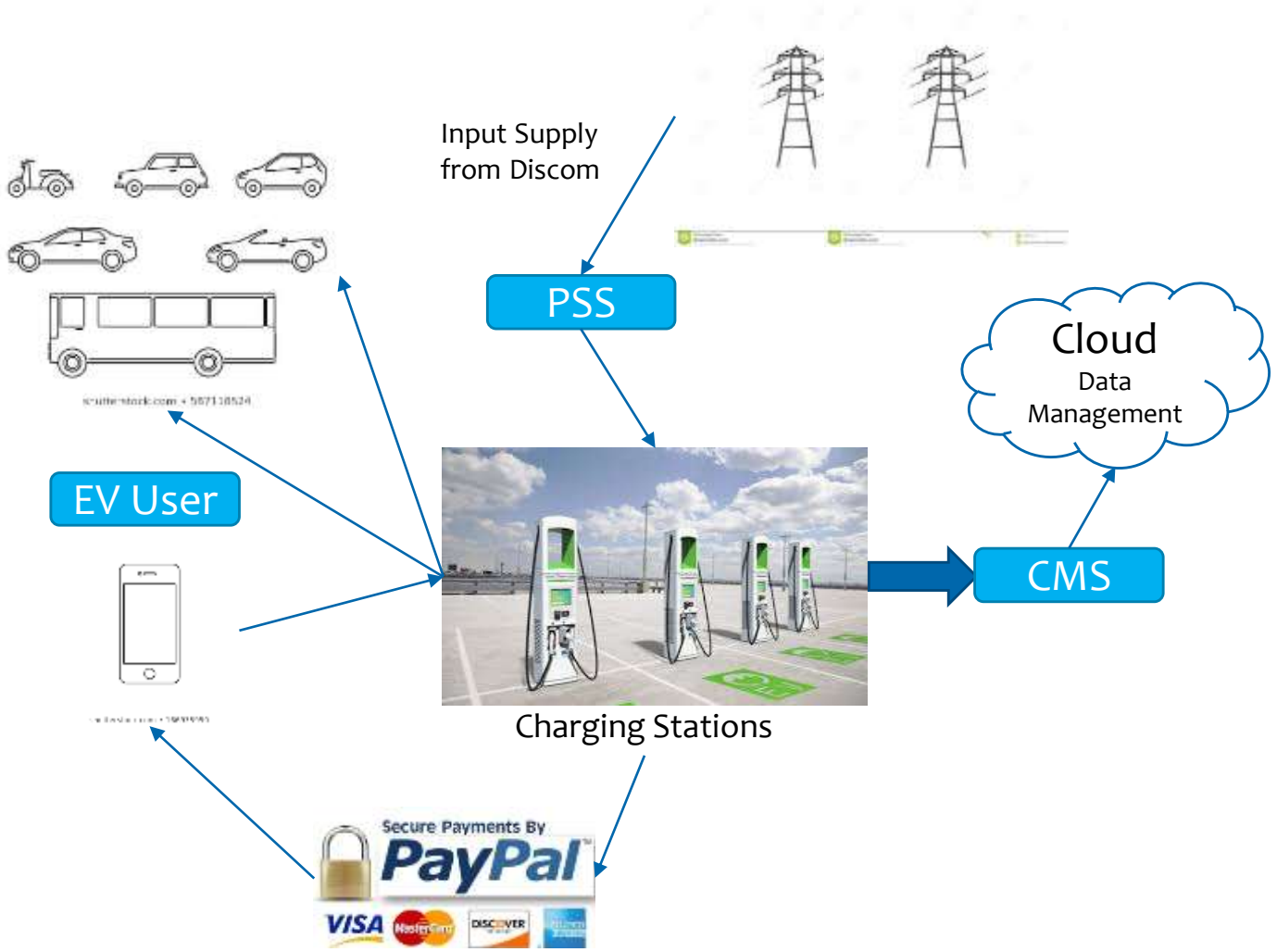
Investment in Electric Buses for market development & creating initial critical demand

NTPC offering for States

Vehicle Segment	Vehicle Ownership	Charging Infra by NTPC
E-Bus	STU/CTU +	Off-Board Charging (Depot Charging + Top up Charging)
E-4-wheelers	Private Owners/ Government Offices/ Private Aggregators	Off-Board Charging
E-3- wheeler/ E-2Wheeler	Private Owners/Aggregators	Battery Swapping Model (Batteries owned by NTPC)

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

Challenge	NTPC's Role
Higher Cost of EVs	**Optimised Battery Size** matching Operational requirements – (Average Daily Run -200 Kms.)
Optimised System Cost	Vehicle and **Charging Infra Interoperability**
Financial Support	**Initial Capital Investment for Vehicles** in public transport
Range Anxiety	Creation and Maintenance of Charging Infrastructure **on Build Own and Operate** basis
Technology and Customer Support	• Necessary tie-ups with **Bus Manufacturer** for Maintenance • **Training** for end-customers

E-Bus Solutions for STU's/CTU's

	Dry Lease Model (e-Bus Provider)	Turnkey Solution
Supply	NTPC	NTPC
Finance	NTPC	NTPC
Charging Solutions	NTPC	NTPC
Operations	STU	NTPC(through sub-contract)
Maintenance	NTPC (through OEM)	NTPC (through OEM)
Revenue Collection	STU	STU

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