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Department of International & European Studies
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Thesis:

“Energy Storage and Battery Electric Vehicle (BEV) adoption in Greece”

Anna Pantousi
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Anna Pantousi

Contents

Summary

The Thesis examines the role of incentives, as means of promotion, with regards to their connection with Battery-Electric-Vehicles sales and electric-Mobility growth worldwide. Economic incentives, such as exemptions from purchase tax and VAT among others are discussed and considered strong encouragements and crucial for promoting the purchase and ownership of BEVs.

Apart from fiscal and non-fiscal incentives that are typically introduced by countries and are mostly related to purchase incentives such as subsidies, tax benefits and exemptions, infrastructure promotion measures, traffic regulations and other benefits such as free parking, the Thesis evaluates the revolutionary Vehicle-To-Grid technology and its concept applications with the possibility of becoming a motivating factor which could increase the share of BEVs in transportation sector. The V2G concept allows BEV owners to make a profit from owning a BEV while it is connected to the power grid.

A sociotechnical analysis of e-Mobility and V2G technology along with a SWOT analysis of e-Mobility in Attica, Greece are performed. The Thesis concludes that the V2G concept, already applied by several countries, apart from the technological challenges it has to overcome, comprises an incentive that could assist in the rapid growth of BEVs, create new business and employment opportunities, promote innovation and partnerships, benefit public health and the environment.

Abbreviations

Abbreviation	Definition
BEV	Battery Electric Vehicle
CO2	Carbon dioxide
E-Mobility	Electric Mobility
EU	European Union
EV	Electric Vehicle
EVSE	Electric Vehicle Supply Equipment
GHG	Green House Gas
ICEV	Internal Combustion Engine Vehicle
NO2	Nitrogen Dioxide
OEMs	Original Equipment Manufacturers
PEV	Plug-In Electric Vehicle
RES	Renewable Energy Sources
SFIO	Plans for Charging Stations of Electric Vehicles
SUMPs	Sustainable Urban Mobility Plans
USA	United States of America
V2G	Vehicle to Grid
VAT	Value Added Tax
VGI	Vehicle-grid integration
YLL	Years of Life Lost

Chapter 1: Introduction

The Aim

The aim of this Thesis is to present the means of promotion, incentives, and their role to the integration of Battery Electric Vehicles (BEVs) and electric Mobility (e-Mobility) in the transportation sector worldwide. The Thesis shall examine the current fiscal and non-fiscal incentives adopted by various countries leading the global market, aiming to present a case applicable to the Greek market. The newly introduced and revolutionary concept of Vehicle-to-Grid (V2G) shall be also examined and the possibility to be applied in the Greek market and work as an incentive that will increase the use of BEVs.

The Methodology

The methodology to develop and present the V2G realization in Greece comprises of a sociotechnical review that shall evaluate the benefits and challenges of e-Mobility and the V2G concept. The sociotechnical analysis is performed by breaking down the analysis into four distinct categories that of technical, financial, socio-environmental and behavioral, similar methodology applied in studies by Sovacool (Sovacool et al., 2017; Sovacool et al., 2018). Additionally, a SWOT analysis shall be performed with regards to e-Mobility in Attica - Greece, in order to explore and discuss the possibility to integrate the V2G prospect in the Greek market.

The Structure

The second chapter of the Thesis provides a background review of the incentives currently in place in EU and other key markets and introduces the V2G technology and its concept applications. Latest developments in key markets are also presented and results discussed focusing on the efficiency of incentives adopted for the promotion of e-Mobility and BEVs integration to the transportation sector. A comprehensive literature review regarding the existing incentives promoting BEVs, V2G technology and several pilot V2G projects already in operation are presented as well. The third chapter analyses e-Mobility and the V2G concept from a sociotechnical point of view along with a SWOT analysis of the e-Mobility and the prospect of V2G application in the Greek market. The fourth chapter discusses the significance of the findings and concludes with the most important issues raised in this Thesis.

The Contribution

Previous research has shown that the most common motivating factors that countries have introduced for the promotion of BEVs are mainly fiscal incentives such as tax benefits and exceptions from purchase tax and VAT (Bjerkan et al., 2016; Kempton et al., 2014; Sierzchula et al., 2014). However, such incentives are economically and politically dependent on the country's policies and financial status. The Thesis supports that the V2G technology comprises a potential strategic tool that could be used worldwide to promote the use of BEVs in transportation sector, to reduce pollution, improve public health, protect the environment, create new business and employment opportunities, and benefit the society without requiring additional financial aid to be allocated from Governments.

Chapter 2: Literature review: The role of incentives as boosters of e-Mobility

2.1 Introduction

Globally and in European Union particularly, countries are trying to tackle climate change by reducing carbon dioxide (CO_2) and other Green House Gas (GHG) emissions by adopting new policies and setting long term targets.

The transportation sector being one of the main contributors of GHG emissions emerged the need for reducing such emissions and to decarbonize the sector by introducing non fossil fuel-based solutions. Electrifying the transportation sector is considered the most appealing way to achieve this goal and many countries have introduced various types of incentives to promote the purchase and ownership of Hybrid and Battery Electric Vehicles (BEVs).

This Chapter explores the various types of incentives that countries have adopted and discusses the importance and effectiveness of such means for the promotion of BEVs and their integration in the transportation sector. Furthermore, the case of Greece shall be particularly considered for the purpose of the Thesis, with the main legal framework of e-Mobility and the most recent incentives being presented along with a discussion on the initial results.

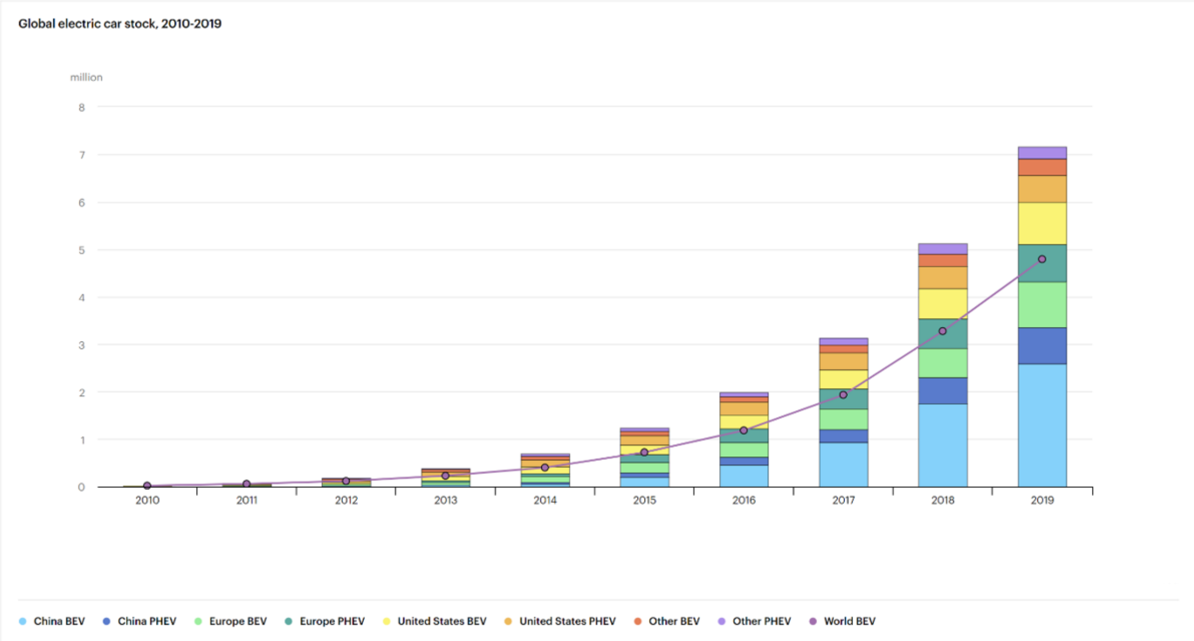
Furthermore, the V2G concept will be introduced and evaluated along with several V2G pilot projects already in operation. The concept shall be evaluated as an alternative mean of BEV promotion, which does not necessarily rely on the financial and political status of a country and could greatly benefit the society, economy, employment, and environment.

The global forecast for BEV market is also briefly presented in order to demonstrate the increasing global trend and discuss the opportunities that derive from this tendency, as the widespread adoption of BEV could significantly contribute not only to the successful V2G realization, but also to EU 2030 targets to promote e-Mobility and cut CO_2 emissions from the transportation sector.

2.2 Global key Markets and the role of incentives

Globally, BEVs and electric mobility have shown a significant growth in the recent years. According to IEA, (2020), in 2019 the total number of electric cars sold globally was increased by 2.1 million which is approximately twenty-nine percent (29%) from the record year of 2018.

Figure 1: Global electric car stock, 2010-2019.



Source: (IEA, 2020)

Figure 1 shows the increase in Global Electric car stock from 2010-2019. Globally, the leading country in the electric car market is the Republic of China, which is followed by Europe and the USA.

A variety of promoting measures is observed to be used by the leading countries in the sector, mainly in the form of policies regarding zero and very low emission vehicles and economic aid related to purchase cost. The most common economic aid that countries introduce are fiscal related and mainly refer to reduction of up-front purchase costs and tax and VAT exemptions (Bjerkan et al., 2016). Such types of incentives are dependent on the country's economic status and political and environmental views. Consequently, the more ambitious policy announcements, the more critical role in stimulating the evolution of e-Mobility in the market.

The importance of having economic incentives is greatly understood by observing global sales in 2019, in the key markets of China and the USA, where purchase subsidies were decreased. In China electric car purchase subsidies reduced by approximately half in 2019 and the US federal tax credit program ended for key electric vehicle automakers. These actions contributed to a significant drop in electric car sales in China in the second half of 2019, and a ten percent (10%) drop in the United States over the year. With a ninety percent (90%) of global electric car sales made in China, Europe and the United States, this situation influenced the global sales and overshadowed the significant fifty percent (50%) sales increase in Europe in 2019. This affected the upward trend, observed in the previous years, to be decelerated (IEA, 2020).

The following table summarizes various types of fiscal and non-fiscal incentives currently in place by EU countries with regards to e-Mobility.

Table 1: Different fiscal and non-fiscal incentives regarding e- Mobility in EU countries.

Country	Purchase Incentive or Subsidies	Tax benefits and exemptions	Other benefits (i.e. free parking)	Infrastructure promotion measures	Traffic Regulations (i.e. bus lanes, low emission zones)
Austria	▪	▪	▪		
Belgium	▪	▪			
Bulgaria	▪				
Croatia		▪			
Cyprus		▪			
Czech Republic		▪			
Denmark		▪		▪	
Finland	▪	▪			
France	▪	▪	▪	▪	
Germany	▪	▪	▪	▪	▪
Greece		▪			
Hungary		▪	▪		▪
Iceland	▪	▪	▪	▪	
Ireland	▪	▪	▪	▪	
Italy		▪		▪	
Latvia		▪	▪		▪
Lithuania		▪	▪		▪
Luxemburg		▪			
Malta	▪	▪			
Netherlands		▪			
Norway	▪	▪	▪	▪	▪
Portugal	▪	▪	▪		
Slovakia	▪	▪			
Spain	▪	▪	▪		▪
Sweden	▪	▪		▪	▪
Switzerland	▪	▪			
United Kingdom	▪	▪	▪	▪	▪

Source: (HAEE, 2019)

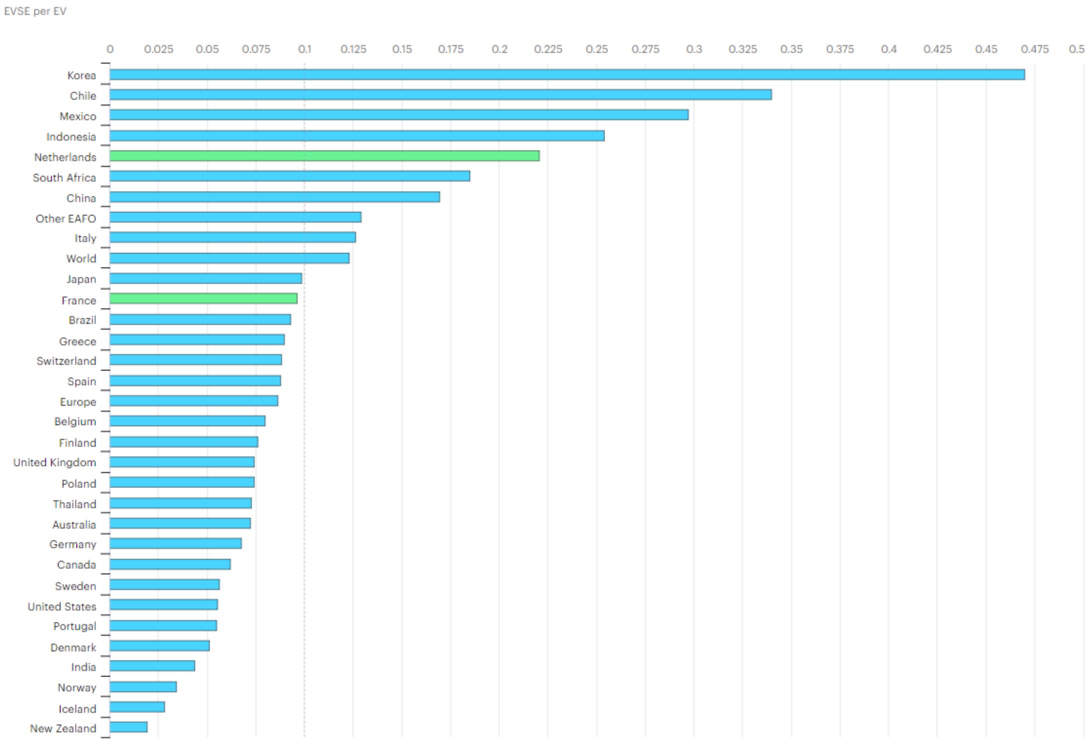
It can be observed from Table 1 that the majority of countries in EU focus mostly on fiscal incentives such as tax benefits and tax exemptions or relief. On the other hand, countries such as Germany, Norway, and the United Kingdom, in addition to instituting monetary subsidies for EV purchases, are investing in charging infrastructure as part of their economic-stimulus programs, ranging from direct investments for public charging stations to subsidies for private charging stations at homes and workplaces (Gersdorf et. al, 2020).

Norway is one of the leading countries in terms of BEVs adoption (IEA, 2021; Tschiesner et al., 2020). As illustrated in Table 1, the benefits for electric vehicle owners in Norway include monetary and non-monetary aspects. Kempton et al., (2014) suggests that the Norwegian EV success story is explained by "the combination of different and complementary elements" to make EVs appealing to private users, such as no purchase taxes applied to EVs in contrast to conventional vehicles, no charges on toll roads, free municipal car parking access and free access to bus lanes along with sufficient charging stations and charging points to alleviate the range anxiety problem and to sustain the large fleet of private EVs.

Greece lacked non-fiscal incentives compared to other European countries. Until recently, electric vehicle owners in Greece have gained benefits from luxury tax exemptions, circulation and registration costs. However, the latest developments with regards to incentives in Greece, are encouraging and being further examined in the next section.

Public charging is an important element for the widespread adoption of BEVs, without which e-Mobility growth would be very difficult to be achieved. Based on IEA, (2021) most European countries did not reach 2020 Alternative Fuel Infrastructure Directive (AFID) targets for publicly accessible chargers. The vast majority of countries in Europe did not succeed to meet the recommended Electric Vehicle Supply Equipment (EVSE) per EV 2020 targets for publicly accessible chargers set by AFID.

Figure 2: Ratio of public chargers per EV stock by country, 2020.



Source: (IEA 2021)

Figure 2 demonstrates that countries with the highest EV penetration tend to have the lowest public EVSE per EV ratios, such as Norway (0.03), Iceland (0.03) and Denmark (0.05). In such countries, where population typically stays in sparsely detached houses with private parking spaces and is not that concentrated in big cities, most EV owners rely on the use of private home charging. It should also be noted that the Nordic countries have a higher proportion of fast chargers, with shares of forty percent (40%) in Iceland, thirty-one percent (31%) in Norway and seventeen percent (17%) in Denmark (IEA, 2021).

It is necessary to create a sense of security in BEVs drivers, regarding the issue of public and private charging, in order to facilitate car owners in their decision to purchase an electric vehicle. For the successful implementation of e-Mobility in Greece, it is necessary to have the appropriate infrastructure, such as several charging stations to accommodate the fleet of electric vehicles, as well as a reliable electricity network.

2.3 Electric Mobility and incentives in Greece

In Greece, tax incentives for electric vehicle owners are in place. The fiscal related benefits are linked with tax exemptions, circulation and registration costs. According to HAEE's Greek energy market report, (2019), the promotion of both fiscal and non-fiscal incentives in Greece are required to create a significant increase in the share of electrical vehicles.

HAEE, (2019), considering the country's economic capabilities, low GPD per capita, as well as the previous years of recession in the country, suggests that in order to achieve a high and quick penetration of e-Mobility in the transportation sector, the incentives should be focused on economic factors, so as to provide a solution appealing and viable for the Greek buyer. In addition, considering the "special user groups" like bus and taxi fleets and the inadequate presence of charging stations, the need of a comprehensive plan tackling these issues is highlighted.

In year 2020, a major step has been made to promote e-Mobility and to entice the country's drivers for the purchase of electric vehicles. The new legal framework for e-Mobility provided both fiscal and non-fiscal incentives for the growth of e-Mobility such as subsidies for the purchase of EVs, the creation of new parking spaces, the imposition of an environmental tax and a prohibition on the import of old used vehicles as well as tax exemptions for the purchase and lease of BEV.

The state subsidized program, "*move electrically*" (Ministry of Environment and Energy, 2020), was introduced for the purchase or lease of electric vehicles, subsidizing up to twenty percent (20%) of total purchase cost for electric cars and up to forty percent (40%) for electric bicycles. The considerable amount of the subsidy granted was also linked with an additional bonus for the withdrawal of old and polluting cars, as well as for the purchase of domestic electric car chargers. The program was also applicable to professional drivers i.e. Taxi drivers, aiming to tackle the issue of the old and polluting Taxi fleet in the country.

According to the Ministry of Environment and Energy, (2020), the first results of the program were very encouraging. In the initial 15 days, about 5,000 applications were submitted for a subsidy to purchase an electric vehicle, which accounts for approximately ten percent (10%) of the available funds allocated. The Program created a turnover in the market of 35 million euros during a period of economic recovery and COVID-19 pandemic, which cannot be disregarded. The Program, apart from the obvious environmental benefits and aforementioned economic growth results, showed a sustainable and viable way of promoting e-Mobility. It should be noted that the participation of Greek islands reached approximately twenty percent (20%) of the total vehicles subsidized through the Program. In addition, initiatives are made by Private sector for the installation of electric vehicle charging points.

Large and medium-sized municipalities are obliged to prepare electric vehicle charging plans (SFIO) for the allocation of a sufficient number of publicly accessible charging points and relevant parking spaces, which will consider the urban and traffic characteristics of each area. In addition, the licensing procedures for vehicle charging infrastructure installations were simplified.

Due to the new established framework for the promotion of e-Mobility, Greece was recently included in the eight EU countries, providing a holistic network of incentives, both direct and indirect, to replace old, polluting vehicles (Sdoukou, 2021).

At last, according to the latest news and announcements at the Electric Vehicle Conference 2020, the strategy of the Ministry of Infrastructure and Transport is to further promote e-Mobility by focusing on the renewal of the aging fleet of cars and the creation of a wider network of publicly accessible charging stations (Karamanlis, 2020).

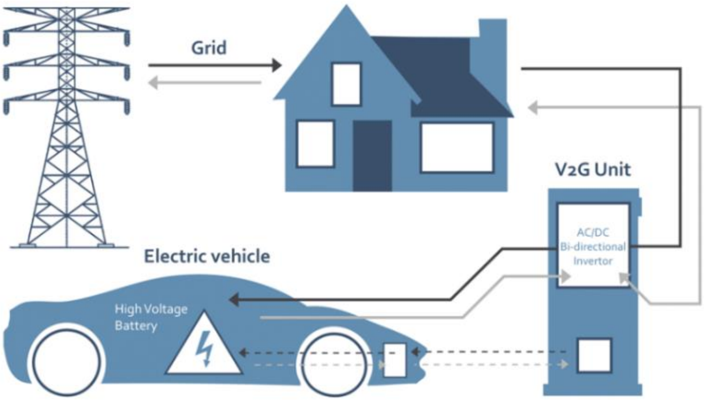
2.4 Vehicle-to-Grid (V2G) technology

Along with the BEVs evolution, a new concept that has been recently introduced and appears promising for the rapid development of e-Mobility, is the Vehicle-to-Grid concept. The V2G is a more technically advanced concept based on the Vehicle to Grid Integration technology (VGI). A technology that basically approaches to link the electric power system and the transportation system in ways that would both benefit from (Sovacool et al., 2017).

In the V2G concept, a vehicle is connected to the Grid not only to charge its battery but inject electricity from its battery to the Grid in certain occasions. Such occasions include the vehicle's battery to be used as a tool by the Grid Operator to overcome Grid stability issues.

Figure 3 illustrates, the V2G technology, which allows a battery powered electric vehicles to act as a mobile energy storage unit through the use of a bidirectional charging unit. This bidirectional way of charging assists to better manage electricity and thus avoid any waste of energy resulting in better Resource management.

Figure 3: V2G technology.



Source: (Energy Storage Journal, 2019)

It becomes apparent that BEVs are intended to serve the power grids as temporary energy storage units. This results in the optimization and stabilization of the network with smart technologies. In addition, owners of BEVs that will provide power to the grid, will be compensated for this service. Malmgren, (2016), suggests that V2G could serve as an additional revenue source and as the BEV market and technology advances, as valuable tool or resource to the grid as well.

The V2G concept comprises a revolutionary way to promote e-Mobility and is different in nature from the incentives introduced by the Governments and presented in the previous sections. As already discussed, the most frequently applied incentives for motivating the use of BEVs were in the form of subsidies or tax exemptions which require financial aid to be allocated by the countries.

The V2G concept serves as an extra incentive by turning BEVs from an energy "consumer" into a "producer" or literally into a "prosumer", that both consumes and produces (Söderbom, 2020). Such concept allows BEV owners to sell electricity to the Grid during peak demands, when electricity consumption is at its highest and cost of electricity much greater than the daily average. The V2G technology can create a profit to BEV owners from the sale of electricity stored in the BEV's battery and from the aforementioned grid support services when the BEV is connected to the Grid.

V2G concept supports to achieve sooner EU targets set for cleaner, more affordable, renewable energy. It also supports the transformation to a smarter, more stable, flexible grid, that does not rely on fossil fuels (Topping, 2021). Increasing the use of electricity from renewable sources of energy builds a cleaner environment without the need of consuming carbon-based fuels.

2.5 The V2G potential

The majority of research on incentives for BEV adoption relates to financial incentives and taxation (Bjerkan et al., 2016). Sierzchula et al., (2014) support that financial incentives, along with an adequate amount of charging stations and a production of BEV, are strong predictors for BEV adoption. Additionally, Bjerkan et al., (2016) investigate the role of seven different (fiscal) incentives, exemption from purchase tax, exemption from VAT, vehicle license fee reduction, exemption from road tolling, free parking, bus lane access and free ferry tickets and concludes that purchase cost reduction is the strongest incentive in promoting BEV adoption. Similarly, Kempton et al., (2014), propose purchase subsidies, EVSE strategic development and the removal of barriers in the market for grid-services.

Söderbom, (2020), from another point of view supports that a high penetration of BEVs in the future transport sector is inevitable and will result to high demand of electricity from the grids and supports that V2G technology is one of the few viable flexibility assets that could support the grids and financially benefit the BEV users. Similarly, Uddin et al. (2018), argue that BEV growth offers great potential of V2G to play a significant role in grid services and highlighted that establishing the appropriate compensation model is necessary for V2G expansion. Malmgren, (2016), distinguish the incremental cost of the vehicles as the main barrier that EV market encounters whereas the benefits gained from the integration of BEVs include public health, air quality, economic growth, and grid resilience.

Kester et al., (2018) examine policy suggestions for BEVs and V2G growth, identifying double taxation, dynamic pricing, and the need for technical and regulatory guidelines being the most important. Lack of awareness and deeper understanding of the V2G concept and its applications in the transportation and electricity sector are important obstacles that need to be addressed.

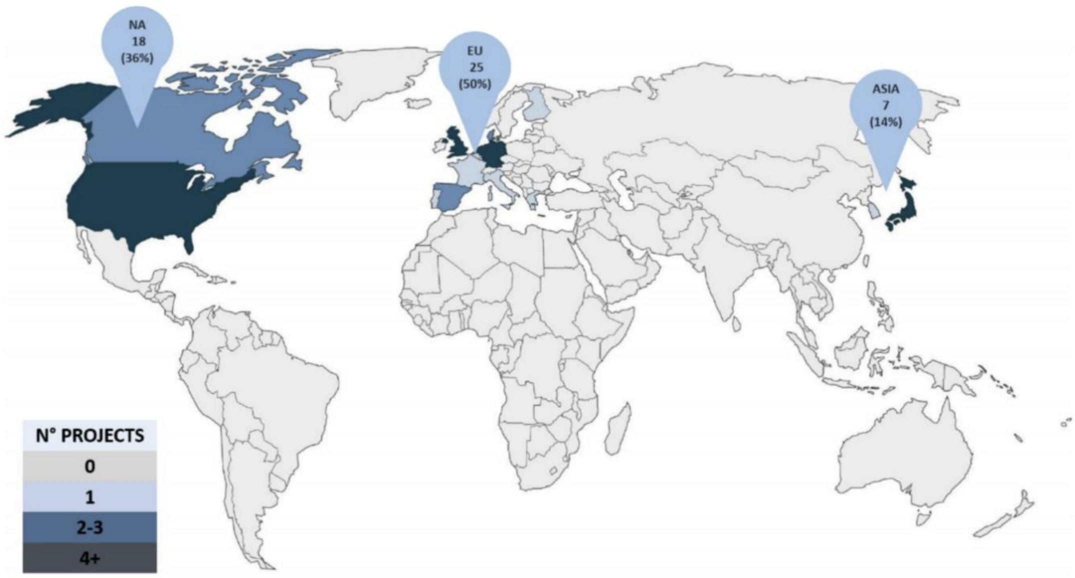
Sovacool et al., (2017), identify various opportunities, and challenges relating to V2G and introduce different aspects and possible application of VGI. Noel et al. (2019) are elaborating on the idea that the technical barriers of V2G form the basis of other sociotechnical barriers, discuss how the technical elements of V2G impact its economic effectiveness, and conclude that challenges arise from the pricing and revenue schemes, ownership structures, and the integration with other technologies.

2.6 V2G pilot projects

More than fifty V2G pilot projects are in operation globally, out of which twenty-five are located in Europe, eighteen in North America, and seven in Asia. In Europe, Northern European countries dominate with the Netherlands, Denmark, UK and Germany being the market leaders (Everoze and EV Consult, 2018).

Figure 4 below shows the location of V2G projects currently in operation worldwide.

Figure 4: V2G projects around the world.



Source: (Bianconi, 2019)

Six V2G projects will be briefly discussed in this section, five located in Europe and one in South Korea. The projects presented are selected in a way to show the different aspects they investigate in order to provide a comprehensive understanding of the current features of the technology, its limitations and future challenges and opportunities related to the V2G concept adoption globally.

The Kepco project located in South Korea, is a Research & Development Project that has no real users/customers. It is a Laboratory Testing facility managed by researchers that are working to find a better range of state-of-charge for batteries used for V2G applications. Many different testing cases are performed in various charging and discharging time periods, with the main ones being charged during night time or afterwork time and discharged during day time. The project is part of a broader VGI program seeking to ease the BEV integration in the transportation sector of South Korea and investigate different battery technologies that could overcome current limitations in battery technology (Everoze and EV Consult, 2018).

The Smart Solar Charging project is a pioneering V2G project that combines Car Sharing Business Model and Renewable Energy. Electricity produced by solar photovoltaic installations in the area is used to charge BEVs with the goal to develop a sustainable energy storage system utilizing green energy and supplying to the grid at time periods where Solar Photovoltaic installations are not producing (Bianconi, 2019).

Similarly to the Smart Solar Charging Project, the New-Motion V2G project also examines the concept of integrating "green" electricity from renewable energy sources to BEVs. The project is testing the ability of V2G technology to store energy during times when demand on the grid is stable and inject it back to the grid during times when the main energy system is stressed (Nhede, 2018).

Grid Motion Project is another pilot V2G project, the first developed in France. V2G chargers were installed with a commercial BEV fleet and smart charging at consumer homes (Everoze & EV Consult, 2018). The Project examines smart charging and discharging strategies that of shifting charging times during low demand hours and discharging during high demand hour periods. Specifically, BEVs sell electricity during high demand, peak hours, at a high electricity price while charging during low demand hours at a lower electricity price. The price difference creates a profit to BEV owners (Bianconi, 2019).

The Parker Project located in Denmark is the first commercial European V2G test project. The purpose of the project is to validate whether BEVs can enhance the power grid by becoming a vertically integrated resource supporting the power grid both locally and system wide (Parker, 2017).

The Project proved that V2G technology works in a number of commercial electric cars and that the technology can be commercialized. The project was able to show the business potential of V2G technology, as the ten BEVs provided approximately 100 hours of V2G services per vehicle, injecting approximately 130,000 kWh to the grid in a two year period, which is equivalent to the annual consumption of 21 households. At the same time, 130,000 kg of CO2 emissions were saved, and each car generated 1,860 € per year by participating in energy markets, selling electricity back to the grid (Parker, 2017).

At last but not least, the Astypalea Project located in Astypalea island in Greece is worth to be mentioned as it is a promising initiative performed by the public and private sector for the promotion of e-Mobility. The Greek government and Volkswagen Group designed a pioneering project for a shift to e-Mobility and the full electrification of the island of Astypalea, in the South Aegean. The Astypalea project is a pilot project aiming at transforming the island into the first smart green island in the Mediterranean. BEVs, including the first fully electric police car in Greece, were delivered by Volkswagen Group along with the first public and private charging points on the island. The Greek government will establish renewable-energy infrastructure, including solar panels and batteries, and potentially use the entire vehicle fleet for V2G applications. The plan also includes the installation of a Solar PV plant and Battery Storage system by 2023 (Tugwell and Rauwald, 2021). "Green" energy and energy storage will be combined with smart charging technologies to manage the additional demand generated by EVs. Charging shall not be performed during hours of high energy demand, neither at the same time for all vehicles but will be synchronized with the hours when there is high production from the wind and solar photovoltaic plants.

The project will also include a study conducted by the University of Strathclyde in Scotland and the University of the Aegean in Greece that will monitor and evaluate the transformation on Astypalea. It will focus on the local residents and their attitudes towards the transformation. A series of surveys will examine the general views on e-Mobility and the readiness to switch to an electric vehicle, providing a deeper understanding of the key levers and barriers of the transformation. The final results of the study will be made public and can help to accelerate the switch to e-Mobility in other regions (Kathimerini, 2021).

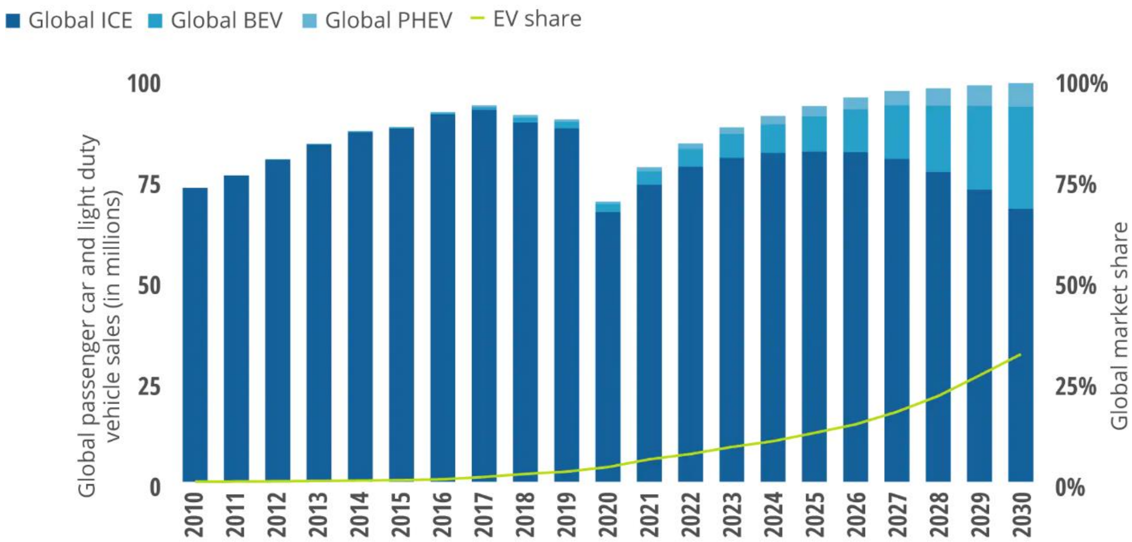
2.7 Global trend and sales forecast

In the EU framework for energy and climate, Greece, like all European countries, has set air pollution targets by the year 2030 to cut CO_2 emissions from cars by approximately thirty-seven percent (37.5%) and vans by thirty-one percent (31%) (EEA, 2019; EU, 2019), leading to an increasing global trend of EV in the transportation market, as an increase in the uptake of electric vehicles could contribute to achieve these goals. The transportation sector globally accounts about twenty-four percent (24%) of direct CO_2 emissions from fuel combustion (IEA, 2020b). As BEVs do not emit CO_2 or other pollutants directly, their expansion will assist in the reduction of such emissions and pollutants and will support EU's targets for 2030.

Deloitte Insights, (2020) forecasts an annual growth rate of twenty-nine percent (29%) for BEV sales to be achieved over the next decade. Total BEV sales are expected to increase from 2.5 million in 2020 to 11.2 million in 2025 and reaching 31.1 million by 2030.

As shown in Figure 5, Deloitte Insights, (2020), forecasts that BEVs would account approximately thirty-two percent (32%) of the total market share for new vehicles sales by 2030, gradually leading to a "cleaner" mode of transport and to a higher penetration of RES, increasing security of supply.

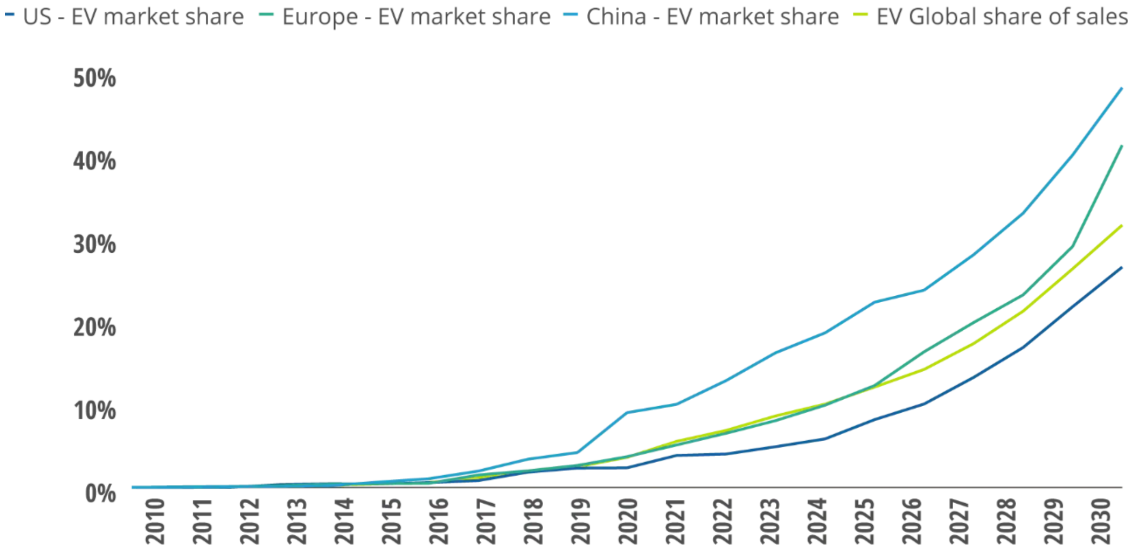
Figure 5: Outlook for annual global passenger- car and light-duty vehicle sales to 2030.



Source: (Deloitte Insights, 2020)

Figure 6 below shows the expected share of new electric car sales in the leading markets. A significant variation can be observed across the markets, showing China on the top of the ranking with a domestic market share of around forty-eight percent (48%) by 2030, the United States twenty-seven percent (27%) almost half of China's share, and Europe achieving approximately forty-two percent (42%) (Deloitte Insights 2020).

Figure 6: Outlook for EV market share by major region.



Source: (Deloitte Insights, 2020)

The private sector also shows the same commitment and pace for zero-emission vehicles. Despite the COVID-19 pandemic, many international companies are accelerating the transition to e-Mobility by replacing their conventional fossil-fuel car fleets to BEVs and installing charging stations (IEA, 2021).

Table 2 below provides a summarized view of the recent announcements made by major companies in order to accelerate their transition to e-Mobility.

Table 2: Private sector demand for zero-emission commercial vehicles amplifies market signals for OEMs to develop EVs.

Company	Operating area	Announced	Actions
Amazon	Global	2020	Orders 100,000 BEV light-commercial vehicles. Amazon aims to be net-zero emissions by 2040.
Anheuser-Busch	United States	2019	Orders up to 800 hydrogen fuel cell heavy-duty trucks.
DHL Group	Global	2019	Delivery of mail and parcels by EVs in the medium term and net-zero emissions logistics by 2050.

FedEx	Global	2018	Transition to an all zero-emission vehicle fleet and carbon neutral operations by 2040.
H2 Mobility Association	Switzerland	2019	19 of Switzerland's largest retailers invest in hydrogen trucking services that will deploy up to 1,600 heavy-duty zero-emission trucks.
Ingka Group (IKEA)	Global	2018	Zero-emission deliveries in leading cities by 2020 and in all cities by 2025.
Japan Post	Japan	2019	Electrify 1,200 mail and parcel delivery vans by 2021 and net-zero emissions logistics by 2050.
JD	China	2017	Replace entire vehicle fleet (> 10, 000) with New Energy Vehicles by 2022.
SF Express	China	2018	Launch nearly 10,000 BEV logistics vehicles.
Suning	China	2018	Plan to deploy 5,000 of new energy logistics vehicles.
UPS	North America	2019	Ordered 10,000 BEV light-commercial vehicles with potential for a second order.
Various companies	Multinational	2018	Large multinational corporations pre-order 2,000 Tesla Semi models within six months of truck's debut.
Walmart	United States	2020	Electrify the whole vehicle fleet by 2040.

Source: (IEA, 2021)

Additionally, according to IEA, (2021), Original Equipment Manufacturers (OEMs) worldwide have set electrification targets for 2030 and several other plans to reconfigure their production lines and produce only electric vehicles such as Ford, Volvo, Volkswagen, and General Motors. These announcements align with the global forecasts and justify the anticipated forecasted sales of electric vehicles.

2.8 Conclusion

In this Chapter, a comprehensive literature review is made regarding the current status of BEV growth globally, the means of promotion of e-Mobility by countries and the V2G application along with several pilot V2G projects in operation.

The majority of incentives introduced by countries are fiscal related, which creates a strong link between means of promotion and a country's financial and political status. Such dependency on incentives and polices set by countries can be tackled by the introduction of V2G technology and its applications.

The V2G technology is considered a very efficient application that can incorporate electricity produced by renewable energy sources, become a tool for grid operators to regulate the Grid during instabilities and eventually provide potential earnings to BEV owners. The V2G technology could play a key role in overcoming the challenges of the shift to a more energy efficient renewables-based transportation sector, enabling vehicles to simultaneously improve the efficiency of electricity grids, reduce greenhouse gas emissions in transport and provide an incentive for the massive adoption of BEV's and the evolution of e-Mobility without requiring any financial aid to be granted by the Governments.

As explored in this Chapter, Greece set a legal framework and provided guidelines for the successful implementation of e-Mobility and auxiliary services. Apart from providing fiscal incentives for the BEV purchase and lease, a more comprehensive plan was also made to promote the development of additional services and create demands that will have a positive impact in the BEV growth. The results of this promotion demonstrated a positive effect on BEV market share, despite the pandemic.

Additionally, the global forecast for BEV market reveals an increasing global trend and highlights the opportunities that can be derived from e-Mobility. The considerable growth of BEVs leading up to 2030 will create significant opportunities and challenges for traditional OEMs, new entrant OEMs, dealerships, and companies.

Chapter 3: The Methodology

3.1. Introduction

In this Chapter, in order to explore e-Mobility and to develop and present the V2G realization in Greece, the methodology to be applied is a sociotechnical review and a SWOT analysis.

The sociotechnical review on the benefits and challenges of e-Mobility and the V2G concept is applied by breaking down the analysis into four distinct categories, the technical, financial, socio-environmental and behavioral aspect, similar methodology followed in prior studies (Sovacool et al., 2017; Sovacool et al., 2018). The sociotechnical approach pursues to identify the "dynamics between technology and the social, professional, and cultural environment in which it is used" (Whetton, 2005).

In addition, a SWOT analysis is performed with regards to e-Mobility in Greece, for Attica region, by emphasizing on factors that could benefit, challenge, assist or risk the rapid penetration of BEVs in the transportation sector. The SWOT analysis will allow to identify and exploit the strengths of e-Mobility, with the purpose of investing in them and to take advantage of future opportunities that arise. Weaknesses will be also identified as areas for improvement along with the potential Threats that might occur in order to avoid them with the appropriate mitigating actions.

3.2 The Sociotechnical perspective

To better understand the potential and challenges of e-Mobility and V2G, and for the purpose of the study the transport and electricity infrastructure is considered as a sociotechnical system, in line with existing studies in the same field (Sovacool et al., 2017; Sovacool et al., 2018). The concept of a sociotechnical system aids to reveal that technologies must be understood in their societal context, and that the different ideals and principles expressed by inventors, managers, and consumers shape technological change (Sovacool et al., 2017).

The sociotechnical review shall be performed considering future benefits and challenges of e-Mobility and the V2G concept. At first, the technical aspect is assessed, followed by the financial aspect of e-Mobility and the socio-environmental part that addresses how the subject relates to society and finally, the fourth category focuses on the individual behavior of consumers and users.

3.2.1 The technical aspect

The significant technological advancement on electric car motors and batteries as well as the associated charging equipment has significantly enhanced the transportation market compatibility with electric vehicles.

An important technical aspect of BEVs and V2G technology is that they turn “unused equipment” such as a vehicle’s battery into useful services for the power grid (Sovacool et al., 2017). A vehicle is used on road, on average, five percent (5%) of a day, consequently ninety-five percent (95%) of the time is being unused, and parked, usually near an electrical infrastructure (Pasaoglu et al., 2014). The V2G concept allows a more efficient use of the asset, assisting the power grid and providing cleaner mobility and innovative energy storage solutions.

Another technical benefit is related to the fact that the evolution of e-Mobility requires innovation, leading inevitably to new advancements in technology such as improved system efficiency, lighter vehicles, smart power grids and fast charging stations among others. In addition, given that the investment costs of e-Mobility are considerably high, many partnerships and collaborations among the manufacturers, technology providers and other interested parties are being formed to share costs and innovations (SPI Lasers, 2021).

Additionally, BEVs comprise a safer option than their Internal-Combustion-Engine-Vehicle (ICEV) equivalent, since there is no combustible fuel (gas, gasoline, diesel) which reduces the risk of explosion, particularly during accidents. Whereas, in the case of BEVs, after an accident the electricity supply from the battery is cut-off (SPI Lasers, 2021).

However, V2G technology comes with some considerable technical barriers including communication, control, battery integrity and charging time (Sovacool et al., 2017). Another technological barrier at the time is that the extensive use of V2G services results to a reduced battery life and consequently to additional cost related to battery replacement (Wang et al., 2016). These challenges show that there are still improvements to be made on the technological aspects of BEVs for users to be able to adopt and adapt to e-Mobility.

Tschiesner et al., (2020) support that BEV industry must focus on regulation and incentives, battery technology, and charging infrastructure in order to overcome such technological obstacles and expect that future key technological developments in the e-Mobility industry will be made on autonomous vehicles, car sharing and enhancing connectivity between the vehicle, the driver and the driver’s devices.

3.2.2 The financial aspect

E-Mobility in the transportation sector will contribute to economic growth and generate employment opportunities, as the need of new businesses and sectors is increasing in order to support new applications of the technology and its users. The V2G concept could provide additional revenue to owners that wish to sell electricity or grid services back to the electric grid.

Malmgren, (2016) supports that employment opportunities will be created in the automobile industry for manufacturing, research and development, battery manufacturing and also indirectly as a result from installation and maintenance of electric vehicle supply equipment (EVSE).

Another financial benefit of BEVs is that of reduced costs. As the overall cost to the consumer such as vehicle purchase, charging infrastructure, cost of charging and maintenance cost of BEVs is much lower than the equivalent cost of ICE vehicles. Mainly due to high purchase taxes on conventional vehicles, the electric cars are only marginally more expensive than a comparable gasoline car and the price difference specifically in Norway is much more favorable to EVs than in many other countries (Kempton et al., 2014). In addition, the increase in global sales of BEVs creates economies of scale in the manufacturing industry and allows further reduction in the total BEV purchase price. Also, several developments in technology lead to battery prices decrease and BEVs will soon provide cheaper mobility solutions (Scalise et al., 2018; Tschiesner et al., 2020).

Furthermore, by carefully planning charging times, BEVs could provide additional economic benefits. V2G systems and Smart charging could schedule BEVs to charge when electricity prices are low and discharge and sell electricity when demand for electricity is higher. BEV batteries can also store surplus electricity and distribute it back to the grid on demand, a feature that could be particularly significant for large fleets of BEVs (Scalise et al., 2018).

It should also be noted that currently the financial potential of V2G remains constrained by the "first-cost hurdle" as VGI-enabled PEVs can be more expensive than regular PEVs, which are already more expensive than their conventional alternatives (Sovacool et al., 2017). However, as discussed above the cost of electric cars, influenced by the continuous technological advancements, and increase in demand and the production rates, is being reduced gradually.

Additionally, the V2G program needs the continuous use of the battery leading to its degradation sooner than anticipated which can create unexpected costs. Nevertheless, as technology advances, new innovative systems arise to tackle this challenge.

Malmgren, (2016), supports that the transition to a transportation sector powered by electricity will have both positive and negative aspects. A widespread adoption of BEVs even though it will create new business and employment opportunities, will also result to fewer jobs in the oil and gas industry, and probably in the car maintenance and mechanic industry, as BEVs require less maintenance compared to conventional gasoline and diesel vehicles.

3.2.3 The socio-environmental aspect

The socio-environmental related benefits and challenges describe the factors of e-Mobility that affect society in a positive or negative way. These societal benefits are recognized often through the reduction of negative externalities, meaning anything that causes an indirect cost to individuals, such as environmental and health impacts (Malmgren, 2016).

The benefits of e-Mobility and V2G technology, from a socio-environmental point of view include among others, improved air quality through a reduction of CO2 and other air pollutants, reduced energy usage and noise pollution, less reliance on fossil fuels and increased penetration of renewable sources of energy (Sovacool et al., 2017).

The quality of air is responsible for thousands of deaths every year in Europe due to excessive concentrations of air pollutants (EEA, 2020). The use of fossil fuels in transport worsens local air quality and the climate. A significant problem that urban centers face and is eliminated by the widespread use of BEVs, is the noise pollution from internal combustion engine vehicles. Road traffic is by far the main source of noise pollution throughout Europe. Recent surveys show that there is a link between noise pollution and mental health issues (Cheng and Alstrom, 2019), leading to the need for adoption new healthier ways of living and commuting in high density urban centers in order to protect and enhance public health. It is obvious that the integration of electric vehicles into the fleet can lead to a significant reduction in overall GHG emissions, air pollution and noise, especially if the electricity is produced by renewable energy sources.

There are challenges that need to be considered, with the main barrier being that of the BEV manufacturing process being polluting, by involving mining of rare earth minerals and other elements for batteries, drivetrains, and components and ultimately having environmental costs (Hawkins et al., 2012, Ramoni et al., 2013). In addition, the reuse and recycling of batteries are becoming emerging priorities, worldwide in order to protect the environment and address the increasing need for critical metals (Zhao et al., 2021).

Another concern of users is whether the charging infrastructure can support long distances outside urban centers. Therefore, the fast development of charging infrastructure is necessary, as the sales of electric vehicles increase annually.

It must be noted, that in order to take full advantage of the environmental benefits of e-Mobility, the energy consumed to build and use BEVs should come from renewable sources. Additionally, if the batteries of an electric vehicle will be used after the end of their life for a second time, their environmental performance will be much better than that of a conventional car. Finally, when the time comes for the complete withdrawal of a BEV, all its construction materials must be able to be recycled.

3.2.4 The behavioural aspect

The behavioral aspect focuses on the individual behavior of the consumers, users and the other interesting parties and describes how e-Mobility and the V2G concept affect or may affect them by means of confusion, frustration, or inconvenience.

The main benefits that e-Mobility and V2G technology can offer to its users are cost savings and environmental benefits (Sovacool et al., 2017). Additionally, ensuring public health, contributing to economic growth, creating new employment opportunities, and improving quality of life by means of reduced air and noise pollution. Other benefits of BEVs include increased property value, safety, reduced healthcare costs, environmental benefits, more stable energy prices, and a more resilient and reliable energy system (Malmgren, 2016). V2G programs can provide revenues through compensation schemes that will be financially beneficial for BEVs users, the society and support the needs of a flexible power Grid.

E-Mobility and V2G technology may benefit the society and the environment in many ways, however there are several potential concerns related to this application. Firstly, there is the potential inconvenience of a V2G program, in the way it affects the available battery range of the BEV (Sovacool et al., 2017), secondly consumer confusion can be created regarding the concept of BEVs (Axsen et al., 2016.) and a third potential challenge to V2G deployment is consumer concern over battery degradation (Sovacool et al., 2017).

It can be assumed that BEV owners would entice in e-Mobility and V2G, for its eco-friendly technology, since they are interested on tackling environmental issues, and the useful means for the environment's sustainable protection. However, Sovacool et al., (2017) supports that environmental benefits might be a significant motivator for "mainstream PEV buyers", but such benefits are not likely enough to persuade considerable PEV buyer enrollment in a V2G system.

3.3 SWOT analysis for e-Mobility in Attica

In this section, the tool of strategic planning, SWOT analysis, is used to further evaluate the development of e-Mobility in Attica - Greece.

SWOT analysis derives from the initials of the words Strengths-Weaknesses-Opportunities-Threats. It is a strategic planning tool with the primary goal to assist in increasing awareness of the factors in decision making, which is accomplished by analyzing the internal and external factors that can impact the viability of a decision.

The internal and external factors influencing the integration of e-Mobility in Attica are divided into two subcategories. The two subcategories relating to the internal factors are "Strengths" and "Weaknesses", while for the external factors are "Threats" and "Opportunities".

"Strengths" are referring to the internal attributes and resources that can create a successful outcome, while "Weaknesses" refer to the internal attributes and resources that work against it. "Opportunities" relate to the external factors that can be used as an advantage and "Threats" to examine the external factors that can risk the project's success.

In this section, the SWOT analysis is firstly presented in Table 3 and afterwards follows the analysis in more detail for each issue raised.

Table 3 summarizes in bullet points the factors used for the purpose of the SWOT analysis regarding e-Mobility in Attica.

Table 3: SWOT analysis for e-Mobility in Attica.

Strengths	**Weaknesses**
• Important existing legislative framework promoting e-Mobility • Municipalities drafting their own Sustainable Urban Mobility Plan • Average daily travel distance less than 50km • State and European funding related to the installation of charging stations • Special traffic regulations for electric vehicles	• Lack of common policy between the various public authorities and bodies • Limited public awareness of new technology • High purchase cost of electric vehicles • Limited Battery Autonomy considering long distances between main cities • Limitation of battery technology i.e slow charging • Very limited amount of charging stations • Limited variety of vehicles

• Tax reliefs/exemptions/subsidies • Lower commuting cost • Zero CO2 emissions / air pollutants • Lower or zero noise pollution - public health • High level of system efficiency	
Opportunities	**Threats**
• Vehicle fleet renewal •New investment and employment opportunities • Innovation - New mobility models • Improve quality of life by reducing air pollutants and noise levels • Increased demand for "green" technologies • Increasing the percentage of renewable energy sources •Lower dependency on fossil fuels •Technological development in battery storage technologies •European funding •Security of Supply, Energy independence on fossil-fuels imports from other countries •Reduction of accidents, in transport and commercial use that related to import and distribution of conventional fuels	•High installation costs for upgrading current infrastructure to accommodate charging stations. • Lack of cooperation between the various public authorities and bodies •Co-Existence of public and private charging stations •Safety issues for users of electric vehicles •Different types of charging stations • Low level of battery recycling • Delays due to bureaucracy • Economic crisis • Different stakeholders in the road network (highways, provincial, urban) • Procedure for locating charging stations for electric vehicles • Insufficient training of employees in technical services • Incomplete participation of bodies and citizens • Low interest and public awareness

3.3.1 Strengths

E-Mobility benefits the environment and public health through reduced CO2 emissions and other pollutants and through lower or zero noise pollution, major issues in big cities like Athens. BEVs extensive adoption assists in the decarbonization of the transportation sector and in the increase of renewable energy sources.

E-Mobility is considered a better, more efficient way of mobility, sufficient to be applied in Attica where the average daily travel distance is less than 50km, a distance that can be covered by any BEV in the market without the need of daily recharging. In addition, BEVs comprise a safer option than their ICEV equivalent, because there is no combustible fuel such as gasoline or diesel to risk an explosion during accidents. Also, BEVs despite the relatively higher purchase price which could be encountered by the state subsidies, provide a cheaper option for mobility as their maintenance and operating costs are lower that their ICEV equivalent.

As explored in Chapter two, the Greek government and the EU actively promote e-Mobility and have established a legal framework providing mostly financial incentives. The financial incentives make the purchase and use of the electric vehicle more accessible both to people and companies. The fiscal incentives recently introduced by the Greek government for the purchase and lease of EV gave a boost to the Greek market for both cars and two-wheelers.

Similar incentives were also given for the development of publicly accessible recharge infrastructure, which in combination with the expected increase in sales of purely electric and hybrid external charging and low vehicle emissions is expected to create additional demand.

In addition to the financial incentives provided, other important regulations and guidelines with regards to technical, urban and spatial planning, needed for the widespread adoption of BEVs, were introduced. More specific, the related strategic tool of Sustainable Urban Mobility Plans (SUMPs) which is basically a planning concept applied by local and regional authorities for strategic mobility planning, is now starting to be embraced and implemented by Greece and can significantly improve the overall quality of life for residents by tackling issues such as congestion, air/noise pollution, climate change, road accidents, unsightly on-street parking and the integration of new mobility services (European Commission, 2021). Financing is also provided and currently there are several Municipalities that have been eligible to a funding program to develop SUMPs (Stavropoulou, 2019).

Moreover, an important beneficial element of the recent regulations and guidelines provided by the Government included the replacement of old polluting public vehicles or Taxis, expecting to improve the quality of air and life of citizens in cities and urban centers. Combining electric buses with a modern and functional public transport network could greatly assist to tackle air pollution and the reliance from fossil fuels.

E-mobility supports a much lower dependency on fossil fuels and along with the V2G technology promotes further the increase of the share of renewable energy sources in the transportation sector. A large share of energy production in Europe comes from fossil fuels, making the shift to renewable energy sources to seem non-negotiable. One of the European Union's immediate goals is to cut CO2 emissions and increase energy production from renewable sources. BEVs support this need and through the use of V2G systems could greatly assist in this transition.

3.3.2 Weaknesses

In Greece, the majority of the vehicle fleet runs on fossil fuels, while low-emission vehicles, such as hybrids, electric or gas-powered vehicles, do not exceed 0.6% of the fleet (ACEA, 2021). According to ACEA, (2021) Greece has the third oldest car fleet in the EU with an average fleet age of 16 years. The financial crisis reduced the purchasing power of the consumer which led to the purchase of used and polluting vehicles that were least expensive.

This causes a significant burden on air quality, not tolerated especially in the context of the outbreak of the COVID-19 pandemic, as recent studies have shown a direct link between human respiratory complications and atmospheric stress (Cheng and Alstrom, 2019). According to EEA, (2020), Greek cities have among the highest rates of nitrogen oxides (NO2) concentrations, and years of life lost (YLL) per 100,000 residents, which shows the intense need to move from ICEVs to BEVs.

High purchase prices of electric vehicles along with the limited battery autonomy comprise the main most important "weaknesses" when considering to buy a BEV. However, due to state subsidies and tax exemptions BEVs become less expensive and more cost efficient compared to the conventional vehicles. Additionally, the limited electric vehicle models and the limited number of charging stations (public and private) constitute other important challenges.

A proper EV charging infrastructure is a necessary condition for drivers to be able to operate their BEVs. The Greek government already has announced plans and incentives for the development and improvement of the charging network and soon the results will affect positively the future of e-Mobility and BEV owners. One of these necessary infrastructures is the plans for charging points of electric vehicles (SFIO) which municipalities are required to make. The lack of common policy between the various public authorities and bodies, the long bureaucratic procedures, the weak power grid, along with the potential problems of SFIO implementation comprise areas of further development and improvement.

From an environmental point of view, the low level of recycling of batteries is an issue that needs to be addressed. Zhao et al., (2021) support that the significant increase in battery sales, resulting from the increased demand in different applications, such as electric vehicles and energy storage systems will create waste and disposal issues in the following years as batteries reach their end of life. Technological innovation in battery manufacturing process and recycling capabilities would assist tackling this challenge.

Recycling BEVs and especially their batteries is an important issue that needs to be addressed mainly because of the great amount of energy required for their production and the use of limited natural resources. Governments could promote reusing the batteries of electric vehicles, after their end of life, for other applications, in order to ensure a significant reduction of environmental impact.

Energy storage technologies is another factor that plays an important role for BEVs expansion and need to furtherly evolve in order to meet the current demands. Commercially available energy storage technologies are yet not mature in many aspects and "achieving a suitable technology that can overcome all the shortcomings of energy storage is not expected to be available in the near future" (Adib et al., 2019).

Another concern is that of current regulatory barriers related to storage adoption and the "undetermined asset classification" (Staffell and Rustomji, 2016). "Energy storage systems are multifunctional, and may act as generator, consumer or network asset at different points in time or simultaneously" (Staffell and Rustomji, 2016). Typically, regulation classifies storage based on its primary function (Rastler, 2010), leading to issues with ownership. However, whether storage is classified as a generator or consumer impacts on transmission and distribution use-of-system charges (Staffell and Rustomji, 2016). According to EU law (National Grid, 2015), transmission network operators are forbidden from participating in the electricity markets, and hence would be unable to supplement their return on storage devices through competitive market participation (Staffell and Rustomji, 2016).

The aforementioned "weaknesses" of e-Mobility in Attica need to be addressed and mitigated, since they comprise internal attributes that work against the promotion and widespread adoption of BEVs and therefore the V2G.

3.3.3 Opportunities

The Opportunities presented in Table 3 refer to the favourable external factors that could promote e-Mobility in Greece and provide a competitive advantage. There are concepts that can turn weaknesses into strengths.

An opportunity emerged is that of the renewal of existing vehicle fleet, not only with regards to private vehicles, but also and most importantly to the public transport fleet (taxis, buses etc.). Delivery of goods, normally made by polluting trucks and vans can be also replaced by their electric equivalent.

The new reality will attract investments and will create new employment opportunities in order to cover the demands of the new developing market, i.e. new mobility models, V2G technology, charging stations etc. This will greatly benefit positively not only the society but also the economy. As discussed in the sociotechnical analysis in section 3.2, innovation and clusters among technicians and manufactures seems to be unavoidable due to high installation and front up costs. Economic growth and employment opportunities seem also correlated with the rapid growth of e-Mobility and its technologies.

From an environmental point of view, apart from the obvious advantages of reduction of air pollution and noise leading to the upgrading of living standards in urban centers, e-Mobility also appears to lead into an increased demand for “green” technologies, lower dependency on fossil fuels and an increasing percentage of renewable energy sources.

From a technological point of view, regarding the slow charging of BEVs, there are opportunities for technological advancements such as the concept of “Dynamic Wireless Charging” (Adib et al., 2019) that in essence makes autonomous mobile platforms that BEVs can charge without human assistance. It is an approach to overcome the need for extremely fast charging and the need for “heavy and expensive” batteries in BEVs through substantially reducing the onboard energy storage and delivering instead power wirelessly to the vehicle while it is moving (Adib et al., 2019). With battery size reduction, dynamic wireless chargers can reduce up to twenty percent (20%) of the installation cost when compared to stationary chargers (Vasiladiotis and Rufer, 2015).

The V2G technology can be developed in Attica. The recent developments with regards to the legal framework to support e-Mobility and its relevant services and infrastructure along with given incentives by the Greek Government and the European Union are considered sufficient to create the foundations that can accommodate the expected growth of the sector. It seems a great opportunity to implement V2G technology in Greece, apart from Attica which can be considered an ideal candidate.

Attica holds many opportunities regarding the widespread use of BEVs, the promotion of e-Mobility and the successful adoption of V2G systems. Those opportunities could turn into strengths if being rightly exploited, create economic growth and be beneficial for both companies and citizens.

3.3.4 Threats

A very common negative factor that affect investments and development in general are the long lasting bureaucratic procedures in Greece. There is a significant potential threat for delays due to bureaucracy, also the lack of cooperation between the various public authorities and bodies is common issue that contributes to such delays.

The economic crisis created uncertainties in economic growth that affected consumers' appetite and intentions related to investments. Such a factor is a great example showing that incentives should be introduced in order to create motivation and assist to the e-Mobility transition.

Despite the small size of the Greek vehicle market, it has specific peculiarities compared to those of other EU member states, mainly due to the fact that the Greek market for new passenger cars has shrunk significantly in the period 2010-2018 (Moschovou and Tyrinopoulos, 2018). This is due, firstly, to the fact that ownership of vehicles has suffered severe tax burdens and secondly, to the prolonged financial crisis of the last decade. An important threat is also created, that of importing and circulating used vehicles of old technology, consequently more polluting.

The road network (highways, provincial, urban) also needs to be upgraded, as it is an important technical issue that influence the rate of growth of e-Mobility and VGI technologies. Public and private charging infrastructure must be developed along with innovative technology and procedures such as locating charging stations to be explored and applied in order to assist the BEV drivers with greater reliability.

In addition, the current level of information and understanding about the importance and benefits of e-Mobility should be improved. Safety instructions for users of electric vehicles must be issued since not all drivers can easily adapt to the technological requirements and technical know-how. Proper technical training regarding the new services and requirements is also needed. Higher public interest and awareness would assist in reducing the potential risks of misimpression and greatly assist in the widespread adoption of BEVs.

Finally, from an environmental point of view, the battery recycling issue discussed in the "weaknesses" section is a very important issue that must be addressed and mitigated. As e-Mobility is a concept that supports the environment and promotes "green" energy, its components should also serve such a "green" goal.

The aforementioned external factors could threaten Greece’s success in e-Mobility and the V2G application and therefore need to be addressed and taken into consideration while taking decisions or planning future strategies.

3.4 Conclusion

In this Chapter, two methods have been employed in order to examine the future benefits and challenges of e-Mobility and V2G application in Attica – Greece. The first method is a Sociotechnical analysis that explores in which way BEVs and energy storage, by means of V2G systems, affect the society, the economy, and the environment. The second method is a SWOT analysis that explores the strong and weak elements, the current opportunities, and the areas for improvement of e-Mobility in Attica.

The analysis shows that the massive adoption of BEVs seems achievable in Attica with the V2G successful implementation following more easily and providing additional opportunities, beneficial both for the users and for the society to exploit.

The most important benefit of e-Mobility is that of reducing air pollution and noise pollution. The most severe pollution problems, which are directly related to the use of conventional internal combustion engine vehicles, exist in densely populated areas due to increased traffic and high emission concentrations. Undoubtedly, BEVs are silent and less polluting that makes them a better, more socio-environmentally friendly solution for a city.

E-Mobility also assists in the reduction of mobility costs and in particular, both in terms of BEV operational costs and maintenance and repair costs compared to the conventional ICE vehicles. Even though BEVs are yet subject to initial high purchase costs, due to their relatively new technology, are usually being subsidised and when adding the aforementioned lower operational and maintenance costs, makes them the least expensive way of mobility, apart from environmentally beneficial.

Macroeconomic benefits also arise from the widespread use of BEVs. The development of the electromobility market in Greece will create significant opportunities for investment and employment leading to economic growth. The emerging needs for new services and technological advancements essential for the expansion of e-Mobility will lead to innovation and partnerships. The increasing use of BEVs could reduce the country’s dependency on imported fossil fuels and its exposure to the instability of international oil markets, since the most of the electricity required to charge BEVs would be generated by domestic renewable energy sources.

There are several challenges that need to be addressed regarding the BEV adoption. Apart from the initial high cost of buying a BEV, which can be tackled by the fiscal incentives provided, the battery autonomy issue and the long time required for refuelling are areas for further improvement. The road network, from highways to urban, needs to be upgraded in order for BEVs to be able to operate smoothly and additional services that will support and improve the charging infrastructure. In addition, the environmental issues that arise from the battery production process are crucial and need to be confronted through technological advancements and re-use or recycle of the battery. With higher public awareness, technology innovations and partnerships, regulatory improvements, and policies the remaining obstacles will be overcome and BEVs will be soon easier to adopt and e-Mobility to prevail as a new way of transport.

Chapter 4: Discussion & Conclusion

The Thesis investigated the role of incentives for the promotion of BEVs and the potential of V2G technology to serve as an additional motivating factor that could contribute to the growth of e-Mobility. From the literature review provided in the Thesis, it is observed that there is a strong link between incentives, especially fiscal, set by a country and the sales of BEVs. Incentives adopted by countries regardless their nature, either fiscal or non-fiscal, appear to be both important for the growth of e-Mobility. The policies and regulations of a country have a great effect on the promotion efforts and are mainly designed to address the matter that BEVs have relatively new technology accountable to high initial purchase costs. Subsidising BEVs, make them more affordable and with the adoption of advanced VGI services such as the V2G systems are consider the most effective means of e-Mobility promotion.

The analysis focused on the Greek market investigating the industry's dynamics and potential capabilities. Greece has recently developed a legal framework for the promotion and realization of e-Mobility that gave motives for the purchase and use of BEVs along with technical and urban guidelines and policies. The initial results are encouraging and show an upward trend in the BEV sales despite the pandemic. Efforts are made to improve and expand the current charging infrastructure and to establish rules and standards essential to make e-Mobility as appealing as possible. To meet the high demand in connection with the Grid and various other supportive services, the new legal framework provided financing for the local authorities and other interested parties that assists greatly to meet the new emerging needs of e-Mobility and make the realisation more probable to succeed and prevail.

Relying on fiscal incentives for the long term promotion of e-Mobility is considered to be unsustainable. The concept of V2G technology can assist to a greater growth of e-Mobility in the country without requiring additional state funds. This would result in a more sustainable market growth of e-Mobility and as explored in this Thesis, the benefits that BEVs and V2G systems could bring, are among others, economic growth through innovation and the creation of new business and employment opportunities.

The V2G concept has been experimentally examined by various countries through pilot projects. There are many pioneering projects, in operation worldwide, attempting to determine whether such technologies are easy to adopt and apply in e-Mobility. The technology is beneficial to society, the environment, and could also provide potential revenues to the BEV owner and such would serve as an accelerating factor in the promotion of e-Mobility and BEVs.

The expansion of BEV growth with the adoption of the V2G technology would not only be environmentally beneficial, but also serve as a mobile energy storage unit.

The benefits, and challenges of e-Mobility and V2G technology were firstly discussed and analysed through a sociotechnical review that explores e-Mobility and V2G application from a technical, financial, socio-environmental and behavioural aspect. A SWOT analysis of e-Mobility in Attica is also applied in order to demonstrate the future potential application of V2G in the Greek market. The favouring and undermining factors, the increased opportunities that arise from e-Mobility and the potential risks that might occur were analysed relating to BEV adoption in Attica. This approach allowed a more spherical and clear view of the benefits and challenges of BEVs, as not only technical but also societal aspects of e-Mobility and V2G were explored.

The findings of the research have shown a significant potential of e-Mobility growth in Attica. The Greek Government has provided the proper motivations to boost BEVs market and local authorities have already started to implement guidelines and regulations to support their smooth operation. The increasing need for new services and technology advancements can lead to innovation, partnerships and new business and employment opportunities. On top of the appealing economic returns that are available to be offered to BEV owners with VGI systems adopted, V2G is considered an important application that could be ideal for the Greek market.

The potential of V2G to serve as a useful source of energy storage was also evaluated. The high amount of circulating BEVs will make the V2G system more sustainable and autonomous, as more energy would be generated from RES and injected back to Grid when needed. The variety of Grid services that will be created will facilitate the accelerated penetration of renewable sources of energy.

For the V2G transition technological challenges need to be addressed that come along with the endeavour of applying such technologies. Challenges are related to battery technologies and communication systems, financial obstacles such as the fairly high purchase cost, possible environmental impact and behavioural challenges of inconvenience and confusion, that typically accompany any new technology that is attempted to be accepted by a new market.

The main factors that contribute greatly to the introduction of e-Mobility are the European targets for the reduction of CO_2 emissions and the Governments' initiatives to support them by providing fiscal and non-fiscal incentives, developing the necessary infrastructure, and introducing a legal framework to cover the emerging needs of BEVs. Greece has presented positive results for the transition to a “greener” way of mobility. The concept of e-Mobility should not be limited by incentives and the V2G technology is considered to an effective mean to maintain a sustainable growth.

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