DEP 302 Design Studio

Systems Design

Atish Waghwase

Vanshaj Kumar

Zaid Khuram

PRESENTATION 4 OBJECTIVE

Narrow down our project scope and work on design guidelines. Come up with design objectives of each subsystem to that will constitute the final system

Recap

RECAP

SECONDARY RESEARCH

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Customer perception towards electric two-wheeler innovation

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Abstract: The research paper titled a study on customer's perception towards electric two-wheeler. The objective of the study is to identify the factors that influence electric bikes purchase. Explanatory research is applied using convenience method of sampling with 145 respondents. The tools used of the study is frequency analysis, independent T-test, one-way ANOVA, regression analysis. It is found that factors related to customer perception are charging time, a smaller number of models, distance travelled for one full charge and environmental concern.

Keywords:customer perception,two-wheeler

INTRODUCTION

The innovation of internal combustion engine is one of the best creations of humankind. The vehicles that we use nowadays may give us a good performance but are the major cause for poor efficiency and environmental pollution across the country.

The basic objectives of the study are to analyse consumer perception towards Electric two wheelers and for improving B2B sales of Electric Two wheelers and to identify the means to enhance the consumer awareness level towards electric vehicles. An Exploratory research was conducted with a sample of 50 respondents conveniently selected from Chennai City. A structured questionnaire was administered to capture the primary data from the selected respondents.

Even though in each Bharat Stage (BS) level they try to decrease the fuel consumption and carbon emissions they cannot completely get rid of that. So, decreasing the fuel consumption and carbon emissions are the most important goal among the present-day plan across the globe.

For the future of the country, an efficient and eco-friendly electric two wheelers are designed and manufactured. This study is based on customer's perception towards electric bikes in Chennai city with a sample of 145 respondents. The study concludes that that people's perception about the product is negative but with the support coming forward from the Central govt. and ever-increasing prices of petrol, sooner or later the electric bike industry is going to grow drastically.

While the market's abounds in motorbikes, electric bikes will soon be the mode of commutation for almost every household. Electric bikes are like ordinary bikes just that they run on chargeable batteries instead of fuel. These bikes have a motor that is activated by a throttle. These bikes are struggling to stand in the market, despite their popularity. Electric bikes usually have different kinds of batteries, these vary according to the total charge, capacity, voltage, etc. The charging takes about 8 hours for full charge, but people are working on this. The noise of these electric bikes is almost negligible and when turned to high speed it sounds like a spaceship.

Electric bikes and bicycles alike serve many purposes in our world. Some are considered a tool with which the rider makes a living or a mode of transportation with roots in a cleaner technology. For others, it simply serves a recreational or leisurely purpose or as a way to experience the world around them. With over one billion bicycles in the world and 40 million of them expected to be electric bikes by 2023, it is incredible to see how far electric bikes have come and just how far they can take us.

Today, worldwide production and usage of electric bicycles is steadily rising with riders new and old integrating ebikes into their lives. With the assistance of an electric motor, biking is now considered more accessible to riders of all ages and backgrounds. Even mountain biking is growing in popularity due to the addition of ebikes and fat tire bikes, making it possible for more people to participate in the sport. Commutes by bike that would be too far, too long, or too slow are made possible with an ebike. Many other modern ebikes are designed with city riding and commuting use in mind. With the benefits, comfort, and efficiency of ebikes, combined with the componentry and infrastructure designed to get people from point-A to point-B, many riders have adopted an electric bike for day-to-day city riding.

In addition to people's day to day transportation, electric bikes offer a cleaner alternative of transport for commerce and products. With cargo bikes and commercial trikes revolutionizing the way commerce flows, no

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Electric vehicles adoption: Environmental enthusiast bias in discrete choice models

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ABSTRACT

A Stated Choice (SC) survey, employing a Best-Worst choice design, was administered to 440 households in Perth, Australia as part of a major investigation into consumer preferences and attitudes towards electric vehicles. It was noted that 48 (10.9%) respondents chose EV as their best/most preferred option across all six choice replications. We hypothesise that for most of these respondents their choices reflected their desire to present themselves in a favourable light, with social desirability biasness manifested in non-trading behaviour. There were also 24 (5.5%) respondents who chose EV as their worst/least preferred option. We hypothesise that for these respondents lack of interest or confidence in the new technology and inertia may have driven their decisions. The paper offers demographic and psychographic profiles of non-traders facilitated by additional items being included in the experiment. While there was little difference between the demographic profiles, the attitudinal scores of the non-traders were significantly higher than for traders, which may indicate social desirability. Non-traders (Best) scored significantly higher on environmental concerns and subjective norms and were more likely to rate their intention to purchase and use an EV higher. Conversely, non-traders (Worst) had the lowest environmental concerns and subjective norms. From a choice modelling perspective, keeping non-traders in the estimation biases the taste parameters and therefore the willingness-to-pay (WTP) measures. However, when incorporating the worst alternatives into the choice models, the 'social desirability' non-traders do appear to be making decisions based on the attributes, which is consistent with the rest of the sample.

1. Introduction

The recent revival of electric vehicle (EV) technology is in its early days and in markets like Australia the number of EV's on the road is very small. With limited real market data available, stated choice (SC) experiments have emerged as a popular tool to study the factors influencing the uptake of EVs. Typically, this involves participants being presented with a set of vehicle and fuel alternatives (including the EV) and choosing their preferred alternative by trading-off key attributes such as purchase price, running costs, environmental performance, safety, range, and refuelling/recharging considerations (Kurani et al., 1996; Dagsvik et al., 2002; Hess et al., 2006; Lieven et al., 2011; Ziegler, 2012; Bühler et al., 2014). This information can in

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You are what you drive: Environmentalist and social innovator symbolism drives electric vehicle adoption intentions

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ABSTRACT

Electric vehicles (EVs) have the potential to dramatically reduce vehicle emissions contributing to climate change without significantly reducing convenience or mobility. Despite their potential, EV market share remains low, necessitating research to identify factors that could encourage more widespread adoption. For instance, concern about climate change is associated with intent to adopt an EV, but little is known about mechanisms through which this concern may translate into action. This study builds on previous work investigating the roles of symbolic and instrumental attributes in low-emissions vehicle adoption, focusing exclusively on EVs to better understand perceptions associated with their unique technical capabilities. Prior work has examined symbolism rather generally (e.g., in terms of status). We examine specific aspects of self-identity that EVs may reflect, representing the extent to which consumers perceive EVs as symbols that they are environmentalists and/or social innovators. In addition, extending prior work, we quantify the relative influence of these separate aspects of symbolism on EV adoption intentions alongside instrumental, psychological, and demographic factors. We find differing impacts of these two symbols on EV adoption intentions. Environmentalist symbolism is consistently the strongest predictor of adoption, across three dependent variables. Innovator symbolism predicts willingness to lease/buy an EV, trailing only environmentalist symbolism in effect size, and outperforming instrumental attributes as well as psychological and demographic factors. Additionally, we examine a potential mechanism through which concern about climate change may translate into EV adoption intentions: we find that seeing EVs as environmentalist and social innovator symbols partially mediates the relationship between concern about climate change and EV adoption intentions. These results have implications for EV marketing and policy, and suggest that emphasizing the potential for EVs to reinforce specific self-identities may be a more promising strategy to increase adoption rates than emphasizing instrumental attributes such as fuel-efficiency.

1. Introduction

Significant reductions in anthropogenic emissions of greenhouse gases, including carbon dioxide, are necessary to stem climate change and its associated consequences (Allen et al., 2009; Meinshausen et al., 2009). In the United States (U.S.), the transportation sector accounts for roughly 28% of all greenhouse gas emissions, with light duty vehicles making up 62% of

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RECAP

PROBLEMS DEEP DIVE

RECAP

ADDRESSING ‘WHAT IFS’

What if there is a power cut?

- Privatized electricity supply
- Battery rental services with fully charged batteries
- Public charging stations with emergency power back up when required.

What if there is no charging station nearby?

- Home charger comes free with EV
- Battery renting with home delivery

What if the Charging cable is on the other side of the port?

- Standardization of charging cables and port placement
- port placement accessible from both sides
- long cable?

What if the user cannot park the vehicle close to residence? How will it be charged?

- Get verification from govt. for installing a semi-private charging spot at the desired location, will have guidelines on ownership and time alottment
- Allow applications for public chargers to private and public manufacturers.
- Community website to put up applications for charging stations.

What if petrol has become more expensive and people can't afford EVs?

- cycle chalao -_-
- Biometric authentication to start vehicle. Add biometric markers of all users.

What if a user gets locked out of a 'smart' vehicle?

- There is a backup key
- Biometric authentication to start vehicle. Add biometric markers of all users.

What if users reach a charging station but it is all occupied?

- System that shows the soonest available charger, worker plugs your EV in after that
- Shows estimated waiting time on Google Maps so user is prepared before hand for any delay or will make plans ahead of time.

What if the user wants to make a long journey asap?

- EV app that suggest the route based on where the user would like to charge (stations, malls, restaurants, etc)
- Battery rental services to provide fully charged batteries when needed

What if the user cannot afford a new battery when battery health has deteriorated?

- Schemes for recycling old battery and subsidizing new battery
- Buyback scheme

What if third party business are not willing to invest in EV chargers?

- Private individuals can open up small scale EV charging stations and increase visibility through Google Maps

What if users are overly cautious about over charging and battery health?

- Built in smart charging to fast charge to 80% and then slow charge to 95% (or whatever other method is optimal)

What if the users destination is farther then the vehicles range?

- Increased spread of public charging infrastructure.
- Association with Google Maps to increase visibility of businesses with public chargers

What if manufacturers are not willing to invest heavily in the EV market because of competing sales with their ICEV counter parts?

- Supply side incentives to encourage more profits from EVs
- Government regulations (like China) could require manufacturers to produce certain % of EVs per year.

What if power of EV is insufficient for heavier people and heavy drivers?

- Power management options for power at the cost of efficiency

What if the charger at the charging station is not compatible with the E2W?

- Standardised hardware for EV charging set up by the government
- Charger models will become part of local language and knowledge. People will enquire about charger type before stopping.

What if battery longevity isn't as advertised?

- Certification and testing for battery longevity
- Battery health checkup facilities at service stations

What if climate conditions affect battery and range isn't as estimated?

- Companies will have to allow for flexible range promise based on circumstances and usage.
- With increase in charging infrastructure and charging speed, people will not be worried about exact promised range unless majorly different.

What if second hand E2W are too risky to buy?

- Business that certifies battery health
- People will trust official certificate

What if the user forgets the E2W is plugged in and rides off?

- Placement of the charging port such that it's very evident, such as where the fuel tank would have been
- Beeping or light indicator of being plugged in
- EV doesn't start without unplugging
- Magnetic (Magsafe) connector that would automatically pull off when pulled away with force. No damage done.

What if the user cannot remember if they plugged in the E2W?

- some reminder notification before users sleep time
- vehicle beeping if not plugged in at night
- automatic plug in when parked
- Battery percentage monitoring from phone to check if battery is charging or battery charge status

What if users don't believe that EVs are more sustainable then ICEVs?

- Awareness campaigns to increase visibility of EVs
- Government incentives and regulations to increase EV usage. Advantages on roads for EV users like special EV lanes, or prime access to traffic prone areas.
- Monetary incentives to buy EVs through subsidies
- Increase hype about EVs through social media. Word of mouth recommendations of Independency from middle east oil.

What if the the user wakes up and sees no charge in their EV?

- Foolproof and safe overnight charging system
- Public EV battery renting banks

What if there is no authorized service station nearby?

- 24x7 roadside assistance is offered, the OEM sends a tow truck during warranty period
- Self diagnose kits, repair kits can be delivered to be installed with the help of a technician

What if the battery gets damaged in an accident?

- New battery at a discounted price in exchange of old battery (which will go through recycling)

What if a certain area has non renewable electricity supply?

- Solar energy remains a viable option
- Privatized electricity supply

RECAP

BROAD LEVEL IDEA GENERATION

Home Charging
Quick release (magsafe) safety charging
Foolproof and safe overnight charging system
EV doesn't start without unplugging charger
Multiple charging pins on vehicle
Standardized charging hardware
Cable management for parking lots
Battery
Removable battery ergonomics for battery swapping
New battery at a discounted price in exchange of old battery (which will go through recycling)
Battery buy back program from companies for recycling old batteries

Business Opportunities
Battery health checkup facilities at service stations
Public EV battery renting banks
Battery renting with home delivery
Battery charging shops to swap fully charged batteries
Privatized electricity supply
Rental Service for last mile connectivity. Reinforces public transport use
Exchange schemes with manufacturers to sell ICEVs and buy EVs
Public Policies
No parking charge for EV vehicles in City Centres + increase parking charge for ICEVs
Uncertainty of E2W range can be used as an advantage by the government to promote public transport for longer journeys.
Special EV lanes for faster traffic

Public Charging Stations
Public charging stations becoming a business feature
Private individuals can open up small scale EV charging stations and increase visibility through Google Maps
Shows estimated waiting time on Google Maps so user is prepared before hand for any delay or will make plans ahead of time.
Booking for charging stations before hand.
Emotional Connect
Haptics and sound simulation of MT for enthusiasts
Modes like efficiency, balanced and performance for increased electricity efficiency based on usage
Promoting Silent riding / silent engine as a feature for youth

Charge Management
System that shows the soonest available charger, worker plugs your EV in after that
Charge management tool/app for travels
Remote monitoring of vehicle battery and charging status
Innovative Features
Theft prevention through manual override and tracking
Keyless authentication becoming a norm
Parental Speed controls
Biometric authentication to start vehicle. Add biometric markers of all users.
Regenerative braking in E2W
EV app that suggest the route based on where the user would like to charge (stations, malls, restaurants, etc)

Areas of Interest

AREAS OF INTEREST

LISTING THE POSSIBILITIES

Haptics and sound simulation of MT for enthusiasts	System for battery buyback, exchange and recycling
Battery renting and swapping	Battery Charging mechanism for minimum obstruction
System to increase adoption of public chargers by third party businesses and private individuals	Removable battery ergonomics for battery swapping
Booking and pre-booking system for public chargers	Rental Service for last mile connectivity. Reinforces public transport use
Battery health and charge monitoring system	Incentives to increase EV transition
Making Home Charging convenient and easy to use	Remote EV monitoring and control
Installation and repair of Home chargers	Regulations in public spaces for EV transition
Public chargers business workflow (space design)	Redesigning infrastructure for an EV era

Evaluation

EVALUATION

REAL - WIN - WORTH

IDEA	REAL	WIN	WORTH	TOTAL
Haptics and sound simulation of MT for enthusiasts	1	9	1	11
Making Home Charging convenient and easy to use	9	3	9	21
Installation and repair of Home chargers	9	3	9	21
Removable battery ergonomics for battery swapping	9	3	3	15
System for battery buyback, exchange and recycling	3	1	3	7
Incentives to increase EV transition	9	1	3	13
Public chargers business workflow (Space design)	9	9	3	21
Redesigning infrastructure for an EV era	3	3	3	9
EV mechanism for minimum obstruction	3	9	3	15
System to increase adoption of public chargers by third party businesses and private individuals	9	1	9	19
Battery renting and swapping	9	3	3	15

EVALUATION

CHARGING INFRASTRUCTURE

IDEA	REAL	WIN	WORTH	TOTAL
Haptics and sound simulation of MT for enthusiasts	1	9	1	11
Making Home Charging convenient and easy to use	9	3	9	21
Installation and repair of Home chargers	9	3	9	21
Removable battery ergonomics for battery swapping	9	3	3	15
System for battery buyback, exchange and recycling	3	1	3	7
Incentives to increase EV transition	9	1	3	13
Public chargers business workflow (Space design)	9	9	3	21
Redesigning infrastructure for an EV era	3	3	3	9
EV mechanism for minimum obstruction	3	9	3	15
System to increase adoption of public chargers by third party businesses and private individuals	9	1	9	19
Battery renting and swapping	9	3	3	15

Problem Identification

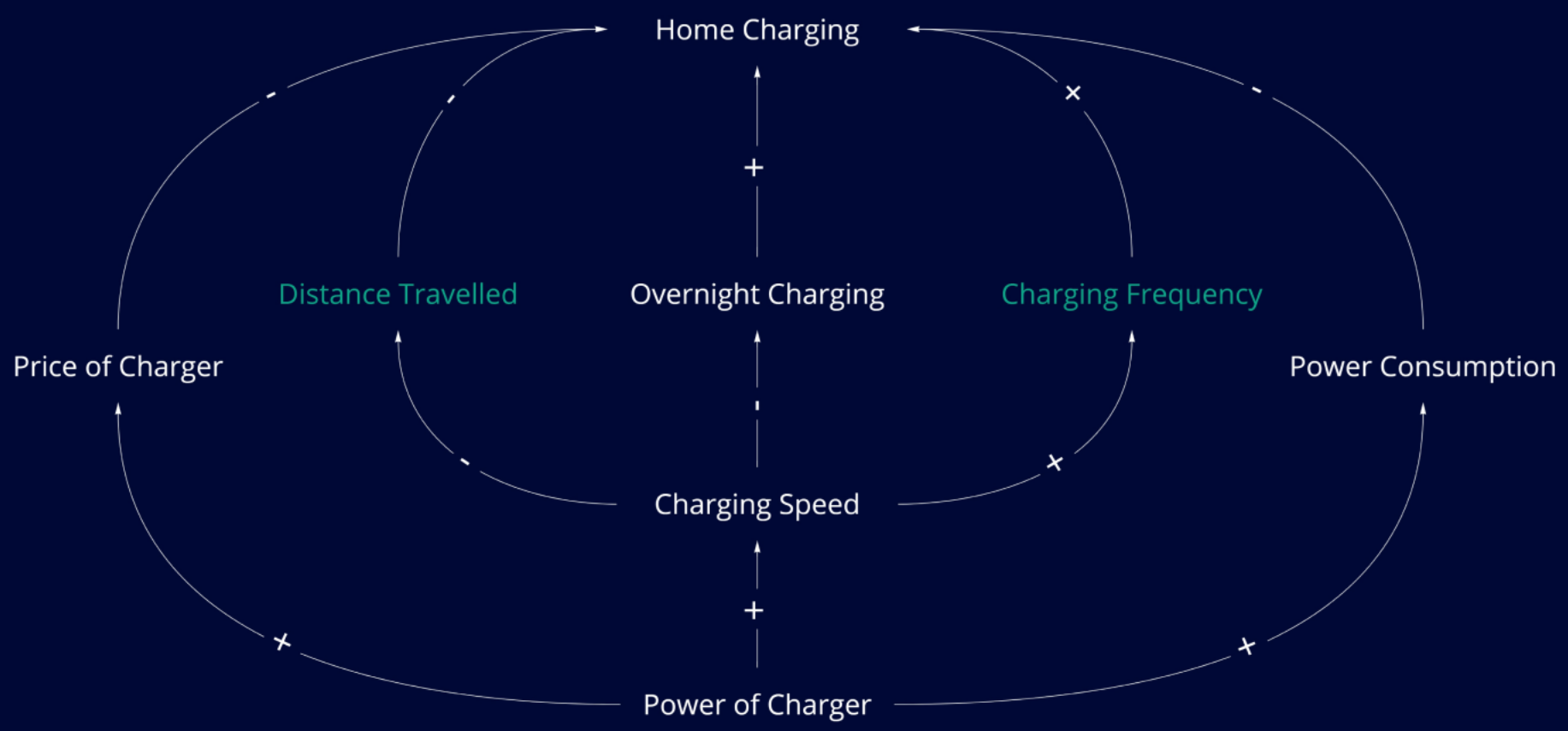
PROBLEM IDENTIFICATION

SCENARIOS

- Overcrowded parking lot with cable clutter
- Slums with milti storey houses
- Teenager that does chores for the family and attends classes
- Delivery-persons of supermarkets and restaurants
- Using of E2W for reaching the last mile from public transport hubs
- Middle class commuter who does spontaneous short trips
- People who carry heavy items on a two wheeler
- Online delivery services like Zomato that use E2W throught the day

PROBLEM IDENTIFICATION

CAUSAL DIAGRAM



PROBLEM IDENTIFICATION

ANTICIPATING PROBLEMS

Making Home Charging convenient and easy to use

- Uncertainty of what plug gives 15A
- Power meter built into plug, shows how fast it will charge
- Common meter connection of basements or ground floors with other neighbours
- Charging lock
- Reduction in life cycle due to charging malpractices
- Sharing EV chargers with neighbors. Who pays for the electricity then?
- No upfront cost of battery, contract like iPhone
- Forgetting to plug in the EV
- automatic plug in system when EV is detected
- Wireless charging at parking locations
- Weather proofing guarantee isn't standardised
- cable management
- coiled cable
- Requirement of extra plug connection to charge EV
- Charging through double stand? or even side stand?

Installation and repair of Home chargers

- Requires specialised workforce to install EV charger
- Self Installation tool kit
- Charging cable stored within EV that plugs directly into outlet. No extra 'charging infrastructure' required at home
- Uncomfortable with constantly keeping it outside
- Takes up space set up and store
- Trolley charger that can be stored within the home when not in use
- Mass charging overnight will exert load on the city's electricity supply
- Wattage capping at certain hours to manage increased demand for electricity

PROBLEMS

POSSIBLE SOLUTIONS

Public chargers business workflow (space design)

- Is there a need for a 'watchman' while EVs are charged?
- online payment and charger locked in while charging will not require regular monitoring
- Car parking is already a rare commodity in India
- Public space will be occupied for duration of charge. Difficult to find in city centres
- All Parking spaces have an accessible EV Charger
- EV charger that is small, discrete, not costly to set up for all heavy traffic parking areas
- Locating public charing spots on the road
- Distinct signage for parking spots with EV charing availablilty
- app to show all public chargers around
- Payment defectors. Customer may charge and leave without making payment
- pre-set charge amount entered by worker only after payment is done. If battery is fully charged before pre-set amount, money is returned.
- Drive In Cafes/Restaurants
- Option for Prepaid/Postpaid parking
- People might not know how much time they want to spend at a public charging venue
- concerns about source of electricity
- Solar panels set up above fuelling stations as an additional source of power for charging

Design Guidelines

DESIGN GUIDELINES

GROUPING GUIDELINES

Charging Station Design

All parking spaces with EV charging features must be **strictly reserved for EVs only.** An increase in these spaces (especially in high traffic areas) will help create awareness of EVs and possibly become a factor for its purchase.

Parking space organisation such that a single EV charger can reach multiple parking spaces.
- With the help of manual management (valet persons), charging can be queued and efficiency of charger optimised.
- An algorithm could be developed to execute the installation of such stations based on space available and configurations.

With limited parking spots inside the city and the constant demand throughout the day in city centre, introduction of facilities like **valet charging services** or **multi-story EV car parks** would be effective to cater to high traffic and demand.

Rules for places that don't have a proper parking, chargers should only support E2Ws or else people wanting to park EVs in the correct orientation will cause a commotion of the road.
- Make there is sufficient area for a E4W to park and go back without disturbing the road traffic before setting up charging spots and other facilities
- If there isn't sufficient area to ensure well organized charging, demarcate a charging space using markers beforehand, and make sure it complies with the local transport rules. Give preference to fast chargers.

Charging Stations should be located in **well lit areas and preferably slightly populated.** This will make users feel safe in leaving their EV to charge while they use the facilities.

The **height of a charger** should be such that it is visible even if another vehicle is parked in front of it; one should be able to know the total number and location of all chargers in a parking space easily.

Charging Stations should have an invertor like **emergency electricity supply**. This will make sure that a few dozens vehicles will be able to charge even after an electric power cut.

Encourage people to put the charger back in place after the charging is done. Cable management should be easy enough for people to keep it such that it is not lying on the ground.

Charging Station Location

Public charging at all **transit hubs** i.e metro stations, central bus stations should have type2 or higher chargers available.
- Possibility to make charging at these stations free will help stimulate the use of public transport for longer travel as well.
- Will encourage the use of EVs for last mile connectivity

Users should have ability to **apply for a new charging station** location based on demand. This would be helpful for users who do not have a private parking space or have more demand of chargers in some neighbourhoods.

Public Charging Stations should **not be more than 1.5kms** away from any area inside the city. This would be especially important for lesser developed areas of the city (slums, unorganised housing) where home chargers would be very rare.

Charging Stations should be located at **main roads or hotspots** (crossroads) to increase visibility and accessibility. People would be less likely to drive in to smaller lanes to access a service.
- This would also make sure that the area could handle the increased traffic of vehicles due to the charging station
- If the parking is near a commercial area then people will be able to spend their time doing chores while their vehicle is charging

User Lifestyle

Consumer Level

If vehicle is used for **daily commute**, users can pick an E2W since charging can happen at home and there is no need to rely on public infrastructure

If daily distance travelled is **less than 60kms** (average E2W range) for daily commute, users would be **more likely to use home chargers** that would top up the battery overnight. Can use slow chargers as well as fast chargers.

If daily distance travelled is **more than 60kms** (average E2W range) for daily commute, users will be dependent on **charging during the day** and would then have preference for fast chargers. Look for fast chargers in your locality or at your workplace

Administrative Level

With increase in home charger and E2W, **electricity usage during the night** will increase massively for the charge of electric vehicles. This could be handled by directing power towards residential zones of the city from the industrial or office areas, catering to the growing user base naturally.

Indian public in general would be skeptical about leaving vehicles to charge in public. Some form of safety features like **locking mechanisms** or a **security service** while being charged would be highly effective to gain trust.

User Interactions

Charging stations would be accessible to a wider range of the Indian public by having human assistants or **attenders to help first time users**, disabled or senior citizens in charging and making the transaction.

Visual stimulus for connection made and charging has initiated. Will help users avoid any misconnections.

Prepaid payment systems for public chargers would allow for faster movement of traffic and completely automated transactions. For rare customers who are unable to use online payment to top up their accounts, can pay cash to partner vendors and top up their account (similar to prepaid cellphones).
- Possibility of automated vending systems to transfer cash to credit (is already used in ticketing stations and have greater awareness)

Separate visual identities for types of chargers at charging stations to allow users to recognise compatibility. Will also be recognisable from distances.

People may be unaware of power output from different outlets. To solve this, software on the EV (or app) can **show the estimated time to full charge** based on power input to make users aware of charging speed.

Charging Type

Plug In Charging

The option to **plug in** your EV to charge will always be an option. This would be enough for casual users who can work within the max range of the vehicle.
- Type 2 and Type 3 chargers will only increase convenience with speed.

Development of Type 2 and Type 3 public charging stations is recommended as it will also attract third party business to be set up in its vicinity. **Real estate value** around fast charging stations are likely to increase.

Type 1 chargers (with relatively slower speed) would be common for home chargers. Type 2 and Type 3 chargers can be sold to third party business as a **commodity / features** to attracts customers as well.

Any **private investor can set up public charging stations** (level 2 or level 3) as a new business venture.
- Would be recommended to set up smart chargers to reduce maintenance cost of attenders by allowing them to be fully automated.

Users would not mind **Type 1 chargers at their homes** as charging would most probably happen through the night after which they would be topped up for the day. Not networked (or dumb) chargers would make cost even lesser for private chargers.

Battery Swapping

Certification of public battery swapping banks, all publicly swapped batteries will be certified and checked for health.

For users that travel more than 60kms per day (average E2W range), such as delivery agents, **battery swapping subscription** would work out faster, cheaper and more convenient
- Suppose a person has subscribed to the battery swapping subscription then he'll not have to replace the battery after 4-5 years, but for this the cost of swapping batteries can be slightly higher then recharging the dedicated one.
- A user can subscribe this while buying a vehicle so they don't have to spend extra money on the dedicated battery.
- If already bought an EV with a battery and wants to switch to swapping subscription then your dedicated battery would be returned to the company and based on its condition user would be discounted for the subscription.

Battery Swapping would be ideal for users who use the EVs throughout the day and have minimal time to plug into charging outlets. It would also allow be a much quicker task than to wait to top up using a plug in charger.

Charging Accessories

The introduction of **adapters** to allow charging across charging stations with different hardware specification

In case the range requirement is very high or the user needs to make spontaneous long trips, **portable battery banks** can be installed inside the boot space or at the back so that the user can extend battery life at the cost of seating space.

DESIGN GUIDELINES

GROUPING GUIDELINES

- Charging Station Design
- User Lifestyle
- Charging Type
- Charging Station Location
- User Interaction
- Charging Accessories

DESIGN GUIDELINES

DESIGN OF CHARGING STATIONS

Parking space organisation such that a single EV charger can reach multiple parking spaces.

- With the help of manual management (valet persons), charging can be queued and efficiency of charger optimised.
- An algorithm could be developed to execute the installation of such stations based on space available and configurations.

DESIGN GUIDELINES

CONSIDERING USER LIFESTYLE

Consumer Level

If vehicle is used for **daily commute**, users can pick an E2W since charging can happen at home and there is no need to rely on public infrastructure

If daily distance travelled is **less than 60kms** (average E2W range) for daily commute, users would be **more likely to use home charger**s that would top up the battery overnight. Can use slow chargers as well as fast chargers.

If daily distance travelled is **more than 60kms** (average E2W range) for daily commute, users will be dependent on **charging during the day** and would then have preference for fast chargers. Look for fast chargers in your locality or at your workplace

Administration Level

With increase in home charger and E2W, **electricity usage during the night** will increase massively for the charge of electric vehicles. This could be handled by

DESIGN GUIDELINES

TYPE OF CHARGING

Type 1 chargers (with relatively slower speed) would be common for home chargers. Type 2 and Type 3 chargers can be sold to third party business as a **commodity / features** to attracts customers as well.

Any **private investor can set up public charging stations** (level 2 or level 3) as a new business venture.

- Would be recommended to set up smart chargers to reduce maintenance cost of attenders by allowing them to be fully automated.

Charging Station Location

LOCATION OF PUBLIC CHARGERS

Public Charging at all **transit hubs** like metro stations, central bus stations should have type2 or higher chargers available.

- Possibility to make charging at these stations free will help stimulate the use of public transport for longer travel as well.
- Will encourage the use of EVs for last mile connectivity

Users should have ability to **apply for a new charging station** location based on demand. This would be helpful for users who do not have a private parking space or have more demand of chargers in some neighbourhoods.

Public Charging Stations should **not be more than 1.5kms** away from any area inside the city. This would be especially important for lesser developed areas of the city (slums, unorganised housing) where home chargers would be very rare.

Charging Stations should be located at **main roads or hotspots** (crossroads) to increase visibility and accessibility. People would be less likely to drive in to smaller lanes to access a service.

- This would also make sure that the area could handle the increased traffic of vehicles due to the charging station

DESIGN GUIDELINES

USER INTERACTION

Charging stations would be accessible to a wider range of the Indian public by having **human assistants / attendants to help first time users,** disabled or senior citizens in charging and making the transaction.

Visual stimulus for connection made and charging has initiated. Will help users avoid any misconnections.

Prepaid payment systems for public chargers would allow for faster movement of traffic and completely automated transactions. For rare customers who are unable to use online payment to top up their accounts, can pay cash to partner vendors and top up their account (similar to prepaid cellphones).

- Possiblity of automated vending systems to transfer cash to credit (is already used in ticketing stations and have greater awareness)

Separate visual identities for types of chargers at charging stations to allow users to recognise compatibility. Will also be recognisable from distances.

People may be unaware of power output from different outlets. To solve this, software on the EV (or app) can **show the estimated time to full charge** based on power input to make users aware of charging speed.

DESIGN GUIDELINES

EV CHARGING ACCESSORIES

The introduction of **adapters** to allow charging across charging stations with different hardware specification

In case the range requirement is very high or the user needs to make spontaneous long trips, **portable battery banks** can be installed inside the boot space or at the back so that the user can extend battery life at the cost of seating space.

Systems Design

SYSTEMS DESIGN

CHARGING CONNECTORS

Should be usable by E2W with any and all connector types

- Provide cable attatch to station so users do not need to carry cable of their own, remove to charge, and fold when done
- Have adaptors built in to the station so users can customise the connector to fit the outlet in their EV

SYSTEMS DESIGN

PARKING LAYOUT AND QUEUING

Optimising parking spaces for minimizing wait times and ensuring better usability and convenience

- E2W and E4W should have separate charging spaces for better space efficiency and better organization
- All chargers will have indicators on availability status
- System for queuing based on ETA
- One charger will be present between two parking spaces so the person next in queue can park their vehicle

SYSTEMS DESIGN

PAYMENT SYSTEM

Creating futureproof, yet inclusive automation payment systems

- Automated payment systems that work on prepaid credit like Fastag to streamline payment and allow for smart features such as algorithmic queuing and management
- Contingency payment options such as loans and availability of an attender to act as a transactor

SYSTEMS DESIGN

SECURITY AND MALFUNCTIONS

Making the charger secure and contingency solutions in cases of charger malfunctions

- Clearly communicated and implemented standardized security measures to deliver peace of mind to the user
- Adapters and accessories will have additional security standards
- Backup guidelines in account for malfunction of chargers to ensure fair treatment of pending queue jobs

FUTURE PLANS

WHAT NEXT?

- Make a model charging station that incroporates all of the subsystems into one whole cohesive system
- Ensuring the system is foolproof by addressing all the ‘what ifs’ and future proofing
- Showing that the current set of guidelines are deployable and to make them accessible by all

feedback pls