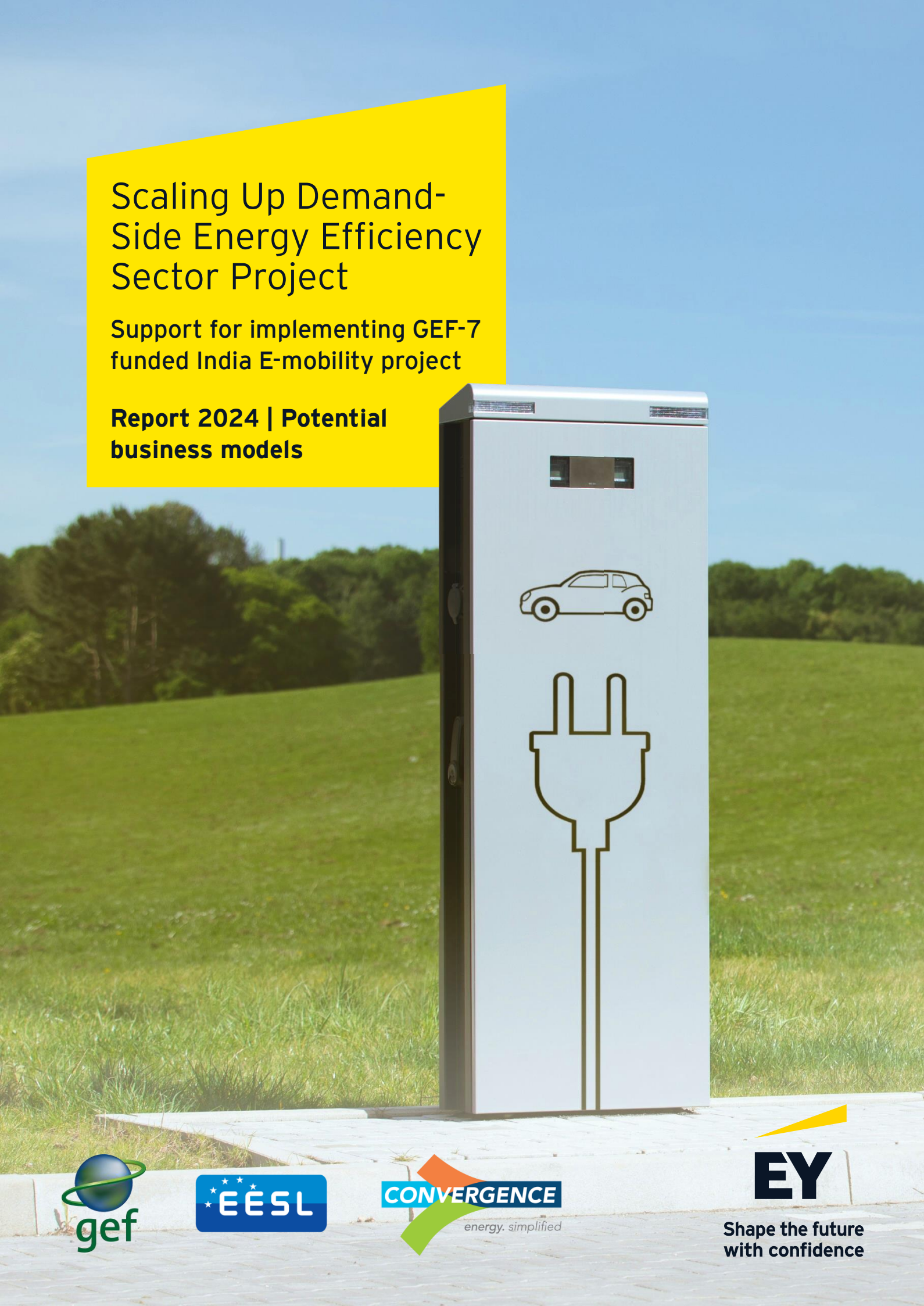
Scaling Up Demand-Side Energy Efficiency Sector Project

Support for implementing GEF-7 funded India E-mobility project

Report 2024 | Potential business models



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Acknowledgement

India's Transport Sector faces critical challenges amidst population growth and urbanization, prompting a need for sustainable solutions. Recent initiatives like FAME and PLI highlight a shift towards EVs. Collaborative efforts with ADB and CESL underscore a commitment to greener transport.

For the project "**Scaling Up Demand-Side Energy Efficiency Sector**", Special recognition is extended to the Asian Development Bank (ADB), represented by Mr. Choon Sik Jung, Mr. Samrat Ray and Mr. Vikas Atre, for securing technical assistance from the Global Environment Facility (GEF) for supporting scale up of electric mobility and charging infrastructure in India through partnerships into new domains. Their collaborative efforts aim to catalyse the transformative shift towards decarbonizing transport modes and reducing air pollution, aligning with the overarching goal of fostering e-mobility uptake in India.

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List of
Abbreviations

2W	Two-Wheeler
3W	Three-wheeler
4W	Four-Wheeler
ADB	Asian development Bank
ARAI	Automotive Research Association of India
ARAI	Automotive Research Association of India
ASHA	Accredited Social Health Activist
BaaS	Battery as a Service
BDS	Battery Development Ecosystem
BEE	Bureau of Energy Efficiency
BESS	Battery Energy Storage System
BIS	Bureau of Indian Standards
BLDC	Brushless Direct current Motor
BOOT	Build-Own-Operate-Transfer
BSCDCL	Bhopal Smart City Development Limited
CaaS	Charging as a Service
CAGR	Compound annual growth rate
CAN	Controlled Area Network
CEA	Central Electricity Authority
CESL	Convergence Energy Services Limited
CMVR	Central Motors Vehicles Rules
CNA	City Nodal Agencies
CNG	Compressed Natural Gas
CO_2	Carbon Di-oxide
COP	Conference of the Parties
CPO	Charging Point Operator
CPSU	Central Public Sector Undertaking
DHI	Ministry of Heavy Industry
DULT	Directorate of Urban Transport
E3W	Electric 3-Wheeler
EESL	Energy Efficiency Services Limited
EV	Electric Vehicles
EVCI	Electric Vehicles Charging Infrastructure
EVSE	Electric Vehicle Supply Equipment
EY	Ernst & Young
FAME	Faster Adoption and Manufacturing of Electric Vehicles
FI	Financial Institute
FI's	Financial Institutions
GDP	Gross Domestic Product
GEF	Global Environment Facility
GIS	Geographic Information Systems
GOI	Government of India

I2C	Inter-integrated Circuit
ICAT	International Centre for Automotive Technology
ICE	Internal Combustion Engine
KPI	Key Performance Indicators
LFP	Lithium Ferrous Phosphate
LLP	Limited Liability Party
MCC	Mysore City Corporation
MoEF&CC	Ministry of Environment, Forest, and Climate Change
MoF	Ministry of Finance
MoHUA	Ministry of Housing and Urban Affairs
MoP	Ministry Of Power
MoRTH	Ministry of Road Transport & Highways
MoST	Ministry of Science & Technology
NBFC	Non-Banking Financial Companies
NDMC	New Delhi Municipal Corporations
NiMH	Nickel-Metal Hydride
NMT	Non-Motorised Transportation
O&M	Operations and Maintenance
OEM	Original Equipment Manufacturer
PBS	Public Bicycle Sharing
PCS	Public Charging Stations
PLI	Production Linked Incentive
PMC	Pune Municipal corporation
PMSM	Permanent Magnet Synchronous Motors
PPA	Power Purchase Agreement
PPP	Public private Partnership
PV	Photovoltaic
RE	Renewable Energy
SHG	Self Help Group
SLB	Service Level Benchmark
SMEV	Society Of Manufacturers of Electric Vehicles
SNA	State Nodal Agencies
SoC	State of Charge
SOP	Standard Operation Procedure
TA	Technical Agreement
TCO	Total Cost of Ownership
UART	Universal Asynchronous Receiver/Transmitter
ULB	Urban Local Body
UT	Union Territory
VAHAN	Vehicle in Sanskrit
WTi Cables	Winding Temperature Indicator

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1. Executive summary

The Transport Sector in India plays a critical role in fostering economic growth and facilitating the movement of goods and people across the country. With the increasing population and urbanization, the demands placed on the transport infrastructure have been growing exponentially. In recent years, there has been a greater emphasis on adopting sustainable and environmentally friendly transportation solutions to mitigate the adverse effects of greenhouse gas emissions.

India is the world's fourth largest car manufacturer, making EVs a potential source of economic growth and exports. There are two flagship national programmes to support road transport electrification in India: The Faster Adoption and Manufacturing of Electric Vehicles (FAME) scheme, which provides purchase incentives and charging infrastructure support and the Production-Linked Incentive (PLI) schemes that provide incentives for manufacturing in different sectors. Numerous state-adopted policies complement national programmes.

In recent years, the emergence of Electric Vehicles (EVs) has revolutionized the transport sector in India. EVs offer a sustainable alternative to conventional fuel-powered vehicles, reducing air pollution and dependence on fossil fuels. The Government of India has been actively promoting EVs through various initiatives such as tax incentives, subsidies, and setting up charging infrastructure. These measures have led to a significant increase in the adoption of EVs across the country.

Furthermore, the transport sector in India is witnessing a transformation with the introduction of innovative technologies and digital solutions. The integration of information technology in transport operations has resulted in improved efficiency, safety, and reliability. Technologies such as GPS tracking, online ticketing systems, and real-time traffic updates have made traveling more convenient and seamless. Additionally, app-based ride-sharing services have gained popularity, offering an efficient and cost-effective mode of transportation.

The Asian Development Bank (ADB) has secured technical assistance (TA) from the Global Environment Facility (GEF) for India electric mobility (e-mobility) project. The overall objective of the TA is to enable the Government of India and other relevant stakeholders to make the transformative shift to de-carbonize modes of transport and reduce air pollution in cities in India by wider up-take of e-mobility. This TA has been processed by ADB as additional financing to the ongoing Scaling Up Demand-Side Energy Efficiency Sector Project 1 which is aligned with ADB approved loan to Energy Efficiency Services Limited (EESL) Scaling Up Demand-Side Energy Efficiency Sector Project to target upstream energy efficiency opportunities, including deployment of e-vehicles and charging infrastructure, smart metering system, and distributed solar photovoltaic systems.

The assignment is supporting the executing agency, EESL, and Convergence Energy Services Limited (CESL), to deliver two key interlinked set of activities under the GEF funds (i) market assessment, charging infrastructure plans, business models and financing applications developed, and disseminated to city authorities and public and private entities; and (ii) pilot subprojects implemented establishing business model (2 wheels, 3 wheels, and 4 wheels) for further investments by public and private entities and financing institutions.

This report has been developed as part of ADB-GEF-EESL Collaboration on upcoming technologies and advancements in the electric mobility sector and how the country can boost the EV deployment exponentially.

The report has primarily covered following five case studies:

(i) E-Micro mobility -Electric Bicycles an optimal solution

(ii) Three-Wheeler Retrofit Market in India

(iii) Electric Vehicle Battery Swapping in India

(iv) Integrating Renewables with Electric Vehicle Charging and Battery Storage System

(v) EV Charging as a Service (CaaS)

Based on current trends and market analysis, it is evident that two- and three-wheelers are leading the way in the electrification sector. The shift towards electric mobility is driven by several factors, including increasing concerns about environmental sustainability, rising fuel prices, and government initiatives promoting clean and green transportation.

Two- and three-wheelers have emerged as the frontrunners in electrification for various reasons. Firstly, these vehicles are highly suitable for urban environments, where short commuting distances and heavy traffic congestion are common. The compact size and manoeuvrability of two- and three-wheelers make them ideal for navigating through crowded streets, reducing travel time and fuel consumption. Secondly, the adoption of electric technology in two- and three-wheelers provides significant benefits in terms of reduced emissions and improved air quality.

The first case study on Electric Bicycles highlights the substantial advantages in operational costs when compared to internal combustion engines and other electric two-wheelers. Electric bicycles stand out due to their simplicity, with fewer moving parts leading to reduced maintenance requirements and lower servicing costs. Moreover, the cost of charging is notably economical, surpassing both electric vehicle counterparts and traditional fuels. These factors contribute to significant long-term savings for both owners and operators.

In summary, despite being in the early stages of development, electric bicycles emerge as frontrunners in the electrification of micro-mobility. Their adaptability to diverse urban and rural environments, coupled with environmental benefits, minimal operational costs, and the simplicity of charging infrastructure, positions them as a preferred choice for sustainable transportation. The swift adoption of electric bicycles has the potential to revolutionize the mobility sector, ushering in a greener and more sustainable future.

The second case study sheds light on the less-discussed retrofit market in India, focusing on the process of modifying or upgrading existing vehicles for enhanced efficiency, environmental friendliness, or compliance with specific regulations. In the Indian context, retrofitting predominantly involves the conversion of conventional petrol or diesel-powered three-wheelers into electric vehicles (EVs).

The Indian government's proactive stance on promoting electric vehicles to mitigate pollution and reduce reliance on fossil fuels has led to the introduction of several schemes and incentives. These initiatives aim to encourage the retrofitting of three-wheelers with electric powertrains, aligning with the broader goal of transitioning towards cleaner and more sustainable transportation solutions.

This section delves into the evolving retrofit market in India, highlighting challenges such as financing barriers, limited awareness about government incentives, and the nascent presence of original equipment manufacturers (OEMs). These factors collectively contribute to hindering the full realization of the potential of retrofitting technology in the country.

The third case study examines the significance of battery swapping in the context of the growing demand for sustainable and eco-friendly transportation in India. With personal and commercial two- and three-wheelers taking the lead in electrification, the challenges associated with limited battery life and long charging times have prompted the exploration of battery swapping as a viable solution.

Advancements in battery technology, including longer ranges, faster charging times, and improved overall performance, have paved the way for electric vehicle manufacturers to invest in enhancing battery efficiency and optimizing vehicle design.

The section emphasizes how the implementation of battery swapping infrastructure has the potential to transform the electric mobility landscape in India. With a rapidly expanding market and increasing government support, battery swapping facilities can

play a crucial role in accelerating the adoption of electric two- and three-wheelers nationwide.

The technology's ability to swap depleted batteries with fully charged ones addresses range anxiety and enhances operational efficiency for electric vehicles. Additionally, the section highlights the multiple benefits of battery swapping, offering convenience, flexibility, and scalability to the electric vehicle ecosystem.

Battery swapping also presents a lucrative business opportunity, allowing entrepreneurs to establish and operate battery swapping stations as a service. This not only generates employment opportunities but also contributes to the growth of a sustainable and green economy. The section concludes with an analysis of ongoing and potential business models, underscoring the importance of collaboration between the government, original equipment manufacturers (OEMs), and charging infrastructure providers in driving widespread adoption and contributing to a cleaner and sustainable future.

The fourth case study delves into the crucial integration of renewable energy (RE) with electric vehicles (EVs) and the added dimension of a Battery Energy Storage System (BESS). Recognizing the global shift toward cleaner energy sources, the alignment of transportation systems with clean energy is paramount for a sustainable future.

The integration of RE with EVs serves as a key strategy to substantially decrease greenhouse gas emissions and decrease reliance on fossil fuels. While EVs inherently offer lower emissions than traditional internal combustion engine vehicles, coupling them with renewable sources, such as solar or wind power, elevates their environmental impact.

A pivotal challenge lies in the development of robust charging infrastructure fueled by clean and sustainable energy sources. Investments in charging stations equipped with BESS, powered by renewable energy, not only support the growth of EV adoption but also contribute to an overall reduction in the carbon footprint.

Moreover, this integration creates opportunities for storage and grid management. EV batteries can act as a storage solution for excess renewable energy generated during off-peak hours, which can be tapped into during peak demand or when renewable resources are limited.

The section further explores the concept of solar carports, a technology gaining traction in India. In the context of the country's emphasis on renewable energy and sustainable transportation, solar carports stand out as an innovative solution. By combining solar power generation with covered parking spaces and BESS, these structures redefine energy consumption and mobility.

India's increasing demand for clean and affordable energy aligns well with the potential of solar technology. With abundant sunlight year-round, harnessing solar power becomes an attractive option for residential and commercial sectors. Solar carports not only generate renewable energy but also offer advantages such as reducing carbon footprint, enhancing energy efficiency, and promoting sustainable practices. The widespread integration of these structures into parking lots across India signifies significant progress toward achieving sustainability goals.

The fifth and final case study underscores the critical role of Electric Vehicle (EV) Charging as a Service (CaaS) in facilitating the accelerated adoption of electric vehicles to decarbonize the transport sector. Establishing a safe, affordable, and accessible Public EV Charging Infrastructure is deemed essential for this transition.

EV Charging as a Service (CaaS) stands out as a holistic solution, offering a comprehensive package that includes EV charging equipment, installation, software, maintenance, and driver support. The model operates on a predictable monthly payment structure, providing convenience and transparency for users. This approach is particularly sought after by fleet operators, especially those in e-commerce and delivery sectors. The services are often operated in a captive mode, allowing for customization based on specific vehicle and business requirements. Parameters such as the combination of fast and slow chargers, the strategic location of charging hubs, and the number of EV chargers are tailored to suit individual needs.

In conclusion, the transport sector in India is undergoing significant transformations driven by a strong commitment to sustainability and technological advancements. The growth of EVs, coupled with the innovative solutions highlighted in this report, contributes to the creation of a more sustainable environment. These developments not only promote cleaner transportation options but also have the potential to further transform the sector, reducing reliance on fossil fuels and fostering a greener future.

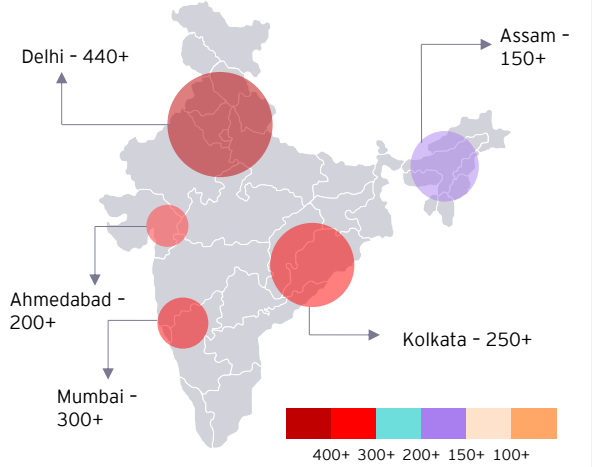
2. Introduction

India is undergoing rapid urbanization and facing severe air pollution issues. One of the primary sources of pollution is traffic emissions, contributing to respiratory issues among citizens. With increasing vehicle numbers and inadequate emission controls, air quality in major cities is declining, posing health risks. In 2022, India ranked eighth for having polluted air.[1] The significant pollution generated by traffic underscores the urgent need for sustainable transportation solutions to address both urbanization challenges and public health concerns.

Figure 1: Emissions for ICE vehicles

Electric mobility presents a promising solution to mitigate air pollution resulting from traffic. Traditional internal combustion engine vehicles emit pollutants such as nitrogen oxides and particulate matter, contributing significantly to poor air quality, respiratory issues, and environmental degradation[2]. In contrast, electric vehicles are emission free, reducing the release of harmful pollutants into the atmosphere. By transitioning to e-mobility, cities can effectively reduce traffic related air pollution, creating cleaner urban environments and improving public health. Additionally, integrating renewable energy sources for EV charging further diminishes the overall carbon footprint associated with transportation. As governments and Private sector invests in electric infrastructure and incentivize the adoption of EVs, they pave the way for a sustainable and healthier future by addressing the root cause of traffic-related air pollution.

Figure 2: AQI levels of different cities

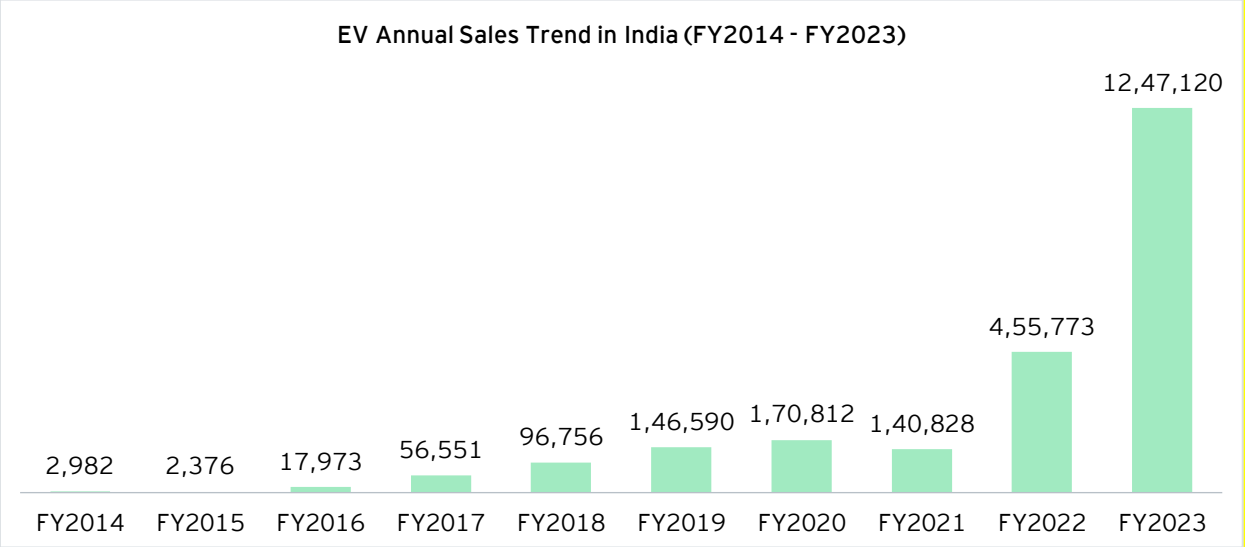


The electric mobility sector has experienced significant growth over the last five years, positioning the country to emerge as one of the largest EV markets globally by 2030. Several factors contribute to the increasing demand for electric vehicles, including growing concerns about air quality, rising fuel prices, favourable policy support from the government, and the expanding availability of EV models across various segments.

As of now, the Indian EV market is predominantly dominated by the Electric Two-Wheeler (E-2W) and Electric Three-Wheeler (E-3W) segments, collectively holding approximately 90% of the EV market share in India. By the conclusion of the fiscal year 2023, EV sales in India reached around 12 lakhs, signifying a remarkable 170% year-on-year sales increase compared to the FY 2022 sales of approximately 4.5 Lakhs[3].

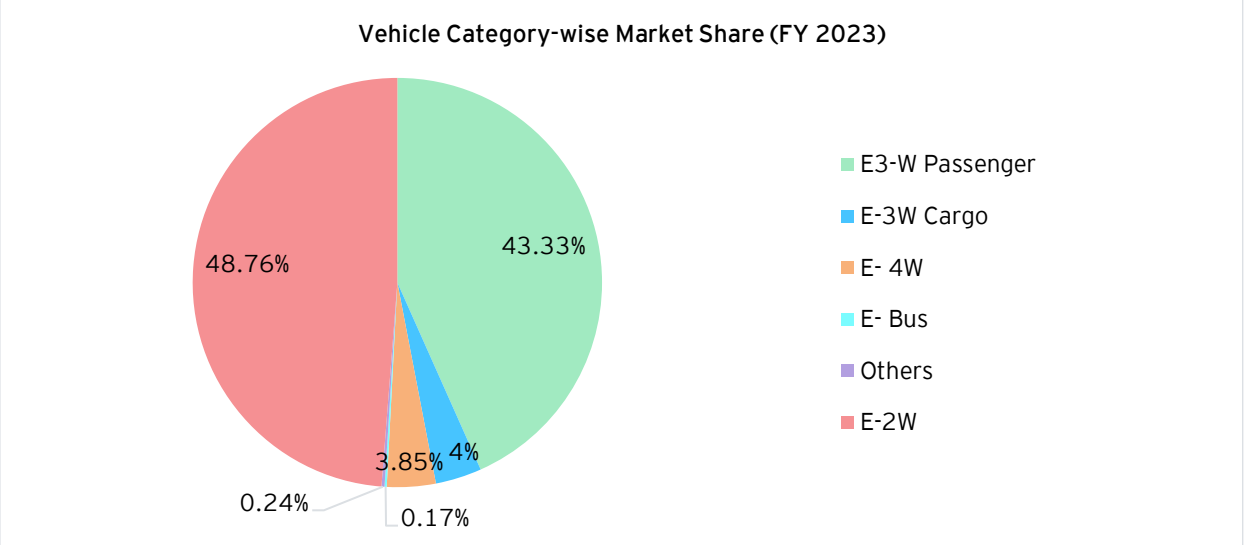
[1] https://www.iqair.com/in-en/world-most-polluted-countries
[2] https://www.siam.in/statistics.aspx?mpgid=8&pgidtrail=14
[3] https://jmkresearch.com/annual-india-ev-report-card-fy2023/

Graph 1: Annual EV sales in India



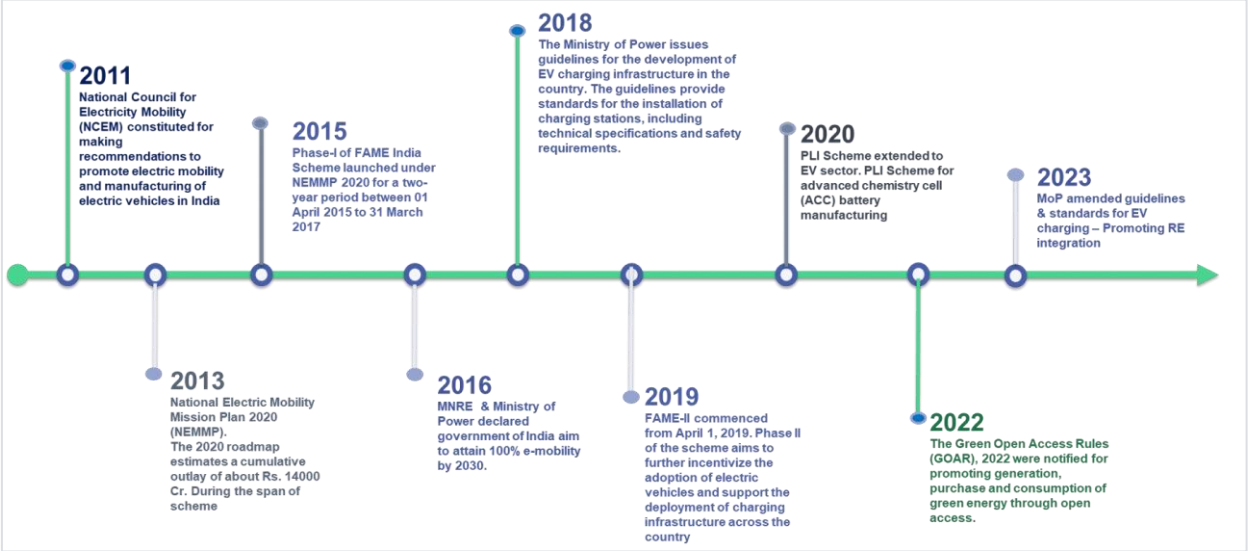
Market Share

Graph 2: Market share of different vehicle segments



On the policy landscape, Ministry of Power (MoP) in India has taken a lead role in defining the overarching architecture, Department of Heavy Industries (DHI) has taken up the task of setting up charging infrastructure across the country by providing incentives. MoP designated Bureau of Energy Efficiency (BEE) as the Central Nodal Agency (CNA) for Public EV charging infrastructure in India.

Figure 3: Initiatives taken to promote electric mobility in India



Multiple other agencies such as Ministry of Road Transport and Highways (MoRTH), Ministry of Housing and Urban Affairs (MoHUA), Ministry of Finance (MoF), Ministry of Science & Technology (MoST) & Ministry of Environment, Forest, and Climate Change (MoEF&CC) are also formulating EV friendly policies to support the transition.

The global transition towards sustainable and eco-friendly mobility solutions has ushered in an era of transformative changes in the transportation sector. As nations grapple with the challenges posed by climate change and environmental degradation, the integration of Electric Vehicles (EVs) and related technologies has become a focal point in the pursuit of cleaner and more efficient transportation.

This report delves into diverse case studies that encapsulate innovative strides in the realm of sustainable mobility. Each case study serves as a testament to the dynamic and evolving nature of the electric mobility sector, showcasing real-world implementations that span across various facets of the transportation ecosystem. From individual modes of personal transport to large-scale infrastructure projects, these case studies provide insights into the challenges, successes, and the overall impact on fostering a greener and more resilient future in the realm of transportation.

As we navigate through these case studies, the underlying narrative is one of innovation, adaptability, and a collective commitment to steering the transportation industry towards a sustainable and low-carbon future. Through the lens of these exemplary cases, we explore the technologies, policies, and strategic approaches that are shaping the electrified and renewable energy-driven mobility landscape.

Through the examination of Electric Bicycles, 3-Wheeler Retro fitment to Electric Vehicles, Solar Carports, Battery Swapping, and Electric Vehicle Charging as a Service, we aim to unravel the multifaceted landscape of advancements in electric and renewable energy-driven transportation


EV
EV

3.

Case study 1

Electric Bicycles

An Optimal Solution to promote Micro-mobility in India

In recent years, there has been an extraordinary growth in mobility, with expanding road infrastructure and increased vehicle ownership leading to a reduction in intra-city distances. However, this mobility boom has also brought about adverse effects such as severe traffic congestion, rising fuel costs, and escalating air pollution. Micro-mobility services, particularly those involving fleets of shared electric vehicles, emerge as an intelligent and sustainable solution to address these challenges, especially in metropolitan areas.

Micro-mobility is a transportation service designed for short-distance travel, typically covering the first or last mile of a journey. It caters to one or two passengers at a time and is characterized by the use of compact, electric vehicles. Electric bicycles and scooters are popular options in the micro-mobility space, offering an accessible and convenient alternative to traditional modes of transportation. One of the prevalent business models is bike-sharing, allowing users to rent bicycles for short durations. Additionally, pick-up and drop-off services at designated locations contribute to the flexibility and efficiency of micro-mobility solutions.

In a country like India, where traffic density is exceptionally high, the adoption of electric vehicle-enabled micro-mobility emerges as a promising business model. This approach holds the potential to significantly save commuting time for individuals, offering a more efficient and convenient mode of transportation amid congested urban areas.

3.1. Promoting Micro-mobility through Electric Bicycles

Micro-mobility solutions, including electric and non-electric bicycles and scooters, present a promising alternative to tackle issues related to first and last-mile connectivity, air pollution, noise pollution, and congestion. These devices have the potential to decrease the dependence on motorized two-wheelers in Indian cities, consequently reducing the demand for petroleum products. In several global cities, the count of Micro-mobility devices is starting to surpass the number of cars, highlighting their increasing popularity and potential impact on urban transportation.

Electric bicycles, or e-bicycles, are equipped with an electric motor that allows for both manual pedalling and electric support. In contrast to traditional bicycles, e-bicycles provide an additional boost with the electric motor, enhancing manoeuvrability on uphill terrains and extended journeys. Primarily advantageous for commuting, these bicycles seamlessly combine the health benefits of cycling with the convenience of electric assistance. E-bicycles prioritize environmental friendliness, emitting zero emissions when in electric mode.

Figure 4: e-bicycle to commuter

e-bicycles can empower women workers in rural areas, including SHG, ASHA, and Anganwadi workers. These electric cycles enhance commuting efficiency, providing a sustainable and accessible mode of transportation.

There are two basic models in an e-bicycle – **throttle-assist and pedal-assist.**

Throttle-assist means the motor can be shifted on and the bicycle will move forward without pedalling, while pedal-assist means the motor will only engage when the user is pedalling.

3.2. e-bicycle types

E-bicycles can be largely categorised as:

1. Commute e-bicycle
2. Cargo e-bicycle and
3. Low speed pedal assist electric mopeds.

Commute e-bicycles are designed for individual commuting, offering a sustainable and efficient mode of personal transportation. Cargo e-bicycles serve the purpose of transporting goods, making them ideal for product deliveries. Low-speed pedal assist e-mopeds are generally used for commuting while carrying a limited load, typically around 15 kg. These low-speed pedal assist e-mopeds can provide a more comfortable travel solution, especially for women in rural areas.

Table 1: Different type of electric bicycles

Categories	Commute E-bicycles	Cargo E-bicycles	Low speed pedal assist electric moped
Image			
Description	Common commute e-bicycles have lightweight frames and pedal assistance; they are made for daily commuting	Cargo e-bicycles are designed with an extended frame or additional attachments to accommodate cargo	Pedal assist electric moped typically feature a pedal-assist system, allowing riders to pedal while receiving electric assistance
Aim and Applications	The goal of commuter e-bicycles is to reduce dependency on traditional vehicles and lessen traffic congestion by offering an environmentally friendly option for short-distance transportation.	E-cargo bicycles are particularly relevant where conventional delivery vehicles face limitations.	These low-speed electric mopeds, which prioritize urban mobility, are made for short-distance transportation.
Popular OEMs	Geekay Hero Lectro HI Bird	Nexzu Aurita Bikes	Essel Energy
Motor capacity	Max 250W	Max 250W	Max 250W
Battery Capacity	36V- 7.8 Ah/10Ah	36V – 14Ah/23.3 Ah	36v - 20 Ah
Speed	Max 25 kmph	Max 25 kmph	Max 25 kmph
Payload	~80Kgs - 100Kgs	~120Kgs -140 Kgs	~80 Kgs
Range	PAS- ~30-55 Kms Throttle: 30-40 Kms	PAS – ~45-85 Kms Throttle – 30-40Kms	~60- 80 Kms
Battery Life	1.5-2 Year warranty	1.5-2 Year warranty	1.5-2 Year warranty

3.3. e-bicycles component s

Figure 5: Components of electric bicycle

There are four major components of an electric bicycle:

1. Battery Pack

The battery serves as the energy source that powers an electric bicycle, and it is typically the most expensive component of an e-bicycle system. In the early days of e-bicycles, batteries were commonly made of lead-acid, Nickel Cadmium, or NiMH. However, modern e-bicycle batteries are predominantly lithium-ion.

The evolution of lithium battery technology has led to batteries that are lighter, more powerful, more reliable, and have a longer cycle life. Modern lithium-ion batteries, especially those made with top-tier cells, are significantly lighter than the lead batteries used in the past. When treated properly, these batteries can be expected to provide well over 5-6 years of regular use.

Figure 5: Battery pack

The configuration of cells in the battery pack, including how they are wired together in series and parallel, determines both the voltage and the capacity of the final pack. Most e-bicycle batteries are designed for voltages of either 36V or 48V. However, there are variations available, with e-bicycle packs ranging from as low as 24V to as high as 72V, catering to different performance requirements.

Factory e-bicycles frequently integrate the battery pack seamlessly into the frame tubing, resulting in a neat and integrated external appearance. On the other hand, conversion kits often come with batteries designed to mount either on the downtube inside the triangle or on a rear carrier rack. The design of conversion kit batteries allows for greater flexibility, making it easier to swap or upgrade the battery as needed.

Figure 6: electric bicycle battery

2. Motor

Motor The electric motor serves to convert electrical energy from the battery into mechanical power, propelling the bike forward. In the case of a hub motor, the electric motor is situated inside either the front or rear bicycle hub. This design facilitates a relatively straightforward conversion process, wherein a regular bike wheel is replaced with a motorized wheel. Most contemporary e-bicycle motors are of the permanent magnet Brushless DC (BLDC) type, featuring three-phase wires to supply motor power. Additionally, these motors typically incorporate five hall sensor wires, aiding the electronics in determining the motor position to ensure smooth operation at low speeds. The wires may be configured as separate connectors or integrated into a single plug that combines both power and signal wires.

Figure 7: Motor

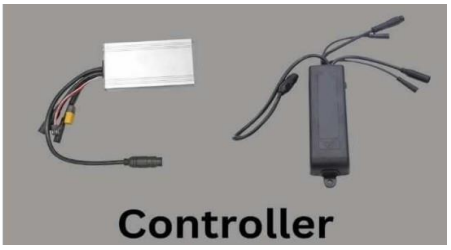
3. Controller

The motor controller, while often unfamiliar to many, is a crucial component in any e-bicycle system. This is because a brushless motor cannot be directly connected to a battery pack without the intermediary function of the motor controller. The motor controller serves two critical functions:

- Converts the DC voltage of the battery pack into 3 phase alternating current for the motor windings without which the motor could not spin, and
- Continuously adjust the voltage going to the motor, from 0V up to the full battery pack voltage, in response to the user's throttle signal, pedal sensors, and various current limits.

The motor controller is crucial in regulating the voltage that reaches the motor, allowing it to adjust between zero and the battery voltage. For instance, with a 48V battery pack, the motor might experience only 10-12V at low speeds, around 25V at moderate speeds, and reach the full 48V as you approach the final cruising speed.

Figure 8: Controller



4. Frame

E-bicycle frames are integral in providing support and integration for electric components. Usually constructed from materials such as aluminium or steel, these frames are designed to accommodate electric motors, batteries, and control systems. Their construction prioritizes durability, weight distribution, and often includes features to conceal or protect electrical components.

Figure 9: Electric bicycle frame

In addition to above, there are a number of other accessories and add-on components that form the part of the package such as Throttle, E-Brake and Display.

5. Throttle

A throttle is the most basic and familiar way of allowing the rider to regulate the amount of power they get from the motor by pressing a throttle lever or twisting a grip that is mounted on the handlebar. A throttle gives the rider full control of the amount of power coming from the electric motor at any given time, regardless of how hard they are pedaling.

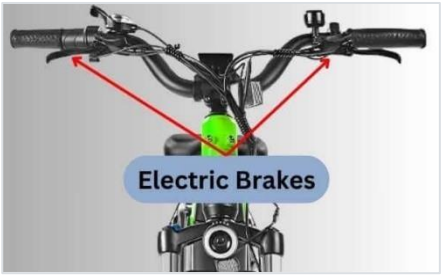
The two most common throttle types would be categorized as thumb or lever throttles which are actuated by the thumb pushing on a paddle, or twist grip throttles that operate from rotating a handgrip.

Figure 10: Throttle

6. E-brakes

An e-brake sensor is an optional device which passes signal to the motor controller when brake lever is pressed. There are two reasons why people might want an e-brake sensor on their e-bicycle. One is to have a safety cut-off so that, regardless of the situation, the motor will shut off whenever you press the brake levers. The second reason is to activate regenerative braking on hub motor systems that support regen. This allows you to gently squeeze the brakes, causing the motor to transition from powering the bicycle to providing a smooth and steady braking force. The braking energy is then redirected back into charging the battery pack.

Figure 11: Electric bicycle e-brakes



7. Display

Almost all e-bicycle kits and full e-bicycles these days come equipped with a fairly detailed display computer, providing a dashboard to monitor various aspects. This marks a significant improvement from the early days of e-bicycles when most systems relied on just a few LEDs to indicate the battery level. However, unlike displays for computers or televisions, which follow standard protocols, the displays connecting to e-bicycle motor controllers lack standardization. This lack extends to their functions, communication bus (I2C, Canbus, LIN, UART, etc.), and communication protocols. Typically, these displays are developed in tandem with specific motor controllers and designed for a particular set of kit functions.

Figure 12: Electric bicycle display unit

3.4. Potential users

Electric bicycles can serve as a sustainable transportation solution in both rural and urban areas. The figure below highlights potential users and the associated benefits of adopting electric bicycles:

Figure 14: Potential users of electric bicycles

3.4.1. Expected Benefits

Using electric bicycles (e-bicycles) offers several benefits, contributing to their growing popularity:

Table 2: Benefits of electric bicycles

S. No.	Benefits	Details
1	**Environmental Sustainability**	Reduced carbon footprint compared to traditional vehicles, as e-bicycles produce zero emissions during operation. Further, it is a tool to assist in converting campuses and townships to Green Campus/Township.
2	**Cost-Efficiency**	Lower operational costs compared to cars or motorcycles, with significantly reduced fuel and maintenance expenses.
3	**Health and Fitness**	Promotes physical activity by allowing users to pedal when desired, contributing to improved cardiovascular health.
4	**Traffic Congestion Mitigation**	Navigating through traffic is often faster for e-bicycles, especially during peak hours, helping to reduce congestion
5	**Access to Bicycle Infrastructure**	Takes advantage of existing bicycle lanes and infrastructure, offering a convenient and eco-friendly mode of transport
6	**Quiet and Low Impact**	E-bicycles operate quietly, minimizing noise pollution, and have a smaller overall environmental impact compared to traditional vehicles
7	**Ease of Parking**	Easier to park than larger vehicles, enabling users to find parking spaces more conveniently in crowded urban areas
8	**Flexibility in Commuting**	Offers a flexible commuting option, allowing users to switch between manual pedalling and electric assistance as needed
9	**Promotion of Sustainable Transportation**	Contributes to a more sustainable and eco-friendly transportation landscape, aligning with global efforts to reduce reliance on fossil fuels
10	**Community Health Benefits**	Encourages a shift towards healthier and more active lifestyles, benefiting overall community health
11	**Last-Mile Connectivity**	Provides an excellent solution for covering short distances, especially for the "last mile" of a commute, when combined with other modes of transport.
12	**Employment opportunities**	Using electric bicycles may lead to additional opportunities of employment for rural women

These benefits make electric bicycles a compelling choice for individuals and communities looking for sustainable, cost-effective, and healthy transportation alternatives.

3.5. Vehicle Cost Ownership

Total Cost of Ownership of a vehicle is defined as the cost incurred in purchasing, operating and retiring the vehicle. The ownership cost of a electric bicycle (commute cargo), low speed pedal assist mopeds, electric scooters and ICE 2 wheelers is estimated basis the following parameters:

- On road price of vehicle
- Distance travelled per year
- Battery range for electric vehicles and mileage for ICE 2W
- Life of the vehicle
- Maintenance expenses per year
- Insurance for electric scooter and ICE 2W
- Salvage value after end of life of the vehicle

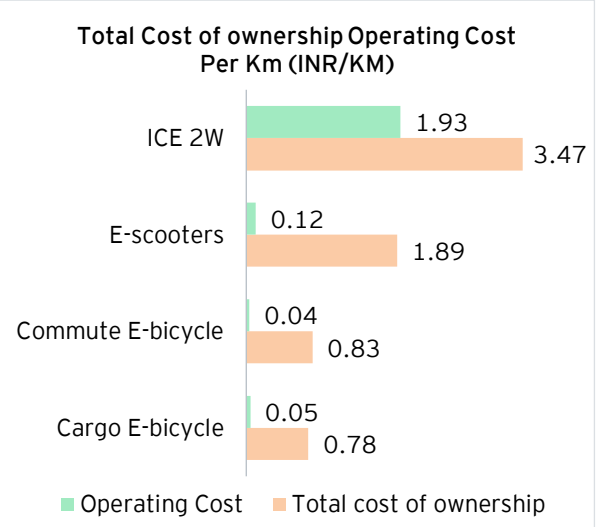
The comparison of total cost ownership of commute & cargo electric bicycles, low speed pedal assist electric mopeds, e-scooter and ICE 2W is shown in the below table:

Table 2: TCO comparison

Parameter	Commute E-bicycle	Cargo E-bicycle	E-2W	ICE 2W
On road price of vehicle (INR)	30,000	50,000	1,10,000	97,000
Battery Range (km)	30	60	90	
Mileage of ICE 2W (kmpl)	-	-	-	50
Battery replacement cost (INR)	7,200	16,000	52,000	
Life of vehicle (years)	5	5	5	5
Energy consumption per km (kWh/km)	0.007	0.01	0.022	

*100% equity investment considered for TCO calculation

Graph 3: TCO & Operating cost comparison



Thus, E-bicycle is an eco-friendly and cost-effective alternative for the large population using ICE two-wheeler/ public transportation (buses and shared e-autos) offering a high-quality seamless journey to the commuter and providing Micro Mobility Solutions.

3.6. Global Scenario

3.6.1. China

Policy Regulations: In the People's Republic of China, electric bicycles are classified as bicycles. The latest regulation stipulates that electric bicycles must have working pedals, with a maximum design speed not exceeding 25 km/h, weight (including battery) up to 55 kg, motor power up to 400 W, and battery voltage up to 48 V.[4]

Electric bicycle sales: The presence of electric bicycles and electric scooters in major cities traces back to the 1980s in China, where the high cost of ownership initially impacted their popularity. However, their adoption unfolded in three distinct phases mentioned below:

1. Phase 1 (1980s):

In the 1980s, the mass adoption of electric bicycles and scooters in China faced a hurdle – the high cost of ownership. The batteries available at that time were of poor quality, both in terms of performance and lifespan. Their subpar quality not only impacted the vehicles' efficiency but also contributed to the overall cost, making electric vehicles more expensive than their conventional motorbike counterparts.[5]

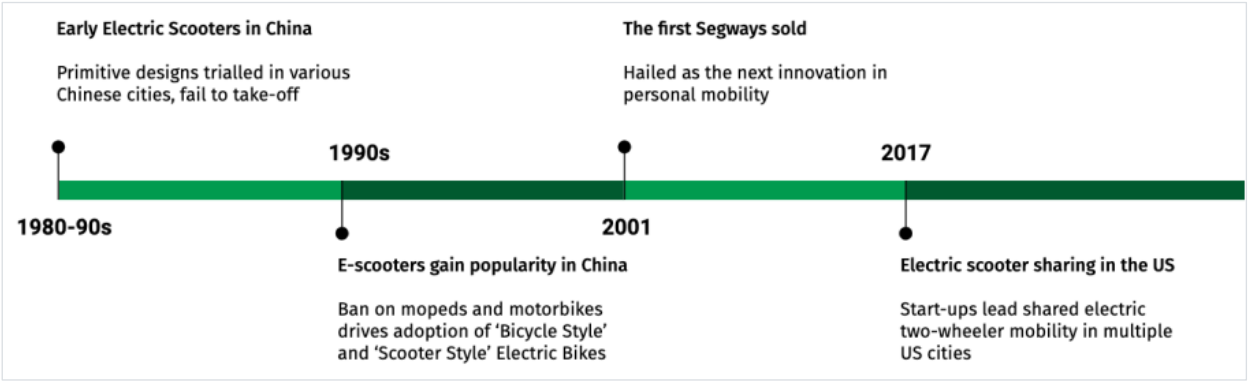
2. Phase 2 (Early 1990s):

In the early-1990s, the landscape began to shift as the Chinese government actively promoted energy efficiency. This led to a significant drop in the cost of electric bikes, making them more affordable. Despite this, the shift to e-bikes was gradual, as people were accustomed to traditional motorbikes that had been their primary mode of transportation for decades.

3. Phase 3 (Subsequent Years):

A turning point occurred when major cities, such as Shanghai and Guangzhou, imposed bans on motorbike usage. This restriction propelled the mass adoption of electric two-wheelers in China, as the ban redirected commuters towards the more sustainable and permitted electric alternatives. This marked a transformative phase, firmly establishing electric bicycles and scooters as mainstream modes of transportation in urban areas.

Figure 13: Initiatives taken to promote electric bicycles in China



In 2016, the Asia Pacific region dominated global e-bike sales, with the Chinese market standing out as the largest contributor. Additionally, key European countries, namely Germany, the Netherlands, France, and Italy, collectively accounted for over 68% of global e-bike sales in the same year.

[4] https://www.chinadaily.com.cn/a/201904/16/WS5cb5858da3104842260b6805.html#:~:text=A%20qualified%20electric%20bicycle%20must,Watts%20and%2048%20volts%20respectively.

[5] Jonathan Xavier Weinert, The rise of Electric Two-wheelers in China: China: Factors for their Success and Implications for the Future, 2007

3.6.2. Europe

Policy Regulations: European Union regulation established the L-category vehicles as a reference for member countries. L-category vehicles are powered by two, three and four-wheel vehicles. The category uses power, power source, speed, length, width and height as classification criteria. Some types of micro-vehicles that can be mapped to the L1e category called "light two-wheel powered vehicle" [6]are:

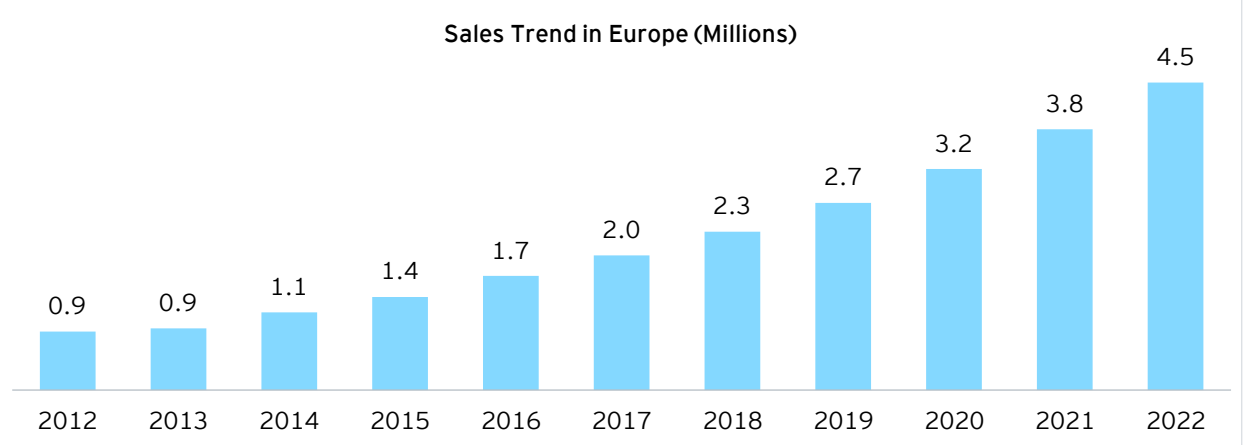
- **L1e-A powered cycle:** Electric bicycle equipped with auxiliary propulsion with a maximum speed of 25 km/h and a net power between 250 watts and 1,000 watts. This category includes low-powered throttle-only electric bikes.
- **L1e-B two-wheel moped:** Any two-wheel vehicle with a design speed of more than 25 km/h and up to 45 km/h and a net power of up to 4,000 watts. It includes speed-pedelecs, though most speed-pedelecs have a power of 500-750 watts.

Other micro-vehicles are left outside the L1e category, most notably:

- Human-powered vehicles, such as bicycles, skates and kick scooters
- Pedelecs, defined as bicycles with pedal assistance up to 25 km/h and with an auxiliary electric motor having a maximum continuous rated power of up to 250 watts.
- Self-balancing vehicles and vehicles not equipped with a seat (ie. Standing scooters).

Electric bicycle sales: Sales in Europe in 2017, 2018 and 2019 were 2.2 million, 2.78 million and 3.33 million respectively, with growth rates of 25.6%, 26%, and 19.8% respectively. According to Technavio's (a leading market research and advisory company with global coverage) forecast, the average annual growth rate of e-bike sales in the European market is 18% from 2017 to 2022 or 4.5 million e-bikes in European Market.

Graph 4: E-Bicycle sales trend in Europe



According to the annual report of the CONEBI Association in 2016, the top three users of e-bicycles per 1,000 people were in the Netherlands, Belgium and Austria, while the top three total sales were in Germany, the Netherlands and Belgium.

1. Germany

E-bike sales in 2015, 2016, 2017, and 2018 were 530,000, 600,000, 720,000, and 850,000, respectively, with continuous growth of 13%, 19%, and 18%. In 2021, sales were 1,200,000, up 9.1% from 2020. According to the Federal Statistical Office, the share of electric bicycle imports in 2021 was 32%.

Characteristics of electric bicycle usage in Germany

The German federal government implemented the **'National Bicycle Plan 2020**,' allocating an annual budget of approximately ₹257 million to financially support and promote cycling for 3.2 million individuals."

- In May 2017, Germany introduced a new road safety law, the StVZO, which revised the requirements for bicycles and electric bicycles.

[6] https://d1wa5qhtul915h.cloudfront.net/app/uploads/2015/09/bike-europe-e-bike-regulations-version-aug-2016.pdf

Bicycles and e-bikes with a speed of up to 25 km/h are grouped into one category by adding lighting features to the bikes.

- According to the Zweirad-Industrie-Verband (ZIV), there are currently more than 2.5 million electronic bicycles on German roads. The willingness of consumers to buy electric bicycles is constantly increasing.

2. The Netherlands

The Netherlands, with a population of 17 million, boasts over 20 million bicycles, including 2 million electric bicycles. Sales of electric bicycles in the country in 2015, 2016 and 2017 were ~2.75 lakhs, ~271 lakhs and ~2.94 lakhs respectively.

The growth in electric bicycle sales has been consistent. Notably, between 2008 and 2016, traditional bicycle sales decreased by 4,444 units, while electric bicycle sales saw a steady increase from 2012.

However, the COVID-19 pandemic had an impact in recent years. Electric bicycle sales experienced a 12.5% decline from 549,000 in 2020 to 479,960 in 2021. Despite the decrease in sales, the market share increased by an impressive 52%.[7]

3. France

France boasts a well-developed cycling infrastructure, contributing to the rapid growth of e-bike sales in recent years. The sales volume of e-bikes was 102,000, 134,000 and 200,000 in 2015, 2016 and 2017, respectively, with growth rates of 32%, 31% and 49% showing a significant growth. During this period, the average sale price was 1,500 euros, totalling 121,000 euros. On February 16, 2017, the French government implemented a subsidy of 200 euros (equivalent to ₹16,000) for Electric Pedal Assist Cycles (EPAC) as part of their policy to promote micro-mobility.[8]

Notably, in 2021, sales of electric bicycles in France set a new record, reaching 659,337 units, marking a remarkable 28% increase compared to the previous year. This achievement underscores the evolving characteristics of electric bicycle use in France.

3.6.3. United States

Policy Regulations: In the United States, regulations for e-bikes and e-scooters are predominantly managed at the state level. State-by-state legislation distinguishes these electric vehicles from mopeds and other motor vehicles, allowing their use in bike lanes and often exempting them from licensing and registration requirements.[9]

For e-scooters, regulations vary across states, with some setting minimum age requirements ranging from 8 to 18 years. Some states only mandate helmet usage, while others have both minimum age and helmet requirements. Speed limits for e-scooters are also state-specific, ranging from 20 km/h (12.5 mph) to 32 km/h (20 mph).

For the use of e-bikes, state regulations typically impose that an e-bike falls within one of the following three classes:

- **Class 1** electric bicycles are equipped with a motor that provides assistance only when the rider is pedalling, and that ceases to provide assistance when the bicycle reaches the speed of 20 mph (32 km/h).
- **Class 2** electric bicycles are equipped with a motor that may be used exclusively to propel the bicycle, and that is not capable of providing assistance when the bicycle reaches the speed of 20 mph (32 km/h).
- **Class 3** electric bicycles are equipped with a motor that provides assistance only when the rider is pedalling, and that ceases to provide assistance when the bicycle reaches the speed of 28 mph (45 km/h) and is equipped with a speedometer.

Electric bicycle sales: In the United States, electric bicycle sales reached 273,000 in 2020 and 368,000 in 2021. The utilization of shared Micro-mobility services also saw an increase, with 34 million trips recorded in 2017, 136 million in 2018, and 820 million in 2019.[10]

[7] https://www.bike-eu.com/42402/dutch-e-bike-and-bicycle-market-shrinks-by-15-9-in-2021
[8] https://www.bike-eu.com/42620/french-e-bike-market-share-hikes-to-25
[9] https://www.federalregister.gov/documents/2020/11/02/2020-22129/general-provisions-electric-bicycles
[10] https://www.sciencedirect.com/science/article/pii/S1361920921004296?via%3Dihub5

In Europe, the prevailing belief in most regions is that any bicycle serves as a viable means of transport. This cultural foundation has contributed to the rapid growth of the electric bicycle market across the continent.

In contrast, American consumers often view bicycles as a means of sport, exercise, and recreation, with automobiles being the primary mode of transportation. The divergence in these cultural perspectives has influenced the dynamics of the cycling industry.

Additionally, the shared e-scooter market experienced significant growth in 2018, marked by Lime and Bird reaching valuations exceeding $1 billion (equivalent to ₹78 billion). Major players like Uber, Lyft, and prominent automakers also entered the e-scooter space, impacting the demand for short-distance rides.

3.7. Major Global Players

Some of the leading global e-bicycle manufacturers and available models are mentioned below:

1. RAD Power Bikes - US

With a vision to transform existing transportation to energy-efficient, enjoyable, and accessible to all North America's largest ebike maker started of 15 years back with professionally crafted, rugged, comfortable, and high-performance ebike that could replace car, truck, and SUV trips at a massive scale. With over 550,000 riders across the globe, and more jumping in the saddle every day, Rad Power Bikes is committed to more than award-winning electric bikes. They are focused on redefining transportation at large. Their longstanding approach has been **design products that address customers' specific needs and empower them with the support to stay moving.**

Figure 14: Bicycles by RAD power

2. Riese and Muller - Germany

Riese & Müller founded in 1993 is a bicycle manufacturer in Darmstadt, Germany[11].

The company develops a range of electric bicycles for personal transport and cargo applications. The bikes are powered by Lithium-Ion batteries and use the Bosch drive systems. Frames are produced by companies such as Pacific Cycles, Taiwan. All of their bikes are assembled by hand in Germany.

The company's declared objectives are **to provide high-quality, well-thought-out bikes for the 'mobility revolution', to create an awareness of mitigating climate change and a responsible lifestyle and to become the market leader in the premium E-Bike growth sector.**

Figure 15: Bicycles by Riese And Muller

3. FITRIDER – China

Hangzhou RiDi Vehicle Co.,Ltd "FitRider" located in Hangzhou City, is an innovative high-tech company with combination of R&D, manufacturing, sales, and service of electric bicycle, two-wheels & three wheels electric scooters.[12]

As the pioneer in the line of sharing scooter, Fitrider supplies the whole sharing scooter solution includes sharing scooter and swappable battery along with charging solution and IoT/GPS device. Its sharing scooter products have been launched to 15 countries

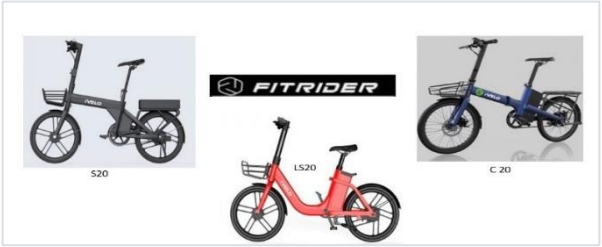
[11] https://www.r-m.de/en-gb/enterprise/history/

[12] https://www.fitriderscooter.com/

including USA, Chile, Australia, Russia, Singapore, Dubai, Denmark, Sweden, Germany, Finland, etc.

Their products have the following advantages: **novelty in style, refined in structure, high in quality, rich in sorts, safe and reliable. They focus on design techniques and keep up with the latest market trends.**

Figure 16: Bicycles by FITRIDER



4. Stromer - Switzerland

With a Vision of shaping the future of mobility and providing more riding joy, efficiency and quality of life Stromer develops and markets innovative e-bikes.

The strength of the company lies in the development of and mechanical components, electric components, software, and the complete system integration. The Swiss company was founded in 2009. In March, 2013 the company opened its headquarters in Oberwangen near Bern, Switzerland.[13]

Figure 17: Bicycles by Stromer

The entire facility's energy is provided by rooftop solar cells, and every battery used in the assembly of Stromer e-bikes is filled with solar-derived energy. At the Oberwangen campus, management, engineering, research and development, assembly, logistics, customer service and even a Stromer flagship retail store are located under one roof.

3.8. Electric Bicycle - A viable solution to promote micro mobility and reducing dependence on public transportation in India

The rapid growth of India's population has led to a significant increase in the number of vehicles on its roads, exacerbating traffic congestion and posing environmental threats. The escalating vehicle population contributes to intensified air pollution, resulting in respiratory issues and contributing to climate change. As roads become more congested, the adverse impact on urban air quality and the overall environment highlights the urgent need for sustainable transportation solutions. These solutions are crucial to mitigate the hazards associated with increased vehicle numbers and promote a healthier, eco-friendly future.

Electric micro-mobility emerges as a vital solution for India, considering a confluence of factors that address pressing challenges and align with the nation's sustainable development goals (SDG). Firstly, India grapples with a severe urban congestion and traffic issues, especially in densely populated cities. The compact and nimble nature of electric micro-mobility solutions presents an opportunity to navigate through congested urban landscapes with ease.

> **e-bicycles offer a convenient and efficient means of navigation through congested Indian urban landscapes, contributing to reduced traffic congestion and improved air quality**

Secondly, the environmental impact of conventional transportation, primarily fueled by petrol and diesel, is a significant concern in India. Electric micro-mobility presents a cleaner and greener alternative, helping to **mitigate air pollution and reduce the carbon footprint associated with short-distance travel.** With India's commitment to environmental sustainability and a transition towards cleaner energy sources, embracing electric micro- mobility aligns with the national agenda. The adoption of electric micro-mobility solutions not only contributes to a healthier environment but also supports the country's ambitious goals in renewable energy adoption and emission reduction.

[13] https://www.crunchbase.com/organization/stromer

Figure 18: Traffic and air pollution on Indian roads

Electric bicycles with their flexibility and accessibility, complement existing transport infrastructure and provide a sustainable solution for short-distance commuting

Furthermore, **electric micro-mobility can enhance last-mile connectivity**, a critical aspect of India's evolving transportation ecosystem. As cities expand and public transportation systems grow, the need for seamless integration between different modes of transit becomes increasingly important. Electric micro-mobility solutions, such as e-scooters and e-bicycles, offer a convenient and sustainable option for commuters to bridge the gap between major transportation hubs and their final destinations. This not only reduces dependency on personal vehicles for short trips but also contributes to the efficiency and accessibility of the overall transportation network.

The adoption of electric bicycles in India is a response to the challenges of urbanization, environmental degradation, and the imperative for enhanced connectivity. In rapidly urbanizing areas, traditional transportation infrastructure struggles to keep pace with the increasing demand, leading to congestion and environmental stress. Electric bicycles offer a sustainable and efficient mode of personal transportation, mitigating the impact of urbanization on traffic congestion and reducing the carbon footprint associated with short-distance travel. Additionally, these electric alternatives contribute to last-mile connectivity, addressing gaps in the existing transportation network and providing individuals with a flexible and eco-friendly option for their daily commute.

3.8.1. Indian regulation defining electric bicycles Motor vehicle rules

E-bicycles comply with the following conditions as mentioned in the Central Motor Vehicle (5th Amendment) Rules, 2014

a) vehicle is equipped with electric motor having thirty-minute power less than 250W,

b) maximum speed of the vehicle is less than 25km/hr.

c) vehicle is fitted with suitable brakes and retro-reflective devices.

d) Unladen weight (excluding battery weight) is not more than 60kg.

In consideration of above points, electric bicycles are not categorized as motor vehicles. Thus, the transport rules (insurance, taxes, etc.) are not applicable for **e-bicycles and they become certified for exemption from license and registration**.

3.9. E-bicycles Manufacturers in India

List of some of the leading e-bicycles manufacturers in India is mentioned below:

1. Hero Lectro

Hero Lectro is revolutionizing the mobility and short-distance commute in India, to give everyone a chance at a healthier and greener life. The aim is to design products that suits the needs of the consumer. The vision is to revolutionise the personal transportation industry by making e-cycles which are fun, environment-friendly and ideal way to stay fit and happy.

Figure 19: Electric Bicycle by Hero Lectro

2. Geekay Electric

Geekay Bikes based out in Ludhiana is dedicated to providing high-quality electric bicycles to its customers at affordable prices while maintaining the highest standards of customer service since 1961. Since then, Geekay has been working on improving standards of their products and deliver bicycles of prime quality. They sell their products under our flagship brand of "GEEKAY".

Figure 20 Electric Bicycles by Geekay

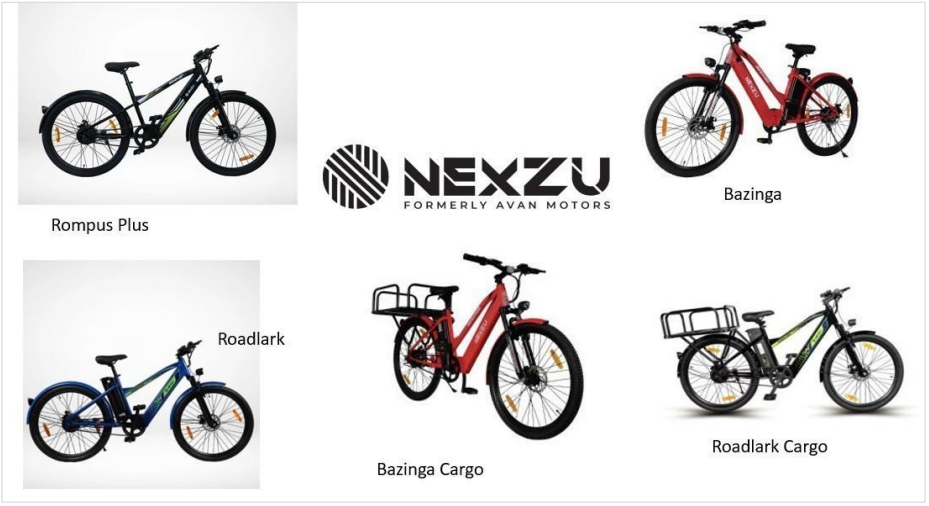
3. Nexzu

Geekay ElectricNexzu Mobility, a trailblazing leader in the realm of sustainable and innovative urban transportation solutions. With a steadfast commitment to revolutionizing the existing traverse in the modern landscapes, Nexzu Mobility stands at the forefront of the electric mobility revolution. As purveyors of high-end Electric Cycles and soon-to-be-revealed Electric Scooters, NEXZU embodies the fusion of cutting-edge technology, impeccable design, and eco-conscious values.

Understanding of the need for greener, smarter, and more efficient transportation options. Nexzu's Electric Cycles exemplify this ethos, offering a seamless blend of style, functionality, and sustainability.

Nexzu Mobility envisions a world where clean energy propels us forward, and where every journey becomes a step towards a brighter, greener future.

Figure 21: Electric Bicycles by Nexzu



4. Motovolt

Motovolt Mobility Pvt Ltd brings smart e-mobility with cutting edge technology and modern design. Technology is one of the differentiating factors and foundational pillars at Motovolt. They have the proprietary and indigenous technology used at all stages – Design, Development, Validation & Production of the product is truly world class. Motovolt cycles have already clocked 1 million KMS.

Figure 22: Electric Bicycles by Motovolt

5. E Motorad

With a mission to let everyone have their "movEMents of fun" EMOTORAD has expanded from India to Europe, Japan, Australia, and the UAE. They are constantly pushing boundaries, reinventing innovation in the electric cycle industry to engineer what's rare and to provide the consumer the best in world and unparallel experience.

Figure 23: Electric Bicycles by E-Motorad

6. Aurita

AURITA is a jellyfish breed otherwise called as moon jellyfish is the world's most energy-efficient animal. It is an integral part of Aurita's central vision, being energy efficient is their core aspect in creating sustainable urban mobility. Bicycle is one of the most energy-efficient and ancient invention of mankind. Combining it with the latest electric drive technology gave birth to a new breed of mobility - Pedal assisted electric bikes.

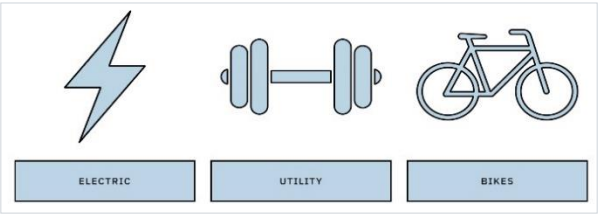


Figure 24: Electric Bicycles by Aurita

3.10. Technical specifications of e-bicycles

Below table highlights the technical specifications of different types of electric bicycles in accordance with Indian regulations:

Table 3: Technical specifications of commute, cargo electric bicycles

Parameter	Passenger electric bicycle	Cargo electric bicycle
Motor		
Type	Brush Less DC (BLDC)	
Capacity	Maximum 250 W with IP65 protection	
Battery- Lfp Type having 2,000 Cycles		
Type	Detachable Rechargeable Lithium-ion battery (Lfp) with IP65 protection	
Battery Range	Minimum 30 km pedelec mode	Minimum 40 km in throttle mode
Charging rate	0.2C	
Charger Type	36V/2A, Input 230V AC – Waterproof Charging Pin (IP 65 Protection)	
Battery Warranty	2000 Cycles with battery degradation of not more than 2.5% annually	
Electronics		
Display and Controller	Displaying On/Off, battery level, speed modes etc.	
Cabling	Internal with IP65 protection	
E-Braking	E-brake cut off (cut off power supply while braking)	

Parameter	Passenger electric bicycle	Cargo electric bicycle
Brakes and Reflectors and other equipment		
Front wheel	Disc Brake	
Rear wheel	Disc / Drum brake	
Front reflector	One white reflector (to be placed as per industry standards)	
Back reflector	One red reflector (to be placed as per industry standards)	
Indicators	LED Type (preferably orange) - Left - Right Indicators (Rear)	
Headlights	LED Type - Front (On Mudguard)	
Electric Horn	On Handle and between 83-112db	
Locking Mechanism	Ignition Cut off	
Other Components		
Frame	Steel tubes – 2039 (parts 1 to 3): 1991	
Frame Type	UNISEX	
Rim Type	Double wall alloy	
Rim size	24" X Minimum 1.9"	
Gear	Single speed	
Fork	Spring Type Suspension	
Saddle	Extra Foam and Wide seat with Min Size- 24.1 x 29.2	
Max Speed	25 kmph	
Unladen weight of the cycle	<60 kg	
Payload (Including rider weight)	90 kg	120 kg
Tyre	Nylon tube tyre	

3.11. Policy and Regulatory Interventions to promote Micro-mobility and reducing dependence on public transportation by States

Phase 1 of the Faster Adoption and Manufacturing of (Hybrid &) Electric Vehicles (FAME-I) scheme was launched by the Ministry of Heavy Industries, in 2015, to accelerate electric vehicle (EV) adoption under the National Electric Mobility Mission Plan 2020. Initially the scheme was launched for a period of two (02), commencing from 1st April 2015, which was subsequently extended from time to time up to 31st March 2019.

The main objective of the scheme was to catalyse penetration of electric vehicles by providing demand incentives in the form of upfront subsidies to the end users. Under Phase-I of the scheme, the incentive for advanced battery-based two-wheelers with max power not exceeding 250 watts was provided at ₹17,000/-.

3.11.1. State EV Policies promoting electric bicycles:

1. Tamil Nadu

Government of Tamil Nadu launched its first Electric Vehicle Policy in 2019.The policy envisioned attracting INR 500 billion in investments with an opportunity to create 150,000 new jobs and outlined several measures to support them. Taking proactive steps to improve the low electrification rate, the state government started the process of revising the policy in 2021, to plug the gaps in the 2019 policy and address EV adoption with a more comprehensive approach. The state launched the revised EV policy in February 2023.

The revised policy gives the state an edge over others by attracting investments in manufacturing, revolutionising it as an EV hub for the nation and, at the same time, encouraging the shift of commercial fleets to EVs by giving upfront capital subsidies. For consumers to shift to EVs, the availability of charging infrastructure is critical. The aspect of public charging infrastructure was not addressed in the previous policy, but the current policy incentivises investment and the setting up of public charging and swapping stations.

Incentive for e-cycles:

Table 4: e bicycle incentive - Tamil Nadu EV policy

Type	Vehicle category	Incentive	Maximum incentive	Maximum no. of vehicles to be subsidized
Private	E-cycle *	-	20% of the cost upto Rs. 5,000	6,000

*1. Only e-cycles procured for initiatives under Government programmes such as Smart Cities in EV Cities shall be eligible for availing incentives listed in the Table above.

2. Further, E-cycles will need to adhere to the definition as per Central Motor Vehicles Act 1989 as mentioned below:
   - The thirty minutes power of the motor is less than 0.25 kW.
   - The maximum speed of the vehicle is less than 25 km/h.
   - Bicycles with pedal assistance which are –
     - equipped with an auxiliary electric motor having a thirty-minute power less than 0.25 kW, whose output is progressively reduced and finally cut off as the vehicle reaches a speed of 25 km/h, or sooner, if the cyclist stops pedalling.
     - Fitted with suitable brakes and retro-reflective devices, i.e., one white reflector in the front and one red reflector at the rear.

2. Chandigarh

The UT of Chandigarh rolled out the EV policy in 2022 with the following Vision, Mission and Objectives:

Vision: To enable zero emission mobility adoption for achieving carbon neutrality in Chandigarh by 2030.

Mission: To provide an enabling framework through incentives and initiatives for promoting zero emission mobility with societal, economic and environmental considerations at forefront.

Objectives: To accelerate adoption of EVs in the UT so that they contribute to 70% of new vehicle registrations by the end of policy period.

Incentive for e-cycles:

Table 5: e bicycle incentive - Chandigarh EV policy

Type	Incentive	Maximum incentive	Maximum no. of vehicles to be subsidized
Private	Upfront: 25% of Cost of Bicycle	Rs. 3,000	First 25,000 Bicycle purchased during the policy period

Additionally, an early bird incentive of Rs. 2,000 will also be provided for the purchase of e-cycles.

One of the key objectives of the policy is to leverage the cycling track infrastructure of city for promoting usage of Electric Bicycles as a replacement of 2/4W especially for short trips.

3. Punjab

The state of Punjab, rolled out the Punjab EV Policy 2022 in February,2023 for a period of three years with the following objectives:

- To bring reduction in vehicular emissions by end of policy
- To promote creation of public and private EV charging infrastructure in the state
- To establish Punjab as a favoured destination for manufacturing electric vehicles, components and batteries.
- To establish Punjab as a R&D hub in electric vehicles led by a Centre of Excellence.
- To enable job creation and introduce vocational and academic training programmes for catering to Human Resource needs of ecosystem.
- To minimise damage to environment by promoting recycling and reuse of discarded batteries.

Incentive for e-cycles:

To promote adoption of e-bicycles the policy shall provide purchase incentives in the state subject to following performance and eligibility criteria:

- Maximum speed of e-bicycles should not exceed 25km/hr
- Unladen weight of vehicle should not exceed 60kg
- Minimum range of e-bicycle (passenger) should be 20 km while that of e-bicycle cargo should be 40 km
- E-bicycle should be powered by Advanced battery (as per FAME II)

The purchase incentive shall be applicable for first 20,000 e-cycle owners only as elaborated below:

Table 6: e bicycle incentive - Punjab EV policy

Type	Incentive	Maximum incentive
Private	25% of maximum sale price or Rs. 4,000 / cycle (whichever is lower)	Rs. 3,000
Cargo	33% of maximum sale price or Rs. 10,000 / cycle (whichever is lower)	-

4. Delhi

Launched in October 2020, Delhi EV Policy has been called the most progressive EV policy in India and among the best globally. It was well-received because it sets an ambitious vision for Delhi to drastically reduce vehicular air to become one of the world's top cities in terms of EV adoption.

The Delhi EV Policy aims to achieve the overarching objective to improve Delhi's air quality and create an entire supply-chain ecosystem for this new segment of vehicles. In order to significantly benefit Delhi's air quality, the policy intends to deploy 25% of all new vehicles to be battery-operated vehicles by 2024.

Incentive for e-cycles:

- E-cycles are eligible for a purchase incentive of 25% of the MRP (not exceeding INR. 5,500 per vehicle).
- An additional INR 2,000 to the first 1,000 individual owners of e-cycles
- E-cargo cycles are eligible for a purchase incentive of 33% of the e-cycle price (not exceeding INR. 15,000 per vehicle).
- A scrapping incentive of INR 2,000- INR 3,000 subject to evidence of matching contribution from the dealer/OEM.

3.12. Shared E-Micro-mobility in India & relevant Case Studies

Many cities in India are proactively addressing issues such as traffic congestion, air pollution, and related health concerns. In response to these challenges, there is a growing emphasis on providing citizens with healthier and more active lifestyles. Public Bicycle Sharing (PBS) systems have emerged as a key focal point in transforming urban mobility, driven by increasing environmental awareness and a rising demand for efficient connectivity.

PBS systems in India cater to the needs of users looking to cover shorter distances, typically around 2 kilometres. The strategic implementation of PBS schemes at public transport hubs, particularly in areas with limited connectivity, plays a crucial role in enhancing accessibility. With budget-friendly pricing structures and the option for long-term subscriptions, PBS systems emerge as a cost-effective transit solution appealing to a diverse range of users. This approach not only addresses environmental and health concerns but also contributes to the development of sustainable and connected urban landscapes.

3.12.1. Key Players and Operating Models

PBS initiatives commonly feature various bicycle types, such as regular, geared, electric, or pedal-assist, alongside diverse rental models, including one-time rentals, subscriptions, and long-term arrangements. Following table highlights some key private operators from different cities:

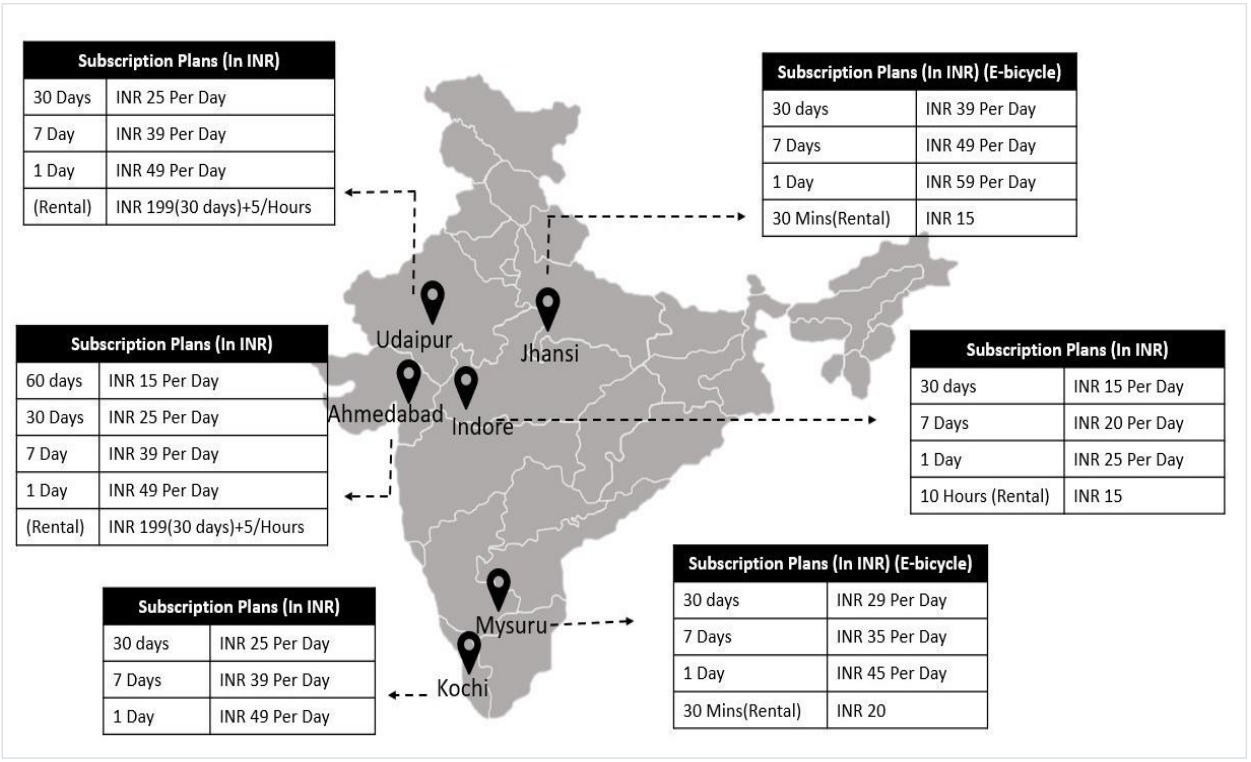
Table 7: Key private electric bicycle operators

Parameters	MYBYK	Chartered Bike	My Smart Bike
Models			
Locations[14]	▶ Ahmedabad ▶ Jhansi ▶ Udaipur ▶ Indore ▶ Mumbai ▶ Mysuru ▶ Kochi	▶ Surat ▶ Ranchi ▶ Kolkata ▶ Srinagar ▶ Prayagraj ▶ Moradabad ▶ Bhopal	▶ New Delhi ▶ Chennai ▶ Hyderabad ▶ Chandigarh
Fleet Size	10,000(Approx)	2850 (Approx)	7000 (Approx)

[14] https://coorides.in/, https://mybyk.in/, https://charteredbike.in/, https://smartbikemobility.com/

1. MYBK

Figure 25: MYBYKS PBS stations



Subscription Plans (In INR)	
30 Days	INR 25 Per Day
7 Day	INR 39 Per Day
1 Day	INR 49 Per Day
(Rental)	INR 199(30 days)+5/Hours

Subscription Plans (In INR) (E-bicycle)	
30 days	INR 39 Per Day
7 Days	INR 49 Per Day
1 Day	INR 59 Per Day
30 Mins(Rental)	INR 15

Subscription Plans (In INR)	
60 days	INR 15 Per Day
30 Days	INR 25 Per Day
7 Day	INR 39 Per Day
1 Day	INR 49 Per Day
(Rental)	INR 199(30 days)+5/Hours

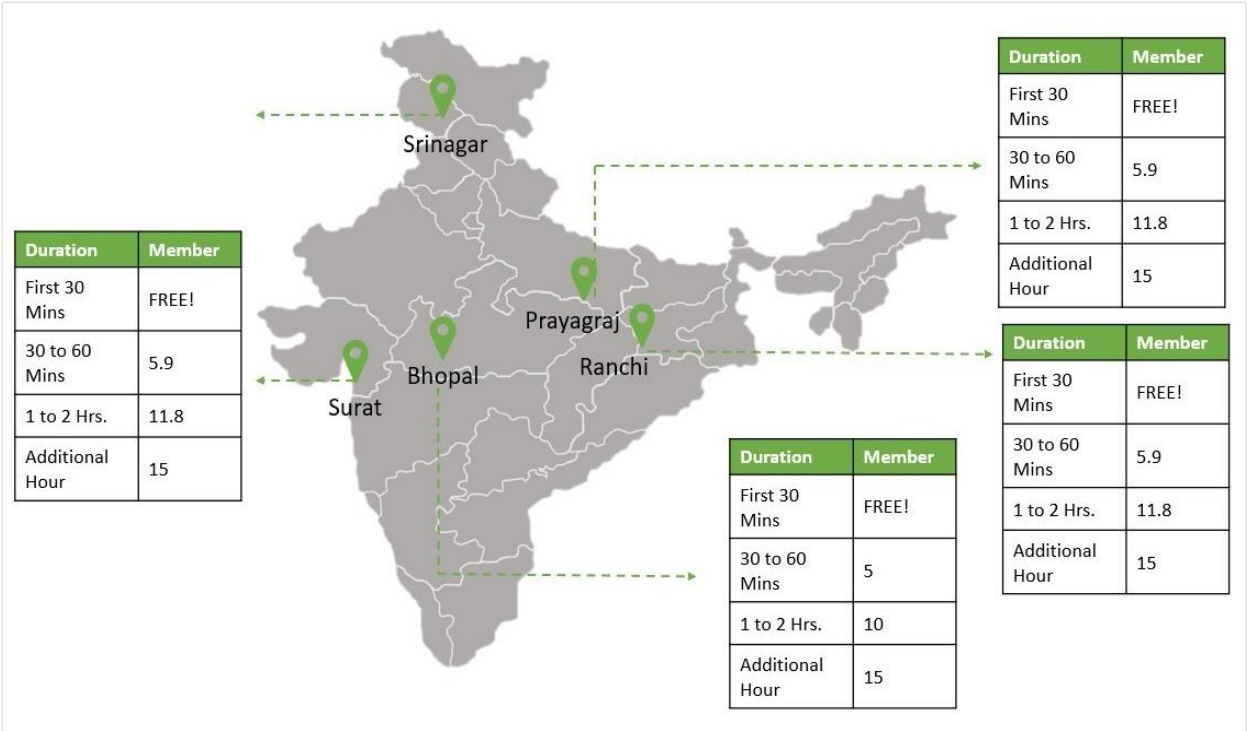
Subscription Plans (In INR)	
30 days	INR 15 Per Day
7 Days	INR 20 Per Day
1 Day	INR 25 Per Day
10 Hours (Rental)	INR 15

Subscription Plans (In INR)	
30 days	INR 25 Per Day
7 Days	INR 39 Per Day
1 Day	INR 49 Per Day

Subscription Plans (In INR) (E-bicycle)	
30 days	INR 29 Per Day
7 Days	INR 35 Per Day
1 Day	INR 45 Per Day
30 Mins(Rental)	INR 20

2. Chartered Bikes

Figure 26: Chartered Bikes PBS station



Duration	Member
First 30 Mins	FREE!
30 to 60 Mins	5.9
1 to 2 Hrs.	11.8
Additional Hour	15

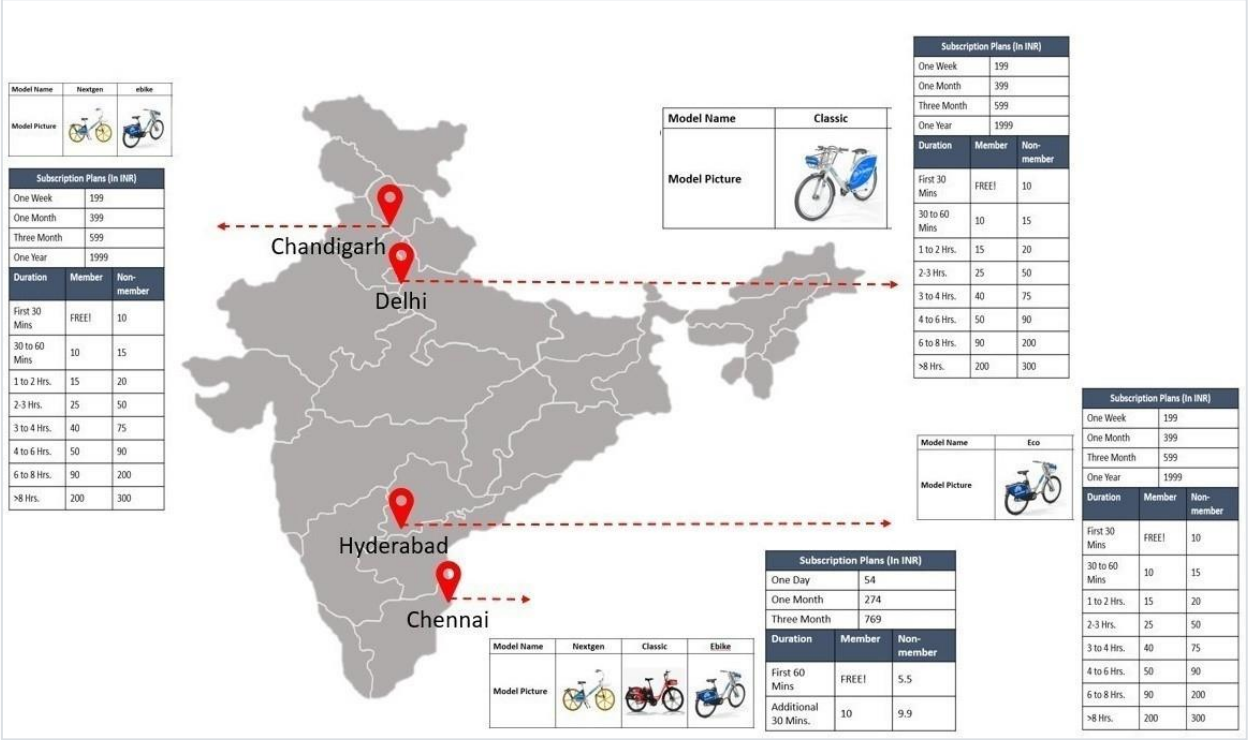
Duration	Member
First 30 Mins	FREE!
30 to 60 Mins	5.9
1 to 2 Hrs.	11.8
Additional Hour	15

Duration	Member
First 30 Mins	FREE!
30 to 60 Mins	5.9
1 to 2 Hrs.	11.8
Additional Hour	15

Duration	Member
First 30 Mins	FREE!
30 to 60 Mins	5
1 to 2 Hrs.	10
Additional Hour	15

3. Smart Bikes

Figure 27: SmartBikes PBS stations



The advantages and disadvantages along with risks perceived risks of the current operating models identified are summarized in the below table:

Table 8: Advantages, disadvantages, and perceived risks for different PBS models

Model	Ownership	Implementing Agency	Public Agency Role	Risk	Profit	Pro	Con
Private Owned and Operated	Private Contractor	Private Contractor	The Public agency only plays a limited role in, **station placements and obtaining permits.**	Complete risk is absorbed by the private player	Private contractor shares revenue with the public agency	Has the ability to mobilize equipment and personnel from other systems if required.	Initial CAPEX requirement for private entity is higher.
Publicly Owned / Privately Operated	Public agency	Private Contractor	The public agency oversees **capital investment, possesses the infrastructure and equipment, manages the contract** with the private operator,	The **public agency assumes financial risk,** while operational risk is shared by the private contractor.	Agency Retains the profits	Profits may be directed back to the city or regional entity as revenue or reinvested to expand the system.	Concerns may arise regarding potential liability to the city, county, etc.

Model	Ownership	Implementing Agency	Public Agency Role	Risk	Profit	Pro	Con
			and holds decision-making authority, guiding the program's direction.				
Publicly Owned / Publicly Operated	Public agency	Public Agency	The public agency manages capital investment, possesses infrastructure and equipment, and **supervises all operational** aspects.	Complete risk is on the public agency	Agency Retains the profits	Maximum public oversight and transparency are ensured.	Government might need extra source including manpower and funds to run the system efficiently.

Relevant Case Studies

1. Mysuru

Mysuru is the second-largest city and the cultural capital of the state of Karnataka in South India. A historical city with numerous palaces and ancient monuments, it relies on tourism as a mainstay of the economy. However, like many rapidly growing population centers, Mysuru faces traffic and transportation challenges, including in the city's heritage core, which is located fairly close to the central business district. To tackle these issues, the city authorities sought a low-cost and environmentally friendly mobility option and decided on a PBS transit program designed to reach both city residents and visitors.

Figure 28: Mysuru on Indian map

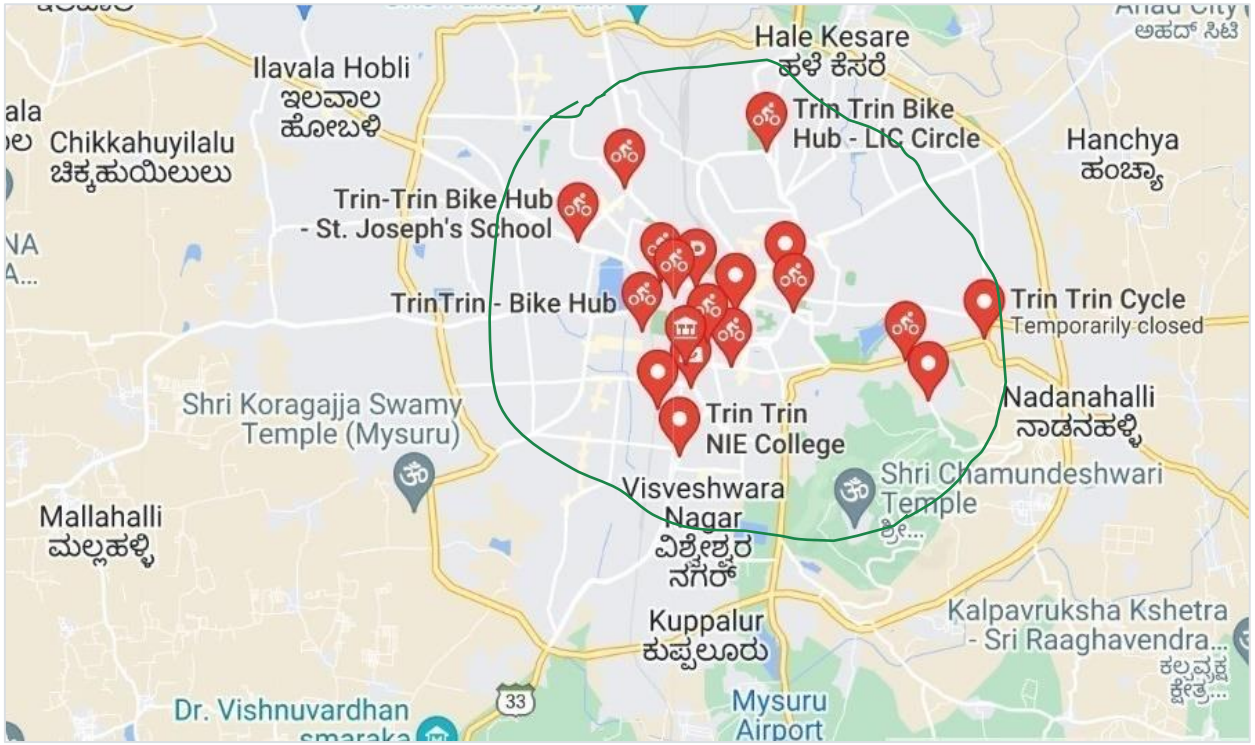
Trin Trin stands as a notable initiative by the Karnataka government, receiving support from the World Bank's Global Environment Facility (GEF) Grant. Under the execution of the Directorate of Urban Land Transport and the Mysuru City Corporation, the project was inaugurated on June 4, 2017. During the launch, there were only 430 conventional bi-cycles. However earlier in 2023 the MCC and DULT, took an initiative to launch e-bicycles as well. Marking garnered more than 17,000 subscribers. The initiative took a forward leap in 2023 by introducing e-bicycles to enhance public sharing services, aligning with the growing demand for sustainable and eco-friendly urban transportation solutions in the region.

PBS Information:

Table 9: Mysuru PBS details

Parameters	Details
PBS Operator	Trin Trin
Launch year	2017
Fleet size	450
No. of docking stations	48
City Area Covered	28 sq.km.
Users	> 14,000
Fare structure[15]	**First half hour is free; the minimum fare is INR 5 (for 30–60 min).** 1–2 hr: INR 15; 2–3 hr: INR 35; 3–4 hr: INR 65; 4–6 hr: INR 95; 6–8 hr: INR 120; 8–12 hr: INR 145; >12 hr: INR 245. Users register online through the Trin Trin smartphone app, in one of six designated registration centers, or in any Mysuru One centers by paying INR 360. This includes a refundable security deposit of INR 250 and processing fees of INR 50. Both cash and credit/debit cards are accepted for payments.

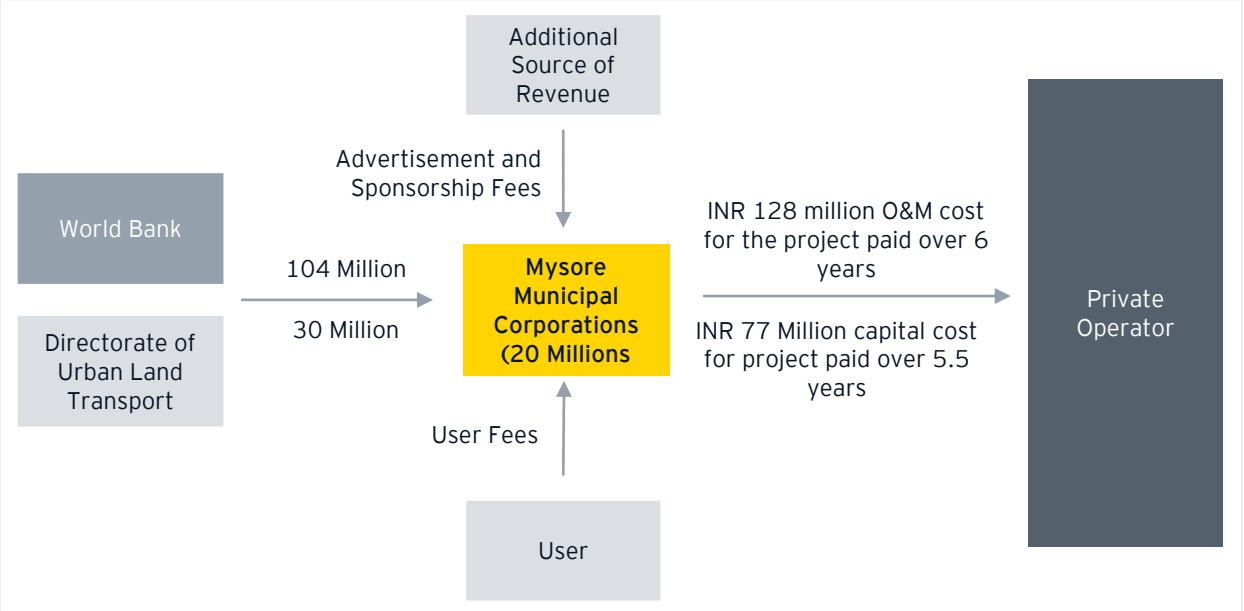
Figure 29: Locations of Dockless Public sharing bicycles in Mysuru, 2024



[15] https://wri-india.org/sites/default/files/FINAL_Public%20Bicycle%20Sharing%20India_WP_3July.pdf

Business model[16]:

Figure 30: Business Model of Mysuru PBS



Current Status and Operating Challenges

- **Initial consumer views[17]:** The rental bikes in Mysuru, offered for durations ranging from one hour to a month, have garnered immense popularity, particularly among students and small traders. The flexibility of rental periods has made these bikes a preferred and widely embraced mode of transportation in the city.
- **Road Damage:** Deteriorating road infrastructure within the city has resulted in limited utilization of bicycles in the city. This has impacted the overall usage and popularity of the PBS.
- **Issues at the docking stations:** Technical issues and various other problems led to limited availability of bicycles at docking stations. Network problems across the city also made it difficult for people to find and use the bicycles around the city.
- **Granting Permits through Scheme:** Following the introduction of trin trin, DULT introduced a scheme for issuing permits to set up and operate PBS systems in Bengaluru. The scheme was launched in 2018 and issued permits to 4 PBS operators for covering the entire Bruhat Bengaluru Mahanagara Palike (BBMP) jurisdiction. The private operators required to register on Karnataka governments website and pay the permit fee to DULT.

[16] https://wri-india.org/sites/default/files/FINAL_Public%20Bicycle%20Sharing%20India_WP_3July.pdf
[17] https://timesofindia.indiatimes.com/city/mysuru/poor-roads-to-blame-for-fall-in-patronage-for-trin-trin/articleshow/95155929.cms

2. Pune

Pune, the seventh-largest city in India and the second largest in Maharashtra after Mumbai, was once renowned as a city of cyclists. Pune faced rising cyclist fatalities due to increased motor vehicle use, highlighting insufficient infrastructure for walking, cycling, and public transport. To combat this, Pune Municiapal Corportaion (PMC) developed mobility plans from 2008 to 2017, focusing on safe, connected spaces for walking and cycling.

Figure 31: Pune on Indian map

Figure 32: Pune Cycle Plan logo

PMC implemented a series of mobility plans spanning with the goal of ensuring safe, comfortable, convenient, and connected walking and cycling experiences. This strategic approach led to the launch of India's first dockless Public Bicycle Sharing (PBS) system in December 2017. The innovative dockless technology minimized the requirement for extensive parking station infrastructure, facilitating a swift citywide rollout managed by private operators through MoUs with PMC. As of March 2018, the system boasted nearly 2,500 bikes and served over 350,000 users. PMC exercises oversight and provides diverse support for the program, and a recent publication has reported an average of 1.2 trips per cycle per day, reflecting the success and popularity of the PBS in Pune.

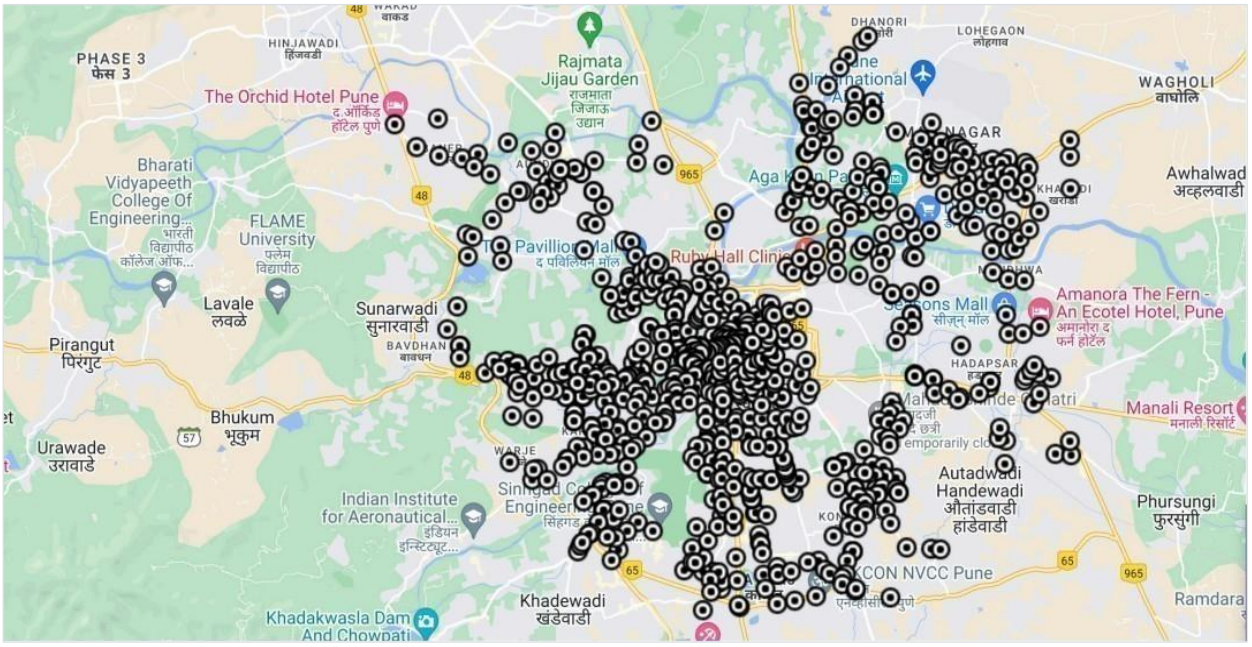
PBS information

Table 10: Pune PBS details

Parameters	Details
PBS name	Pune Public Bicycle Sharing System
Launch year	2017
Fleet size	2500
City Area Covered	Entire city
Users	> 3,50,000
Fare structure[18]	The 4 operators charge different fares. The minimum charge for the first 6 months after launch was INR 2 for 30 minutes. The minimum charge later rose to INR 6 for 30 minutes.

[18] https://wri-india.org/sites/default/files/FINAL_Public%20Bicycle%20Sharing%20India_WP_3July.pdf

Figure 33:Pune e-bicycle network



Business model[19]

Figure 34: Business Model of Pune PBS

Current Status and Operating Challenges

- **Covid scare:** Amid the COVID-19 pandemic, concerns about virus transmission had deterred people from utilizing PBS systems. The pandemic significantly impacted the overall utility and usage of PBS, as individuals prioritized personal safety over shared transportation options.
- **Buying more and sharing less:** In Pune, there is a prevailing preference for bicycle ownership rather than opting for rental or sharing services. This choice suggests a cultural inclination towards personal ownership, possibly driven by the desire for convenience, reliability, and the flexibility to use bicycles as a long-term personal mode of transportation.

[19] https://wri-india.org/sites/default/files/FINAL_Public%20Bicycle%20Sharing%20India_WP_3July.pdf

3. Bhopal

Bhopal, the capital of Madhya Pradesh in central India, has experienced a significant increase in road traffic, noise, and air pollution due to a growing vehicle population. In response, city authorities developed a plan to promote walking, cycling, and public transport, emphasizing the implementation of a PBS system and dedicated bicycle lanes. The objectives of this initiative include addressing pollution, congestion, and road safety concerns. The city aims to achieve a reduced carbon footprint, enhance last-mile connectivity, improve access to the Bus Rapid Transit System (BRTS), and encourage the conversion of walking trips to faster bicycle travel.

Figure 35: Bhopal on Indian Map

Bhopal introduced its PBS scheme, CharteredBike, in 2017, marking a pioneering effort as the first Public-Private Partnership (PPP) for PBS in the city. Since its inception, CharteredBike has evolved to include a fleet of bicycles, aligning with the growing trend toward sustainable and eco-friendly urban mobility.

Figure 36: Charteredbike logo

Implemented as a fully automated system, Bhopal's PBS operates under a build-operate-transfer concession model, fostering accountability for operations and maintenance (O&M) between the city authorities and the private operator. This accountability is ensured by tying a portion of the O&M costs to Service Level Benchmarks (SLBs) and related incentives, while the funding for system installation and O&M is shared between public and private partners. The CharteredBike consortium, formed by Chartered Speed of India and nextbike of Germany, secured the project bid. The government, through BSCDCL, contributed a fixed INR 29.5 million in capital costs, and 40 percent of the operating costs for 500 bicycles over the seven-year contract period.

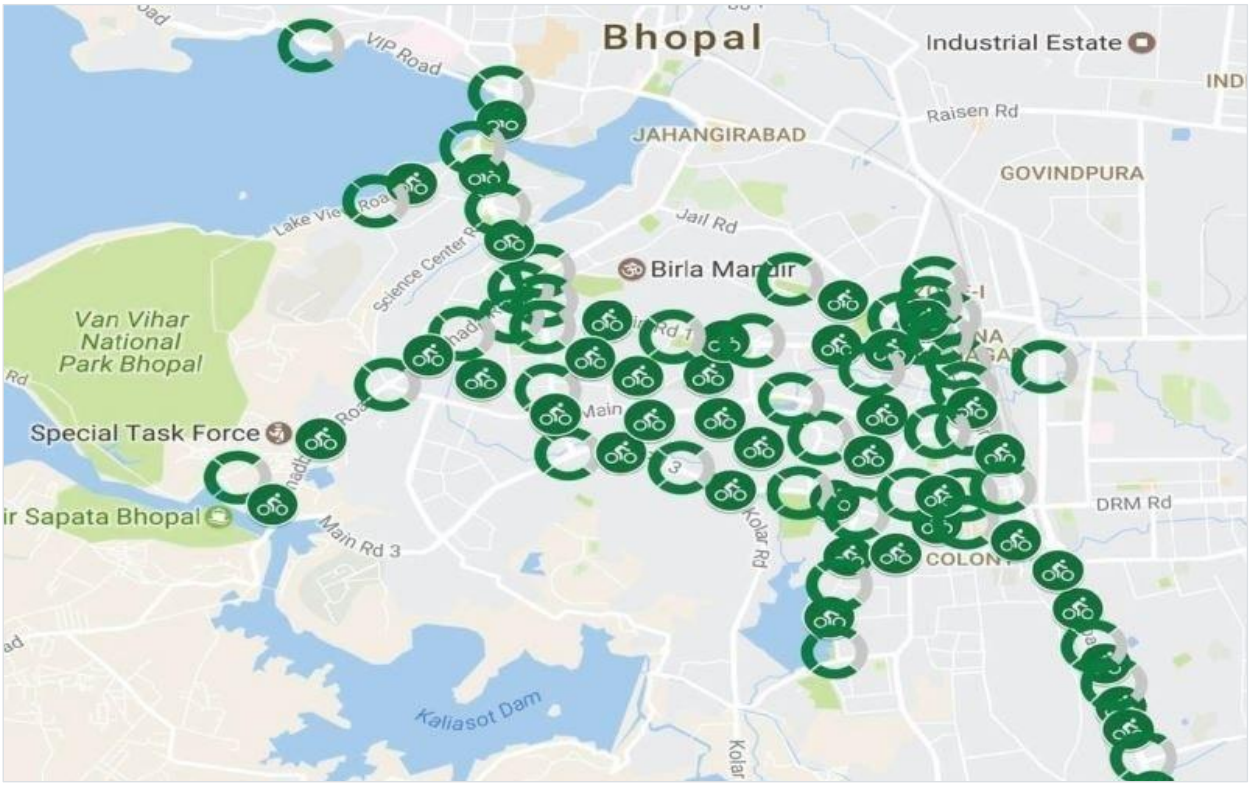
PBS information:

Table 11: Bhopal PBS details

Parameters	Details
PBS Operator	Chartered Bike
Launch year	2017
Fleet size	500
No. of docking stations	50
City Area Covered	20 sq.km.
Users	> 65,000
Fare structure[20]	**For members, the first 30 minutes is free**, and the minimum fare is INR 5 for 30–60 min. For 60–90 min the fare is INR 20, and after 90 min, INR 15 will be charged for each additional 30 min. Users register as members through the CharteredBike smartphone app or at registration centers by paying a refundable INR 500 security deposit and processing fees of INR 50. Payments can be made by cash or credit/ debit cards, in person or through the app.

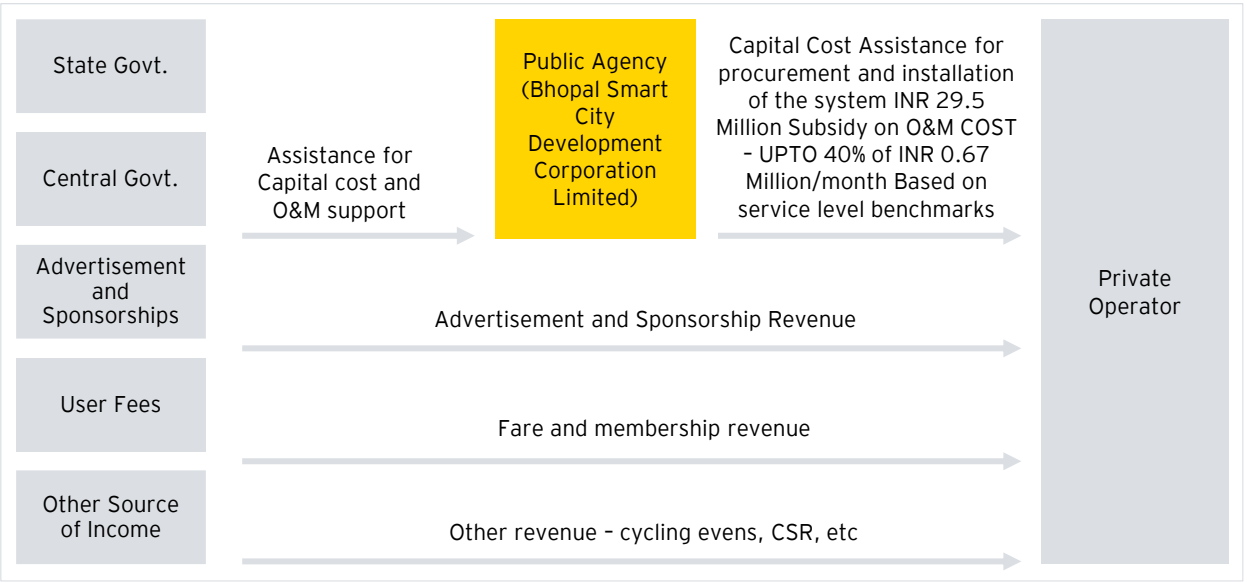
[20] https://wri-india.org/sites/default/files/FINAL_Public%20Bicycle%20Sharing%20India_WP_3July.pdf

Figure 37: Bhopal chartered e-bicycle docking stations network



Business Model[21]:

Figure 38: Business Model for Bhopal PBS



Current Status and Operating Challenges

Lack of cycle tracks: The existence of PBS in Bhopal is endangered due to a lack of supervision and the limited capacity to safeguard dedicated cycle tracks. The absence of proper management and protection for these tracks poses a significant threat to the sustainability and success of the PBS system in the city.

[21] https://wri-india.org/sites/default/files/FINAL_Public%20Bicycle%20Sharing%20India_WP_3July.pdf

4. Chandigarh

Chandigarh exemplifies a ground-breaking modern architectural and urban planning concept in India, consistently leading in visionary development. As a Smart City, Chandigarh envisions a substantial promotion of Non-motorised Transport (NMT) as a fundamental sustainability concept. Despite being among India's top cities in motor vehicle ownership, the city aims to enhance liveability and reduce dependence on motorized vehicles

The increasing population of the city has led to a demand for an effective transportation sharing system to support its growth. In response, the administration sought to address this need by introducing a bicycle sharing system, which experienced a successful launch and garnered significant attention during its trial phase.

Figure 39: Chandigarh on Indian map

Figure 40: Chandigarh Smart Bike at their docking station

The Electric Bike project in Chandigarh, initiated on December 10, 2020, is a remarkable venture. As part of this initiative, Smart Bike initially unveiled 225 bikes designed for the people of Chandigarh, featuring two distinct variants: the electric bike in red and the next-gen bike in silver and yellow colours.

Figure 41: Smart bike logo

PBS information

Table 13: Chandigarh PBS details

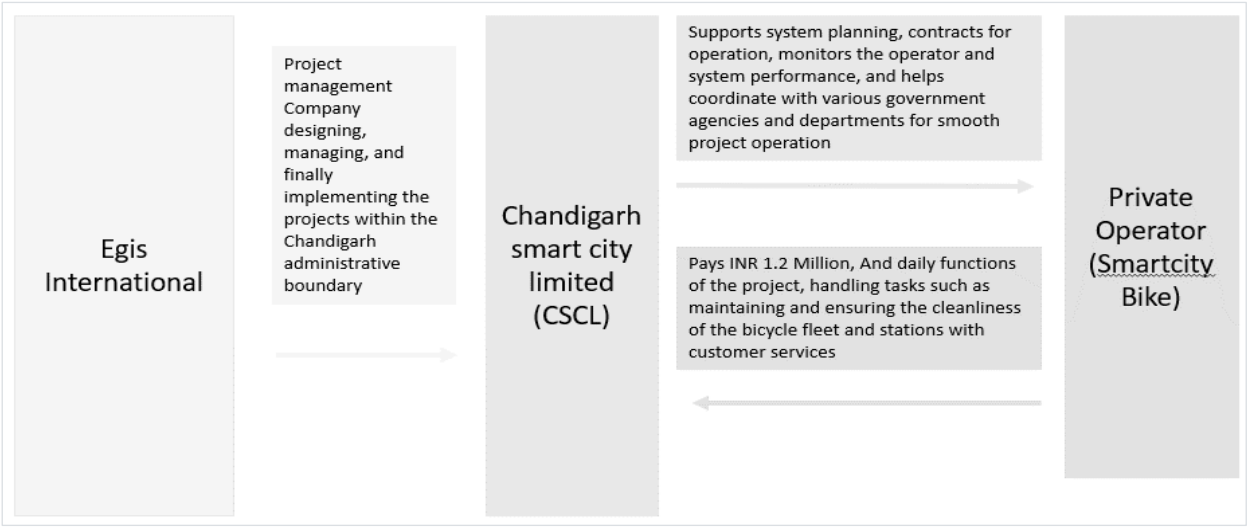
Parameters	Details
PBS name	SmartBike
Launch year	2020
Fleet size	3,750
No. of docking stations	465
Hours of operation	9:00 a.m. – 11:00 p.m.
Coverage	114 Kms
Subscribers	Estimated 1,500 daily users
Fare structure[22]	Annual Subscription of INR 500/-. **Rental for 30 Mins for Nonsubscriber**: INR 10 **Rental for 30 Mins for subscriber**: INR 5 **Rental for Additional 30 Mins for Nonsubscriber**: INR 10 **Rental for additional 30 Mins for subscriber**: INR 5

[22] https://smartbikemobility.com/

Figure 42: Chandigarh Map for PBS

Business Model:

Figure 43: Business Model for Chandigarh PBS



Current Status and Operating Challenges

- **Phase 3 Completed:** The completion of the third phase has increased the total count of bicycles to 3,750, distributed among 465 docking stations across Chandigarh. This expansion enhances the availability and accessibility of bikes within the city, fostering a more comprehensive and efficient public bicycle sharing system.
- **Vandalism/Theft:** The initiative is facing the detrimental impact of vandalism, leading to significant concern for the managing agency. Acts of damage and destruction have adversely affected the project's seamless operation and overall efficiency. The severity of the situation is evident, with almost 3,000 instances of vandalism occurring in 2022 resulting in losses amounting to ₹5 crore. Additionally, the absence of advertisers to support the project is exacerbating the challenges it currently faces.

5. Delhi

Delhi, the capital of India, is a bustling metropolis. The city grapples with severe traffic congestion and alarming levels of air pollution. The exponential growth in population, coupled with an increasing number of vehicles on the roads, has led to chaotic traffic conditions, prolonged commuting times, and a significant environmental burden.

Figure 45: People at the docking station

PBS emerges as a potential solution to alleviate some of Delhi's transportation challenges. By providing an eco-friendly and efficient mode of transportation for short distances, PBS can reduce dependence on

Figure 44: Delhi on Indian Map

motorized vehicles, easing traffic congestion and mitigating air pollution.

Some private entities have independently installed bicycle docks, indicating a continued interest in contributing to sustainable urban mobility in the city. The collaborative efforts of public and private players will be a key to address Delhi's complex transportation and environmental issues. [23]

PBS information

Table 12: Delhi PBS details

Parameters	Details
PBS name[24]	MOBYCY
Launch year	2017
Fleet size	5000
No. of docking stations	500
Hours of operation	6:00AM-10:00 PM
Fare structure	Users can sign up on the Mobycy app with Aadhaar identification and pay a security deposit of Rs 999, which is refundable. The security deposit for students is Rs 499

[23] https://mcdonline.nic.in/ndmcportal/downloadFile/public_bicycle_sharing_pbs_211203044402122.pdf
[24] https://www.zeebiz.com/small-business/news-mobycy-launches-dockless-bike-sharing-service-app-33081

Table 13

Parameters	Details
PBS name[25]	Smartbike Mobilty
Launch year	2018
Fleet size	300
No. of docking stations	36
Hours of operation	6:00AM-10:00PM
Coverage	NMDC AREA
Subscribers	17000
Fare structure[26]	Ride Time / Member Fee / Pay as you go First 30 Minutes / FREE! / INR 10 30 to 60 Minutes / INR 10 / INR 15 1 to 2 Hours / INR 15 / INR 20 2 to 3 Hours / INR 25 / INR 50 3 to 4 Hours / INR 40 / INR 75 4 to 6 Hours / INR 50 / INR 90 6 to 8 Hours / INR 90 / INR 200 >8 Hours / INR 200 / INR 300

Operating Challenges

- **Limited users:** A significant portion of respondents, 46.1%, expressed hesitancy towards using the Public Bicycle-Sharing (PBS) service, according to the survey. Additionally, 31.1% mentioned using the service only once. Only 14.5% reported utilizing PBS weekly, and a minimal 8.3% claimed to use it nearly every day.
- **Usage limited for recreational and fitness purpose:** In Delhi, the Public Bicycle Sharing (PBS) service is not a regular component of people's daily transportation. The survey reveals that most users engage with the service for recreational and fitness purposes rather than daily commuting. Of those who have used the service, 30.6% cited fitness, and 29.7% mentioned recreation. Only 12.6% cycle to work, while 8.5% use it for errands. The remaining 18.6% use it for leisure activities such as fun, roaming, or as a hobby.
- **Lack of planning:** Among 1,329 respondents, 836 expressed concerns about the Public Bicycle Sharing (PBS) system, citing insufficient docking stations and considerable distances between them. The issue arises when users must return bicycles to the same station due to limited options near their destination. Safety concerns are prevalent, with 733 individuals noting the lack of dedicated cycling lanes and safety measures as a deterrent. Additionally, 617 respondents find the use of multiple mobile apps for different service providers inconvenient, advocating for a unified app or card system, similar to the Delhi metro.

[25] https://www.hindustantimes.com/cities/smart-cycles-a-hit-among-professionals-in-delhi/story-hGizibKDuiqYj4UPHOaWqK.html
[26] https://smartbikemobility.com/new-delhi/

3.13. Last mile delivery using electric bicycles in India

Public bicycle sharing in India is an excellent choice for local food delivery personnel, relieving them of initial investment. Some cities and last mile fleets are adopting this approach, offering a cost-effective and sustainable solution for delivery boys, optimizing their efficiency without the need for personal bicycle ownership.

Swiggy partnering with Hero Lectro and Sun Mobility

Hero Lectro Cargo (HLC) and Swiggy, a prominent on-demand delivery platform in India, are collaborating to test cargo e-bikes for food delivery. Swiggy, aiming to integrate EVs, deployed **Hero Lectro's WINN in Hyderabad**, partnering with Fast Despatch Logistics and A.S. Group for the pilot. This aligns with Swiggy's commitment to expanding EV adoption in its delivery fleet.

This initiative enhances riders' earnings due to reduced maintenance and running expenses. It also aligns with broader aims of curbing carbon emissions, coinciding with government efforts promoting cleaner e-mobility for improved air quality. In addition to their lack of emissions, electric bicycles do not require immediate swapping or recharging when the battery depletes. They can either be charged using standard electrical outlets or continue operating through pedal power.[27]

Figure 46: electric bicycles used for Swiggy delivery

Recently, Sun Mobility and Swiggy have formed a strategic alliance to electrify over 15,000 e-bikes in Swiggy's delivery fleet.[28]

PBS Information

Table 14: PBS information - Swiggy & Sun Mobility partnership

Parameter	Details
Location	Hyderabad
Launch Year	2021
OEM	Hero Lectro
Vehicle Model	Hero Lectro WINN
Fleet/Food Delivery App[29]	Swiggy in association with FDL and AS Group
PMC	Fast Despatch Logistics and A.S. Group for the pilot

[27] https://www.socialnews.xyz/2021/08/05/swiggy-commits-to-increase-deployment-of-evs-by-2025/
[28] https://www.carandbike.com/news/sun-mobility-and-swiggy-partner-to-electrify-15000-ebikes-in-next-12-months-3209166
[29] https://pedalandtringtring.com/2021/08/09/swiggy-partners-with-hero-lectro-winn-to-pilot-food-delivery-with-electric-cargo-bikes/

About Bicycle

Table 15: electric bicycles specifications used for swiggy delivery

Parameter	Details
Bike Specifications[30]	maximum speed of 25 kmph with a range of 70-75 kms per charge
Storage Capacity	Storage Capacity - Up to 180 Ltrs.
Charging Time	60% -> 4 hrs., 100% -> 7 hrs.
Motor/ Max Power	BLDC 36V/250W
Battery	11.6 Ah Battery

Activity Sequence

Timeline

2019	2020	2020-21	2022-23
Swiggy collaborated with Hero Lectro, an electric bicycle manufacturer, to facilitate complete delivery of Swiggy orders using cargo e-cycles	Swiggy, partnered with Fast Despatch Logistics and A.S. Group, launched a trial program in Hyderabad	Swiggy plans to use Hero Lectro's WINN for its operations	Swiggy has planned to work on battery swapping and invested in a partnership with Sun Mobility

3.13.1. Operational Models for public bike sharing in India

1. Subscription Model

The subscription model within Public Bicycle Sharing (PBS) presents users with a convenient and economical approach to accessing shared bicycles.

To access the PBS system, subscribers receive a membership card, unique access code, or utilize a designated mobile application, ensuring secure and personalized usage.

Figure 48: Subscriber taking out their bicycles

Key features

Membership card & App	Daily, Monthly, Annual payment options	Accomodating different user needs	Cost saving with discounted rates	Incentives for long term memberships

[30] https://www.herolectro.com/winn-SHLE24GYGY01HM_main.html

2. Rental Model

The rental model within Public Bicycle Sharing (PBS) is tailored for users seeking a flexible, **pay-as-you-go approach.**

Flexible rental durations, allowing users to go for short-term, one-time rentals and providing diverse options for individual needs.

Figure 49: Bicycles available on rent

Key features

No subscription fees	Pay as per your usage	Suited best for occasional users	Suitable for first time users

3. Docking system

Docked bicycle stations are integral components of bike-sharing systems**, providing organized and designated locations for users to pick up and return bicycles**. Docked stations require users to retrieve and return bikes to specific docking points.

Docking stations provide designated locations for users to pick up and return bikes, ensuring a reliable and predictable availability of bicycles at specified points within the system.

Figure 50: Docking system

Key features

Designated docking points for bike placement	Secure locking mechanisms for bike safety	Accessible charging facilities for electric bikes	Structured system to minimize bike clutter

4. Dock-less System

Dockless bicycle stations represent a modern and flexible approach to bicycle-sharing systems. Unlike traditional bicycle-sharing programs where bicycles must be picked up and returned at designated docking stations, dockless systems provide users with the freedom to locate, rent, and return bikes anywhere within a defined operational area.

Dock-less system provides flexibility and addresses the last-mile connectivity challenge in urban transportation, allowing users to cover short distances efficiently without the constraints of fixed docking infrastructure.

Figure 51: Dockless system

Key features

Designated docking points for bike placement	Secure locking mechanisms for bike safety	Accessible charging facilities for electric bikes	Structured system to minimize bike clutter

Merits and Demerits of various PBS Models

Table 16: Merits and Demrits of PBS models

PBS Type	Subscription Model	Rental Model	Docked bicycle System	Dock-less System
Merits	▸ Cost-Efficiency ▸ Convenience ▸ Regular Usage Incentives	▸ Flexibility and Convenience ▸ Affordability for Occasional Users	▸ Organized System ▸ Predictable Availability ▸ Charging and Maintenance Facilities ▸ Enhanced Security	▸ Flexibility in Parking ▸ Enhanced Accessibility ▸ Quick Deployment
Demerits	▸ Limited Flexibility ▸ Initial Membership Cost	▸ Potential Higher Costs compared to subscribers ▸ Transaction Overhead compared to subscription model	▸ Infrastructure Costs ▸ Limited Flexibility ▸ Dedicated Space Requirements ▸ Station Imbalance of bicycles	▸ Bike Clutter ▸ Security Concerns ▸ Challenges in Regulation

3.14. CESL Strategy

3.14.1. Demand Aggregation and partnership with potential users

CESL is focused in delivering clean, affordable, and reliable energy solutions that enable a faster energy transition. CESL is a critical player working in development of e-mobility ecosystem in the country. To enable commercialization of these solutions at scale, Convergence employs business models that utilize blend of concessional and commercial capital, Carbon finance and grants as appropriate.

The Central government has identified electric micro mobility as one of the drivers for encouraging resource efficiency in transport sector. To meet this objective, CESL seeks to procure Electric Bicycles (Passenger, Cargo and Low Speed Pedal Assist Mopeds) by aggregating demand from various government agencies, religious institutions, educational institutes, CPSUs, hotels and other agencies etc.

With an aim to accelerate implementation of Green Mobility solutions in India, CESL intends to bring about a market transformation in the non-motorized electric micro-mobility segment (electric-bicycle) through economies of scale by aggregating demand & thereby creating a lucrative proposition for all stakeholders.

By strategically consolidating demand**, CESL envisions widespread deployment at the state level, nurturing both environmental sustainability and economic empowerment.** CESL is in discussion with various ministries and departments like Ministry of Environment, Forest and Climate Change (MOEFCC), Ministry of Rural Development (MORD), Department of Posts, Municipal corporations, CPSUs, Bureau of Energy Efficiency (BEE), religious & educational institutes, and other such organizations for deployment of e-bicycles at different places covering pan India locations.

> **CESL's envisioned plan for e-bicycle deployment is carefully tailored to address diverse needs, particularly empowering rural working women**

Furthermore, CESL commits unwavering support throughout the entire e-bicycle lifecycle. From the initial procurement stages to deployment, the team ensures seamless coordination, maintaining the highest quality standards and regulatory compliance. Post-deployment, comprehensive support shall be provided during the warranty period through the OEMs ensuring a seamless user experience.

CESL, invites collaboration to realize sustainable Micro-mobility, initiating a transformative shift in the e-bicycle market. With a proven history of market transformations and a commitment to eco-friendly solutions, CESL strives to drive positive change by promoting micro mobility and large-scale deployment of electric bicycles and low speed electric mopeds in India.

3.14.2. Business Models for Deployment of Electric Bicycles

1. Upfront payment

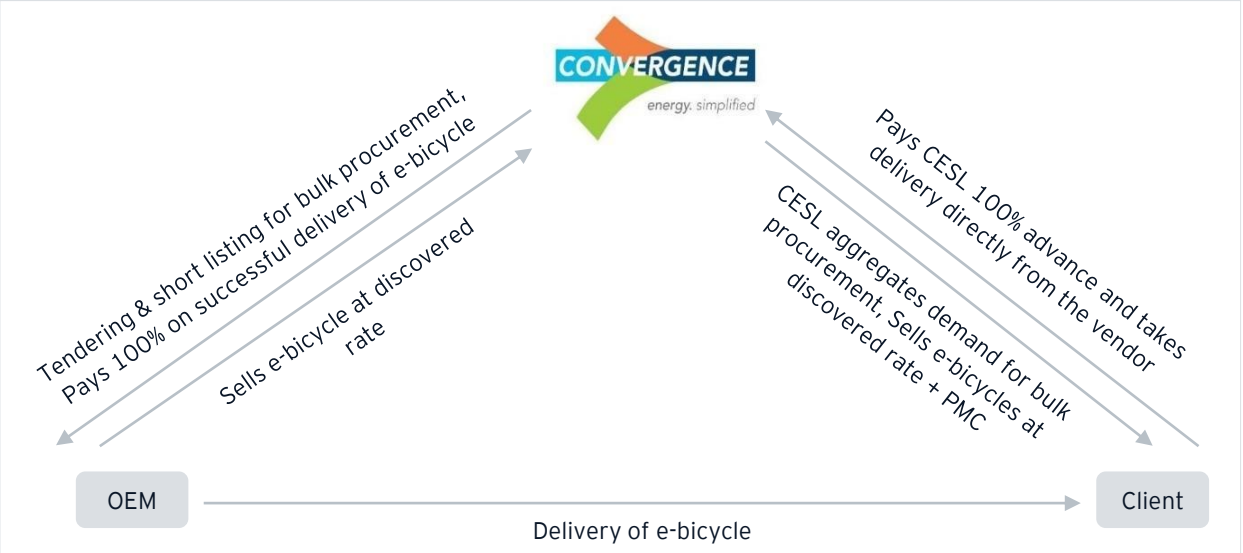


Figure 52: Upfront Business Model

CESL	Client	OEM
► Discussion with client for demand aggregation ► Ensuring price reduction through demand aggregation ► Transparent tendering and procurement process ► Ensure OEM (successful bidder) provides complete support during warranty period	► Demand aggregation within organization ► Contract signing with CESL ► Receipt of electric bicycles ► Payment as per agreed terms	► Participation in tendering process ► Delivery of electric bicycle at designated location ► Providing complete support during warranty period

2. Part Payment - EMI

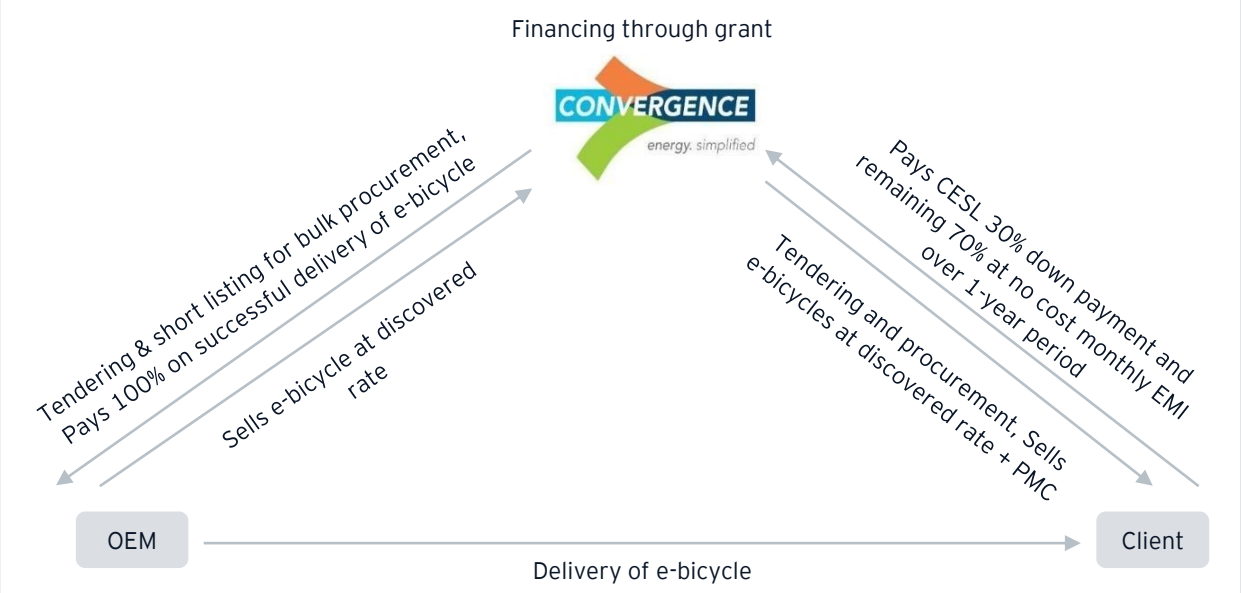


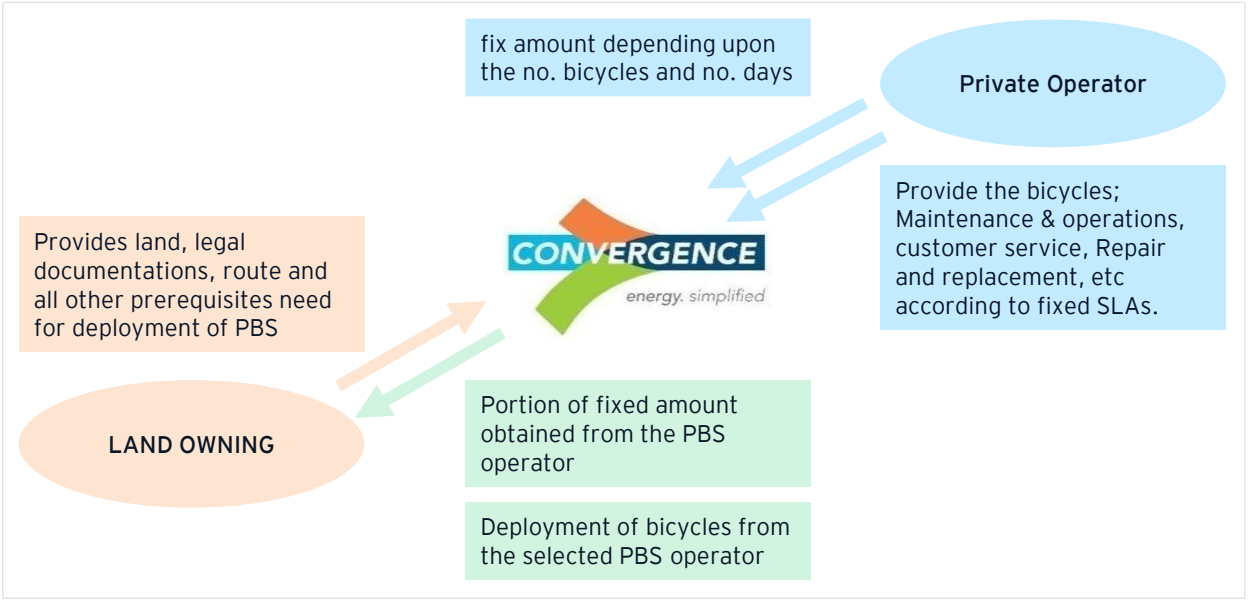
Figure 53: Part Payment Business Model

CESL	Client	OEM
► Discussion with client for demand aggregation ► Ensuring price reduction through demand aggregation ► Transparent tendering and procurement process ► Ensure OEM (successful bidder) provides complete support during warranty period	► Demand aggregation within organization ► Receipt of electric bicycles ► 30% advance payment ► Remaining payment as per agreed terms over 1 year period ► Providing payment security for EMI portion	► Participation in tendering process ► Delivery of electric bicycle at designated location ► Providing complete support during warranty period

3. Public Private Partnership

The Public-Private Partnership (PPP) model emerges as an optimal business model for public bicycle-sharing systems due to its multifaceted advantages. In this collaborative approach, private entities bring substantial investment, technical expertise, and operational efficiency, alleviating the financial burden on public agencies. The sharing of risks and responsibilities ensures a sustainable and well-managed system. Additionally, private sector involvement fosters innovation, technological advancements, and seamless integration, enhancing the overall quality and viability of the bicycle-sharing service. This collaborative synergy between public and private sectors under the PPP model leads to the successful establishment and sustainable growth of public bicycle-sharing systems.

Figure 54: Public Private Partnership



- **Shared Responsibility:** Entering a new state is frequently accompanied by uncertainties and potential risks. The Public-Private Partnership (PPP) model provides a framework for the equitable distribution of risks between the public and private sectors. Through shared responsibilities, the risks linked to project construction, operation, and maintenance are divided more fairly, alleviating the burden on any single entity. This foster increased collaboration, encourages innovation, and enhances overall risk management practices.
- **Technological Benefit with expertise and innovation**: Private sector collaborators frequently bring specialized expertise and experience that proves invaluable when venturing into unfamiliar territories. Their inventive methods in project conception, execution, and administration can result in streamlined processes and enhanced results. This injection of knowledge has the potential to accelerate the establishment of cutting-edge infrastructure and services.
- **Risk Sharing**: The Public-Private Partnership (PPP) model facilitates the equitable distribution of risks between the public and private sectors. Through shared responsibilities, the potential risks linked to project construction, operation, and maintenance are divided more fairly, alleviating the burden on any single entity. This promotes increased collaboration, fosters innovation, and enhances overall risk management practices.
- **Faster Implementation:** Conventional public sector projects often encounter bureaucratic hurdles and delays. Public-Private Partnerships (PPPs) can accelerate project execution by harnessing the agility of the private sector and facilitating more efficient decision-making. This becomes particularly crucial when venturing into a new state, as swift deployment can create a competitive advantage and enable the exploration of emerging opportunities.
- **Long term viability with job creation and economic development:** Public-Private

Partnership (PPP) initiatives are frequently designed as enduring collaborations, surpassing the initial construction stage to encompass ongoing operation and maintenance. This strategy emphasizes sustainability, as private partners are motivated to preserve the asset's value. States gain from long-lasting infrastructure that remains valuable and operational for an extended period. Venturing into a new state yields economic advantages such as job generation, heightened demand for local products and services, and increased tax revenues. PPP projects enhance these impacts by drawing private investments, fostering economic expansion, and supporting local development.

Key roles of stakeholders

Figure 55: Roles of Stakeholder

CESL	Client	PBS Operator
► Empanelling Public Bicycle Sharing (PBS) operator. ► Collection of fixed revenue and subsequently sharing it with the Client.	► Providing necessary land, routes, and essential legal documentation. ► Support in approvals for the successful implementation of PBS.	► Deploying e-bicycles at the allocated spaces and adhering to agreed SLBs. ► O&M of e-bicycles and addressing operational challenges.

3.14.3. Potential challenges in scaling up deployment of electric bicycles

EV deployment especially in the 2W segment has picked up pace in India, but electric bicycle deployment is still in nascent stages. The major hurdles observed in scaling up deployment of electric bicycles are:

- High upfront cost compared to conventional bicycles
- Financing of E-Bicycles
- Lack of awareness
- Social barrier in rural areas
- Government Support
- Rider safety

To overcome these challenges, it is important to reduce upfront cost of the electric bicycles and to increase awareness among rural communities and other potential beneficiaries, as mentioned in the above section, about the benefits of electric bicycles by way of providing demand incentive and demand aggregation.

Safety challenges on e-bicycles include lack of awareness among riders and motorists, inadequate infrastructure such as bike lanes, limited regulations specific to e-bikes, potential for higher speeds leading to accidents, and risks associated with sharing roads with larger vehicles. Additionally, issues like improper maintenance and battery-related hazards pose safety concerns.

Keeping in mind the safety of commuters, OEMs should consider providing accessories like helmet and kneecaps to their consumers. Additionally, ULBs should develop dedicated bicycle tracks for commuters travelling via personal bicycles or public bicycles. Such initiatives will lead to safer road conditions and ensure higher adoptability among masses.

In rural areas, social barriers like aspiration for motorized 2 wheelers, reluctance of women to use electric bicycles, can be overcome by the low-speed pedal assist electric mopeds. These electric mopeds are lower in height, making it easier for women to ride and can also act as a solution for the aspirational barrier.

3.15. Scaling up E-bicycles from ADB Grant

While the high upfront cost of electric bicycles remains a significant obstacle for their widespread use, the pressing need to address climate change demands immediate action. While it may take time for E-bicycles to achieve price parity with traditional bicycles, expediting their adoption is crucial to meet India's commitments in reducing carbon emissions and promoting cleaner energy and transportation. Accelerating the integration of E-bicycles into our transportation systems is an essential step toward a more sustainable and environmentally friendly future.

Customizing pilot programs to suit local needs is essential, and the collaboration between GEF, ADB, and CESL presents a valuable opportunity to deploy e-bicycles across cities at different stages of their electric vehicle adoption journey. This partnership brings together a blend of local and international expertise, along with funding for exploration and the establishment of an institutional framework for scalable business models – crucial elements for expanding a country's electric mobility.

The GEF-ADB funds will play a pivotal role in stimulating the bulk procurement of e-bicycles. GEF's contribution of technical assistance, drawing on its global and regional experience with new technologies and business models, adds a significant dimension. CESL, acting as an implementing agency, will drive demand aggregation for e-bicycles.

Moreover, the motivation for development financing may encourage private sector involvement, fostering the growth of localized electric vehicle manufacturing and related segments. This holistic approach not only addresses the immediate need for sustainable transportation but also lays the groundwork for long-term electric mobility solutions in diverse urban landscapes. Asha workers and SHG workers, serving as crucial community health advocates in rural India, stand to gain significantly from the adoption of e-bicycles. In regions where public transportation is limited, these electric bicycles serve as a valuable tool, enhancing the mobility of Asha workers and enabling them to reach remote villages more efficiently. This not only enhances the overall effectiveness of healthcare services but also plays a pivotal role in the economic and social upliftment of women. By fostering empowerment and inclusivity in rural India, e-bicycles emerge as a transformative solution, addressing mobility challenges and positively impacting the lives of both Asha workers and the communities they serve.

> **The adoption of e-bicycles empowers women, offering them a sustainable means of transportation and reducing the physical burden of traveling long distances.**

There is a significant desire for individual transportation, particularly among women participating in Self-Help Groups, Anganwadi, and ASHA workers, who travel daily for distances of 10-15 km. Nevertheless, the substantial initial expense of electric bicycles, varying from INR 30,000 to INR 50,000, acts as a major obstacle to widespread use. This financial obstacle emphasizes the necessity for external assistance to enhance accessibility to sustainable transportation in these regions.

The scaling up of electric bicycles involves reaching a broader audience through strategic initiatives. Key strategies include forging partnerships with private entities such as educational institutes, collaborating with government departments and organizations, implementing effective marketing campaigns, and prioritizing customer support. These steps are designed to enhance accessibility and foster the widespread adoption of electric bicycles.

CESL may engage in large-scale procurement and collaborative efforts to aggregate demand, with the primary goal of reducing overall costs in the supply chain. By consolidating e-bicycle demand, CESL would facilitate the acquisition of these vehicles at discounted rates, ensuring affordability for end-users. The selected contractor or vendor would be entrusted with providing comprehensive support, encompassing everything from manufacturing to the efficient delivery of e-bicycles.

Figure 56: Scaling up model for E bicycle

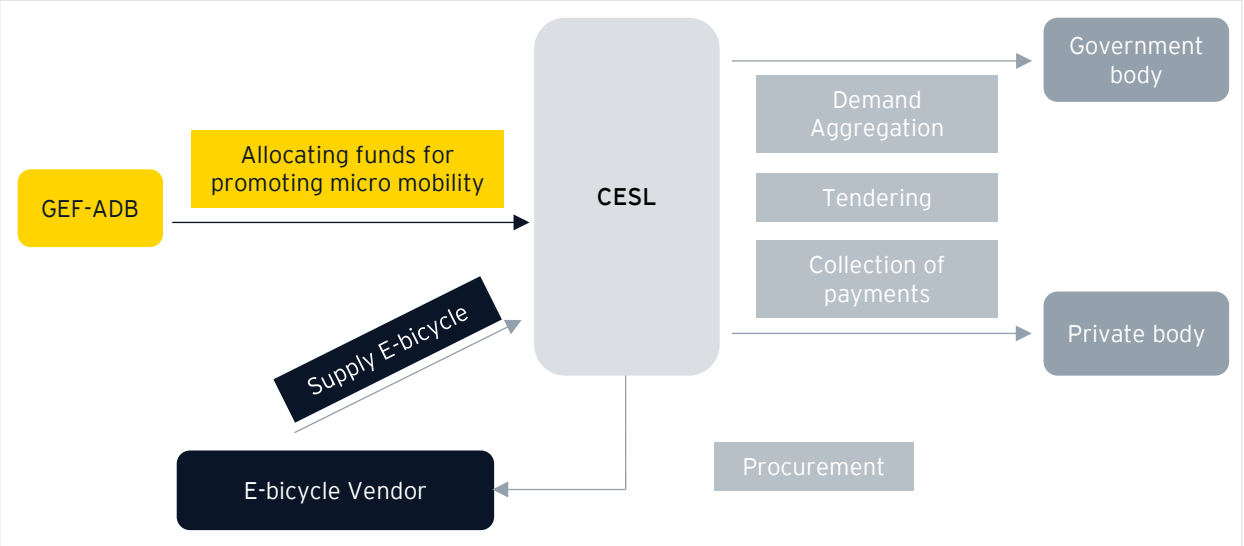


Table 17: Role of various stakeholders

Stakeholder	Portfolio	Current offering	Example support
GEF	The Global Environment Facility (GEF) offers financial assistance to governmental projects for various sustainability projects. The selection of the executing agency is determined by the respective governments.	▶ Scaling up of e-bicycles program. ▶ Technical support and enabling activity.	▶ Enabling the activity program and providing
ADB	ADB provides grants for electric vehicles and energy solutions, supporting projects aimed at enhancing sustainability and reducing carbon emissions. These grants may be directed towards initiatives such as EV infrastructure development, renewable energy projects, and energy efficiency programs in various Asian countries.	▶ Allocation of grants/ fund to CESL for procuring of e-bicycle from manufactures/ vendors.	▶ Providing with grants for bulk purchase of e-bicycles
CESL	CESL provides affordable and sustainable energy solutions, including the distribution of energy-efficient devices and the deployment of electric charging infrastructure for EVs.	▶ Demand Aggregation of electric bicycles ▶ Procuring bulk bicycles at discounted rates ▶ Finalizing vendor/s and supplier/s for the manufacturing e-bicycles ▶ Development of appropriate business model for deploying of e-bicycles.	▶ Demand aggregation with potential beneficiaries ▶ Reaching out to manufacturers for e-bicycle deployment

3.16. Recommendations

Figure 57: Recommendations for scaling Public bicycle sharing

3.16.1. Government incentive:

Crucial for increasing adoption, government incentives for e-bicycles involve providing financial benefits, tax reductions, or subsidies. These measures aim to motivate individuals to opt for e-bicycles, fostering sustainable and environmentally friendly transportation.

Such incentives enhance the affordability and appeal of e-bicycles, leading to reduced carbon emissions, decreasing the traffic congestion, and overall improvements in public health. Moreover, governmental backing stimulates innovation within the e-bicycle industry, propelling technological progress and enhancing accessibility to these eco-friendly modes of transportation for a broader demographic.

1. Collaboration of different bodies

Effective promotion and deployment of e-bicycles require a collaborative effort involving government agencies, departments, local bodies, and private entities. A united strategy is essential to address regulatory, infrastructural, and promotional aspects comprehensively.

Government departments play a role in providing regulatory frameworks, incentives, and infrastructure. Collaboration with private entities will encourage innovation, investment, and operational efficiency in e-bicycle programs.

This cooperative approach not only creates a favourable environment for e-bicycle adoption but also augments the overall success of sustainable mobility initiatives, presenting a comprehensive and well-integrated strategy for eco-friendly urban transportation.

2. Identifying consumer preferences

Conducting market research and analysis is essential for the successful deployment of e-bicycles. The collection of data from diverse agencies assists in identifying consumer preferences, evaluating infrastructure requirements, and comprehending regulatory standards.

3. Microfinancing

Microfinancing can play a significant role in the large-scale deployment of electric bicycles in India, particularly in addressing the financial barriers that may hinder widespread adoption. Some key aspects defining role of microfinancing for large scale deployment of electric bicycles is mentioned below:

Table 18: Significance of microfinancing for promoting usage of electric bicycles Awareness Campaigns

Sr. No.	Benefits	Details
1	**Affordability and Accessibility**	Microfinancing provides individuals with limited financial resources the means to afford electric bicycles. This makes these sustainable transportation options more accessible to a broader segment of the population.
2	**Easing Upfront Costs**	The upfront cost of purchasing an electric bicycle can be a deterrent for many potential users. Microfinancing allows individuals to acquire these vehicles through affordable instalment plans, easing the burden of a significant one-time expense.
3	**Entrepreneurial Opportunities**	Microfinancing can empower entrepreneurs who aim to establish e-bicycle rental services or small-scale businesses. By facilitating access to funds, it encourages the creation of micro-enterprises that contribute to the deployment of electric bicycles.
4	**Community Empowerment**	Microfinancing initiatives can be structured to involve local communities, empowering them to collectively invest in electric bicycles. This community-driven approach fosters a sense of ownership and responsibility, contributing to the sustainability of the initiative.
5	**Promoting Green Transportation**	By making electric bicycles financially viable for a broader population, microfinancing supports the transition to greener and more sustainable transportation options. This aligns with India's goals of reducing carbon emissions and promoting eco-friendly mobility solutions.
6	**Partnerships with Financial Institutions**	Collaborations between e-bicycle providers, microfinance institutions, and traditional financial institutions can facilitate the development of tailored financing solutions. This ensures that repayment structures align with the income patterns of potential users.
7	**Education and Awareness**	Microfinancing initiatives can include educational components to raise awareness about the benefits of electric bicycles and the financial mechanisms available. This helps potential users make informed decisions and enhances the overall success of the deployment
8	**Scalability and Replicability**	Microfinancing models designed for electric bicycles can be scalable and replicable across various regions in India. This scalability is essential for achieving a large-scale impact and reaching diverse communities

4. Awareness

Consumer awareness plays a crucial role in the successful deployment of electric bicycles in India. Some of the key aspects highlighting its significance are mentioned below:

Table 19: Significance of consumer awareness campaigns for promoting usage of electric bicycles

Sr. No.	Benefits	Details
1	**Educating on Benefits**	Consumer awareness initiatives help educate potential users about the numerous benefits of electric bicycles, including cost savings, reduced environmental impact, and improved personal health. Understanding these advantages motivates individuals to consider e-bicycles as a viable transportation option.
2	**Addressing Misconceptions**	There may be misconceptions or lack of understanding about electric bicycles, including their capabilities, maintenance, and cost-effectiveness. Consumer awareness campaigns can address these misconceptions, providing accurate information and building confidence in the technology.
3	**Highlighting Cost Savings**	Communicating the long-term cost savings associated with electric bicycles compared to traditional modes of transportation is essential. Consumers need to be aware of the potential financial benefits, such as reduced fuel costs and maintenance expenses.

Sr. No.	Benefits	Details
4	**Promoting Environmental Sustainability**	Creating awareness about the environmental impact of traditional transportation methods and showcasing how electric bicycles contribute to sustainability encourages consumers to make eco-friendly choices. Understanding the role of electric bicycles in reducing carbon emissions is particularly important.
5	**Showcasing Convenience and Accessibility**	Consumer awareness efforts should emphasize the convenience and accessibility of electric bicycles, especially for short-distance commuting. Highlighting their suitability for urban environments and the flexibility they offer in terms of parking and manoeuvrability can attract more users.
6	**Demonstrating Technology Features**	Educating consumers about the technology features of electric bicycles, such as pedal-assist modes and rechargeable batteries, ensures they understand how these bicycles function. Hands-on demonstrations or informational materials can effectively convey this information.
7	**Creating Test Ride Opportunities**	Offering test ride opportunities allows potential consumers to experience electric bicycles first-hand. This hands-on experience is invaluable in overcoming scepticism and demonstrating the ease of use and comfort associated with e-bicycles
8	**Involving Influencers and Ambassadors**	Leveraging influencers, community leaders, or ambassadors who endorse and use electric bicycles can significantly impact consumer perceptions. Their experiences and endorsements can carry weight in encouraging broader adoption.
9	**Engaging in social media and Online Platforms**	Utilizing social media and online platforms for awareness campaigns allows reaching a wider audience. Engaging content, testimonials, and interactive discussions can enhance understanding and generate interest in electric bicycles.
10	**Supporting Policy Advocacy**	Consumer awareness can also involve advocating for supportive policies and incentives. Awareness campaigns can inform consumers about existing government incentives, subsidies, or regulatory support for electric bicycles, fostering a favourable environment for adoption.

In summary, a well-executed consumer awareness strategy is pivotal in promoting the deployment of electric bicycles in India. By addressing knowledge gaps, dispelling myths, and showcasing the benefits, such initiatives can drive interest and contribute to the successful integration of e-bicycles into the transportation landscape in India.

4.

Case study 2

Three-wheelers

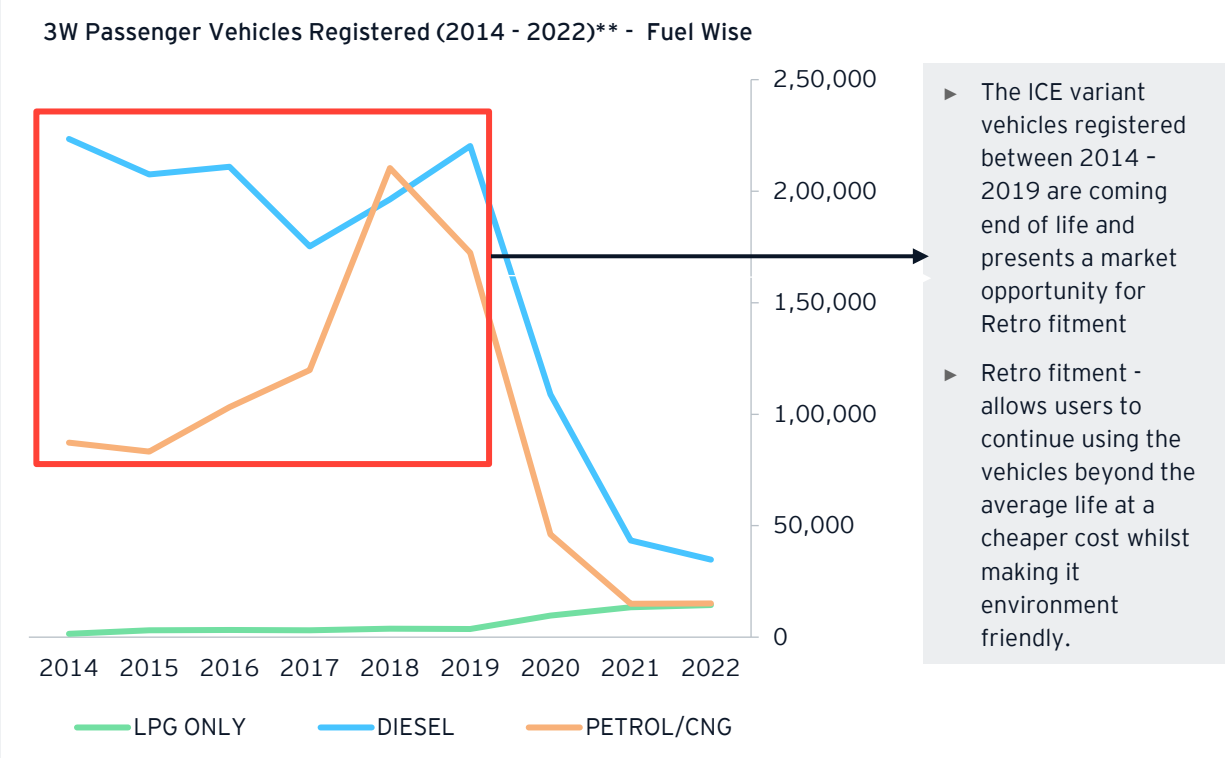
Retro-fitment in India

In India, the total number of registered 3W passenger vehicles between 2014 to 2023 is approximately 38 lakhs31. The 3W passenger vehicle market experienced a growth rate of 6.27% CAGR before the onset of the covid-19 pandemic.

During Covid-19 period, the registration of new 3W passenger vehicles faced a decline due to repeated lockdowns and travel restrictions. Additionally, the public's preference for private vehicles increased post covid-19, leading to lower growth in 3W passenger vehicle sales from 2020 onwards.

An analysis of fuel wise registrations reveals the impact of lockdown restrictions, rising fuel prices, and increased public awareness towards electric vehicles. These factors contributed to lower sales figures for Petrol/CNG and Diesel variants three wheelers, evident in the reduced number of vehicle registrations.

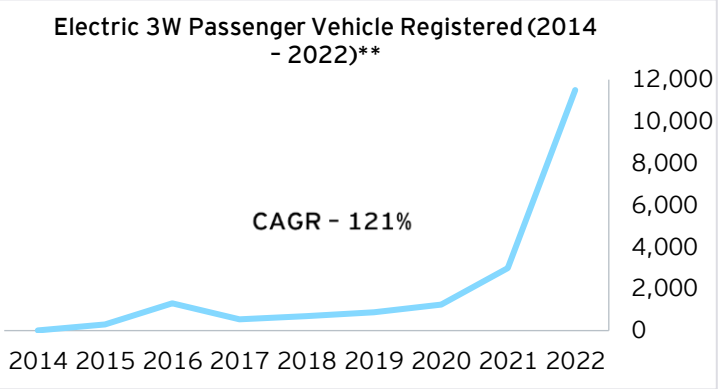
Graph 5: 3W Passenger Vehicles Registered



[31] Source – Vahan Portal and EY Analysis - 3W (Passenger) registered between 2014-2023, Fuel variants considered – Petrol, CNG, Diesel and LPG, SMEV

At COP 26, India made a significant commitment to reduce the emissions intensity of its GDP by 45 percent by the 2030[32]. The country's policies and government incentives have played a pivotal role in accelerating the transition to e-mobility as a cleaner alternative for transporting goods and people. As part of this transition, the 3W electric vehicle (passenger) segment is experiencing robust growth at a CAGR of 121%.

Graph 6: Electric 3W Passenger Vehicle Registered (2014-2022)



Electric 3Ws have low maintenance and operating costs, leading to increased daily savings for drivers. The high Compound Annual Growth Rate (CAGR) in Electric 3W sales can be attributed to robust support from central and state government policies, coupled with the cost-effectiveness of operating electric 3Ws .

Market size for 3W Passenger vehicles in India

Vehicle retrofitment allows users to extend the life of their vehicles at a lower cost while making them environmentally friendly. ICE (Internal Combustion Engine) vehicles that are nearing the end of their operational life are particularly suitable for retrofitment. Therefore, in our market study, we focus on vehicles registered between 2014 and 2018 for 3W retrofitment.

In India, the total number of registered 3W passenger vehicles between 2014 and 2018 is approximately 21 lakhs. Remarkably, around 73% of these registrations are concentrated in nine major states. Moreover, more than 50% of the vehicles registered during this period were of diesel variant, accounting for around 11 lakhs.

The number of registered diesel variant vehicles is primarily concentrated in six states in India. These states collectively account for over ~56% of the total diesel variant 3W market, representing nearly 6.2 lakhs diesel 3W registrations. The breakdown of states along with their respective percentage share of diesel 3W registrations is as follows:

Table 20: Diesel 3W registration (2014-18)

Sr. No.	States	Diesel 3W registration (2014-18) in %
1	Andhra Pradesh	21%
2	Kerala	11%
3	Uttar Pradesh	9%
4	Tamil Nadu	6%
5	Karnataka	6%
6	Gujarat	6%

[32] https://pib.gov.in/PressReleaseIframePage.aspx?PRID=1847812

4.1. Need for three-wheeler vehicle retro-fitment

Retrofitting holds the potential to address several significant challenges and contribute to the overall improvement of our transportation system. Below are some key points highlighting the need for three-wheeler vehicle retrofitment:

Table 21: Significance of retrofit of three wheelers

Sr. No.	Benefits	Details
1	**Faster adoption of EVs**	The retrofit process can often be completed much more quickly than the production of a new EV, offering an alternative solution to accelerate the transition to zero-emission vehicles. By converting current vehicles on the road, this approach reduces the need for scrapping and contributes to a more sustainable and efficient adoption of cleaner transportation solutions.
2	**Environment Friendly**	EV retrofitting serves as a valuable aid in reducing oil imports and advancing toward our net-zero targets. In the Indian context, retrofitting commercial vehicles, particularly 3-wheelers, holds significant promise for achieving a substantial reduction in carbon emissions.
3	**Air Quality Improvement**	The urban areas often grapple with air pollution, primarily caused by the combustion of fossil fuels. Converting three-wheelers to electric power can substantially contribute to improved air quality, creating healthier living environments in the cities
4	**Financially attractive**	A retrofitted E3W, inclusive of batteries, is available at approximately 30% lower cost compared to purchasing a new E3W. This cost advantage not only makes electric mobility more accessible but also contributes to the economic viability of transitioning to cleaner transportation solutions.
5	**Reduced Operating cost**	Electric vehicles are known for their efficiency and lower operating costs compared to traditional combustion engine vehicles. Retrofitting three-wheelers can lead to reduced fuel expenses, offering economic benefits to both vehicle owners and operators
6	**Market penetration**	The slow uptake of 3W retrofitting, attributed to a lack of financing willingness, presents a distinct market challenge. However, it also opens up a significant opportunity for CESL to enter a new market stream. By addressing financing barriers and providing innovative solutions, CESL can play a pivotal role in accelerating the adoption of 3W retrofitting and contributing to a more sustainable and environmentally friendly transportation landscape.

4.2. How can Financial Institution (FI) - CESL can support in 3W retro fitment

Financial institutions play a crucial role in supporting the retrofitment of three-wheelers, particularly in the transition to electric vehicles (EVs). Here are key aspects of their role:

Table 22: Role of FIs in promoting 3W retrofitment

Sr. No.	Benefits	Details
1	**Access to Low-Cost financing**	CESL has the opportunity to fill a critical gap in the market by offering support in low-cost financing for retro-fitment technology. Currently, such financing options are not widely available, and CESL's involvement in this space can significantly enhance the affordability and accessibility of retrofitting solutions, fostering a more sustainable and environmentally friendly transportation ecosystem
2	**Improve livelihood of fleet owner**	Retro-fitment emerges as a valuable solution, contributing to the improvement of livelihoods for fleet owners by increasing their income when compared to traditional Internal Combustion Engine (ICE) vehicles. This positive impact not only enhances the economic sustainability of fleet operations but also underscores the socio-economic benefits associated with embracing cleaner and more efficient transportation solutions
3	**Smart adoption of EV's**	The lower upfront cost of retrofitment makes it an attractive option for fleet owners, contributing to potential reductions in road congestion by limiting the number of new vehicles. To ensure safety and compliance, the government has established standards for the retrofitment of 3Ws. The retrofitment kit and vehicles must undergo testing and certification by authorized agencies such as the Automotive Research Association of India (ARAI) and the International Centre for Automotive Technology (ICAT). Our preliminary research indicates that the retro fitment market in India is currently fragmented, with a majority of players being startups. Notably, this market is more established in cities like Hyderabad and Bangalore, where respective states have issued EV retrofitment guidelines.

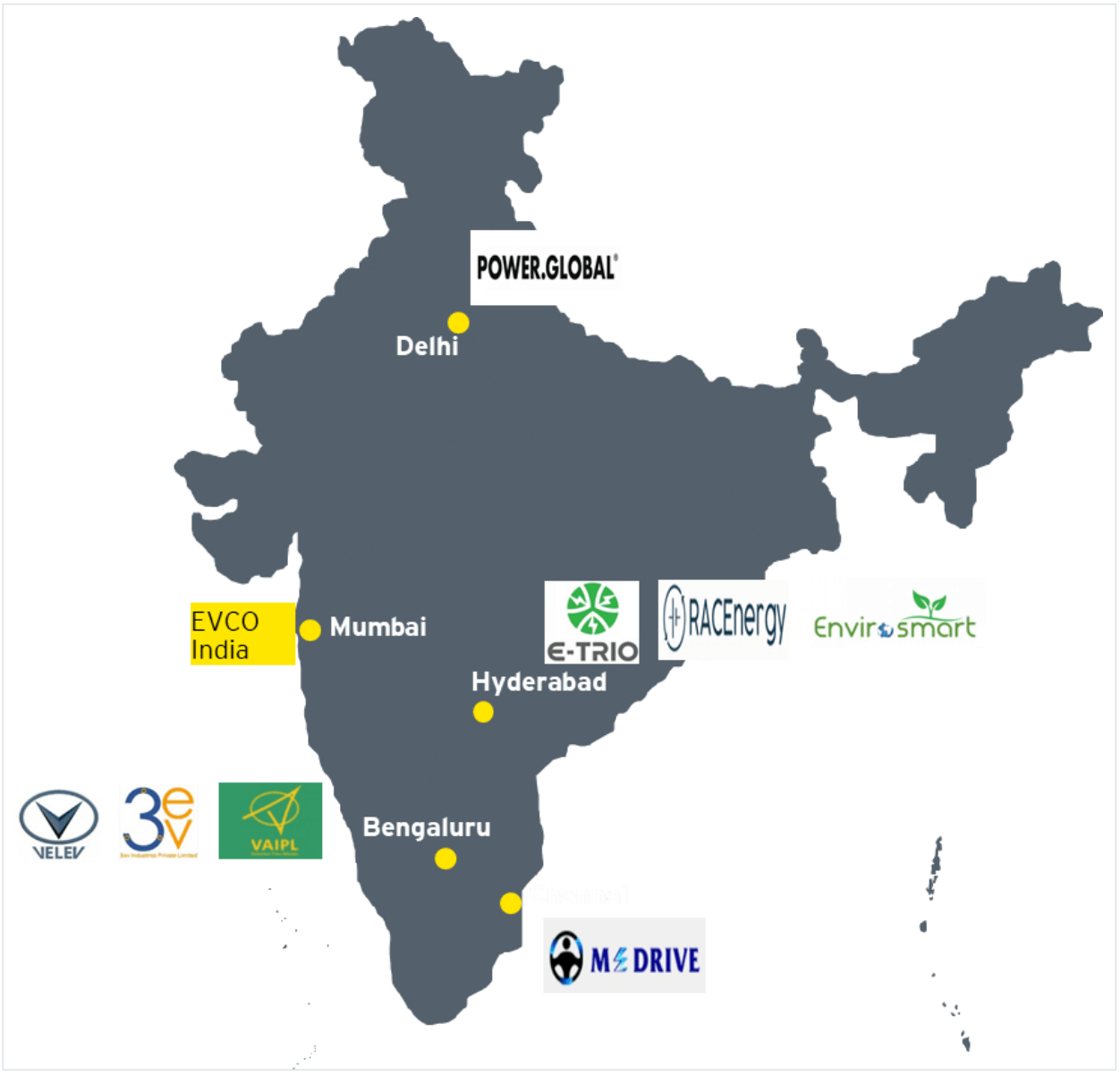
4.3. Presence of Retrofit players in India

There were several retrofit players in India involved in the conversion of conventional internal combustion engine (ICE) vehicles to electric vehicles (EVs). These players often focus on the retrofitment of three-wheelers, especially in the context of the growing demand for electric mobility solutions. List of some retrofit players in India is mentioned below:

Table 23: 3W EV Retrofit players identified in India

Firm	City, State	ARAI Certified
E-Trio	Hyderabad, Telangana	Yes
Zero21	Hyderabad, Telangana	Yes
Volta Automotive	Bengaluru, Karnataka	Yes
RACEnergy	Hyderabad, Telangana	Yes
3EV Industry Pvt Ltd	Bengaluru, Karnataka	Yes
EVCO India	Mumbai, Maharashtra	Yes
Enviro Smart	Hyderabad, Telangana	Yes
Manatec EV Drive Pvt Ltd	Chennai, Tamil Nadu	Yes
Power Global	New Delhi	Yes
Velev Motor India Pvt Ltd	Bengaluru, Karnataka	Yes

Figure 58: 3W Retrofit players across India



4.4. Key Challenges

Despite the evident economic and environmental benefits of electric three-wheelers (E3Ws), the industry's transition towards this segment is proceeding at a moderate pace. During preliminary consultations with industry players, following challenges have been identified that can be categorized as follows:

i. Technical:

- Alignment of the electric power train with the original chassis and other components
- Equal distribution of weight for steady, safe, and balanced drive
- Safe and high-quality electric wiring
- High quality material to be used to withstand the pressure and load of the power train

ii. Regulatory/Policy/Financing:

- Need for standardisation/ Homologation of model, variant, and year
- Lack of clarity and cumbersome steps to collect state level approvals
- Push and support from the central and state level to promote retro fitment of Electric 3W's either through priority sector lending/financing
- Uncertainty regarding the ability of the rider/operator to pay back the loan and lack of secondary market resulting in high interest rates on these loans.
- Lack of awareness from financing facilities

iii. User and Customer Acceptance:

- 3W operators and users, are currently unaware of the potential of E3W improving their livelihoods.
- Perceive risks regarding reliability of batteries and availability of service and maintenance. Also, limited visibility of retrofit 3W in the market also increases the perceived risks and thereby transition to E3W.
- Low accessibility of charging points for E3Ws.

iv. TCO of New EV's is high:

- The slow pace of penetration in new 3W EVs is primarily attributed to the high upfront costs associated with these vehicles. This poses a significant challenge in meeting the Net-Zero targets as the adoption rate falls short of the required acceleration. Addressing the cost barriers and implementing measures to make new 3W EVs more financially accessible is essential for achieving the desired transition to sustainable and zero-emission transportation.

v. High Financing Cost:

- Fleet owners for new EVs currently face financing rates ranging between 18% and 21%, which can pose a substantial financial burden. Addressing and potentially reducing these financing costs are crucial steps in making electric vehicles more financially viable and accelerating their adoption within fleet operations.

4.5. Technical specifications required for 3W EV retro fitment kits

Based on the research on retrofitment kits (inclusive of batteries) for E3Ws, along with stakeholder consultation held with existing retrofit players, the table below provides a list of technical specifications:

Table 24: Specifications of Electric Retrofit Kits for 3W

Parameters	Details
Motor Type	PMSM
Motor Capacity	3kW and above
Controller Type	Closed loop/Sine Wave Vector Controlled Controller with suitable voltage
Converter Capacity	160 Ampere peak
Maximum Speed	45 Kmph
Grade ability	14%
Gear Box	New
Kerb Weight	375 Kgs and above
Vehicle Category	L5 M, 3-Wheeler 3+1 Passenger Auto
Certification	ARAI/ICAT or any other designated labs under CMVR
Instrument Cluster	Fully digital, 5.4" LCD screen or higher
Range Indication	Yes
Location Tracking	Yes
Battery Indication	State of Charge (SoC)%, Temperature and Voltage

Table 25: Standards, Specification and safety of Battery Lithium Ion/Lithium Ferrous Phosphate/NMC Lithium or any other advanced chemical batteries

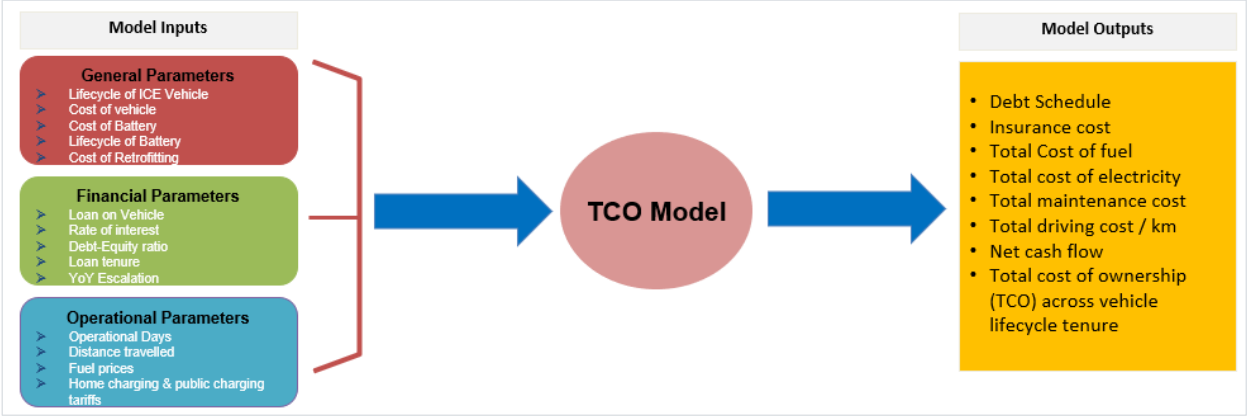
Parameters	Details
Nominal Voltage	50.4 and above
Energy	>6 kWh Fixed battery suitable to run 100 Kms with (1 Driver + 3 Passengers)
Battery Weight	>12 kg
Battery Enclosure Dimension	347X242X115 (LXWXH in mm) or suitable to fit for an auto
Charge cut-off voltage	42 V
Discharge cut-off voltage	58.4 V
Continuous discharge current	40A
Peak discharge current	60A
Battery Protections	Overcharge cut-off, over discharge cut-off, short circuit over-temperature cut-off, cell imbalance cut-off
Communication	Controller Area Network (CAN)
Usable Capacity	More than 80%
Battery Cycles	2,000 or more

4.6. Total Cost of Ownership (TCO)

To evaluate the economic feasibility of an Electric 3W in comparison to an ICE 3W, an analysis of Total Cost of Ownership (TCO) is done. Total cost of Ownership (TCO) accounts all the costs associated with purchase, operating and maintenance costs of a vehicle during its lifetime. TCO analysis provides valuable insights for policy makers, fleet owners and consumers. Through TCO analysis, policy makers can design financial incentive instruments in a better way to support EV adoption. The fleet owners through TCO analysis can assess the viability of transitioning into electric vehicles. Similarly, the consumers can take better purchase decisions with the help of TCO analysis by comparing total costs of owning and operating a vehicle.

In this study, the TCO model is considered to calculate the vehicle ownership cost over a 10-year period. The TCO model evaluates the Total Cost of Ownership for ICE vehicles, CNG vehicles, retrofitted 3W EVs and new 3W EVs. The picture below illustrates the model inputs, outputs, along with the underlying assumptions:

Figure 59: TCO Model inputs and outputs



The ownership cost is estimated based on the following 3 parameters that act as model inputs:

- **General Parameters** that include vehicle and battery lifecycle, vehicle and battery costs, costs of retrofitting
- **Financial Parameters** include loan amount on vehicle, interest rate, Debt-Equity ratio, and YoY escalations in the costs.
- **Operational Parameters** consider number of operational days, distance travelled per day, fuel process and escalations, EV charging tariffs etc. The TCO model provides total cost of ownership on per-km basis along with debt schedule, total operating costs, net cash flows, total fuel costs total electricity costs and total insurance and maintenance costs.

The ownership cost of a different type of 3W vehicle segment is estimated in the below graph[33]:

General Assumptions

- Vehicle lifecycle – 10 years
- ICE (Diesel) vehicle cost -Rs. 2,80,000 – 3,50,000
- ICE (CNG) vehicle cost – Rs. 2,80,000 – 3,15,000
- Electric 3W cost– Rs. 3,00,000 – Rs 4,00,000
- Cost of Battery – Rs. 15,000/ kWh
  Life cycle of Battery – 5 years
- Cost of Retrofitting – Rs. 2,00,000
  Battery capacity – 8 kWh
- Range in full charge – 120 kms

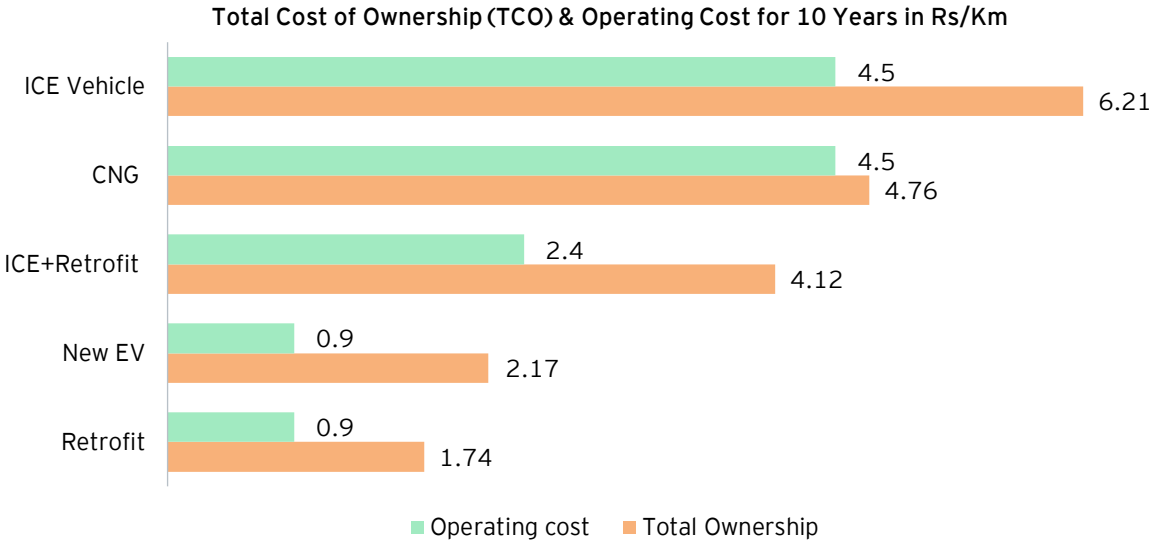
Operational Assumptions

- Operational days – 340 days/year
- Distance travelled per day – 100 kms
  Cost of Diesel – Rs. 90/Litre
- Cost of CNG – Rs. 79.56/Kg
- YoY escalation – 5%
- Home Charging tariff – Rs. 5.5/kWh
- Public Charging tariff – Rs. 15/kWh
- Mileage of ICE (Diesel) – 25kmpl
- Mileage of ICE (CNG) – 30kmpl

Financial Assumptions

- Loan tenure – 4 years
- Rate of interest – 12% per annum
- Debt-Equity ratio- 80:20
- Insurance rate – 1.5% per annum
- Maintenance expense of ICE - 8% per annum
- Maintenance expense of EV – 1.25% per annum
- YoY escalation – 5%

Graph 7:Total Cost of Ownership (TCO) for 10 years



According to the analysis, the total cost of ownership for a diesel-based ICE 3W is Rs. 6.21/km, for a CNG-based 3W is Rs. 4.76/km. When a new retrofit kit is installed in an ICE 3W post 5 years of operations, the total cost of ownership is Rs. 4.12/km considering 10 years life of a vehicle. Conversely, if a new 3W Electric Vehicle is utilized for 10 years, the total cost of ownership is Rs. 2.17/km. The Retro fit 3Ws operating for 10years have the lowest cost of total ownership i.e., Rs. 1.74/km.

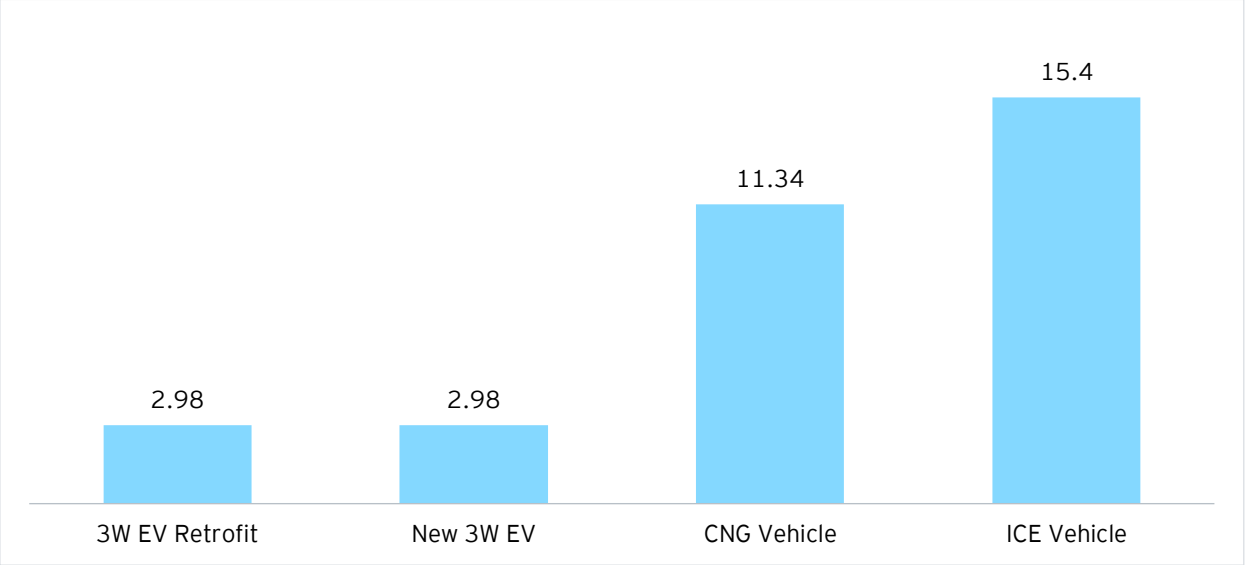
Similarly, the operating cost for a diesel-based ICE 3W is Rs. 5.39/km, while the total operating cost for a CNG-based 3W is Rs. 4.15/km. In the case of both new and retrofitted 3W passenger vehicles, the operating

[33] Source – EY Analysis

costs over a 10-year period are nearly in the same range.

In the case of total fuel/electricity costs for using a 3W over 10 years, the fuel cost for operating an ICE 3W for 10 years is approximately Rs. 15.40 Lakhs, and the fuel cost for operating a CNG 3W is around Rs. 11.34 Lakhs. Similarly, the total electricity costs for both new 3W EVs and retrofitted 3W EVs are approximately Rs. 2.98 Lakhs, considering similar battery size and charging cycles for both categories.

Graph 8: Fuel/ Electricity cost for 10 years



Based on the TCO analysis for a 10-year time period, it is evident that the Total Cost of Ownership (TCO) for a retrofitted 3W is approximately 70% less compared to the TCO of an ICE vehicle. Similarly, the TCO for a retrofitted 3W EV is approximately 20% less compared to the TCO of a new 3W EV. Additionally, a retrofitted 3W EV helps in saving approximately 77% in fuel costs compared to using an ICE 3W over a 10-year time duration.

~70% less ownership cost for 3W retrofit compared to ICE vehicle in 10 years

~80% saving in fuel cost in 10 years by using EV retrofitted vehicle compared to ICE vehicle

~20% less ownership cost for 3W retrofit Compared to new 3W EV in10 years

4.7. Financial Benefits observed through 3W retro-fitment

The operating and maintenance costs of running an ICE 3W are major expenditures for the drivers that impact their daily savings. These expenditures can be reduced through retrofitment as the operating and maintenance costs for a retrofitted 3W passenger vehicle is much lower as compared to ICE 3W passenger vehicle. This reduction in expenditures can enhance the savings for drivers, contributing to an improvement in their livelihood.

For an ICE three-wheeler vehicle, factors such as fuel costs, vehicle mileage, daily running, and annual maintenance are crucial in evaluating the operational costs and driver savings. Similarly, in the case of a retrofitted 3W EV, parameters like battery capacity, charging tariff, vehicle range, operating days, and daily running play a vital role in assessing operational costs and driver savings. The key assumptions for evaluating daily operating expenditure and driver savings are outlined below:

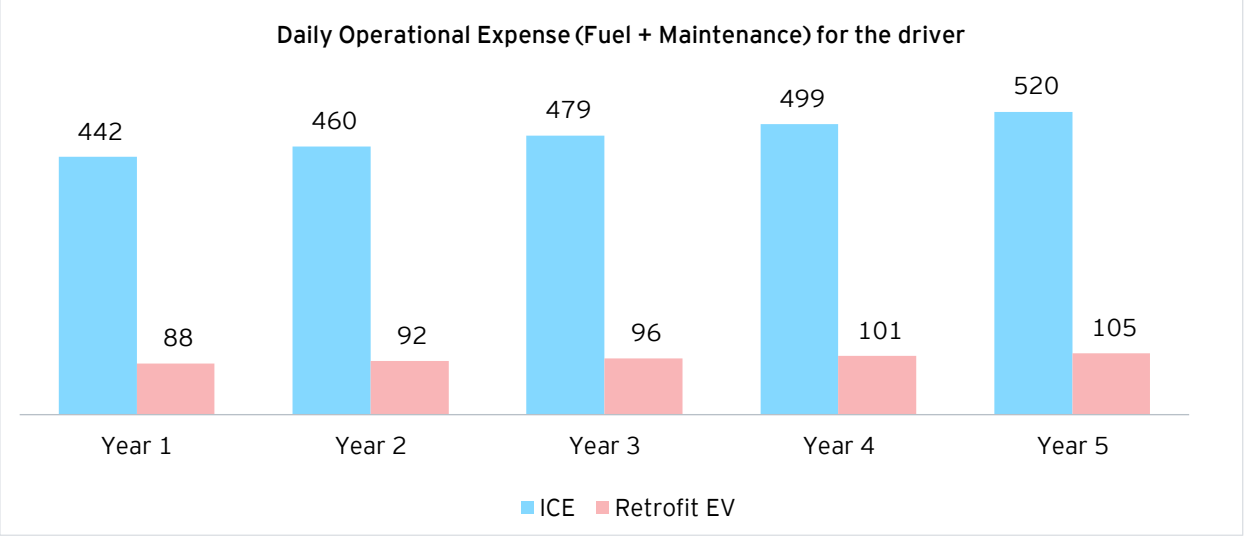
Assumptions for ICE 3W

- Fuel cost - Rs. 90/Litre
- Fuel cost escalation – 5%
- Mileage – 25 km/Litre
- Per day run – 100 km
- Operational Days per year – 340 days
- Per Km rate charged to passenger– Rs. 22/km
- Escalation in per day earnings – 3%
- Annual Maintenance – Rs. 30,000
- Daily earning – Rs. 1,300
- Daily rental – Rs. 500

Assumptions for retrofitted 3W EV

- Battery capacity – 8 kWh
- Charging Tariff – Rs. 12/kWh
- Tariff escalation – 5%
- Range – 120 km
- Per day run – 100 km
- Operational Days per year – 340 days
- Per Km rate charged to passenger – Rs. 13/km
- Escalation in per day earnings – 3%
- Annual Maintenance – Rs. 3,000
- Daily earning – Rs. 1,300
- Daily rental – Rs. 500

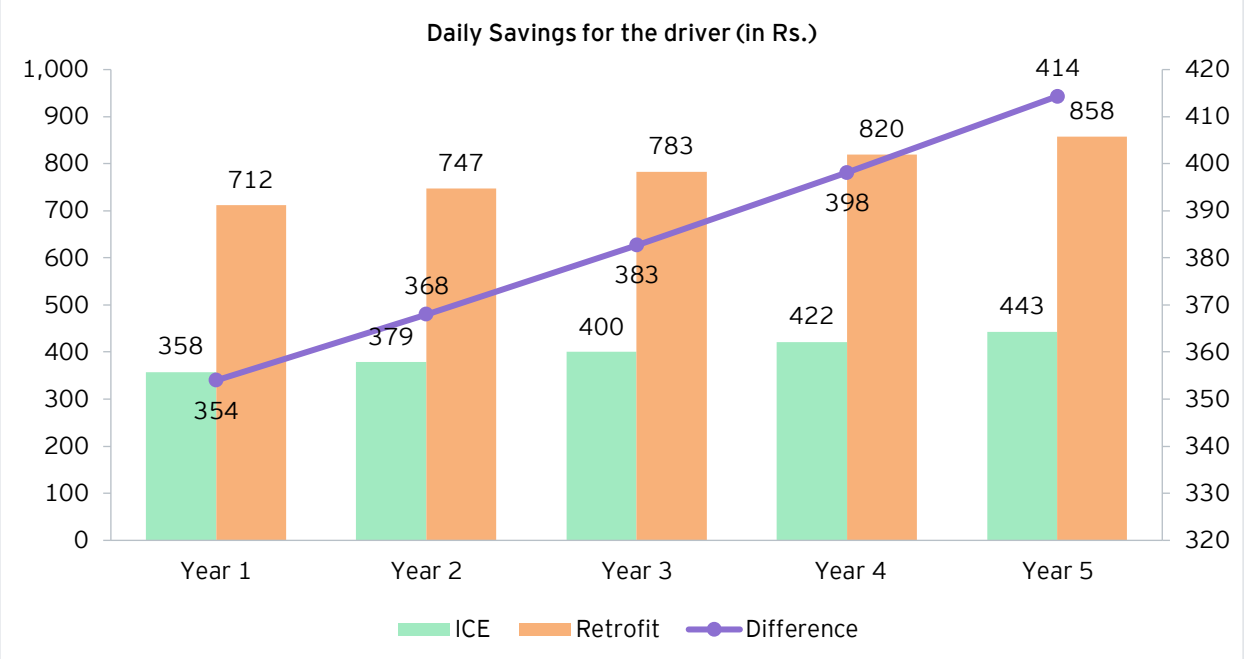
Graph 9: Daily Operational Expenditure for Driver (in Rs.)



Note: The calculations are based on the assumptions mentioned above

With the reduction in operational expenses, daily savings for the driver increase when using a retrofitted 3W. The daily savings for an ICE 3W amount to ~Rs. 358, while the daily savings after retrofitted 3W installation increase to ~Rs. 692. This results in a rise of ~Rs. 334 in daily savings for the driver within a one-year timeframe. The savings may further increase with higher daily mileage and as fuel rates for ICE vehicles increase over time.

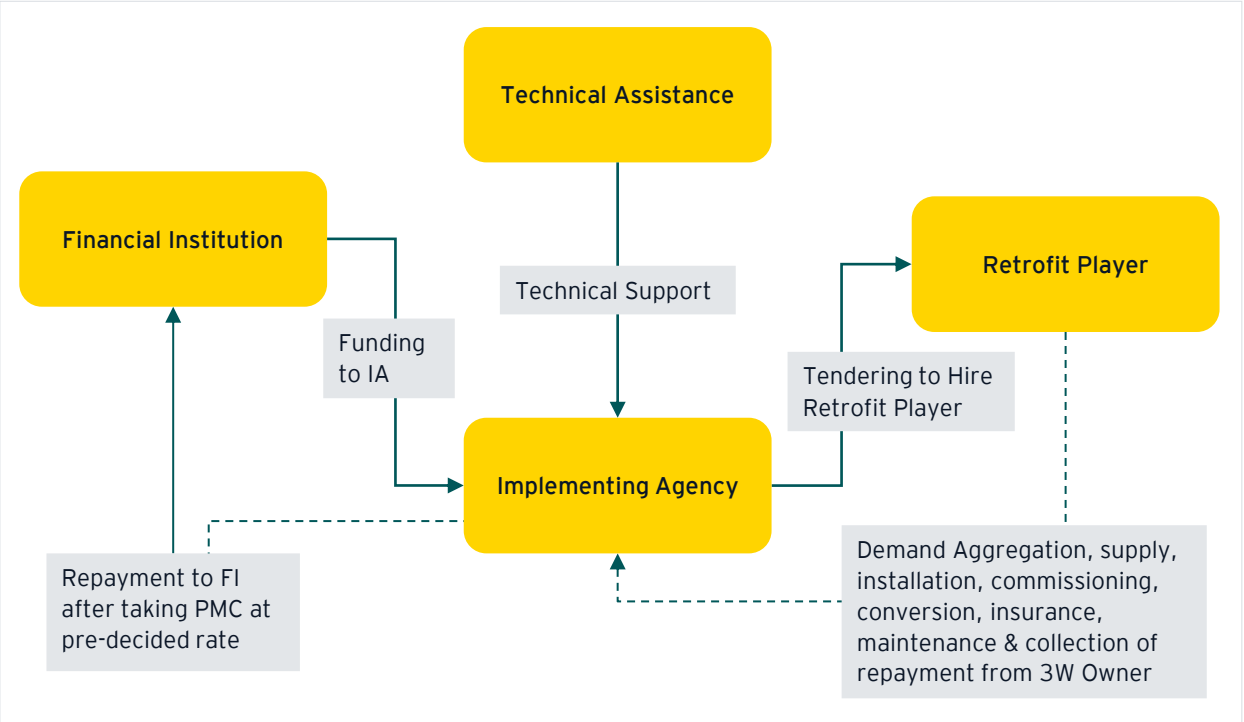
Graph 10: Daily Savings for the Driver (in Rs.)



*Note: The calculations are based on the assumptions mentioned above

Furthermore, retro-fitment will save 1,360 litres of diesel per year, resulting in approximately 10,934 kg of CO2 reduction over a three-year period by converting an ICE vehicle into an EV through retro-fitment.

4.8. Proposed Business Model



The Business Model leverages various sources of financing, such as concessional loans or grants from donor agencies and government budget allocations. These funds are then allocated to public agencies (Implementing Agencies) to cover the initial investment costs of Energy Efficient projects.

The Implementation agency, in turn, is responsible for tendering either independently or through a technical agency to hire a retrofit player for converting ICE 3Wheelers to Electric 3Wheelers. The retrofit player role includes aggregating demand, supplying retrofit kits, successfully converting vehicles, providing insurance and hypothecation, as well as handling maintenance & repayment collection from 3Wheeler owners.

The repayment is to be made to Implementing Agency along with the pre decided PMC.

The repayments can then be used to finance additional projects, thereby allowing the capital to revolve creating a sustainable financing mechanism.

**Note: Hypothecation of the vehicles would be under the scope of retrofit player. As per current practice, retrofit player has an internal arrangement with a financial institution for hypothecation of vehicles.*

4.9. E-autos and financing

In contrast to the ICE three-wheelers (diesel or CNG autos) that are eligible for financial lending by conventional banks and major NBFCs, e-autos have limited options. There are very few financial institutes—IndusInd Bank and Manappuram Finance are among the few that provide finances for both ICE and electric autos.

However, several new NBFCs and fintech companies have come forward to fill the gap of EV financing but their charges are much higher than that of conventional banks, with the interest rate around 20–25 per cent.

Similarly, the loan payback period for e-autos is much shorter than the ICE autos. The payback period for ICE autos can be four to five 5 years for banks and up to three years for NBFCs. But for e-autos it is shorter—usually two years. This low payback period discourages passenger e-autos as the EMI amount increases from Rs 8,000–8,500 (purchased with subsidy) to Rs 11,000–12,000 (purchased without subsidy). This is an almost 40–100 per cent increase in EMIs compared to Rs 4,300–6,200 that diesel and/or CNG autos are required to pay. As a result, a major share of the monthly profit (i.e. around Rs 15,000) is utilized for loan repayment for e-autos.

This review has brought out several challenges that impact e-auto financing:

- **Uncertainty around the vehicle technology:** The e-auto technology is new and there are several new market players in this segment without proven track records. The financial institutes are unsure about the quality of the product. It has been observed that small start-ups/dealers are customizing the product according to the requirements stated by the customers (largely related to battery type and size etc.) which have bearing on the performance of the product.
- **Underdeveloped market for second hand e-autos:** Given the uncertainty around the technology, the resale value of e-autos is not been established yet. There is no second-hand market for e-autos. Thus, financial institutes are unsure about the cost of recovery and payback in case there is default payment.
- **Differences in warranty period:** In the case of diesel or CNG autos, the original equipment manufacturers (OEMs) generally provide a minimum of three years or 100,000 km warranty (whichever is earlier) on the whole vehicle. Extension of warranty period is also possible. In the case of e-autos, differentiated warranty is offered for different e-auto components. Battery warranty is for three to five years, motor and controller for one year and charging system for six months. Extended warranty scheme is not available for e-autos. This creates uncertainty in the market.
- **Difficulty in ascertaining the value of the vehicle:** As often some models of e-autos are customized according to the needs of the customers (particularly battery) and are not tested, it becomes difficult for financial institutions to decide and ascertain the right value of the product.
- **Difficulty in dispute resolution:** E-battery performance and warranty depends on the usage pattern of the vehicle. For example, if a certain goods e-auto battery is designed to operate for five years with a 500 kg load, then it has to be used in the same way to sustain it for five years. Overloading can affect the battery durability. In such situation it becomes difficult to resolve the dispute between manufacturers and vehicle owners/operators.
- **Lack of credit worthiness:** Majority of the e-auto owners/operator's customers are new and there are concerns around their credit worthiness. Often, they do not have experience in banking transactions. The creditors are apprehensive of providing credit.
- **Fragmented and small markets reduce access to financial services:** As the market is new and demand is low, fragmented and dispersed, financial institutions or lenders find it difficult to widen the scope of services and serve across geographies.

4.10. Three-wheeler electrification – Way Forward

With strategic intervention and appropriate support from the Government, it is possible to catalyse the change. To accelerate this process, it is necessary to focus on the following steps.

Need policy mandate targeted development: It is possible to mandate time-bound electrification of the auto-segment in the country. This will require an ecosystem approach, including charging infrastructure for rapid transformation.

Strengthen incentive programme to including non-fiscal incentives: Exemption of the e-autos from MV tax and registration fees for e-3Ws, and other purchase incentives. This may be further strengthened by adding scrapping incentives based on de-registration of old ICE vehicles. In addition, the state/city authority may also think of providing additional non-fiscal benefits to e-3W owners, such as discounted parking facilities, creating special zones for electric or zero emission vehicles etc.

Product development: Retrofit manufacturers may be empanelled after rigorous testing and trials of their product and allow only those vehicles to avail of government subsidy. The state governments can create strong regulatory and monitoring framework to improve product quality.

All new manufacturers/start-ups need to take more responsibility for product development and testing and certification. This also requires product rebranding for the second-hand market or resale market. Product quality and durability need to be increased and warranty comparable to conventional diesel and CNG autos including extended warranty need to be provided. Advanced technology to track and monitor vehicle performance will help to increase the life of vehicles and resolve vehicle-related disputes.

Resolve financing issues: Several steps are needed to address the uncertainty around financing. During the initial stages, the governments may act as a credit guarantor for providing easy loans, with decent interest rates to individual auto drivers or owners. The governments may consider providing purchase subsidies directly into the loan account of the loan recipient to reduce EMI burden.

Also consider interest subvention or paying of a part of the interest to reduce EMI burden. State/city authority may think of creating green, low- or zero-emission zones within the city scape for increasing the demand for e-autos.

Support to create e-three-wheeler ecosystem: Lack of charging was perceived by auto drivers as one of the major obstacles for 3W electrification. As these vehicles rely largely on night-time home charging supported by top-up charging in public charging infrastructure, this requires public charging facilities at the community parking locations at subsidized fees. It also requires building audits to assess adequacy of the connected load of households and ancillary requirements and incentives/grants to e-3W owner for setting up charging point at home.

Battery swapping also emerges as a cost-effective solution for retrofitted electric three-wheelers (3Ws). The swappable batteries will not only mitigate the burden of the upfront cost of the battery packs in retrofit E-3Ws but will also shift the battery failure risk from driver to the swapping operator. As total distances covered by autorickshaws in a day are beyond the e-autorickshaw range on full charge, installing battery swapping stations at strategic locations will help in reducing the range anxiety among the E-3W owners.

Disincentivize ICE 3Ws: To promote e-autos, it is also necessary to disincentivize ICE 3Ws. A strategy to limit the number and operations of diesel 3Ws, banning registration of new diesel 3W and phasing them out is needed.

Create awareness to build public support for e-three-wheeler services: The auto operators were observed to have limited knowledge about e-3W vehicle technology and its pros and cons etc. It is necessary to design an outreach programme to sensitize them about the technology, its operational aspects, availability of incentives, charging needs and safety requirements.

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5.

Case study 3

Battery Swapping as a Service (BaaS)

5.1. Background

A substantial hurdle to the widespread acceptance of EVs is the time-consuming nature of the charging process. The conventional charging method, which involves connecting an EV to a household electrical outlet or charging station for an extended period, poses a challenge to mainstream adoption. Notably, high-power charging stations capable of recharging an electric car in as little as 20 minutes exist, but their deployment may bring about potential drawbacks, including potential impacts on energy quality parameters.

In the quest for cleaner and more efficient energy solutions, 'battery swapping' has emerged as a game-changing innovation. Battery swapping is a process in which an electric vehicle's (EV) depleted or low-capacity battery is quickly replaced with a fully charged one, allowing the vehicle to continue its journey without waiting for the battery to recharge. This method aims to minimize the time and inconvenience associated with traditional charging methods, such as plugging in and waiting for the battery to charge. By enabling the quick exchange of depleted batteries with fully charged ones, this technology has the potential to revolutionize the energy landscape. In this section, we will dive deep into the concept of battery swapping and explore its potential to transform the way we power our lives.

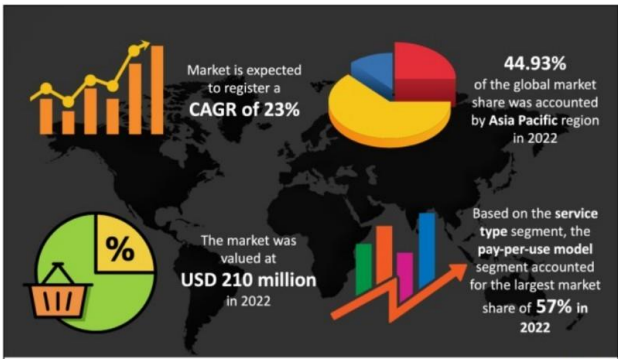
5.2. Global Scenario

In the specified regions—North America (comprising the U.S., Canada, Mexico), Europe (encompassing the UK, Germany, Netherlands, Norway, and the rest of Europe), Asia-Pacific (including China, Japan, India, South Korea, and the rest of Asia-Pacific), and LAMEA (Latin America, Middle East, Africa)—the electric vehicle battery swapping market attained a size of $1.8 billion in 2022. It is expected to reach $49.3 billion by 2032, with a projected compound annual growth rate (CAGR) of 39.6% from 2023 to 2032.

The global battery swapping market is expected to grow from USD 210 million in 2022 to USD 1,664.44 million by 2032, at a CAGR of 23% from 2023-2030. The growing demand for electric vehicles will augment the growth of the global battery-swapping market.

The major challenge impeding the growth of the market is fluctuations in battery technology and design, along with the substantial initial setup and operational expenses of battery swapping stations. Nevertheless, the swift rise of shared e-mobility and the introduction of inventive and sophisticated battery swapping models and services by industry participants offer promising opportunities for market expansion in the foreseeable future.

Figure 60: Global market scenario of battery swapping



The Asia Pacific has emerged as the most dominant region within the global battery swapping market among regions like North America, Europe, South America, Asia Pacific, the Middle East, and Africa, with a 44.93% market revenue share in 2022. The demand for electric vehicles in the Asia Pacific region is on the path of exponential growth, considering the alarming rate of climate change brought on by the overexploitation of fossil fuel resources such as petroleum and gas and their resulting carbon emission.

Figure 61: Asia Pacific- Battery swapping Market share in 2022

China and India, with the highest population in the world, are significant contributors to the rising global temperatures and need to push for sustainable reforms to mitigate the negative consequences. With a majority of countries pledging net-zero emissions by 2050, it has become imperative for governments to look for alternative fuels to reduce carbon footprints. Through subsidies and production incentive-linked schemes, government support will drive the market for Electric bikes. Adding to this, the price of petroleum is reaching new heights due to instability in oil-producing countries and the shortage of petroleum due to its non-renewable nature.

The electric vehicle battery swapping market within the Asia-Pacific is moving from the nascent to the expansion phase. Range anxiety, and lengthy charging process are cited as among the most barriers hindering the broader adoption of EVs. Battery swapping offers a quicker solution to handle range anxiety, where each swap takes but 10 minutes and requires much smaller space to put in compared to charging stations. Offering Battery as a Service is another solution gaining traction within the region's EV industry, given its impact on reducing the high upfront price of EVs by separating battery ownership, and hence, cost. rather than owning the batteries, customers can subscribe battery swapping plans to fulfill their unique needs.
According to data, the sales volume of electrical two-wheelers in China in 2021 reached 53.375 million units, up 16.5% year on year, and therefore the sales volume of lithium two-wheelers reached 9.287 million units, up 22.6% year on year, with a penetration rate of 17.4%.

On the other hand, India has been actively pursuing battery swapping across the country and has been testing the viability of the swappable batteries. During Budget 2022-2023, the Indian government announced plans to introduce a Battery Swapping Policy and interoperability standards, with the intent of building and improving the efficiency of the battery swapping ecosystem, thereby driving EV adoption.

In April 2022, NITI Aayog released the draft Battery Swap Policy. Such supportive signals for the growth of the battery swap ecosystem are commendable. Until now, the focus at the national level has been mainly on creating a large network of electric vehicle charging stations, with limited emphasis on developing battery swapping infrastructure. The emergence and successful piloting of battery swapping solutions provides an opportunity to facilitate a solution-independence environment, providing a level playing field for different potential solutions in the market and ensure a list of options for electric vehicle users.

Similarly, Europe is expected to follow Asia-Pacific region in adopting battery swapping on the back of growing usage of electric two wheelers for cargo, logistics and delivery activities owing to the increased logistics and e-commerce companies across the region. [34]

[34] Source: https://www.mordorintelligence.com/industry-reports/battery-swapping-for-electric-two-wheeler-market

Figure 62: Battery swapping for electric two wheeler market

5.2.1. Key Global Market Players

1. BattSwap Inc.

Identifying the bottleneck in power infrastructure that was preventing the EV revolution from taking off, BattSwap began a decade ago with ground-breaking work in making Nissan and Streetscooter swappable. However, with customers demanding more flexibility and simplicity in their EV infrastructure, BattSwap responded with a battery wappable solution that is compatible with any electric vehicle on the market. Their innovative technology has revolutionized the EV industry and has put BattSwap at the forefront of the industry.

Figure 63: Battswap 4W Swapping Station

Figure 64: Battswap Swapping Station

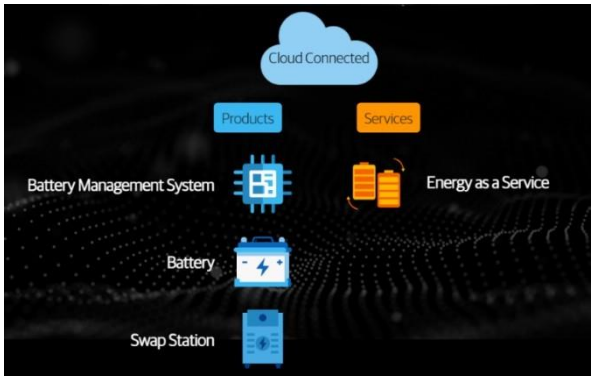
2. Esmito Solutions Private Limited

Esmito is among the top battery swapping companies that provide swapping solutions by its IoT enabled, cloud-based software integrated battery swapping technology.

Their smart battery swapping stations also come with a virtual locking of batteries via proprietary battery swapping protocol.

The cloud-based platform tracks battery health and assures long lifecycle making it more economical to end users. These smart battery swapping stations are available for both electric two-wheeler and electric three-wheeler applications.

Figure 65: esmito products ad services



3. Gogoro Inc.

Gogoro is aTaiwan based company that develops and sells electric scooters and battery swapping infrasrructure. In order to achieve its green energy goals, the company has built battery swapping stations which runs on solar power for 2Ws in Taiwan.

A Gogoro customer who buys a vehicle gains membership access to a charging network. Rather than parking at a charging station to plug in, a scooter owner swaps depleted batteries for fresh ones. The battery swapping model reduces the number of batteries in circulation. Further, by keeping tabs on real time battery demands, Gogoro can use algorithms to optimize where to distribute battery inventory and when to charge its batteries, taking advantage of lulls iin utilities' electricity demand to avoid paying high energy prices and over stressing the grid. Gogoro has differentiated itself from the competition through its early and compelling vision to develop battery swapping for E2Ws and an extensive product portfolio across the battery swapping supply chain. It also ranks number one because of its strong track record on quality and performance with its current product line and due to its unmatched partner network highlighted by several of the world's largest two-wheeler OEMs.

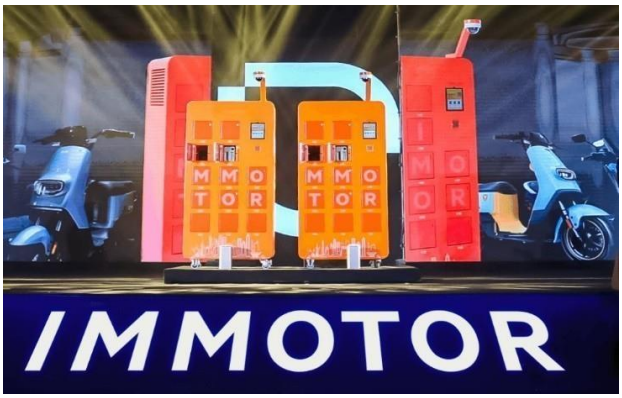
Figure 66: Gogoro launches operations in India

Figure 67: Gogoro produces 1 million smart batteries

4. Immotor

Shenzhen Immotor Technology Limited is a national high-tech enterprise and a leading player of green energy network for electric two-wheel vehicles. Founded in 2015, it released the Immotor brand in December 2017 and launched the world's first Intelligent Green Energy Platform integrating super batteries, intelligent battery exchange stations, energy management system, APP and big data platform.

Figure 68: Immotor swapping station



5. Leo Motors Inc.

Leo Motors focuses on development of electric vehicles and energy storage products. The company specializes in development of batteries for electric vehicles. The company has developed cartridge batteries that can be easily replaced and swapped in electric vehicles. The company is developing connected battery swap system for implementation of the same. The company also plans to develop electric vehicle around the system. The company is listed on the OTCMKT and has offices in Korea & US.

Leo Motors serves in the **B2C** space in the High Tech, Energy Tech, Auto Tech, Transportation and Logistics Tech, Environment Tech market segments.

Figure 69: Leo Motors logo

6. NIO Power

An Innovative Smart Power Service Solution

NIO Power is a mobile internet-based power solution with extensive networks for battery charging and battery swap facilities. Enhanced by Power Cloud, it offers a power service system with chargeable, swappable and upgradable batteries to provide users with power services catering to all scenarios.

Figure 70: Nio Power Swapping Station

5.3. Battery Swapping in India

Government of India is committed in achieving 30% penetration of EVs in total vehicles sales by year 2030. With continuous effort from Government of India in making the Electric Vehicle as mainstream, the automobile industry is on track to achieve this transition.

The foundation stone for promoting battery swapping in India laid down in year 2015 with the launch of FAME-India (Faster Adoption and Manufacturing of (Hybrid &) Electric Vehicles in India). The scheme provided incentive for purchase of EVs across various vehicle segments. Post the launch of FAME-II, Government of India launched various policy & regulatory initiatives promoting EV adoption including setting up of necessary infrastructure such as charging and battery swapping infrastructure. Below illustration provides initiatives taken by the government for accelerated EV adoption:

India has taken a proactive stance in acknowledging the pivotal role of batteries in ensuring the overall sustainability of electric vehicles. NITI Aayog is working to bring Battery Swapping Policy with a primary objective of **"Promoting enhanced lifecycle management of batteries, including maximizing their utilization throughout their operational lifespan and facilitating end-of-life recycling."** Furthermore, India's vision for electric vehicles now places significant emphasis on performance benchmarks for EV batteries, actively cultivating a Battery Development Ecosystem (BDS). This initiative involves providing research and development support, as well as grants for activities related to material modelling, synthesis of new electrodes and electrolytes, material characterization, lab-scale prototype testing, and recycling processes. Being the second-largest producer of two-wheelers and the largest producer of three-wheelers globally, India stands as one of the most significant target markets for battery swapping. Noteworthy players like Bounce, SunMobility, and Battery Smart are executing thousands of swaps daily, and various entities, including startups, oil companies, conglomerates, public sector undertakings (PSUs), and original equipment manufacturers (OEMs), are venturing into the battery swapping domain. **Nineteen states have embraced electric vehicle (EV) policies that actively encourage the adoption of battery swapping. The cumulative figures include over 1 million swaps, involvement from more than 10 companies, and an investment exceeding 100 million dollars.**

According to industry projections, half of all two- and three-wheelers are expected to be electrified by 2027, with this figure rising to 80 percent by 2030. Achieving this transformation would necessitate an investment of approximately $50 billion and the establishment of over 50,000 battery-swapping stations.

Currently, with approximately 3 million e-rickshaws and a minimum of 2 million electric vehicles currently in operation, the Indian battery-swapping market is valued at nearly US$2 billion.

5.4. Policy Initiative to promote Battery Swapping

5.4.1. Draft Battery Swapping policy 2022

Objectives:

- Drive EV acceptance by promoting Advanced Chemistry Cell (ACC) batteries in battery swapping to decouple costs from initial EV expenses.
- Enhance user flexibility by endorsing battery swapping as a practical alternative to traditional charging for electric vehicles.
- Promote market-driven innovation in battery swapping ecosystems by establishing principles for technical standards ensuring component interoperability.
- Mitigate risks and enable competitive financing options by using policy and regulatory measures in the battery swapping ecosystem.
- Encourage collaborative ecosystems by fostering partnerships among battery providers, OEMs, and relevant entities for integrated services to end users.
- Advocate for enhanced battery lifecycle management, emphasizing utilization optimization and end-of-life recycling.

According to the preliminary policy, battery swapping will be categorized under the Battery-as-a-Service (BaaS) business model, requiring interoperability between EVs and batteries for successful integration as an alternative.

- **Minimum Technical Standards:** The policy outlines essential technical and operational requirements for battery swapping ecosystems to ensure effective, efficient, reliable, safe, and user-friendly implementation.
- **Financial Support:** Direct and indirect financial support is proposed for Battery Providers (covering battery costs) and EV users.
- **Tax Reduction:** The draft suggests that the Goods & Services Tax Council consider reducing the differential tax rates on Lithium-ion batteries and electric vehicle supply equipment. Currently, the tax rate is 18% for the former and 5% for the latter.
- **Unique Identification Number:** The policy recommends assigning a Unique Identification Number (UIN) to swappable batteries during manufacturing for tracking and monitoring purposes.

As per Notification No.: ----- In an aim to make EV more attractive to the Indian consumer, the Ministry of Road Transport & Highways (MoRTH)has allowed the sale of electric two and three wheelers without batteries.

However, due to non-standardisation of EV batteries, the battery swapping operators are facing significant challenges. In ideal case, the OEMs need to set their own battery swapping station with 1.5-2.0 times a greater number of battery pack than the vehicle. Which will ensure the availability of batteries all the time. This makes the business CAPEX intensive.

5.5. Battery Swapping Market

Over the past five years, the battery-swapping technology sector has raised an impressive $16,17,61,883 in funding underscoring the significant demand and potential within this sector. It also positions India as a potential global leader in successfully implementing this technology on a large scale.

Some of the notable startups in the space include Battery Smart, SUN Mobility, RACEnergy, Echargeup, Esmito, Batterypool, and Mooving. As per data from Tracxn, recent years have witnessed increased investor interest in this space, with approximately $135 million raised since 2021 across 17 funding rounds.

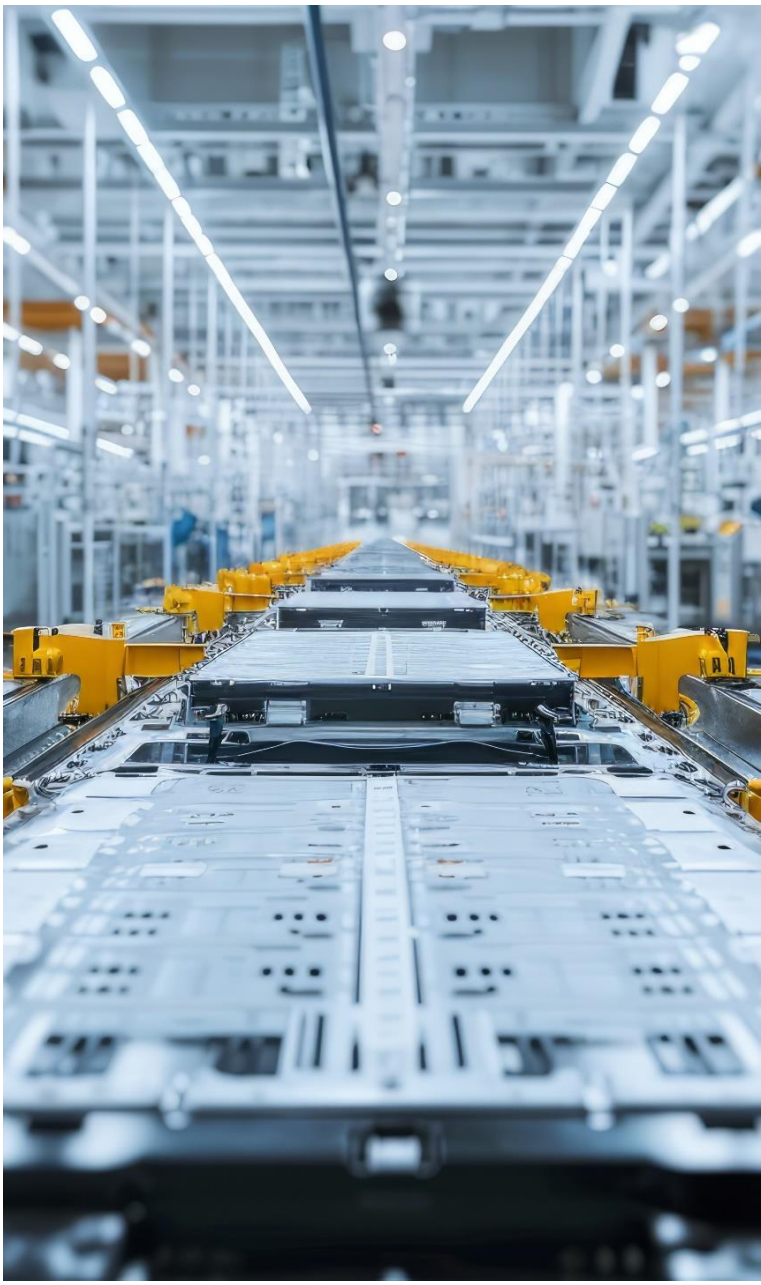
Although battery-swapping technology is still in its early stages in India and has seen limited success beyond Taiwan, its potential for adoption in the Indian market, particularly for two- and three-wheelers, is optimistic.

Furthermore, with growing investor interest and government support, the sector is gaining momentum in India, attracting both domestic players and international industry giants such as Gogoro.

India, being the largest market for two-wheelers and three-wheelers in the micro-mobility segment, with 85 per cent of its population regularly using these vehicles, is poised to make a significant impact in the sector[35].

With the right infrastructure in place, swapping technology could contribute to a 30 to 40 percent growth in electric vehicles (EVs) in India, provided certain conditions are met, including government mandates, subsidies, interoperability and safety assurances, and battery-swapping roadmaps for different segments, from two- and three-wheelers to e-commercial fleets.

Battery swapping market in India is expected to grow $6.1 million USD by year 2030, registering 31% growth during 2020-2030 [36]. In India, public as well as private sector companies have come up or planning to come up with Battery Swapping Stations (BSS). IOCL has tied up with SUN Mobility, BPCL has tied up with Kinetic Green Energy and IIT Madras while HPCL has tied up with VoltUp for setting up Battery Swapping stations in India. SUN Mobility, one of the early movers and major player in battery swapping in India, has set up 65 BSS across 14 cities. Battery Smart has also developed lithium-ion battery swapping network for e-2Ws and e-3Ws. Battery Smart has more than 200 swapping locations across the country and have completed nearly 1 million swaps in their operation period[37].



[35] SUN Mobility

[36] https://cp.catapult.org.uk/wp-content/uploads/2021/03/210318_1020_CPC_India_Report.pdf

[37] https://www.fortuneindia.com/40under40/pulkit-khurana-siddharth-sikka?year=2022#:~:text=Battery%20Smart%20currently%20operates%20in,of%20operations%20and%20supply%20chain.

5.6. Key Indian players and Initiatives of Battery Swapping Technology

Several key players in India have been involved in initiatives related to battery swapping technology for electric vehicles (EVs). Some key Indian players and initiatives in the battery swapping technology space are mentioned below:

Table 26: Key Indian players doing battery swapping

Company Name & Logo	Operational locations	No. of operating swapping stations	Vehicle segment catered to	Scaling
Sun Mobility	Chandigarh, Mohali, Panchkula, Calicut, Vijaywada, Trivandrum, Noida, Faridabad, Delhi, Ghaziabad, Pune, Bengaluru, Gurugram, Hyderabad, Jaipur, Mumbai, Kochi, Karnal, Sonipat, Panipat	~600	2W, 3W, Shared mobility	Power 1 million EVs by 2025
Battery smart	Delhi, Faridabad, Ghaziabad, Gurugram, Karnal, Noida, Panipat, Jaipur, Sonipat, Meerut, Kanpur	~878	2W, 3W	Battery Smart aims to capture a $17 billion swapping market by 2025, envisioning the establishment of a Swap Station within every square kilometer in the Delhi-NCR region.
VoltUp	Mumbai, Jaipur, Delhi, Lucknow	~90	2W, 3W	To establish 650 swapping stations featuring more than 7,800 charging docks across 50 cities within the upcoming three years.
Charge-up	Delhi NCR	~120	3W	The goal is to establish a network of battery swapping stations, ensuring a charging station every 2 km in urban areas such as Delhi. Also, declared its intention to establish 3,000 EN battery swapping stations by the year 2024.
Charge+Zone	Vadodara, +31		2W, 3W	Aims to deliver battery swaps/ charging services to 1000+ e-rickshaws and e-autos in Delhi NCR across 25 micro hubs.

5.7. Benefits of battery swapping over EV charging

Battery swapping involves exchange of discharged battery with a charged one at a swap station. While the swapping technology is available for all types of EVs, battery swapping is more appropriate for lower-capacity batteries for electric two and three-wheelers.

Battery swapping stations address several barriers in EV adoption especially for adoption of e-2W and e-3W as compared to charging infrastructure. Below are some of the salient features of Battery Swapping:

Table 27: Benefits of battery swapping

Sr. No.	Benefits	Details
1	**Reduced initial investment**	As batteries accounts for 40-50% of the total cost of an EV, with battery swapping mode, vehicle can be separated from batteries, making cost of battery becomes variable, thus reducing the EV upfront cost.
2	**Eliminating long charging time**	Plug-in charging takes longer to refuelling an Internal Combustion Engine (ICE) vehicle. Battery Swapping is done in minutes, equivalent to time required to refuel an ICE vehicle at petrol bunks, as the batteries are pre-charged in swapping stations.
3	**Reduced Infrastructure requirement**	A charging station needs large area for installation. However, Battery Swapping Stations requires only limited space to install battery kiosks.
4	**Improved battery life**	Fast charging can lead to degradation of battery in due time. Swapped batteries can be charged via slow charging in a controlled environment to enhance the battery life.
5	**Location**	Batteries can be charged away from swapping point, allowing freedom in setting up swapping stations at city outskirts as well.

5.8. Functional Description

The following definition defines the battery swapping ecosystem:

Battery as a Service (BaaS) Outlet: An installation that provides a removable battery swap service for electric vehicles.

Battery Charging Station (BCS): A unit in the BaaS Outlet through which the discharged batteries can be swapped with charged batteries. A BaaS Outlet can have more than one BCS or BSS.

Battery Swapping Stations (BSS) shall include the following:

a) storage system;

b) charging system; and

c) supervisory and control system.

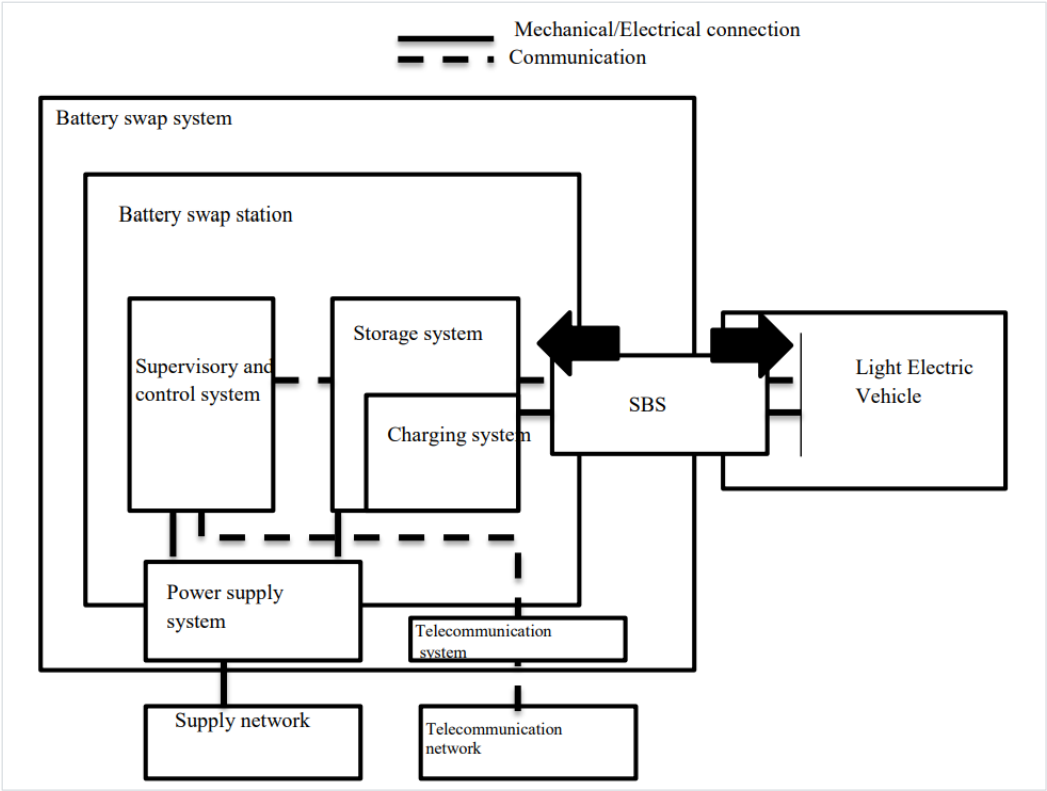
d) supporting system which includes the following:

1. power supply system; and
2. telecommunication system.

Figure 71: Battery Swapping models

The swapping of battery packs shall be through manual means. Suitable safety measures is to be ensured to place compatible chemistry battery packs in EVs.

Figure 72: Components of a battery swapping station



5.9. Key Stakeholders

The stakeholders in the battery swapping based on revenue sharing model are:

1 Land Owner	2 Battery Swapping Operator	3 EV Manufacturer	4 Customer
► Owns the plot of land where the Battery Swapping Station will be set up.	► Owns and operates the Battery Swapping Stations ► Has tie-ups with EV Manufacturer for ensuring their battery matches the manufacturer design	► Owns and operates EV manufacturing facility	► Procures the EV from manufacturer and takes battery on lease from Battery Swapping Operator

Figure 73: Applications of battery swapping

5.10. Business Models

Two different models of Battery as a Service (BaaS) identified for feasibility assessment is mentioned below.

a) **Revenue sharing model**: In this model, the total capital cost including the cost of kiosk will be borne by the operator and the operator will be paying certain revenue to the land-owning agency in lieu of providing land for setting up BSS.

b) **Franchise model**: In this model, the partner provides the batteries and charger at subsidized rate to the operator while the cost of owning the BSS is borne by the partner.

5.10.1. Revenue Sharing Business Model

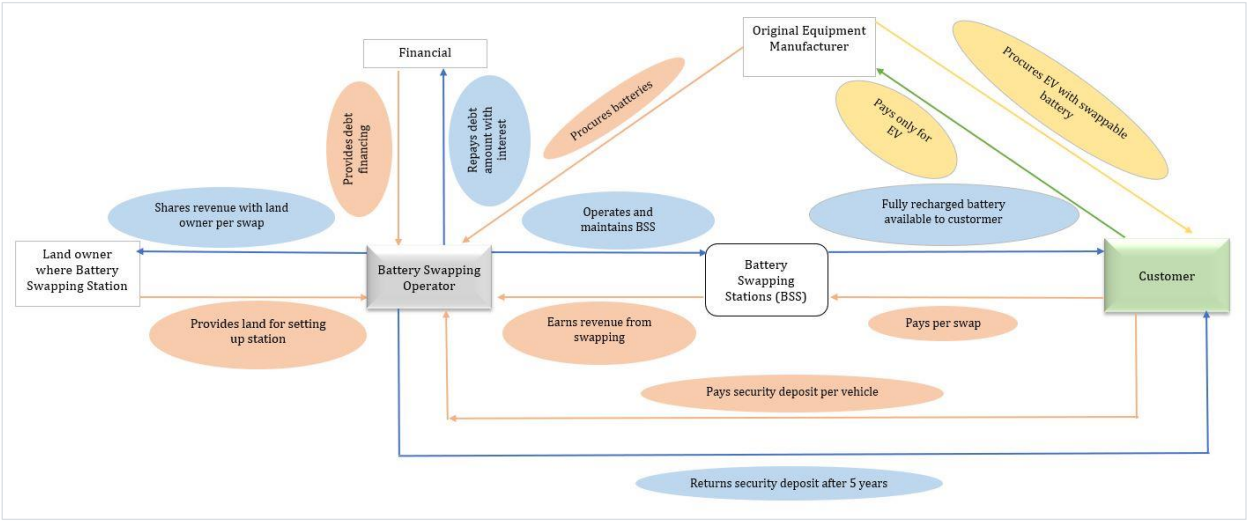


Figure: Revenue Sharing Model in Battery swapping

5.10.2. Franchise Business Model

Landowner	Battery Swapping Operator (BSO)	EV OEM	Customer
▸ Leases out land to BSO for setting up Battery Swapping Station ▸ Receives a share of revenue per swap	▸ Sets up battery swapping station by taking loan from financial institutes ▸ Owns the batteries ▸ Ties up with EV manufacturer to ensure their batteries match manufacturer design ▸ Provides battery swapping facility to customer and charges customer a security deposit per battery along with a charge per swap ▸ Returns security deposit after 5 years ▸ Shares revenue per swap with land owner	▸ Designs and manufactures EV to match BSO battery specifications and design ▸ Sells EV without battery to customer	▸ Procures EV without battery from OEM ▸ Takes battery from BSO and pays security deposit ▸ Pays per swap to BSO

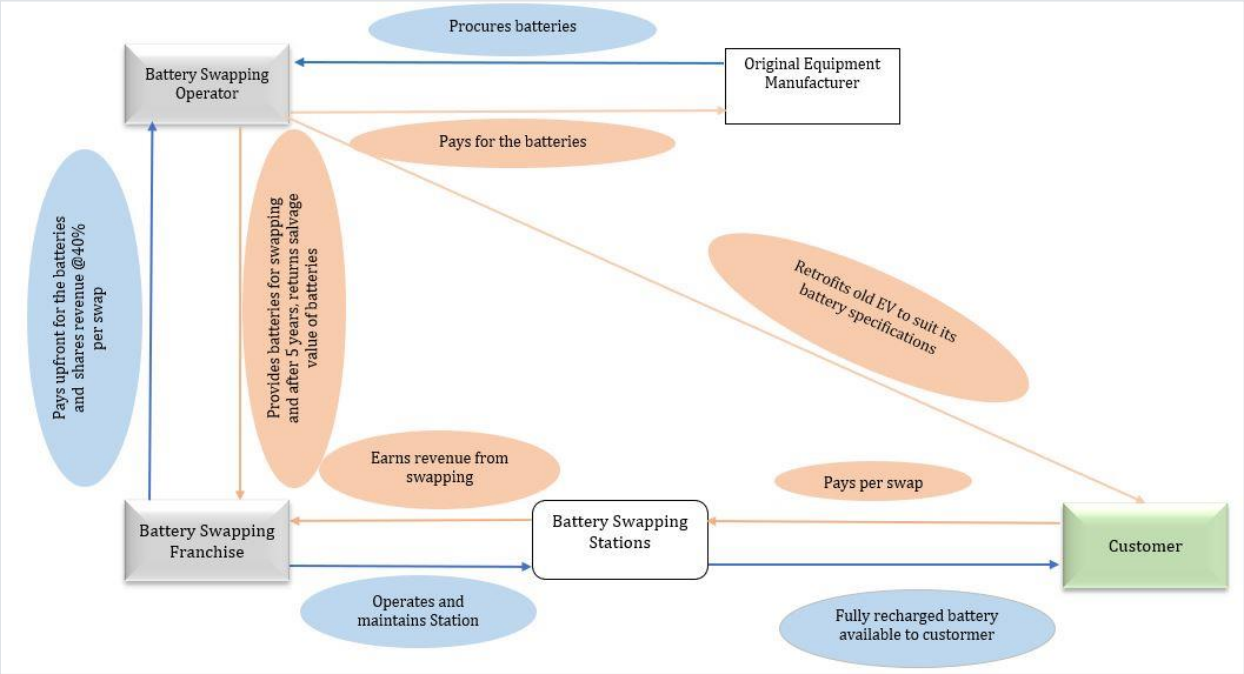


Figure 74: Franchise Model in Battery Swapping

Franchise Partner	Battery Swapping Operator (BSO)	OEM	Customer
► Procures batteries from BSO for 5 years period by paying upfront ► Shares 40% of revenue per swap with BSO ► Sets up and maintains battery swapping station	► Ties up with customer to retrofit their vehicles to match the battery design ► Provides batteries to franchise partner for 5-year period and returns salvage value of batteries after 5 years ► Earns 40% of the revenue per swap from franchise partner	► Provides cells to BSO for assembling & designing battery ► Sells EV to customer	► Gets EV retrofitted by BSO ► Takes battery from BSO's franchise partner ► Pays per swap to BSO's franchise partner

5.11. CESL Strategy

The transportation sector soon is about to experience a massive shift to electric vehicles (EVs). From an environmental point of view, this will help in reducing greenhouse gas emissions and overcome the energy crisis and climate change. With EVs being adopted for mobility around the globe, the development of battery swapping infrastructure is bound to make the future interesting in the automotive industry.

In the B2B industry, brands like Flipkart, Amazon, Delhivery, and Dominoes are now upgrading their business model and planning to utilize the Swapping Battery benefits to reduce delivery costs and save the environment. The adoption rate of EVs in India especially for the smaller vehicle segment will witness exponential growth in upcoming years. As the technology accelerates, it is expected for a lot of private players and government-backed agencies to enter the battery swapping space.

India in present times is aggressively pushing itself toward electrification. In Union Budget 2022-23, the Centre made great emphasis on electric vehicles or EVs becoming the future of mobility in India in the next decade.

CESL can play a key role in development of the battery swapping infrastructure at its existing land parcels which are currently having only 4-Wheeler charging infrastructure. By collaborating with a Battery swapping player, there is a huge potential for CESL to provide a one of its kind complete charging solutions for charging of 2, 3 and 4 wheelers at the same spot.

CESL can collaborate with an existing battery swapping player and support them in setting up swapping stations at its existing public charging locations on revenue sharing basis. This will not only be a boost to the overall swapping ecosystem but also will attract financing institutions to invest in the overall development of this ecosystem.

Battery Swapping Operator	CESL
► Setting up of Battery Swapping Facility (BSF) at its own cost (Including civil & electrical work) Operating & maintaining the setup infrastructure. ► BS Operator shall pay as per the units recorded in the meter / sub meter installed by DISCOM for the BSF installed, owned and operated by SUN Mobility. ► Branding at designated spaces	► Provide encumbrance free land (Existing land parcels of CESL) to BSO on fixed rental model (Approximately 10 x 10.ft for placingbattery swapping station) ► Facilitates dedicated power connection

Electric Vehicles are the next revolution in the automobile industry that will take us a step closer to a greener tomorrow. Battery swapping thus in present times becomes a feasible solution for commercial and privately owned Electric vehicles for emission-free driving.

5.12. Key Recommendations

Table 28: Recommendations for battery swapping

Area	Recommendation
Standardization	Establishing industry standards for battery modules and swapping interfaces is crucial to ensure compatibility among different EV models and manufacturers. This enables a more widespread adoption of battery swapping technology.
Automated Systems	Implementing automated or robotic systems for battery swapping can enhance efficiency, reduce human error, and make the process more user-friendly. These systems can speed up the swapping process and improve overall reliability.
Fast Swapping Times	Achieving fast swapping times is essential for the success of battery swapping stations. The aim is to make the process as quick as, or even quicker than, refueling a traditional internal combustion engine vehicle. Stations targeting swapping times of around 5 to 10 minutes are considered more practical.
High-Energy Density Batteries	Investing in high-energy density batteries allows for longer driving ranges between swaps, reducing the frequency of visits to swapping stations. This contributes to a more convenient and acceptable user experience.
Remote Monitoring and Maintenance	Implementing remote monitoring systems allows operators to track the health and status of batteries in real-time. This helps identify any issues early on and facilitates proactive maintenance, ensuring the reliability and safety of the swapping process.
Energy Management and Grid Integration	Integrating battery swapping stations with smart energy management systems and the electricity grid can help optimize energy use. This includes charging batteries during periods of low electricity demand and possibly providing grid services, such as demand response.
User Experience and Payment Integration	Prioritizing a positive user experience is critical for the widespread adoption of battery swapping. This involves intuitive interfaces, clear instructions, and convenient payment methods. Integration with mobile apps and seamless payment processes can enhance user satisfaction.
Fleet Operations and Commercial Use	Targeting fleet operations and commercial vehicle use can be an effective strategy for battery swapping adoption. Fleet operators may benefit from reduced downtime and increased operational efficiency.
Partnerships and Collaboration	Collaborating with automakers, energy companies, and infrastructure developers can accelerate the deployment of battery swapping infrastructure. Partnerships can also help address technical and regulatory challenges.
Regulatory Support and Incentives	Governments and regulatory bodies can play a crucial role in promoting battery swapping by offering incentives, streamlining regulations, and supporting infrastructure development. Clear and supportive policies can attract investment and foster growth in the sector. Need to notify the battery Swapping policy to provide clear visibility to battery swapping operators and other stakeholders to develop a battery swapping network across the country.

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6.

Case study 4

Solar Powered Electric Vehicle Charging Carport with Battery Energy Storage System

6.1. Background

India, one of the world's fastest-growing economies and soon-to-be the most populous country, faces a complex challenge in its road transport sector. While road infrastructure development has traditionally driven socio-economic progress, it has concurrently led to environmental issues. Notably, the expansion of road transport in India has resulted in a substantial increase in CO2 emissions, along with pollutants like nitrogen oxides (NOX) and fine particulate matter (PM2.5)

Currently, road transport accounts for 12% of India's energy-related CO2 emissions, contributing significantly to urban air pollution.[38] The ongoing surge in the demand for private mobility and goods transport indicates that energy use and CO2 emissions from road transport could double by 2050. The proliferation of private cars and an expanding truck fleet, coupled with continued reliance on gasoline and diesel, are primary drivers of this trajectory. Although two-wheelers dominate India's vehicle fleet, the imminent electrification wave is expected to mitigate their energy needs and emissions starting in the mid-2020s.

In response to these challenges, India's Prime Minister announced a visionary goal in 2021 to achieve net-zero carbon emissions by 2070. Implementing ambitious policies become crucial in realizing this vision. Such policies could potentially reduce energy demand by 30% in 2050 compared to current policies, resulting in substantial savings of 70 million tonnes of oil equivalent -approximately 80% of the sector's current energy needs.[39] By 2030, these reduction can be achieved through intensified energy efficiency measures and accelerated adoption of electric vehicles (EV).

The extent to which CO_2 emissions can be mitigated by EVs hinges on the pace of India's transition to a low-carbon power sector, currently dominated by coal. Presently, the reduction in tailpipe CO2 emissions from EVs is roughly offset by the emissions at the power plant level.

However, this scenario is expected to evolve. By 2030, India's EV fleet is projected to avoid approximately 5 Mt CO2 emissions. Looking ahead to 2050, this impact could range from 110 to 380 Mt CO2, contingent upon factors like the size of the EV fleet and the speed of decarbonization in the power sector. It's worth noting that beyond CO2 reduction, widespread EV adoption also promises a significant reduction in citizens' exposure to air pollution.[40]

[38] https://www.iea.org/reports/transitioning-indias-road-transport-sector/executive-summary
[39] https://www.iea.org/reports/transitioning-indias-road-transport-sector/executive-summary
[40] https://www.iea.org/reports/transitioning-indias-road-transport-sector/executive-summary

6.2. Need for integrating RE with EV charging

Renewable energy sources, such as solar, wind, and hydroelectric power, offer a sustainable solution for generating electricity. Installing solar panels or wind turbines at or near EV charging stations enables the production of clean energy on-site. This approach significantly reduces the carbon footprint associated with transportation, promoting the use of eco-friendly energy for charging electric vehicles and making the overall charging infrastructure greener.

EV charging stations can be seamlessly designed to integrate with the local power grid, utilizing a mix of renewable energy sources. Excess electricity generated from renewables can be fed back to the grid, offsetting the energy consumed during charging. This not only balances the intermittency of renewable energy generation but also optimizes its utilization.

The inclusion of energy storage systems, such as batteries, in EV charging stations and renewable energy setups allows for more efficient energy flow management. Storing excess renewable energy in batteries ensures a stable power supply during periods of low generation or high demand, contributing to a more reliable grid. Smart charging systems can schedule EV charging during peak renewable energy generation, further optimizing resource utilization and reducing stress on the grid.

Using renewable energy for EV charging leads to long-term cost savings by eliminating operational costs associated with traditional fossil fuel-based sources. It also reduces dependence on non-renewable resources, lowers greenhouse gas emissions, and fosters a more sustainable and environmentally friendly transportation system.

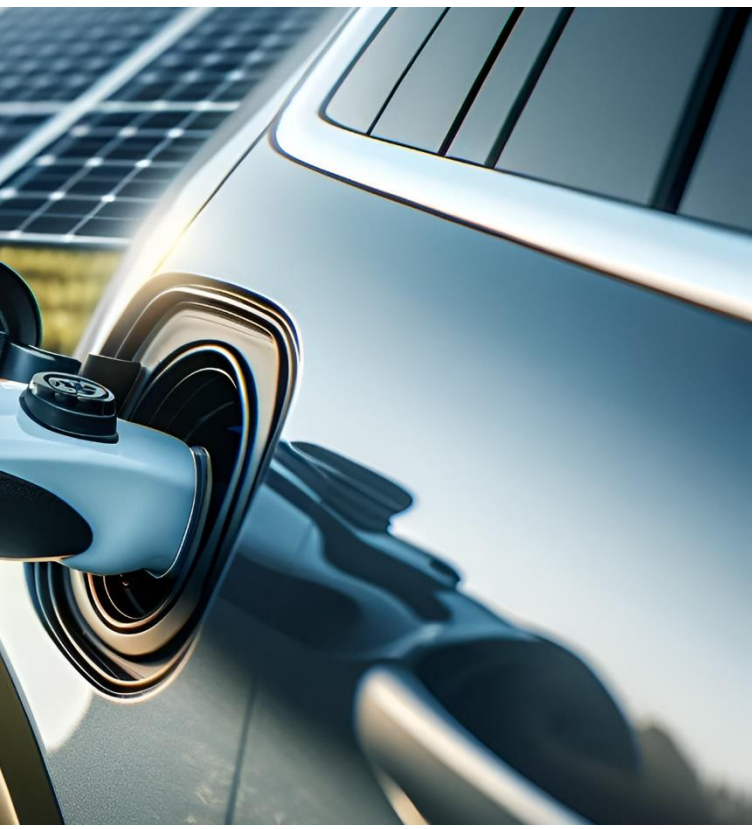
The Integration of renewable energy with EV charging stations aligns with the increasing demand for sustainable practices. It not only builds a positive public perception but also encourages the adoption of renewable energy while enhancing the brand image of charging station operators, EV manufacturers, and other stakeholders.

6.3. Solar Carport Photo Voltaic systems – A viable solution for integrating RE with EV charging

Solar carport with Battery Storage (BESS) is a popular technology to source clean energy and store energy onsite. This stored energy can subsequently be utilized to charge vehicles, providing an independent and sustainable alternative to traditional grid-dependent charging.

Figure 75: Solar Powered EV Charging station in Delhi

A solar carport serves a dual purpose, offering shelter for vehicles while harnessing clean, renewable energy from the sun. The amount of electricity generated by a solar carport depends on factors such as its size, the number of installed solar panels, daylight hours, and light intensity.



In the face of escalating energy demands, it is imperative to develop clean energy alternatives to ensure cities self-sufficiency in renewables. The

Table 30: Recommendations for battery swapping

installation of carport solar solutions is a prudent strategy, particularly for businesses seeking to invest in solar energy without extensive property redesign.

The incorporation of a solar carport with EV Chargers and BESS serves as a sustainable energy generation source, simultaneously addressing various facility needs. Moreover, businesses can leverage solar PV systems to initiate sustainable initiatives, including the establishment of electric car charging stations. This aligns with the objectives of NITI Aayog, aiming to bolster commercial electronic vehicle sales by 70% and contribute to the Indian government's ambitious target of achieving zero carbon emissions by 2070.

6.4. Benefits Of Integrating Battery Energy Storage Systems (BESS) With Solar Carport System

The integration of Battery Energy Storage Systems (BESS) with solar carport systems presents a comprehensive solution to address various challenges related to electricity affordability, power shortages, and high consumption. The key points regarding this integration are as follows:

Table 29: Benefits of integrating BESS with Solar Carport for EV charging

Sr. No.	Benefits	Details
1	**Energy Storage Capability**	Battery Energy Storage Systems (BESS) are incorporated into the solar carport system to store the electricity generated by the solar panels. This stored energy serves as a backup and can be utilized during peak demand periods or in the event of power blackouts. The ability to store excess energy enhances the reliability and resilience of the solar carport infrastructure.
2	**Peak Demand Management**	One of the significant advantages of integrating BESS with solar carports is the effective management of peak demand. During periods of high electricity demand, the stored energy in the batteries can be tapped into, reducing the reliance on the grid. This not only helps in managing peak loads more efficiently but also contributes to cost savings during periods of higher electricity rates.
3	**Addressing Electricity Affordability**	The solar carport system with BESS offers a sustainable solution to address challenges related to electricity affordability. By harnessing solar energy and storing it for later use, businesses can reduce their reliance on conventional grid power, leading to potential cost reductions in the long run.
4	**Fuel Cost Reduction and Lower Energy Bills**	Solar carports, when equipped with BESS, provide businesses with the opportunity to cut fuel costs and lower energy bills. The clean and renewable energy generated by the solar panels, coupled with the ability to store excess energy, contributes to overall cost savings for businesses relying on this integrated solution.
5	**Promotion of Clean Energy Practices**	The adoption of solar carports with BESS aligns with the broader goal of promoting clean and sustainable energy practices. Businesses can contribute to environmental conservation by reducing their carbon footprint and reliance on traditional energy sources.

In summary, the integration of BESS with solar carport systems offers a holistic solution that not only addresses immediate concerns related to electricity management but also contributes to long-term sustainability and cost-effectiveness for businesses in India. In addition, it also supports businesses to diversify their revenue streams in the evolving energy landscape. The flexibility and capabilities of BESS contribute to the resilience and economic viability of solar carport installations.

6.5. Challenges for setting up RE Based EV charging with BESS

While the concept of setting up off-grid renewable energy (RE) based EV charging stations with battery energy storage systems (BESS) in India holds great potential, there are several challenges that need to be addressed for successful implementation. Some of the key challenges include:

Table 30: Challenges associated with RE based EV charging with BESS

Sr. No.	Benefits	Details
1	**Initial Capital Costs**	The upfront costs associated with establishing off-grid RE-based EV charging stations with BESS can be significant. Investing in solar panels, battery storage systems, and charging infrastructure requires substantial capital, and businesses or entities may face challenges in securing adequate funding.
2	**Technology Costs and Efficiency**	The cost of solar panels and battery storage technologies, while decreasing over time, can still be a barrier to widespread adoption. Achieving cost-effective solutions with high efficiency is crucial to make off-grid systems economically viable.
3	**Land Availability and Zoning**	Identifying suitable land for setting up solar carports or panels can be a challenge, especially in densely populated urban areas. Zoning regulations and land-use policies may also pose obstacles to obtaining the necessary space for off-grid charging infrastructure.
4	**Intermittency and Seasonal Variability**	Solar energy generation is intermittent, and its availability depends on weather conditions and time of day. Seasonal variations can impact energy production. Balancing the intermittency of solar power with BESS becomes essential to ensure a reliable and consistent power supply.
5	**Battery Performance and Lifespan**	The performance and lifespan of batteries are critical factors. Ensuring that the battery storage system has a sufficient capacity, long cycle life, and reliability under various conditions is crucial for the success of off-grid EV charging.
6	**Regulatory and Policy Framework**	The regulatory framework for off-grid RE-based EV charging is evolving. Clear and supportive policies are necessary to encourage investments, streamline approvals, and provide incentives for businesses to adopt off-grid solutions.
7	**Grid Integration Challenges**	In certain cases, integrating off-grid systems with the existing power grid may pose challenges. Coordination with local utilities and adherence to grid codes and standards become important to ensure seamless integration and avoid disruptions.
8	**Technical Expertise and Maintenance**	Off-grid RE-based systems require specialized technical expertise for design, installation, and maintenance. A skilled workforce is needed to address technical issues promptly and ensure the optimal performance of the entire system.
9	**Consumer Awareness and Adoption**	Awareness among consumers about the benefits of off-grid EV charging with renewable energy may be limited. Encouraging adoption and creating awareness about the environmental and economic advantages is crucial for the success of such projects.
10	**Scalability and Standardization**	Achieving scalability and standardization in off-grid RE-based EV charging solutions is essential for widespread deployment. Standardized components and systems can lead to cost reductions and easier replication.

Addressing these challenges will require collaborative efforts from government bodies, private enterprises, and technology providers to create an enabling environment for off-grid RE-based EV charging with BESS in India.

6.6. Types of Solar Carports

1. **Commercial Solar Carports:** Commercial solar carports are fitted with photovoltaic cells to provide energy for the building it's attached to, but they can also be used as standalone structures. Commercial carports can be used as garages or parking lots for commercial purposes such as offices, malls and showrooms. They are usually located near the main entrance so customers can park their vehicles easily before entering the establishment.
2. **Industrial Solar Carports:** Industrial solar carports are structures that cover one or more parking spaces with a roof and have installed solar PV systems. The solar PV systems on the roof generate electricity from the sun, which is then stored in batteries for use at night or during cloudy weather days.

6.7. How Do carport solar PV systems Work?

The Photovoltaic (PV) systems on a solar carport can be configured in various ways, depending on the desired capacity to capture and store solar energy for future use. Configurations range from systems capturing a modest amount of sunlight to those capable of harnessing more than enough energy to meet commercial needs.

A solar carport integrated with battery storage systems offers backup power during outages or cloudy days when the PV systems may not produce sufficient electricity to meet demand. The stored energy can power heavy machinery and various units in a production facility.

6.8. Critical Components of a Solar Carport

Details of different components of a solar carport system is mentioned below:

Figure 76: Solar Panels in parking lot

PV Cells – Absorb and convert the sunlight into direct current electric power

Figure 77: Mounting structure for panels

Mounting Structure – Activates the PV cells along the solar canopy

Figure 78: Inverters

Inverter - Transform the DC energy into AC (alternating current) electricity to power your business facility.

Figure 79: Energy meters

Energy Metering System- Tracks the volume of green energy created by the solar canopy and its subsequent consumption.

6.9. Things to Consider while opting for a Solar Carport System

Carport Size, Height and Positioning

Assess the size of car shed to determine the area required to install solar PV system. Determine the ground clearance of the shed before building the solar canopy.

Figure 80: Solar panels at parking lots

Factors to be considered for planning Installation of solar carports:

- Carport must not be under the shade of trees or any buildings.
- It must be away from exhaust fumes from nearby factory chimneys and other sources.
- The distance of the carport from the power evacuation point (LT panel) must be manageable.

Carport Position

The position of the carport plays a very crucial role in designing the solar canopy. For instance, if business facility is in a region that witnesses rainfall frequently, the solar canopy must be of a tilted design which would prevent rainwater accumulation on the solar PV systems.

Figure 81: carports

Energy Load Analysis of a business

Certainly, the daily energy requirement is a crucial factor in determining the appropriate size and capacity of a solar carport system. Additionally, estimating the number of electric vehicles (EVs) to be charged is essential for designing an efficient and effective solar carport solution. By considering both factors, businesses can optimize the system to meet their energy needs and support the growing demand for electric vehicle charging.

Energy Generation Analysis

After opting the type of canopy design, it is important to find out the energy generation capacity of the solar carport installation. The capacity must be determined on a daily, monthly and hourly basis.

Battery Size Determination

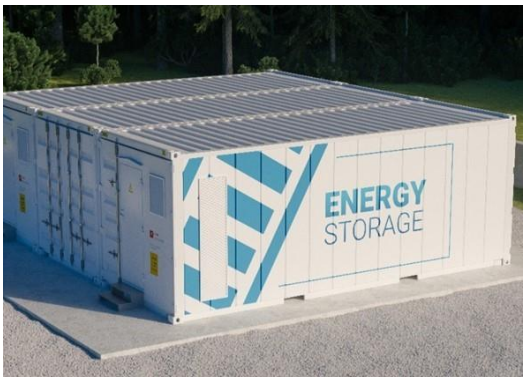
Conducting a comprehensive comparison between the energy requirements of the business and the power generation capacity of the solar carport is crucial for effective system design. By assessing the surplus power generated, businesses can identify opportunities for optimizing energy usage and potentially contributing excess energy back to the grid.

The integration of a battery backup system plays a key role in managing surplus power, allowing for energy storage during periods of excess generation and supplying power during times of high demand or when solar generation is insufficient. Proper sizing and structuring of the battery backup system are essential to ensure efficient energy storage and utilization.

Figure 82: Energy metering devices

Figure 83: PV system control with drone energy generation analysis

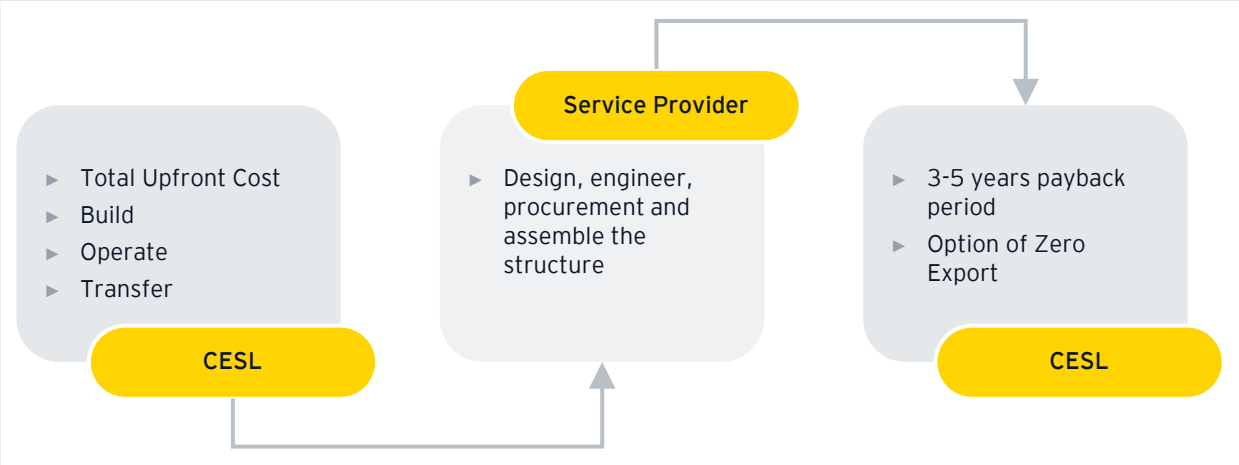
Figure 84: energy storage system



6.10. Business Models

On-site solutions enable business facility's self-sufficiency in producing solar energy. This benefits the business with energy efficiency, saving on utility bills and minimizing your carbon footprint.

6.10.1. CAPEX Model



The Capital Expenditure (CAPEX) model for solar carport systems outlined here involves the business owner making the initial investment for the installation of the solar infrastructure. Here's a breakdown of key points:

Upfront Investment: The business owner covers the entire upfront installation cost of the solar carport system. This includes expenses related to design, engineering, procurement of components, and the actual construction of the solar carport structure.

Service Provider's Role: The service provider is responsible for designing, engineering, and procuring the necessary components for the solar carport system. They also handle the installation process at the client's location.

Power Usage: The client, in this case, utilizes the solar energy generated by the carport solar PV systems for their operational needs. This can contribute to energy savings and reduced reliance on grid-supplied electricity.

Surplus Power Export: Depending on local policies and regulations, the client may have the option to export surplus solar power back to the grid. This can potentially provide additional benefits, such as credits or payments for the excess energy generated.

Payback Period: The CAPEX model typically involves a payback period, which is the time it takes for the business owner to recover the initial investment through energy savings. In this scenario, the estimated payback period is mentioned as 3-5 years.

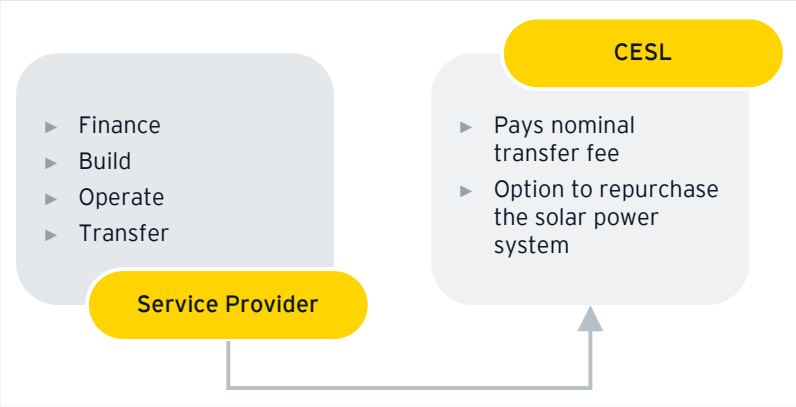
Free Green Power: After the payback period, the business owner becomes eligible to receive the solar power generated by the system essentially for free for the remaining operational life of the solar infrastructure (25 years is mentioned).

Zero Export Project: An alternative variation of the CAPEX model is the "zero export" project, where the client aims to consume all the solar power generated on-site without exporting any surplus to the grid.

Factors influencing the payback period include the specific infrastructure of the solar carport system, the geographical location of the business facility, prevailing electricity costs from the grid, available rebates, and incentives.

This CAPEX model provides a path for businesses to achieve long-term energy savings and sustainability by leveraging solar energy for their operations.

6.10.2. OPEX Or BOOT Model



The Build-Own-Operate-Transfer (BOOT) model for solar carport systems is outlined as follows:

Financing, Building, and Operating: In the BOOT model, the service provider takes on the responsibility of financing, building, and operating the solar carport plant within the business owner's facility. This involves the initial investment and ongoing operational aspects.

Power Purchase Agreement (PPA): The service provider, as the owner of the solar infrastructure, sells the power generated by the carport solar system to the business owner through a Power Purchase Agreement (PPA). The PPA typically includes terms such as the duration of the agreement, pricing, and other relevant conditions.

Competitive Charges: The power is sold to the business owner at competitive charges, providing them with solar-generated electricity without the need for upfront investment in the solar infrastructure.

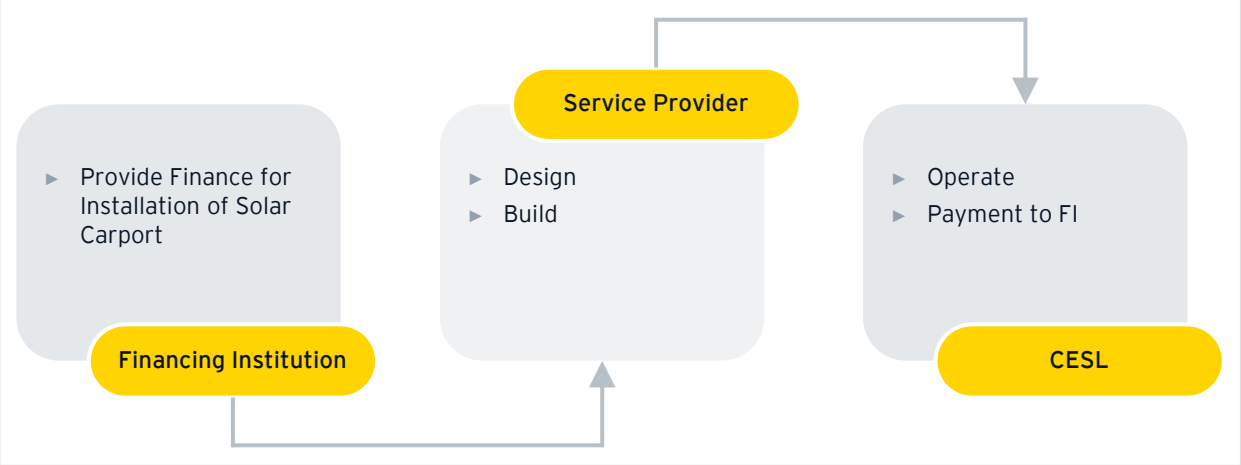
Ownership Transfer: At the end of the PPA term, the service provider transfers ownership of the carport solar system to the business owner. This transfer is facilitated through a nominal fee, allowing the business owner to take full ownership of the solar infrastructure.

Repurchase Option: The business owner may also have the option to repurchase the solar power system at any point during the PPA term. This can be done at a pre-decided rate, offering flexibility for the business owner.

The BOOT model provides a pathway for businesses to benefit from solar energy without the initial capital expenditure. It allows them to access clean energy through a PPA, and once the agreement concludes, they have the option to take ownership of the solar infrastructure. The competitive charges and potential repurchase option add flexibility to the arrangement.

This model aligns with the broader trend of third-party financing arrangements in the renewable energy sector, providing a viable and cost-effective means for businesses to adopt sustainable energy practices.

6.10.3. Lease Rental Model



The financing option described involves the collaboration of a service provider, a business owner, and a Non-Banking Financial Company (NBFC). The key features of this arrangement are outlined as follows:

Responsibility of Service Provider: The service provider assumes the responsibility for designing the solar infrastructure, purchasing necessary installation materials, and assembling the system at the business owner's location. This includes the upfront investment and technical aspects of setting up the solar carport.

Monthly Payments to NBFC: The business owner, instead of making an upfront payment for the solar carport system, opts for a financing arrangement facilitated by a Non-Banking Financial Company (NBFC). The business owner commits to making monthly payments to the NBFC over a specified period, which is outlined as five years in this case.

Fixed Monthly Payments: The pre-decided monthly payment serves as a fixed instalment that the business owner pays to the NBFC. This payment structure spreads the financial commitment over time, making it more manageable for the business owner.

Five-Year Financing Term: The financing arrangement has a fixed term of five years, during which the business owner makes regular payments. This term allows for the gradual repayment of the solar infrastructure investment.

Ownership of Solar Infrastructure: Upon the completion of the five-year financing term and the fulfilment of payment obligations, the business owner attains ownership of the solar carport infrastructure. At this point, they have fully paid for the solar system and can enjoy the benefits of renewable energy without ongoing financial commitments.

This financing option provides an avenue for businesses to adopt solar energy without the need for significant upfront capital. The collaboration with an NBFC allows for structured and predictable payments, making the transition to renewable energy more feasible for the business owner. The ultimate ownership transfer ensures that the business can continue to benefit from clean and sustainable energy in the long run.

6.11. CESL initiative to promote off grid RE based EV Charging with BESS

6.11.1. Pilot initiative

CESL is embarking on a transformative initiative to deploy green energy technologies through the implementation of off-grid Solar Carport with Battery Energy Storage System (BESS) EV charging stations across various locations in India. This strategic move represents a significant leap toward harnessing renewable energy for electric vehicle (EV) charging, promoting self-reliance, and optimizing expenditure on energy requirements. The initiative takes advantage of the abundant solar energy resources available in the region.

Key aspects of CESL's solar carport and BESS EV charging initiative:

Renewable Energy Integration: The project involves the installation of standalone solar-powered carports equipped with integrated Lithium-ion battery storage systems. This innovative approach ensures that EV charging stations operate using clean, renewable energy, thereby contributing to environmental sustainability.

Carbon Neutrality: By utilizing solar energy and incorporating BESS technology, CESL aims to make the electric vehicles charged at these stations completely carbon neutral. This aligns with the broader goal of reducing carbon emissions associated with transportation.

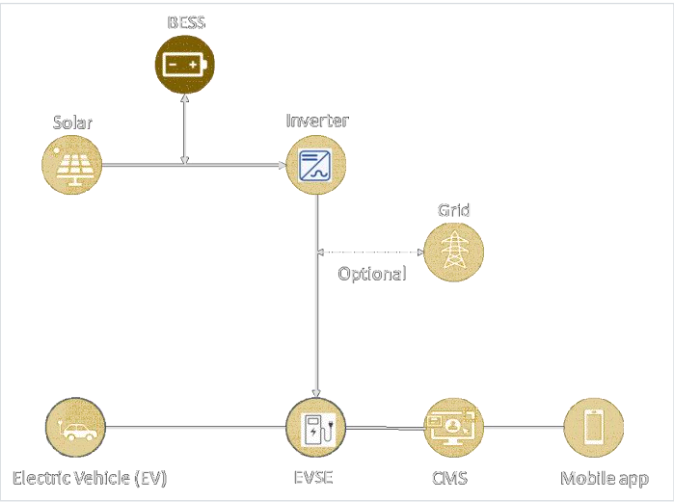
Pilot Demonstration: CESL plans to demonstrate the feasibility and effectiveness of this initiative through a pilot program. The pilot involves the installation of ten Solar Carport with BESS and EV Chargers at strategic locations, including government offices, state secretariats, religious places, urban local bodies (ULBs), and other public offices.

The pilot program is structured into two lots, each comprising five locations. Within each lot, four locations are designated for 25 kWp solar carports, while one location features a larger 50 kWp solar carport. The BESS systems associated with these locations have capacities of 100 kWh and 200 kWh, respectively.

By implementing solar carport infrastructure with BESS capabilities, CESL aims to showcase the viability of renewable energy solutions for powering EVs in diverse public settings. This initiative not only aligns with the objectives of energy sustainability and carbon neutrality but also serves as a model for future projects aimed at leveraging clean energy for transportation.

The below image illustrates the energy flow of a Solar Powered Electric Vehicle Charging Station with Battery Energy Storage System:

Figure 85: Energy Flow Diagram



6.11.2. Specifications considered for the pilot program

The following table shows the specifications/ requirements to install an Off grid Solar Carport EV Charging Station with Battery Energy Storage System.

Table 31: Specifications of Solar Carport

Type	Specifications*	
	Option 1	Option 2
Solar Capacity	25 kWp	50 kWp
Estimated area required for 1kW panel	5 sqmt/kW	5 sqmt/kW
Estimated Total Area Required for installation of 50kWp Panels	125 sqmt	225 sqmt
Battery Energy Storage system capacity	100 kWh	200 kWh
Fast Chargers- CCS II 60 kW (Dual Gun)	1	2
Slow Charger- Type II- AC (7.4)	1	2
Slow Chargers- AC001 (9.9kW)	1	1
Estimated No. of cars charging in a day at a time	5	10
Parking Space required per car	12.5 sqmt	12.5 sqmt
No. of cars that can be covered under the carport	10	20

6.11.3. Reduction in Carbon Emissions

Solar carports generate clean, renewable energy from sunlight. This reduces the dependence on traditional fossil fuels for electricity generation, which often leads to greenhouse gas emissions. By generating electricity on-site, solar carports can offset the need for electricity from the grid, which is primarily produced from fossil fuel sources. This helps reduce the overall carbon footprint associated with electricity consumption.

The below table depicts reduction in carbon emissions through ten solar carports (8 of 25kWp and 2 of 50kWp):

Table 32: 4W car description

4-Wheeler Car*			
Description	**ICE**	**EV+ Grid**	**EV+ Solar**
Carbon Emission/year/vehicle	~3,440 kg	~2,780 kg	0 kg
Reduction in Carbon Emission/year/vehicle	0 kg	~660 kg	~3,440 kg

Table 33: Reduction in carbon emissions

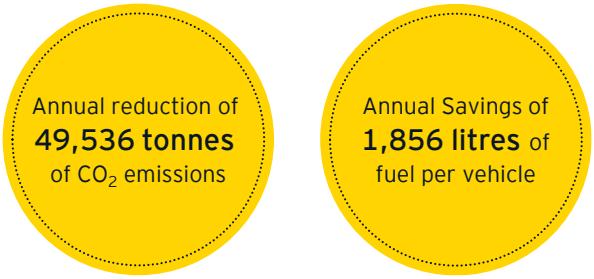
Description	25 kWp	50 kWp
Estimated no. of cars charging in a day at a time	4	8
Battery Energy Storage system capacity	100 kWh	200 kWh
Total No. of Vehicles Charged in a Year (300 Days)	1,200	2,400
Reduction in carbon emission	41,28,000	82,56,000
Total per year reduction in carbon emission in tCO_2*	**49,536**	

Assumptions for CO2 emissions reduction from Solar Carport

Table 34: Assumptions for CO2 emissions

Description	ICE	EV+Grid	EV+Solar
Vehicle Model	Nexon XM	Nexon/ Kona	Nexon/ Kona
Vehicle Range (KM)	1020	350	350
Battery Capacity (kWh)	-	40	40
Fuel Tank Capacity (Ltr)	44	-	-
Fuel Mileage (KM/Ltr)	23.22	-	-
Fuel/Energy Consumption per KM	0.04	0.11	0.11
Daily Running KM	100	100	100
Days in a year	300	300	300
Fuel Consumption/Energy Consumption	1,294.12	3,428.57	3,428.57
Carbon emission of fuel (kg/liter)	2.653	-	-
Grid Emission factor(kg/kWh)	-	0.81	0
Carbon Emission (kg)	3,440.00	2,780.00	0.00
Reduction in Carbon emission (kg)	**0.00**	**660.00**	**3,440.00**

Figure 86: Annual reduction of CO2 and saving of fuel per vehicle



Additional features of carport

Table 35: Additional features of Carport

24 Hrs CCTV monitoring facility	LCD screen for showcasing EV benefits	Space for drivers to rest during EV charging
Screen for showcasing EV benefits	App based charging and monitoring	Space for advertisement

6.11.4. Impact on indirect emissions through solar carports

Indirect emissions through solar carports with battery storage refer to the environmental benefits achieved by combining solar panels on carports with battery energy storage systems. This combination enhances the capability of solar carports to reduce greenhouse gas emissions and offers various advantages:

Table 36: Impact on indirect emissions

Parameter	Description
Load Shifting	Solar carports with battery storage can capture excess solar energy generated during the day and store it for later use, including during periods when the sun is not shining. This load shifting helps to reduce the need for electricity from conventional, fossil-fuelled sources during the evening or cloudy days, indirectly lowering emissions associated with grid electricity.
Grid Stability	Battery storage integrated into solar carports can also contribute to grid stability and reliability. By storing excess solar power and releasing it when needed, these systems can mitigate peak demand on the grid, potentially reducing the reliance on peaking plants that often burn fossil fuels.
Reduced Energy Losses	Battery storage can improve the overall efficiency of a solar carport system. It can minimize energy losses during electricity transmission, which can be significant in some areas, and lead to indirect emissions reductions due to the decreased energy wastage.
Electric Vehicle Charging	Solar carports with battery storage can offer a reliable source of electricity for charging electric vehicles. This indirectly reduces emissions associated with conventional petrol or diesel vehicles, as electric vehicles produce zero tailpipe emissions
Enhanced Resilience	In regions prone to power outages or unreliable grid electricity, solar carports with battery storage can serve as a reliable source of backup power. This can indirectly reduce emissions associated with the use of backup generators that typically run-on fossil fuels.
Reduced Air Conditioning Load	In India, where temperatures can be extremely high, solar carports provide shade for parked vehicles. This reduces the need for vehicle owners to run air conditioning at full blast when they return to their cars, which can lead to fuel savings and a reduction in greenhouse gas emissions.
Encouraging Electric Vehicle (EV) Adoption	Solar carports can also promote the adoption of electric vehicles. When EV charging infrastructure is integrated into the carports, it can make charging more convenient and attractive for EV owners. By supporting the transition to electric vehicles, which produce zero tailpipe emissions, solar carports can indirectly contribute to a reduction in overall transportation-related emissions.
Increased Renewable Energy Awareness	The installation of solar carports in public spaces or commercial areas can serve as a visible reminder of the importance of renewable energy and sustainability. This increased awareness can encourage individuals and organizations to consider their own clean energy options and reduce their carbon footprint.
Lowering the Carbon Footprint of Businesses	Many businesses in India are now integrating solar carports into their operations. By doing so, they can reduce their own emissions, cut energy costs, and align with corporate sustainability goals. This can have a positive ripple effect on the reduction of emissions within their supply chains and communities.

It's important to note that the impact of indirect emissions reduction through solar carports with BESS depends on various factors, including the capacity of the solar panels, the size of the battery system, and how the stored energy is used.

These systems are especially valuable in areas where the grid relies heavily on fossil fuels, as they can provide a cleaner and more sustainable alternative.

Additionally, the environmental benefits will vary based on the energy mix of the grid and the local climate. In regions with abundant sunlight and a grid powered by fossil fuels, the reduction in indirect emissions can be more pronounced, contributing to a cleaner and more sustainable energy ecosystem.

6.12. Scaling up and development financing

While electric vehicle (EV) charging stations contribute to a cleaner environment by promoting sustainable transportation, **the increased demand for electricity from numerous charging stations may strain the electricity grid**, leading to potential overload or the need for costly grid upgrades. This heightened demand can stress existing infrastructure, impacting its efficiency and reliability.

The source of electricity used at these stations plays a crucial role. **If the electricity primarily comes from non-renewable sources, such as coal or natural gas, the environmental benefits of EVs might be offset by increased emissions from conventional power generation**. Therefore, the overall environmental impact of EV charging depends on the energy mix of the grid.

To address these issues, a transition to renewable energy sources with storage system is essential. Emphasizing cleaner energy generation can ensure that the growth of EV charging infrastructure aligns with environmental sustainability goals while also maintaining a reliable and resilient electricity grid.

Integrating Renewable energy to EV charging has a promising future, offering prospects for a more environmentally friendly and sustainable world. With technological progress, it is anticipated continuous improvements in renewable energy options and the accompanying smart charging systems. As EV adoption increases, charging infrastructure will become more widespread and user-friendly, facilitating a seamless shift to clean and sustainable transportation. Integrating solar panel on the charging stations can power battery storage systems, enabling charging station to function during peak hours, without affecting the electricity grid. This stored energy also helps alleviate stress on the power infrastructure during peak demand periods.

Integrating solar carports lowers the operational expense by enhancing energy independence and helps offset carbon emission, making it eco-friendly and valuable solution for the end users.

> **Solar carports provide a dual advantage by generating clean energy from the sun to power EV charging stations while offering shade for parked vehicles. This reduces the environmental impact by minimizing reliance on conventional power sources and contributes to the overall sustainability of the EV ecosystem**

Figure 87: Conventional charging station VS Charging with RE integration with BESS

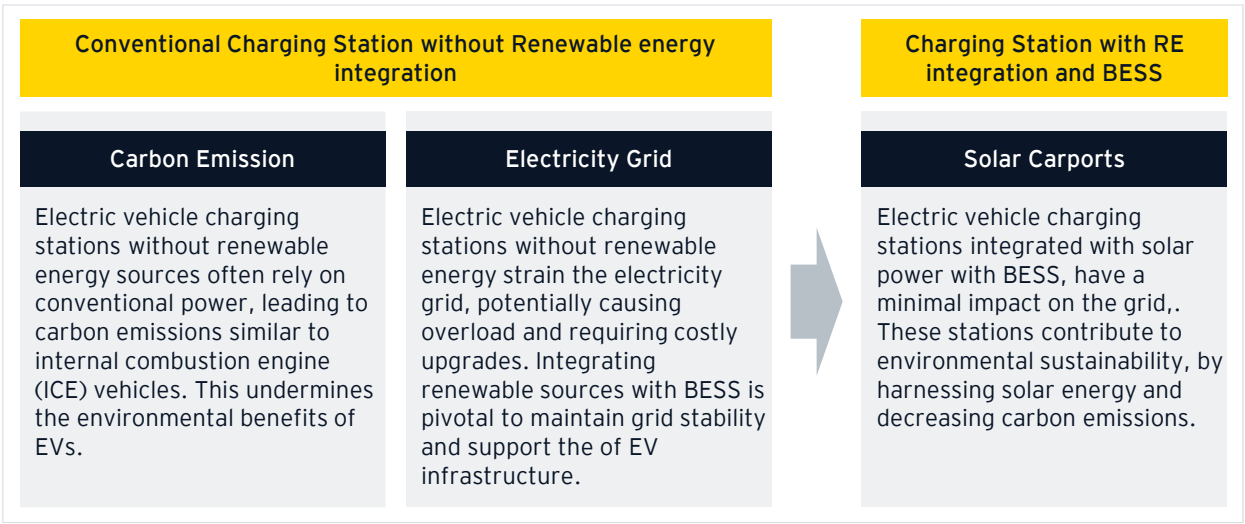


Table 37: Roles and responsibilities of stakeholders

Stakeholder	Portfolio	Current Offering	Example work
GEF	The Global Environment Facility (GEF) provides financial support for governmental sustainability projects, with the choice of the executing agency being determined by the respective governments.	Enabling activity and fund allocation.	Facilitating the program
ADB	ADB offers grants for electric vehicles and sustainable energy projects, targeting initiatives like EV infrastructure, renewable energy, and energy efficiency programs across Asian countries to promote sustainability and reduce carbon emissions.	Fund allocation to CESL.	Support in scaling up of solar carports.
CESL	CESL offers cost-effective and environmentally friendly energy solutions, encompassing the distribution of energy-efficient devices and the establishment of electric charging infrastructure to support electric vehicles (EVs).	► Hiring of agency for setting up solar carports with BESS. ► Finalizing Site across govt offices, public places and private fleet operators.	Setting solar carport at government Offices, parking, and commercial fleet.

6.13. Recommendations

Table 38: Recommendations for setting up Solar Carport

Parameters	Description
Site Selection	► Identify locations with ample sunlight exposure for optimal solar energy generation. ► Consider proximity to urban areas or commercial hubs to maximize the impact of EV charging infrastructure.
Regulatory Compliance	► Ensure compliance with local regulations and standards related to solar installations, EV charging stations, and energy storage systems.
Integrated Design	► Design solar carports that seamlessly integrate with EV charging stations and BESS for a cohesive and efficient system. ► Optimize the placement of solar panels to provide shade for parked vehicles while maximizing energy production.
Scalability	► Plan for scalability to accommodate future increases in the number of EVs and energy demand. ► Consider modular designs that allow for the easy addition of solar panels, charging stations, and storage capacity.
Grid Connectivity	► Establish a stable connection to the grid to facilitate energy exchange and grid support services. ► Explore opportunities for net metering or other incentive programs to enhance the economic viability of the project.
Energy Management System (EMS)	► Implement a robust EMS to monitor and control the solar carport, EV chargers, and BESS. ► Use predictive analytics to optimize energy storage, charging schedules, and grid interactions.
Battery Technology	► Choose reliable and sustainable battery technologies that are suitable for the specific application and environmental conditions. ► Consider lithium-ion or other advanced battery chemistries with a focus on energy density, cycle life, and safety.
EV Charging Infrastructure	► Install a mix of fast and standard charging stations to cater to different types of EVs. ► Ensure compatibility with various EV models and standards to promote widespread adoption
Financial Models	► Develop innovative financing models, such as public-private partnerships or leasing arrangements, to enhance the financial feasibility of the project. ► Explore available subsidies, incentives, and grants to support the initial investment.
Community Engagement	► Engage with local communities and stakeholders to build awareness and garner support. ► Consider educational programs to promote the benefits of renewable energy, EV adoption, and sustainable practices.
Maintenance and Monitoring	► Implement a comprehensive maintenance plan to ensure the longevity and optimal performance of the solar carport, EV chargers, and BESS. ► Use real-time monitoring systems to promptly identify and address issues.
Environmental Impact Assessment	► Conduct an environmental impact assessment to minimize any negative effects on the local ecosystem and wildlife.

7.

Case study 5

EV Charging as a Service

7.1. Background

India is one of the fastest-growing economies in the world, however huge dependence on oil imports (~85%), rising import bills and rising environmental concerns are creating a serious socio-economic challenge for the country. This has resulted into a growing need for sustainable & mobility solutions. Road transport accounts for 12% of India's energy related CO_2 emission and is a key contributor to air pollution in urban areas[41].

With increasing demand for private mobility and goods transport, energy use and CO_2 emissions could double by year 2050. Electric Mobility is one such alternative that has started finding acceptability globally to restrain emission of greenhouse gases and rise in air and noise pollution thus, providing both environmental and socio-economic benefits to countries. As per the target announced at COP-26, India has committed to reduce its emission intensity (of its Gross Domestic Product) by 45% from the 2005 level by the year 2030. To achieve this target Government of India has undertaken multiple initiatives, and sustainable transportation is one of them.

The transition to EVs is expected to enhance energy security of our country. Electric Vehicles provide spectrum of benefits including economic, environmental, and operational benefits over the conventional fossil fuel-powered vehicles. Electric Vehicle (EV) ecosystem in India is currently at a nascent stage and poised for substantial growth till year 2030 and beyond. Electric Vehicle adoption is bound to play a pivotal role in enabling the country to meet its ambitious international commitments on climate change about its Nationally Determined Contributions (NDCs). Government of India (GoI) has undertaken several initiatives to promote e-mobility in the country.

At the Central level, various ministries are working in close coordination to achieve the target. Central Ministries and concerned departments have taken several proactive steps to lay down a foundation for Electric Mobility in the country.

To support the accelerated proliferation of electric vehicles to decarbonize transport sector, creation of a safe, affordable, and accessible Public EV charging Infrastructure is crucial. Public EV charging infrastructure refers to the network of EV charging stations and battery swap stations that are required to charge EVs reliably while on the road. The availability of public charging infrastructure is vital for the adoption of EVs. Large-scale public infrastructure development can assist potential buyers to overcome range anxiety and connect urban, regional, and rural areas. In this direction, MoP clarified in year 2018 that charging EV batteries through charging station does not involve any of the activities namely transmission, distribution, or trading of electricity. Therefore, it does not require any license under the provisions of Electricity Act, 2003. This initiative formed the backbone of rapid deployment of public EV charging infrastructure across the country.

Further, Ministry of Power issued Charging Infrastructure for Electric Vehicles – Guidelines and Standards" – on 14th December 2018 with amendments issued on 1st October 2019, 8th June 2020, 14th January 2022 and thereafter on 7th Nov 2022 mentioning the roles and responsibilities of various stakeholders at Central & State level, with the objective of expediting the rollout of public EV charging infrastructure across the country. Under the guidelines, it has been specified that tariff for supply of electricity to public EV charging stations shall be single part tariff and shall not exceed Average Cost of Supply, till 31.03.2025. The same tariff shall be applicable to battery charging stations.

To make Public EV charging a feasible business proposition, the supply tariff for EV charging has been specified as amendment in the MoP guidelines of 14th Jan 2022, on 27th April 2023, with introduction of renewable based EV charging tariff.

The launch of these provisions is poised to create safe, affordable, and accessible EV charging infrastructure across the country. The number of operational public EV charging stations witnessed a year-on-year growth of 200%, with 16,000+ public EV charging stations currently operational across the country[42].

[41] IEA

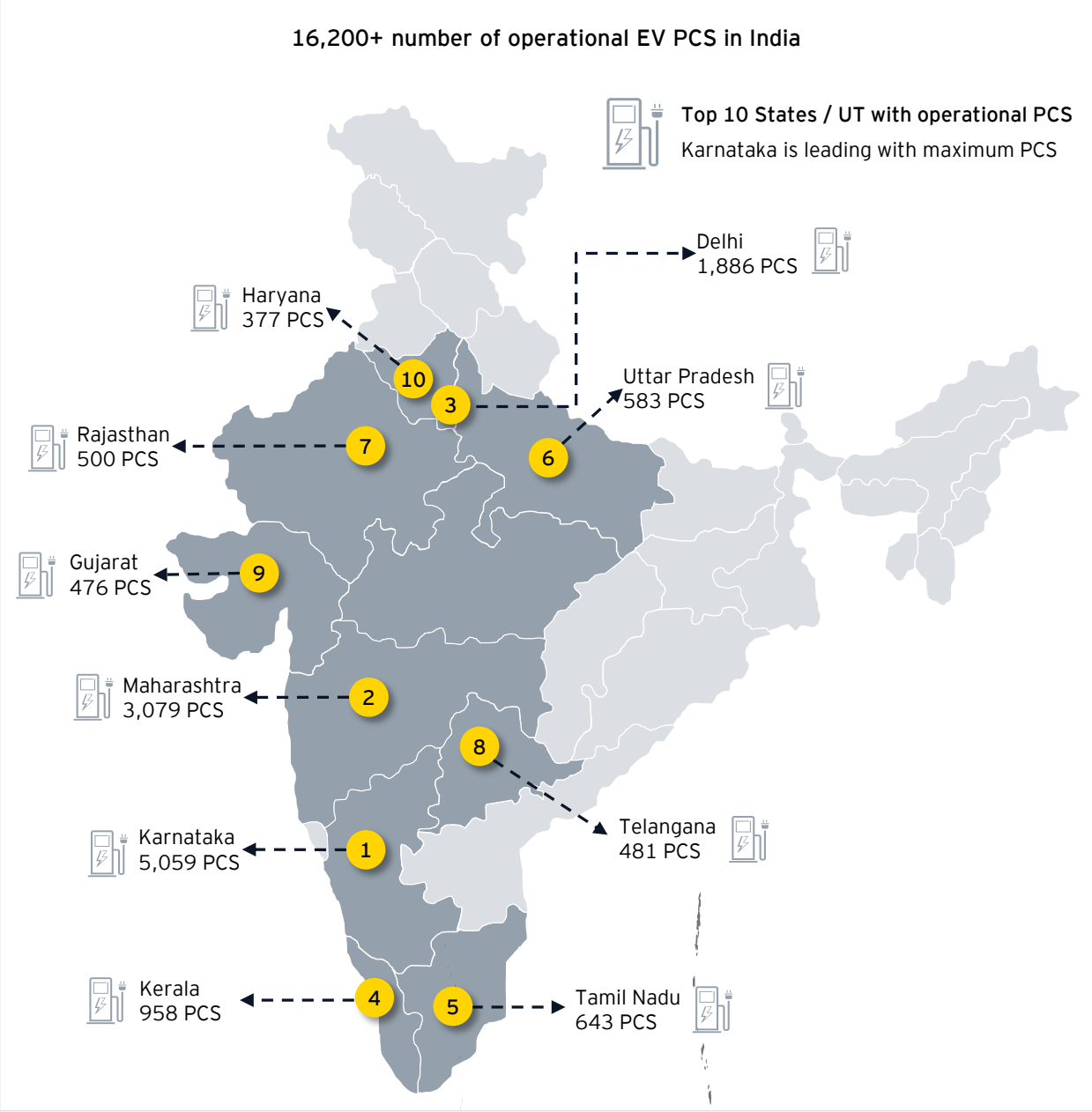
[42] https://evyatra.beeindia.gov.in/

7.2. EV charging ecosystem in India

The Indian EV charging ecosystem has experienced remarkable growth in recent years, marked by a substantial increase in the number of operational public EV charging stations (PCS). As of now, there are 16,271 operational public EV charging stations across the country. Notably, Karnataka leads in the deployment of EV charging infrastructure with 5,059 operational PCS, followed by Maharashtra with 3,079 operational PCS. This growth signifies a concerted effort towards creating a robust charging infrastructure network to support the increasing adoption of electric vehicles in India.

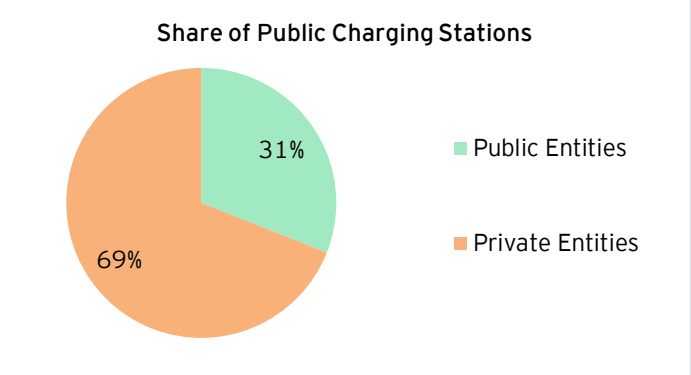
In terms of the share of deployed Public Charging Stations (PCS), private entities have taken the lead in deployment across the country. Private companies have contributed significantly, deploying approximately 11,270 PCS, while public entities have deployed around 4,990 PCS. The illustration effectively portrays the distribution of PCS deployment between public and private entities, reflecting the active participation of the private sector in advancing the EV charging infrastructure in India.

Figure 88: State wise PCS deployment - Top 10 states

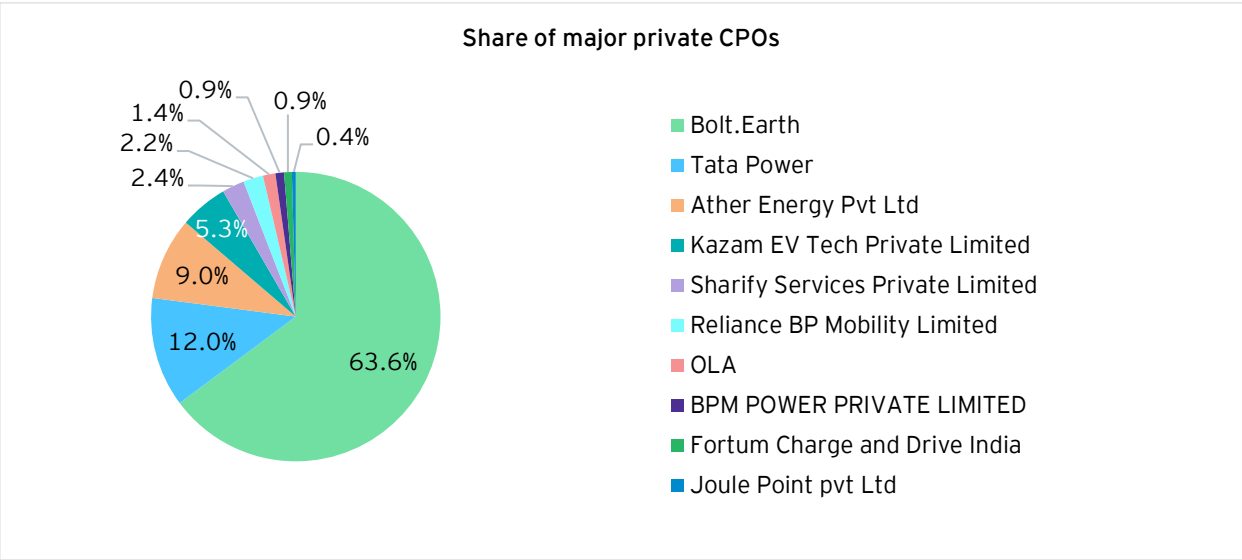


In terms of the market share of charge point operators (CPOs), private entities are prominently led by Bolt.Earth and Tata Power, collectively holding an impressive 76% share in the total Public Charging Stations (PCS) deployed by private companies. On the other hand, in the public sector, Oil Marketing Companies, specifically Indian Oil Corporation Ltd. (IOCL), Hindustan Petroleum Corporation Ltd. (HPCL), and Bharat Petroleum Corporation Ltd. (BPCL), command a substantial 70% share in the total PCS deployed by public entities. The below illustrations provide a clear visual representation of the significant market presence of these major public and private CPOs in the deployment of PCS.

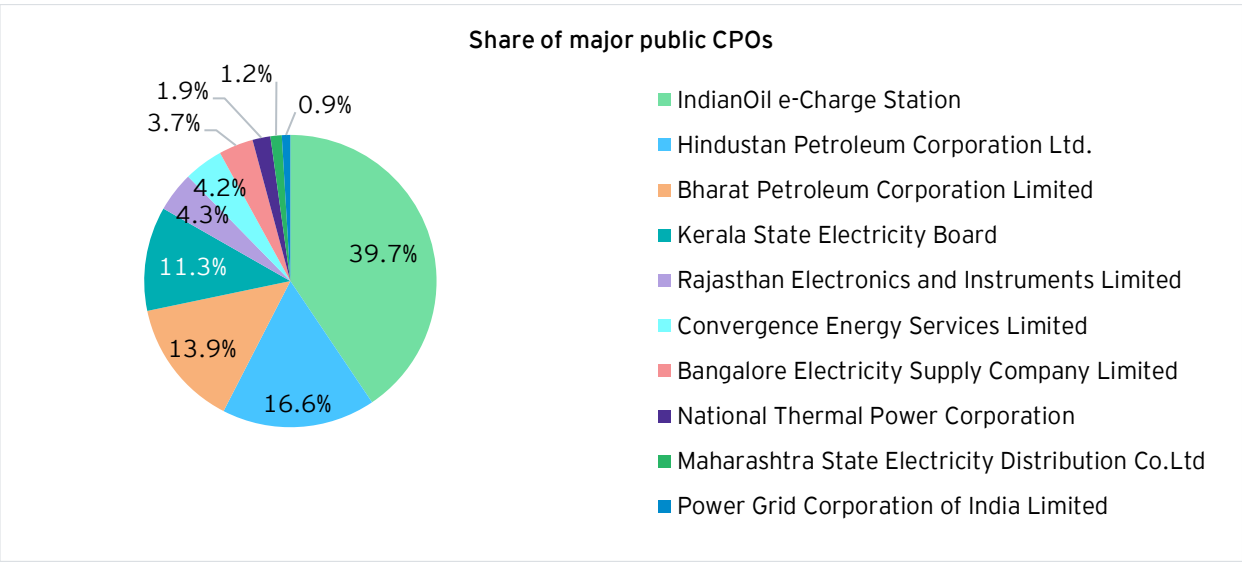
Graph 11: Share of PCS deployed by public and private entities



Graph 12: Share of major private CPOs



Graph 13: Share of major public CPOs



Despite government initiatives aimed at the deployment of Public Charging Stations (PCS) and the rapid rollout of EV charging infrastructure in India, certain challenges persist in the Indian EV charging ecosystem.

In terms of the discussions with various stakeholders, challenges that persists in faster deployment of PCS across the country are as follows:

- **Lack of provision of subsidy for setting up upstream infrastructure**– Setting up upstream infrastructure require significant investment and it has become a major challenge in deployment of Public EV charging Infrastructure as CPOs are reluctant to make such huge investments, particularly due to low utilisation of public EV chargers thereby making the business unviable.
- **Identification of feasible land packages**: Finding suitable land in urban areas for PCS deployment is one of the challenges, due to its high population density. Additionally, high cost of land acquisition is also becoming bottleneck in PCS deployment.
- **Timely electricity connection**: Getting timely electricity connection for PCS is one of challenges being faced by CPOs. In terms of revised guidelines & standards issued by MoP, timeline for getting electricity connection for PCS has been stipulated, which is to be complied by state DISCOMs.
- **Existence of multiple charging standards across the country**: Due to existence of multiple EV charging standards in India, vehicle manufacturers are producing with whatever standard they feel appropriate and charging infrastructure companies continue to set up charging points with whatever standards they feel appropriate.
- **Low utilization of public EV chargers**: The utilization of public EV chargers is currently on lower side, less than 10%. The installation of EV charging infrastructure including cost of upstream infrastructure involves significant cost. Higher capital expenditure with low utilization of EV charger is making the public EV charging business not viable.

Given the challenges persisting in the deployment of EV charging stations, EV Charging as a Service (EV CaaS) emerges as a solution, specifically addressing issues such as low utilization of public EV chargers, which can make the public EV charging business financially viable. The EV CaaS model ensures higher utilization by offering customized deployment of EV chargers tailored to the requirements of EV fleets. Further details about the EV Charging as a Service model are elaborated in the subsequent sections.

7.3. About EV charging as a service

EV Charging as a Service (CaaS) is a comprehensive, turnkey solution that offers electric vehicle (EV) charging businesses a seamless package covering charging equipment, installation, software, maintenance, and driver support, all bundled under a predictable monthly payment structure.

This innovative model empowers EV charging businesses to deploy charging stations without the need for substantial upfront investments in infrastructure. The service provider takes charge of the entire process, including the installation, maintenance, and ongoing management of the charging stations. Instead of capital expenditures, EV charging businesses opt for a subscription or usage fee, simplifying financial planning.

The demand for EV charging services is particularly prominent among fleet operators serving e-commerce and delivery companies. These services often operate in a captive mode, tailoring the charging infrastructure to meet specific vehicle and business requirements. Customizations may include a combination of fast and slow chargers, strategic placement of charging hubs, and determining the optimal number of EV chargers.

> **Electric Vehicle (EV) Charging as a Service (CaaS) model is a business approach where charging infrastructure is offered as a service rather than being owned or operated by individual EV users or fleet operators**

In essence, EV Charging as a Service is an adaptable solution that not only addresses the financial barriers to entry but also offers tailored configurations to cater to the unique needs of fleet operators in the rapidly growing electric mobility landscape.

7.4. Key features and components of EV Charging as a Service model

EV charging as a service has several benefits over public EV charging stations as mentioned below:

- **Customized Deployment:** EV CaaS allows for the customized deployment of charging infrastructure based on the specific needs and requirements of EV fleets, businesses, or specific locations. This flexibility ensures efficient use of resources and targeted accessibility.
- **Third-Party Management:** A third-party service provider or infrastructure company takes responsibility for the installation, operation, and maintenance of EV charging stations. This relieves end-users, such as businesses or fleet operators, from the complexities of managing the charging infrastructure.
- **Pay-Per-Use or Subscription model:** EV CaaS typically operates on a pay-per-use or subscription-based model. Users pay for the energy consumed or subscribe to a service plan, allowing them access to charging infrastructure within the CaaS network.
- **Scalability:** The CaaS model is scalable, allowing for the expansion or reduction of charging infrastructure as per the need of the fleet companies, including different charging speed, connector types and management systems. This scalability ensures that the charging network can adapt to the growth of the EV market.
- **Enhanced Utilization:** One of the primary advantages of EV CaaS is addressing the challenge of low utilization. By offering tailored deployment for specific fleets or businesses, the model aims to increase the utilization rates of charging stations, making the overall business more economically viable.
- **Maintenance and Upgrades:** The service provider takes care of maintenance, repairs, and upgrades of the charging infrastructure. This ensures that the charging stations remain in optimal condition, providing reliable services to users.
- **Data Monitoring and Analytics:** EV CaaS often includes data monitoring and analytics capabilities. The service provider can collect data on charging patterns, usage trends, and station performance. This data-driven approach allows for better management and optimization of the charging network.

- **Integration with Smart Grids:** Many EV CaaS models integrate with smart grids, allowing for better energy management, load balancing, and coordination with renewable energy sources. This integration contributes to the overall sustainability of the charging infrastructure.
- **Regulatory Compliance:** The service provider ensures that the EV charging infrastructure complies with relevant regulations and standards. This includes safety standards, accessibility requirements, and any other regulatory aspects associated with EV charging.
- **Simplified management of charging infrastructure:** By outsourcing charging infrastructure management to CaaS provider, EV fleet companies can focus on their core operations without the burden of handling operation and maintenance of charging facility. This model allows fleet operators to save time, reduce operational complexity, and allocate their resources more efficiently.
- **Enhanced efficiency and optimization:** CaaS providers deploy advanced charging infrastructure management system and technologies to optimize the charging process. These systems can monitor charging station usage, collect data on charging patterns, and adjust charging rates to ensure efficient energy consumption. By analysing data and implementing smart charging algorithms, CaaS providers can minimize energy waste, reduce peak demand charges, and optimize the overall charging process. This results in cost savings and improved energy efficiency for EV fleet operators.
- **Future proofing and advanced charging technologies:** CaaS providers can help fleet companies with latest technologies related to EV charging, integrate new features, and incorporate emerging standards such as higher charging speeds or wireless charging capabilities. This ensures that EV fleet operators can benefit from the latest innovations in charging technology without the need for continuous infrastructure replacements.

Additionally, CaaS model provides other benefits as mentioned below:

- **Easy deployment of EVs:** Makes easier to deploy EVs by lowering upfront cost as user pays a subscription or usage fees instead of incurring high upfront capital expenditure for charging infrastructure.
- **Higher uptime of EV charger:** As the operation, maintenance, and installation are taken care of by the service provider, EV chargers are less likely to experience downtime.
- **Promote the integration of renewable energy:** Charging as a service can encourage utilizing renewable source of electricity for EV charging with smart charging features, optimizing operating cost of charging stations. This not only contributes to a more sustainable transportation system but also helps reduce greenhouse gas emissions and support the transition to a low-carbon economy.

7.5. Global scenario

Globally, EV charging as a service is gaining popularity owning to its benefits mentioned in the above section. Some of the companies that have ventured into the business includes, Shell Recharge, Enel X Way and Electrify America in US, bp Pulse and ChargePoint in UK and Virta in Finland.

Details of some of the companies working on CaaS business model across the globe is mentioned below:

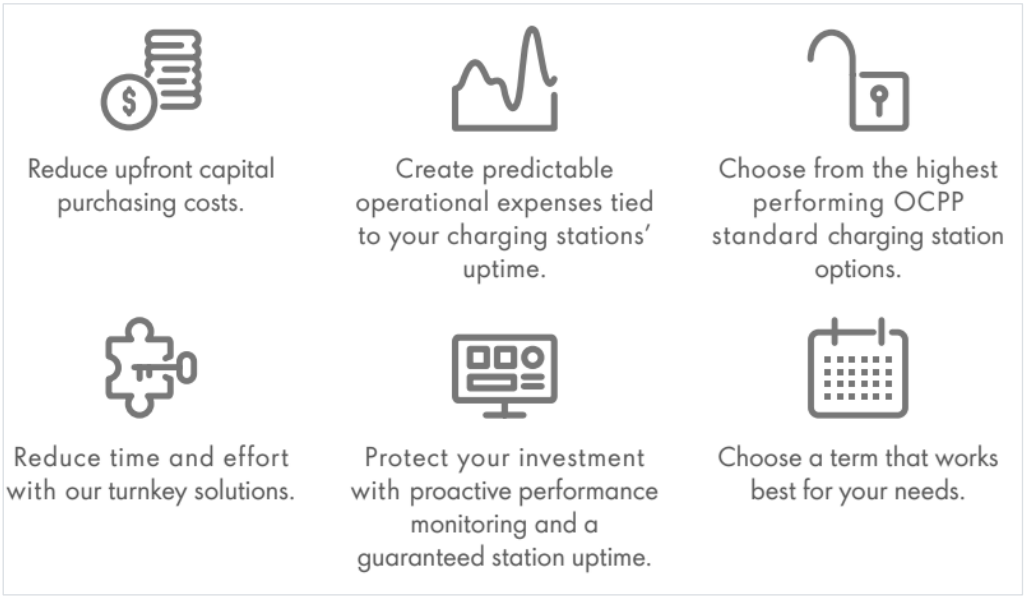
1. Shell Recharge Solutions

Shell Recharge provides standard EV charging solutions to its customers while reducing upfront costs with its Charging as a Service (CaaS) subscription-based solution which is a subscription-based EV charging package that provides turnkey EV charging solutions with minimal upfront purchasing costs.

Below figure illustrates charging as a service offering provided by Shell Recharge:

Figure 89: Shell Recharge Logo

Figure 90: EV charging as a Service offerings



2. Enel X Way

Enel X Way's Charging-as-a-service (CaaS) offers flexible solutions for various EV charging projects. The company provides, comprehensive, turn-key solutions that provide electric vehicle supply equipment (EVSE), software, installation, and maintenance for a monthly fee with flexible terms.

Figure 91: ENel X way Logo

CaaS allows fleet owners to access to EV chargers with no up-front costs and pay in a way that makes sense for individual business. It allows fleet operator to upgrade equipment's at the end of term without any upfront investment which removes the burden of ownership and maintenance of EVSE equipment's.

Below table provides offering of Enel X Way's for EV charging as a service business:

Table 39: EV CaaS model - Enel X

Charging as a Service model	
Upfront cost	None
Payment frequency	Monthly
Term	~5 – 7 years
Ownership	Service provider (Enel X)
Operation & Maintenance	Included with uptime guarantee (99%)[43]

3. bp Pulse

Figure 92: Bp Pulse Logo

bp pulse's Charging-as-a-Service removes the burden of high capital investment and stakeholder engagement with comprehensive project management and amortized costs. The company combines site design, infrastructure deployment, software, and service to make EV fleet operations seamless.

The overall services provided by the company are divided into 4 phases:

Phase	Description
Phase 1 Design	Includes infrastructure site analysis, engineering drawings, vehicle route analysis and more. In addition, team also conducts a holistic charging strategy analysis and procures the appropriate electrical and charging equipment.
Phase 2 Deploy	Identification and selection of licensed subcontractors, secure permits, commission equipment, and provide comprehensive project management support. In addition, team handles all stakeholder engagement on the behalf of a client to ensure project implementation happens on time.
Phase 3 Operate	Once the chargers are installed and energized by the utility, company onboards Omega, its proprietary, cloud-based charge management software, to automate and orchestrate charging sessions and manage energy costs.
Phase 4 Maintain	To help keep charging equipment running, bp pulse's CaaS includes Elevate, its hassle-free, preventative maintenance and support that goes beyond existing equipment warranties provided by manufacturers.

While transitioning to an electric fleet, operators are tasked with navigating an exhaustive list of requirements for implementation. With Charging-as-a-Service, fleet operator can remain focused on the work of delivering people, goods, or services as bp pulse handles the build and overall health of a charging infrastructure.

Various responsibilities taken up by bp Pulse in a partnership with a fleet operator is mentioned below:

[43] https://www.enelxway.com/content/dam/enelxmobility/north-america/images/resource-pages/media-kit/company-product-collateral/pdfs/CaaS_Data%20Sheet_2_7_2023.pdf

Table 40: Responsibilities taken up by bp Pulse

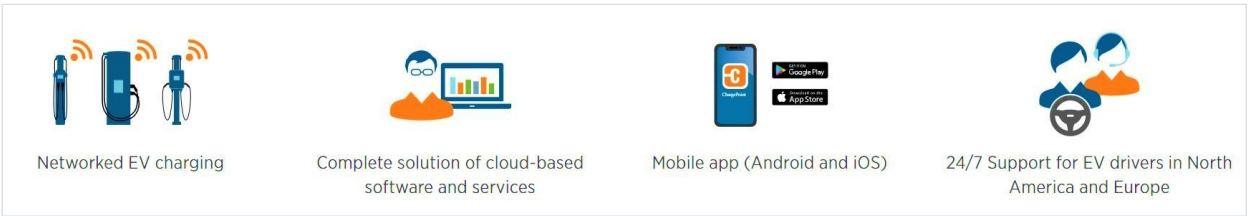
Responsibility	Fleet operator	bp pulse
Moving goods, people, or services	•	•
Engineering and site design		•
Procuring electric vehicle supply equipment		•
Construction and installation		•
Managing charging operations		•
Managing fuel (electricity) costs		•
Operating and maintaining charging infrastructure		•
Managing fuel credits		•
Sourcing clean energy		•
Managing demand response and grid service programs		•

4. ChargePoint

Figure 93: Charge Point Logo

ChargePoint is a well-established global player providing comprehensive EV charging solutions. They offer a cloud subscription service that includes station management, driver support, and access to their charging network.

ChargePoint as a Service (CPaaS) removes barriers to entry to EV charging by lowering upfront costs and protecting investment in EV charging. CPaaS includes all of the hardware, software, installation and setup needed to succeed with EV charging.



Below section highlights CPaaS operating model of Chargepoint:

Table 41: EV CaaS model - ChargePoint

Phase		Description
Before installation	Site readiness	Fleet company to provide site readiness confirmation with filing the site readiness notification form to ChargePoint
During installation	Delivery, installation, and set-up work are included in our offering	Once the site is prepared, ChargePoint takes care of delivering, installing, and setting up the charging station(s)
	Installation and commissioning services for your charging stations	These services ensure that charging solutions are correctly installed and commissioned
	Activation and configuration	During this part of the process, ChargePoint make sure that fleet company can achieve the charging goals by configuring intelligent features, such as pricing models, access control, administration rights, adverts and more.
	Access controls	Access controls allow station operators to specify who can use the charging stations and when.
Post Installation	Software upgrades	All software upgrades are managed so that fleet company can always have the latest features available.
	Proactive monitoring of hardware and maintenance services available around the clock	ChargePoint's proactive monitoring service minimizes downtime and includes spare parts and labour costs for repairs (including vandalism, misuse, and accidents) so there are no unforeseen costs for fleet company
	Ongoing support for operators and drivers	ChargePoint's team offers 24/7 support for electric vehicle drivers who have questions about the charging process.
	Charging data and analyses	The fleet company will receive reports on key metrics from the charging station, including status, power and energy usage, information about charging processes and more
Features	Energy management	This feature manages the energy available at the circuit, panel, or site level, meaning that more charging stations can be installed without the need to overhaul the existing electrical infrastructure. Energy management also reduces costs.
	98% uptime guaranteed throughout the year	We keep the fleet company's charging stations functional so that drivers can charge their vehicles at your site without any problems.
	All repair costs covered	ChargePoint's offering covers any labour and repair costs that may be necessary so there are no unforeseen costs for you to worry about. [44]

[44] https://chargepoint.ent.box.com/v/CPaaS-DS-EN-USA

5. Virta

Virta is a global pioneer in developing smart electric vehicle charging services. Founded in 2013 at Helsinki, Finland, it was ranked on the Financial Times 1000 Europe's Fastest Growing Companies list for the fourth time in a row in 2023.

Figure 94: Virta Logo

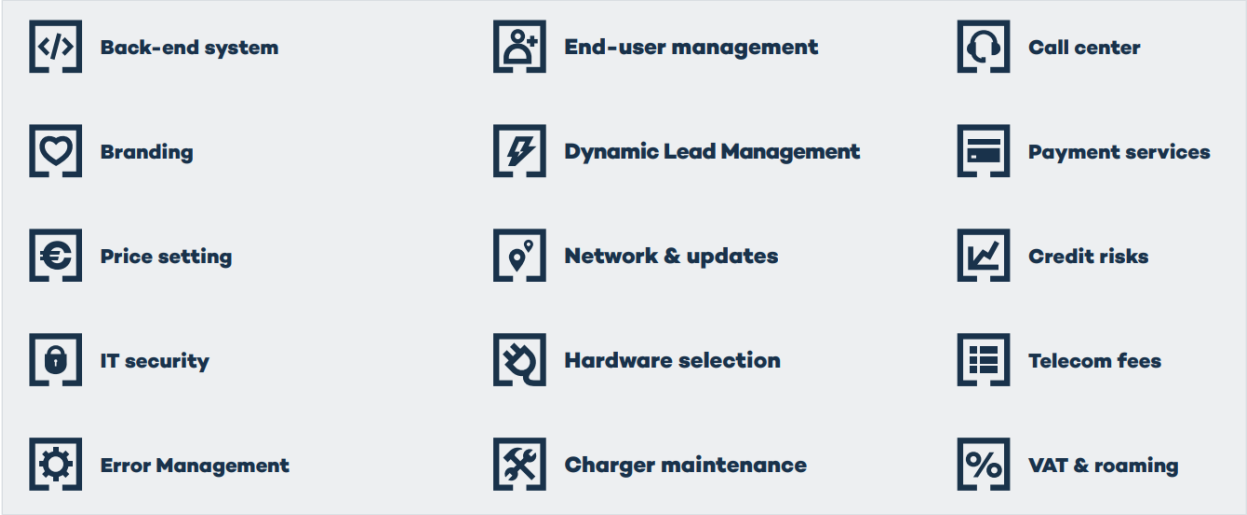
Virta's digital EV charging platform is used by over 1,000 private and public companies and organisations in retail, hotel, real estate, parking, petrol retail, automotive, and energy industries. These customers operate over 100,000 chargers in 35 countries, forming the "Powered by Virta" network. Through roaming, EV drivers can access over 420,000 charging points in over 65 countries.

Virta provides a comprehensive service package and end to end solution for following services:

- Selecting and installing the most suitable EV chargers at a particular location
- Management and maintenance of installed EV chargers
- Dealing with payments and invoicing
- Facilitating EV driver services such as the mobile app

Virta's EV charging as a service business takes care of all the complexities:

Figure 95: Service offering by Virta



7.6. Indian scenario

The deployment of EV charging as a service in India has been gaining traction with several companies and initiatives aiming to establish and expand electric vehicle (EV) charging infrastructure. Considering global acceptance of EV charging as a service, various Indian as well as global companies have introduced the model in Indian market such as Reliance Jio bp, Amplify Mobility (EVRE), Tata Power.

Some of the aspects of the EV charging as a service landscape in India are mentioned below:

1. **Public and Private Initiatives:** Both public and private entities in India have been actively involved in the deployment of EV charging infrastructure. Public charging stations have been set up by government agencies, and private players have entered the market to offer charging services.
2. **Private Charging Service Providers:** Several private companies are operating in the EV charging space, offering services such as charging station deployment, management, and user support. These companies often operate on a business model where users pay for the charging service.
3. **Integration with Renewable Energy:** Some initiatives aim to integrate EV charging with renewable energy sources. This includes setting up charging stations powered by solar energy to enhance the sustainability of EV charging services.
4. **Smart Charging Solutions:** Smart charging solutions are being explored, allowing users to access charging services through mobile apps or RFID cards. These solutions often include features such as real-time monitoring, remote control, and payment integration.
5. **Partnerships and Collaborations:** Partnerships between government bodies, utility companies, and private sector players are common in the EV charging as a service ecosystem. Collaborations aim to address challenges related to infrastructure development, interoperability, and grid integration.
6. **Customized Charging Solutions:** Some companies are offering customized charging solutions tailored to the needs of businesses, fleet operators, and residential complexes. This includes deploying charging infrastructure based on specific requirements and usage patterns.

7.6.1. Key players in India

Details of some of the companies working on CaaS business model in India is mentioned below:

1. Amplify Mobility

Figure 96: Amplify Mobility Logo

Amplify Cleantech Solutions Private Limited ("Amplify Mobility") through the EVRE EV Charging Solution is in the business of, among other things, creating, operating, and maintaining public EV charging infrastructure, collecting fees for the usage of charging stations and on behalf of owners of charging stations for electric vehicles, fees charged to users by such owners for access to their charging stations.

Amplify Mobility provides charging infrastructure for residential, commercial, and public charging with end-to-end installation, maintenance, and service. Amplify creates public charging infrastructure through the brand, EVRE. Amplify Mobility business model in charging infrastructure involves below features:

- Working on creating shared spaces for EV charging.
- Charging infrastructure is being installed at shared spaces that can be leveraged by multiple players and benefit various stakeholders simultaneously.
- Amplify Mobility is planning to bring more innovative solutions such as Solar integrated EV charging and Intellipole (Street light integrated charging)

The Solution, the EVRE mobile App, the EVRE web dashboards and the Charging stations owned and/or operated by Amplify Mobility or its partners using the EVRE Network, and other products, services made available by Amplify Mobility including the payment gateway and app-based advertising are collectively referred to as the "Service".

2. Tata Power EZ Charge

Tata Power stands as a prominent EV charging network provider in India, having installed more than 4,930 charge points, over 61,000 home chargers, and 440 e-bus charge points nationwide. Committed to enhancing the EV ecosystem, Tata Power has also developed the EZ Charge web and mobile application. This application empowers EV users to conveniently locate the nearest charging station, facilitating a seamless and accessible charging experience.

Figure 97: Tata Power EZ logo

Tata Power extends its comprehensive EV charging solutions to a diverse range of beneficiaries, catering to the specific needs of Fleet Organizations, Offices and Workplaces, Malls and Hotels, as well as Home and Housing Societies. This inclusive approach reflects Tata Power's commitment to fostering electric mobility across different sectors of the community.

Some of the services being offered by the Tata Power under CaaS model is mentioned below:

Table 42: EV CaaS model - Tata Power

EV Charging Service Model	Services
For Fleet Organizations	► Complete End-to-End Services, from Captive Charger Installations to Maintenance ► EV CMS Software ► Solutions for Cars and Buses ► Attractive offers at Tata Power Public Charging Stations
For Offices and Workplaces	► Solutions for charging EVs operated by Fleet service providers

7.7. Challenges in promoting EV Charging as a Service

While Electric Vehicle (EV) charging as a service holds great potential for widespread EV adoption, some of the challenges associated with this model are mentioned below:

- **High capital expenditure:** Setting up a robust charging infrastructure involves significant upfront costs. Investors and service providers face the challenge of making substantial initial investments before seeing widespread EV adoption and high utilization rates.
- **Identification of feasible land packages:** Finding suitable land in urban areas for PCS deployment is one of the challenges, due to its high population density. Additionally, high cost of land acquisition is also becoming bottleneck in deployment of EV charging stations.
- **Timely electricity connection:** Getting timely electricity connection for PCS is one of challenges being faced by CPOs. In terms of revised guidelines & standards issued by MoP, timeline for getting electricity connection for PCS has been stipulated, which is to be complied by state DISCOMs.
- **Business Viability:** Ensuring the business viability of EV charging services can be challenging, especially in regions with low EV penetration.
- **Interoperability:** Lack of standardization and interoperability among different charging stations and networks can be a hurdle. Users may face difficulties accessing charging stations from different providers, hindering the seamless experience of EV charging as a service.
- **Grid Capacity and Stability:** Rapid deployment of EV charging stations may strain the existing power grid infrastructure. Ensuring grid stability and upgrading capacity to handle increased loads, especially during peak charging times, is a critical challenge.
- **Payment and Billing Systems:** Implementing secure, user-friendly, and standardized payment and billing systems across various charging networks can be complex. Developing a seamless

payment experience is essential for user satisfaction.

- **User Awareness and Education:** Many potential EV users may be unfamiliar with the availability and benefits of EV charging services. Creating awareness and educating the public about the convenience, cost-effectiveness, and environmental benefits of EV charging as a service is essential.
- **Developing EV charging technologies**: Electric mobility being an evolving field, various technological advancements are happening across the globe, thus deploying a particular EV charger becomes challenging as it might get replaced with more efficient EV charger. As deployment of EV charger involves significant investment, selecting a particular EV charger standard might be challenging for the Charger Point Operator.

7.8. Role of CESL

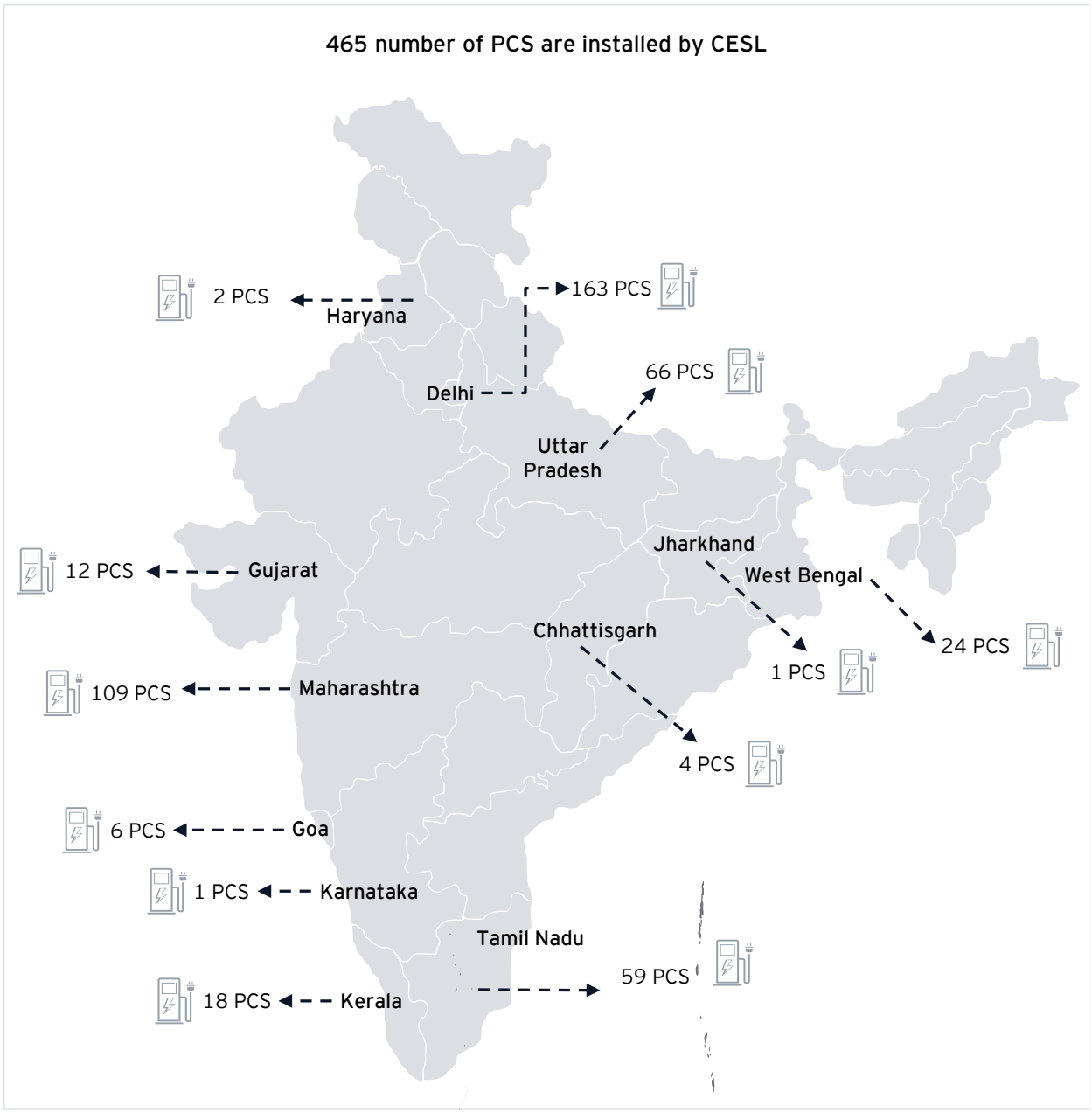
Convergence Energy Services Limited (CESL) is playing a crucial role in advancing the installation of Public Charging Stations (PCS) to facilitate the development of a sustainable electric vehicle (EV) ecosystem in various states and cities. CESL's efforts aim to promote local adoption of e-mobility by strategically establishing charging infrastructure.

To achieve this goal, CESL has engaged in collaboration with multiple stakeholders, including municipalities and Distribution Companies (DISCOMs). These collaborations involve the signing of Memorandums of Understanding (MoUs) to conduct locational assessment studies. These studies are essential for identifying optimal locations within the jurisdiction of municipalities and DISCOMs for the setup of charging infrastructure.

By setting up charging infrastructure in these identified locations, CESL contributes to the expansion of the EV charging network, making it more convenient for users to charge their electric vehicles. This, in turn, supports the broader goal of promoting and encouraging the adoption of electric mobility in the region.

A brief overview of number of charging stations installed by CESL is mentioned below:

Figure 98: PCS installed by CESL - State wise



Considering the global acceptance of EV CaaS business model, CESL may witness following benefits:

- Increased utilization of EV chargers and further increase revenue from EV charging business.
- Reduced financial risk.
- Simplified charging operation.
- Enhanced brand value of CESL in EV charging space.

7.9. Proposed business model

Basis the ongoing business model adopted by EV CaaS companies, below illustration provides model that may be adopted by CESL for its EV CaaS business:

Figure 99: Methodology for installing EV charger under CaaS model

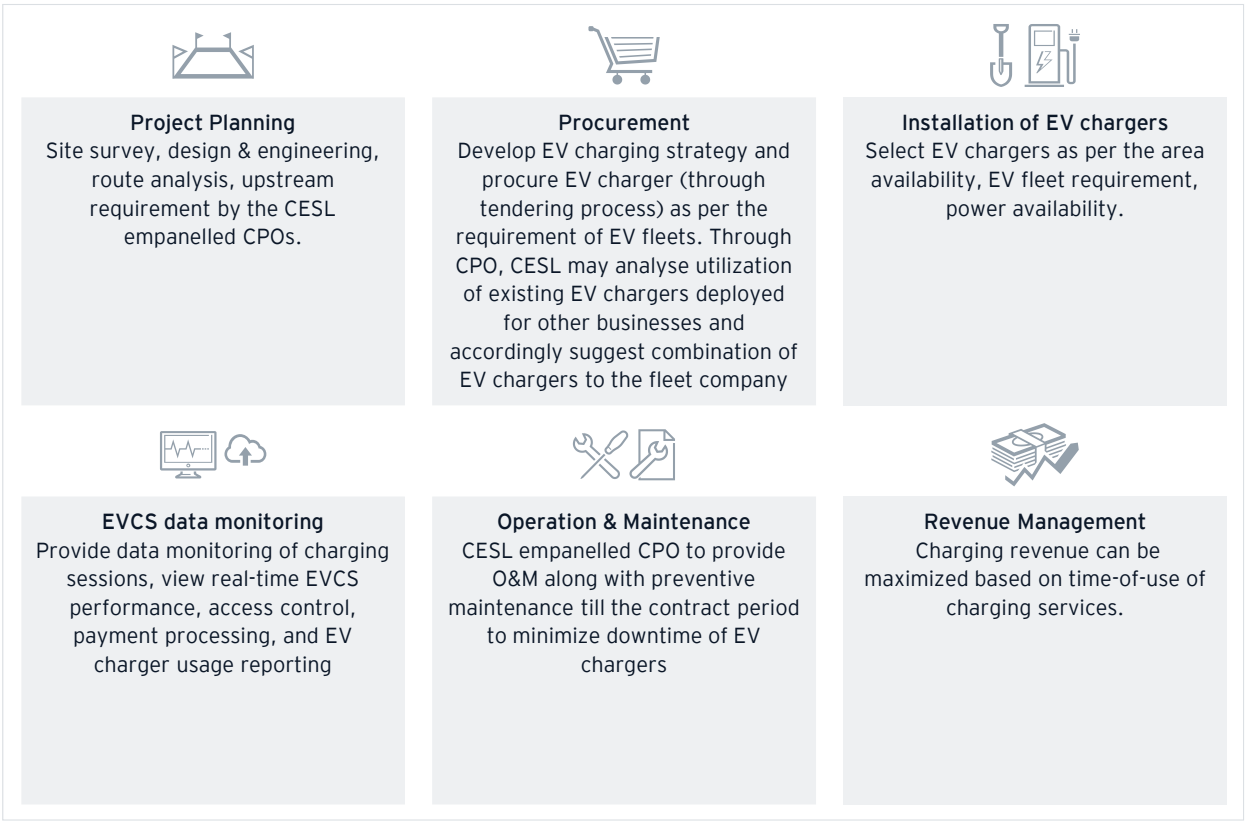
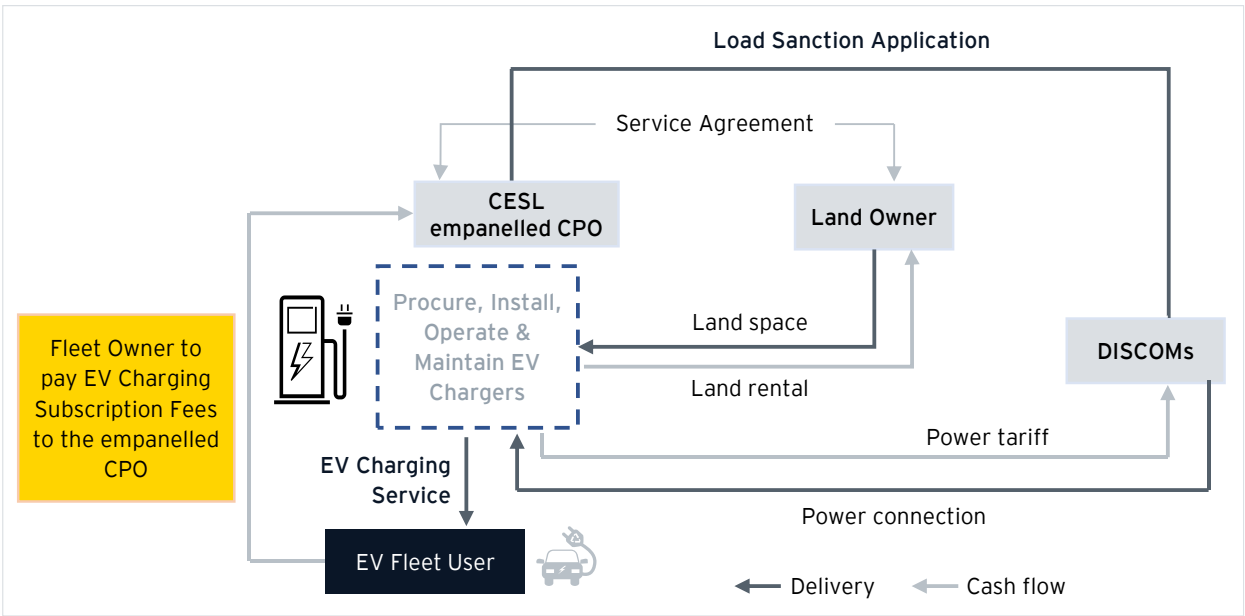


Figure 100: Business model for EV CaaS



7.10. Roles and responsibilities of different stakeholders

Table 43: Roles and Responsibility of Stakeholders

Sr. No.	Stakeholder	Responsibility
1	CESL	▶ Discussion with landowners for allocating space for setting up EV charging stations. ▶ Signing MoUs with land owning agencies for developing EV charging infrastructure
2	CESL empaneled CPO	▶ Conduct site survey for installation of EV chargers. ▶ Procure, install, operate, and maintain EV chargers. ▶ Apply for appropriate sanctioned load to respective DISCOM. ▶ Manage EV charging on agreed subscription charges
3	EV Fleet User	▶ Utilize EV charging services
4	Landowner	▶ Enter into service / lease agreement with CESL at pre-defined land rental.
5	Discoms	▶ Augmentation of upstream infrastructure in coordination with CESL. ▶ Provide timely electricity connection of public charging stations.

7.11. Scaling up through development financing

The Government of India has introduced favourable policies to accelerate the deployment of EV charging stations nationwide, leading to the evolution of the EV charging business in recent years. Companies have adopted diverse business models, including fixed revenue sharing and subscription-based approaches. The Ministry of Power has introduced a revenue-sharing model for public EV charging, where the charge point operator pays fixed revenue to the land-owning agency.

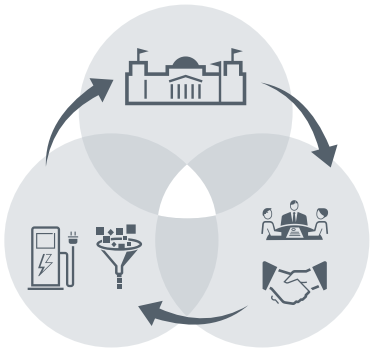
In this evolving landscape, EV Charging as a Service (EV CaaS) is gaining prominence, particularly for fleet-operating companies. Under this model, fleet companies do not need to acquire charging assets, providing a flexible and asset-light solution. Noteworthy players in the Indian EV ecosystem, such as Uber Green, WTi Cabs, Sea Hawk Travels, and startups like ALT Mobility, Lithium Urban Technology, Prakriti E-Mobility Private Limited, Blu Smart Mobility, Snap e-cabs, Zypp Electric, and eee-taxi, are introducing EVs to their fleets or establishing new ventures in the EV fleet business.

As the number of EV fleets on the roads continues to rise, the demand for EV charging is expected to increase significantly. The EV CaaS model emerges as a tailored solution to address the specific charging requirements of EV fleets. Collaborative initiatives, such as those between the Asian Development Bank (ADB) and Convergence Energy Services Limited (CESL), can be instrumental in deploying the EV CaaS model. CESL, functioning as an implementing agency, can aggregate demand for EV chargers, engage in large-scale procurement, and collaborate to reduce overall supply costs. Development financing incentives may further attract private sector involvement, fostering the growth of EV fleet companies across various segments.

Overall, the collaboration between ADB and CESL, leveraging the EV CaaS model, presents a strategic approach to meet the growing demand for EV charging services in the evolving Indian electric mobility landscape.

7.12. Recommendations

Figure 101: Recommendations



Policy & Regulatory regime

In terms of MoP guidelines & standards for EV charging, captive charging stations can install any number of chargers

Industry Collaborations

Long terms collaboration with relevant e-mobility players such as land-owning agencies (private / public), charger OEMs is necessary for making the EV CaaS model feasible.

Industry preferences

Understanding preferences from direct beneficiaries EV fleet companies) is necessary to provide customized EV charging products, for optimum utilization of assets.

7.12.1. Policy & Regulatory regime

In terms of MoP revised guidelines & standards for EV charging infrastructure, captive charging infrastructure for 100% internal use for company's owned or leased fleet for its own use will not be required to install chargers as per the charger combination provided in the guidelines. Thus, GoI is also supporting captive EV charging stations along with public EV charging stations.

7.12.2. Industry collaborations

To ensure the long-term viability and sustainability of the Electric Vehicle Charging as a Service (EV CaaS) model, collaboration with key industry stakeholders is essential. Engaging with relevant players, including land-owning agencies, EV charger manufacturers, Distribution Companies (DISCOMs), and State Nodal Agencies for EV charging infrastructure, is crucial for the timely execution of projects and the overall feasibility of the EV CaaS model.

In the pursuit of efficient project execution, CESL can foster collaborations with parking operators such as Park+, real estate developers like Mindspace, Vatika, DLF, and other stakeholders to identify feasible land packages for EV charging stations. By leveraging demand aggregation strategies for EV chargers, CESL can discover the most cost-effective solutions for procuring charging infrastructure.

Furthermore, collaboration with State Nodal Agencies for EV charging infrastructure, utilizing a single-window system for project approvals, can expedite the necessary regulatory processes. This streamlined approach facilitates the timely execution of EV charging station projects, ensuring that the EV CaaS model remains feasible and impactful in the long term.

By fostering partnerships and coordination across the industry spectrum, CESL can contribute to the successful implementation and sustainability of the EV CaaS model, creating a robust and efficient electric mobility infrastructure in the country.

For making EV CaaS model viable and sustainable in the long term, collaborating with relevant industry players such as land-owning agencies, EV charger manufacturers, DISCOMs, State Nodal Agencies for EV charging infrastructure for timely execution of project and making the EV CaaS model feasible. CESL may collaborate with parking operators such as Park+, real estate developers such as Mindspace,

Vatika, DLF, etc. for identifying feasible land packages. Through demand aggregation of EV chargers, CESL may discover least cost of EV charger. State Nodal Agencies for EV charging infrastructure through single window system for deployment of EV charging stations may facilitate for getting necessary approval for timely execution of projects.

7.12.3. Empanelling private entity

For optimal utilization of EV charging assets, Convergence Energy Services Limited (CESL) may consider empanelling a private entity. This private entity can be tasked with deploying EV chargers after thoroughly understanding the EV charging requirements at various locations across the country identified by CESL. This strategic approach ensures that the deployed EV chargers align precisely with the diverse charging needs at different locations, promoting efficient and effective utilization. **Adopting an asset-light model through collaboration with a private entity enhances flexibility and operational efficiency of CESL in the deployment of EV charging infrastructure.**

By engaging a private entity through empanelment, CESL can leverage external expertise to streamline the deployment process, ensuring that the EV charging infrastructure meets the specific demands of EV fleets in various regions. This collaborative effort contributes to the successful implementation of EV charging stations tailored to the unique requirements of different locations across the country.

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