INCLUSIVE STRATEGY FOR ELECTRIC VEHICLES IN INDIA

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CONTENTS

ABBREVIATIONS

2W	TWO-WHEELER
3 PH	THREE PHASE
3W	THREE-WHEELER
4W	FOUR-WHEELER
AC	ALTERNATING CURRENT
AH	AMPERE HOUR
AMC	ANNUAL MAINTENANCE CONTRACT
AT&C LOSSES	AGGREGATE TECHNICAL & COMMERCIAL LOSSES
B2B	BUSINESS TO BUSINESS
B2C	BUSINESS TO CONSUMERS
BEV	BATTERY ELECTRIC VEHICLE
BN	BILLION
BOO	BUILD OWN OPERATE
CDM	CLEAN DEVELOPMENT MECHANISM
CER	CERTIFIED EMISSION REDUCTION
DC	DIRECT CURRENT
DISCOM	ELECTRICITY DISTRIBUTION COMPANY
EMI	EQUATED MONTHLY INSTALMENTS
EV	ELECTRIC VEHICLE
EV-CS	ELECTRIC VEHICLE - CHARGING STATION
BSS	BATTERY SWAPPING STATION
EVSE	ELECTRIC VEHICLE SUPPLY EQUIPMENT
GOI	GOVERNMENT OF INDIA
GPS	GLOBAL POSITIONING SYSTEM
HEV	HYBRID ELECTRIC VEHICLE
HT SUPPLY	HIGH TENSION SUPPLY
ICE	INTERNAL COMBUSTION ENGINE
₹	INDIAN RUPEE
JV	JOINT VENTURE
KVAH	KILOVOLT AMPERE HOUR
KWH	KILOWATT HOUR
LI-ION	LITHIUM ION
LT SUPPLY	LOW TENSION SUPPLY
MBPD	MILLION BARRELS PER DAY
MN	MILLION
MWH	MEGAWATT HOUR
NCT	NATIONAL CAPITAL TERRITORY
NEV	NEW ENERGY VEHICLE
OEM	ORIGINAL EQUIPMENT MANUFACTURER
PAYG	PAY AS YOU GO
PEV	PLUG-IN HYBRID ELECTRIC VEHICLE
REC	RENEWABLE ENERGY CERTIFICATE
SP	SERVICE PROVIDERS
SUV	SPORTS UTILITY VEHICLE
W	WATTS

AN INCLUSIVE STRATEGY FOR ELECTRIC VEHICLE IN INDIA

EXECUTIVE SUMMARY

India has a young and growing working age population and is seeing rapid urbanization with yet low levels of motor vehicle ownership today (20 out of 1,000) which is projected to grow by 775% (175 out of 1000) by 2040[1] . Cities like Delhi and Bangalore are already reeling from high levels of smog and traffic congestion seriously affecting the quality of life of their inhabitants. Additionally, the growth in vehicles on the road will also stress the energy security as there is already significant level of oil imports (40% of total oil demand[2] , 3% of GDP[3]). Despite fuel economy improvements in the light and heavy-duty vehicle fleets, transport oil demand is expected to rise from its present 1.5 million barrels per day (mbpd) to more than 5 mbpd in 2040. Presently the transportation sector in India accounts for 15% of all greenhouse gas emissions[4] . Switching to an entirely electric fleet can help reduce 1 Gigatonne of carbon dioxide emissions by 2030 and save India US$330 billion by cutting oil imports[5]. For India to transition to a new sustainable future it needs to leapfrog into an electric future. The EV market also provides the opportunity to drive localized innovation in battery technology, create local manufacturing and services jobs and adds to the potential of distributed energy generation.

The Indian automobile industry is one of the largest growing markets of the world, and has the potential to increase manufacturing sector's contribution to India's GDP from 15% to 25% by 2022[6] - with production of Electric Vehicles. Electric vehicle (EV) sales in India are expected to witness a double-digit growth till 2020 and is projected to grow at a CAGR of over 37%, during FY2018-FY2023[7]. Robust market growth is anticipated on account of rising number of government initiatives including incentive schemes, tax rebates, growing consumer inclination towards EVs, concerns over harmful effects of air pollution, and huge investments by local and global corporates for developing electric vehicle eco-system that caters across socio-economic classes and business needs in the coming years.

The Government of India has set an ambitious target of having 100% electric vehicles for public transport and 40% electric for personal mobility by 2030 but let the market make the choices in technology adoption. Various state governments like Karnataka and Maharashtra have come up with EV policy to push adoption of EVs providing various fiscal incentives (tax, subsidy, etc). Along with policy framing, Karnataka is looking to attract investments to the tune of ₹31,000 Crores from companies setting up R&D and manufacturing of electric vehicles (EVs) in the state. Meanwhile, Maharashtra (Tata) and Delhi (EXICOM) have set up EV charging stations for public and private use with special subsidized energy rates for EV charging (Delhi).

From the investor's perspective, everyone seems to want a piece of the pie. From Finnish state-controlled energy utility, Fortum, which plans to develop EV charging infrastructure in India to billionaire Sajjan Jindal's JSW Group, which is exploring a partnership with China's Zhejiang Geely Holding Group Co. to make EVs, the list of investors drawn to India's EV sector is quite long[8]. SUN Mobility promoted by the Khemka Group and Mani Group (the pioneers of EVs in India) plans to partner with Leclanché for developing battery storage solutions while already working with Ashok Leyland to develop EV public buses with swapping infra for intra-city travel. China's Zhuhai Yinlong New Energy is also planning to set up an EV manufacturing plant in Punjab.

1 https://economictimes.indiatimes.com/industry/auto/news/passenger-vehicle/cars/775-per-cent-jump-in-passengercar-ownership-in-24-years-report/articleshow/52958430.cms
2 https://www.iea.org/publications/freepublications/publication/IndiaEnergyOutlook_WEO2015.pdf
3 https://economictimes.indiatimes.com/industry/auto/news/industry/india-is-betting-big-on-electric-vehicles-butwhere-does-that-leave-the-makers-of-hybrids/articleshow/59195648.cms
4 http://nbr.org/downloads/pdfs/eta/pes_2016_working_paper_Shastry_Pai.pdf
5 https://yourstory.com/2018/02/electric-vehicles-future-transport-india-world/
6 https://enincon.com/wp-content/uploads/2017/07/Flyer-EV-Market-in-India_enincon.pdf
7 https://www.techsciresearch.com/report/india-electric-vehicle-market/1360.html
8 https://www.valueresearchonline.com/story/h2_storyView.asp?str=34978

India's electric vehicle industry (0.1% share of global EV market) is in its infancy compared to other international markets such as US, China & Europe etc. India sold 3 0,46,727 passenger vehicles in financial year 2016-17 of which only 22,000 were electric vehicles. The three main reasons consumers are still shying away from EVs are 1) range anxiety, 2) high capital cost of electric vehicles and 3) Lack of charging infrastructure. According to Bloomberg, EVs are expected to become price competitive on an unsubsidized basis beginning in 2025. Presently, the share of battery price, mainly Li-Ion batteries today, is around 48-55% which is expected to come down to 18-23% in BEVs by 2030[9] . It is also expected that, the average energy density of a Li-Ion battery will double by 2030 to more than 200 Wh/kg, on the back of continuous improvements in battery chemistries, higher material efficiencies and better engineering resulting in smaller battery capacity requirements and lower vehicle weight.

There is a lot of potential for new entrants in the EV sector of India. Various startups from 2W manufacturers like Ather Energy, GoGreenBov, Lithos Motors to 3W manufacturers like Gayam Motor Works have come up to reap the benefits of this transition. In 4W sector apart from big automobile players, Tata Motors and Mahindra & Mahindra, no new start-ups have come up yet. Alongside companies like Ion Energy, Sun-Mobility are working on various storage and swapping technologies to fill the void in the charging sector. Investments ranging from few thousand dollars in seed to millions of dollars in Series B are already happening. For early investors in this space, while taking on technology development and adoption risk, betting on the right service platforms and business models and driving the vision of what an electric future for India looks like driven by customer and partner feedback is more valuable.

It is undeniable that the current electric car market uptake is largely influenced by key support mechanisms like deployment of charging infrastructure and an anchor load of electric vehicles. We believe that for EVs to be successful, the entire ecosystem needs to be addressed or smaller self-sustained eco-systems need to be created to witness a sustainable growth. Successful and scalable business models which have worked outside India or innovative models which can work in India and replicated globally can be instrumental for the success for EV adoption. In India, we believe that the entire EV ecosystem growth can be driven by the private sector, initially by venture capital funding while growth or expansion stage can be funded by private equity or corporate investments.

In this report, a demand-based approach has been analysed to address various business models with respect to various business models for private and public transport as well as B2B models for supply chain or logistics companies involved in last mile delivery. We believe that urban areas are excellent platforms for the experimentation of novel passenger and freight transport services based on vehicle and ride-sharing concepts alongside distributed generation and storage of energy and future technologies like autonomous vehicles owing to the fact, that these concepts have strong synergies with transport electrification[10]. By testing and demonstrating best-practice for EV and EVSE in a few cities, enterprises can not only define models that can be replicated across the nation and accelerate our transition to electric driving but also provide an example for a wide application of best practices globally.

9 https://about.bnef.com/electric-vehicle-outlook/
10 https://www.iea.org/publications/freepublications/publication/GlobalEVOutlook2017.pdf

INTRODUCTION

PRIMER

The first automobile was created in 1769[11a], by Nicolas-Joseph Cugnot which was the first steam powered auto-mobile. The biggest disadvantage of the steam vehicles was that it required 45 minutes to startup. Also, the frequent water required refill limited their range. After Nicolas, in 1807 the French Francois Issac de Rivaz designed the first car powered by an internal combustion engine fuelled by hydrogen. It was only at 1886 when the first petrol or gasoline powered auto-mobile was invented by Karl Benz. The Benz Patent-Motorwagen was considered to be the first vehicle in production as Benz made several identical copies. Gasoline-powered cars which came onto the market, required a lot of manual effort to drive, changing gears wasn't so easy and they needed to be started with a hand crank making them difficult for some to operate. They also were very noisy and their exhausted gases were unpleasant.

BRIEF HISTORY OF ELECTRIC VEHICLES

It's hard to pinpoint the invention of the electric car to one inventor or country. Instead it was a series of breakthroughs -- from the battery to the electric motor -- in the 1800s that led to the first electric vehicle on the road.

In the early part of the century, innovators in Hungary, the Netherlands and the United States -- including a blacksmith from Vermont -- began toying with the concept of a battery-powered vehicle and created some of the first small-scale electric cars. Between 1832-1839[11b], Robert Anderson, a British inventor, developed the first crude electric carriage. In 1835, an American, Thomas Davenport is credited with building the first practical electric vehicle which was a small locomotive. While in 1859, French physicist Gaston Planté invented the rechargeable lead-acid storage battery. In 1881, his countryman Camille Faure improved the storage battery's ability to supply current and invent the basic lead-acid battery used in automobiles today.

But it wasn't until the last decade of the 19th century that French and English inventors built some of the first practical electric cars. Around 1890, William Morrison, a chemist developed a six-passenger vehicle capable of a top speed of 14 miles per hour with a single charge. This helped spark interest in electric vehicles. Around 1893, a handful of different makes and models of electric cars were exhibited in Chicago. The first electric taxis hit the streets of New York City early in 1897. The Pope Manufacturing Company of Connecticut became the first large-scale American electric automobile manufacturer. In 1898 Ferdinand Porsche the founder of the sports car company developed an electric car called the P1. The P1 had only a 3HP electric motor but glorified carriage weighing 2,977 pounds (1,350Kg) from which the batteries made 1103 pounds (500Kg). The P1 ranged 49 miles on a charge with high speed of 21mph and a cruise speed of 15mph. Amazed by the results achieved with the P1, Porsche also invented the first hybrid electric car by combining the gasoline engine with the electric motor.

In 1899, believing that electricity will run autos in the future, Thomas Alva Edison began his mission to create a long-lasting, powerful battery for commercial automobiles. Though his research yields some improvements to the alkaline battery, he ultimately abandoned his quest a decade later. In 1900, the electric automobile was in its heyday; Of the 4,192 cars produced in the United States 28 percent were powered by electricity, and electric autos represented about one-third of all cars found on the roads of New York City, Boston, and Chicago.

The biggest advantages of Electric cars over steam or gasoline was that, they were quiet, easy to drive and didn't emit a smelly pollutant like the other cars of the time. Electric cars quickly became popular with urban residents - especially women. They were perfect for short trips around the city, and poor road conditions outside cities meant few cars of any type could venture farther. Also, the access to electricity was quite limited and the charging time was very long.

11a http://www.sadadaniyeh.com/home/articles.php?do=show&subid=26&details=151
11b http://www.pbs.org/now/shows/223/electric-car-timeline.html

In 1908, Henry Ford introduced the gasoline powered Model T which was mass-produced and gasoline-powered vehicles became the most affordable and popular. By 1912, the gasoline car cost only US$650 while the electric car sold for US$1,750. Later, in the same year, Charles Kettering introduced the electric starter that eliminated the need for the hand crank which boosted the gasoline vehicles sales further. The electric car's downfall is attributable to a number of factors, including the desire for longer distance vehicles, their lack of horsepower, and the ready availability of gasoline. Very few developments happened in 1950s for electric vehicles.

In 1966, the US congress introduced the earliest bill recommending use of electric vehicles as a means of reducing air pollution. In 1970s, soaring oil price and a growing environmental movement resulted in renewed interests in electric cars from both consumers and producers. In 1972, Victor Wouk, the "Godfather of the Hybrid," built the first full-powered, full-size hybrid vehicle out of a 1972 Buick Skylark provided by General Motors (G.M.) for the 1970 Federal Clean Car Incentive Program. During 1974, Vanguard-Sebring's CitiCar made its debut at the Electric Vehicle Symposium in Washington, D.C. The CitiCar had a top speed of over 30 mph and a reliable warm-weather range of 40 miles. AM General, a division of American Motors delivered around 350 electric delivery vans to US Postal Service in 1975.

By 1976, Congress passes the Electric and Hybrid Vehicle Research, Development, and Demonstration Act. The law is intended to spur the development of new technologies including improved batteries, motors, and other hybrid-electric components. By the late 1980s interest was growing, but the sticking point was battery technology. Lead acid batteries are heavy and offer low range, nickel cadmium was being tried with some success, and others were being explored[11c]. In 1988, Roger Smith, CEO of G.M. agreed to fund research efforts to build a practical consumer electric car. G.M, along with California's AeroVironment designed EV1, which one employee called "the world's most efficient production vehicle." Nickel Metal Hydride battery emerged as a front runner in the EV1.

In 1990, California passed its Zero Emission Vehicle (ZEV) Mandate, which required 2% of the state's vehicles to have no emissions by 1998 and 10% by 2003. The same year General Motors unveiled the Impact concept car, which emerged in 1996 as the production EV1 which was leased only and not sold to customers. In 2002 production stopped and in 2003 they were recalled and crushed by GM apart from a few deactivated examples donated to museums. Other vehicles were built for the Californian mandate, including the Toyota Rav4 EV, but legal action by car makers watered down the laws and they were all withdrawn from sale. Its sophisticated nickel metal hydride (NiMH) batteries gave the car a range of 100-120 miles after a five-hour charge. Post this, Toyota unveiled Prius - the world's first commercially mass-produced and marketed hybrid car in Japan in 1997. Nearly 18,000 units are sold during the first production year. Between 1997 to 2000, a few thousand all-electric cars (such as Honda's EV Plus, Ford's Ranger pickup EV, Nissan's Altra EV, Chevy's S-10 EV) were produced by big car manufacturers, but most of them were available for lease only. From 2000 till 2006, there were various ups and downs in the EV sector. Only in 2006, Tesla Motors (Elon Musk) unveiled the ultra-sporty Tesla Roadster at the San Francisco International Auto Show in November. The first production Roadsters was to be sold in 2008 with a base price listing of US$98,950. This was the first production vehicle to use lithium ion batteries and had unheard of range and acceleration. The combination of lithium batteries and three phase AC motor with regenerative braking meant that the Tesla was fast, efficient, and had awesome range. This combination of technologies is basically the blueprint for all factory EVs today.

11c https://electrichighway.net.au/ev-life/a- brief-history- of-electric- vehicles/

During the same time in 2008, Israeli government announced its support for a sweeping project to promote the use of electric cars in Israel. The effort was a joint venture between Better Place and Renault-Nissan. The plan was to create an extensive network of charging spots and to sell EV drivers mileage in their cars like minutes on a cell phone plan. But it failed. In Dec 2008, BYD, a Chinese battery manufacturer turned automaker, released F3DM, the world's first mass produced plug-in hybrid compact sedan. Though they packed less energy than more conventional lithium ion batteries, BYD opted to power the F3DM with a more stable lithium iron phosphate battery. BYD planned to release the F3DM in the U.S. in 2011, but the sales of the car remain sluggish.

The American Recovery and Reinvestment Act of 2009 allocated US$2 billion for development of electric vehicle batteries and related technologies. The US Department of Energy adds another US$400 million to fund building the infrastructure necessary to support plug-in electric vehicles. British Prime Minister Gordon Brown announced that the British government will promote the use of electric vehicles in the U.K. by offering a £2,000 subsidy to purchasers.

During mid-2009, Nissan unveiled its new electric car, called the LEAF ("Leading, Environmentally Friendly, Affordable, Family Car"). The LEAF had a maximum speed of more than 90 mph, could travel 100 miles on a full charge, and has a battery that can be recharged to 80% of its capacity in 30 minutes. Similar to the Better Place initiative in Israel, Nissan planned to work with the Japanese government and private companies to set up charging station networks across several countries. The first production LEAFs were scheduled to go on sale in Japan, Europe, and the U.S. in the fall of 2010. The Nissan Leaf today is the highest-volume electric car produced in history, with more than 300,000 sold. Late 2009, several new models including Chevrolet Volt, and Mitsubishi i-MiEV hit the streets. Despite promising signs, the electric car needs to navigate a bumpy road before it can become a viable option for many drivers. Challenges to mass adoption include high initial prices, limited battery life and travel range and building charging stations and other infrastructure to support electric vehicles.

With various new battery technologies and better charging infrastructure, Electric vehicle is picking up the pace again. According to Navigant Research, electric vehicles sales could grow to nearly 7% -- or 6.6 million per year -- worldwide by 2020 and according to Morgan Stanley[11d] there could be 1 billion battery electric vehicles on the road by 2050 as the sales penetration rate swells: 9% of global sales by 2025, 16% by 2030, 51% by 2040, and 69% by 2050.

ELECTRIC VEHICLES TECHNICAL OVERVIEW

Fuelled by environmental concerns, the rising cost of fuel and the advancements in battery technology[12] , the electric vehicle continues to march toward mainstream society. There are several terms that are widely used to describe electric vehicles.

Hybrid vehicle: A vehicle that uses two or more distinct power sources to propel a vehicle. The term most commonly refers to hybrid electric vehicles (HEV) which combine a combustion engine and one or more electric batteries which is recharged by regenerative braking.

PHEV (Plug in Hybrid Electric Vehicle): An electric hybrid vehicle with rechargeable batteries that can be restored to a full charge by connecting to an external power source (charging stand).

11d https://pitchbook.com/news/articles/vc-activity-revs-up-as-electric-vehicles-prepare-to-go-mainstream
12 http://apps.geindustrial.com/publibrary/checkout/EV-Whitepaper?TNR=White%20Papers|EV-Whitepaper|generic

BEV (Battery Electric Vehicle): A vehicle that uses one or more electric motors for propulsion and uses rechargeable batteries as the sole power source.

Basic Components[13]: The basic components of an EV are the following. Based on various technologies, there is either inclusion or exclusion of some components.

Fig.1. Battery pack

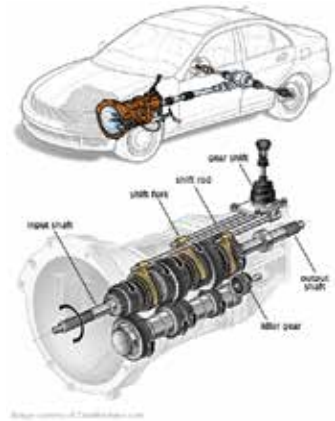


Fig.2. Transmission system

Fig.3. Electric Motor

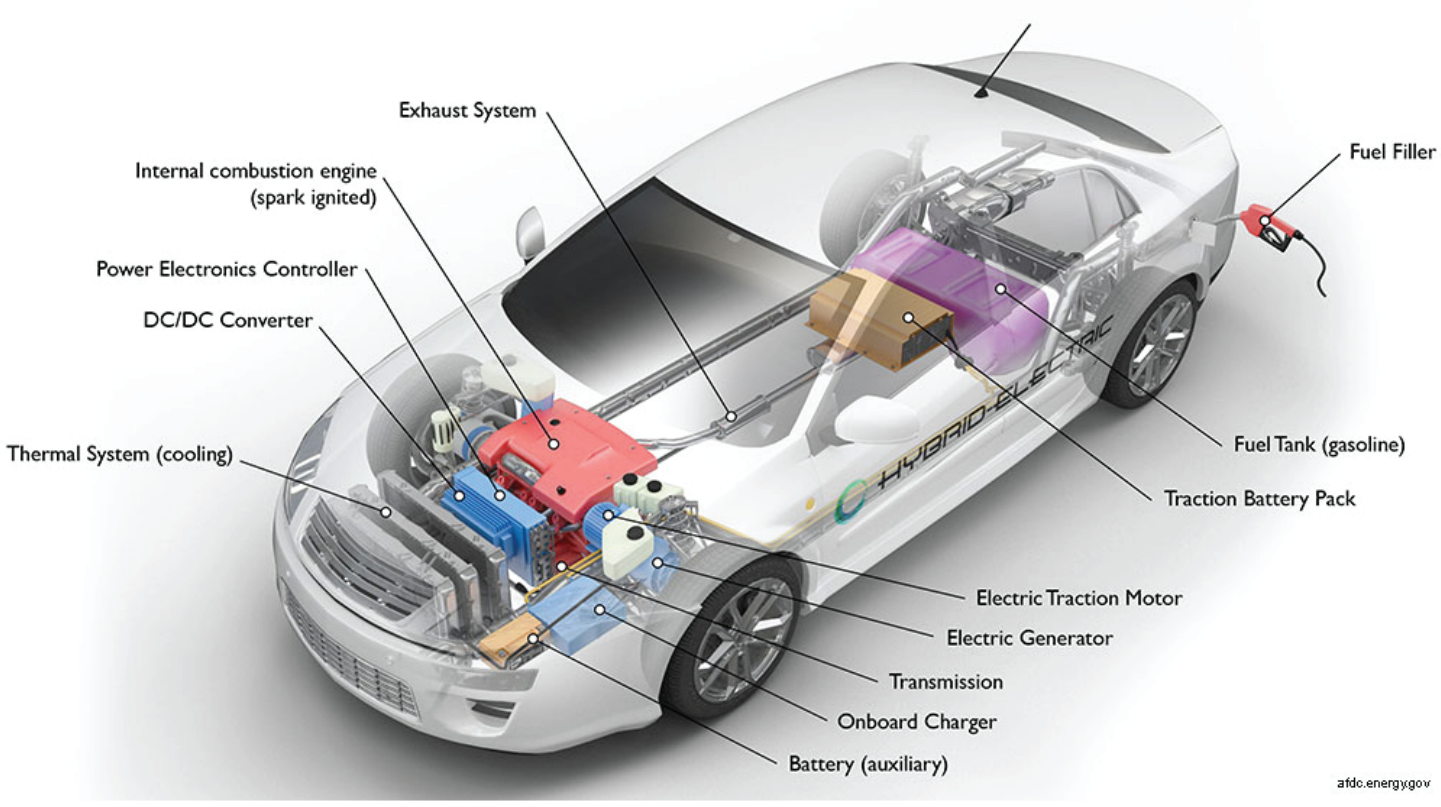


Fig.4. Hybrid Electric Vehicle

Other components include:

DC/DC Converter which converts higher-voltage DC power from the traction battery pack to the lower-voltage DC power needed to run vehicle accessories and recharge the auxiliary battery

Electric generator which generates electricity from the rotating wheels while braking, transferring that energy back to the traction battery pack.

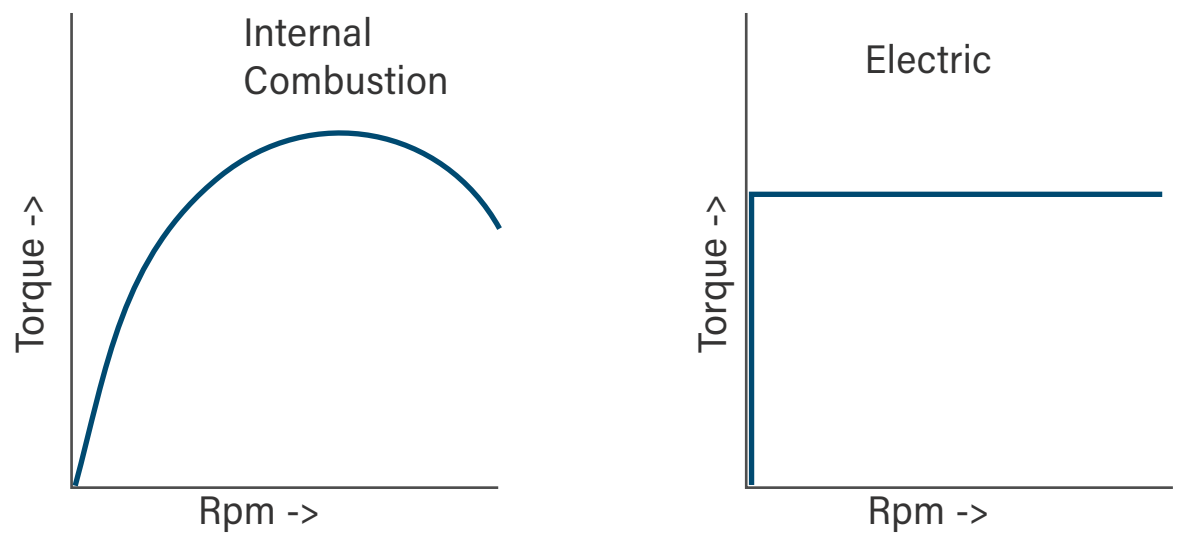
Onboard charger which takes the incoming AC electricity supplied via the charge port and converts it to DC power for charging the battery. It regulates battery characteristics (E.g. voltage, current, temperature, and SOC) while charging the pack

13 https://www.afdc.energy.gov/vehicles/how-do-hybrid-electric-cars-work

Power electronics controller which manages the flow of electrical energy delivered by the battery, controlling the speed of the electric motor and the torque it produces.

Thermal system (cooling) which maintains a proper operating temperature range of the engine, electric motor, power electronics, and other components

Torque Vs RPM Characteristics



Graph.1.

From the above graph, we can observe that the IC engine requires a threshold (idling) speed to produce a torque. The available torque increases when the engine speed (RPM) is increased. A very little torque is produced at low rpm. Then torque increases until it overcome by frictional losses and aspects of an engine's breathing—its intake and exhaust. In addition, this characteristic of the IC engine requires a transmission with several gear ratios. The torque is transferred to the transmission via a clutch or a torque converter. The electric drive motor on the other hand reaches its maximum torque as early as the first revolution. It does not require a start-up phase to reach idling speed. Hence the BEVs have a much simpler transmission system.

The BEVs have around 100km of driving range with one full charge depending on speed, load, topography and driving style. And more the voltage of the battery bank, the faster one can go. To understand battery capacity, we need to understand few terms like Energy Density, Life and Efficiency.

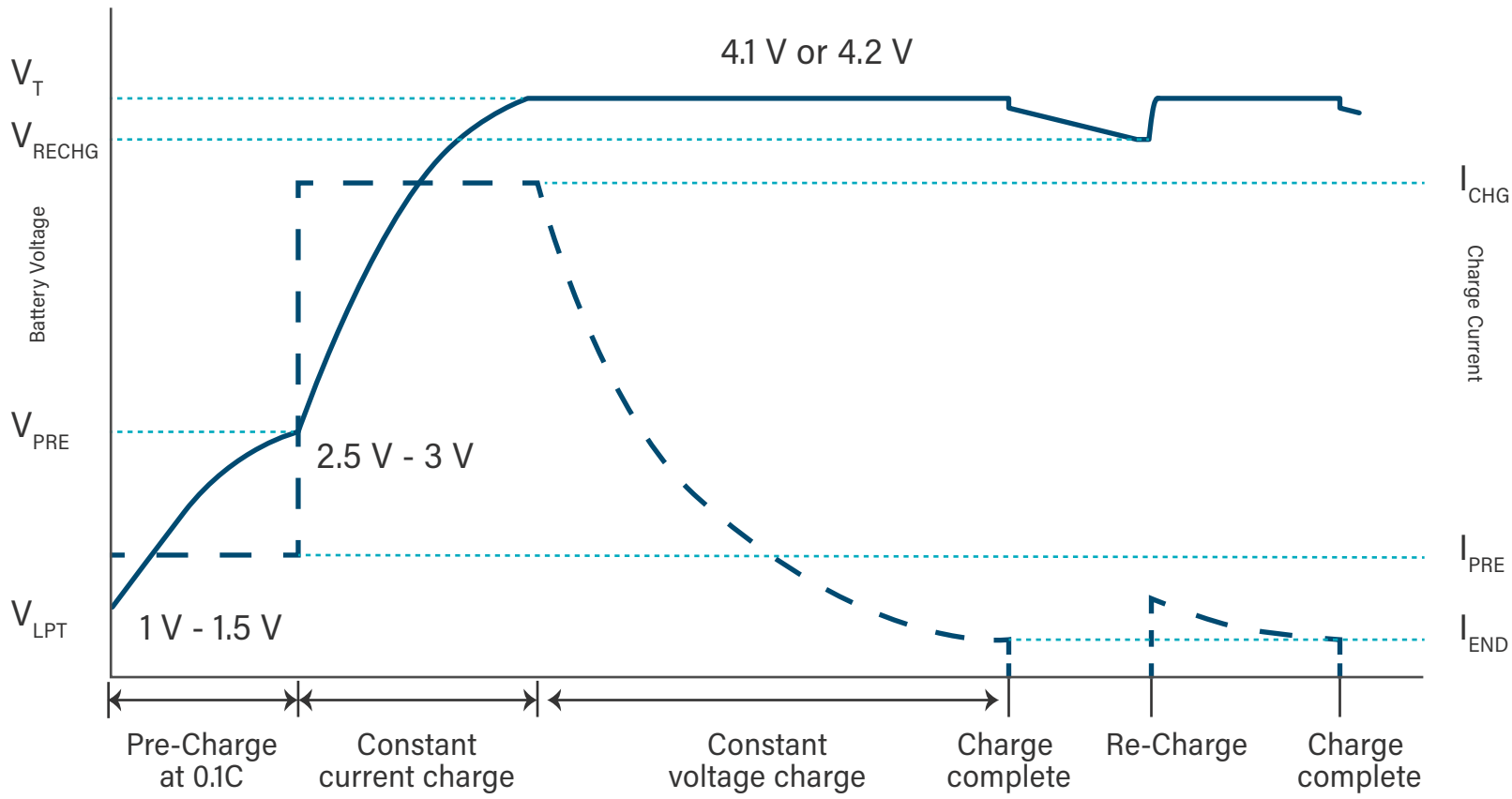
Energy Density is measured by Wh/kg. The higher the energy density, the more energy can be stored. The range of an electric vehicle can be determined from the energy density.

Life is measured by the no of cycles over a period of time. For longer life, high voltage batteries are provided with a certain no of cycles for a particular period of time. A 3,000-cycle battery of life 10 years can have around 300 cycles of charging and discharging over a period of one year.

The efficiency indicates how much of the energy that is invested into charging can be made useful again when the battery is discharged. If the efficiency of the battery is around 85% it means 15% of charge is lost due to heat loss.

CHARGING AND SWAPPING INFRASTRUCTURE

A typical Li-ion charging profile is as follows[14]:



I_{CHG}: Charge current
0.5C-1C can be considered as fast charge.
I_{PRE}: Pre-Charge current, e.g. 0.1C.
I_{END}: Ending Charge Current, e.g. 0.02 C.

V_T: Battery terminal voltage.
V_{RECHG}: Threshold voltage to start recharge.
V_{PRE}: Voltage when pre-charge finished.
V_{LPT}: Low protection threshold voltage.

Graph.2.

Constant Current Charge: Here a charging voltage which is applied to the battery is controlled to maintain a constant current to the battery. The challenge is to determine the completion of a charge (SOC=100%).

Constant Voltage Charge: This method is suitable for all kinds of batteries and one of the simplest charging scheme. The battery charging current can be large at the initial stage and gradually decreases to zero when the battery is fully charged. The only drawback is the requirement of very high power in the early charging stage. This is not available for residential / parking structures.

The combination: Graph.2. shows a charging profile of a Li-ion cell. At the initial stage, the battery can be pre-charged at a low, constant current if the cell is not pre-charged before. Then, it is switched to charge the battery with constant current at a higher value. When the battery voltage (or SOC) reaches a certain threshold point, the charging is changed to constant voltage charge. Constant voltage charge can be used to maintain the battery voltage afterward if the DC charging supply is still available.

Different Types of Charging Stations:

TYPES	POWER LEVELS	TIME	POSSIBLE LOCATIONS
Level 1	1 Phase 16A/230V	7-9hrs	Home/Office
Level 2	3 Phase 32A/440V	2-4hrs	Office/Society/Malls/Railway Stations
Level 3	DC Charging	15-30mins	Malls/Bus Depots/Stations etc.

Table .1.

14 www.springer.com/

Level I: The Level 1 charge consists of around 10-15mt of heavy duty cables with a 15A (three pronged) socket which can be easily found in any residential place. The minimum Overcurrent device should be 15A-20A.

Fig.5.

Fig.6.

Level 2: These charging stations consist of a designated charging unit (electric vehicle supply equipment, or EVSE) that plugs into or hardwires into a 3phase 440V circuit. The minimum overcurrent device here is 32A. There can be two types of Level 2 units[15]:

Level 2 Installation Style	Installation Method	Considerations
Floor mount (Bollard Style)	Mounted to the ground and wired through the base	Generally requires concrete work along with underground trenching
Wall/ Pole Mount	Installed on any wall or pole and can be wired through a garage wall	Offers flexible placement options and takes up less floor space than a floor mount

Table .2.

Usually, if a residential customer is having a three-phase connectivity, then VDE connector with EVSE can be provided and installed at his/her place for personal use. But presently, three phase systems are provided for commercial purpose. The following picture shows a wall mounted public charging station in India.

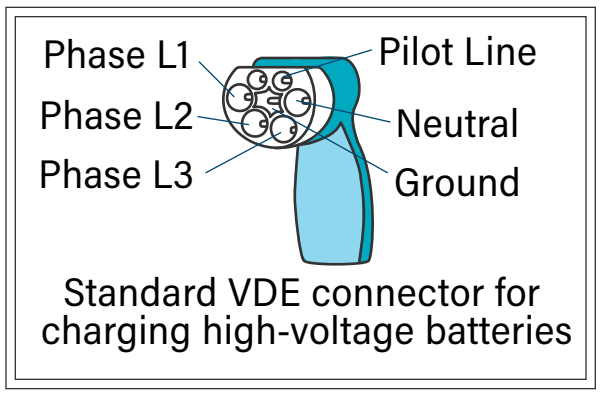


Fig.7.

Fig.8.

15 http://valleyair.org/grants/documents/chargeup/A-guide-to-Plug-In-Electrice-Vehicle-and-Charging-Infrastructure.pdf

Level 3[16]: This type of Level 3 equipment is not compatible with all vehicles, and there is currently no industry standard for this level of charging. These charging stations are Level 3 equipment with DC fast charging, charges through a 480V, direct-current (DC) plug. Minimum overcurrent MCCB used here is 100A. Most Level 3 chargers provide an 80% charge in 30 minutes. Cold weather can lengthen the time required to charge. This type of Level 3 equipment is not compatible with all vehicles, and there is currently no industry standard for this level of charging.

OTHER CHARGING OPTIONS

Apart from the conventional charging methods there are few others that have hit the market. Of them mobile charging and inductive charging are the two main options.

Inductive Charging: Essentially wireless charging uses electromagnetic fields to safely transfer power from a transmitting source to a receiving device for charging a battery. Wireless charging is based on the principle of magnetic resonance, or Inductive Power Transfer (IPT) where the electrical current is transferred between two objects through the use of coils to induce an electromagnetic field. Two aligned magnetic coils send power to the EV over an air gap between the vehicle and the included Wireless Charging Station. The EV needs to be equipped with wireless charging feature (an inductive coil) at the base to charge the battery. Hence this charging method is not very popular now.

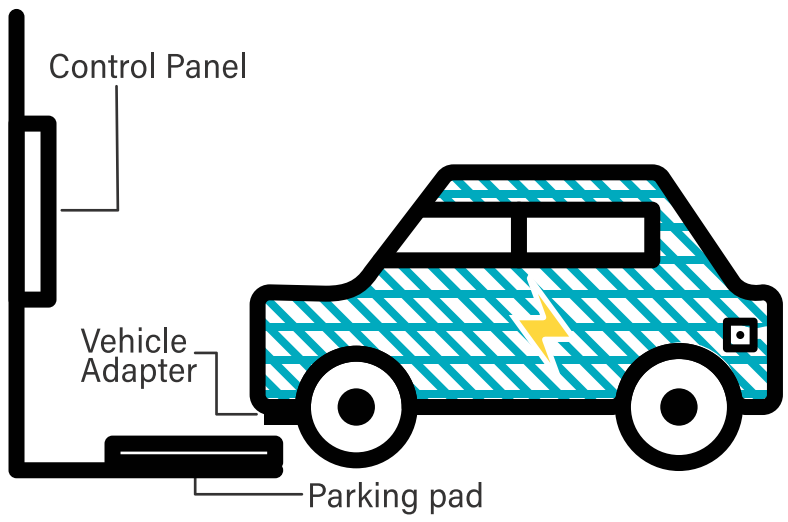


Fig.9.

Mobile Charging: This can be considered as a LEVEL 3 fast charging option but requires no additional infrastructure upgrade[17] . The chargers are compatible with any electric vehicle. It is fast and can be used almost 5-6 times faster. The mobile charger resembles a bulked-up ice cream cart 2 with a battery bank of 48 kWh or more[18]. When the battery bank is discharged, these units can be charged either through grid or through any renewable energy technology like solar PV. Instead of plugging into a permanent station connected to the grid, the cart can be moved around anywhere as per requirement. EV drivers can fire up an app and enter their location. An attendant can roll up with a cart, plug the EV and charge it. The customer can avail this PAYG service though an online payment system in the app. This kind of set up can be used by residential customer as well as commercial customers. With rising EVs on road, the demand for PAYG model for charging will be booming, leading to expansion of mobile charging units.

Fig.10.

16 http://www.evtown.org/about-ev-town/ev-charging/charging-levels.html
17 https://freewiretech.com/ev-charging/
18 https://www.wired.com/2015/07/rolling-battery-fixes-ev-chargings-big-problems/

CHARGING INFRASTRUCTURE COST

The costs of owning and operating a charging station include capital costs of equipment, installation, maintenance, and electricity costs[19].

Equipment Cost: The Level 1 charging equipment can be simple overcurrent MCB (15A/16A) with 3 prong connectors. Hence there is no additional cost involved. For Level 2 charging stations there are either residential or public units. The residential unit expenditure is in the range of US$500-US$1,000. The expensive ones include additional features like charge management, smartphone integration or even grid integration.

The public charging stations :The price of Level 2 EVSE is approximately US$1,000 to US$7,000 depending on the level of sophistication."Intelligent" or networked Level 2 products have enhanced durability and features like card payment facility, billing software, advanced displays, wireless communication, automated diagnostics, computer-controlled power flow, internal metering, and smart-grid integration[20]. Level 3 DC fast-charging products are almost similar to intelligent or networked Level 2 products but cost substantially more. They cost typically around US$20,000 to US$50,000. There are two main contributors to their high cost :
1) expensive equipment and
2) frequently the need to install a 480V transformer because of their high-power operation.

Installation and Maintenance Cost: The overall installation cost can be broken down into various segments. Unlike home stations, installation is the major contributor to public station cost (60–80% of total). The installation cost includes Labour (55-60%), materials (30-35%), Permits (5%) excluding taxes. Installation Cost Drivers are Trenching to lay electrical supply conduit, Modifying or upgrading the electrical panel, Upgrading the Contract Demand, Locating underground or overhead electrical service line. Distance to the breaker box (trenching) is usually the most important factor for determining installation cost, typically ranging from 50 to 100 feet. Distances longer than 150 feet are usually too expensive to justify station installation. Level 1 installation cost ranges from US$0-US$3,000 as per requirement. The cost range of Level 2 units are between US$1000-US$12,000 while for Level 3 the range varies from US$40,000 to US$70,000. For an example, an estimate is $12,000 for a station with one Level 2 EVSE unit and US$45,000 to US$100,000 or more for a station with one DC fastcharging EVSE unit.

Typically, there are relatively few EVSE maintenance requirements. Periodic inspection, testing, corrective and preventive maintenance by a qualified electrical contractor is recommended. An estimate of annual maintenance costs ranges from US$25 to US$50 per EVSE unit. For Level 3 units the maintenance cost will be more.

Operational Cost: This depends on the Electrical tariff and ToD tariff structure of the distribution companies. Usually it will incur a fixed part (Contract demand) and a variable part (energy charge/duty/FAC/Taxes). The energy tariff can be either commercial or industrial based on the consumer/customer. The consumption of electricity will vary based on the number of vehicles using the EVSE, power output of the EVSE, vehicle power acceptance rate, climate, and amount of time the vehicles charge.

Type of Charger	Equipment Cost	Installation Cost
Level 1	US$500- US$1,000	US$0- US$3,000
Level 2	US$1,000-US$7,000	US$1,000-US$12,000
Level 3	US$20,000-US$50,000	US$40,000-US$70,000

Table .3.

19 Plug-In Electric Vehicle Handbook-US Dept. of Energy
20 https://www.afdc.energy.gov/pdfs/51227.pdf

SWAPPING INFRASTRUCTURE

Battery chemistry is too limited to provide 200-mile electric cars at a low price. Hence, battery swapping is another key element in addition to dc fast charging stations, that can catalyse widespread electric car adoption. It is important to note that the battery swapping concept itself is nothing new. It was first implemented by the Hartford Electric Light Company in the early 1900's for electric trucks. Electric forklifts have used the technology since the mid-1940s. The vehicle owner purchased the vehicle, without a battery, from General Vehicle Company, part-owned by General Electric, and the electricity was purchased from Hartford Electric through the use of an exchangeable battery. Both vehicles and batteries were modified to facilitate a fast battery exchange. The owner paid a variable per-mile charge and a monthly service fee to cover maintenance and storage of the truck. During the period of the service, the vehicles covered more than 6 million miles. Beginning in 1917, a similar successful service was operated in Chicago for owners of Milburn Electric cars. A rapid battery replacement system was implemented to keep running 50 electric buses at the 2008 Summer Olympics[21]. Battery swapping stations for electric buses exist all over China today[22].

The following benefits are claimed for battery swapping:

- Fast battery swapping under 5 minutes[23]
- Unlimited driving range where there are battery switch stations available
- The driver does not own the battery in the car hence less capital and maintenance cost

In recent years, Better Place, Tesla Motors, Mitsubishi Heavy Industries, Sun Mobility, Ionex, ACME have been involved with integrating battery switch technology with their electric vehicles to extend driving range. However, electric vehicle manufacturers working on battery switch technology have not standardized anything yet.

In India, ACME[24] has setup manual BSS with lithium batteries for electric vehicles at multiple locations in Nagpur for a fleet operator OLA in May 2017. The EcoCharge Battery Swapping & Charging stations can cater to 200 vehicles, including bus, auto and car. ACME's swapping station[25] comes with a fixed cost of around ₹5-7 lakhs/unit and can swap a battery for 3Ws within 2-3min. Each station can serve around 25 vehicles per day with an electricity consumption of 6units per vehicle (600 units per 100 vehicle). Customer pays around ₹65-70 per swap for a 57Ah battery which gives them a range of 45km. The company's long-term plan is to provide BSS after every 5-7km stretch integrated with Solar PV units.

Fig.11.

Sun Mobility's patented technology to create smart, modular batteries[26], is aiming to build an open-architecture ecosystem to accelerate the adoption of electric cars. At the core of this plan are interchangeable smart batteries that fit across a range of vehicles. The batteries will all be IOT-enabled and be part of a network of energy storage devices that can be easily swapped in and out of vehicles. The battery / energy becomes a service, through a PAYG model, much like fuel today.

Fig.12.

21 https://en.wikipedia.org/wiki/Charging_station
22 https://cleantechnica.com/2015/01/08/battery-swapping-can-now-scaled/
23 http://www.jpost.com/Enviro-Tech/Better-Place-launches-1st-Israeli-battery-switching-station
24 https://www.acme.in/
25 As per discussion with ACME team
26 https://factordaily.com/chetan-maini-reva-electric-car-battery-sun-mobility/

The energy charges (powered by rapidly falling renewable energy prices) are also likely to be cheaper than gasoline. The company has developed an automated BSS[27]. At the, station, the swapping robotic arm telescopes all the way into the bus's battery bay, which locks onto the discharged battery pack (500kg) and pulls it out. The battery gets rotated around and taken to the charging dock. A fully charged battery then inserted in the same way inside the bay. The whole process is estimated to take only 3min.

In China, another battery swapping model has come up. There are **centralized charging stations** which are generally huge grid connected battery storage place housing thousands of batteries. Swapping stations are located at various points within the city. The discharged batteries are carried away to these centralized stations via pick-up trucks replacing them with charged units. Companies like Key Power Tech, XJ group are into this kind of operation. This requires a lot of manpower and logistics support along with a robust operation and maintenance. The centralized stations are also used by DISCOMs as energy storage stations as per requirement[28]. A station with 10 battery chargers, the cost of infrastructure, the cost of energy distribution and the cost of maintenance for one year (employees and devices) are about 2,400,000¥ (US$380,000), 2,000,000¥ (US$317,000), and 360,000¥ (US$57,000), respectively which comes to around US$754,000[29].

Fig.13.

Founded in 2007 in Palo Alto[30], Better Place's solution was to **separate the most expensive component of an electric vehicle, the battery, from the car.** Drivers would buy or lease an electric car for a price comparable to a gasoline-powered model and Better Place would own the batteries. **Paying a monthly fee of around US$350[31] drivers would gain access to Better Place's network of robotic switch stations to let them swap out depleted batteries for fresh ones in a matter of minutes.** Each battery switch station cost about US$500,000 and they needed to deploy dozens, even in a small country like Israel.

With almost US$1 billion in funding, Better Place was poised to become one of the most innovative companies in the electric mobility market. But it failed to make any progress in Denmark and Israel, the first two markets it operated in, and subsequently declared bankruptcy, selling off its collective assets for less than US$500,000[32]. The reasons were as follows:

- Better Place was trying to corral numerous manufacturers but failed as auto manufacturers were not able to offer a wide variety of makes and models. As a result, Better Place swaps were limited to special versions of the Renault (Fluence). Hence volume was too less to operate.
- Better Place didn't understand its customers[33] . It's a well-known fact that consumers make buying decisions based on a human nature that readily embraces trends. But Better Place didn't ask, "How many of these consumers live in metro Tel Aviv?"
- Over promise and under-deliver. Better place made bold promises that it would bring millions of electric cars to cities around the globe. But as the cars failed to appear, public interest waned.
- The Renault[34] that Better Place offered was another sub-100-mile electric car akin to Nissan's Leaf. Nothing about Better Place's swap stations was going to change that. Having to pull over every hour for a new battery would never have worked for the Renault (Fluence).

27 http://www.team-bhp.com/forum/commercial-vehicles/195366-ashok-leyland-circuit-s-bus-auto-expo-2018-a.html
28 http://www.cse.anl.gov/us-china-workshop-2012/pdfs/session3b_demos_standards/hua_3B-4-HUA-Tsinghua%20Univ-Progress%20in%20Battery%20Swapping%20Technolo.pdf
29 www.mdpi.com/1996-1073/10/10/1667/pdf
30 https://qz.com/88214/the-lesson-from-better-places-bankruptcy-be-more-like-tesla/
31 https://www.forbes.com/sites/stephenwunker/2013/05/28/288/#1023aaa05ed7
32 https://www.sciencedirect.com/science/article/pii/S0301421516301987
33 https://www.entrepreneur.com/article/238962
34 https://www.forbes.com/sites/markrogowsky/2013/06/21/6-reasons-teslas-battery-swapping-could-take-it-to-a-better-place/#d3f2b8d46d9f

Sl No.	Battery Charging	Battery Swapping
1	Time required to charge varies from 20 mins to 8 hrs	Fast turn-around time. It requires between 2-5min per swap.
2	Low Cost of installation	Expensive infrastructure required
3	Can be set up/installed easily and anywhere	Requires a lot of planning to find strategic locations for swapping as bigger infrastructure is required
4	Battery is owned by the EV owner. Hence cost of EV adoption is high.	Battery can be owned by the EV-CS owner or any 3rd party. Cost of EV comes down to almost similar to ICE vehicles.
5	Design of the EV-CS and battery pack independent of each other.	Design Feasibility of the battery pack has to be such that it can be easily/ rapidly removed and re-attached[35]
6	No battery Inventory is required.	High Inventory cost for battery
7	Charging stations can be upgraded as per requirement of the battery	Need to change every battery if the chemistry/form factor changes.
8	Standardization of battery is not required.	Standardization of battery is needed for optimization
9	Low O&M cost	High O&M and manpower cost
10	Cannot be automated. Manual intervention required	Can be both automated and Manual
11	Can be individually owned	Only possible for EV-CS OEMs

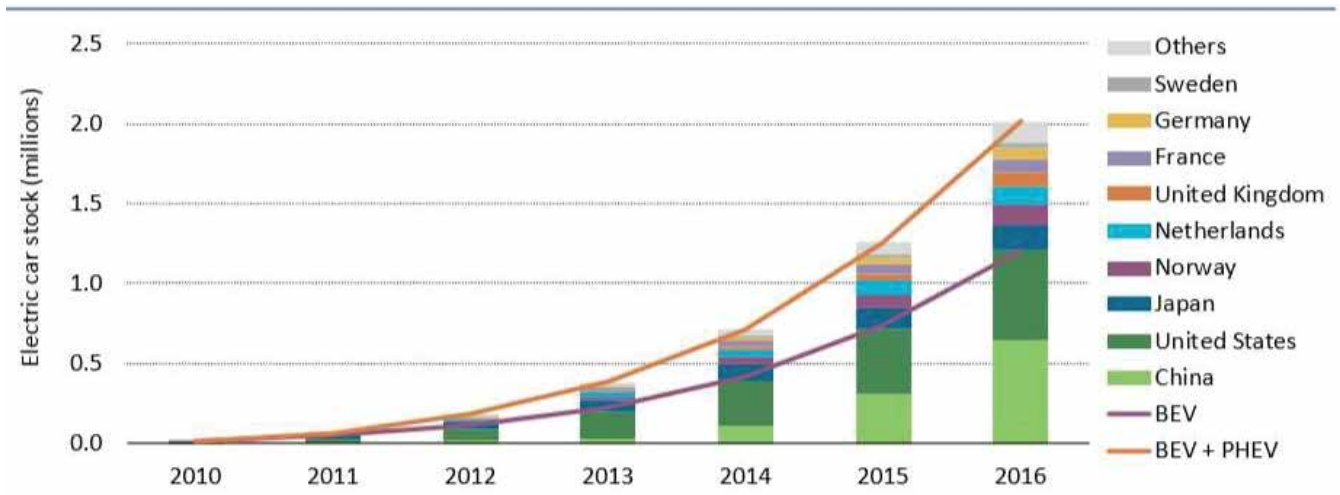
Table .4.

GLOBAL SCENARIO

Electrification, or the use of battery powered electric vehicles and driverless cars, are the two major trends in today's auto industry. In the context of the Paris Agreement, which set the goal of keeping the increase in global average temperature below 2°C above pre-industrial levels[36], transport sector became a natural target for decarbonisation initiatives since it accounts for a third of total greenhouse gas emissions to the atmosphere.

35 https://www.linkedin.com/pulse/challenges-battery-swapping-over-charging-stations-evs-khairnar
36 https://www.bbvaresearch.com/en/publicaciones/u-s-the-road-ahead-for-electric-vehicles/

World electric vehicle sales was 773,600 units in 2016 which was 42% higher than 2015[37] . The number of electric cars on the roads around the world rose to 2 million in 2016 from 1 million in 2015[38]. Even though the global electric car stock doubled last year, it is only 0.2% of the total number of passenger light-duty vehicles in circulation. Prospects for mass adoption are still constrained by technological limitations, charging infrastructure and policy uncertainty. China (336,000 units or 43.4%)[39], the US (159,139 units or 20.5%)[40] and Europe (221, 614 till Dec 2016[41] or 28.6%) made up the three main markets, totalling around 92% of all EVs sold around the world.

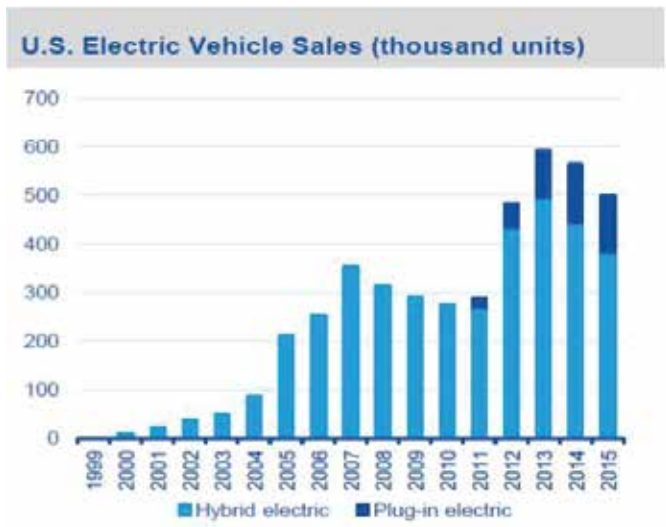


Notes: The electric car stock shown here is primarily estimated on the basis of cumulative sales since 2005. When available, stock numbers from official national statistics have been used, provided good consistency with sales evolutions.

Sources: IEA analysis based on EVI country submissions, complemented by EAFO (2017a), IHS Polk (2016), MarkLines (2017), ACEA (2017a, 2017b) and EEA (2017).

Graph.3.

Graph.4.



Graph.5.

China was by far the largest electric car market in 2016, accounting for more than 40% of the electric cars sold in the world. With more than 200 million electric two-wheelers and more than 300,000 electric buses, China is by far the global leader in the electrification of transport. The Chinese Government has announced ambitious NEV (New Energy Vehicle) share mandates of 8% for 2018, 10% for 2019 and 12% for 2020[42] . It is

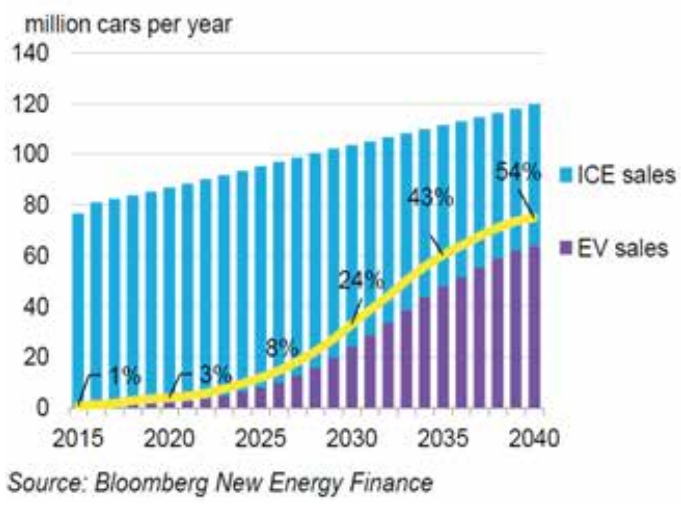
37 http://www.ev-volumes.com/news/global-plug-in-sales-for-2016/
38 https://www.iea.org/newsroom/news/2017/june/electric-vehicles-have-another-record-year-reaching-2-million-cars-in-2016.html
39 http://carsalesbase.com/china-ev-sales-2016/
40 https://www.forbes.com/sites/rrapier/2017/02/05/u-s-electric-vehicle-sales-soared-in-2016/#8185293217f1
41 https://evobsession.com/us-europe-china-electric-car-sales-2016/
42 http://www.ev-volumes.com/country/china/

expected that passenger car NEV sales will reach 530 000 units, 80% of which are BEVs and 20% are PHEVs. In addition, over 190,000 commercial vehicles were sold in the NEV category in 2016. For 2017 this number is expected to be 270,000 units, 80% of which are large buses, most of them fully electric. Presently 98% of world sales of electric buses are in China. An important reason for the Chinese lead in NEVs is their success in offering ultra-affordable EVs in the mini and small segments. EVs are now available within a range of €12,500 to €20,000 after subsidies. This is still about twice as much as for a comparable to a Chinese ICE car, but makes EVs accessible to a much broader consumer base.

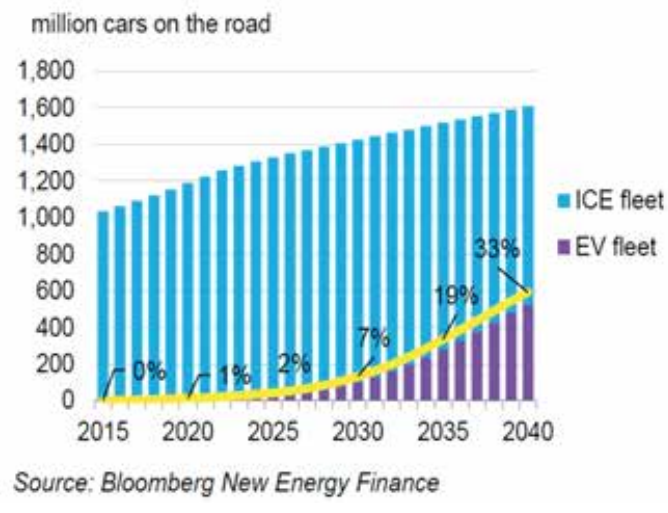
Europe is also not far behind; with a 29% market share, Norway has incontestably achieved the most successful deployment of electric cars in terms of market share, globally. It is followed by the Netherlands, with a 6.4% electric car market share, and Sweden with 3.4%[43].

In US, since 1999 -2000, around 60 models of HEVs have been launched and approximately 4.2 million units have been sold as of 2016. Plug-in electric vehicles came a decade later. Today, there are about 28 different models of PEVs with nearly 517,000 units sold as of 2016 in US alone. Despite their relatively short presence in the market, both HEV and PEV sales have grown significantly. Hybrid electrics experienced a significant boost in 2005 due to tax incentives and rebates to consumers, and again in 2012 due to the economic recovery and the tightening of CAFÉ (Corporate Average Fuel Economy) standards as well as elevated gasoline prices. PEVs gained momentum after 2013 due to battery improvements, expanded charging infrastructure, fiscal incentives and economic growth. This trend is not guaranteed, though, as there are still challenges that need to be overcome.

Bloomberg[44] conducted a study to of how EV adoption will impact automotive and energy markets. It looks at how economics, technology, policy, and consumer behaviour will impact EV adoption between now and 2040. As per the report, by 2040, 54% of new car sales and 33% of the global car fleet will be electric. Electric vehicles are expected to become price competitive on an unsubsidized basis beginning in 2025. Some segments will take longer, but by 2029 most will have reached parity with comparable internal combustion engine (ICE) vehicles



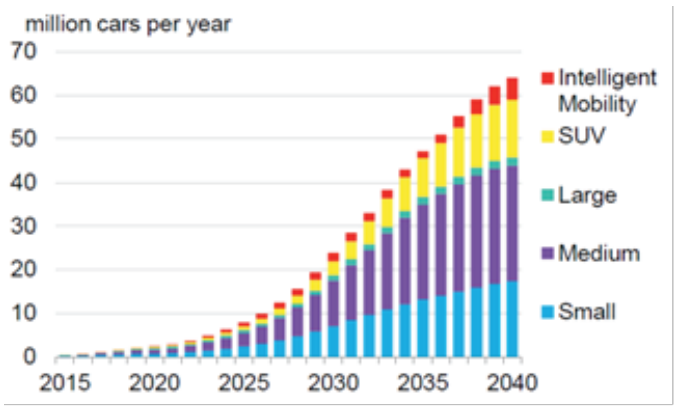
Graph.6.



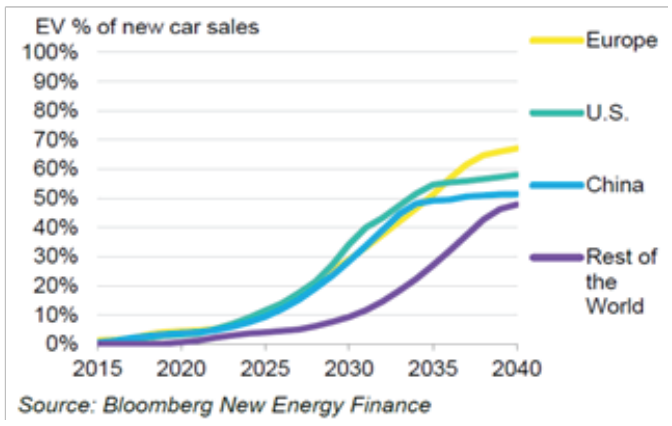
Graph.7.

The following two figures and graphs will show the global annual sales of different segments of electric vehicles and long term EV penetration of different countries.

43 https://www.iea.org/publications/freepublications/publication/GlobalEVOutlook2017.pdf
44 https://about.bnef.com/electric-vehicle-outlook



Graph.8.



Graph.9.

The above graph shows, that both China and US will reach a saturation point with steady sale while Europe will continue to grow slowly and other developing countries will continue to grow. While the rate of sale of different segments are unclear with respect to regions, it is pretty obvious that the saturated market will have major share of sales of intelligent mobility, SUVs and large segment while the growing markets will see a vast penetration of medium and small segment of EVs.

INDIAN CONTEXT

The Indian automobile industry is one of the largest growing markets of the world and contributes to 15% of India's GDP which is likely to become 25% by 2022[45], with production of Electric Vehicles. To boost the EV market in India, the government has launched the FAME (Faster Adoption and Manufacturing of Hybrid & Electric Vehicles) scheme which targets to achieve production of approximately 7 Million EV's by 2020. India is planning to provide consumer incentives (planned subsidy of 30-40% based on current price) rather than incentivizing the R&D. With over 3 million passenger cars sold in the previous fiscal, the Indian passenger car segment is expected to scale to new heights in the near term with EV in picture.

In terms of what is happening in the market, here are some of the recent headlines on the EV market

- Around 200 charging stations are proposed to be set up in Delhi, Jaipur & Chandigarh and companies like Smart Charging Company and New Motion has announced to invest ₹100 Crores in India on charging infrastructure.
- JSW group, India wants to build 20,000 EVs and will invest ₹40Bn(US$623Mn)[46] in the venture
- Maruti Suzuki, India's largest consumer car-maker by market share, is planning to set up a US$600Mn lithium ion-battery factory.
- Mahindra& Mahindra, one of India's largest automobile manufacturers, is investing some US$1Bn to ramp up its EV division.
- The SUN Group has tied up with the Mani Group to set up a JV, SUN Mobility.
- Ashok Leyland has announced a strategic partnership with SUN Mobility, to develop a battery swapping system for electric buses.

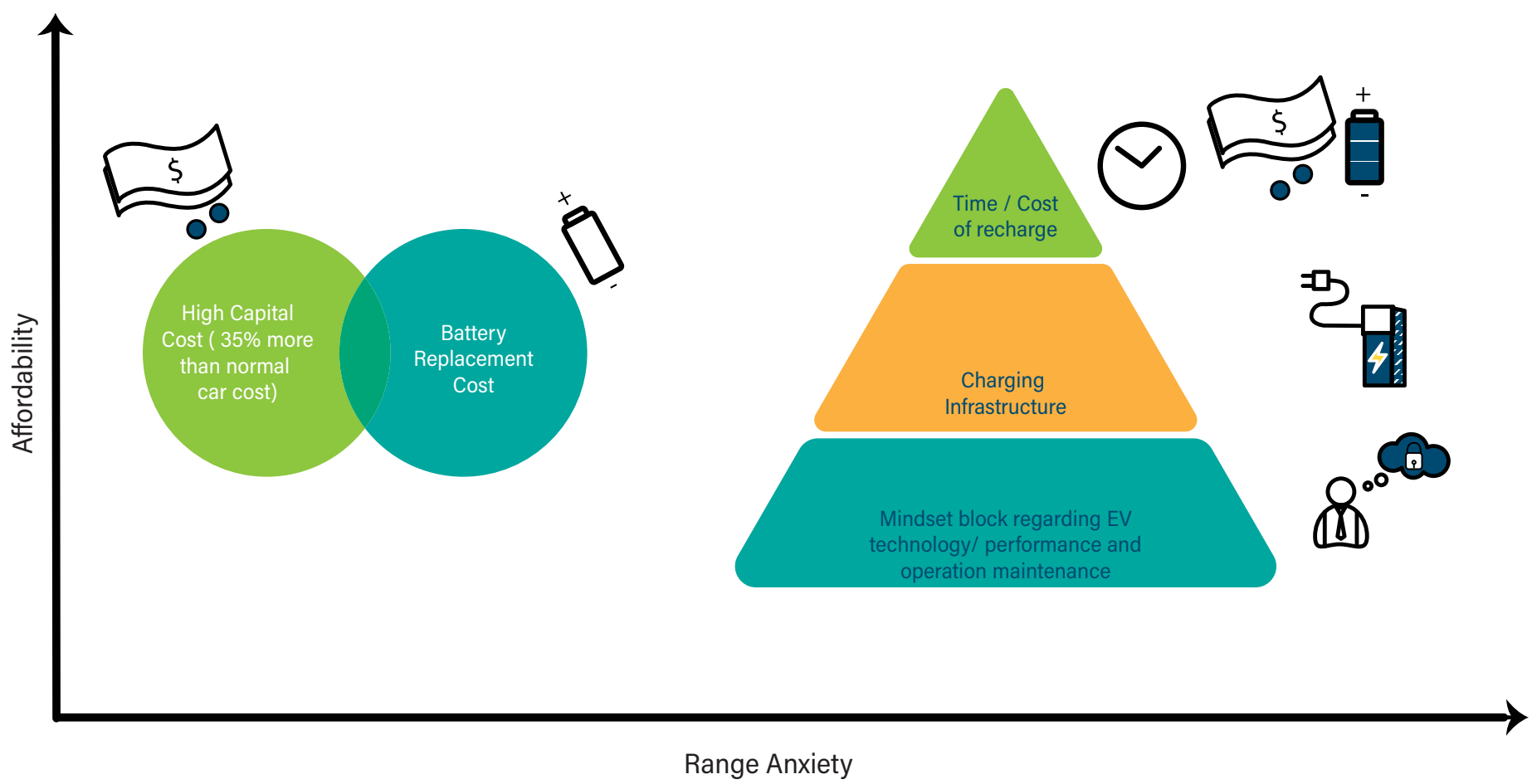
45 https://enincon.com/wp-content/uploads/2017/07/Flyer-EV-Market-in-India_enincon.pdf
46 https://in.reuters.com/article/india-jsw-energy-electric-cars/indias-jsw-energy-to-invest-up-to-623-million-in-electric-cars-idINKBN1AR1HC

- Hero MotoCorp Ltd invested ₹205 Crores (US$30.75Mn) to acquire around 26-30 per cent stake in Ather Energy Pvt Ltd (Bangalore). Ather is also planning to install and operate charging stations. Rivals, TVS Motors have bought 14.78 per cent stake for ₹5 crore in Ultraviolette Automotive Pvt. Ltd[47].
- Ministry of New and Renewable Energy was appointed as the nodal agency to help procure some 10,000 electric cars in 2017 to replace existing government vehicles which was won by TATA Motors.

At the state level, Karnataka and Maharashtra have taken the first step towards EV policy. Maharashtra have waived taxes for EVs while Karnataka have come up with an EV policy for the state. Delhi is also not far behind, apart from setting up charging stations, they have fixed the EV charging energy tariff at ₹5 per kVAh (HT) and ₹5.50 per kWh to push charging infra installation and operation.

CHALLENGES

While the government and the private sector is abuzz with excitement, India's electric vehicle industry is in its infancy compared to other international markets. The Indian consumer is yet to join the EV party. India sold 30,46,727 passenger vehicles in 2016-17 of which only 22,000 were electric vehicles. The hurdles facing the Indian EV market is as follows:



Graph.8.

47 https://auto.ndtv.com/news/tvs-buys-14-78-stake-in-electric-vehicle-start-up-ultraviolette-automotive-1785665

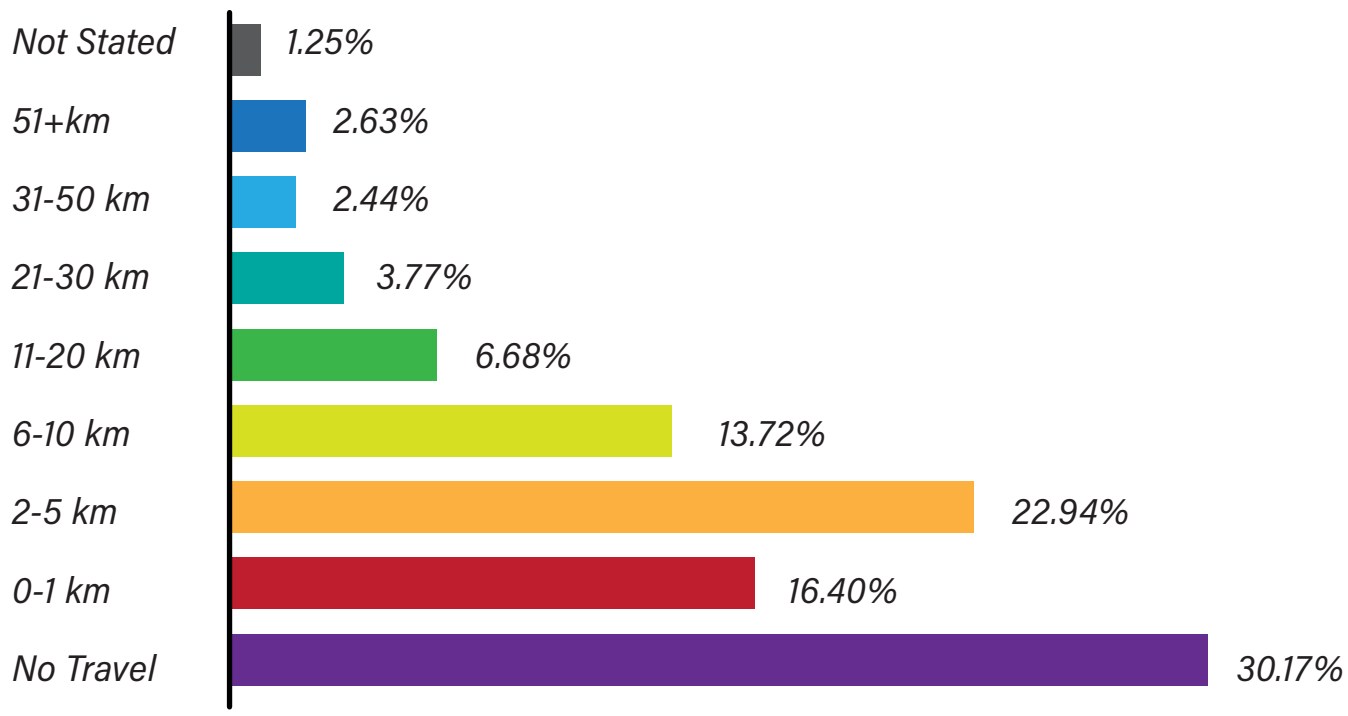
Range anxiety is a frequent deterrent of EV sales. It is commonly agreed that a range of 200 miles (322km) per charge is sufficient to overcome this fear. Majority of EV models have ranges between 60 and 120 miles per charge, while only a few models go beyond the 200 miles threshold and they tend to be more expensive. Presently, IC engines cars takes few minutes to refuel a car. Battery swapping in EVs takes between 2-5min but infrastructure and maintenance cost is too high as compared to charging. The charging time of Electric Scooters is around 1-1.5 hrs[48](Ather Energy/GogreenBov) where the battery is charged to 80%. While for cars like Mahindra E2O, it takes around 5hrs with normal AC slow charging and 1hr with a DC fast charger. With normal AC slow charging one can get 40% of the charging within 2hrs. Also, the number of charging stations is less than 1% when compared to petrol pumps. As per Economic times[49], India had only about 350 public EV chargers compared with around 57,000 petrol stations.

Cost is another important element deterring adoption. The price of a pure electric sedan is about significantly higher than the price of a standard vehicle. Primary driver for higher cost of the EV is the battery, which accounts for about a third of the total cost. According to Bloomberg New Energy Finance (BNEF), battery prices need to fall below US$200/kWh in order to make battery-operated electric vehicles competitive. Presently, the average cost of a lithium-ion battery pack dropped from US$1,000/kWh in 2010 to US$273/kwh in 2016 and US$209/kWh in 2017[50] which needs to fall further. BNEF analysis suggests that cost parity could be achieved in the first half of the next decade[51] .

48 https://www.bikedekho.com/ather-energy/s340
49 https://economictimes.indiatimes.com/industry/energy/power/in-dia-is-said-to-mull-power-law-change-to-boost-ev-stations/articleshow/62517319.cms
50 https://cleantechnica.com/2017/12/11/batteries-keep-getting-cheaper/
51 Bloomberg New Energy Finance. 2016. "Electric Vehicle Cost Competitiveness. Only Batteries Have the Answer."

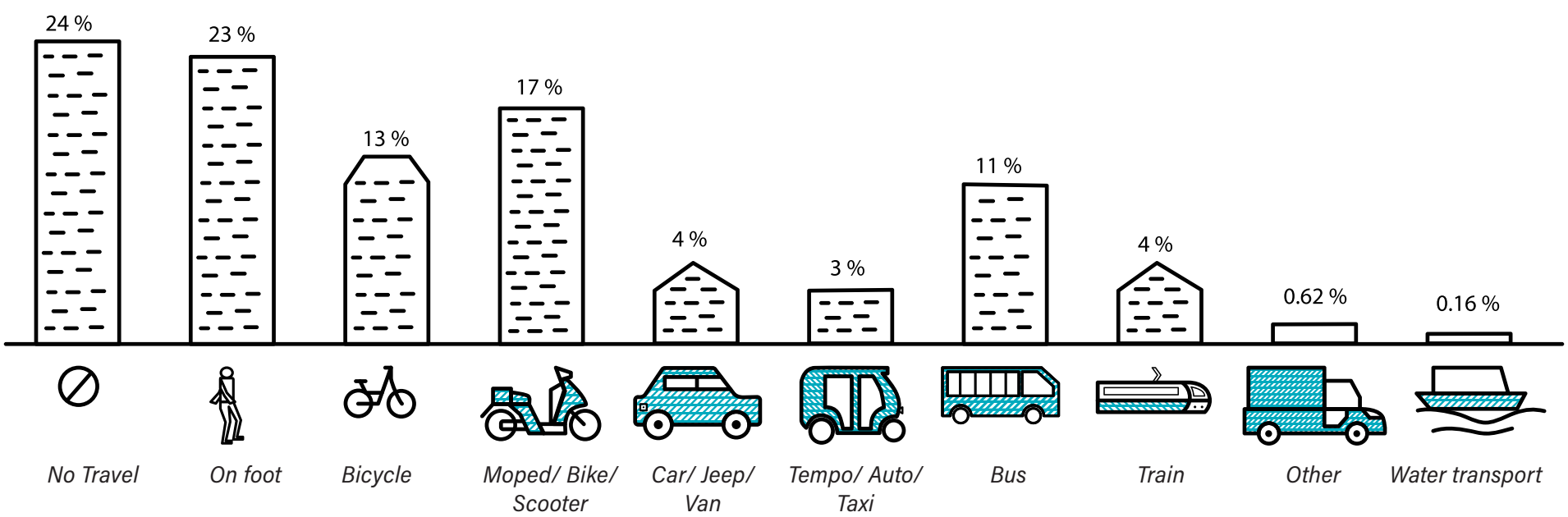
TRAVEL PATTERN OF INDIA

According to the 2011 Census survey, among 140 million workers commute for work, the distances tend to be quite small[52] . It can be observed from the following Graph.9. around 53% travel less than 10km per day while only 7% travel somewhere between 11-20km per day. The highest percentage of vehicular travel is between 2 to 5km which comprises of around 23% (approx. 45million).



Graph.9. - Travel Pattern of urban India to work[53]

Now, if we look at the modes of transport (Graph.10.), it is quite surprising to see that in Urban India, almost 23% prefer walking (offices being close by), around 17% use two wheelers (bikes/scooters), 13% use bicycles while only around 4% use their four wheelers. Rest 20% rely on public transport, a majority of which is by bus (11%) followed by trains at 4% and only 3% use shared private services like taxis, autos and tempos.



Graph.10. - Modes of transport (Urban India)[54]

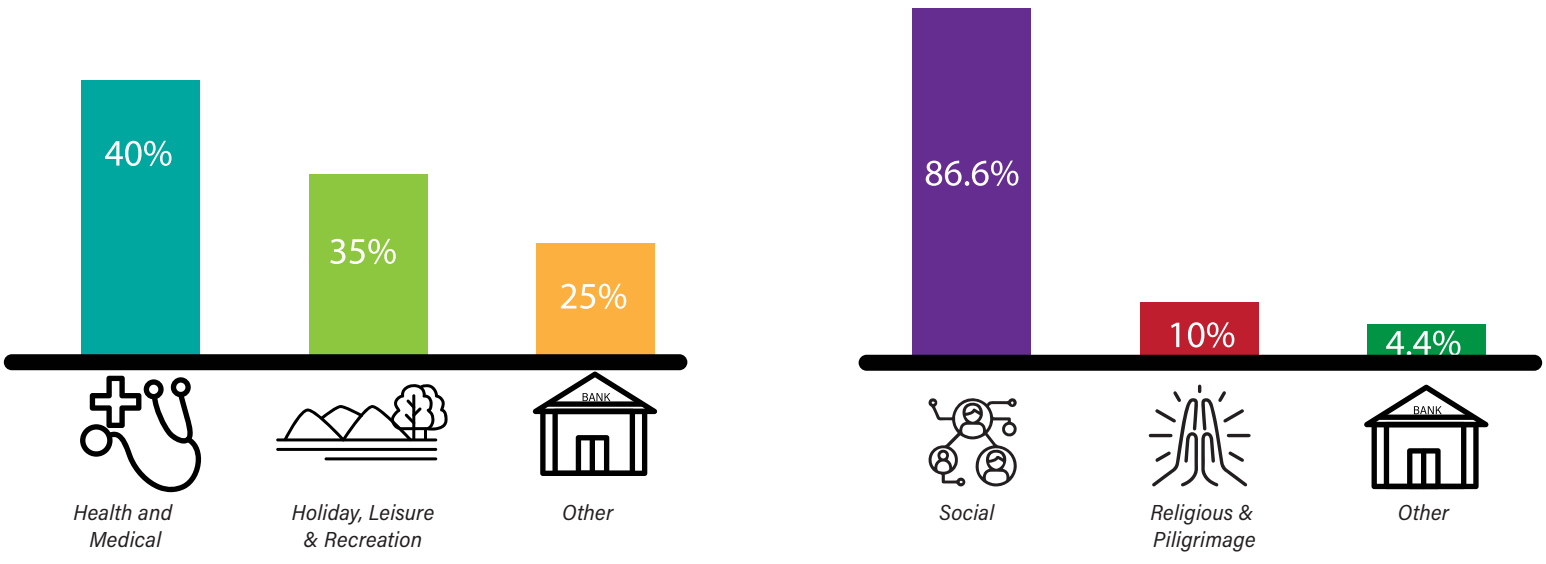
52 http://www.indiaenvironmentportal.org.in/media/iep/infographics/transport/index.html
53 https://data.gov.in/resources/other-workers-distance-residence-place-work-and-mode-travel-place-work-2011-india
54 https://data.gov.in/resources/other-workers-distance-residence-place-work-and-mode-travel-place-work-2011-india

Mode of Travel	Hyderabad	Gurgaon	Faridabad	Bangalore	Pune	Nagpur	Mumbai	Bhopal	NCT Delhi	Chennai	Lucknow	Kolkata
On foot	15.25%	22.60%	18.08%	23.51%	19.24%	17.27%	25.74%	23.48%	22.15%	15.99%	14.43%	27.42%
Bicycle	6.39%	7.36%	17.11%	4.42%	7.62%	25.28%	1.08%	10.41%	8.95%	9.81%	16.83%	6.95%
Bikes/Scooters	20.76%	14.21%	17.98%	18.53%	28.93%	29.28%	4.54%	25.19%	14.10%	22.94%	22.18%	3.84%
Car/Jeep/Van	4.81%	23.23%	10.89%	8.53%	5.86%	2.66%	4.69%	4.33%	10.94%	6.15%	4.07%	3.76%
Auto/Taxi	3.47%	5.63%	6.48%	2.79%	3.88%	2.88%	1.65%	2.92%	2.31%	2.16%	5.35%	2.94%
Bus	13.88%	6.40%	5.05%	23.13%	16.01%	4.71%	13.90%	10.77%	21.58%	19.38%	2.60%	22.09%
Train	0.92%	2.35%	3.10%	0.89%	1.73%	0.92%	23.91%	1.02%	2.94%	3.00%	2.64%	3.37%
Waterways	0.11%	0.05%	0.07%	0.10%	0.04%	0.04%	0.15%	0.06%	0.04%	0.21%	0.06%	0.15%
Any other	0.54%	0.72%	0.59%	0.43%	0.42%	0.66%	0.41%	0.25%	1.14%	0.48%	0.47%	0.61%
No travel	33.87%	17.45%	20.65%	17.66%	16.26%	16.30%	23.93%	21.59%	15.83%	19.88%	31.37%	28.87%

Table .5. Mode and Share of Transport to work in Various Cities of India[55]

From the above table, we can see, that around 30% people travel in two wheelers in Pune and Nagpur with Bangalore at almost 19% in third place. The private car segment share is highest in Gurgaon at 23% with 11% in Delhi NCT region. Public bus travel is highest in Bangalore followed by NCT Delhi and Chennai while auto and taxi travel is mostly seen in Gurgaon and Faridabad. Local train travel is highest in Mumbai at 24%. The survey data, doesn't include the metro ridership details but according to the DMRC website, during 2011, Delhi metro had an average ridership of 1.55Mn which is around 34% of total travellers[56] . At present, Delhi NCT, has an average metro ridership of 2.76Cr in 2016-17[57] .

Apart from travel to work, NSSO (National Sample Survey Organisation), carried out a survey in 2014-15 to understand India's travel pattern. According to the survey, in 365-day category, "health and medical" was the leading purpose of the trip in both rural and urban areas, accounting for 40% of all travel. It was followed by leisure activity (35%). In the 30-day recall period, social visits are the leading purpose of a trip, accounting for a massive 86.6% of all travel[58].

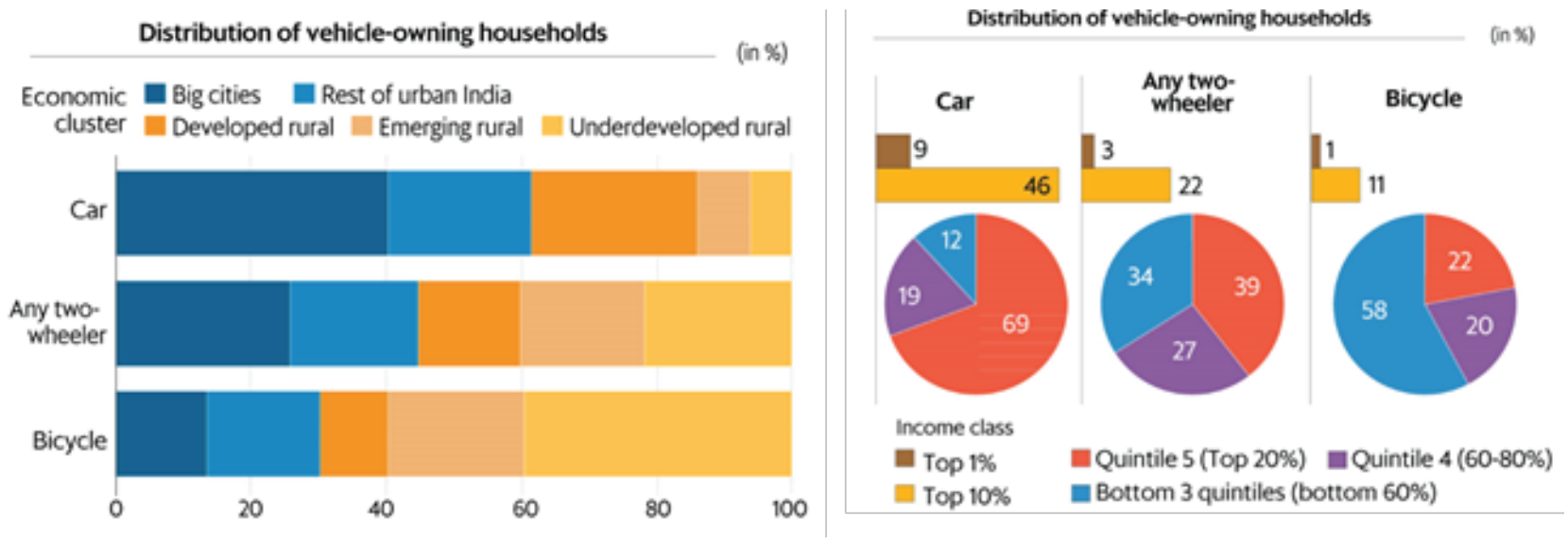


Graph.11. - India's Travel Pattern (non-work) 365 days and 30 days: NSSO

55 http://www.censusindia.gov.in/2011census/B-series/B_28.html
56 http://www.delhimetrorail.com/press_reldetails.aspx?id=JUVWaUlI0G0lld
57 http://www.delhimetrorail.com/press_reldetails.aspx?id=ZlXC4jMrU00lld
58 http://www.livemint.com/Consumer/0Db5IJ5ZsAMoP2s2hH1SUK/The-average-Indian-tourist-doesnt-travel-by-air-or-stay-in.html

PRIVATE VEHICLE OWNERSHIP

According to 2011 census, the proportion of car-owning households in the country was 5%. During 2016 this stands at 11% per the ICE 360° survey. The proportion of two-wheeler owners has increased to 36%, while the proportion of bicycle owners has increased to 58%. Households in the top quintile account for a majority of the cars and more than a third of two-wheelers in the country. The top 10 % accounts for 46% of the cars and 22% of two-wheelers in India while the bottom quintile accounts for a majority of the bicycles in the country[59]. Which implies that affluent customers own multiple modes of transport for different members of the household – redacting the top 10% reveals low levels vehicle ownership with a bias towards two-wheelers



Graph.12. -Vehicle ownership distribution

Big cities, which include all million-plus cities (metros, boom towns, and niche cities), together account for 40% of car owners[60]. More than half of the households in developed rural areas own a two-wheeler, and roughly a quarter of them own a car. As per the above, the share of households owning a two-wheeler in emerging rural areas is only a little less than the share of households owning a two-wheeler in smaller urban centres.

Looking at vehicle ownership data, it seems that India's vehicle ownership is quite low and there is a huge scope of growth. In the new policies scenario, passenger car ownership is expected to grow from less than 20 vehicles per 1,000 inhabitants today to 175 cars per 1,000 people in 2040, and overall road passenger vehicle activity increases more than six-times as per the World Energy Outlook. Data shows that the share of 2W is almost similar in all urban and rural areas. While for 4Ws 60% of ownership lies in all urban areas. Hence, it can be concluded that although ownership of 4Ws is more than that of 2Ws in urban areas, commuters prefer either 2Ws or shared public transport for their daily commute.

59 http://www.livemint.com/Politics/Yd2EAFIupVHDX0EbUdecsO/One-in-three-households-in-India-owns-a-twowheeler.html
60 http://www.livemint.com/Politics/Yd2EAFIupVHDX0EbUdecsO/One-in-three-households-in-India-owns-a-twowheeler.html

ELECTRIC VEHICLE ECOSYSTEM

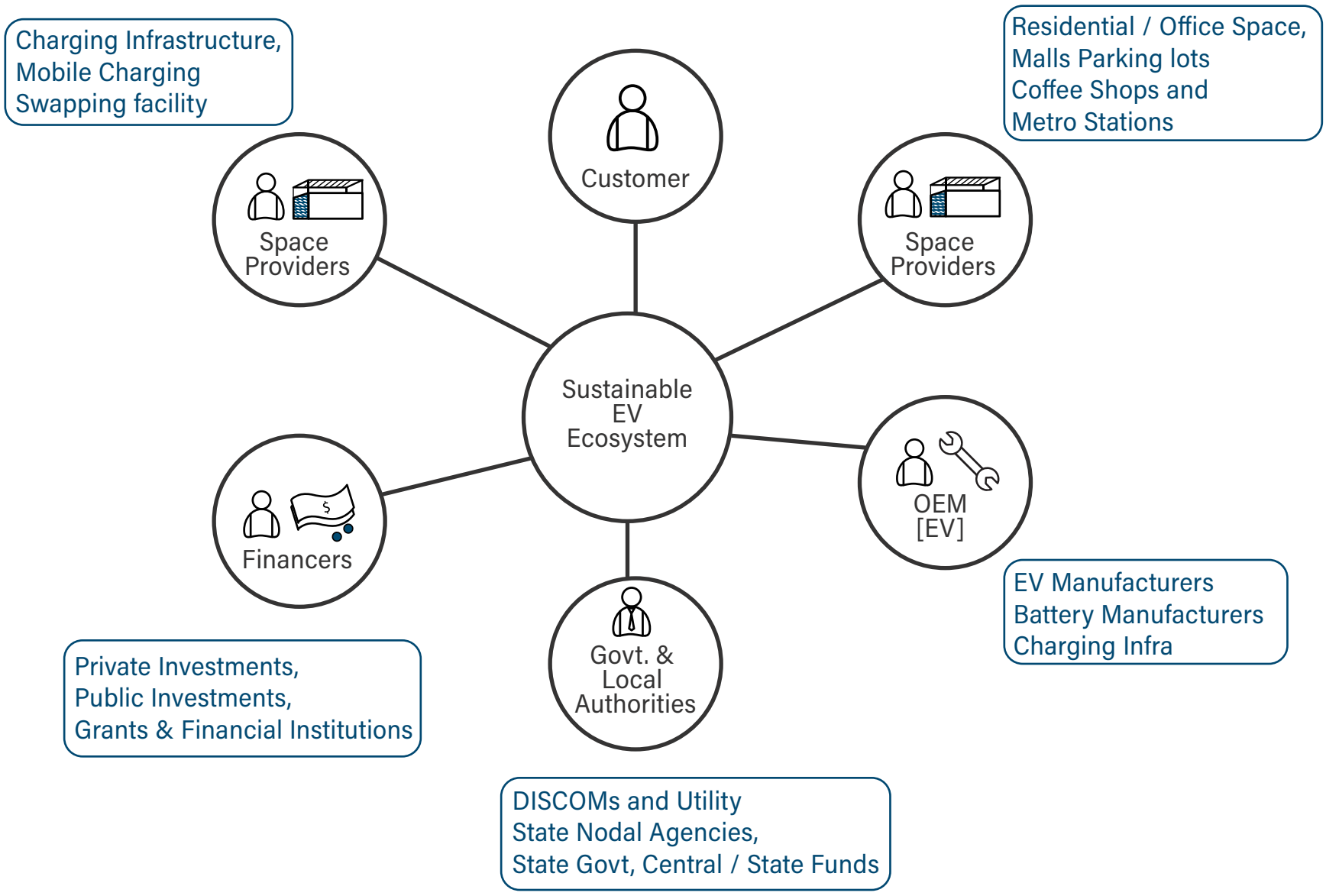


Fig .14. Ecosystem of Electric vehicles

The above figure encompasses all the stakeholders involved in the EV Ecosystem. Having said that, it is important to understand how an inclusive EV strategy will look like for India. Leaving aside Government support (financial aids and policy), the rest of the ecosystem needs to be aligned in a way such that the Electric Vehicle adoption and operation is sustainable

AN INCLUSIVE STRATEGY FOR ELECTRIC VEHICLE IN INDIA

SCOPE OF DIFFERENT STAKEHOLDERS FOR FASTER EV ADOPTION

OEMs	Space Provider	Service Provider	Financer	Government
Low cost EVs with low cost EMIs, financial Leasing model (3-5 year) for private customers, Rental Model for fleet vehicles, Operational Lease model, Subscription models with free charging through partnerships with Service providers 2-3wheeler vehicles with 80-100km range, fast charging and swapping capability Battery Techs which reduces initial battery cost (lowering CapEx) or retrofittable units New battery techs with long range travel (100-200km per charge) and fast charging (15-30min), BMS to optimize load vs range, swappable modular batteries. Commercial EV Buses Fleet (small sized Travellers) to provide feeder service from Metro stations	Commercial Spaces like malls, hospitals, hotels, office parking and other parking infrastructure providers to allocate space for charging infra AC / DC fast charging or mobile charging. Metro stations/Bus Depots as charging Infra space (slow charge) on rent or lease model or joint venture partnership model. Airports, Railway stations and Metro station as a point of EV rental service (2 & 4 wheelers) for local commute within a range of 20-30km Parking lots of residential societies (high rises) as charging facility during the day for fast charging State or privately-owned Bus Depots as charging infra for commercial / private vehicles.	Charging Infrastructure provider for commercial and residential spaces Setting up DC fast (15-20min) and 3 Phase AC (30min) at various strategic locations within the city. DC charging units at various strategic locations for providing mobile charging facility (PAYG) to customers. Mobile charging units on highway toll plazas or spaces nearby highways to push long range EV drive at every 50-80km range. Swapping facility for commercial vehicles (3 wheelers/Taxis and Buses) travelling 100-300km per day within city. Centralized swapping facility driven by various satellite swapping stations. powered initially by conventional electricity while later with Renewables Provide year wise subscription to daily customers (especially office goers) with discounts to push usability of each charging station Provide charging infrastructure and vehicles on Lease or start partnerships with various Car Rental services at various points of the city.	Finance low risk operational lease models (secured PAYG Models) for OEMs and Lessors Formulate various Low interest EMIs in coordination with OEMs and Service providers Ease out loan structure for technology innovators in battery technology and EVs JVs with service or space providers – Financing Charging Infrastructure while getting profit out of operations	Provide various tax exemptions to EVs customers to push adoption Formulate strategies / subsidies encompassing the entire EV ecosystem from OEMs to customers Formulate strategy like US which mandate setting up of charging infra in high rises Create a CDM like process where a certain share of the total manufacturing batch should be mandated as EV. More EV means more credit. The credit certificate (CER) will be traded in the market between manufactures. Incentivize DISCOMs to move into JVs and partnerships with Service providers to set up DC fast charging infra within the city.

Table 6

MATCHING SUPPLY AND DEMAND

B2B MODEL (FLEET – INSTANT DELIVERY) – 2-WHEELERS.

Fig .15. B2B Model – Food Delivery

In the above figure, we can see a simple self-contained B2B model for 2-wheeler EVs. Delivery companies (e.g. Swiggy, UberEats, Freshmenu, Zomato etc) can make use of Electric two wheelers for their delivery system. Usually delivery personnel travel around 50-60km per day for deliveries. Within a period of 3hrs (peak), they make a minimum of 5-6 deliveries. Most of them are part-time employees and work for around 5-6hrs per day. Usually within a 3hr window, they do 5-6 deliveries per day within a distance of 50-60km. On the other hand, full time employees (8-10hrs per day) travel around 80-100km per day providing with 100-120 deliveries during peak time. There is an hour rest for each employee in between which can be used for charging apart from on road swap or charge. E-cycles can be quite beneficial to employ as they can increase the number of deliveries from 5 to 6 nos. to 10-12 nos. within a 3hr window during peak hours. It can beat heavy traffic as they are not subject to one way or No- U-turn rules. The maximum distance covered by an e-cycle is between 65-70km per charge. The e-scooters and e-motorbikes can be used to do delivery of long ranges or distances (within 40-50km range one way). The travel distance is within a radius of 5-8km from the nodal point. Let us see few business models for the B2B segment of two wheelers.

Charging or swapping Infrastructure	Logistics Co 2W	Delivery person 2W	EV OEM Co or Third Party Owned 2W
Model 1			
EV-CS OEM Co owned in EV-CS OEM Co Locations	EV-CS: Pay-per-charge, annual subscription fee	EV-CS: Pay-per-charge by Delivery person	EV-CS: Pay-per-charge, annual subscription fee
	EV: Direct Purchase or Financial Lease	EV: Direct Purchase/EMI or PAYG Mode	EV: Operating Lease, PAYG, Annual subscription fee
Model 2			
EV-CS OEM Co Owned in Logistic Co Hubs	EV-CS: Pay-per-charge, annual subscription fee or Operational Lease	EV-CS: Pay-per-charge, annual subscription fee or Operational Lease	EV-CS: Pay-per-charge, annual subscription fee or Operational Lease
	EV: Direct Purchase or Financial Lease	EV: Direct Purchase/ EMI or PAYG Model	EV: Operating Lease, PAYG, Annual subscription fee
Model 3			
Logistics Company Owned + AMC in Logistic Co Hubs	EV-CS: Direct Purchase / EMI or Financial Lease	EV-CS: Direct Purchase / EMI or Financial Lease	EV-CS: Direct Sale / EMI or Financial Lease
	EV: Direct Purchase or Financial Lease	EV: Direct Purchase/EMI or PAYG Model	EV: Operating Lease, PAYG, Annual subscription fee
Model 4			
Independent Providers as well as + EV-CS OEM Co Locations + Logistics Co Hub	EV-CS: Pay-per-charge, annual subscription fee, shift in-house at volume	EV-CS: Pay-per-charge, annual subscription fee, shift in-house at volume	EV-CS: Pay-per-charge, annual subscription fee, shift in-house at volume
	EV: Direct Purchase or Financial Lease	EV: Direct Purchase/EMI or PAYG Model	EV: Operating Lease, PAYG, Annual subscription fee

Table .7. Business Models for Food Delivery Sector

In the above table, Model 1, shows EV-CS OEMs will have a BOO (Build own operate) model through either a Pay-per charge or a yearly subscription. The EV-CS will be located at strategic locations en-route of delivery. The delivery personnel will pay per charge (₹/km or ₹/kWh) while logistics companies will either do a pay-per charge or go for an annual subscription model. The charging subscription model will have a certain capping of charging per day/per month or per year basis. As per the travel pattern, the maximum number of charging will be restricted to 2 per day. Hence, it can be around 600 charges per year (300 operational days) depending on the contract. The 2W can also be charged at delivery company locations or delivery personnel residence for overnight charging. They require a common 15A, plug point which is available in every household.

For the EV-PAYG model, the OEM will give their vehicles (minimum 20-30units) on a per day or per kilometre basis to the delivery companies or delivery personnel. There will be a km cap per day for PAYG model like 120-150km (approximately 2 battery charging cycle per day maximum). The Yearly subscription model is where the delivery organization will be taking a minimum set (depending upon OEMs) of two wheelers for a lock-in period of 2-3 years while paying a yearly subscription fee. The kilometre range will depend upon subscription fee (for e.g. ₹ 5000 per unit p.m. up to 3,000km). This fee will be paid either yearly, half-yearly or quarterly. For bulk orders, OEMs can give out their vehicles on an operational lease to the logistics company or a 3rd party buyer. The operational lease will have monthly lease (instalments) and tenure of the entire life cycle (e.g. 5 years) of the vehicle with AMC borne by the OEM. One needs to keep in mind, that these two wheelers can also be charged at any regular plug point (15A socket) available at customer residence.

Model 2 is almost the same with a small tweak. Here, the charging infrastructure is located at the fleet delivery company hubs. The Operational cost (Energy cost) is borne by the customer while AMC is done by the EV-CS OEMs. The EV-CS OEM will implement their CS at the delivery hubs either on a Pay-per charge, annual subscription or operating lease. The Logistics company will pay as per agreement. For annual subscription, the number of charging will have a certain capping per month or per year. While for operating lease, the EV-CS OEM will own the CS and logistics company will pay a monthly instalment and there will be no capping for charging as such. The Delivery personnel can also charge their own 2W at their residence with a 15A plug point.

In Model 3, the delivery company will have the complete ownership of the charging ecosystem. The delivery company will buy out EV-CS from EV-CS OEMs or do a financial leasing. Charging stations will be set-up and maintained at different forward stocking locations or central hubs for overnight charging or in between (during break of 1 hour) as per requirement. They can also set up few EV-CS on route of heavy traffic delivery. The space leasing will depend on agreement between the logistics companies or space providers.

EV OEMs will sell or lease out the 2Ws to the delivery companies or to a 3rd party or do a PAYG model with delivery personnel. There is also a possibility of financial or operational leasing where the delivery company will pay monthly lease in instalments. During the lease period a financial institution will own the vehicle, post which, the ownership will be transferred to the delivery company. Operational leasing will be an option where ownership will OEMs can be responsible for AMC for 2-3 years if a contract is executed.

Model 4, signifies an open system where the EV-CS can be owned by independent service providers (SP) located in either EV-CS OEM locations or Delivery company hubs or forward locations. The model can be a Pay-per charge or an annual subscription (with no. of charging/day or per year capping). The idea is to bring this EV-CS infrastructure in-house at volume. The delivery personnel will also be able to charge the 2Ws from on-road public EV-Cs (OEM owned) or delivery hub stations as and when required. They will either pay per charge or have an annual subscription fee based on the agreement.

The EVs on the other hand will be with delivery companies on financial /operating lease or direct sale. While delivery personnel will have to buy the EVs on EMI/direct sale or go for PAYG model (with distance capping per day/month). As per market study, GPS enabled tracking and mobile application-based tracking system is available with the vehicle from specific OEMs. The subscription or the PAYG fee will depend on the use of GPS systems or app-based tracking system. With all mobile based tracking system, the subscription cost per month will be higher than that of regular model.

B2B MODEL (E-COMMERCE) – 2-WHEELERS AND 3-WHEELERS

Figure 16 represents another sector of the B2B model which is the e-commerce sector (Flipkart, Amazon, Runnr, Jabong or their logistics providers like Delhivery etc). The e-commerce sector delivery pattern is quite different from what we saw in the food delivery. This sector involves heavy baggage load starting from 20kg to few 100kg. There is a huge potential of engaging e-bikes, e-scooters (upto 40kg) and electric 3-wheelers (50kg and above) in this logistics sector. Distance covered is around 80-90km per day which can be covered in one charge (overnight – 100km per charge) while deliveries range between 60-70 per day which goes up to 80-100 per day during festive season (peak) with a distance of 100-120km per day. The shift usually starts at around 8am in the morning where the delivery guys pick up 20-30 parcels to deliver which they complete in around 4-5hrs.

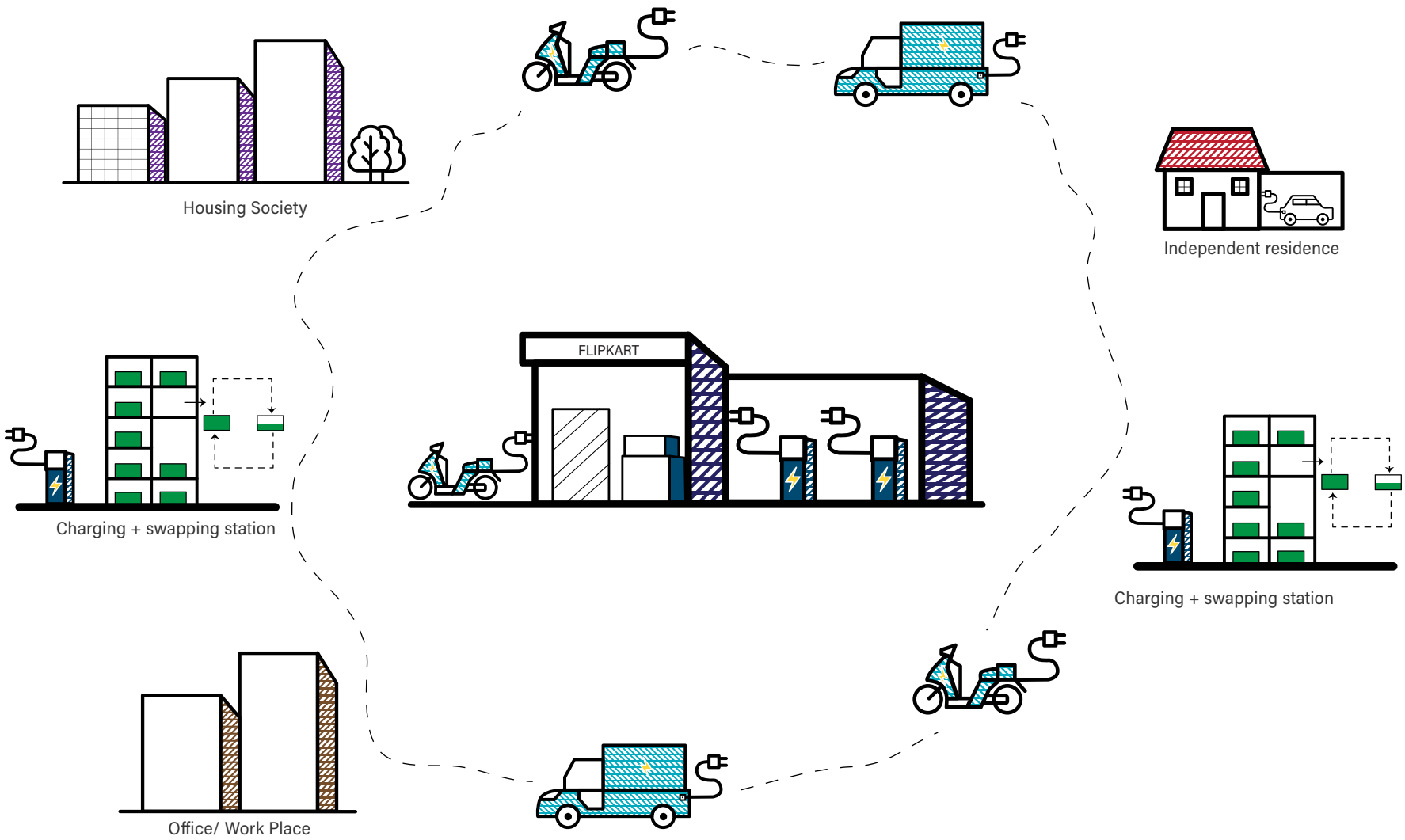


Fig .16. B2B model – e-commerce / Logistics

They return back around 12-1pm to their nodal distribution point to rest for an hour or so. This time can be utilized for on-hub charging. The next set of delivery either ends by 5-5.30pm or continue till 8-9pm. In the former case, they return to the nodal point to pick up the last batch of delivery which ends usually by 8-9pm. The 3-wheelers usually picks up all the delivery items around 8-9am once and completes the delivery by 9-10pm including an hour of rest in between. Returning to nodal points for 3-wheeler delivery guys depends mainly on the size and weight of the parcels. As per the diagram, both 2W and 3W should have charging / swapping stations located en-route. The break time of an hour can be utilized for charging or swapping as per need. Let us see few models for the logistics sector in the following section.

The four models described in Table 8 are almost identical with B2B food delivery company except the inclusion of 3W EV-segment. Similar to the food delivery sector in *Model 1*, it will be a BOO (Build own operate) model where the EV-CS OEMs will own the entire charging ecosystem. AC slow and fast charging or swapping stations will be set up all along the delivery routes at strategic locations. The model will be through either Pay-per charge (Delivery personnel) or an annual subscription fee. The annual subscription fee will again have some kind of capping per year (around 600/year for 2W while 700 for 3Ws). Delivery personnel owing 2Ws can also charge their EVs at their own residence overnight.

EV-OEMs will give out their vehicles on either an operational lease or yearly subscription fee to the logistics company apart from direct sale/EMI or financial leasing. For delivery personnel, it can be a PAYG model with a capping of distance travelled per day or month for 2Ws. For 3Ws, the annual subscription model seems to be a better option with a distance capping per month with a lock-in period of 2-3 years.

Charging or swapping Infrastructure	Logistics Co 2W /3W	Delivery person 2W/3W	EV OEM Co or Third Party Owned 2W/3W
Model 1			
EV-CS OEM Co owned in EV-CS OEM Co Locations	EV-CS: Pay-per-charge, annual subscription fee	EV-CS: Pay-per-charge by Delivery person	EV-CS: Pay-per-charge, annual subscription fee
	EV: Direct Purchase or Financial Lease	EV: Direct Purchase/EMI or PAYG Model (2W), Annual Subscription (3W)	EV: Operating Lease, PAYG, Annual subscription fee
Model 2			
EV-CS OEM Co Owned in Logistic Co Hubs	EV-CS: Pay-per-charge, annual subscription fee or Operational Lease	EV-CS: Pay-per-charge, annual subscription fee or Operational Lease	EV-CS: Pay-per-charge, annual subscription fee or Operational Lease
	EV: Direct Purchase or Financial Lease	EV: Direct Purchase/EMI or PAYG Model (2W), Annual Subscription (3W)	EV: Operating Lease, PAYG, Annual subscription fee
Model 3			
Logistics Company Owned + AMC in Logistic Co Hubs	EV-CS: Direct Purchase / EMI or Financial Lease	EV-CS: Direct Purchase / EMI or Financial Lease	EV-CS: Direct Sale / EMI or Financial Lease
	EV: Direct Purchase or Financial Lease	EV: Direct Purchase/EMI or PAYG Model (2W), Annual Subscription (3W)	EV: Operating Lease, PAYG, Annual subscription fee
Model 4			
Independent Providers as well as + EV-CS OEM Co Locations + Logistics Co Hub	EV-CS: Pay-per-charge, annual subscription fee, shift in-house at volume	EV-CS: Pay-per-charge, annual subscription fee, shift in-house at volume	EV-CS: Pay-per-charge, annual subscription fee, shift in-house at volume
	EV: Direct Purchase or Financial Lease	EV: Direct Purchase/EMI or PAYG Model	EV: Operating Lease, PAYG, Annual subscription fee

Table .8. Business Models for e-Commerce Logistics Sector

For the logistics companies, the lease will have monthly instalments to be paid while the subscription model will have quarterly, half yearly and yearly payments in instalments. The operational lease will be for the entire life cycle (e.g. 5 years) of the vehicle with AMC borne by the OEM. The subscription model however will have a lock-in period of 2-3 years depending on contract but will have a certain kilometre range per year of subscription (around 3,000km per month).

Model 2, is where the EV-CS OEM will own the EV-CS located in logistics hubs. The EV-CS OEMs will install the CS at logistics hubs on Pay-per charge, Operating lease or annual subscription model. Except Pay-per charge, the operating model and subscription model will have instalments to be paid. There will be a capping of charging per month or year for subscription model which will not be there for operating model. The energy charges incurred will be borne by the logistics company itself. Retail customer can charge their 2W vehicles at home in their regular 15A socket (AC slow charging) overnight.

In *Model 3*, the entire ecosystem is owned by the logistics company itself including the vehicles (except operating lease) and the EV-CS. Apart from EMI based or direct down payment, there is an option of financial lease. Here, the logistics company will have to pay monthly instalment as lease to the lessor. Only disadvantage is during the leasing period, the ownership lies with the financial institution or the lessor.

Model 4, is where the EV-CS can be owned by independent service providers (SP) located in either EV-CS OEM locations (on route delivery) or Logistics company hubs or forward locations. The model can be a Pay-per charge or an annual subscription (with no. of charging/day or per year capping). The idea is to bring this EV-CS infrastructure in-house at volume. The delivery personnel will also be able to charge the 2Ws from on-road public EV-Cs (OEM owned) or delivery hub stations as and when required. The logistics company or the delivery personnel will either pay per charge or have an annual subscription fee based on the agreement.

The EVs on the other hand will be with Logistics companies on financial /operating lease or direct sale. The delivery personnel will have to buy the 2W EVs on EMI/direct sale or go for PAYG model (with distance capping per day/month). For 3Ws, they will have to go for direct sale or annual subscription based on contract. As per market study, EVs with GPS enabled tracking and mobile application, the subscription cost per month will be higher than that of regular model.

B2C MODEL: PRIVATE TRANSPORT SYSTEM MODEL A

Daily Commuter (office or college) and Weekend Leisure

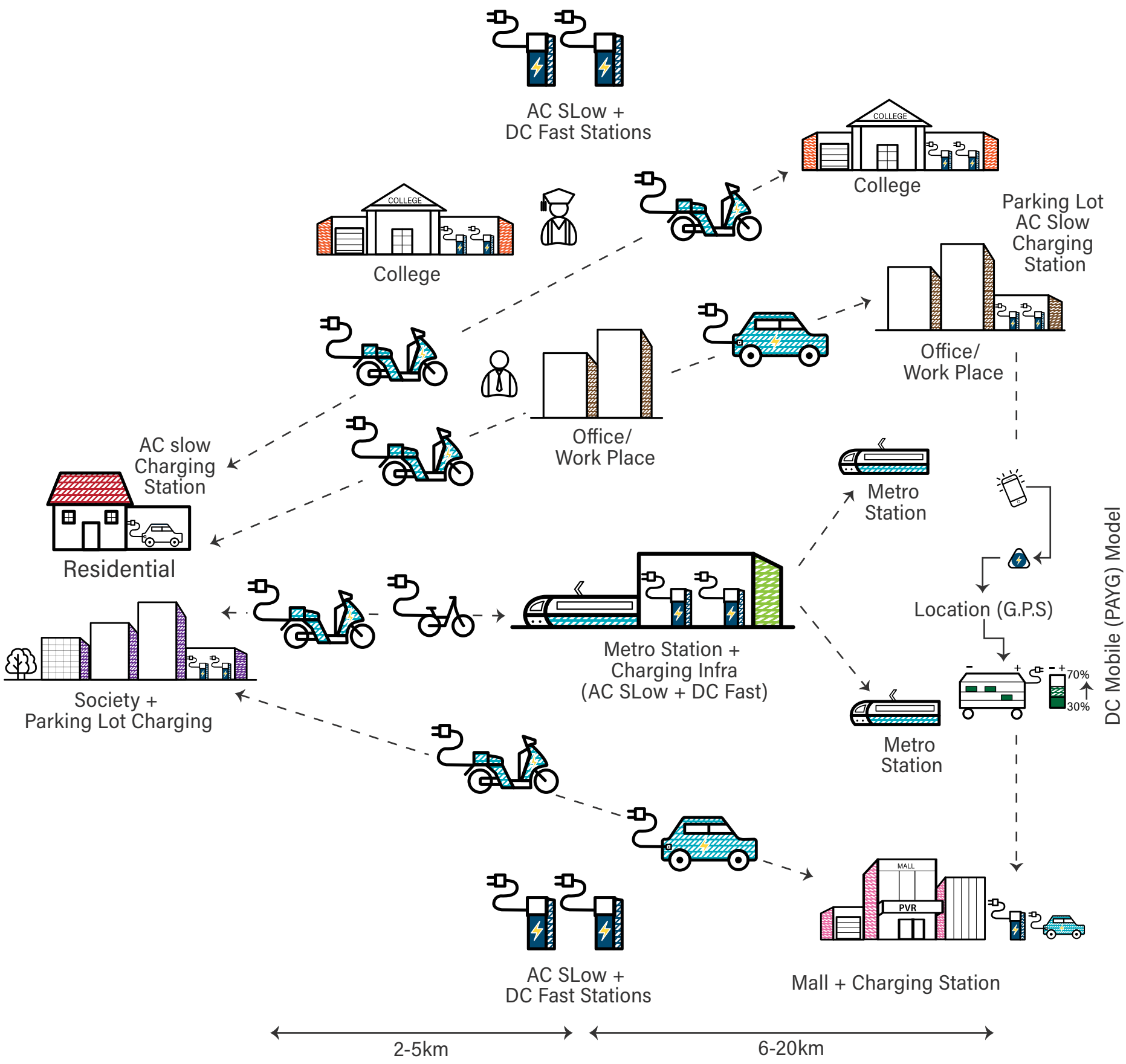


Fig 17. B2C model – Private Transportation for Daily Commuter

The previous Figure 17 shows a daily commute scenario for office goers and college students who either own a 4W or a 2W or both. As per Census data[61], around 60% travel within 2-20km range per day and while 40% commuter travel within 2-5km range. Among them the highest number of private 4W user usage is between 11-20km range at about 10%. Within this total range of 2-20km the 2W commuter is around 25-28%. Bicycle usage is almost similar to motorized 2Ws within 2-5km range at 26%.

Having said that, the above model shows a few standard travel patterns of the daily office commuter. Without disrupting the business as usual (BAU) scenario, most 4W and 2W owners (cycles, bikes, scooters) travel to their offices within the range of 20km. 4W which are mostly owned by office goers, prefer to use their own vehicle within 11-20km range. College students and even office goers use bicycles for a range of 2-5km distance from their residence. Some of the discerning passengers in cities with metros, park and ride to work from the nearby metro or railway station which is within 5km distance from their residence. From the metro station either they continue the journey till their office or colleges using shared last-mile connectivity providers like public transport buses, auto-rickshaws or off late e-trikes.

Considering the fact, the entire distance (to and fro) is around 40-50km maximum, it can be covered with a single charge (overnight slow charging at residence) which gives 100-120km range. Besides that, EV OEMs and EV-based last mile service providers can put up public charging stations (AC and DC fast) at public transport hubs and along the arterial roads to reduce range anxiety. A provision of AC charging option has been considered at office parking lots for charging EVs (for 6-8hrs) as well as malls and public spaces depending on space availability.

The same structure can be made use of for weekend leisure travel (local eat out/movies, etc) where people either take their own vehicle (4W or 2W) with family to some malls, movie halls or museums. People prefer mostly personal vehicle at their disposal during this time. To reduce range anxiety, a DC mobile charging option can be introduced here. The DC mobile charging system charges a vehicle to 80-100% within 20-30

Charging or swapping Infrastructure	**Customer owned 2W**	**Customer owned 4W**
Model 1		
EV-CS OEM Co owned in EV-CS OEM Co Locations	EV-CS: Pay-per-charge, annual subscription fee, develop mixed use commercial + consumer EV-CS models pre-scale	EV-CS: Pay-per-charge, Annual Subscrip-tion fee, develop mixed use commercial + consumer EV-CS models pre-scale
	EV: Direct Purchase or Financial Lease or Yearly Subscription	EV: Direct Purchase or Financial Lease
Model 2		
EV-CS OEM Co Owned at Customer Locations	EV-CS: Pay-per-charge, annual subscription fee or Operational Lease, develop mixed use commercial + consumer EV-CS models pre-scale	EV-CS: Pay-per-charge, annual subscription fee, develop mixed use commercial + consumer EV-CS models pre-scale
	EV: Direct Purchase or Financial Lease or Yearly Subscription	EV: Direct Purchase or Financial Lease
Model 3		
Independent Service Providers Owned as well as + EV-CS OEM Co Locations + other locations	EV-CS: Pay-per-charge, annual subscription fee, develop mixed use commercial + consumer EV-CS models pre-scale	EV-CS: Pay-per-charge, annual subscription fee, develop mixed use commercial + consumer EV-CS models pre-scale
	EV: Direct Purchase or Financial Lease or Yearly Subscription	EV: Direct Purchase or Financial Lease

Table .9. Business Models for B2C Sector (Daily commuter- Private Transport)

61 https://data.gov.in/resources/other-workers-distance-residence-place-work-and-mode-travel-place-work-2011-india

minutes. People can book a mobile EV-charging service providing their vehicle's GPS location in the mobile app once parked if there is no provision of charging points.

Table 9, shows various models of EVs in the private B2C sector. *Model 1*, customer can have their 2Ws or 4W on direct purchase, financial lease or a yearly subscription fee (only for 2Ws). During the entire lease tenure, the owner of the vehicle will lie with the financial institutions. The lease model will have monthly instalments (lease) to paid to the financial institutions. While in 2W yearly subscription model customers will have to pay an one-time yearly security deposit payment along a monthly subscription-fee with distance capping per month (E.g. ₹4000/month for 2000km).

The EV-CS OEM can set up EV-CS in their own stand-alone locations similar to gas stations or space like malls and parking lots of offices within the city. The payment mode is either as Pay-per usage (₹/km or ₹/kWh) or through an annual subscription model. The subscription model will have monthly and yearly charging caps for 2W and 4Ws. The charging cap will be dependent on the subscription fee and agreement between the customer and EV-CS service providers ensuring minimum off-take or revenues for an EV-CS. The charging stations can be installed, operated and maintained by the EV-CS OEMs or other service providers including the owners of the real estate or operators of parking spaces. The EV-CS can be developed for mixed use between the delivery and logistics companies in the prior B2B business model discussed in which case they can be provide additional capacity utilization to existing closed loop charging station setups. Apart from that, customers can have their own charging options (AC slow) at their residence.

Model 2 is where the EV-CS OEMs will own and install the CS at customer locations. These will be either AC fast charging or DC fast charging options. Slow charging can also be an option which the customer where the customer can charge their EVs with a 15A plug point at their residence. Specific attention needs to be paid to the growth of this model and the customer preference towards it as it affects the potential demand and utilization of public or shared use EV-CS. The EVs will be owned by the customer through direct purchase, financial lease or a subscription-based model (2Ws).

In *Model 3*, independent service providers will install, operate and maintain the charging stations at various strategic locations within the city, malls or office or housing society parking spaces. The AMC can be done by the charging infra provider depending on contract with EV-CS OEMs. These independent service providers can even be space providers like malls or offices who wants to earn an extra revenue from EV charging. The model can be a pay as per charge or an annual subscription model (with charging cap per year/month).

The Independent service providers can also have a mobile DC unit which can be moved to any location as per need from the customer. This will be owned by the service provider (charging service or OEMs) who will recharge EV batteries at points where customers are not able to find charging stations or will have to wait too long to re-charge. These fast (<20min) charging facilities will be available on call or on mobile based applications. It will have GPS feature enabled which will assist the service provider to track the customer vehicle's location. DC mobile charging will cost a little higher due to its location agnostic feature. But it will be a Pay-per charge system based on ₹ per kWh plus a certain amount for logistics (to carry the mobile unit). The DC mobile can also be used for emergency services at higher cost to recharge vehicles which might be stranded on road due to depleted battery.

B2C MODEL: PRIVATE TRANSPORT SYSTEM MODEL B

Fig 18, describes a daily commuter scenario who doesn't own any vehicle and completely relies on public transport system. In this scenario, we have considered three customer categories: white collared professionals, blue collared employees and students (college and school). Although every one of them, rely on public transport, their choice of transport is not always the same. Having said that, it is considered that white collared professionals will either get a shared vehicle ride (Ola/Uber/Auto rickshaw/3Ws) to the

Daily Commuter (office/college/school) and Weekend Leisure

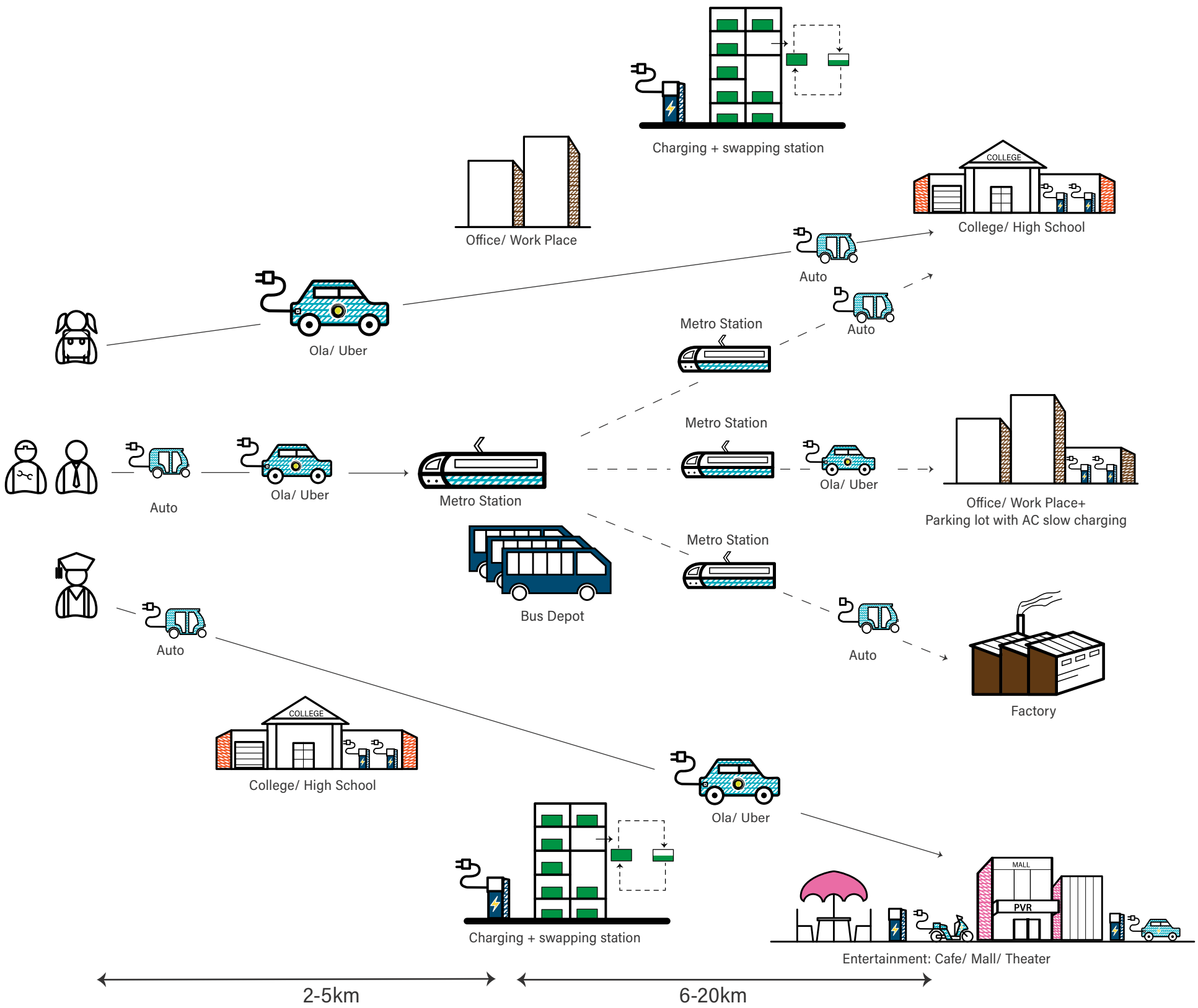


Fig .18. Public Transportation by Daily Commuters

nearest metro or railway station or a bus depot or even hire the same vehicle directly to his/her choice of destination. Usually it is seen from various studies and census reports that around 5-6% people travel in the auto, taxi or other 3Ws within a distance of 2-20km range. Having said that, in the above model we can see, school children (not availing school transport) and blue collared employees preferring shared 3W services (like auto rickshaw) while college students and white collared professional availing all the facilities at their disposal. It can also be observed that point of work or education might not be exactly nearby the metro station or bus depot. Hence travelling from source to destination involves various modes like auto, bus, cabs and metro.

Regarding the vehicles, shared auto rickshaws run for a short distance of around 2-3km radius totalling to about 35km in three hours which comes to around 100-140km per day[62] . While cabs and metered autos usually run around a maximum of 200-250km per day[63] within a city. Hence for auto rickshaws, with swapping facility, it would require two to three swaps (45km per swap) per day. On the other hand, a single charge provides 100-120km range on an average. Hence for an auto, one overnight charge will be good enough while for 4W (cabs) it would require one extra charge every day apart from overnight full charge. The above need created issues in adoption of EV cabs for Ola Cabs in their initial Nagpur roll-out.

Let us consider Mahindra e2O, which is presently the most penetrated and well known EV in India. e2O does have a fast charging facility which provides 90% charge in 90 min. Hence if we consider an hour rest in between the, the driver can get a range of around 90km more. Hence during peak travel, the 4W needs to be charged at least two times a day and thus there will be a loss of 2hrs in between. With AC 3 phase fast charging and DC fast charging or swapping techniques, this range anxiety can be easily removed. The diagram on-road swapping and AC fast charging units which will provide the required security for the fleet operators. Let us now look at few operating or business models:

Charging or swapping Infrastructure	**Fleet Operator's 3W and 4W**	**Driver's 4W and 3W**
Model 1		
EV-CS OEM Co owned in EV-CS OEM Co Locations	EV-CS: Pay-per-charge, annual subscription fee	EV-CS: Pay-per-charge, annual subscription fee
	EV: Operational lease or annual subscrip-tion	EV: Direct purchase or financial lease or annual subscription
Model 2		
EV-CS OEM Co Owned at Customer Locations	EV-CS: Pay-per-charge, annual subscription fee or operational lease	EV-CS: Pay-per-charge, annual subscription fee or Operational Lease
	EV: Operational lease or annual subscrip-tion	EV: Direct Purchase or financial lease or annual subscription
Model 3		
Independent Service Providers Owned as well as + EV-CS OEM Co Locations + other locations	EV-CS: Direct purchase/ EMI or financial lease	EV-CS: Direct purchase/ EMI or financial lease
	EV: Operational lease or annual subscrip-tion	EV: Direct purchase or financial lease or annual subscription
Model 3		
Independent Service Providers Owned as well as + EV-CS OEM Co Locations + other locations	EV-CS: Pay-per-charge, annual subscription fee, shift in-house at volume	EV-CS: Pay-per-charge, annual subscription fee, shift in-house at volume
	EV: Operational lease or annual subscrip-tion	EV: Direct purchase or financial lease or annual subscription

Table .10. Business Models for B2B Sector (Daily commuters – Public Transport)

Model 1, in the above table, shows a BOO model for the EV-CS OEM where the EV-CS will be installed and operated by the EV-CS OEMs. The mode of payment will be either on either pay-as per charge or on an annual subscription fee

62 https://timesofindia.indiatimes.com/city/pune/Autos-give-20-25-km-mileage-per-litre/kg/articleshow/13087815.cms
63 https://factordaily.com/ola-uber-drivers-earnings-reduce/

The annual fee will have a charging cap (kWh per year or no of charges per year). The pay-as per charge will be based on either ₹/km or ₹/kWh depending on the contract. This will be similar for both fleet operator or any driver owing their car and working with the fleet operator. The EV-CS OEMs will set up charging or swapping stations on-road (en route) at strategic locations within a distance of every 5-7km. The charging-cum swapping stations will be operated and maintained by the EV-CS OEMs. The cost of charging will be in ₹ per km while for swapping it will ₹ per swap (e.g. ACME – ₹65-70 per battery swap of 57Ah – range 45-50km).

The fleet operator will have the EVs on operational lease for the entire life cycle (around 5 years) of the vehicle or on yearly subscription model. The leasing period is maximum of 5 years as that is the maximum life of Li-ion battery (it can be increased for batteries with longer life). The fleet operator will pay a monthly instalment (lease) or a annual subscription fee (one time) to the EV OEMs. The subscription fee however will have a distance cap (travelled per month). For 3Ws it will lesser than that of 4W. The AMC will be done by the OEMs.

Model 2 is almost similar except the charging-swapping station locations. Except per charge or annual subscription model, the operating lease period will depend on the lessor and the lessee contract. The locations of the EV-CS will be at the fleet operator hubs or some places designated by fleet operators (like Airport taxi stands). The AMC will be on the EV-CS OEMs while the running charging (energy charges) will have to be borne by the fleet operator themselves. The customer who own the vehicle will have to pay per charge or have an annual subscription fee for charging the EVs. Swapping stations will be installed only for 3Ws.

Model 3, is a complete ownership and operating model of the fleet operator. The fleet operator will own the EV-CS through direct purchase/EMI or financial lease. The charging or swapping station will also be owned and operated by the fleet operator while AMC will be done by the OEMs (for maximum 2-3 years as per contract). The operators will have the option install both either AC slow/ fast or even DC fast charging stations along with swapping stations for 3Ws. In the case that drivers own their EVs they will have the opportunity to use their residential resource of a 15A AC socket for slow charging. The entire ecosystem will be controlled by the fleet operator here to strategically operate the intra-city 4W and 3Ws. Most fleet operators are asset light. Hence all EVs will be on operating lease or annual subscription-based model. Drivers might choose to own an EV (direct purchase/EMI/financial lease) or get it on an annual subscription model (with a km cap and lock-in period 2-3 years) from EV-OEMs.

In *Model 4*, independent service providers will own the EV-CS and these will be located at various locations within the city. They can install EV-CS in commercial places like malls, office, metro stations, hospitals, cafes, restaurants, office parking lots, fleet operator designated spaces. It might also be located at various 4W/3W stands by the road. The stations will be operated by them. Yearly AMC (for 2-3 years) will be provided by the EV-CS OEMs. The service providers CS locations will be visible in google map (integration required) to inform the EV drivers. The station operators will earn revenue from EV drivers either ₹ per kWh or ₹ per swap basis. Fleet operators and retail customers (drivers owning fleet vehicle) will go for either pay per charge or subscription wise charging as discussed above. For customer who owns the vehicle can recharge their EVs overnight (100% charging in 5-8hrs) with regular AC slow charging facility at their place of residence.

RENTAL MODELS (2WS):

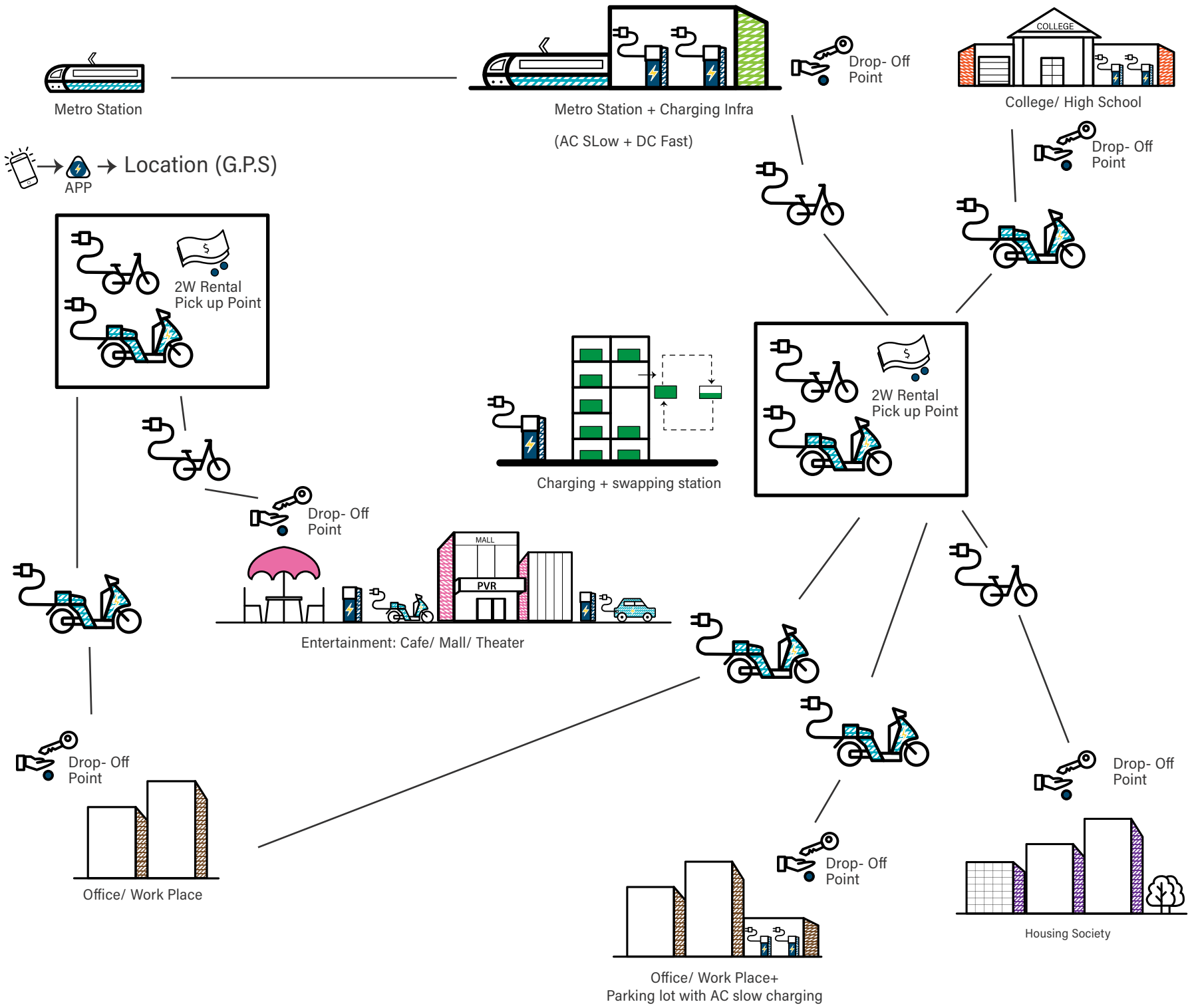


Fig .19. Rental 2W Model

In the above figure, we can observe a simple rental model for 2W within the city. This model targets people who do not want to buy 2Ws but will avail one if given an opportunity. In this case, let us consider a rental company providing Electric 2Ws (cycles/bikes/scooters) to customers from different pick-up points within the city. Apart from a central pick-up zone, the organization will also have an app-based system. The mobile app will work like a Zip Car in US or Zoom Car in India where one can book a ride of his / her choice from one designated point and drop it off at the same or another designated point.

The tariff will be based on either kilometre run or per hour basis. Even week long or month-long hiring will be applicable where charging can be availed depending on tenure and choice of 2Ws. In case of more than a day hire a certain amount of lock in payment will have to be provided to book the vehicle. Identity and address proof documents will have to be submitted during registration or account set-up.

Range of scooters and bikes will vary from 80-120km per charge while for e-cycles it can be between 65-70km. Having said that, customers can even recharge their ride from designated charging or battery swapping stations located at rental hubs (pick-up cum drop-off points), on-road public charging stations or even at various commercial spaces like malls, office parking lots, metro stations etc. For this model to be successful, if swapping is not an option a certain number of fast charging EV-CS might be required to match consumer just-in-time demand. Customers hiring 2W for more than a day can even charge their EVs overnight at their place of residence if required.

In places with high concentration of white collared jobs (like Gurgaon, Pune, Bangalore, Delhi, Mumbai suburbs, etc) a lot of people prefer public transport (like metro, trains, etc.) to cover long distances in a short time. Post riding public transport, they tend to walk or take shared cabs or autos to their place of work or education. Rented electric 2Ws can be an excellent choice for the 2nd leg of travel within the city which will mostly be within a radius of 4-5km from the public transport depots. Commuters travelling within a distance of 10-20km from their residential place can even hire a 2W or an electric cycle and drop it off at designated locations as per need. Hence, we can easily beat range anxiety in this scenario.

For weekend leisure, commuters instead of getting a cab or an auto can easily hire an electric 2W (bikes/scooters or cycles) for a certain period of time (4-6hrs) and get rid of tension of availability of cabs or surge pricing during peak hours. The following table will give an idea about some possible business models:

Charging or swapping Infrastructure	**Rental Company owned 2Ws**	**EV OEMs owned or 3rd Party owned 2Ws**
Model 1		
EV-CS OEM Co owned in EV-CS OEM Co Locations	EV-CS: Pay-per-charge by users	EV-CS: Pay-per-charge by users
	EV: Financial Lease/ Direct Purchase	EV: Operational Lease / Yearly Subscription
Model 2		
EV-CS OEM Co owned + AMC in Rental Company Hubs	EV-CS: Pay-per-charge, annual subscription fee or Operational Lease	EV-CS: Pay-per-charge, annual subscription fee or Operational Lease
	EV: Financial Lease/ Direct Purchase	EV: Operational Lease / Yearly Subscription
Model 3		
Rental Company Owned in Rental Company Hubs	EV-CS: Direct Purchase / EMI or Financial Lease	EV-CS: Direct purchase / EMI or financial lease
	EV: Financial Lease/ Direct Purchase	EV: Operational Lease / Yearly Subscription
Model 3		
Independent Providers Owned as well as + EV-CS OEM Co Locations + Rental Company Locations	EV-CS: Pay-per-charge, annual subscription fee, shift in-house at volume	EV-CS: Pay-per-charge, annual subscription fee, shift in-house at volume
	EV: Financial Lease/ Direct Purchase	EV: Operational Lease / Yearly Subscription

Table .11. Business Models for Rental Model (2W segment)

Model 1, is where the EV-CS OEMs, will own the charging ecosystem and will operate on a BOO model. EV-CS OEMs will also be responsible to install and operate charging cum swapping stations at various strategic locations based on the operating route of the rental company. The payment will be done as per charge by users in ₹/kWh or ₹/km. Their charging locations will be available in the Rental company app for public usage. One EV-CS OEM company can serve one or many rental companies depending on volume.

The EVs however will be either be owned by the rental company through some financial lease or direct purchase or EV OEMs will lease out vehicles to the rental company through operating lease or through an annual subscription. The
operational lease will be on entire life cycle of 3-5years while subscription model will be similar as per other models.

In Model 2, the EV-CS OEM will own and set up AC/DC fast or slow charging stations or swapping stations (to be chosen based on customer demand profiles) at rental company hubs or locations like pick up or drop-off points within the city. These EV-CS will be owned, operated and maintained by the EV-CS OEMs. The ones which will be on operational lease or yearly subscription model will have a certain limitation on charging. Pay per usage will not be capped. The operational lease and subscription amount will be in the form of instalments as per other models above.

Model 3 is where the Rental company will own, operate and maintain the EV-CS. They will install the EV-CS (charging cum swapping stations) at designated points (strategic locations) for overnight charging as well as during the day according to their requirement before and after renting to customers. The locations can also be various metro stations, malls, parking lots etc. depending on route and requirement. In the first case, the rental company will have entire control of their assets. They will own both the 2Ws as well as the EV-CS infra. But for the 2nd one, 2Ws will be owned by EV-OEMs or 3rd party which will be either on operating lease or subscription-based model with the rental company.

Model 4 however states that the rental company will focus on leveraging the EV-CS assets of Independent service providers who will own the EV-CS infra with charging cum swapping stations located at various points within the city alongside setting up EV-CS at the rental company hubs only when there is significant scale. Pay per charge will be there for users who will want to recharge their own personal or rented 2Ws. Apart from that, independent service providers can take annual subscription fee from rental companies for charging their 2Ws at rental company hubs or locations like pick up and drop off points. Metro stations, Movie halls, Malls, Office parking space all can be used by the service providers for installing and operating the EV-CS units.

RENTAL MODELS (4WS):

The above figure represents a 4W rental model within as well as outside the city. Within the city, presently there are options of either renting a cab for one day (e.g. 8hrs-80km or 12hrs-120km) or for point to point pick up and drop. Additionally there are car rental agencies like Zoom Cars and Voler Cars who are moving towards renting vehicles by the hour for intra-city use. In the later use case, a consumer might choose to rent an EV. The rental companies will have a mobile app similar to that of 2Ws rental system. This app will be GPS location enabled which will detect the location of customer. Based on that, either the nearest pick up point will be provided. The designated drop off can also be some pick-up points with charging and swapping stations present at few strategic rental hubs within the city.

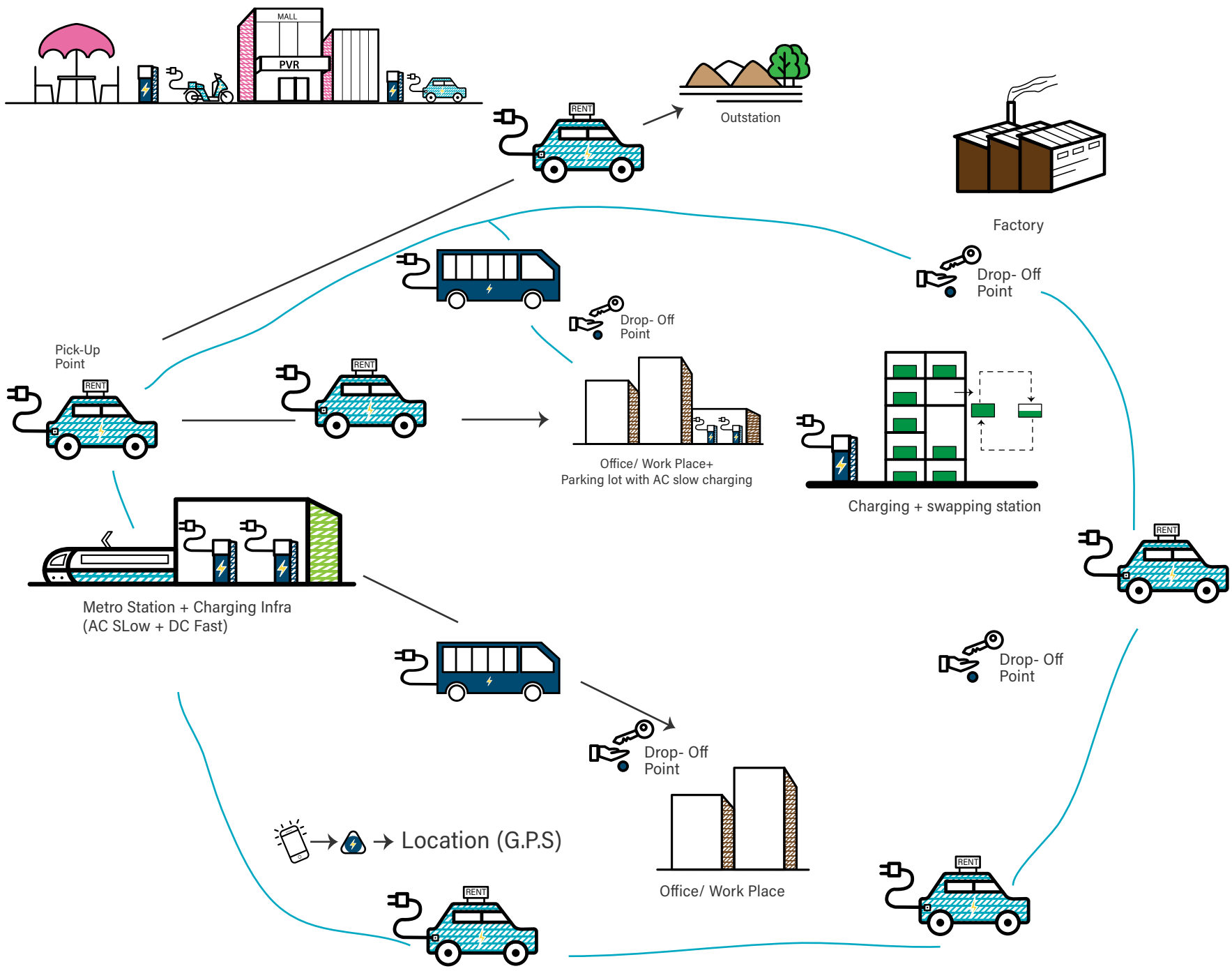


Fig .20. Rental 4W Model

Offices use traveller buses (maximum 20 seats) for point to point pick up and drop within the city and its suburbs. The pick points can be either various metro station location (feeder buses) or even door-to door area wise pick up and drop. The distance covered is usually within 20-25km per day one way which means around 40-50km per day. Charging and swapping infrastructures will be located at designated areas within the travel route (GPS and app based) which can be utilized for recharging if the travel distance crosses 100-120km per day. Within city or intra city, there will be option of both charging and swapping infrastructure while for outstation travel for more than 150km (inter-city travel) only AC and DC fast charging and swapping options might make sense.

During inter-city travel, one usually rests for an hour or so for lunch or for a cup of coffee which can be utilized for recharging the vehicle. The cost of renting will be based on ₹ per hr or point to point pick up and drop off at a fixed rate. Outstation travel (more than 150km) with EVs in India is still a premature thing due to lack of charging infrastructure on highways. But with time and development of charging ecosystem for EVs it can become a reality.

Charging or swapping Infrastructure	Rental Company owned 4Ws	EV OEMs owned or 3rd Party owned 4Ws
Model 1		
EV-CS OEM Co owned in EV-CS OEM Co Locations	EV-CS: Pay-per-charge by users	EV-CS: Pay-per-charge by users
	EV: Financial Lease/ Direct Purchase	EV: Operational Lease / Yearly Subscription
Model 2		
EV-CS OEM Co owned + AMC in Rental Company Hubs	EV-CS: Pay-per-charge, annual subscription fee or Operational Lease	EV-CS: Pay-per-charge, annual subscription fee or Operational Lease
	EV: Financial Lease/ Direct Purchase	EV: Operational Lease / Yearly Subscription
Model 3		
Rental Company Owned in Rental Company Hubs	EV-CS: Direct Purchase / EMI or Financial Lease	EV-CS: Direct purchase / EMI or financial lease
	EV: Financial Lease/ Direct Purchase	EV: Operational Lease / Yearly Subscription
Model 3		
Independent Providers Owned as well as + EV-CS OEM Co Locations + Rental Company Locations	EV-CS: Pay-per-charge, annual subscription fee, shift in-house at volume	EV-CS: Pay-per-charge, annual subscription fee, shift in-house at volume
	EV: Financial Lease/ Direct Purchase	EV: Operational Lease / Yearly Subscription

Table .12. Business Models for Rental Model (4W segment)

Similar to 2W rental above, Model 1 is again a BOO model for EV-CS OEMs. Since it will not be under the control of the rental companies, the payment model will be based on Pay per charge. This will be paid by the users using the rented cars. The rental hubs can also have 15A plug point for charging EVs overnight (7-8hrs full charge) apart from the EV-CS installed units across the city. The EV-CS OEMs will implement both charging and swapping infrastructure for intra-city travel while AC and DC fast charging stations for inter-city commute. In the 2nd case of Model 1, the rental companies will neither own the vehicle nor the charging station but will have GPS enable mobile apps which will let the commuters know regarding the locations of next charging or swapping stations on their way.

Model 2, is where the EV-CS OEMs will have the ownership of the EV-CS ecosystem (charging/swapping infra). But charging or swapping stations will be located at rental company hubs/locations. These locations will be within the city at various pick up and drop off points (commercial and public places like malls, office parking lots, hospitals, metro stations etc.) or few rental hubs. The stations will be operated and maintained by the EV-CS OEMs and generate revenue from the customers in ₹ per kWh, ₹ per km or ₹ per swap as deemed appropriate.

Model 3, is similar to the Model 1, replacing the EV-CS OEMs with the Rental Company. Here, in case 1, the rental company owns the entire ecosystem from the EV fleet till the charging or swapping stations. In this scenario, the rental company will either get their EV fleet through financial lease or direct sale (EMI based).

Only during financial lease period, the ownership will lie with the financial institution. Post lease tenure, ownership will be transferred to the rental company. The company will set up various swapping and charging infra within the city at different pick up or drop of locations and various rental hubs. The locations of the charging cum swapping infra will be provided to the users while they are using the mobile application (GPS enabled). Strategic locations within every 5-7km radius will be considered to set up this stations for customers. For outstation travel in near future, DC mobile charging options will also be available along with regular charging options in restaurants or café along the highway. The app-based DC mobile charging units will also be available within the city at any location for emergency as well as regular use. The 2nd case is where the EV ownership will lie with the EV OEMs or 3rd party. It will be either an operational lease or annual subscription.

Model 4, is where EV charging/swapping infra will be owned and operated by the independent service providers. The space for setting up charging cum swapping units will be provided by the commercial locations (malls, hospitals, metro stations, private office spaces, etc.). These commercial players can either lease out or give their parking slots on rent to the service providers or they can be the service providers themselves. The AMC will have to be done by the lessee while energy charges incurred can either be adjusted in lease or directly paid by the space-lessor.

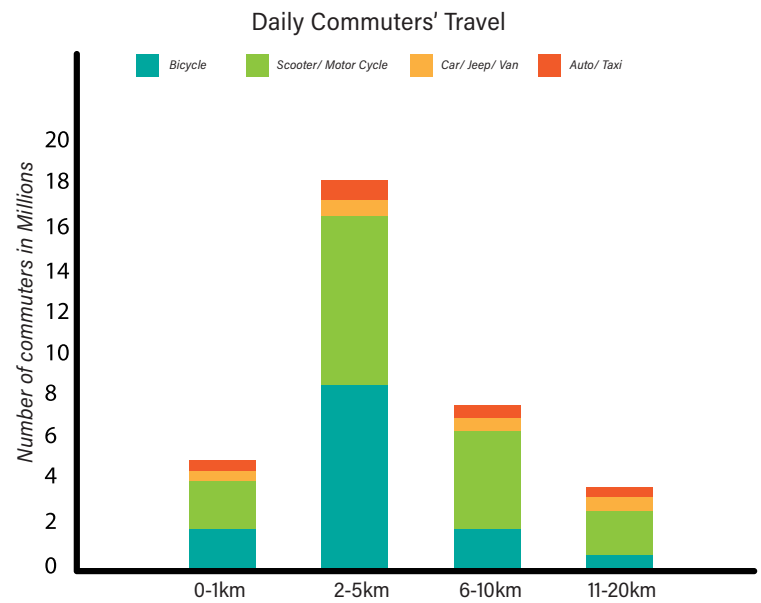
In some cases, a 3rd party will rent out their cars to the rental companies with drivers or drive the vehicles themselves to earn a living. Usually tempo travellers (12-20 seater EVs) or other 4Ws are considered here. People or customers who do not want to drive but need a vehicle for a certain amount of time along with drivers, they can avail the rental facility. Here, the EV ownership lies with a retail customer (3rd party) who has rented or leased his/her vehicle to the Rental company. They can utilize any charging ecosystem infra through pay-per charge, annual subscription model (with the rental company) but will neither own, operate or maintain the same.

MARKET OPPORTUNITY

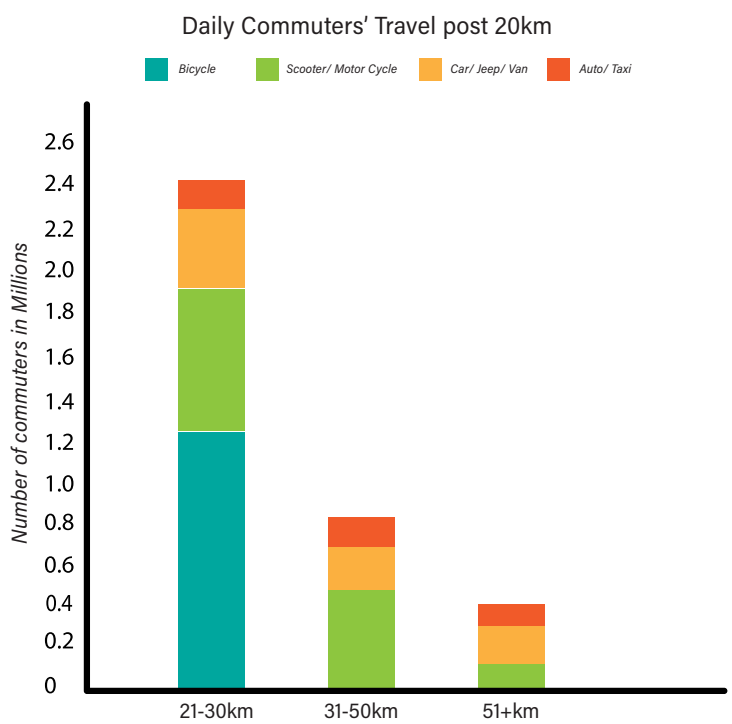
In India around 88 Mn people travel to work in cities among which 30% travel by foot, 22% use two wheelers (bikes and scooters), 17% use bicycle, 5% use their own four wheelers, 4% uses taxi, auto while rest 22% use other travel modes like public buses, trains (including metro) and water transport or other modes. Among people who travel, around 86% travel between 1-20km range while around 40% within this is between 2-5km range. Hence, the maximum share of market will be for commuters between 1 to 20km has been considered. Keeping that in mind, the following distance wise break up will show the share of bicycles, 2Ws, 4Ws and public transport (3W and 4W) in each case.

From Graph.13., we can see that around 17Mn people drive their own 2 wheelers (bike, scooters, moped, etc) while 14Mn uses bi-cycle for work. Commuters using their own vehicle is only around 3Mn which is almost similar to people using shared, hired or rental public transport system like 3 wheelers (autos), cabs, etc.

Now let us look at the same modes post 20km range.

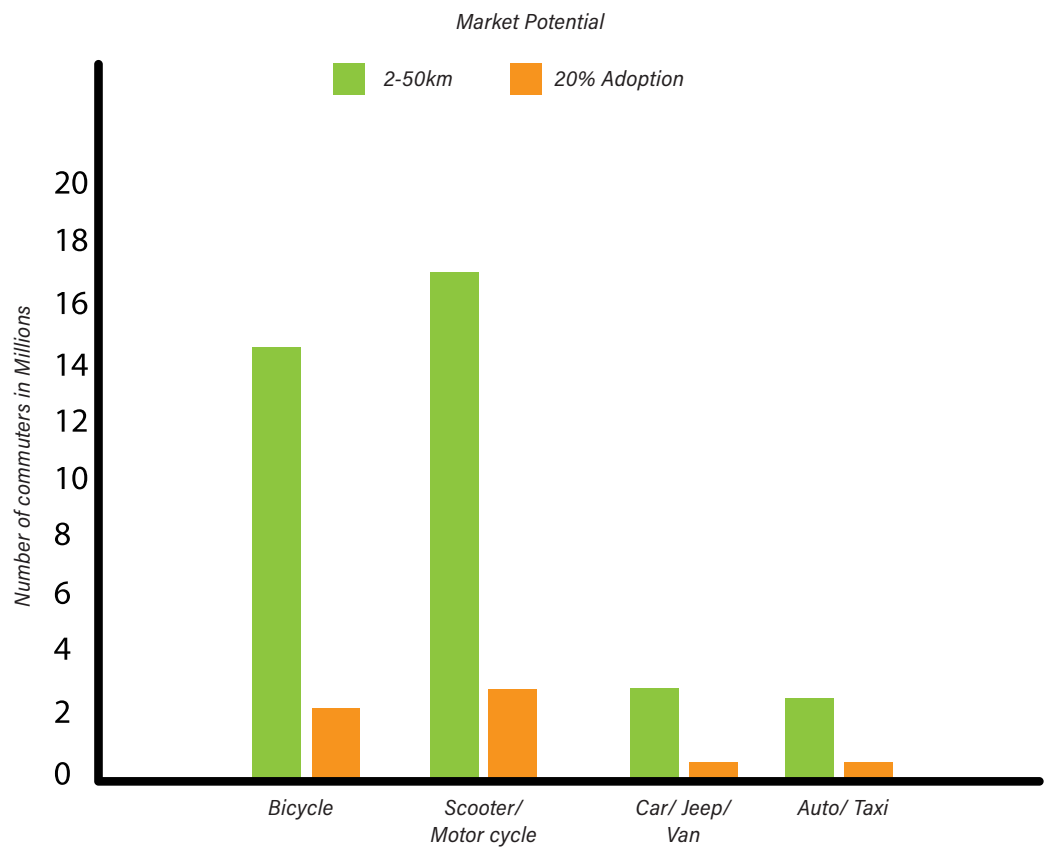


Graph.13. No of Commuters within 20km range in various modes



Graph.14. No of Commuters between 20-51km range in various modes

From Graph.14., it can be seen that still around 1.3Mn people uses their own bicycle to reach office till 30km while there is no usage of bicycle post that which is again obvious due to distance factor. Having said that, the %age of usage of personal 4 wheelers is maximum in 50+km range at 39% between all these four modes. The following figure will give an idea of market size of each mode in total between 2-50km range for daily commuters.



Graph.15. No of Commuters between 2-50km in various modes

Hence from the above, we can see that highest potential lies in Electric 2W segment (including bicycles) where around 33Mn commuters own their own vehicle. With 20% adoption rate of the same we can easily reach the Government of India FAME target of 6Mn vehicle by 2020 can be achieved and crossed. With others included (at 20% adoption rate) around 8Mn electric vehicle can targeted in all the above four sectors. The public sector (cabs and autorickshaws) with 20% adoption rate, there is an opportunity of having around 7,20,000 units of electric 3 wheelers, and 4-wheelers on road.

CONCLUSIONS

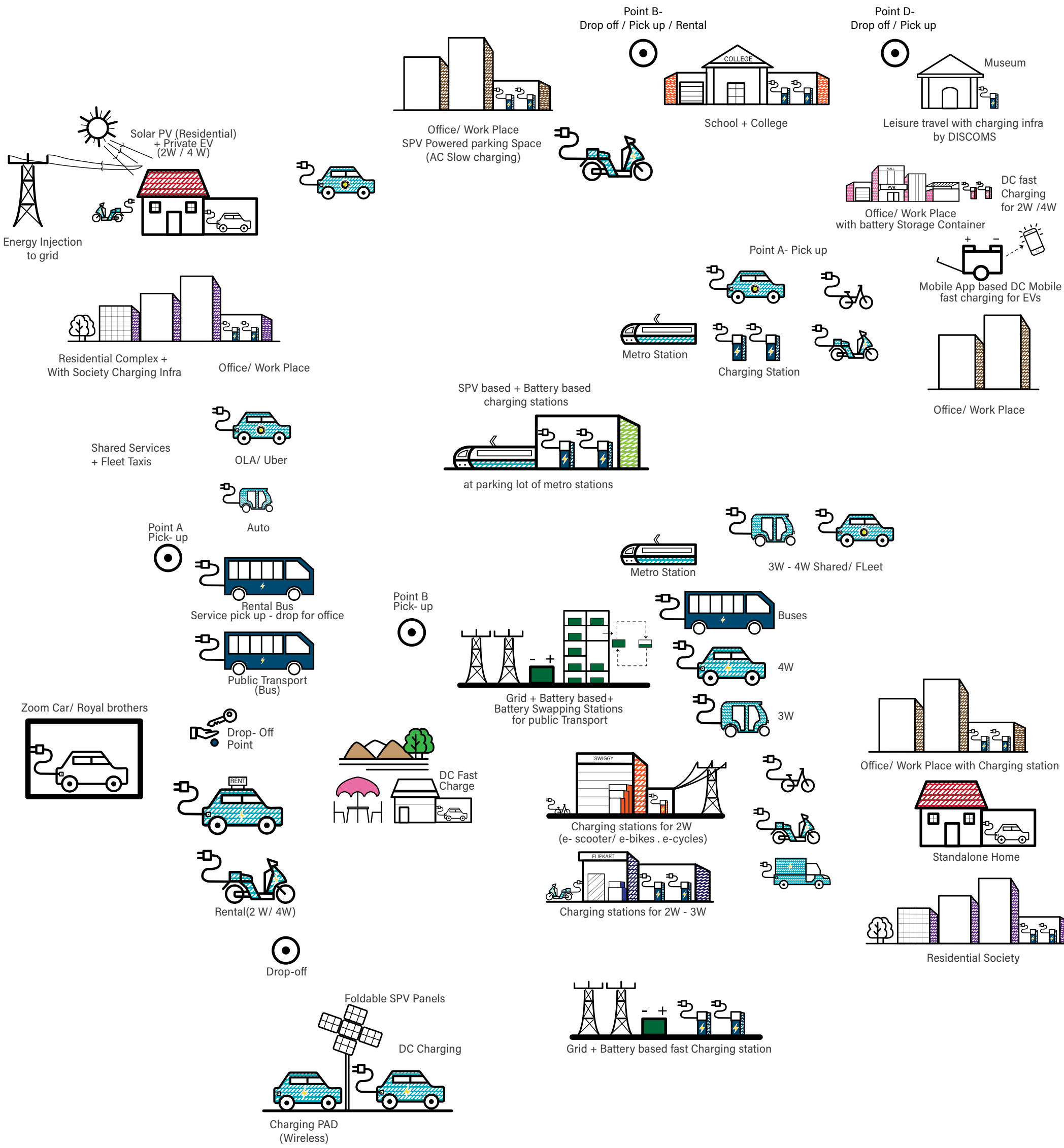


Fig 21: Electric Vehicle Scenario in future

As discussed in the beginning of the report, vehicle ownership is expected to grow at 775% by 2040 which is clearly a huge potential for EVs. With a strong consumer-led demand growth, we see EV ownership in most Tier-II and Tier-III cities and towns will go hand in hand with the spread of decentralized renewable energy (mainly rooftop solar PV) and storage. We are hoping to see fast charging (<1hr) capabilities with high energy density (more kWh/kg) batteries with smarter energy management systems for not just EVs but overflowing into home appliances which will revolutionize the DRE and EV market as a whole. The new self-reliant EV customers will have their own 2W and/or 4W which will be charged at their homes and offices either through the grid or through rooftop solar PV systems not depending on any public infrastructure to be setup. With development of modular battery technology, these customers will have the opportunity to leapfrog into a distributed RE future where EV batteries can be used for energy storage and households will be able to provide the utility services for grid stability by sending energy to the grid based on demand.

The tale might be slightly different in Tier-I cities where housing societies and rented homes are more prevalent. In Tier-I cities shared charging infrastructure or norms for community ownership might need to come up or see a strong eco-system of public charging stations before EVs are taken up. Installation of private and public charging stations in societies is already happening in places like Palo City, California where a new ordinance has been passed which requires all new apartments, hotels and commercial buildings to now come with electrical hook-ups in place for the "easy installation" of electric vehicle charging equipment and/or have the equipment itself in place[64] . The same thing can be adopted in Tier-I cities of India where large number of multi-family residential apartment buildings are being constructed, but, there might be a simpler solution for us to get started. We are hoping that infrastructure developed in Tier-I cities to support B2B logistics and delivery players, last-mile connectivity providers and public transport providers might act as the initial anchors for the shared charging infrastructure (ala telecom towers for energy access in rural India). Consumer vehicles which need charging on their way, can use these charging stations through a PAYG or subscription model adding revenues to the EV-CS service providers and addressing range anxiety issues for consumers. One will be able to request a quick DC fast charging for their vehicle. The chargers will either be a mobile unit having battery packs or simple stationary flow batteries to charge the car battery within minutes (<30min). In urban spaces like shopping malls who might not have enough provision for charging stations, can have a PAYG on-demand mobile charging services for vehicles parked inside their parking area. Mobile charging as a service can provide convenience to urban consumers for scheduling of charging at a convenient location or in emergency scenarios if stranded without a charge.

We believe mobile charging on demand will be equally popular in rural and semi-rural areas. In rural India today, diesel generator sets are used by energy service providers for various social and religious ceremonies or local mandis where electricity is unreliable. The same service providers can diversify their business in providing PAYG services for EVs in those areas. In-semi rural and rural areas, where the share of 2Ws is high, apart from residential charging stations, shared charging stations run by local shops in mandis (markets) might come up where people will pay per use to the charging station owner similar to how mobile charging happens today. These micro EV-CS have the opportunity to utilize DRE and storage to ensure reliability or use the services of micro-grids in their community adding to their viability. Given that typical uses for mobility in rural areas is around connectivity to regional district headquarters and for potentially transportation of produce or procurement of goods, we believe the penetration of EVs beyond 2W would need introduction of light and heavy duty EV vehicles and the charging infrastructure to go with it.

64 https://insideevs.com/palo-alto-now-requires-new-apartments-condos-hotels-etc-ev-charging-ready/

In the B2B segment, the most important challenge will be time and place of charging to drive peak asset utilization rates. Last mile eCommerce and logistics companies like Flipkart and Amazon or even big logistics companies like DHL and Blue Dart will set up their own charging / swapping stations at their central hubs and also in few of their strategically located forward hubs. The setting up of charging station will not depend on whether they are asset heavy but will depend on how much distance (hence delivery) each unit needs to cover per day to provide the best return on investment. We do not expect these organizations to create shared EV-CS infrastructure unless dictated by a need for driving up RoI. The stations can either be set up by themselves or even run by a third party with potential partnerships with EV / EV-CS OEMs or DISCOMs. The stations with higher frequency of EVs can be connected with the national grid through large battery storage where energy will be stored for the use of DISCOM as per need. DISCOMs can use these charging / swapping station storage units as their decentralized source of power to cater to local loads (less distance hence less distribution loss). B2B delivery companies like Swiggy and Scootsy on the other hand can work with EV-CS service providers and large customer locations to develop shared charging infrastructure for example in office parks and malls from where they do pick-ups for restaurants and stores.

Unlike logistics and delivery cos., fleet operators, rental car cos. and last mile logistics providers have a strong business case to capture the shared EV-CS market to capture the customers that use their own means of transport. Fleet operators presently do not own any assets (Ola/Uber) and we expect them to be asset free in future too. With the potential of EVs dominating their fleets (let us assume 70%), they will have to have get into long term contracts with charging / swapping infrastructure providers to have smart access of charging infrastructure along their route. These companies have the opportunity to work with EV-CS service providers and public parking space providers like metro-stations, airports, malls, tourist hubs, office spaces and housing societies to develop shared charging stations that could benefit commuters or tenants and improve the economics.

We expect 2W and 4W rentals for short-term use to increase with increasing number of people travelling in public transport like metro, local trains for office and leisure. Most rental companies own their asset and we expect them to develop and maintain EV-CS infrastructure for not only point to point pick-up and drop or daily/weekend/weekly rentals but also shared ownership (Zoom car Zap program) and cars on lease based on consumer demand.

Unlike, B2C sector, the food delivery and logistics sector, distance capping works well. Here the vehicles usually travel a fixed maximum distance per day with an increased amount of 10-20% during peak seasons (festivals/weddings etc.). Hence if some organization wants to be asset light, there are three options: Operating lease, PAYG and subscription model. 3Ws PAYG model won't work as PAYG model tenures are less (daily to monthly) and hence will not be economical for OEMs.

For delivery companies (2W and 3Ws), who wants to own assets, it is best to go for Financial Lease wherein they have the option of owning the asset post lease tenure and also avail tax benefits due to lease period. The only capital cost, the companies might have to bear is the cost of new battery for replacement if required. For other cases, PAYG or Subscription model will be best for 2Ws as the daily / monthly payment will be fixed as per distance travelled per day (hence per month). Extra capping of 20% per year can be added to make up for festive sales.

CUSTOMER	MODELS				
	Direct Sale/EMI	Operational Lease	Financial lease	PAYG	Subscription Model(Yearly)
B2B 2W(Food + Logistics 2W)					
Financing	Usual interest rate @18% p.a. for 3 yrs i.e. around ₹2,500-3,000 per month	OEMs lease out vehicles based on distance travelled per month	OEMs/ Financial institutions lease out vehicles based on distance travelled per month	Payment based on distance travelled per day	No less than ₹3,000 per month with distance capping (km/month)
Loan Tenure	18-36 months	12-36 months	12-36 months	1-130 days	12-36 months
Post lease Benefits	Delivery Comp. Ownership	OEM Ownership	Delivery Comp. Ownership	OEM Ownership	OEM Ownership
Distance Capping	No	No	Yes/No	Yes	Yes
Tax Benefits	No	Yes	Yes	No	No
O&M	Delivery Comp	OEMs	No	OEMs/Customers	OEMs
B2C(Logistics 3W)					
Financing (Assuming Rs 4 Lakh per vehicle)	Usual interest rate @12% p. a. for 5 years i.e. around ₹8,000/ month	OEM lease out vehicles based on distance travelled per month	OEMs/ Financial Institutions lease out vehicles based on distance travelled per month		Based on distance covered per month or the entire tenure
Loan Tenure	12-84 months	36-60 months	36-60 months		12-60 months
Post lease Benefits	Delivery Comp. Ownership	OEM Ownership	Delivery Comp. Ownership		OEM Ownership
Distance Capping	No	No	Yes/No		Yes
Tax Benefits	No	Yes	Yes		No
O&M	Delivery Comp	OEMs	No		OEMs

Table .13. Pros and Cons Different Model for B2B Food and Logistics sector

CUSTOMER	MODELS			
	Direct Sale/EMI	Operational Lease	Financial lease	Subscription Model(Yearly)
B2B 2W(Fleet)				
Financing		OEMs lease out vehicles based on distance travelled per month	OEMs/ Financial institutions lease out vehicles based on distance travelled per month	OEMs/3rd party will provide EVs to fleet operators on yearly subscription based on distance travelled per month
Tenure		36-60 months	12-84 months	12-36 months
Post Tenure Benefits		OEM Ownership	Delivery Comp. Ownership	OEM/3rd Party Ownership
Distance Capping		No	Yes/No	Yes
Tax Benefits		Yes	Yes	No
O&M		OEMs	No	OEM/3rd Party
B2C(Rental 2W/4W)				
Financing	Interest rates @10-12% p.a. i.e. around ₹15,000/month for 4Ws and around 18% interest rate @ ₹3,000/month for 2Ws	OEM lease out vehicles based on distance travelled per month	OEMs/ Financial Institutions lease out vehicles based on distance travelled per month	Only for 2W segment. Based on distance covered per month or the entire tenure
Tenure	12-84 months	36-60 months	36-60 months	12-36 months
Post Tenure Benefits	Delivery Comp. Ownership	OEM Ownership	Delivery Comp. Ownership	OEM Ownership
Distance Capping	No	No	Yes/No	Yes
Tax Benefits	No	Yes	Yes	No
O&M	Delivery Comp	OEMs	No	OEMs

Table.14. Pros and Cons Different Model for B2B Fleet and Rental sector

B2B sectors in public transport may seem similar but, if we observe closely, both are quite different. The fleet operators tend to be asset light while the self- driving rental business is mostly asset heavy (Zoom has 2,200 cars running across Bengaluru, Mumbai, Delhi, Pune, Chennai, Hyderabad and Chandigarh and plans to have more than 25,000 cars across 25 cities by 2018.[65]). According to industry experts, the intra-city taxi market is bound to be dominated by Ola and Uber, with barely any room for a third business to spread its wings. Thus, the scope of a self-drive car rental start-up is constricted to leisure rides within the city and inter-city travel.

Keeping in mind the above, we can see the best options for fleet operators (4Ws) would be Operational Lease or Subscription model. There's no point of having financial lease because of two things: 1) there might be a distance capping per month for lease payments depending on the contract and 2) Fleet operators will like to stay asset light. Hence, the post-tenure benefit of taking the ownership of the vehicle doesn't make sense.

For the rental segment (2W and 4Ws), companies like zoom car, royal brothers all have their own vehicle. Presently they own and maintain them. For 2Ws, since distances are usually fixed (point to point), kilometre capping works well. With reduction in CapEx (no upfront payments) and AMC on OEMs, subscription and operational lease will work best for these service providers in the long run.
For 4Ws new models of EVs can be tried out for a period of 1year to 3years depending on requirement through operational lease model while rest can be done through financial leasing where the ownership lies with the rental company. Since, inter-city, long distance or leisure travel is mostly the target, distance capping won't work. Hence, to reduce initial CapEx burden, rental companies can go for financial lease for a certain period. During the Leasing period, they can also enjoy tax benefits.

Against the backdrop of the different business models of EV adoption, the following models will depict the best possible options for various segments of EV users

65 https://insideevs.com/palo-alto-now-requires-new-apartments-condos-hotels-etc-ev-charging-ready/

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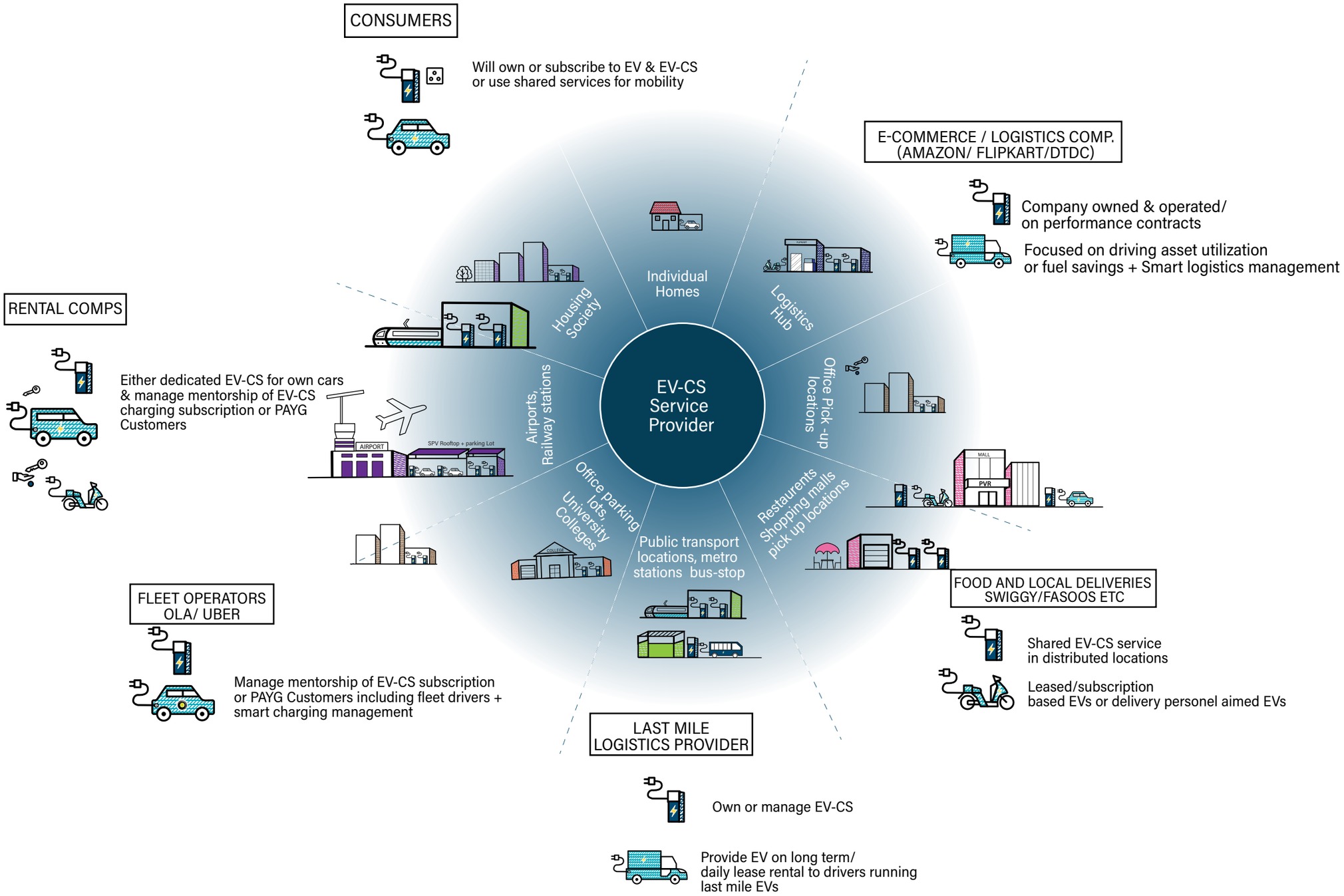

Fig 22: TIER I City Model

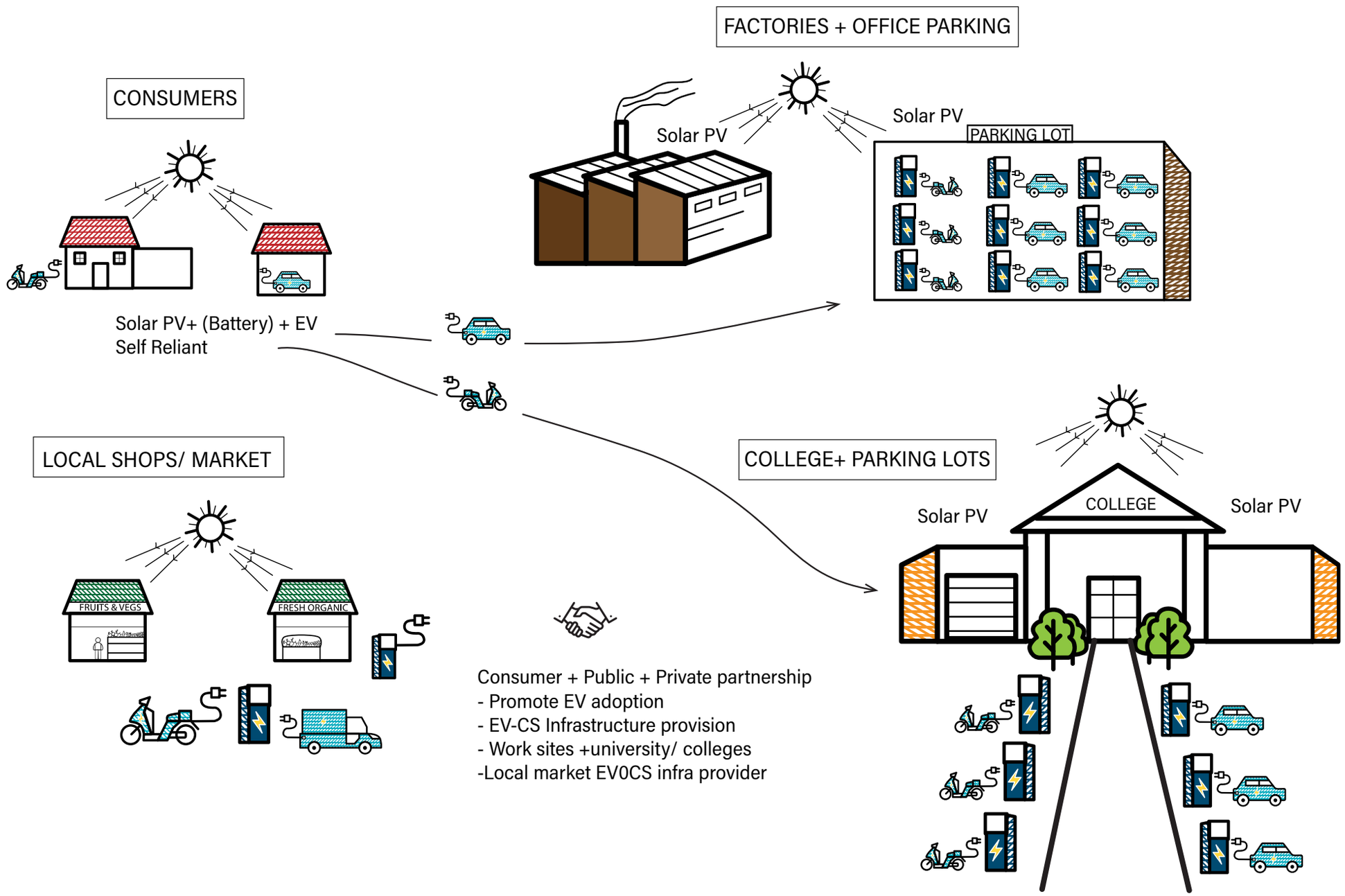

Fig 23: Tier II and Tier III City Model

PARTING THOUGHTS

Suppose all goes well and we have the desired number of EVs on road, then what's next? How will this new electric driven future look like? How will the utilities behave with so much EV integration and power requirement from EVs? Will we able to use EVs as storage too? Will we be able to do inter-city travel? Who will provide charging infrastructure in highways? How will the residential society charging infrastructure look like? Will people be able to use their charging stations at home as a mode of an extra income? Will the utilities' REC requirement be fulfilled by putting up renewables powered charging stations? Will we be able to charge EVs within minutes? How many petrol /gas stations can be converted into charging stations? How will the rural or semi-rural EV market develop? Is it possible?

For EV adoption, we have given our perspectives of various ways for it to be successful and sustainable, in this report till now. Many more can be added as we move forward, with better technological developments and innovative business models. At Sangam, we believe all this is possible. As Dr. A.P.J. Abdul Kalam once said, "You have to dream before your dreams can come true."

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