

The Growth Potential of Electric Vehicles in the U.S.A

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ABSTRACT

With rising air emissions and its consequential environmental effects combined with depleting oil and gas supplies, the government authorities in the United States, Europe, China and various nations, have taken proactive measures to combat these challenges. Transportation sector in United States consumes about 70% of oil demand, out of which 70% is then consumed by passenger vehicles. To meet these oil demands there is an increasing reliance on imported oil, which implies money supplies flow out of the economy. The interests of the governments to reduce oil consumption and thereby reduce reliance on foreign oil have propelled a change in the future of transportation industry with the adoption of electric vehicles. Electrifying the transport sector provides a possible solution to climate change, U.S. energy security, employment growth and ultimately a sustainable, greener economy. The purpose of this paper is to understand the current scenarios of; Electric Vehicle industry, Oil and Gas sector, and Energy sector. Based on the understanding, this paper assesses the circumstances for: a) large scale adoption of electric vehicles and b) electric vehicles being a viable option from consumer perspective.

1. Introduction

Electric vehicles:

Electric vehicles are both passenger vehicles and goods vehicles which run on battery power via electric motors or with the combined use of both internal combustion engine and electric motors. Electric vehicles are said to be the future of transportation and are highly likely to make conventional vehicles obsolete.

Types of Electric Vehicles

BEVs:- Battery Electric Vehicles are composed with only electric motor and battery instead of a fuel tank constituted in a conventional Internal Combustible Engine (ICE). Thus, BEVs are solely run on the energy stored in their battery packs. Range of BEVs directly depends on the power stored in the battery packs, generally providing a range of 100km-250km (Cite Source) on a single charge, whereas top-tier models have a range of about 300km-500kms. BEVs are highly beneficial to the environment since they do not produce any greenhouse gas and are not noisy. Although this advantage is coupled with a limitation of slow charging, i.e., it takes as long as 36hrs to completely replenish the batteries in comparison to the quick refilling of a fuel tank.

PHEV -: A Plugin Hybrid Electric Vehicle (PHEV) is a hybrid vehicle composed of both an Internal Combustible Engine (ICE) and electric motor and batteries. A PHEV operates on a combination of fuel and battery power. Although a PHEV runs solely on electricity for most of the time, only a part of the driving is done using fossil fuels. PHEVs start running on an 'all electric' mode until the charge depletes, at which point the fuel engine is turned on to charge the batteries and extend the range. PHEVs thus exhibit the following advantages: a. less fuel consumption, hence reduced overall emissions, b. increased fuel efficiency b. increased range due to hybrid technology.

Factors influencing the Global Electric Vehicles Market growth:

With constant growth in production and sales of automobiles, there is an ever increasing demand for electric vehicles. Owning a car is becoming increasingly affordable with the growing disposable incomes around the globe. Even though the percentage share of electric vehicles in the market is very low in the current market, it is expected to grow at an exponential rate owing to the constant demand and growing depletion of fossil fuels. Governments all around are bringing out policies to reduce the amount of greenhouse gasses emitted by vehicles. Tax exemptions, discounted selling prices and free charging of electric vehicles at many charging stations have also encouraged people to make the switch to electric vehicles.

Electric vehicles in the United States of America:

There is an active market for plug in electric vehicles. They are the third largest stock plug in electric passenger vehicles after China and Europe They first appeared in the market during the mid-90s and gained popularity from 2011. The American federal government and several state and local government is promoting the use of plug in electric vehicles as they are eco-friendly and helps to reduce the use of petrol. The government provides various subsidies on purchase of electric vehicles. The cost of travelling in an electric vehicle is about \$0.04 per mile whereas the cost of travelling on a regular motor vehicle costs about \$0.464 per mile. The Energy Improvement and Extension Act of 2008 allocated credits on tax for a list of newly qualified plug-in electric vehicles. The American Recovery and Reinvestment Act of 2009 also granted federal tax credits for hybrid plug-ins. The government gives a credit for new electric vehicles based on its battery capacity an amount in the range US\$2500 and US\$7500. There are many other non-monetary benefits like free parking and high occupancy vehicle lane access.

Policies dedicated to increase deployment of EVs:

Global: - The Electric Vehicle Initiative (EVI) is a policy established in 2009 by the Clean Energy Ministerial at a global level which brings together 15 countries including United States, China, Canada, India, France Germany, Norway, Sweden, United Kingdom, etc. The EVI, coordinated by the International Energy Agency (IEA), is committed towards encouraging adoption of electric vehicles worldwide. EVI influences the policy makers working in the governments and a variety of partners to collaborate and support EV deployment.

The EV30@30 campaign: - The EV30@30 is a campaign launched in 2017 at the Eight Clean Energy Ministerial. This campaign has set up a collective goal for all EVI nations including United States to achieve a 30% market share of electric vehicles in proportion to all vehicles in the market by 2030.

United States:-The US government has taken proactive measures to successfully initiate and promote electric vehicles in the market. For electric vehicles to perform well in the US market, there are certain barriers relating to cost and technology that need to be addressed efficiently.

The federal government has heavily subsidized setting up of charging stations, with 16,541 charging stations supplying 45,225 public charging outlets countrywide. To encourage adoption of electric vehicles, both the federal and state government have incentivized consumers via personal income tax credits ranging from \$2,500 to \$7,500 for every EV purchase depending upon battery size.

Apart from the tax credit, various states provide schemes such as: 1. Alternative Fuel or Plug-In Vehicle Rebate 2. Unrestricted HOV (High Occupancy Vehicle) lane access 3. Free Parking 4. Vehicle Inspection Exemption 5. PEV Charging Rate Reduction/Incentives

The U.S. Department of Energy (DOE) addresses the technical barriers, which are mainly related to battery technology and vehicle design. The most critical challenge relating to battery technology is high battery costs and battery range efficiency. The DOE has divided the technical targets into 4 prominent areas: Optimizing Vehicle Weight; battery research and development; electric drive system research and development; advanced climate control technologies. Measures to achieve the mentioned targets include:

1. Expanding energy density from 50 Wh/L in 2012 to 400 Wh/L and reducing battery costs from their current \$500/kWh in 2012 to \$125/kWh
2. Minimizing cost of electric drive systems from \$40/kWh in 2012 to \$8/kWh
3. Reducing about 30% of vehicle weight as compared to a 2012 baseline vehicle by utilizing light weight vehicles parts, i.e., body, chassis, interior, electric drive components, and compounding weight reductions.

Apart from the above policies at global and federal level, the state of California has prioritized implementation of Zero

Emission Vehicles (ZEV) Action Plan. Under the ZEV Action Plan, the state proposes to invest USD 900 million to deploy 250,000 EVSE outlets (Electric Vehicle Service Equipment) by 2025, of which 10,000 outlets should be DC fast chargers. With the implementation of charging facilities, California has deployed targets for 2030 of 5 million EVs on road. [Source: Electrify America, 2018a; State of California, 2018].

2. Review of Literature

a. (Xiaomin, 2018): In this study it has been proven that the demand for electric vehicles have increased since 2010 and this increase depends on renewable and socio economic factors. The variables that have been used for the study are percentage of renewable energies in electricity generation, number of charging stations, education level, population size, petrol price, GDP and urbanization. The study has shown that the first four variable influences the demand of electric vehicles in a positive manner. It was also discovered that for every one percent increase in renewables there is 2% to 6% increase in demand for electric vehicles.

b.(C. I. Chatzikomisk, 2014): The scope of this project is to quantify the economic and environmental benefit due to introduction and use of electric vehicles in Greece. The study shows that there will be a positive impact to the environment after the introduction of electric vehicles in Greece it will help to reduce the emission of green house gases when compared to motor vehicles regardless of the flee composition. The study has shown that there will be a reduction of 668 kT CO₂ in GHG emissions and 362 million € in energy costs every year.

c. (Andrew Xue, 2015): This study aims to verify whether electric vehicles allows consumers to save money that they will spend on petrol and are the beneficial to reduce carbon dioxide emissions in the environment. It has been concluded that the cost of purchasing an electric vehicle has far overpowered its benefit to the consumers. It was also discovered that switching 9 million consumers to electric vehicles is not the most cost effective means to reduce carbon dioxide in the environment.

d. (GANG MA, 2017): This paper aims to study the impact of electric vehicle charging load on nodal voltage deviation. It has been discovered a large scale vehicle to grid system may cause adverse effect in the distribution network and the power network planning. This paper finds a relation factors that affect EV charging load and conclude a model using Monte Carlo method. It has been concluded that the nodal voltage deviation has a close relationship with the node type, node location and EV permeability of the electric vehicle.

3. Research Design

a. Statement of Problem:-

The main problem that we want to address through this study is to understand whether there is a significant impact on demand as well as prices of oil and petroleum after introduction of EVs. We would also like to understand if there is an economic benefit for consumers adopting electric vehicles. With the growing concerns regarding the environment, the impact that the adoption of electric vehicles is taken as part of the study.

b. Sources of Data:-

1. Journals
2. Research Publications
3. News Articles
4. Magazines
5. Reports

c. Hypothesis:-

1. Electric Vehicle (EV) sales will increase substantially in upcoming years
2. Higher proportion of EVs on the road will reduce CO₂ emissions significantly
3. There will be decrease in oil demand and consequential fall in utility prices

d. Limitation:-

1. For the purpose of our study, we have assumed that electricity is generated from renewable sources instead of fossil fuels. We have performed a cost benefit analysis based on the above assumption.
2. The cost benefits of adopting electric vehicles is subject to numerous factors.
3. During the cost benefit analysis we have assumed that the customer is not environment conscious.

4. Data analysis and interpretation

a. Cost benefit analysis

Comparison of Maintenance Charges

1. Even though the Electric vehicles are an advanced technology, they are actually simpler to maintain than ICEs and drive. EVs have only one moving part which is the motor, while ICEs have many moving parts.
2. ICEs will also require frequent oil changes, filter changes, ECU tuning, exhaust system repairs and many other component replacements.
3. The replacement interval for brake pads of electric vehicles will also be lesser than ICEs due to regenerative braking.
4. There are no fluids that need to be changed in an electric vehicle other than the brake fluid. Therefore the running charges for an electric vehicle is going to be significantly lower than an ICE vehicle.

Comparison of Fuel Charges

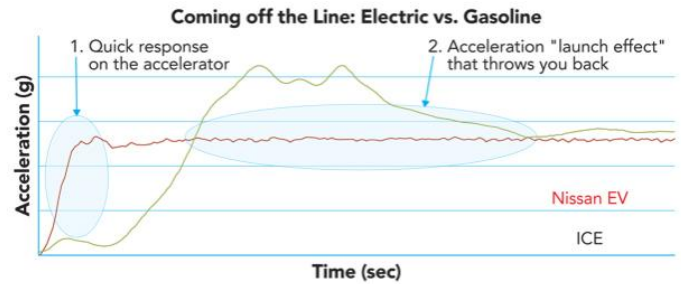
Electric vehicles tend to have lesser range and this can be improved only through increasing the battery capacity. However this also means that the vehicle would tend to be heavier because of the weight of the battery. A heavy battery would be inefficient because it would take more electric power to move. With the advancements in battery technology this is becoming more easier. The average cost to run an electric vehicle is 485\$ per year, and for an ICE vehicle is \$1117. Further electricity cost are more stable than gasoline prices. The costs can be brought down even further if one is able to produce electricity by themselves using solar panels.

Even after considering the fuel savings and savings on maintenance, there is the argument of the initial cost of electric vehicles being greater than their ICE counterparts. This was true a few years back with electric vehicles being too expensive and offering very little range. However, in the

current automotive market the average price of an electric vehicle is around \$3500. A tax refund of \$7500 can also be claimed when buying an electric vehicle. Further different states have different policies which give further benefits when buying an electric vehicle.

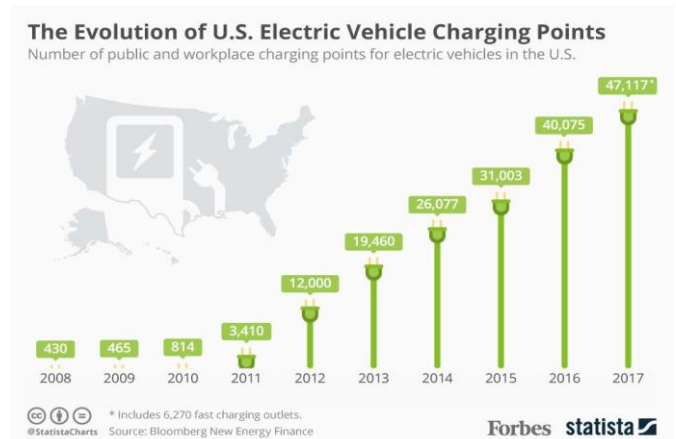
Performance Analysis

Off the line EVs will be quicker as EVs will have a greater torque when compared to ICEs. Electric vehicles provide excellent torque at low speeds but its performance drops at higher speed in comparison with conventional vehicles. Electric vehicles however have low top end, which means they will not be able to maintain high speeds for long.



Electric Vehicle charging stations:

Americans had the option to purchase an electric vehicle from the first half of 2008, but back then there were only one model of electric vehicle available in the market. The customers back then took the risk as the number of charging stations were limited and the battery power of the electric vehicles was one major concern. The countries charging infrastructure was limited and as low as 430 charging stations in the whole of US. Electric vehicles did not gain much popularity back then as the number of charging stations just increased to 465 in the year 2009. But as we come down the line we can find that the electric vehicles has gained popularity amongst the people. After a decade of introducing electric vehicles in the US market the number of charging stations has increased to 47117 charging stations in the year 2017.



Batteries for electric vehicles

The major concern for a customer who purchases an electric vehicle will be the driving range and the battery storage capacity the car offers. There are only two ways by which EVs can be widely accepted those are

- 1) Increasing the range of the EVs
- 2) Adding more batteries to the EV. By adding more batteries the cost to produce an EV increases, therefore it is not an viable option

There are four types of battery in the market

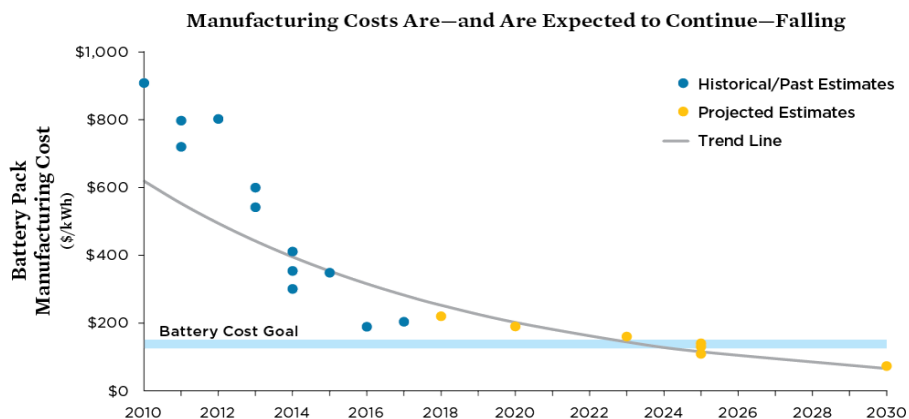
- 1) Lead acid: These type of batteries are the cheapest that are available in the market and it is the most common traction batteries available. Lead acid batteries are of two types, automobile engine starter batteries, and deep cycle batteries. Automobile engine starter batteries, and deep cycle batteries. Lead acid batteries should not be discharged below 50% as it decreases its life. Previously most of the EVs used lead acid batteries due to its mature technology, easy availability and low cost. These batteries have an environmental impact although they produced using recycled materials. These batteries have short life usually shorter than the EV itself. It needs to be replaced every 3 years. Charging and usage of these batteries emits hydrogen, oxygen and sulfur, which are harmless if properly disposed.
- 2) Nickel metal hydride: These batteries are now considered as a mature technology. They are less efficient in charging and discharging power from the EVs that lead acid batteries. But they have a specific energy of 30–80 Wh/kg, higher than that of lead acid batteries. When used properly, these batteries have longer lives and better performance. On the downside these batteries provides poor efficiency, high self-discharge, very finicky charge cycles, and poor performance in cold weather.
- 3) Zebra: This battery uses a molten chloroaluminate sodium (NaAlCl₄) as the electrolyte. Zebra batteries are efficient in charging and discharging and have a specific energy of 120 Wh/kg. these batteries must be heated before use, hence cold weather does not effect its operation. Zebra's can last for a few thousand charges. These batteries have a very poor

power to weight ratio and have to heat the electrolyte to 270 °C, which wastes some energy present in the batteries

- 4) Lithium-ion batteries: lithium ion batteries is popularly used in smartphones, laptops and now in EVs. They are still at the development stage and is undergoing improvements. Lithium batteries consist of lithium cobalt oxide cathode and a graphite anode. These batteries have specific energy of 200+ Wh/kg and have 80 to 90% charging and discharging efficiency. Lithium batteries have short life cycles and significant degradation with time. Traditional lithium batteries pose a risk of fire if not properly charged. Recently most EVs employ new models of lithium ion batteries that sacrifices specific power and specific energy to help the EVs become fire resistance, eco friendliness, rapid charge and very long lifecycles.

Falling electric vehicle battery cost

With the advancement in technology and intensive funding in research and development the prices of electric vehicle batteries are falling steadily. As battery costs forms a major portion of the electric vehicles cost, reducing them can help them be competitive in the market. Battery packs make the cost to manufacture EVs 1.5 to 2.5 times that for manufacturing similarly sized gasoline vehicles and hence is usually priced than gasoline vehicles. However by increasing the production of batteries the cost per unit will decrease significantly. When electric vehicles were first introduced in 2010 the cost of battery packs was estimated at \$1000 per kWh. At present the battery pack of a Tesla model 3 costs \$190 per kWh and Chevrolet Bolt battery pack is estimated to cost about \$205 per kWh. We can see a 70% drop in the battery prices since 2010. Electric vehicles will cost the same as gasoline vehicles or maybe even lower if the price of battery packs are reduced to \$125- \$150 per kWh.



SOURCES: ARB 2017; SOULOPOULOS 2017; VOELCKER 2017; SLOWIK, PAVLENKO, AND LUTSEY 2016; VOELCKER 2016; NYKVIST AND NILSS ON 2015.

As per the figure above, we can see that the price parity can be attained by the year 2020 and while some analyst suggest that the price of lithium ion battery will drop to \$73 by

2030. Electric vehicles are becoming popular by the day and is a key factor that will help achieve this goal.

5. Findings and Suggestions

Through this study, we have found that the cost to run and maintain an electric vehicle is cheaper than that of an ICE. As the demand of EVs keep rising the cost of producing will become lower and the number of electric vehicle charging stations is increasing. As technology advances, electric vehicle battery capacity is also increasing. The US government has also taken many measures to promote the use of electric vehicles over gasoline vehicles. Being an infant industry there are many opportunities for improvement and development.

6. Conclusions

From this study we have been able to conclude that the demand for electric vehicles will rise exponentially over the year owing to multiple factors which include, but are not limited

to: 1. Government policies and initiative 2. Rising fuel prices 3. Increasing environment consciousness amongst consumers. This results in reduced carbon emission and reduced oil consumption. About 80% of the cost incurred on a gallon of gas flows out of the economy. With reduced reliance on foreign oil, this money saved on gasoline is circulated within the economy, thereby indirectly boosting job creation in various industries.

Overall, the automotive industry must seek to reach the level of readiness that can support all emerging technologies. The automotive industry is in a continuous need of skilled manpower, however in the current stage, the training capacity is very limited.

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