Drivers and Barriers to Electric Vehicles Adoption

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Abstract
Electric vehicles (EVs) are expected to contribute significantly in the future growth of automotive industry. The study classifies EVs and compares different EV markets as per their maturity level. The study then reviews existing literature to identify key drivers and barriers to EV adoption. The study found zero emissions & noise, lower operational costs than gasoline cars, better built & performance and suppporting incentives & subsidies among the key drivers. As per the barriers inhibiting future EV growth, the study found inadequate charging infrastructure, long charging time, high procurement costs along with increased stress on generation and transmission networks as potential roadblocks.

Keywords: *Automotives, Electric Vehicles, Drivers, Barriers, Considerations*

Introduction

The global automotive industry is expanding amid sea changes driven by autonomous driving connected car, electric vehicles (EVs) and shared mobility. The global vehicle market grew at a compounded annual growth rate (CAGR) of over 1% from 2012 to 2016 and at 4.6% compared to last year to reach 94.5 million units in 2016. While the passenger car sales expanded by 1.6% from 66.4 million units to 69.5 million units, commercial vehicle sales grew by 4.5% from 23.4 million units in 2015 to 24.6 million units in 2016.

An electric vehicle is driven by one or more electric motors powered by the charge stored in its battery. Depending upon the degree of dependability on electric motor and combustion engine,

Evs can be broadly classified into three categories as shown in the exhibit below.

Exhibit 1 - Comparison of different EVs

Battery Electric Vehicle (BEV)	**Plug in Hybrid Electric Vehicle (PHEV)**	**Hybrid Electric Vehicle (HEV)**
Pure EV, propelled by electric motors through charge stored in the batteries	Electric motor (plug-in to electricity source) and combustion engine work in conjunction to drive the vehicle	Electric motor (non-plug-in to electricity source) and combustion engine work in conjunction
		HEV Mild* Micro*

** Micro and mild hybrid includes start/stop and regenerative braking functions*

Reliance on combustion engine increases along the right direction of the above exhibit from battery electric vehicle towards hybrid electric vehicle (and similarly along HEV, mild and micro). While the movement along the left direction increases reliance on electric motor.EV sales increased by a staggering 43% to reach 466,430 units compared to 325,380 units sold in 2015. China, United States, United Kingdom, Japan, Germany and France are among the significant EV markets.

Several countries are at different maturity level with respect to EV penetration. China is considered as a relatively matured market. Around 336,000 EVs (including plug-in hybrid) were sold in 2016 amid strong government incentives (offering credits upto USD8,700 at purchase). The country further plans to building more than 10,000 additional charging stations by 2020. Brazil on the other hand falls on the other end of the maturity spectrum with very few EV sales owing to its lack of charging infrastructure and inclination towards ethanol powered vehicles.

Review of Literature

Lane B. et. al. (2007) identified attitudinal barriers inhibiting the adoption of cleaner vehicles in the UK. The study reviewed the evidence of consumer attitudes to low carbon cars and showed that car buyers have a poor knowledge of cleaner car technologies, the environmental impacts of road transport and car ownership costs. It also identified key factors that influence consumer's adoption of low carbon products and concluded that identifying where and when these factors occur could enable the formation of initiatives to facilitate consumer adoption.

Hirdue M.K. et. al. (2011) presented a preference study of EV choice using a choice experiment to estimate the user's willingness to pay for 5 EV attributes viz. driving range, charging time, fuel cost saving, pollution reduction and performance. Attributes such as driving range, charging time and fuel cost savings were most important for users. The study revealed that individuals are willing to pay USD35 to USD75 for a mile added in driving range, USD425 to USD3,250 for per hour reduction in charging time. The study concluded that battery costs must reduce significantly before EVs are eligible for mass adoption without subsidy.

Egbue O. et. al. (2012) identified potential socio-technical barriers to consumer adoption of EVs and examined whether sustainability issues influence consumer purchase decision. The study argued that individuals highly connected to technology development are most likely to emerge as early adopters of EVs. It suggested that to increase adoption, certain measures around education, increased investments in technology, infrastructure, battery swap programs, strong warranties on EV batteries and increased tax credits need to be explored.

Tseng. H.K. et. al. (2013) compared the economic and environmental benefits of pure and hybrid electric vehicles with that of conventional vehicles and argued that in absence of tax credits, only the hybrid vehicles (without plug-in) incur lifetime total costs equivalent to a conventional vehicles. The study demonstrated the importance of developing an energy policy that includes tax credits to address the inadequacy of cost differential and consumer affordability. It concluded that the environmental benefits provided by both EV and HEV should satisfy consumers interest in protecting the environment and promoting sustainable road transport.

Figenbaum E. (2016) argued that several BEV incentives offered in Norway, some of which have been in place since 1990, did not yield positive results until 2010. However post 2010, several Norwegian incentives and policies developed gradually through interactions between the international landscape, national governance networks and regimes were able to increase EV

market share to 17.1% in 2015. The study argued that several market actors have been able to utilize opportunities leading to the potential establishment of a BEV regime.

Wang N. et. al. (2017) explored key factors that promote EV sales and presented several suggestions on designing and formulating matching policies when subsidies contract in the one of the biggest EV market, China. The study utilised multiple linear regression method to analyze EV sales by leveraging data for incentive measures and socio-demographic in 41 pilot cities for the year 2013–2014. The results revealed that maturity of charging infrastructure in terms of density, license fee exemption, no driving restriction and priority charging infrastructure construction lands are the 4 most important factors that can further increase EV adoption in China.

Objectives of the Study

a. To identify key drivers responsible for EV development.

b. To identify barriers inhibiting current and prospective EV adoption.

Key Drivers of EV Adoption

EVs possess number of positives that over weigh all their shortcomings. Apart from the more than obvious advantage of no emissions and high efficiency, EVs have a plethora of other benefits more than enough to meet or even exceed the expectations ofmost automotive users. Some of them are detailed below.

a. Zero Emissions and Noise

It is no brainer that electric vehicles do not emit any gases into the atmosphere as it refrain from burning hydrocarbons like in the case of conventional gasoline cars. As a matter of fact, zero emissions continue to be the unique selling proposition for EVs, especially in the case of Tesla which proudly markets its vehicles with "Zero Emission" as their licence plate.

EVs also curb noise pollution as the electric motors working in the background do not produce any sound or vibration. While this enables the driver with a better experience, it sure has downsides for the pedestrians as they are unable to judge the vehicle in their surroundings. To tackle this growing risk, the US National Highway Traffic Safety Administration has mandated EVs to produce some noise when travelling at low speeds.

b. Lower Operational Costs over Gasoline Cars

EVs use electricity as fuel in contrast to gas in gasoline cars. The former is cheaper than fuel which is heavily taxed. The fuel prices are determined by international prices which for the most part remain volatile and susceptible to external forces compared to electricity tariffs. Thus running costs for EVs are lower than gasoline powered vehicles.

Operational costs (includes maintenance costs as well) for EVs are due to the presence of less moving mechanical parts.These fewer moving parts result in avoidance of several maintenance activities common in gasoline cars such as engine oil changes, emission pipe replacement, spark plug replacement, pollution control mechanisms along with other services. Apart from the above, EVs also leverage regenerative braking (a technology that enables the restoration the kinetic energy lost while braking) which leads to less usage of friction brakes resulting in enhanced life of several parts in the brake assembly such as brake pad, rotor and calliper.

c. Better Built and Performance

EVs require lesser parts to be screwed together than in a typical gasoline car resulting in enhanced reliability, safety and performance. The placement of batteries along the footrest results in low centre of gravity which in turn leads to excellent handling. The concept of turbo and lag are all but alien in the EV world which offers instantaneous torque right from zero rotations per minute (rpm). This enables even an entry level EV to have impressive acceleration figure. For example, Chevrolet Bolt claims 0-60 mph acceleration in a wise 6.5 seconds. This instantaneous torque enables regular EVs to boost acceleration figure that other gasoline cars in the same segment would probably shy away from flaunting.

d. Subsidies and Incentives

Lastly in order to facilitate higher EV adoption, the governments of several countries are offering variety of subsidies and incentives. For instance in the United Kingdom, BEVs are eligible for purchase incentive up to GBP4,500 and GBP8,000 for cars and light commercial vehicles. Governments are also coming up with several innovative incentives such as free parking, access to heavy commercial vehicle lanes along with other to market EVs as superior to gasoline cars.

Key Barriers against EV Adoption

a. Inadequate charging infrastructure

With EV sales staring to take off, immediate attention is required on building charging infrasrtructure. Unlike fuel stations, charging stations are rare and involves high capital costs to build making its development slow paced. To cater to this high capital costs, several stakeholders along the EV value chain needs to come together to build a unique buisness model aimed at sharing costs.

b. Long charging time

Long charging duration required to power an EV remains a significant barrier for buyers. While fuelling gasoline cars can happen in a minute or two, EVs take hours to charge depending upon the supply, capacity and model. This reduces the functionality of EV thereby limiting their further development.

While from a technical point of view, this shall require time and investment, some options are available immediately to cater to this barrier in the short term. For instance, as batteries store charge as direct current (DC), direct current fast chargers (DCFCs) of 50-120 kW can help a great deal in reducing the time required to charge the vehicle considerably. Battery swapping stations are another option where a discharged battery is interchanged with a charged battery however their reach is limited to commercial vehicles only.

c. High procurement costs

Although lower operating costs remains a key driver for EV adoption, its higher procurement costs relative to convetional gasoline vehicle continue to remain a key barrier. Batteries for EVs are what fuel tanks are for gasoline carsand constitute a third of the total cost of building an EV. Altohugh battery costs fell from USD1,000/kWh in 2010 to USD225/kWh in 2016, they still remain expensive at these levels.

Technology and production can play a key role in bringing down the procurement costs for an EV. While technology based research should focus on reducing costs through more efficient

manufacturing processes, rise in production shall also help in reducing the per unit cost of production.

d. Higher stress on generation and transmission networks

The mass adoption of EVs is expected to increase the overall demand for electricity in the medium to long term. For instance, Bloomberg New Energy Finance predicts that by 2040 EVs will draw 1,900 TWh of electricity from the grid.This higher demand of electrcity in future calls for planning for addition of generation and transmission at present. From a generation point of view, power utililies need to plan renewable based power capacity additions to support the clean source of transportation.

Conclusion

The study discussed the global automotive industry with focus on EVs. The study identified certain drivers and barriers to EV adoption. The study holds immense implications for several stakeholders including power utilities, automakers, governments as well as buyers. Power utilities need to focus on building charging infrastructure, adding renewable power for achieving full-cycle sustainability, along increasing power generation to cater to increased demand. For automakers, the study recommends to increase research & development in EV technology and batteries to reduce the upfront procurement costs. Governments need to include EVs in public transport to give them a headstart as well as offer several subsidies and incentives to lower EV costs. Lastly, current and prospective buyers need to arrange their peronal charging infrastructure by the time the charging infrastructure gets matured to limit the biggest barrier of immature charging infrastructure.

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