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In Cooperation with
NITI Aayog

Renewable energy-based EV charging

Key findings and Recommendations

Deloitte & PRDC

March 2024

SESSION AGENDA

1 | Transport transition model

2 | Technical feasibility of RE based EV charging

3 | Commercial feasibility of RE based EV charging

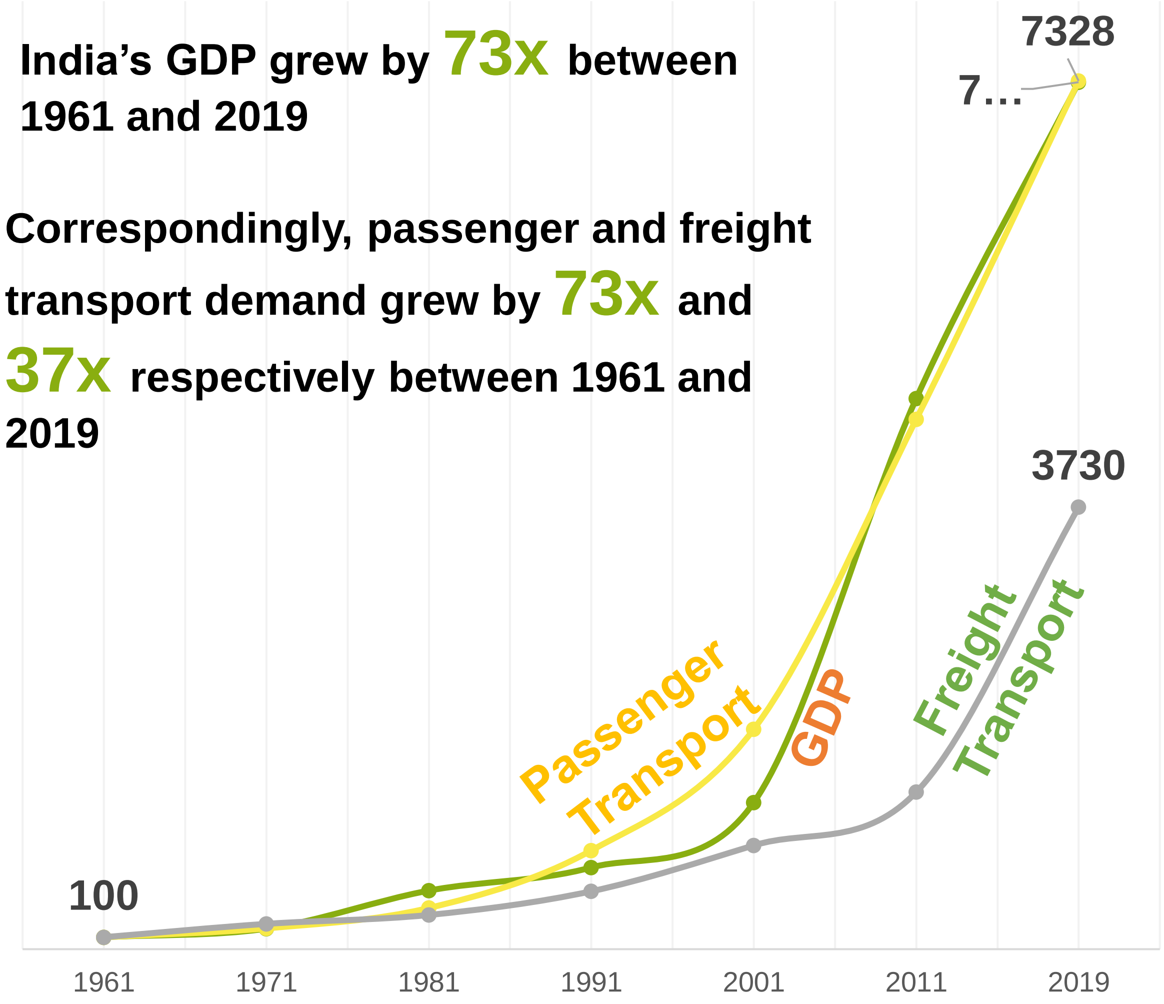
4 | Key policy and regulatory recommendations

India’s GDP growth has been accompanied and sustained by growth in transport demand

Meeting the fast-growing energy demand from the sector in a sustainable way is a top priority for India’s climate goals

India’s GDP grew by 73x between 1961 and 2019

Correspondingly, passenger and freight transport demand grew by 73x and 37x respectively between 1961 and 2019



Transport propels the economy and transport demand is closely linked to economic growth

Key GDP contributor

Transport sector directly contributes **~6.3% of GDP** (2020) in India

Employment generator

Transport **directly** employs **~10%** of the country's working population, and another **18%** indirectly

Multiplier effect

For every **10% increase** in investment in transport, the total output of country may increase by **0.5-1.0%.**

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Methodology

A-S-I Approach for Passenger Transport

AVOID

1. Greenfield alignment of regional routes, removing congestion
2. Invest in NMT infrastructure, public bike sharing platforms
3. Avoid empty movements of freight vehicles
4. Efficiency infrastructure planning to reduce the need for freight transport

Output: Lower transport demand (BPKM/ BTKM)

SHIFT

1. Invest in railways – removing congestion, adding new routes at higher speeds
2. Invest in public transit, offer better quality of service
3. Optimize modal mix to increase the share of climate friendly modes for transport

Output: Modal shift towards public transport and railways

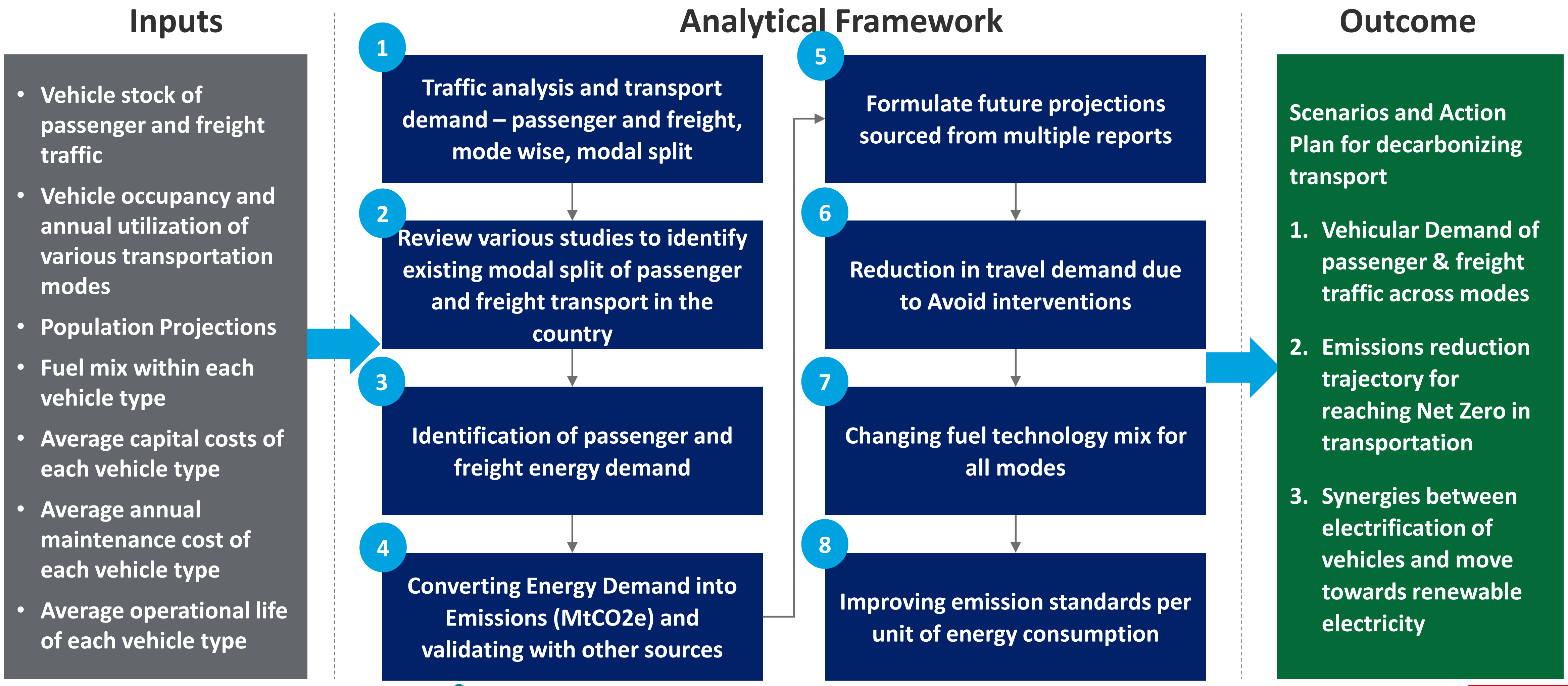
IMPROVE

1. Invest in alternate fuel technology; increase efficiency of existing fuels
2. Use of green logistics (EVs) for first and last mile delivery
3. Full electrification of Indian Railways
4. Use of Sustainable Aviation Fuel in aviation (based on used oil and GH2-based e-fuels)

Output: Improved fuel efficiency, Higher share of ZEVs

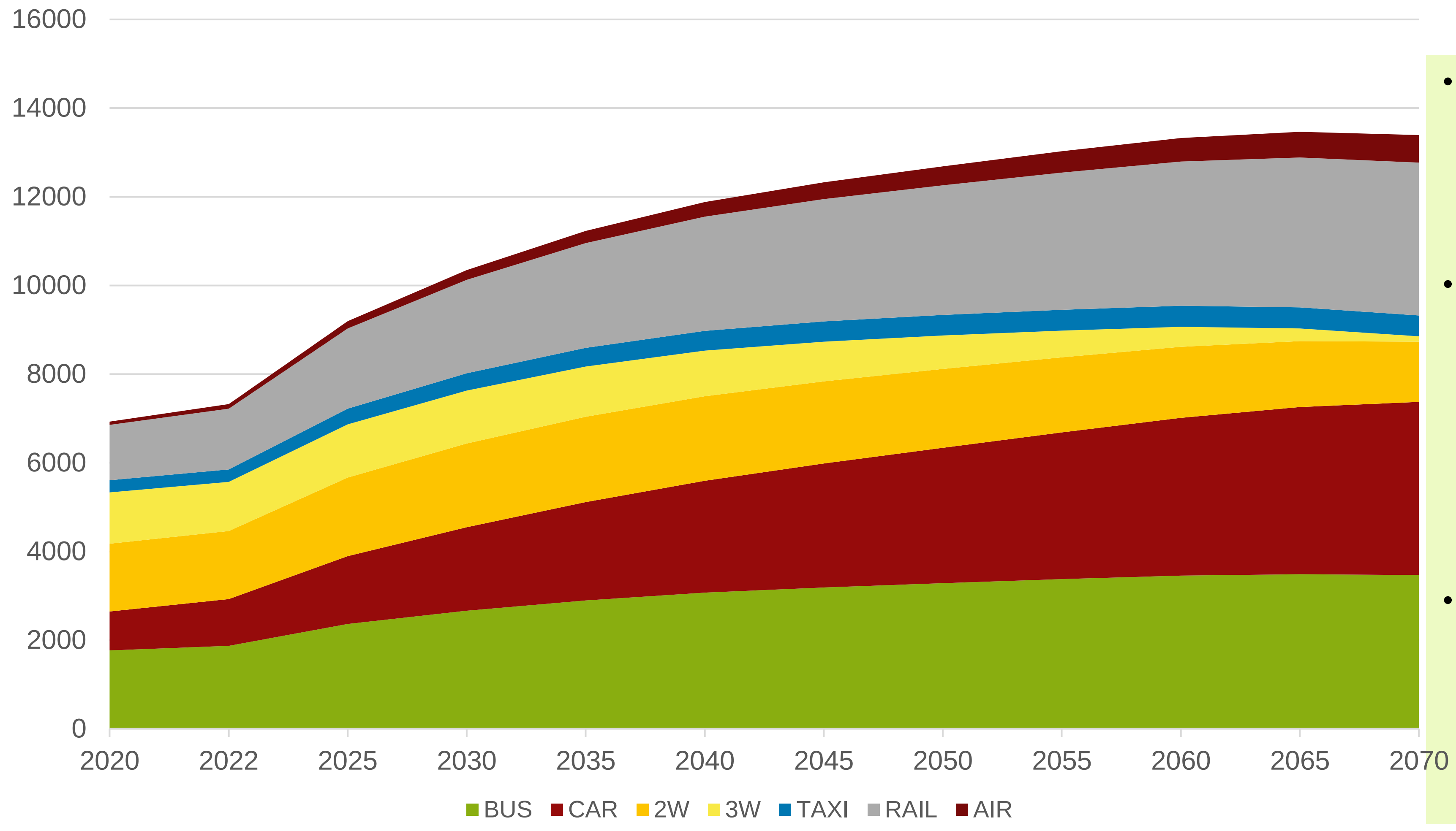
Process to assess transport transition and potential role of financing

We consolidate outcomes from demand and supply assessments to identify transportation emissions within a region



Model Outputs (1/3)

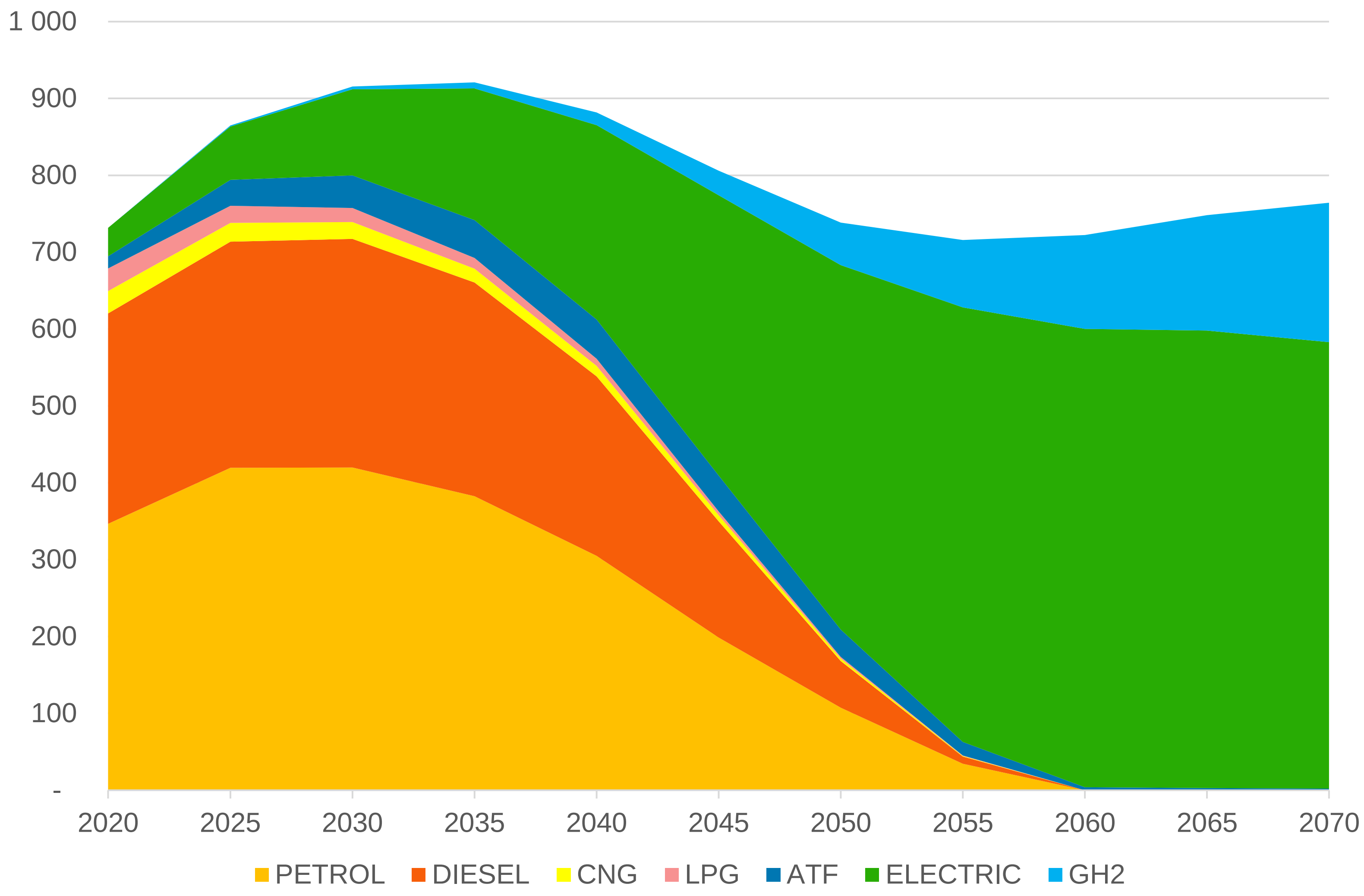
Passenger transport - Transport demand by mode (BPKM)



- Under the NZE scenario, the share of buses declines gradually. However, the decline is limited by additional investments in public transit.
- Further, accelerated electrification of buses is expected on account of reduced cost of e-buses due to active policy push, favourable financing environment and procurement methods and improvements in the battery technology.
- Passengers tend to shift to more personal modes of transport with rising incomes. Timely investments in road and rail networks will be critical to maintaining the share of public transit in the transport mix.

Model Outputs (2/3)

Passenger transport - Energy use by fuel (TWh)

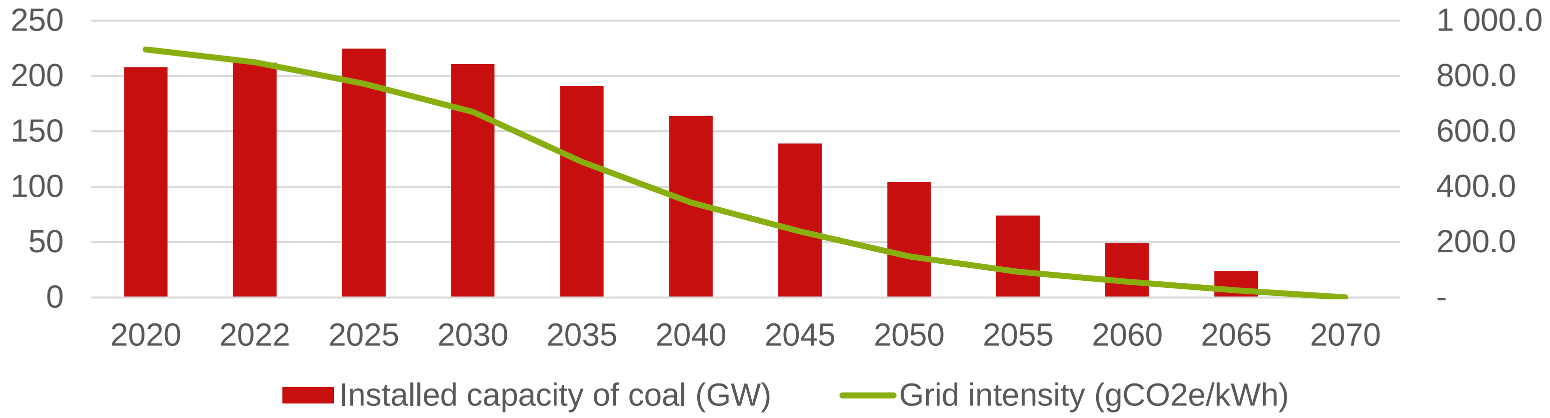


- Diesel presently has a high share of fuel consumption for passenger transport in India due to the high number of buses and use of taxis in the car/ 3W segments.
- However, the demand for petrol/ diesel is expected to peak by 2030s due to the growing share of electric vehicles in the mix
- The shift is first expected in the 2-wheeler and 3-wheeler segments, where BEVs have already achieved cost parity with ICE vehicles.
- Eventually, buses and cars are also expected to shift to electric due to further improvements in battery prices and energy capacities.
- Fuel cell vehicles (FCVs) are only expected to gain market share in the later years (after 2050) once green hydrogen infrastructure has sufficiently developed across the country.

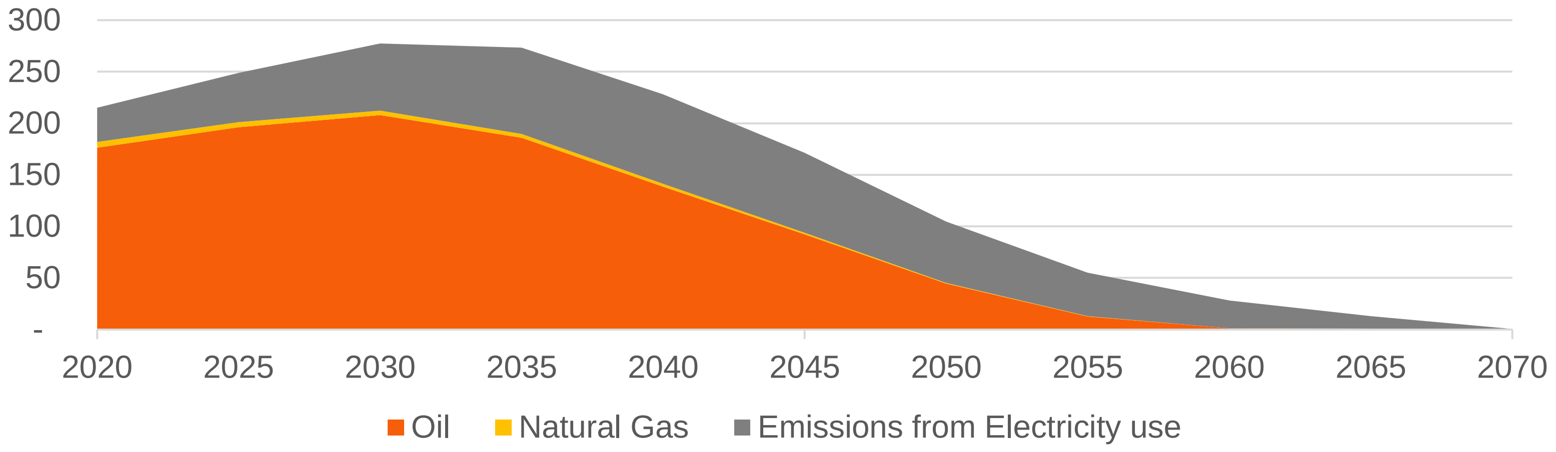
Model Outputs (3/3)

We have considered both emissions from combustion of fossil fuels in engines as well as emissions from production of electricity for charging electric vehicles

Decarbonisation for India's electricity grid under the net zero scenario



Passenger Transport - GHG emissions (MT CO2)



- Tailpipe emissions from the passenger transport sector are expected to plateau at ~200 MT CO2e/year and then start declining by the end of this decade
- However, the model demonstrates that only the uptake of electric vehicles would not be able to stop the rise in emissions from the transport sector
- This is because electric vehicles may initially lead to an increase in the emissions from the electricity sector due to use of coal-based power
- Charging of electric vehicles from renewable electricity thus becomes a crucial part of transport decarbonisation

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Outline

1 | 11 kV feeder analysis for RE based public EV charging

2 | RE based electric bus charging

Impacts of EV Charging on the Grid

NDC TRANSPORT INITIATIVE FOR ASIA

Component Overload

Component Loading:

Tendency for uncontrolled charging in peak hours to result in

- Requirement of Infrastructure Upgrade of T&D network, distribution feeders and transformers
- Procuring Costly generation sources for meeting peak demand

Voltage: to what extent does EV loading adversely impact system voltage regulation

Location of EV charging Station

Unbalance: potential for disproportionate penetration on particular phase and results on system unbalance

Losses: impact on distribution system losses

Power Quality and harmonics

EV battery chargers use power electronic devices to convert AC to DC power. This conversion process can cause voltage and current harmonic distortion

The harmonics have impact on the distribution assets which reduces their life-span and also cause false tripping in the case of protection equipment. Majorly the following assets are affected the most:

- Transformers
- Power Cables
- Relays, Switchgear and Metering Equipment
- Capacitors

Optimal location of EV charging station minimizes the infrastructure cost for distribution companies while achieving same revenue from energy sales

11 kV Feeder Analysis

NDC TRANSPORT INITIATIVE FOR ASIA

Objective

- The objective involves modeling scenarios of Electric Vehicle (EV) charging stations at feeders scenarios including solar rooftop systems and normal daily load profiles in the distribution system.

Key Aspects Studied

01 Hosting Capacity of the Network

02 Power Quality – Voltage Regulationa and Losses

03 Load Profile Changes due to EVs

04 Feeder Simulations with Regular Loads

05 Feeder Simulations with Regular Loads and EVs

06 Feeder Simulations with Regular Loads, EVs and Solar Rooftop

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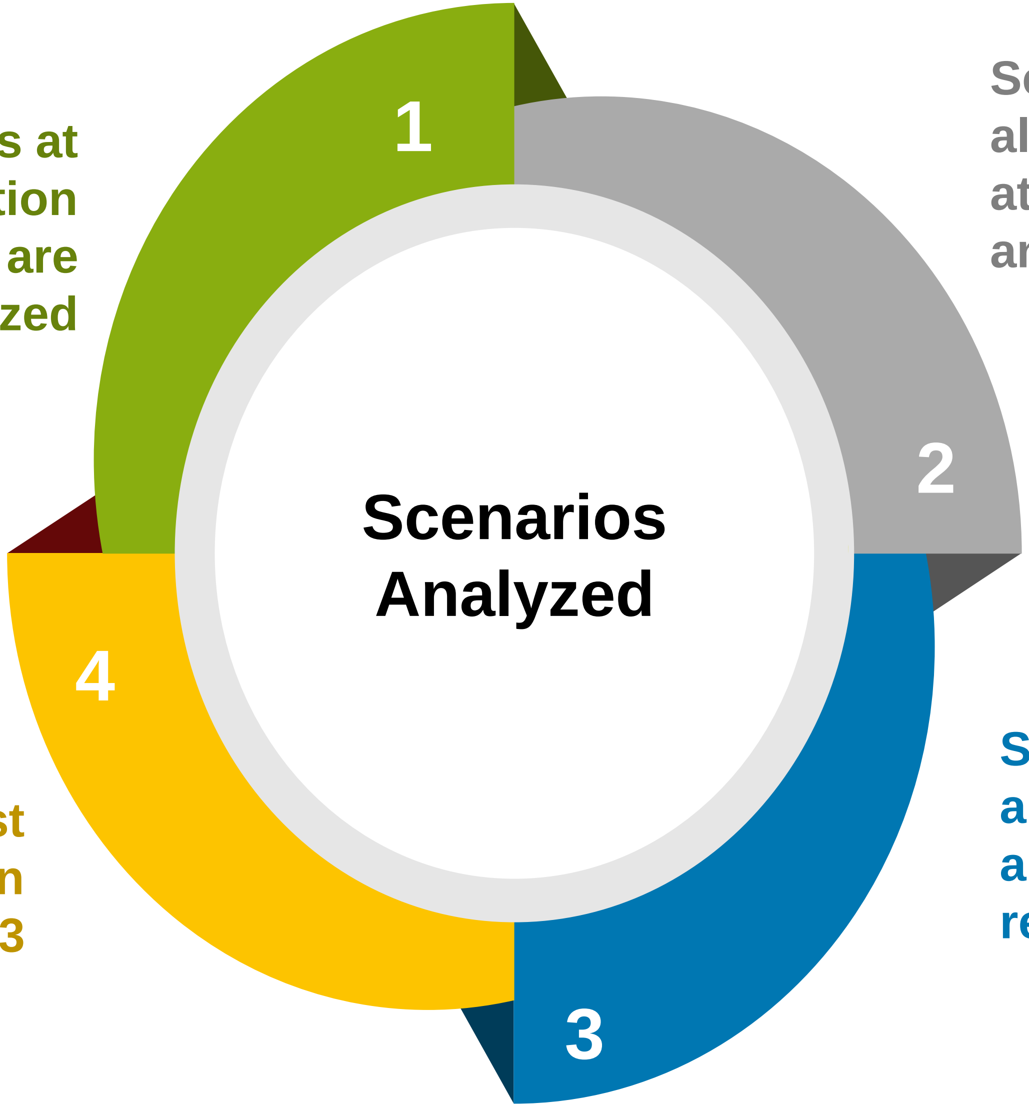
11 kV Feeder Analysis

Scenario – 1: Daily loads at the respective Distribution Transformers (DTs) are analyzed

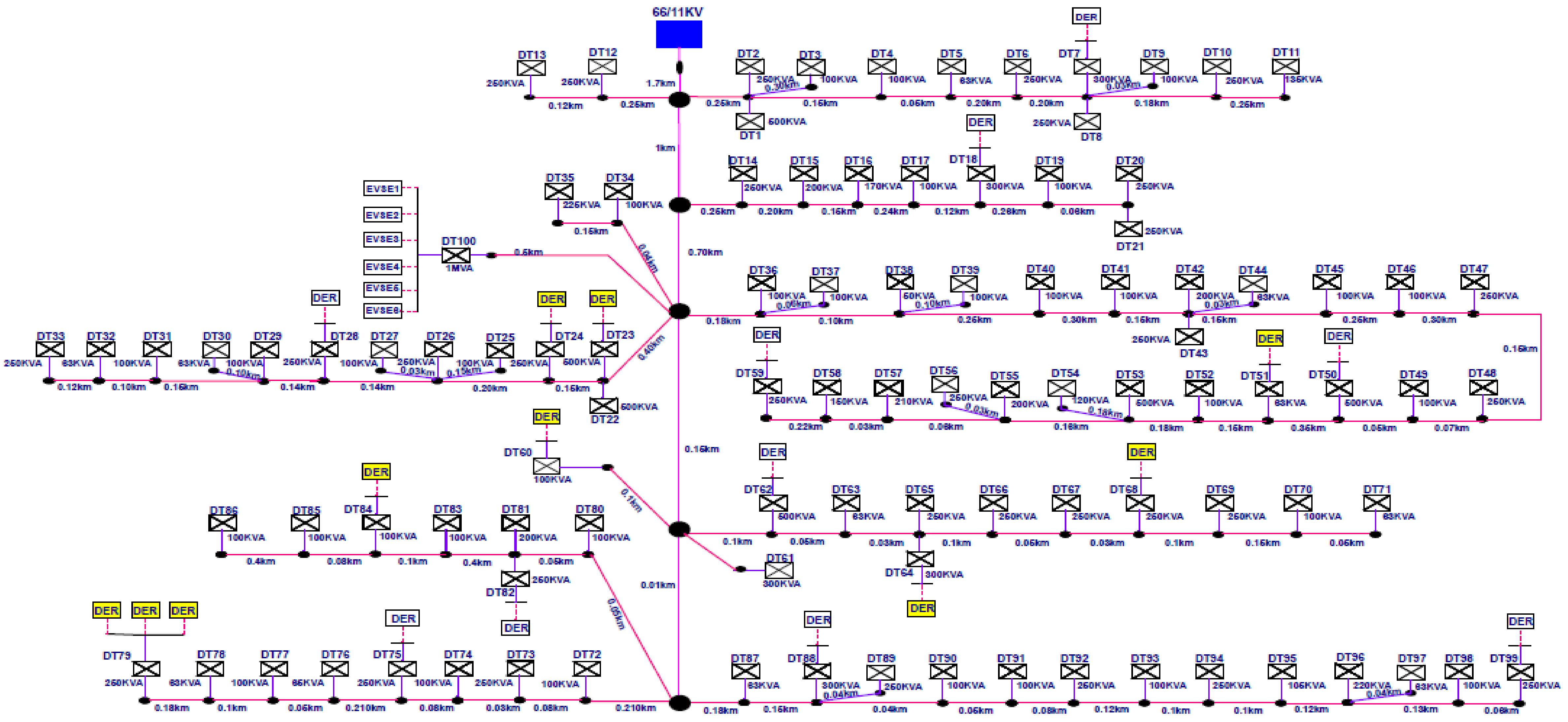
Scenario – 2: Daily loads along with e-vehicle loads at the respective DTs are analyzed



Scenario – 3: Daily loads along with e-vehicle loads and solar rooftop at the respective DTs are analyzed

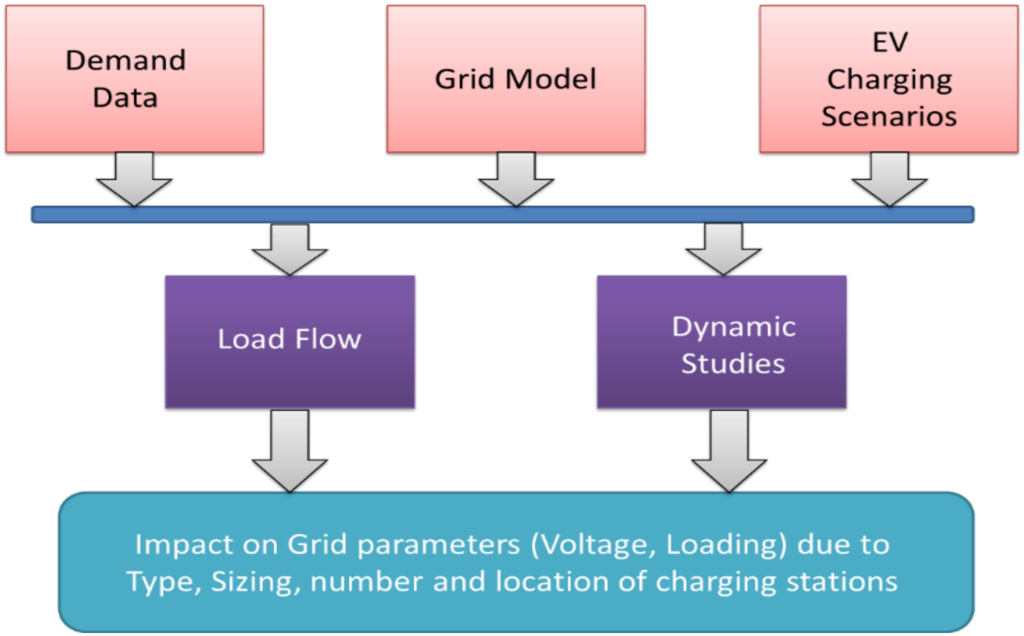
Scenario – 4: Public fast charging has been studied in tandem with the scenario-3

Sample Feeder - Analysis



Methodology

Process Flow of EV Impact Studies



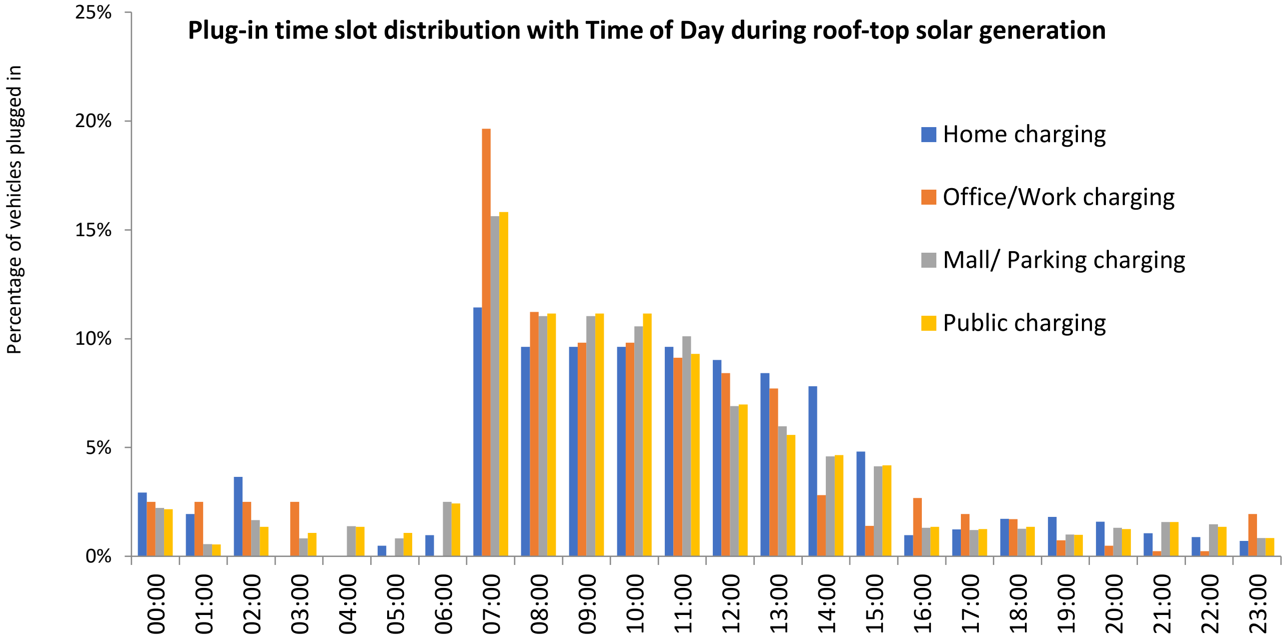
Average Battery Sizes for 2025-26

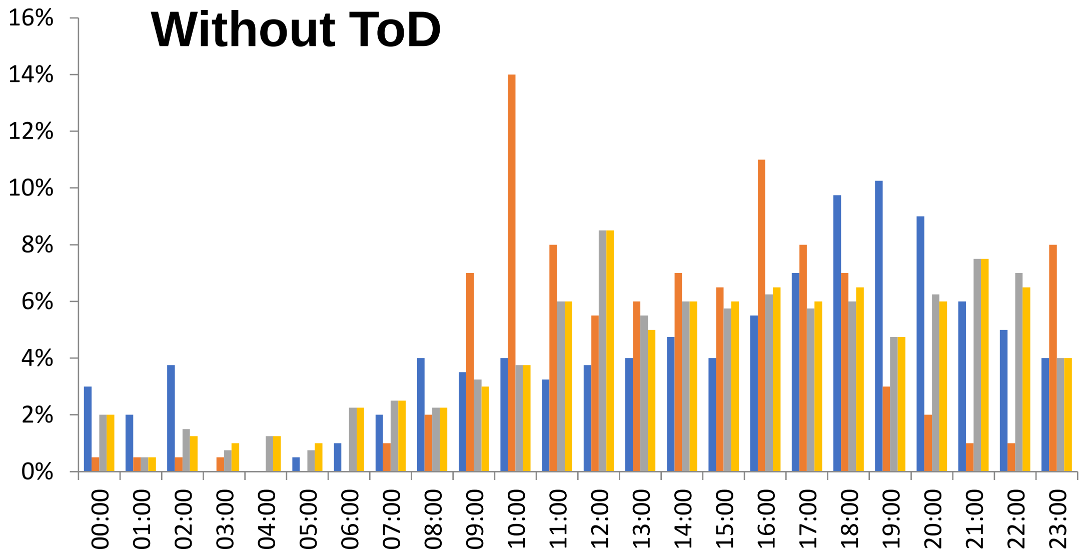
Vehicle Category	Battery Size in kWh
2W	4.5
3W	15
4W	80

Assumptions Considered for the EVs Impact Study

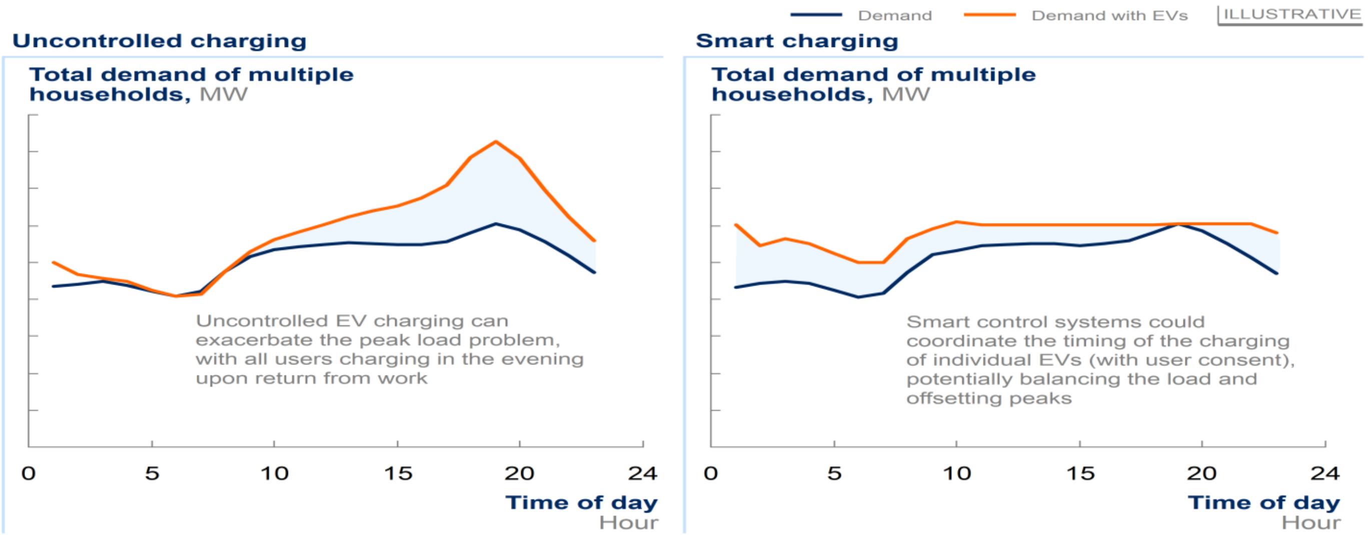
2 Wheelers		
Capacity kWh	Charges/day	Energy Consumed (kWh)/day
4.5	447	2011.5
3 Wheelers		
Capacity kWh	Charges/day	Energy Consumed (kWh)/day
15	102	1530
4 Wheelers		
Capacity kWh	Charges/day	Energy Consumed (kWh)/day
80	202	16160

Simulation Studies for Sample Feeders





Smart charging through time of day (ToD) charge makes the peak demand within the limits and lower the grid infrastrucre requirements while making same revenue from energy sales for distribution companies



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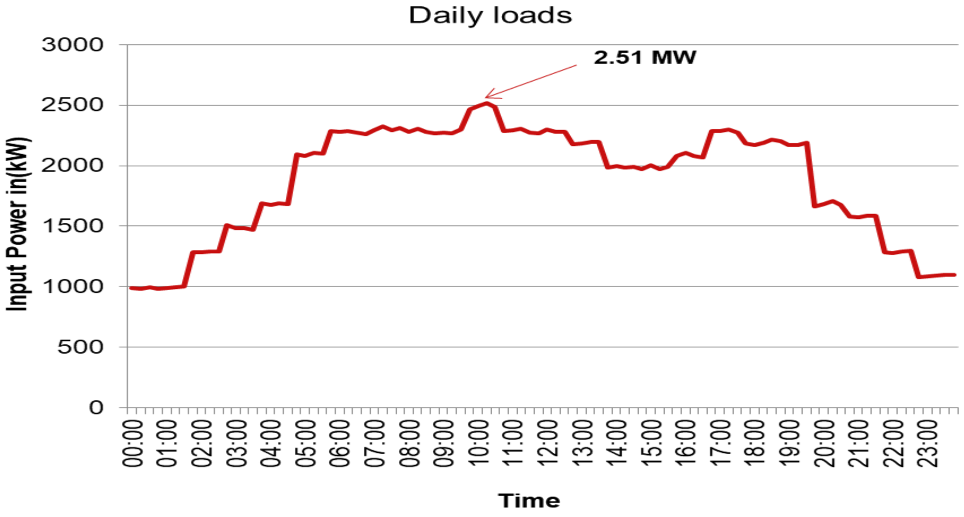
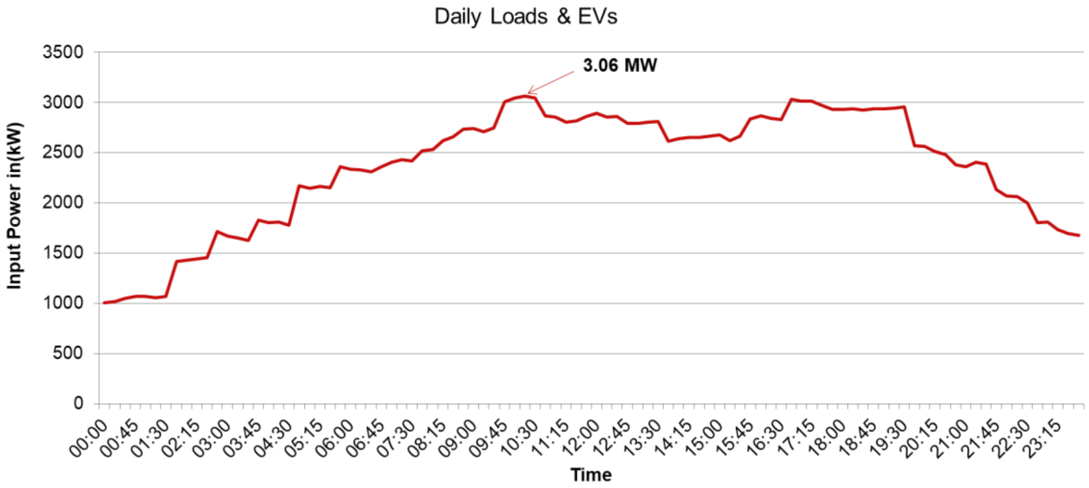
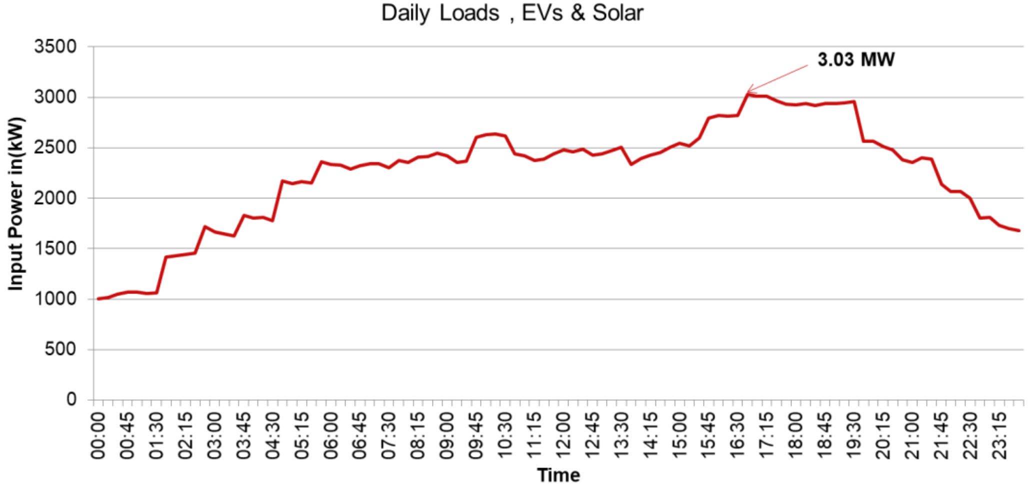
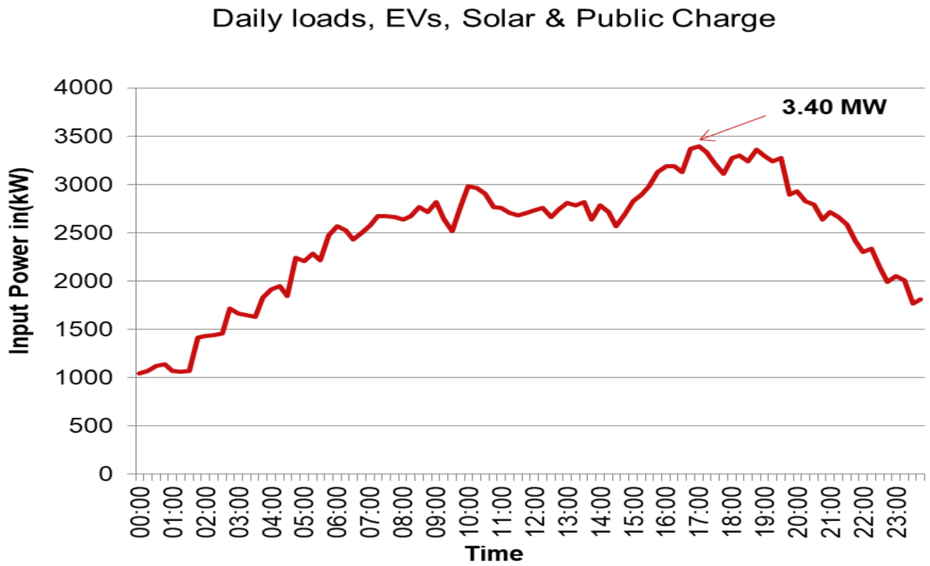
Simulation Studies for Sample Feeder

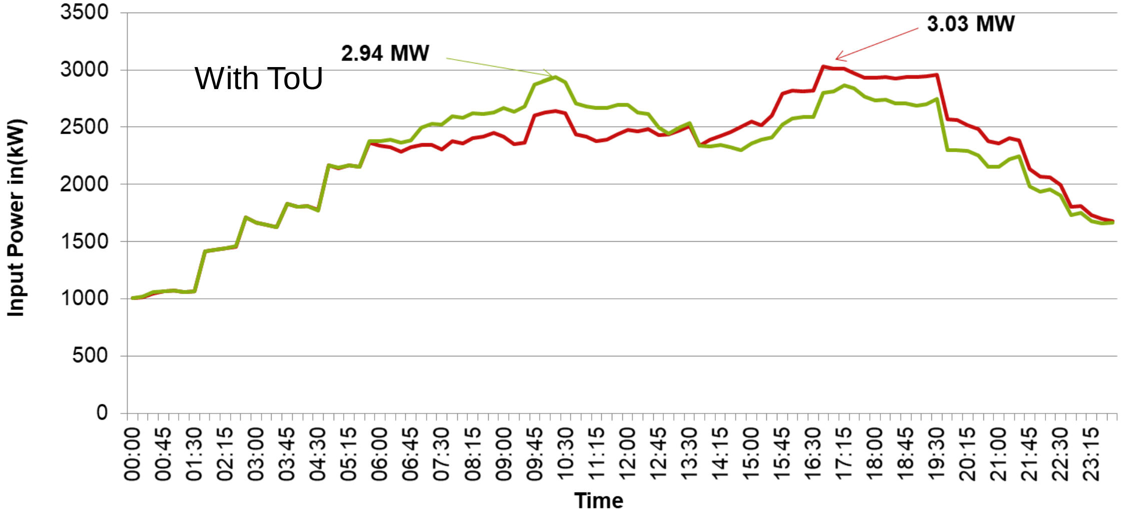




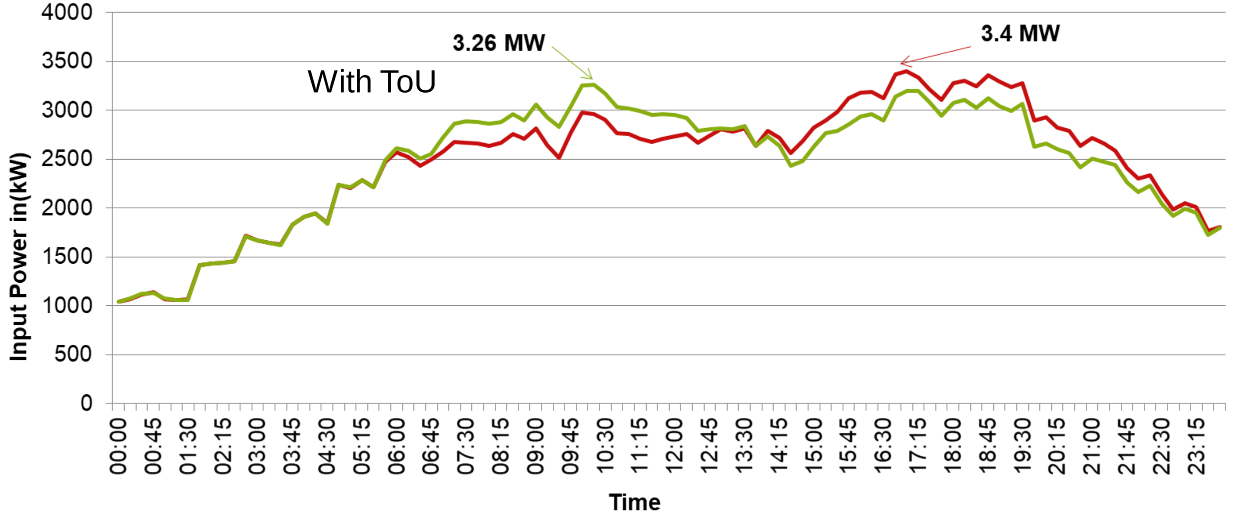




Simulation Studies for Sample Feeder



Comparison of Power Drawn for Daily loads, EVs and solar with TOU and without TOU



Comparison of Power Drawn for Daily loads, EVs, Solar & Public chargers with TOU and without TOU

Grid Integration – RE based EV Charging for Bus Depot

Scenario – 1: Time-series load flow analysis with e-Bus charging load

Scenario – 2: Charging of e-Bus along with bus depot auxiliary consumption (i.e., regular loads) has been presented

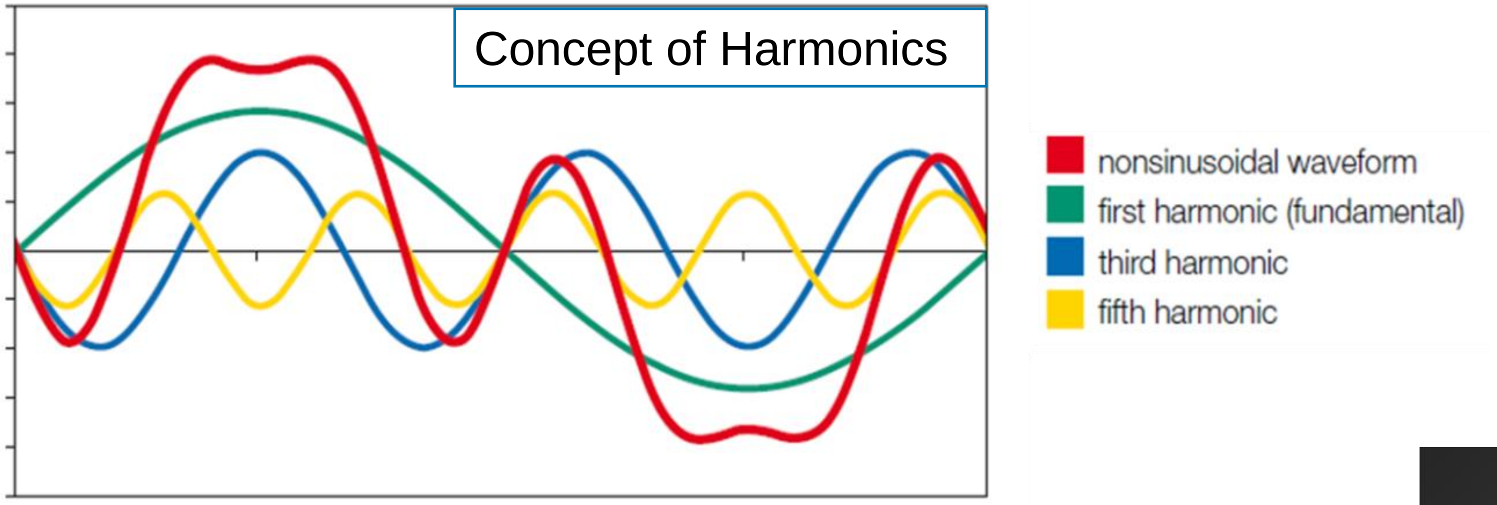
Scenario – 3: e-Bus charging along with regular bus depot loads and solar rooftop generation have been analyzed

Scenario – 4: Optimal e-bus charging was developed by shifting some of the e-buses charging times to minimize the impact on the network loading

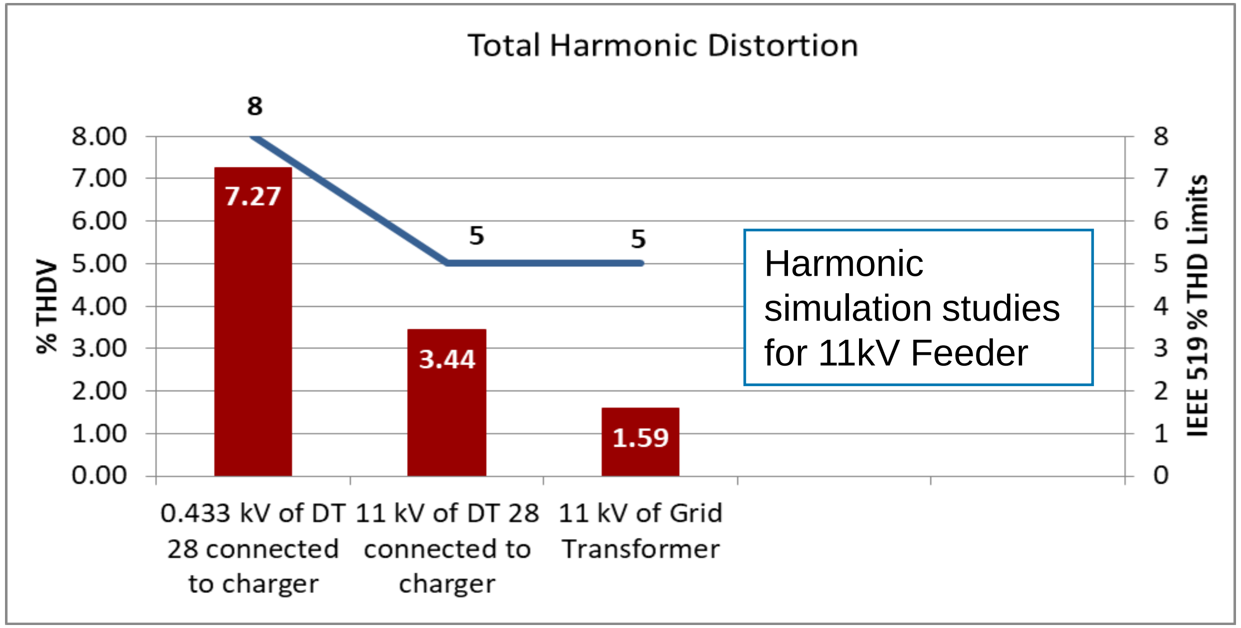
Travel Pattern of e-Bus Charging

TIME	EVSE1	EVSE2	EVSE3	EVSE4
12:15:00	MF378/21(EV10)			
12:30:00	MF378/21			
12:45:00	MF378/21			MF378/18(EV44)
13:00:00	MF378/21			MF378/18
13:15:00	MF378/10(EV11)	MF378/22(EV29)		MF378/18
13:30:00	MF378/10	MF378/22	MF378/5(EV40)	MF378/18
13:45:00	MF378/10	MF378/22	MF378/5	MF378/13(EV45)
14:00:00	MF378/10	MF378/22	MF378/5	MF378/13
14:15:00	MF378/29(EV12)	MF378/27 (EV30)	MF378/5	MF378/13
14:30:00	MF378/29	MF378/27	MF378/1 (EV41)	MF378/13
14:45:00	MF378/29	MF378/27	MF378/1	MF375D/4(EV46)
15:00:00	MF378/29	MF378/27	MF378/1	MF375D/4
15:15:00		MF378/47(EV31)	MF378/1	MF375D/4
15:30:00	MF378/20(EV13)	MF378/47	MF375D/24(EV42)	MF375D/4
15:45:00	MF378/20	MF378/47	MF375D/24	MF375D/7(EV47)
16:00:00	MF378/20	MF378/47	MF375D/24	MF375D/7
16:15:00	MF378/20	MF375D/6(EV32)	MF375D/24	MF375D/7
16:30:00		MF375D/6	MF375D/13(EV43)	MF375D/7
16:45:00	MF375D/25(EV14)	MF375D/6	MF375D/13	MF375D/8(EV48)
17:00:00	MF375D/25	MF375D/6	MF375D/13	MF375D/8
17:15:00	MF375D/25		MF375D/13	MF375D/8
17:30:00	MF375D/25	MF378/26(EV33)		MF375D/8
17:45:00		MF378/26		
18:00:00	MF378/17(EV15)	MF378/26		
18:15:00	MF378/17	MF378/26		
18:30:00	MF378/17			
18:45:00	MF378/17	MF378/7(EV34)		
19:00:00		MF378/7		
19:15:00	MF375D/34(EV16)	MF378/7		

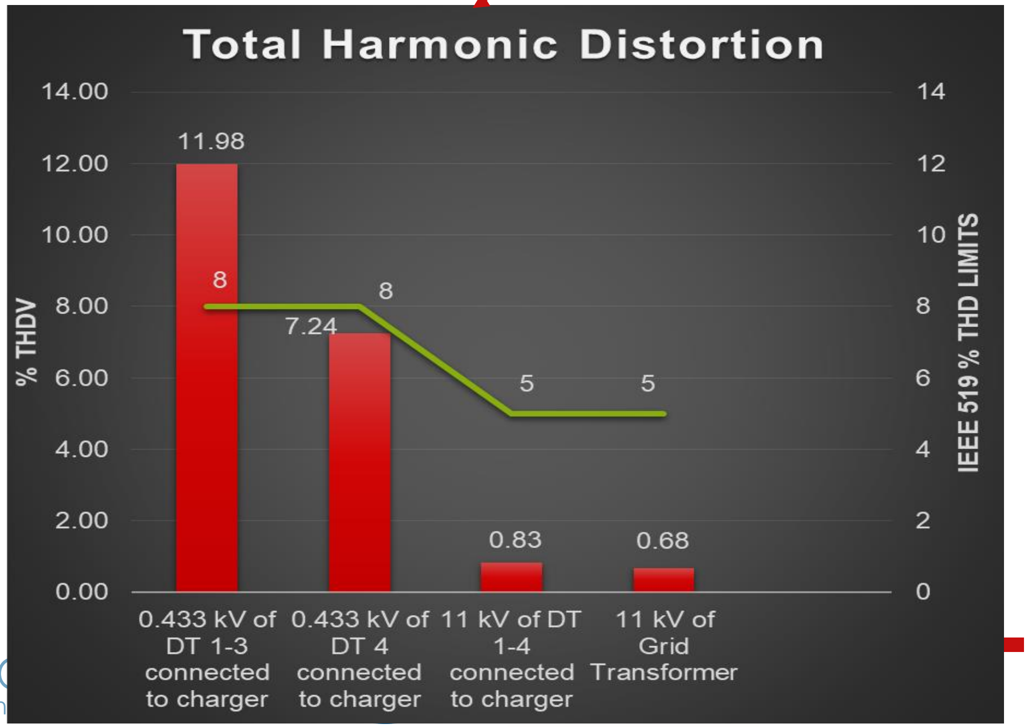
Impact of EV Charging on Power Quality



Harmonics measured are injected in simulation studies to verify whether the harmonic distortion limits is within the limits specified by IEEE 519



Harmonic simulation studies for bus depot



Observations and Recommendations of 11 kV feeder Analysis

Short-term strategy (1 -2 years):	Medium-term strategy (3-5 years):	Long-term Strategy (above 5 years):
• Allow the connectivity of EV charging stations at the start or middle of the 11kV feeder. • The distribution transformer rating can be selected so that the total connected load of EV chargers is below 50% of the DT rating. This will avoid any overloading or overheating issues of DT due to the fast charging behavior of EV chargers. • Impose harmonics compliance for EV charging stations as per CEA connectivity regulations (i.e. compliance with IEEE 519-2014).	• Incentives for EV charging stations with DERs (Distributed Energy Resources) • Identify the potential locations for EV charging stations in such a way that the requirement of new distribution infrastructure is minimal • Perform the load flow studies for deployment of EV charging stations • Implement Time of Day (ToD) or Time of Usage (ToU) tariff • Look for control strategies for EV charging to support grid loading	• Allocate a dedicated group with 1 or 2 resource persons) for planning studies under EVs cell or planning cell for EV charging stations assessment. The role of this group is to plan the required EV charging stations with minimal distribution infrastructure additions while make sure same EV energy sales. • Implement the control strategies for EV charging and Vehicle to Grid services (This requires 2-way communication between DISCOM and EVs through aggregators)

Recommendation for Bus Depot

As per the travel pattern of buses, the required number of EV chargers and its capacity was suggested to charge all the buses. The required grid infrastructure like DT and grid transformer capacity along with import line capacity was suggested

As it is observed from simulation studies, the e-bus charging can be optimised by altering the present bus schedules. Hence, looking into the RE profile and maximum bus charging demand, tranportation departments can look into the possibilities of shifting e-bus charging schedule to reduce the peak load of the feeder.

To optimize the electrical infrastructure further, roof-top solar generation in bus-depot is recommended. RE based e-bus charging enables to minimise the loading on feeder and, distribution transformers.

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Our approach for assessing commercial feasibility

Integrated approach considering multiple RE procurement routes and business models

1. General EV charging assumptions

- Charger types (rating), auxiliary infrastructure (**Capex + Opex**)
- Charger ratings up to 50 kW with 8 years life

- Energy charges (**Discom specific**)
- Charges for Transmission, Wheeling, CSS, AS

Project setup and operational costs

2. Power procurement route specific assumptions

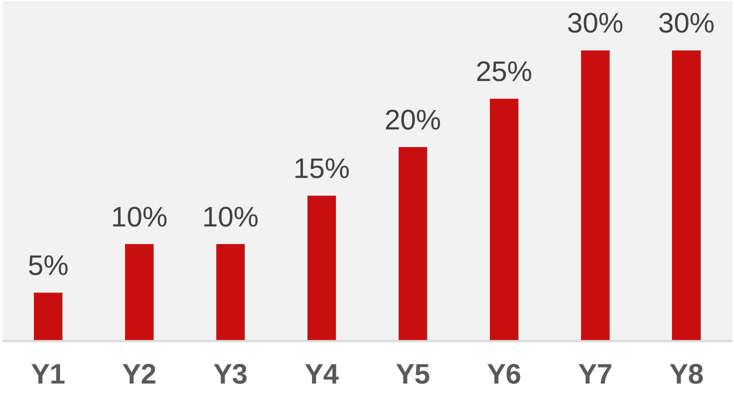
1. **Electricity from the grid (Non-RE)**
2. **Third party open access RE**
3. **Solar installation (On-site generation in capex mode)**
4. **Solar installation (On-site generation in opex mode)**
5. **Off-grid solar and BESS (standalone system with no net-metering provision)**

Scenario specific Capex & Opex costs

Calculate the Levelised cost of energy for each route

Key assumptions

Particulars	Value
Station configuration	• 2 CCS Fast chargers, • 2 CHAdeMO Fast chargers, • 2 Bharat DC – 001 chargers
Charger utilization	(chart below)
Land cost	• **Lease on land?** Yes; INR 1/kWh



Capex assumptions

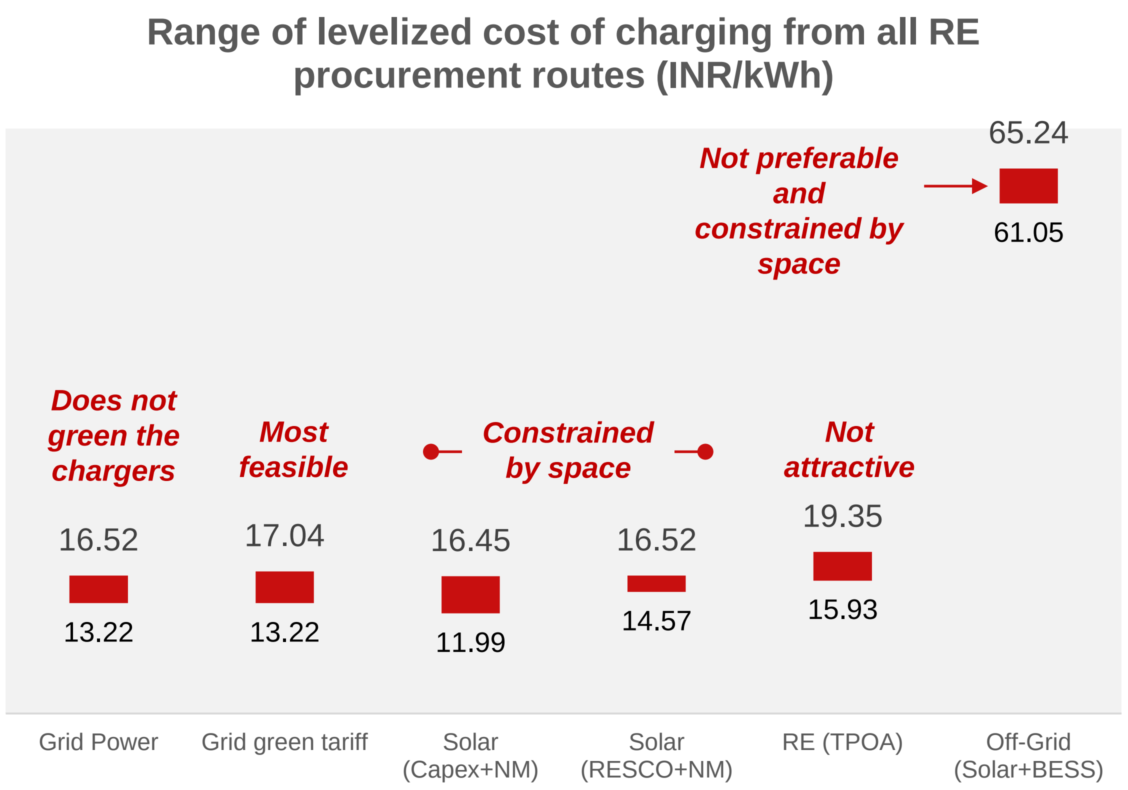
Particular	Value (INR Lacs)
Electricity infrastructure	9.5
Civil Works	2.75
EVSE Management Software	0.65
CCTV Camera System	0.5
Cabling cost	0.52

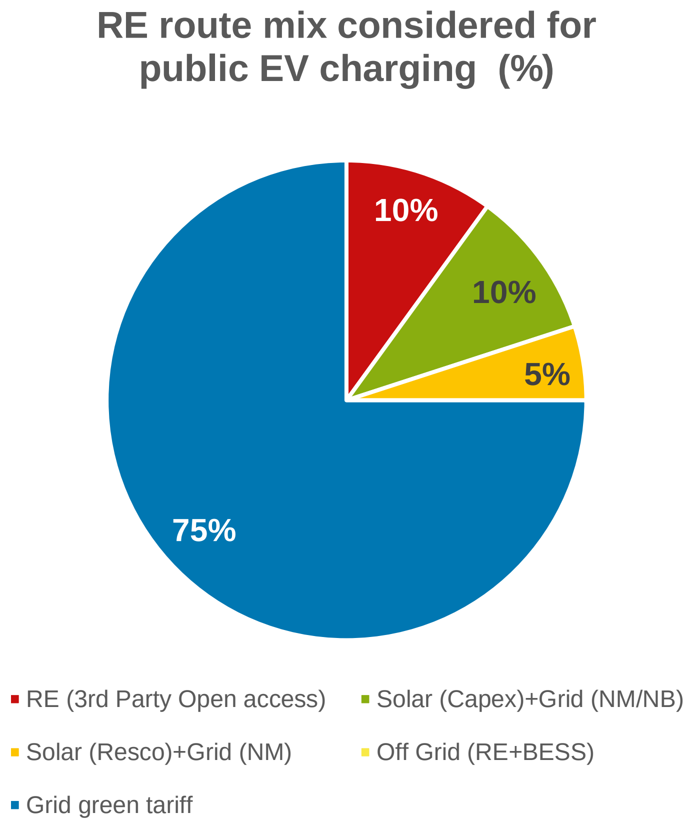
Operational assumptions

Particulars	Unit	Value
Manpower required	nos.	1
Yearly salary per manpower	INR Lakhs	3.00
Annual Network subscription fees	INR Lakhs	0.60
Annual advertisement expense	INR Lakhs	0.60

Key outputs

A comparative view of all RE power procurement routes in Bangalore, Panaji, and Kolkata





Landed LCOE: **INR 12.44 – 13.84/kWh**

Benefits can be accrued by **diversifying** RE procurement routes; In this case LCOE is economical compared to procurement from grid power

- Capex based solar installations with net metering enable the charging station to net off its usual consumption from the grid. However, availability of space is a significant constraint due to presence in high traffic areas.
- Other than off-grid installations, RE third party open access has the highest LCOE. Reduction in open access charges and discovered RE RTC tariff is critical to bring parity with conventional grid power-based charging.

Recommendations

Extend concessions on open access charges from RE sources

Issue addressed: High landed cost of OA

1 Concessions on OA charges to be extended for hybrid

Provide subsidies for solar coupled charging stations

Issue addressed: High cost of off-site installations

2 Subsidies for solar coupled chargers

3 Promote Group / Virtual Net Metering

Group net metering in coordination with building loads can help navigate through space constraints and allow proliferation of solar capacities

Issue addressed: Limited space

4 Creation of State-Level Fund

Fund to provide subsidies for EV charging stations incorporating Solar and BESS installations

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Short and Medium-term recommendations to promote RE-EV charging

Sl.	Recommendation	Applicability	Stakeholders
1	Provide incentives for RE installations dedicated towards EV charging	States	State renewable energy development agency, finance department, Distribution companies
2	Provide incentives on smart/ bi-directional chargers / RE based EV chargers	States	State finance department, Distribution companies
3	Provide land at concessional rates for EV chargers	States	State Nodal agency for EV charging infrastructure
4	Provide incentives to reduce open access charges for RE based EV charging stations	States	Distribution companies, State finance department, SREDA
5	Development of state level fund for RE based EV charging stations	States	State Nodal agency for EV charging infrastructure, State finance department
6	Formulate green tariffs to provide additional avenue for green power procurement	States	Distribution company, SERC
7	Formulate green energy open access (GEOA) regulations	States	Distribution company, SERC
8	Formulate innovative net-metering (NM) provisions	States	State Electricity Regulatory Commission, Distribution companies

Short and Medium-term recommendations to promote RE-EV charging

Sl.	Recommendation	Applicability	Stakeholders
9	Provide relaxation on maximum installed rooftop solar capacity	States	State Electricity Regulatory Commission, Distribution companies
10	Undertake changes in the net-metering regulations	States	State Electricity Regulatory Commission, Distribution companies
11	Enhance remuneration for excess generation by solar rooftop installed in consumer premises	States	State Electricity Regulatory Commission, Distribution companies
12	Adoption of latest communication protocols for RE based EV charging (for chargers and solar installations)	National	CEA, BIS
13	Formulate innovative tariff mechanisms for consumers	States	SERCs, Discoms
14	Benchmarking pilots to establish value streams emerging from EV charging	States, National	CERC, SERCs, Discoms

Long-term recommendations to promote RE-EV charging

Sl.	Recommendation	Applicability	Stakeholders
15	Outline regulations for enabling aggregation of DERs	National	CERC
16	Establishment of virtual power plants (VPP) technology through demonstration programs	States, National	CERC, SERCs, Discoms
17	Formulation of Demand Response (DR) regulations	National	CERC, Forum of regulators
18	Encourage participation of utilities in load control programmes	States, National	Distribution companies
19	Active participation in demand response by utilities	States, National	Distribution companies
20	Conduct pilots on use of bi-directional chargers	States	Discoms, aggregators
21	Enabling virtual PPAs and P2P trading	States, National	CERC, SERC, Discoms

Access the report on Renewable energy-based EV charging

https://greenmobility-library.org/public/index.php/single-resource/MTIvRzRQa2pXMTZZczI4eXZQb0g2QT09

THANK YOU!