Major Research Project on

Building an Efficient EV Infrastructure and its integration with Renewable Energy Sources

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CERTIFICATE

This is to certify that the dissertation report titled "**Building an Efficient EV Infrastructure and its integration with Renewable Energy Sources**", is a bonafide work carried out by Mr. Ankur Varshney of MBA 2019-21 and submitted to Delhi School of Management, Delhi Technological University, Bawana Road, Delhi-42 in partial fulfilment of the requirement for the award of the degree of Master of Business Administration.

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Place:

Date:

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DECLARATION

I, Ankur Varshney, student of MBA 2019-21 of Delhi School of Management, Delhi Technological University, Bawana Road, Delhi – 42, hereby declare that the dissertation report "Building an Efficient EV Infrastructure and its integration with Renewable Energy Sources" submitted in partial fulfilment of Degree of Master of Business Administration is the original work conducted by me.

The information and data given in the report is authentic to the best of my knowledge.

This report is not being submitted to any other University, for award of any other Degree, Diploma or Fellowship.

PLACE: Ankur Varshney

DATE:

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Ankur Varshney

Abstract

This paper basically talks about the steps that Indian auto industries are taking to completely revolutionize the Indian automotive industry. The special focus on the Indian market is because of the fact that India being one of the largest markets of motor vehicles. The company which will cater to the needs of such a big population will get humongous lead in this new Technology market. This paper talks about the current scenario, the opportunities and the challenges which the companies will face while trying their hands in this market.

Few years ago, a mobile device manufacturer known as Micromax said “We will bring a complete disruption in India’s 21 million two wheeler market”. Sometime back Micromax was one of the leading sellers in the mobile market. They made use of cheap manufacturing process and various efficient techniques to produce the electric vehicles at a cost efficient rate. It did not went as expected and the coming of Chinese brands like Xiaomi, Micromax’s market share went down to 2%. The companies are now betting on electric vehicles (via. Economic times). Over the recent years, seeing that the EVs’ sale has picking up the pace, the companies are molding themselves by learning, through the experiences, to achieve the perfection. Therefore, their dynamic performances, the range, the recharge autonomy, and passive safety have recently reached the performance of traditional vehicles, powered by Internal Combustion Engines (ICE). In parallel to the use of various environment friendly techniques, astonishing growth has been seen in the recharging methods of these vehicles and their commercialization. Unfortunately, following the academic literature pertaining to the present research, but also the reality reflected by the public opinion there are traditional purchasing barriers for electric vehicles (He, et al, 2019, O Neil et al, 2019). The cost of investment is very high, in addition to the cost, there are various other factors like the less effective quality of performance, the range anxiety of the customers, non-availability of proper recharging infrastructure, these factors are still in their initial phase and these factors determine the buying behavior of the customers.

TABLE OF CONTENTS

1. Introduction

1.1 Background

Early in the 21st century there were few players who tried their hand in the field of newly created market known as Electric Vehicles such as Tesla Motors in the United states, Think in Norway, BYD in the China and REV in India. The buying behavior of the electric vehicle has come out to be a very contentious in recent times. The companies have launched one or more Electric Vehicle model and have moved one step ahead to completely transform the auto industry. This paper basically talks about the steps that Indian auto industries are taking to completely revolutionize the Indian automotive industry. The special focus on the Indian market is because of the fact that India being one of the largest markets of motor vehicles. The company which will cater to the needs of such a big population will get humongous lead in this new Technology market. This paper talks about the current scenario, the opportunities and the challenges which the companies will face while trying their hands in this market.

Few years ago, a mobile device manufacturer known as Micromax said "We will bring a complete disruption in India's 21 million two wheeler market". Sometime back Micromax was one of the leading sellers in the mobile market. They made use of cheap manufacturing process and various efficient techniques to produce the electric vehicles at a cost efficient rate. It did not went as expected and the coming of Chinese brands like Xiaomi, Micromax's market share went down to 2%. The companies are now betting on electric vehicles (via. Economic times). Over the recent years, seeing that the EVs' sale has picking up the pace, the companies are molding themselves by learning, through the experiences, to achieve the perfection. Therefore, the dynamic performance, their range, the reacharging capabilities and the safety are matching with those vehicles operating internal combustion engine. In parallel to the use of various environment friendly techniques, astonishing growth has been seen in the recharging

methods of these vehicles and their commercialization. “Unfortunately, following the academic literature pertaining to the present research, but also the reality reflected by the public opinion there are traditional purchasing barriers for electric vehicles (He, et al, 2019, O Neil et al, 2019).” The cost of investment is very high, in addition to the cost, there are various other factors like the less effective quality of performance, the range anxiety of the customers, non-availability of proper recharging infrastructure, these factors are still in their initial phase and these factors determine the buying behavior of the customers. The growth rate of electric vehicles is very slow and it has not reached to the position it is destined to be, with the expected speed. The companies are not coming forward in terms of innovating their business policies and so far have not able to remove or even reduce the barriers in the adoption of this technology. This is why the environment is degrading day by day through high CO2 emissions and will continue to suffer in the coming years.

Pollution in the surroundings is one of the most important concerns today, the world is facing. The toxic smoke emission from the engines is one of the basic reasons behind this havoc. In order to reduce this emission and to address the concern of the environment, electric vehicle are being introduced all over the world. Various government are motivating their people to make transition from currently operating engine to the electric engines and for that they are providing subsidies to the customers and giving benefits to the manufacturers as well. The government of India has decided the goal of “only electric vehicles” on road till 2030. Some factors which makes this study important are:

- **Gold Fever**

  Micromax is not alone. There is a gold fever or gold rush afoot in everything relating to the EVs. Every company include all the public to the multinationals establishments to the new ventures and the newbies in the market to the experienced one, are in the line. Country’s EVs trailblazer, Reva Founder Mr. Chetan Maini, is all set to start his new project, sun mobility. Sahara’s Evols is also set to launch its

products in the market such as E-Scooter, bikes, chargers as well as batteries. There are some other companies as well who have previously tries their hands in the similar fields like Vineet mishra's who mainly deals in the two or three wheeler electric vehicles and another such company is a startup named as "lithium urban" which has also tried similar kind of business to provide services to corporate people. Mahindra Electric and Hero Electric, already with an EV Portfolio, are upgrading their products. Various other companies will launch their electric vehicle products this year as well. These companies include "Tata Motors", "Maruti Suzuki" and some others as well.

- **Green Ride**

EVs provide with an opportunity which is once in a lifetime. The Auto Industry today is facing all-round disruptions due to various reasons and the most affecting reasons is the increasing pollution, crude import bill and the energy security is one of the reason for the disruption. With EVs, as an alternative, will provide ease to the government, people and to the every other person concerned. Smart entrepreneurs provided by the government incentives gives a golden opportunity. EVs can also become the marker of the shifting world order. The West dominated the 20th century i.e. mainly the US and the Europe. From the last Decade, China has emerged as one of the car's largest market and china hopes to help its home companies to lead in the market of EVs. Today, the world's attention on EVs is disproportionate. Of the total passenger vehicles sold in 2018, around 2.5% of those were electric vehicles. The number of electric vehicles on the road today is very less but the experts in this domain are of the view that the tilt towards this technology is unavoidable.

1.2. Problem Statement

Will Charging Infrastructure Support EV Adoption?

We need an efficient and accessible charging infrastructure that can recharge the vehicle in an affordable period of time, Most of the motor enthusiast will not be interested in buying the vehicle even if its performance is better and product is

cheaper. Because the risk of having a powerless vehicle is very large when we talk about the infrastructure that is laid down in the countries like India where there is minimal of the facilities available w.r.t. the infrastructure.

If the electric vehicles have to be successful there would be an development of an efficient charging stations which should be accessible to all, easy to use and should not be too expensible than their alternative fuels. But the dilemma is that there are various charging methods available and there are various in the pipeline as well but there are no consensus on what an effective charging infrastructure would be like in the near future. There is less certainty of things today than it was years ago, because batteries used to be smaller at that time than today and and they were relatively inexpensive to charge.

The Problem statement poses various questions:

- "What are the charging options that are, and may become, available? What are their costs?"
- "How does the speed of charging infrastructure affect its commercial viability?"

In order to solve these problems, we need to setup a financial model that should be simple that would highlight these problems and the factors affecting the charging infrastructure. We will focus on the cost of building and the installation of the charging equipment on the roads and the cost of supplying the electric power to them and the amount of revenue require reaching the break even and we will also include the opportunity cost of the time spent in waiting for EVs to charge. We will conclude by addressing various economic challenges which will highlight the problem of the load management in the case if there is high EV penetration and will discuss cases for further research.

All over the world, the government is trying hard to tackle the problem of the air pollution and its emissions by investing various resources to minimize it. In order to achieve this goal will require both sectors i.e. the private and public sectors to come

together and invest in various forms of the clean energies. This will require the conversion of the conventional houses to some smart houses and into electric vehicles (EVs). For this there is necessity to integrate various renewable sources like wind, solar, photovaoltaics with electric vehicles. With this there will another opportunity to decabonise the transport sector. If we go by stats then it is observed that around 10-15% of global greenhouse gas is emitted through transportation sector. There are various clean technology which will reduce the emissions through the transportation sector. This work concentrates on EV adoption integrated with RES.

1.3. Objective and the scope of the study

1. **To check the feasibility of EVs in the Indian market:** This will be achieved by the facilities provided by the company and the government for to new technology like charging stations, subsidies etc.

2. **To analyze the current working in the field of EVs:** This will be achieved by the steps take up by various organization in the recent times.

3. **Will Charging Infrastructure support EV Adoption-** We need an efficient and accessible charging infrastructure that can recharge the vehicle in an affordable period of time, Most of the motor enthusiast will not be interested in buying the vehicle even if its performance is better and product is cheaper. Because the risk of having a powerless vehicle is very large when we talk about the infrastructure that is laid down in the countries like India where there is minimal of the facilities available w.r.t. the infrastructure.

4. **Can EVs be integrated with renewable energy sources like Solar Energy, Wind energy etc.**

2. Literature review

2.1. India's Drive

India will have to make its own path. Its EVs numbers are small- it sold around 7.5 lakh vehicles in FY19, dominated by two wheelers (around 16%) and three wheelers (around 84%) (PwC Report,2019). India's EV Journey is resisted by multiple factors. For eg. If you take cost economics, The price sensitivity in this technology can be estimated through the sale of small cars and more than half of its sale comes from the 5-6 lakh segments and if maruti plans to launch its most popular small car, Wagon-R, then the price difference in both the segment i.e. the petrol version and the electric vehicle version and the gap will of somewhere about the price of the petrol version car. This means that the price will go double of small cars also. The most expensive affair in this EV variant is the battery and the limited variant availability is also one of the other factors. Electric vehicles growth in India will be reaching around 5-6% till 2030s and then will increase sharply to around 30% till 2040s, says a report by Bloomberg. While putting out huge promises on EVs, India must find a solution to other obstacles as well. Power availability would surely be the one.

"I am in Mukteshwar. We just got 7 hours of power in the last four days says Vishnu Mathur, director general of society of Indian Automobile Manufacturers (SIAM). NITI Aayog wants to set deadline for 2023 and 2025 to go for 100% electrification of two- and three- wheelers respectively.(NITI Aayog,2019)"

"In Delhi, Power facility is different but outside, power network may have significant constraints both on the grid infra and supply side", says Sanjay Banga, CEO, Tata Powers DDL. But one of the biggest problems in the growth of electric vehicles in India is the non-availability of the EV atmosphere ranging from the availability of the important components required for the production of the vehicles like motors, batteries etc. to the improper charging facilities.

"We need to build out our EV Ecosystem. There is big gap between government's statements and implementation" says Maini.

2.2. Deloitte's Estimation

A report from Deloitte suggests that after couple of years the price of both the engine vehicles run by the petrol and diesel and the electric vehicles will be equal. With this one of hurdles will be removed in the expansion of electric vehicles in India and then electric vehicles will be more viable option for the customers. There are some of the major reasons identified that will make an impact in the success of the electric vehicles in India like customer's brand experience i.e. in which brand customer feels comfort, next is the strategy of the production, next is right talent acquisition and the last one is the operating model of the business.

The companies must have to invest their resources in the modernization and the advancement in the technology to become successful in this technology. This can happen through working on the modern business techniques and through partnerships and the mergers as well which collectively can find the right direction. The vision should be focused on the long term strategy because it will take some time to make its place in the existing market.

For startups and the new entrants also, a similar approach is required. There are various strength areas a company or a new entrant should be looking at while entering into this business such as confidence, capital availability, innovation and experience.

With the current environment where demand for an EV is high, markets are open to adopt this new technology, constant innovation and funding in this technology, will help increase the pace of growth of these vehicles.

There are two factors through which the EV market is driven by, first is the **Policy Regulation** and other is the **Customer Demand**

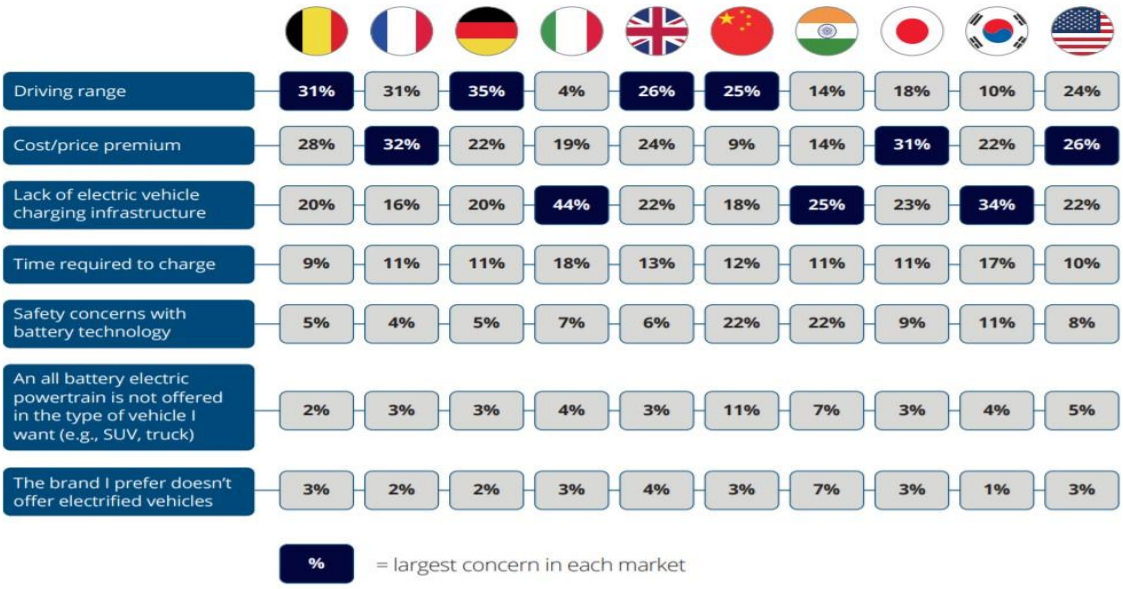
2.2.1. Policy Regulation

There are various policies that both the companies and government should look into, companies should ease up their policies which encourage customers to purchase these cars and the government should announce some policies for the companies so that the producer is encouraged to invest in this new technology like subsidies and availability of the parts at a cheaper rates.

2.2.2. Customer Demand

The policies provided by the government are not enough for the customers to switch towards the electric vehicles. There are some other factors on which customer emphasizes on like efficiency of the technology, range of driving, running cost per km, exteriors and the interiors and the picture below perfectly depicts the majors issues faced by the customers in various countries in the adoption of electric vehicles.

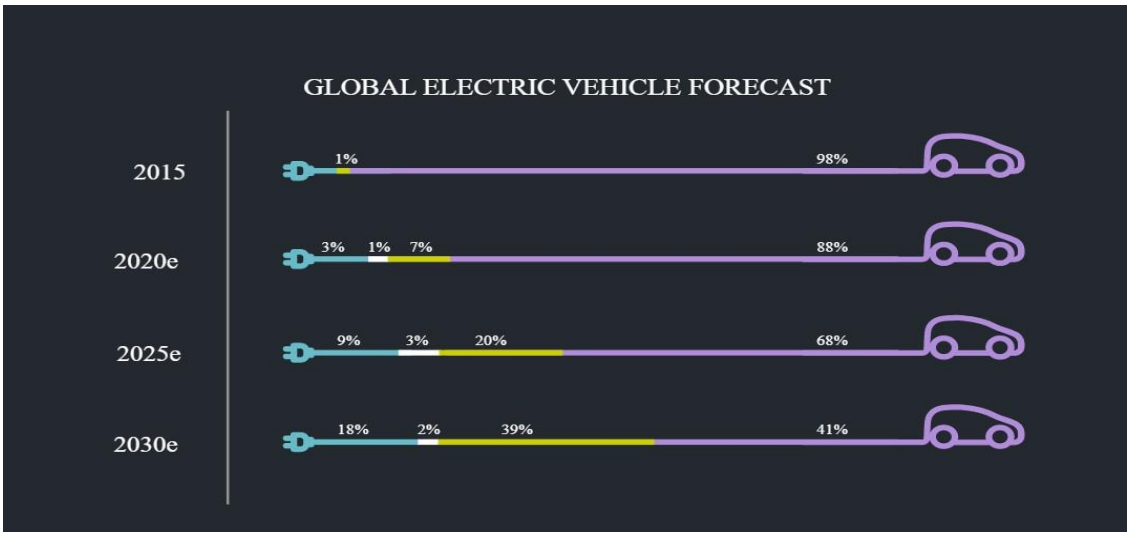
Figure 3. Customer concerns regarding battery electric vehicles



Source: Deloitte Global Automotive Consumer Survey 2018

A report by J.P Morgan says that the number will increase to approximately 10 million vehicles or around 10% of the total market share. The increase is remarkable but not that good as are needed in today's scenario but the situation is about to change as the forecasted number says the number will jump tremendously to around 30 million vehicles

or around 25% of the total sales around the world.



In the region of Europe and some parts of America, hybrids electric vehicles will be the most attracting vehicles for the customers. In major parts of Europe the electric vehicles will see a tremendous increase which is a good sign. In Asian countries as well hybrid electric vehicles will grow faster than the plug in electric vehicles as plug in will increase at around 8% and the hybrids will see the increase of around 30% of the total sales. India needs to look into the fast introduction of this technology in its country because of major two reasons as compared to America and Europe. First is the level of carbon di oxide emissions in India which is greater than America and second is the tighter fuel economy regulations as India is the fuel importing country so it has to look into this aspect as well.

"Over time, the fundamental specific research has strived to dismantle the negative arguments of adopting electric mobility invoked obsessively by potential users or by detractors, including the causes of range anxiety (Patt, et al., 2019). Regarding this subject, new business models for e- mobility should enable us to examine the relative impacts of different purchase factors with different policies, technology development and prices (Schwartz et al., 2017)." The fear of range anxiety is one of the major issues that majority of the customers don't travel the maximum range provided by the full charge also. This fear is because of the fact that most of them doubts of battery used up fully before recharging it. This fear of range anxiety is affecting the customers when it comes to

purchase the electric vehicles. “Range Anxiety introduces the idea that the buyers are psychologically sensitive to the limited range of an EV (Noel et al., 2019).

The range anxiety is defined as the driver’s fear of remaining stranded on the road before arriving to the location due to an empty battery (Salah&Kama, 2017).” The debates have been around from a very long time regarding the desired efficiency as compared to the relatively high cost of the electric vehicles. The desire performance is not at par if we talk about in the current scenario. The anxiety is the result of the undesirable efficiency and the high cost of the car. “A similarly paradoxical situation was registered in 2011 in America where only a few persons had a real interest in analysing and understanding the differences between new hybrid and electric cars (Cholia, 2011). On the other hand, a survey from 2018 stipulates that 83% of the respondents would buy an electric vehicle when they have to change the classic one (Fossdyke, 2018). However, other examples of surveys demonstrate the inconsistency in questionnaire answers due to different competent research standards (Wittenberg, 2016). There are a lot of debates between academicians and practicians regarding competent standards for research (Dima, A., & Vasilache, S. 2016). The other type of consumers are also present who have the required knowledge and the experience, who are likely to understand the importance of electric vehicles and the those who thinks that this is the most viable option for the future. Therefore, these consumers are willing to pay a premium for e-mobility (Jin & Slowik, 2017). Regarding the most influential barriers for purchasing an electric car, there are several factors that influence this process, such as: EVs are expensive, public recharging infrastructure is poor, batteries are not enough technologically developed (Carley, 2013). The techno-scientific research has a relatively linear time dependence concerning the producing an electrical vehicle and the generation of the electricity necessary for charging it (Busu M. et al, 2019).”

2.3. Hypothesis

“In Delhi, Power facility is different but outside, power network may have significant constraints both on the grid infra and supply side”, says Sanjay Banga, CEO, Tata Powers DDL. But one of the biggest problems in the growth of electric vehicles in India is the non-availability of the EV atmosphere ranging from the availability of the important

components required for the production of the vehicles like motors, batteries etc. to the improper charging facilities.

H(1): EV Market proliferation relates directly with the power facilities provided by the country.

There are various policies that both the companies and government should look into, companies should ease up their policies which encourage customers to purchase these cars and the government should announce some policies for the companies so that the producer is encouraged to invest in this new technology like subsidies and availability of the parts at a cheaper rates.

H(2): EVs Growth relates directly to the ease in the policies provided by the country.

Customer's confidence is also a dependent variable with respect to the analysis of the launch of the technology in the market. Customer's Confidence depends on various factors such as what is the efficiency of the technology, how many and where are the service station installed in case if the service break down, what power facilities are provided because if you see you have oil station installedatevery2-3kms.

2.4. Implications for energy transitions

With the coming of the electric vehicles there are great advantages of the energy transitions which have occurred with the replacement of combustion engine vehicles and the greenhouse gases emissions have been comparatively lesser which in turn effect the environment positively.

The advantage of Electric vehicles when it comes to Greenhouse gas emissions is very clear but the advantage will be much greater when the EV growth in the country runs parallel with the improved power supply methods.

The type of fuel in the transportation sectors contributes majorly to the amount of the green house gas emissions. For e.g. the European union contributes to the total of around 31% of the total final energy consumption out of which it emits 20% of the total greenhouse gas emission. Observing this croatia has decided to put out a directive in which it has decided that each member state by 2020 itself should achieve a minimum share of the renewable energy in the total final energy consumption in the transportation sector by 10%. The country has also published "Energy strategy" which has proposed to achieve a total production of 20% of the total renewable energy sources in the total energy consumption by 20% which means that in total energy consumption in Croatia, 20% of it will be in the form of renewable energy sources. The achievement of these goals will hugely depend on the promotion of the electrification in the transportation sector and that electrification should be done by the renewable energy sources. Because of the production of electricity through the renewable energy resources and that corresponding energy system should include reserves as well for energy storage. Promotion of the electric vehicles will provide a required capacity of the chargers which are connected to the grid, which will provide new possibilities to connect the renewable energy sources in the power systems. In this study we have analysed the investment required and the scheduling the distributed energy resources. Renewable energy sources can prove beneficial to the individual because they will reduce the electricity prices in the short run as shown in the case study carried out in Germany. The two technologies can be useful for each other's survival as the electric vehicles will provide as system which will provide storage of huge amount of electricity which is being produced by the renewable energy sources and RES already have proved to be a cost effective manner of producing the electricity and will prove to be a clean way for the electric vehicles energy supply. "EVs can represent the containers of the electricity that might be connected to the grid in order to supply the power system during the lack of electricity production from RES, what is also known as a Vehicle-to-Grid (V2G) model.

3. Methodology

According to the review done earlier, it is very much clear that the acquisition of the electric vehicles in India depends on various factors like cost of the vehicles which is twice of the value of the conventional cars, range problems for the customers, the charging infrastructure, the charging time and the compatibility of different chargers while charging the car, the efficiency of the car in terms of the performance, knowledge and the experience of the buyers of the technology. By analyzing all these problems we have noted down various anxieties for the customers:

- "The fear that one will not be able to reach its destination due to the depletion of the battery (ie "distance anxiety")."
- "The fear that a charging point cannot be found anywhere and at any time, or that the machine's power cord plug may be incompatible with the target charging socket outlet (ie "charging anxiety")."
- "The fear that due to unpredictable situations the working agenda on that day could be disturbed (ie "anxiety of aggravation of the everyday program)."
- "The fear that overloading the utility network could interrupt the operation of home lighting and electrical appliances- such as a refrigerator, air conditioning, TV, computer, etc. (ie "anxiety of damage")."
- "The fear that the car coupled to the power outlet would not be charged (or "hazard anxieties") or could cause a fire in the car (ie, "anxiety of fire")".

3.1. Content analysis

This research is basically carried out to find out the ways to effectively build an EV infrastructure because EVs are going to increase in the near future in India as well and we cannot welcome the electric vehicles with an ineffective charging ecosystem so that there would not be any problem concerning the recharging of the battery and for that effective charging ecosystem we would need sufficient power supply and the sufficient production of the energy. For that what we can do is we can integrate the charging infrastructure with the renewable energy sources so that we would not deplete our

natural resources which are non-renewable and produce sufficient energy. This would result in several benefits mainly of the environment because if generate energy through renewable energy sources then we can save our natural resources and second is benefit of the environment because diesel/petrol cars produce various harmful gases which are polluting the environment. So there will be double benefit for the consumer and for the society as well. But the work is tedious and requires efforts as well because for storing and using that energy for charging the batteries of the electric vehicle we would require an effective charging infrastructure. So in this what we would do is first we will talk about various types of charging and the charging options and next we would talk about how to integrate the charging source with the renewable energy sources and for that what we would do is we will collect the data from government websites regarding the solar and the wind energy produced per year in our country and load requirement of the batteries per year and we would check whether the energy produced from the solar and the wind is sufficient for the load requirement of the batteries per year.

4. Data analysis

4.1. Charging Infrastructure

We need an efficient and accessible charging infrastructure that can recharge the vehicle in an affordable period of time, Most of the motor enthusiast will not be interested in buying the vehicle even if its performance is better and product is cheaper. Because the risk of having a powerless vehicle is very large when we talk about the infrastructure that is laid down in the countries like India where there is minimal of the facilities available w.r.t. the infrastructure.

If the electric vehicles have to be successful there would be an development of an efficient charging stations which should be accessible to all, easy to use and should not be too expensible than their alternative fuels. But the dilemma is that there are various charging methods available and there are various in the pipeline as well but there are no consensus on what an effective charging infrastructure would be like in the near future. There is less certainty of things today than it was years ago, because batteries used to be smaller at that

time than today and and they were relatively inexpensive to charge.

In order to answer these questions, we need to present a simple financial model to understand the factors affecting the charging infrastructure. We will focus on the cost of building and the installation of the charging equipment on the roads and the cost of supplying the electric power to them and the amount of revenue require reaching the break even and we will also include the opportunity cost of the time spent in waiting for EVs to charge. We will conclude by addressing various economic challenges which will highlight the problem of the load management in the case if there is high EV penetration and will discuss cases for further research.

The viability of the options become bleak when the BEV has a 70-100 kWh battery. The battery of this range is required in order to remove the range anxiety from the consumer's mind. The amount of time required to fully charge the mentioned battery would be around 50 hours from a normal wall outlet and almost 11-12 hours with a 220-volt, 6.6 kW line. Various charging options have been tried. For e.g. Tesla is working on to developing an efficient home charging system that can triple the electric output of 220V which can recharge the battery of electric vehicle in just 4-5 hours. But there is some cost constraints on to it because the equipment installment can vary from $4200-$6200 depending upon the customer requirement. So if the electric vehicles has to take place of the alternative fuel vehicles then home charging facility will have to be improved drastically or some type of fast charging systems have to be deployed. Buyers will be less willing to buy the electric vehicles or switch to the electric vehicles if the recharging process or fueling process is too tidy, difficult and time consuming. Many countries have begun to use commercial fast charging stations like U.S., Europe, and Asia. If the producers want to make their sales grow they have to provide them with the basic facilities like smooth and fast charging system so that the investor gets the best return on their investments. The things are possible and practical but the uncertainties have to be removed, cost has to go down and regulation should be make easier.

4.2. The Charging Challenge

The major challenges to the electric utilities are Energy efficiency, distributed energy resources, and demand shifting patterns. With the increase in the deployment of the electric vehicles and increasing demand, the demand of the power will also increase Rapid EV deployment will increase the demand for power, but the current capacity of power generation should meet the demand of the power required by the electric vehicles with the assumption that incremental demand comes in the off peak hours. Then only the power demand can match up to the demand of the vehicles. The demand of the EVs today is less concerning but what the people are more concerned about is that what form that EV charging might take i.e. how fast, when, where, cost of the facility etc. these parameters will determine where the EV charging market will go.

4.3. Types of EV Charging Equipment

The Electric vehicle supplying equipment basically comes in two varieties. The first is the "Level 1" and the "level 2" Electric vehicle supply equipment which operates on AC current and is capable of drawing current directly from the local distribution system. Basically most of the BEVs and HEVs have an inverter as it operates on the direct current and DC current is required to charge the battery. The other variety of the chargers i.e. the level 3 chargers which do not require the inverter for charging the battery as it charges the battery directly and deliver much more power. Otherwise there is no much more difference between the AC and the DC charging process. The chargers in the public use Level 2 or above which comprises of multiple chargers. "Level 1 and Level 2: Alternating Current Level 1, providing 1.4 kW of power in the U.S., is simply a conventional wall socket, and requires no additional circuitry, aside from the adapters required to connect the EV to the socket." In theory, The level 1 chargers are more suitable for charging the batteries at home while Level 2 chargers which operate on 220V outlets, require by other electrical appliances like Fridge, washing machines, can be easily installed. "More modern houses typically have these outlets, while older houses may require electrical upgrades. Depending on the home's electrical infrastructure, this can involve upgraded circuitry, wiring extensions to reach the charging location, or, even in rare cases, an upgraded

transformer." The second type of chargers can also be installed at other places as well like workplace location, hotels, gas pumps etc. and on the street parking space, garages etc. These t ype of chargers start with the rating of 6.6kW and can go upto 19.2kW depending on the amount of the current, circuit can sustain. "Most home Level 2 charging, and almost all commercial Level 2 charging, is limited to 6.6 kW because (a) the onboard inverter on most existing EVs cannot handle significantly more than this level and (b) boosting the current typically requires the installation of more expensive higher-capacity circuitry."

4.4. Level 3 and above:

Direct Current Because direct current do not require the inverter for charging the battery as it charges the battery directly and deliver much more power. Chargers of these types are basically called as "direct current fast chargers (DCFC)" and are basically installed at commercial locations. The continuous usage of DCFC can result in the early deterioration of the battery capacity. "Estimated Direct Current Fast Charger utilization rates," an NREL study concludes, "do not appear frequent enough to significantly impact battery life," Several surveys reports that even after the usage of 150000 km the battery of the electric vehicles is unlikely to fall below 90% of its original ratings. For the purposes of this paper, DCFC charging is classified as follows:

- "Level 3 charging is used to refer to a power delivery of 50 kW;"
- "Level 4 corresponds to 150kW";
- "Level 5 (ultra-fast DCFC) corresponds to 350kW."

Chargers used by most of the third party DCFC are of Level 3 type which operates at around 50KW. Better chargers include tesla's proprietary chargers which has a typical output of around 120KW, which are of tesla's exclusive usage and corresponds to almost to Level 4. Level 5 chargers are in the line next but these level 5 chargers but these level 5 chargers requires special insulation equipment. So they are not yet deployed on commercial basis and hence there is no mass production of such type of chargers. Many major companies have announced more power rated chargers and consortium of OEMs like porshe, ford etc. and they are participating in a joint venture to install around 350kW

network across all Europe. Table below depicts particular type of charger, its power rating (in kW), "the time taken to replenish the expected average daily usage of 13.65 kWh described above, the time taken to replenish 100 miles of charge (i.e. 37 kWh, just under half of a 75 kWh battery), and the miles of range added per minute of charging." The power rating of the charger is of most importance because the charging time is majorly dependent on the power rating but in practice there are various other factors which can add to the charging time of the battery such as electrical supply, inverter capacity etc. Battery size of around 75 kWh is found to be reference battery size of BEVs for the coming 5-10 years.

Table 1. Description of different level of chargers and their capabilities.

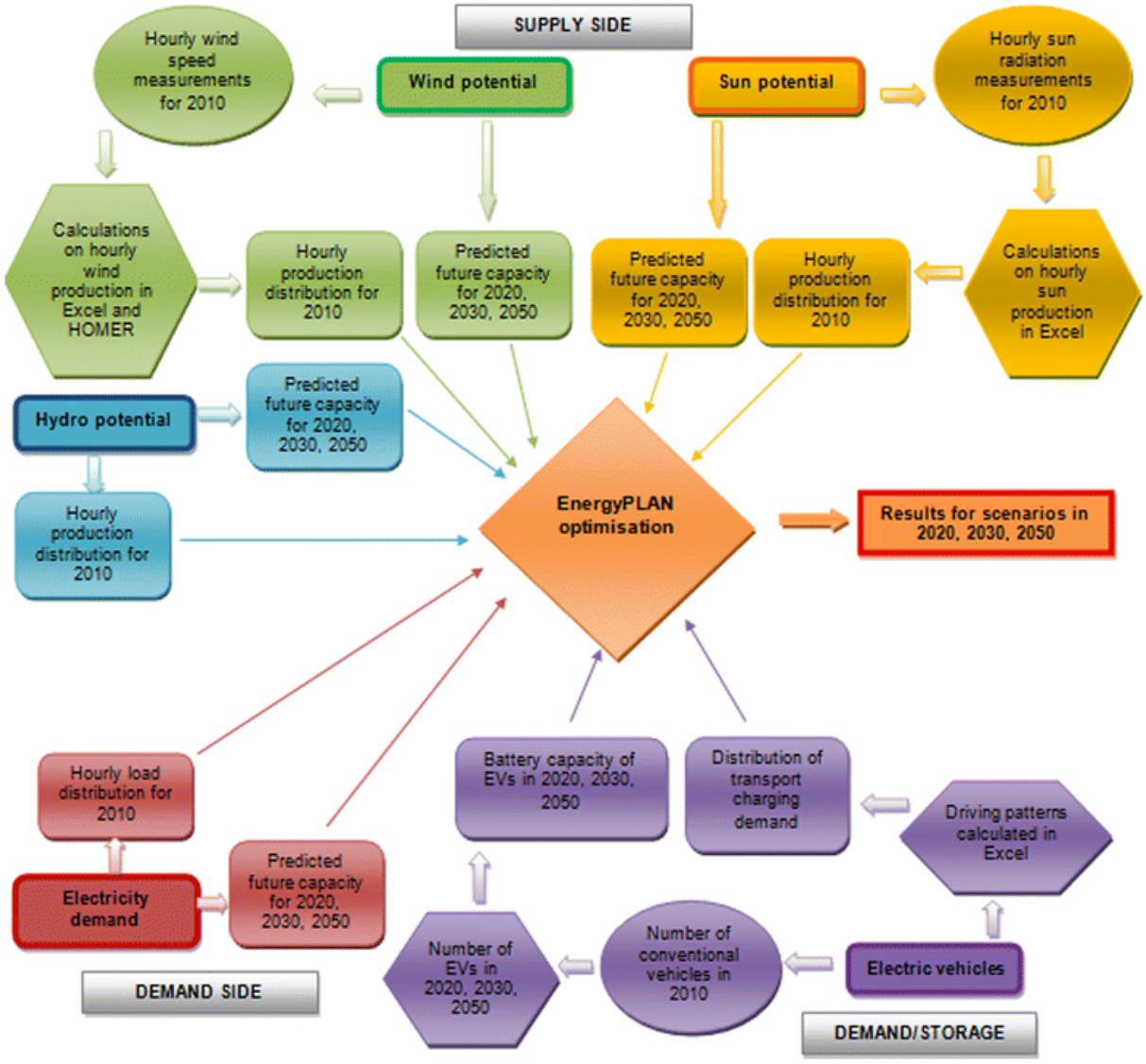
Charger Type	Current Type	Average Power Delivered (kW)	Time taken to replenish daily usage (13.65 kW)	Time taken to charge 100 miles (37 kWh)	Range added per minute (miles)
Level 1	AC	1.4	9h 45m	26h 26m	0.06
Level 2 [standard]	AC	6.6	2h 4m	5h 36m	0.30
Level 2 [maximum]	AC	19.2	43m	1h 55m	0.86
Level 3	DC	50.0	16m	44m	2.25
Level 4	DC	150.0	5m	15m	6.76
Level 5	DC	350.0	2m	6m	15.77

As the table above depicts that even the level 5 chargers takes 6 minutes to fill half of the 75kWH battery and will take around 10-12 minutes to fully charge the empty battery. As the size of the batteries increases the charging time of the battery increases which is normal. Various studies suggest that "Even with Level 5 charging, producing 15.8 miles of additional range per minute, the time it takes to repower an EV, is not comparable to conventional gasoline refueling. Reducing refueling time to the 300 miles per minute enjoyed by a 30 mpg ICE refueling at 10 gallons per minute would require a charger 19 times more powerful, or 6.7 MW. This is far beyond the scope of what is possible today

and likely to remain so for the foreseeable future." The time reuired to charge an Electric vehicle is always greater than fueling an ICE under every circumstance. The gasoline vehicles are very quick to refuel which is the most convenient option. In case of electric vehicles journey of around 310 kms will require almost one to two charging spots and to add around 100 km more of the range will require 15-20 minutes of recharging time with a Level 4 charger and recharging fully will take around an hour which is comparatively high and less convenient that refueling the gasoline vehicles which is more quick. In the places where there is congestion such as person who has come for shopping and has left his car for charging the whole time will extend the waiting time for the other cars i.e. for another 100 miles they would have to wait for more than 30 minutes.

4.5. Intergation with the Renewable energy Sources

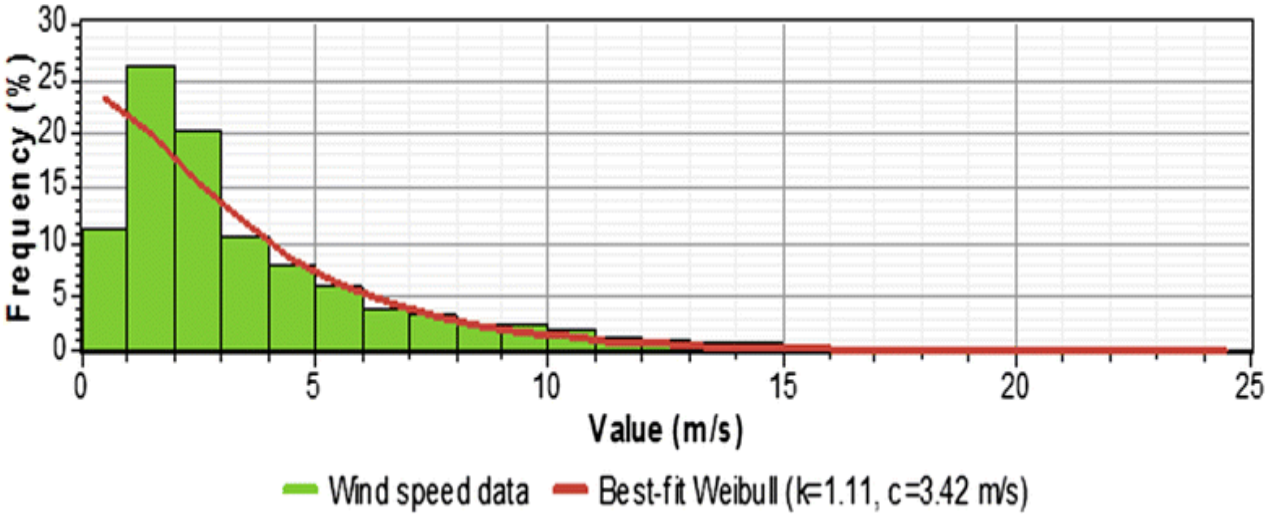
This paper aims to analyse the power generated from the Renewable energy sources to meet the consumption requirements for the electric vehicles.



4.5.1. Wind potential

The data for the hourly wind energy production is carried out from the measurement data of wind speed from the indian meterological and hydrological service for the year 2019. The collected data is then used for a specific wind mill to find out the production of the wind

energy for the country in a particular year. This hourly wind production was provided for the capacity of 6MW. According to the data the maximum speed of the wind was 22km/hr. Similarly the wind energy production per hour was used for higher capacity of the installed batteries. So further wind farms are to be installed if we have to meet the requirements of the electric vehicles upto 2050.



4.5.2. Solar potential

The Asian region has around 5000h of the sunshine per year and it is one of the largest energy time in a particular region. So there is the opportunity for the country to grab and use this solar energy to produce the energy for the electric vehicles. The highest solar power irradiation for the year 2019 was around 1200W/m2. The data for the solar energy production is carried out from measuring data of the solar radiation for the year 2019 and this were taken from the Asian meterological and hydrological service.

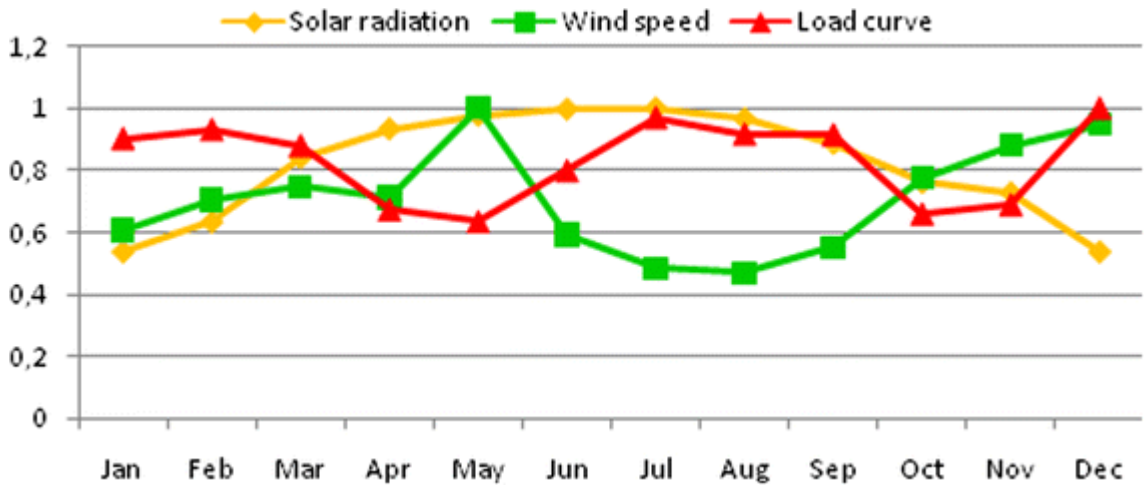
4.5.3. Electricity demand

“The hourly distribution curve of the electricity demand for the Asian region was obtained from the measurements of the substation Komolac.” The electricity demand by 2050 was modelled following a study available for the country.

The figure below depicts the relation in the distribution of the load curve, the solar radiation curve and the wind energy curve. The solar energy as we can see is very impactful if we talk about its production in the summer period. In winters on contrary the relation between the load demand and the wind production is very good because wind speed and rate is higher in winters than in the summers because in October to February the wind rate and the speed is quite high which results in the higher production of the wind energy. The diagram below show the perfect relation between the wind energy load and the solar energy load because both are complementing each other as can be seen from the fact that in summer the solar energy production is high while in winters the wind energy production is high.

Table 2. Description of solar and wind energy produced and corresponding load requirement.

Year	Jan	Feb	March	April	May	June	July	Aug	Sept	Oct	Nov	Dec
Solar	0.55	0.62	0.83	0.95	0.98	1	1	0.95	0.90	0.78	0.7	0.55
Wind	0.60	0.7	0.75	0.70	1	0.6	0.48	0.45	0.58	0.8	0.9	0.95
Load	0.9	0.95	0.88	0.65	0.62	0.8	0.98	0.95	0.96	0.65	0.7	1



The one of the most important factor that will decide how much power generation is required for the electric vehicles is the capacity of battery required for the electric vehicles. Some studies have also experimented the size of the batteries and its impact on the power system required and their combination with the renewable energy sources. “In this work, study was not done in that way, as only three different battery sizes were chosen for EV fleet according to a test described in. Following their battery size, the vehicles were divided into three groups by the provided number of EVs for all chosen scenarios. Each group has the same number of vehicles and has its own kind of battery with different characteristics.”

According to some studies, “the average daily trip of one particular vehicle is chosen to be 45 km.” The known battery capacity will be denoted by (C_B), The range of the battery and the average daily trip of the electric vehicle is taken into consideration to calculate how long the battery would last. “The no of charging times in a day (Ch_i), for every battery type are gained based on the battery life, which gives us the number of EVs ($EV_{tot,i}$), from each group, that is required to be charged in a day. *i* represents each group of vehicles with small, medium and large batteries.”

Table 3. Description of various size of cars and corresponding no of charging per day and no. of cars in coming years.

Size	No. of Charging/Day	2020	2030	2050
Small	**0.450**	**22**	**1000**	**2500**
Medium	**0.346**	**17**	**900**	**2000**
Large	**0.250**	**12**	**650**	**1500**

$$\mathrm{Ch}_i \cdot \mathrm{EV}_i = \mathrm{EV}_{i,\mathrm{tot}}$$

"With a known number of EVs that need to be charged per day, as well as their battery capacities per group, the whole daily capacity demand of the entire fleet ($C_{\mathrm{B,tot}}$) can be calculated for all scenarios as shown in Table."

Table 4. Electricity demand and Transport demand in future.

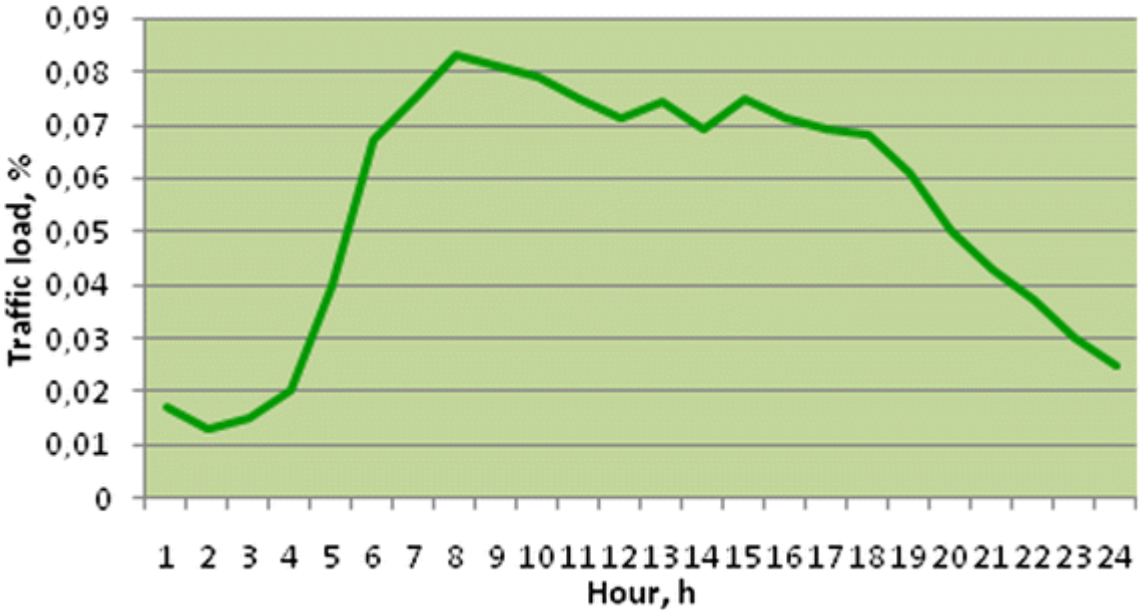
Year	2010	2020	2030	2050
Electricity Demand(GWh/year)	300	350	400	450
Transport Demand(GWh/year)	0	0.5	22	51

$$\mathrm{EV}_{\mathrm{tot},i} \cdot C_{\mathrm{B},i} = C_{\mathrm{B},i,\mathrm{tot}}$$

$$C_{\mathrm{B,tot}} = \sum C_{\mathrm{B},i,\mathrm{tot}}$$

The factors that are required to be given to the energyPLAN would require the capacity data of the transport demand and with this the hourly distribution curve will also be

required for analyzing the data.The transport data is not available so it is taken to be same for every day and the hourly distribution of the demand is taken out on the basis of the transport load profile on a specific day demand gained from study done on transport data.



"The inverted curve (TLC_{inv}) is obtained from the known traffic load curve (TLC) which represents the vehicles that are available for charging. The whole capacity for EV charging in one day ($C_{B,tot}$) is then distributed based on the inverted curve."

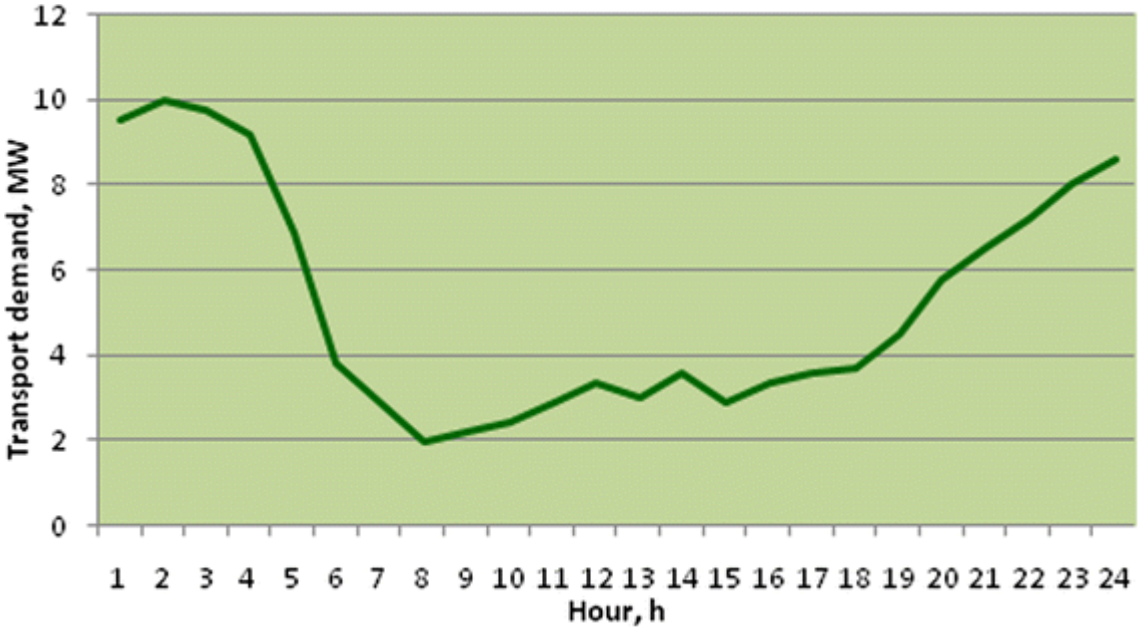
The sum of the data of the inverted curve is equal to 1 as the data will represent the percentage of the total battery capacity (CLC_j) needed in each hour of the day.

$$\mathrm{CLC}_j = \frac{\mathrm{TLC}_{\mathrm{inv},j}}{\sum_{j=1}^{24} \mathrm{TLC}_{\mathrm{inv},j}}$$

$$\sum_{j=1}^{24} \mathrm{CLC}_j = 1$$

The battery capacity per hour of the day is calculated by multiplying the percentage of the capacity load curve (CLC_j) with the total battery capacity per each day ($C_{B,tot}$):

$$\mathrm{CLC}_j \cdot C_{\mathrm{B,tot}} = C_{\mathrm{B,tot},j}$$



4.6. Calculations

Now we will talk about calculation. The aim of this plan is that the production of the energy from the renewable energy sources should satisfy the specific demand of the electric vehicle demand. The amount of the hours required for the each day for the electric vehicles is taken to be 9000 hours. The input for the calculation in this plan will be the distribution curve of the hourly demand of the electricity and its corresponding production of the energy through renewable energy sources. Production (e_{Total}) represents the sum of all the renewable electricity production in the system:

"Total=eRes=eRes1+eRes2+eRes3"

"The total demand (d_{Total}) is the sum of electricity demand (d_{E}) and transport demand which includes the flexible transport demand (d_{FX}), the smart and dumb charging regulation (d_{BEV}) and V2G (d_{V2G})."

“dTotal=dE+dFX+dBEV+dV2G.”

“The difference between the consumption and the production represents an excess or a deficit in the electricity production, depending on whether less or more energy is produced in a particular time span than it is needed.”

“epp=dTotal−eTotal.”

For dealing with the excess and the shortage of the energy generated the electric vehicles have come into the picture. If the energy becomes in the bulk then the electric vehicles are charged and various models are used in case of the shortage of the production of the energy. “When the system produces more energy than what is needed, the energy can be transmitted to the energy transmission lines, i.e. to the neighbouring energy markets. The CEEP represents the production of electricity used in export that goes beyond the capacity values of the energy transmission lines. In this work, the capacity values of the energy transmission lines were not set, so all of the excess of energy produced is observed as critical.”

4.7. Suggestions and Further Study

There are lots of study and further analysis that can be done in this department as there is a huge scope for further analysis on this upcoming technology. As we discussed in this paper about the charging challenges or the charging infrastructure and its link with power produced through the renewable energy sources. The thing that can done next will be to balance the charging time and the idle time at the charging station. Things should be done in such a way that people will not wait for the indefinite time for their turn to charge just because of the other individual who leaves their vehicle on charging for the indefinite period of time such as while going on shopping or at a public place. Next it can be done that the vehicles should have some inbuilt technology which would charge the battery automatically and not needing the charging the charging stations. For e.g. the roof of the car should be made with inbuilt solar plate which would charge the battery automatically when there is sunshine and similarly with the inbuilt small wind turbines which would generate power to charge the batteries.

5. Conclusion

The objective of this theory work was to add to the comprehension of electric vehicle clients and to propose a plan for electric vehicle charging station data. Leading a subjective examination study utilizing semi-organized meetings and playing out a topical investigation of the information brought about four fundamental topics. The subjects can be connected to designs in dispersion of advancement (DOI) hypothesis and unequivocally mirrors the circumstance of EV use starting today. The subjects and their sub-topics gave great understanding to EV use and a plan model was made dependent on EV client attributes and plan methodologies inside the field of practical conduct plan. A major test of today is to discover methodologies to accomplish wanted client conduct with the need for changed conduct being new to a larger part of the clients. The model introduced is an underlying plan that will require broad testing and changes. Because of the subject's solid connect to the circumstance of today and the way that the meeting bunch just comprise portions of the adopter classifications inside DOI hypothesis, a comparable report would should be led later on to keep a client focused plan.

The difficulties confronting EV deployment have gotten more manageable as of late, however they are as yet impressive. The existence cycle cost of responsibility for has fallen generously; further decreases in introduced battery costs beneath Rs 20000 per kWh may prompt certifiable equality with ICEs in the following 5-7 years. Of undeniably more ramification for reasonably scaling EV proprietorship is the financially savvy, proficient arrangement of charging framework. Independent financial investigation of various charging alternatives recommends that private Level 2 charging, where accessible, can be the most ideal choice for the majority of an EV proprietor's charging needs, and that ToU rates (for the most part for the time being charging) can cut down the normal expense of power to underneath the same fuel cost for an ICE. Uncommon degrees of venture and item advancement arranged by practically all major OEMs plainly demonstrates that a lot bigger EV market is approaching. The image is less blushing for the business charging framework needed to serve this extending market. DCFC charging (Levels 3-5) is presented to a lot

higher month to month request charges and more noteworthy requirement for reliably high use to equal the initial investment. The examination has exhibited that for levels of use above 20%, DCFC breakeven power costs can be serious with fuel costs. This is a significant finding—yet is made with regards to numerous uncertain administrative and public approach issues, and huge disadvantage hazards for underutilized foundation. The discussion over utility responsibility for framework is progressing. The standards for choosing whether public possession and rate-basing the expense of charging foundation is the suitable instrument for fostering this market, or whether charging framework ought to be left completely to the private area, are uncertain. A further inquiry is the way utilities, outsiders, and OEMs can most adequately arrange/pool their separate ability in a way which jelly serious elements, yet enhances EVSE charging choices in the most socially proficient way conceivable.. There are contrasts of assessment on the rate at which this change will happen, however there is clear mechanical and financial foothold towards a lot more prominent dependence on electric vehicles. New rate plans, better shrewd metering and charging hardware advancements, and a charging foundation that is helpful and value cutthroat should be created and carried out." These are troublesome however feasible errand. A few reports have been found out on charging models for electric vehicles so far. They analyzed the effects of controlled and unregulated charging on the electrical system. This work depicts something similar. Taking into account the four current EV charging models described in the sections earlier, various combinations of many charging models were analysed for each of the scenarios by 2050, based on their characteristics. Their examination decided the effect of each model on the power interest and the effect on the creation from RES. Correlations were done for every situation. The effect of EVs on the hourly power request was dissected by utilizing the increment of the most extreme yearly pinnacle interest because of charges of EVs. The effect of the model on the power creation from RES is examined as to the increment in the CEEP, which demonstrates an overabundance of energy delivered utilized in trade. In the estimation, the upsides of the energy bandwidth which may be given to the adjoining energy markets were not respected. The framework was set up as a separated one.

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