

# Electric Vehicles and Environmental Sustainability

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**Abstract:** Growing concern for the environment and depleting natural resource has created a need for environmentally sustainable products. The government has also introduced policy measures to slowly replace conventional vehicles into Electric vehicles. Electric vehicles are one such radically disruptive innovative product which are highly energy efficient and zero emissions. Hence, it becomes important to study the driving force towards reintroduction of Electric vehicles. The paper discusses about the environmentally sustainable features of Electric vehicles.

**Keywords:** Electric vehicles, Environment sustainability, Sustainable transport system.

## I. INTRODUCTION

60% of the oil consumed worldwide comes from the transportation sector. Therefore, the transport sector is highly dependent upon the level of energy and in fact, it is the largest user of energy in the economy (Reddy *et al.*, 2001; Samimi, 1995). Life cycle analysis studies of the environmental impacts of road vehicles (Teufel *et al.*, 1993, OECD, 1993) have indicated that the fuel used in running vehicles represents 80-90% of total life cycle energy use. The consumption of energy is likely to grow up further with economic growth, population growth, rapid industrialization, urbanization and agricultural modernization (Ramanathan & Parikh, 1999). Carbon dioxide emissions is biggest contributor to climate change which in turn has to be acknowledged. To minimize air, noise, water and pollution from transport operations, climate change and to mitigate transport impacts on biodiversity there is an urgent need for Sustainable transport system, taking into consideration the environmental impact and concern for fuel resources.

## II. CONCEPTUALIZING SUSTAINABLE TRANSPORT SYSTEM

An effective and efficient transportation is one, which is socially, economically and environmentally sustainable.

Social, Economic and Environmental considerations are the three dimensions of Sustainable transport system. Of all these dimensions there is an urgent need to look into environmental dimension as the existing transportation system is creating health hazards and it has become a global concern.

A commonly used definition of sustainability comes from the Brundtland Commission's report, Our Common Future - "Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (World Commission on Environment and Development, 1987). Sustainable transport system is a subset of Sustainable development. Mobility 2001, report (MIT & Charles River Associates) defines sustainable mobility as the ability to meet the needs of society to move freely, gain access, communicate, trade & establish relationship without sacrificing other essential human and ecological values today or in future.

Sustainable transportation, as defined by OECD, 1997 is that does not endanger public health or ecosystems and meets mobility needs consistent with use of renewable resources at or below their rates of regeneration and use of non-renewable resources below the rates of development of renewable substitutes.

The transport union of European member countries (2001) defines a sustainable transport system as one that:

- Allows the basic access and development needs of individuals, companies and societies to be met safely and in a manner consistent with human and ecosystem health, and promotes equity within and between successive generations i.e. social sustainability;
- Is affordable, operates fairly and efficiently, offers choice of transport mode, and supports a competitive economy, as well as balanced regional development i.e. economic sustainability;
- Limits emissions and waste within the planet's ability to absorb them, uses renewable resources at or below their rates of generation and uses non-renewable resources at or below the rates of development of renewable substitutes while minimizing the impact on the use of land and the generation of noise i.e. environmental sustainability.

The goal of sustainable transport is to ensure that environmental, economic and social considerations are factored into decisions affecting transportation activity (Most, 1999).

Hence, a Sustainable transport system has to imbibe environmental friendly measures, minimize harmful emissions, and use resources that are renewable and inexhaustible.

As there is no universally accepted definition of sustainable transportation (Beatley, 1995), the above definitions brings about various aspects of sustainability viz resource conservation, endangering of public health or ecosystem, balancing of the present and future needs. Of all the dimensions of sustainability i.e. social, economic and environmental, there is an urgent need to address the environmental dimension of sustainability as the present transportation system consumes oil which is exhaustible and carbon emissions are released into the environment creating adverse effects.

### III. SUSTAINABLE TRAVEL BEHAVIOR

As seen from the above the transport related impacts are severe on the environment, therefore the policy measures are needed to permanently shift peoples travel behavior towards more sustainable means.

As Sustainability is largely in terms of resource conservation and defining success is in terms of changing user's behavior (Di Salvo, 2012) towards sustainable travel means. Anything that the traveler does is termed as behavior and tends to repeat itself. The measures of sustainable travel behavior that have been studied across include: trip time, trip length, and mode choice and trip frequency. Travel behavior is a multidimensional concept in which choice of mode of transport is often given most prominence, but it also includes frequency of trips made, destination choice, trip-chaining, driving styles, car purchasing behavior, preferences for particular routes, times of day, levels of comfort and convenience, the arrangements made between individuals in families, neighborhoods, workplaces and other social groups.

Hence, Sustainable travel behavior is engaging in services like carpooling, biking, walking and use of public transport.

- It has a) higher modal shares of transit, walking and biking;
- b) lower household vehicle ownership;
  - c) lower vehicle miles traveled and
  - d) higher rates of electric vehicle ownership.

From the Mode Choice literature as the public transport system is inefficient in Indian cities and many commuters rely on Intermediate public transport system. As income grows and inefficient public transport system has nudged the commuters to use private transport. Therefore, policy-makers, planners and researchers are aiming at measures that permanently shift people's travel behavior towards more sustainable mobility. Hence, sustainable travel behavior is use of alternative means of transport, reduction of private car use (Internal combustion engine vehicle) and preference towards electric vehicles.

### IV. ELECTRIC VEHICLES AS SUSTAINABLE TRANSPORT

The use of electricity is one of the strategy for greening transportation and electric cars are an efficient means of transportation. The increase in demand for oil, which is an exhaustible resource and as 60% of the oil consumed worldwide comes from the transportation sector has created a need for sustainable transport system. Electric vehicles and transport infrastructure and operation that are resilient to the effects of climate change are the need of the hour. Electric vehicle for environmental sustainability focus on air, energy resources which are needed for biodiversity and our communities. Environment and sustainable transportation is through energy management, pollution control, climate change resilience and resource management. Therefore, transportation electrification is necessary in order to achieve sustainability and shift towards carbon-free vehicles resulting in zero oil consumption. Hence, Electric vehicles (EVs) are the obvious choice. EVs have various advantages over traditional gasoline internal combustion engine vehicles (ICEVs), e.g. diversified fuel sources and low emissions of exhaust gas. Therefore, energy saving, emission reduction, and environmental protection have become powerful forces driving the rapid development of the EV industry. Hence, Sustainable transportation goals to mitigate climate change through the introduction and diffusion of EV have become a priority. EVs have the ability to reduce the emissions generated by the transportation sector to achieve sustainable transportation goals. Hence, EVs have proved to be a necessity.

Electric vehicles (EVs) represent a disruptive innovation product in automotive technology whereby the power train of the vehicle operates partly or solely from electricity stored in an on-board battery pack (O. Van Vliet *et al.*, 2010; Tanaka, 2011). Hence, EVs have the potential to improve the energy efficiency and energy security, and reduce the carbon intensity of passenger vehicle transport (Tanaka, 2011).

### V. EVS TECHNOLOGIES

Electric Vehicles (EVs) are going through a series of technological developments before gaining the recent popularity. EVs have reemerged for a variety of reasons—including improvements in battery technology and strengthened vehicle efficiency and air quality standards.

Hence, EVs are a potentially important technology to help reduce greenhouse gas emissions, local air pollution, and vehicular noise (Brady & O'Mahony, 2011; Hawkins *et al.*, 2013).

The continual developments of EV technologies are important in order to compete with the dominant ICEVs and for wider EV deployment. Attentions have been placed on improving technologies, especially the power train, battery and charging infrastructure. Consequently, these components experience major shift along the EV development process. Battery technology has also transformed from lead-acid to nickel-based

to ZEBRA battery and finally to lithium-based types. There are also many potential battery types, such as metal-air battery, which is comparable with conventional internal combustion engine vehicle in term of energy density. Charging infrastructure which provides fast charging facility is adopted into market lately to solve the short coming of long recharging time of the slow chargers. The following features of Electric vehicles support the fact that these products are Environmentally Sustainable.

*Battery Component:* Lithium ion batteries are well known power components of portable devices like mobile phones, laptops, tablets and Electric vehicles (Ghassan Zubi, 2008). Of all the metals available for battery chemistry, lithium is widely available, nontoxic, light and electropositive. Improvement in extraction technologies & higher lithium prices will result overtime in an increase in global reserves. More than 80% of lithium produced today is extracted from brine lakes and salt pans. It is not wise to depend lithium supply entirely on virgin material, initiating for collection & recycling programs is the right path towards sustainability Zengetal, 2014.

Lithium is mined at Chile's Atacama desert in South America and exported to China for processing. Argentina, Bolivia and Chile have more than worlds half supply of lithium ore and next reserves are in Australia. Extraction of lithium has significant environmental and social impacts due depleting water resource and water pollution. Mining of lithium does have a big foot print, but these metals are used for sustainable initiatives which have lower global carbon dioxide emissions.

Lithium ion batteries could support the integration of high shares of photovoltaic (PV) and wind energy in the power mix by providing storage capacity and ancillary services. Thereby, an electricity mix with a small carbon footprint is the healthy basis for the large implementation of electric vehicles (EV), where Li-ion batteries are the technology of choice. Li-ion batteries also have huge potential for use in off-grid power supply systems, especially in combination with solar home systems (SHS), to provide reliable access to electricity in developing regions. The current state of the art of the Li-ion battery in Electric vehicles presented herein, along with its future perspectives with emphasis on the connection between Li-ion batteries and energy sustainability.

The recycling of Li-ion batteries for the purpose of recovering the lithium and other valuable materials such as cobalt was studied, among others, by Georgi Maschler *et al.*, 2012 and Gonçalves *et al.*, 2015. Finally, recycled lithium from batteries used in power supply systems will have a negligible material supply share before 2035. Altogether, recycled Lithium could contribute to 40% of the lithium supply for the manufacture of new batteries (G. Zubi *et al.*, 2008). Hence, Lithium as a source for battery in Electric vehicles is environmentally sustainable.

## VI. EV ADOPTION AND ENVIRONMENTAL SUSTAINABILITY

The following feature of Electric vehicles supports the fact that these products are Environmentally Sustainable.

- *Energy Efficiency:* EVs are three-to-five times more energy efficient than conventional internal combustion engine (ICE) vehicles. ICE has the energy efficiency of only 30%. This provides unmatched energy efficiency improvement potential for vehicle road transport.
- *Energy Security:* Electric mobility boosts energy security as it transitions the road transport sector from its strong reliance on oil-based fuels. It reduces dependence on oil imports for many countries. Furthermore, electricity can be produced with a variety of resources and fuels, and is often generated domestically.
- *Air Pollution:* There is no zero tailpipe emissions, EVs are well suited to address air pollution issues, especially in urban areas and along road networks, where a large number of people are exposed to harmful pollutants from road transport vehicles.
- *Green House Gas (GHG) Emissions:* Increasing electric mobility in association with a progressive increase in low-carbon electricity generation can deliver significant reductions in GHG emissions from road transport relative to ICE vehicles. In addition, EVs can play an expanded role through their use to provide flexibility services to power systems and act in concert with the integration of variable renewable energy sources for electricity generation.
- *Noise Reduction:* EVs are quieter than ICE vehicles and hence contribute to less noise pollution, especially in the two/three-wheeler category.
- *Industrial Development:* EVs are crucially positioned as a potential enabler of major cost reductions in battery technology, one of the key value chains of strategic importance for industrial competitiveness, given its relevance for the clean energy transition.

Therefore, Electric cars have the potential of significantly reducing city pollution by having zero tail pipe emissions. Vehicle green house gas savings depend on how the electricity is generated. With the U.S. energy mix using an electric car would result in a 30% reduction in carbon dioxide emissions. Given the current energy mixes in other countries, it has been predicted that such emissions would decrease by 40% in the UK, 19% in China, and in India the difference is significant in cities. Even after taking battery manufacture into account, electric cars are still a greener option. This is due to the reduction in emissions created over the car's lifetime.

The above are the stated facts from Global Outlook for EV, 2019 in favor of Electric Vehicles for Environmental Sustainability.

Research revealed that three types of attributes are particularly important for the adoption of sustainable innovations: instrumental, environmental, and symbolic attributes (Noppers, 2015). *Instrumental attributes* reflect the perceived functional outcomes of ownership and use of a sustainable innovation (Dittmar, 1992; Noppers *et al.*, 2014). For example, full battery electric cars have a limited driving range due to its battery.

*Environmental attributes* reflect the perceived outcomes of owning and using a sustainable innovation for the environment (Noppers *et al.*, 2014). For example, no harmful gases or particles are emitted while driving an electric car. Several studies revealed that more positive evaluations of the instrumental attributes (Korcaj *et al.*, 2015; Schuitema *et al.*, 2012) and environmental attributes of sustainable innovations (Korcaj *et al.*, 2015; Noppers *et al.*, 2014) enhance the likelihood of adopting sustainable innovations. Hence, adoption of EV will lead to environmental sustainability by reduction in use of fossil fuel and carbon emissions.

Hence, EV adoption positively influences Environmental Sustainability.

## VII. CONCLUSION

It is clear that Electric vehicles have much lower carbon emissions than internal combustion vehicles and however these savings will increase creating a significant opportunity to decarbonize the transport sector. The characteristic features of Electric vehicle like Energy efficiency, zero carbon emissions and noise reduction makes it a truly environmentally sustainable product. However, there are challenges towards successful adoption of such a disruptive innovative product like policy measures and infrastructure readiness.

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