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Electric mobility in Europe: A comprehensive review of motivators and barriers in decision making processes

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ABSTRACT

European Union's (EU) long-term objective of achieving a competitive low carbon economy is mainly based on enabling environmentally sustainable investments, particularly in terms of decreasing energy consumption in buildings, transition to electric vehicles, and developing smart electricity networks, while promoting renewable energy use in order to reduce greenhouse gas (GHG) emissions by at least 80% by 2050 compared to 1990 levels. Since, transport is one of the main sector responsible for EU's emissions; diffusion of Electric Vehicles (EVs) could allow immense reduction. Therefore, since the announcement of 2050 Roadmap in 2009, there has been a great increase in studies exploring the viability of transition to e-mobility in a Europe-wide context, identifying common factors and variables. However, it is usually not that straightforward when decision makers seek to transform these variables into policy implications that will actually help to achieve the EU goals on energy transition. At this point, the motivators and barriers are of utmost importance. Accordingly, this study is based on an extensive and up-to-date review of the existing literature on e-mobility in Europe, with the main aim of identifying and mapping the motivators and barriers for the diffusion of electric mobility through three levels of decision-making: Formal Social Units, Collective Decision-Making Units, and Individual Units. Results of the analysis identifies that the main barriers are lack of charging infrastructure; economic restrictions and cost concerns; technical and operational restrictions; lack of trust; information and knowledge; limited supply of electricity and raw materials; and practicability concerns. Thus, key motivators appear to be environmental, economic and technical benefits associated with EVs, as well as personal and demographic factors.

1. Introduction

The transport sector is one of the main consumers of fossil fuel, and hence is a major contributor to the EU's total greenhouse gas (GHG) emission, accounting for 23% of total GHG emission as of 2015 (EuroStat Greenhouse Gas Emission Statistics, 2015). It is also the only sector to continue showing increasing GHG emissions (EEA, 2016; European Commission, 2016; Taefi et al., 2016). This not only increases the fossil fuel dependency, but also leads to severe impacts on the environment, such as air pollution, noise, resource use and waste, and eventually, causes climate change (EEA, 2016). To address the issue of climate change, the European Commission has set the target of achieving emission-free urban passenger transportation by 2050 (i.e., abandoning the use of conventionally fuelled cars in cities) and emission-free urban freight transportation by 2030 (i.e., CO_2 free logistics) (European Commission, 2011).

However, in order to reach these targets set by the European Commission, there needs to be a shift in the transport sector from

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fossil fuel dependent vehicles to alternative transportation systems that are less dependent on fuel. Key to this shift is electric mobility, and in specific the introduction of electric vehicles (EV) (Usmani and Rösler, 2015). These vehicles are fully or partially electrically powered, and hence reduce fossil fuel dependency and GHG emissions. However, as of now, the acceptance of alternative fuel saving transport vehicles is still marginal, and EU sales volume of EVs is very low. For example, very few countries, such as Sweden (3.8%), and Belgium (2.1%) have market share exceeding 2% of total new car sales by the first half of 2017 (The Electric Vehicle World Sales Database, 2017). The Netherland's 3.87% EV share in new car sales in 2014 dipped to 1.5% in 2017, pursuant to expectations of incentive withdrawals (IEA, 2016; EAFO, 2017). Not being an EU member, Norway maintains generous tax incentives and the country's 28.9% EV diffusion rate is also worth noting in terms of new sale market shares in Europe. In the light of such examples, low figures in EV penetration demonstrate the need for governments and institutions to take action in order to increase market diffusion.

Several research projects have addressed the issue that the electric mobility market is still in infancy, and point to many barriers and challenges to successful diffusion of EVs throughout Europe. These studies also provide recommendations for governments and institutions to remedy this slow diffusion, and recommend policies and incentives to alleviate this concern. Despite the keen interest in this research area, there is a lack of studies providing an extensive overview, considering the existing literature, technical reports and directives. This study therefore provides a comprehensive assessment that (1) investigates the actions conducted so far to reach the 2030 and 2050 goals, (2) analyses the current situation within the EU, and finally, (3) identifies motivators and barriers related to Europe's transition towards electric mobility.

This study is based on an extensive and up-to-date review of the existing literature on electric mobility in Europe, with the main aim of identifying and mapping the motivators and barriers for the diffusion of electric mobility in Europe with a significant focus on the three different decision levels defined as formal social units: (1) formal social units, (2) collective decision-making bodies, and (3) individual consumers. This approach allows this study to produce a critical overview of the overarching importance of varying motivators and barriers in different levels. The study is based on manuscripts, technical reports and directives focusing on Electric Mobility in Europe, published between 2003 and 2017. A keyword search utilizing words and phrases such as "electric mobility", "e-mobility", "electric vehicles", "energy behaviour", "automobility", "electric bus", "hybrid vehicles", "smart charging", "low carbon transport", "consumer awareness", "energy transition", "smart mobility", and "eco-driving" was conducted on major academic databases, including Web of Science, Sciencedirect, Scopus and Google Scholar to generate a list of relevant manuscript in addition to the existing technical reports and directives. The initial list of references contained around 500 sources. These were then refined by omitting first recurring manuscripts, and then those with a focus outside the European experience, while this study selectively included additional relevant items. The manuscripts were then examined thoroughly and classified into categories, and subcategories based on levels of decision-making, method used, and perspective adopted. Following this pre-process, around 90 sources were included in the analysis.

This study first concentrates on the importance of electric mobility in Europe, outlining its role and impact, goals set by the EU and its member states, car manufacturer's efforts, specific objectives with regard to infrastructural dimensions, and main challenges. Following that, it focuses on decision-making processes as a critical dimension in developing the electric vehicle market, highlighting the key motivators and barriers for three levels of decision-making: Formal Social Units, Collective Decision-Making Units, and Individual Units. Then, this study discusses the results of the analyses and main findings.

2. Importance of the electric mobility in Europe

2.1. Role and impact of electric mobility

Transport sector accounts for a quarter of Europe's GHG emission, and therefore is considered to be a major source of air pollution, contributing to climate change (European Commission, 2016). The electrification of transport (electric mobility) not only significantly reduces energy consumption and GHG emissions, but also enhances Europe's energy security. In addition, public health will benefit from the reduction of air pollution. The shift towards electric mobility also offers many opportunities for European car manufacturers through modernized technologies, and these opportunities are needed for market innovations. Besides car manufactures, also energy companies and service providers can benefit from the shift, because new jobs will be created with the development of modernized technologies throughout the different sectors (Haddadian et al., 2015; European Commission, 2016). Electric mobility is hence the focus of discussions concerning sustainable and energy-efficient means of transportation (Peters et al., 2011; Faria et al., 2014).

Innovations enabling the electrification of transport are EVs, plug-in battery-powered electric vehicles that are able to be charged through an external power supply (Chan, 2007). There are several existing types of EVs with a range of varying technologies, including plug-in hybrid electric vehicles (PHEVs), battery electric vehicles (BEVs), extended-range battery electric vehicles (E-REVs) and hybrid electric vehicles (HEVs). According to definitions by Adnan et al. (2016), BEVs run solely on electricity via on-board batteries that are charged by plugging into a power outlet or charging station. These vehicles do not have a gasoline engine, but do have longer electric driving ranges compared to PHEVs, and create no tailpipe emissions. PHEVs have an internal combustion engine powered by conventional or alternative fuel, and an electric motor that uses battery-stored energy power. These types of vehicles can be plugged into a power outlet to charge the battery. Some types of these vehicles can travel more than 70 miles on electricity alone, or, solely on gasoline. HEVs, on the other hand, have primarily an internal combustion engine that runs on conventional or alternative fuel, and an electric motor that uses energy stored in a battery powers. The battery is charged via regenerative braking and the internal combustion engine, and there is no need to plug into a power outlet.