3rd HAEE Energy Conference:
"Energy Transition: European and Global Perspectives"

"Anticipated Penetration Rate of Electric Vehicles in Greece's Motor Vehicle Market"

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Abstract

This paper focuses on the penetration rate and the deployment of Electric Vehicles (EVs) in Greece's motor market. The current state of the market is thoroughly presented. The progress towards legal framework adaptation, as well as the prospects of the EV market's expansion are considered. Moreover, the parameters that are deemed crucial in influencing EV penetration rate in the Greek market are well described. Finally the characteristics of the current EV market of Greece, as related to prospect statistical analysis for forecasting purposes, are discussed.

Keywords

EV, PHEV, EV deployment, market share, volatile market, EVSE, PEV, charging stations

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a. Overview

a.i. Greek EV market - Present Condition

Last year (2017) was significant for electric mobility in Greece, as the EV market share jumped up from 0.06% to 0.19 % with the market almost tripling in volume, achieving a market growth of +243%. The most significant trend is the turn of consumers towards Plug-in Hybrid Electric Vehicles (PHEVs) which accounted for 80.1% of the total sales (+821%). This turn is prompted by the new PHEV models that were introduced in the Greek market in 2017 mainly offered by BMW and Volkswagen (BMW 330e, BMW 225xe Active Tourer, BMW XE 40e and Volkswagen Passat GTE), providing 20 – 50 km electric driving range, which offers capability to provide cheap electric mobility within urban areas in a daily driving schedule. On the other hand, the sales of Battery Electric Vehicles (BEVs) remained stable (-3%), indicating market stagnation due to lack of fiscal incentives and supporting infrastructure.

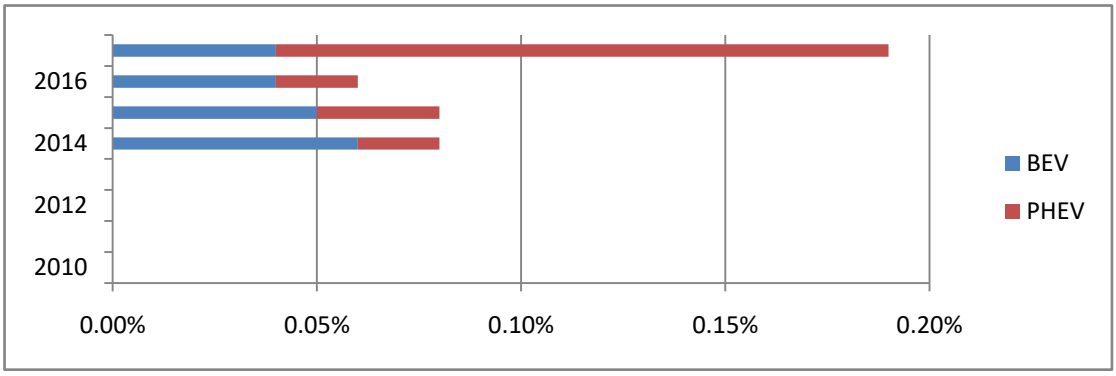

Figure 1 EV market share in Greece 2010-2017 (source: EAFO) [4]

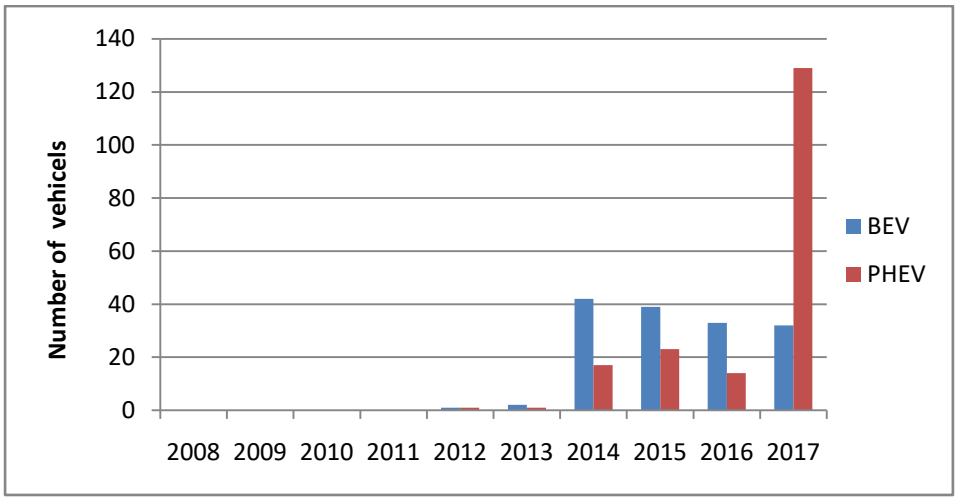

Figure 2 New sales of BEVs and PHEVs in Greece for the last decade (2008-2017) (source: EAFO) [4]

The EV market in Greece is majorly controlled by German OEMs with BMW being the major player with a market share of 65% and 70% on BEVs and PHEVs respectively. The commercial availability of EV models is limited in comparison to

the biggest EV markets in the EU. Specifically, in the Greek market in 2017 there were 7 BEVs and 19 PHEVs available [16]. Moreover, small EV solutions are provided by various small companies, with small market share with most of them offering utility vehicles or small cars, motorcycles and tricycles. Electric mobility is at an early stage of development in Greece, primarily because of lack of charging infrastructure and the lack of education about the advantages of electric vehicles and eco-mobility in general. As for the lack of charging options, they can be developed either privately or publicly. International experience has shown that 85% of electric car users charge them in their own residence. A low percentage of users charge their car in the workspace and fewer of them in public spaces. A wide network of public charging points therefore remains unused and has proven to be economically unsustainable [20]. However, a small percentage of public charging is a crucial parameter in order to get rid of "electric range anxiety" related to the use of electric cars [2].

In Greece according to the Hellenic Institute for Electric Vehicles (HELIEV) there are 45 publicly accessible charging stations providing 64 charging positions [12]. Moreover, 27 charging points are available through the 17 stations participating in the "Fortizo" private charging network [8]. The publicly available charging power sources, which are mostly located in the in the greater Athens metropolitan area, provide AC power at power levels varying from 3.5 kW to 22kW, with only one charging position providing fast DC charging (50 kW) [4]. Publicly available charging infrastructure in Greece reached 1.1MW of installed capacity in 2017, with 650kW being installed in the Athens Metropolitan Area. The majority of the public available chargers are also located in Attiki and the extended capital region of Athens. There are also three charging stations available in Thessaloniki and very few scattered in the rest of the Greek continental territory with the most being in Peloponnese (5). In the islands of the Aegean Sea there are only 8 recorded charging stations provided by local Hotels and accommodation services which operate during the tourist season, serving the charging demand of seasonal visitors [8][14].

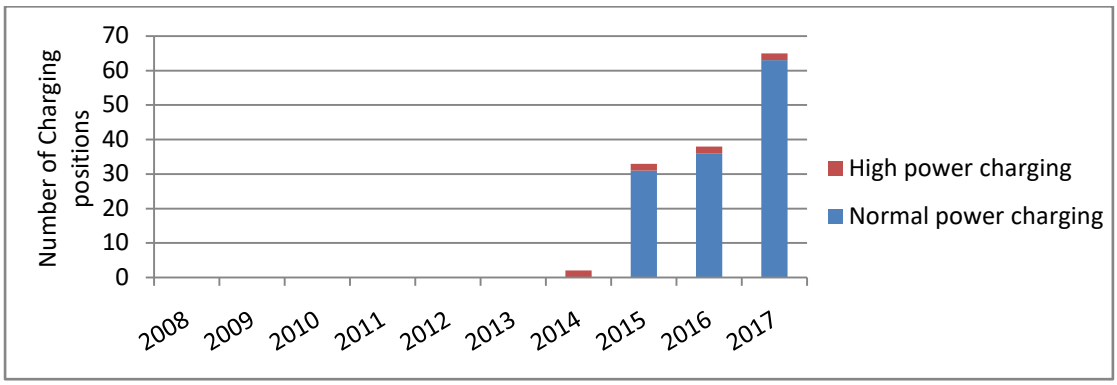

Figure 3 Number of publicly available charging positions (source: PlugShare [14], EAFO [4])

The charging position availability in Greece is 5.2 EVs per charging position, which is following the European average ratio of 6.7 [4][14]This indicator cannot

describe well the adaptation of EVs or success of the support infrastructure in such an immature market as the Greek one. However, such an indication prompts the challenge to maintain this ratio, as the market develops, towards rates that maintain a functional proposition for EV users. Greece, due to its geomorphological terrain, has long distances between regions and thus requires an extensive range of charging network to support electric mobility for intercity transportation. On the other hand Greece is highly urbanized with 78.6% of its population living in the largest cities [15], which creates the need of a more centralized approach in the development of the national EV charging network, in order for this to fit in with the urban transportation needs of Greek drivers.

a.ii. Applied and proposed incentives for the EV adoption in the Greek market

Applied Market Incentives for EVs

Greece implemented for the first time a package for the support of EVs' penetration in the market in 2010, according to which, electric vehicles and low engine capacity hybrid and fuel cell cars registered before November 2010 were exempt from the annual circulation tax. Following November of 2010 the vehicle circulation tax was reformed to support green mobility and thus became CO_2 emissions based. Accordingly, vehicles are now taxed based on CO_2 g/km which ranks all EVs in the lowest category of 90 g/km which are exempt of circulation taxes. All-Electric Vehicles are also exempt from luxury and luxury commodity tax charge since 2013, while hybrids received a 50% discount respectively.

National Goals

The first coordinated attempt to study the prospect of electric mobility in Greece began in 2011 with assembly of a scientific commission under the Ministry of Environment, Energy and Climate change (20/09/2011) for the research, development and penetration of electric vehicles in the country's transport sector. (YA: Δ6/21612/20.09/2011, Α.Δ.Α: 4Α8Κ0-80Β)[1]. Its goal was to analyze and formulate prospective policies and financial incentives to support the initial phase of the penetration of electric vehicles in Greek market as well as the development of implementation proposals. The technical study of the commission, which was concluded in January 2012, indicated that the initial subsidization of the EV market is deemed necessary during the initial phase of EVs' penetration in the Greek market [17]. The environmental benefit of the EV penetration was found to be significant as the EVs would replace more carbon intensive transportation leading to lower CO_2 emissions, which would be further reduced as Greece moves to a less carbon intensive electricity mix after 2013, by phasing out old lignite power generation stations, while increasing electricity generation from RES. [1]

However, Greece's national goals with regard to electric mobility are conservative mainly due to the ongoing economic recession. The targets set are based on the EU directive on deployment of alternative fuels infrastructure (2014/94/EU) [6], according to which

Greece must reduce its oil dependence in the transport sector. In addition Greece must increase the share of RES in the transport sector by 10% by 2020. Following this direction electricity use is expected to rise significantly in the transport sector in the following years, but this rise will not be due to the use of EVs which is expected to be limited [1].

Further Actions to Support the Penetration of Electric Vehicles in the Greek Market

Electric mobility supportive organizations such as CRES and HELIEV are proposing a certain set of measures to promote further the introduction of EVs in the Greek market According to CRES and HELIEV, which support electric mobility in Greece, there are certain actions to support the market for electric vehicles: (a) Investment in development of required infrastructure in the fields of electric power generation and distribution, charging positions etc. (b) political action and measures for support, including subsidization of new technologies, coordination of the competent and local authorities for the development of new infrastructure etc.(c) development and evolution of the available technology from the car manufacturers: new attractive models offering convenience and security, in reduced production and operational cost. (d) The standardization and validation of the available technology, introduction of common rules for quality and adaptation. EU must accept the role of the coordinator, setting the direction for all involved parties. (e) The familiarization of users with the characteristics and specification of the new vehicles and the potential of this vehicle technology to cover consumers' needs. (f) The configuration of the cost for purchase, operation (energy cost), and maintenance of these vehicles.

Investment Infrastructure

According to the current legislation (N. 4439/2016 p.1) by the end of the year 2020 there must be a secure number of charging positions available for the country's emerging fleet of EVs, which must be accessible to the public in order to facilitate the circulation of EVs in the road network. This availability must follow a certain plan indicated by public surveys, which will identify the urban/rural crucial road networks that should be covered. In addition such planning would take into account the number of EVs in circulation as well as up to date relevant practices and indications.

The current legislation (N. 4439/2010 p.7), also predicts the connection of public charging infrastructure with intelligent electricity smart meters (N. 4342/2015, A' 143) accordingly (Secure the appropriate technical specification for the correct operation of the metering devices, in regard to information security and consumer privacy), to achieve the control and recording of the energy consumption, data that should not only be available to consumers and charging station operators, but also available to the electricity network operator. The access to this data by the distribution network operator is important for the security of supply and balancing of the electricity distribution network, taking into account the predicted electricity demand from EV users. This would be also important for the charging station operators and the consumers for data

availability/accessibility reasons, which would also enable the roaming of electricity charging service operations. Furthermore, the estimation of the number of EV charging locations cannot be easily elaborated, while the data used for such studies usually emerges from simple estimations without further documentation. Such estimations usually derive from the development of electric mobility technology and foremost from the performance of the biggest EV markets worldwide.

Legislative measures

Greece, in order to support the penetration of EVs in the market, must revise and upgrade the existing institutional framework so as to predict fast developing needs. Specifically the ministry of Environment and Energy has outlined a package of legislative actions that are directed towards the enforcement of the emerging market for EVs. Analytically this framework predicts: (a) Regulation of the current institutional framework for the development of EV charging infrastructure (N. 4439/2016, 2014/94/EU).(b) Regulation of the institutional framework for the description and the outline of the role of charging infrastructure operators. (c) Inclusion of el. chargers for EVs in new built and renovated buildings (in accordance to 2010/31/EU). (d) Inclusion in the Greek legislative framework of the standards for CO_2 emissions for clean energy in the transportation sector.

The Greek authorities are also examining possible measures that could also support the development of the EV market in Greece, such as the creation of an institutional framework for financing research projects and programmes for electric mobility, such as standards for coalition of the public and private sector ex. “European Green Vehicles Initiative Association”, (EGVIA). Direct or indirect fiscal incentives, such as more tax reliefs for EVs and other “low carbon” vehicles and charging infrastructure are also examined. In addition the ministry is also exploring the adoption of favorable regulations for, parking of EVs, the use of bus/taxi lanes by EVs or the financing of charging infrastructure which is also expected to boost the value proposition of EVs as is the case in other European economies.

iii. Scenarios and predictions for the development of the Greek EV market

The future for electric mobility in Greece until 2030 as forecasted by CRES, HELIEV and the ministry of Environment and Energy does not appear very promising. Various scenarios have been considered for the forecast of the penetration of electric vehicles in the Greek transport market, which take into account: (a) The development of vehicle and battery technology, (b) the development of charging infrastructure and technology for faster service (c) the vehicle market trends under the pressure of environmental and public health agenda. (d) The electric vehicle market assessment in developed European markets and in other European countries that have lower economic growth rates. (e) The normalization of the economic conjuncture. According to this analysis and following the most plausible scenario for the penetration of EVs in the transport sector, CRES and HELIEV predict that the number of electric vehicles in circulation will rise to: 3,500 by 2020, 8000 vehicles by 2025 and 15000 vehicles in 2030. [1]

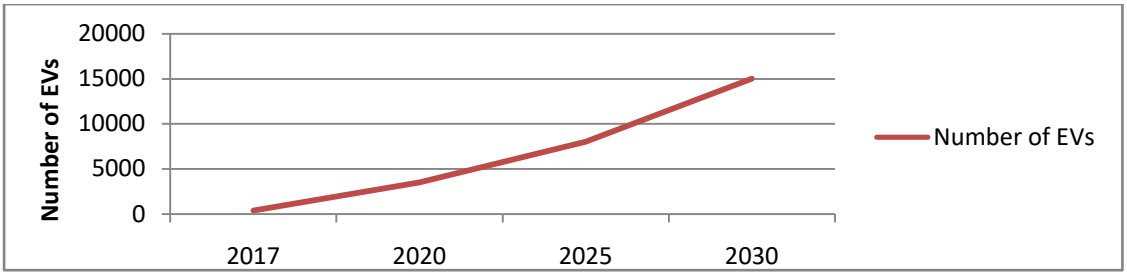

Figure 4 Number of EVs in circulation as forecasted by CRES and HELIEV [1]

According to the worldwide market prediction the above are conservative numbers for a market as large as Greece with 8.1 million vehicles in circulation, of which approximately 5.1 million being light duty passenger cars [1][10]. The Greek ministry of Energy is also predicting that the applied program for public transportation will have 90 electric buses introduced in the Greek public transport system by the year 2030.

With regards to the EV adoption barriers, the Greek EV market is currently experiencing a vicious cycle fed by the inability of the market to provide sufficient publicly accessible charging infrastructure to tackle the electric driving range anxiety of the consumers. To break this cycle, in order to initiate market expansion, the Hellenic Electricity Distribution Network Operator (HEDNO), the local DSO, made a proposal to the Greek Regulatory Authority for Energy (RAE) for the development of Greece's first country scale charging network, composed of 1,200 to 1,500 EV charging stations connected to the national grid [13]. RAE has to make a crucial decision assessing HEDNO's proposal as its acceptance would mean that the charging network investment costs will be passed over to the consumers via their electricity bills. This is an important disadvantage of the DSO model since it will add further socioeconomic costs to Greek consumers who have to confront a continuing economic recession. However the corresponding authorities might consider the DSO model since it is the only option available for EV market initiation. Furthermore the Greek EV market's future is tightly connected with such a decision as HEDNO's proposal includes, in addition to the 100-150 charging stations installed on Greek islands, multiple fast charging stations placed in the Greek highways, enabling the electro mobility for intercity transportation in the continental part of Greece. It is also expected that the installation of such a charging network will initiate an interest by investors in further expanding it, encouraging the transition of the EV charging market from the DSO to the market model. Such an event coupled by the consequent increased interest for EV acquisition by consumers, is expected to lead Greece's catch up in the global electric mobility race. Based on the predictions of CRES and HELIEV for the future of the Greek EV market in urban and suburban areas, charging stations, in their majority private, are estimated to reach approximately 2000 in 2020. Moreover, the charging locations in urban and suburban areas based on the same study are estimated to be approximately 12,000, comprising of 8,000 private and 4,000 public ones in 2025, while in 2030 their number will increase to approximately 35,000 stations publicly

accessible nationwide. These numbers are significantly overestimated, reasonably, based on Greece's congestive urban planning and consequently the unavailability of adequate urban parking space. This prediction indicates that in 2030 the ratio of charging position availability will be 0.43 EVs per position for Greece, which in comparison to the current EU average of 6.7 indicates an excess of publicly accessible charging stations. Therefore, this prediction is further alarming for the significance of the driving range limitation as a barrier of EV adoption in the Greek market.

An indication of the impact that a possible introduction of a regulatory framework for the subsidization of charging equipment purchases, can be found by analyzing the market results from other mature markets such as the US, where state incentives were applied for electric vehicle service equipment EVSE subsidization [5]. Specifically the market experience from LPG adoption, as an alternative transportation fuel, showed that on the aftermath of the implementation of regulatory framework (3710/2008) that allowed the construction of LPG stations in areas within urban planning zones, there was a rapid increase of LPG use in private vehicles in the period 2010 – 2011 which followed (almost eightfold increase) [1]. Thus, similar results could be expected from such incentivisation initiatives for other cost competitive alternative-fuel mobility infrastructure, such as the EV charging infrastructure installation in the case of electric mobility.

b. Methodological Approach

It is evident that considering the current state of the global EV market it is hard to make predictions for its future development due to the short lived market experience and the disruptive nature of EV technology. However, the most crucial parameters that influence EV adoption can be identified by observing the global market. Hereby in this section such parameters are presented and their individual leverage potential in EV deployment is discussed.

b.i. EV Acquisition Cost: Vehicle cost is an important parameter influencing the EV adoption. The high acquisition cost of EVs in comparison to conventional ICE vehicles reduces their market competitiveness. Acquisition cost parity with ICE vehicles is expected as soon as the mid of 2020s. However, signs of market parity of ICE vehicles and EVs are already evident during 2018. However it should be noted that these prices do not reflect economically viable production operations. Specifically, a study by UBS examining the EV industry in the US, estimated that car manufacturers lose $2,800 to $7,400 per vehicle due to the lack of optimal production scale ups [18].The diversification of the available EV models as well as the willingness to pay for EVs by consumers can affect the leverage of the acquisition cost parameter. Consequently the introduction of small BEV could potentially distract the sales of the larger more expensive vehicles as consumers might be driven towards different mobility choices.

EV Acquisition cost includes the cost of the vehicle and the battery cost. Batteries are the most cost intensive component of BEVs comprising of 48% of the vehicles price (BNEF 2016).Battery price forecasts deriving from the industry as well as from competent analysts and researchers converge to a single trend depicted in Figure 1. The main trend of the battery value projections presented are based on the annual lithium-ion battery price index by Bloomberg New Energy Finance (BNEF), with a learning rate of 19% per cumulative doubling of manufacturing installed capacity [19]. Battery prices on these projections are assuming abundance of raw materials and no price development disruptions caused by market manipulation of sensitive minerals like cobalt and lithium. However scenarios on which the price of cobalt rises significantly creating a bottleneck in the EV market growth have been considered both by the automakers and the battery manufacturers, leading them to actions for ensuring security of supply.

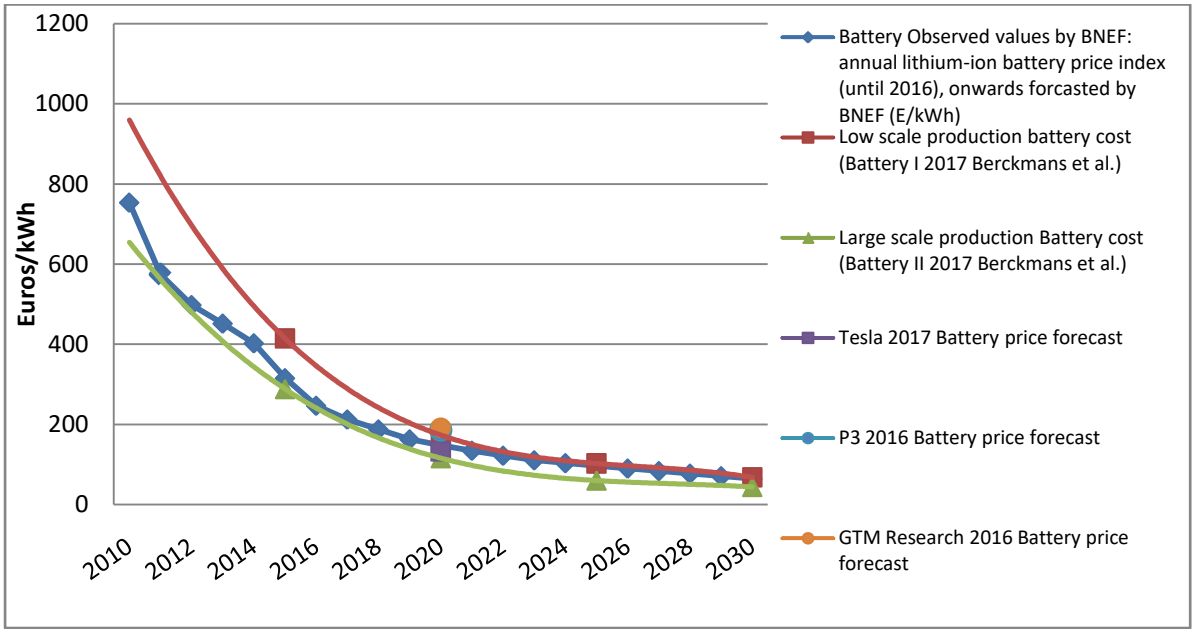

Figure 5 Battery price development and forecasting (sources: BNEF, Berckmans et al.)

b.iii. Total Cost of Ownership: The total cost of ownership considers the capital Acquisition costs (including the vehicle and battery cost) and the battery terminal cost as well as the variable operation and maintenance costs, annual tax, subsidies and the battery replacement cost. This parameter is crucial for the competitiveness of EVs versus ICE vehicles and the improvement of their value proposition in the automotive market. However, the absence of driving behavior studies and consumer behavior analytics for Greece's transport sector add difficulty in considering this parameter in the forecasts for EV deployment.

b.iv. Policies and Incentives: It is evident by observation that, in many European markets, policies and incentives have been the main driver for EV market initiation and growth.

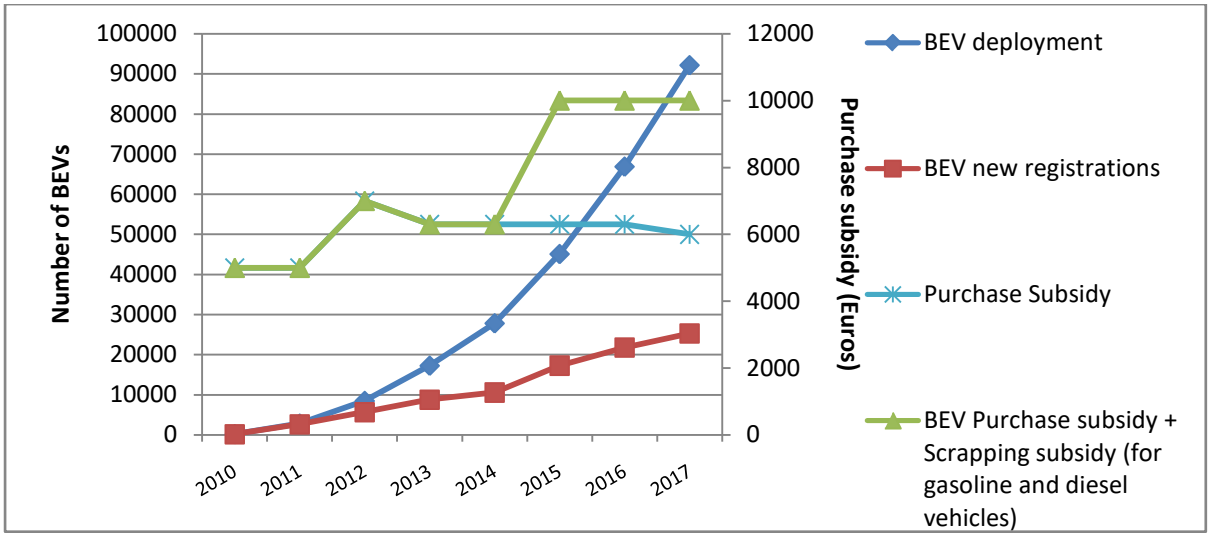

Figure 6 Purchase subsidy effect on EV introduction - The case study of France. (Data derived from EAFO [4])

Most policies and incentives, which are in place, are either affecting the acquisition cost, or the annual operation and maintenance cost of vehicles and therefore the total cost of ownership. Specifically incentives that affect the acquisition cost include purchase rebates and subsidies, subsidization of scrapping of conventional ICE vehicles and their substitution with BEV or PHEV, purchase penalties on emission intensive vehicles and purchase tax exemptions. On the other hand incentives that affect the annual variable costs include annual circulation tax exemptions, road toll exemptions, free parking, bus lane access, subsidization of EVSE etc.

Mandatory levels for the average emissions of the vehicle fleet nationwide is currently the main driver for formulating alternative fuel transportation policies in Greece's transport sector. The emission targets of 95g/km set by the European Commission for 2020 [3] and the anticipated 68-78g/km for 2025 [7] will probably refocus the Greek policy interest on electric mobility. Taking into account the current transportation fuel mix, such goals are estimated to require the market development of many alternative transport fuel technologies.

b.v Public Charging Position availability: By studying various EV markets we can observe that EV deployment is also driven by the reduction of "range anxiety" with the introduction of publicly accessible charging stations. For example, observing the French market, a correlation can be identified between the deployment of BEVs and PHEVs and the installation of publicly accessible charging infrastructure. However, this PEV deployment increment cannot be easily attributed to the charging station availability due to the fact that it occurred in the year 2015 when the subsidization of scrapping and substitution of gasoline and diesel vehicles with PEVs was introduced. However, market analysis in other EU markets also indicates strong influence between charging infrastructure availability and deployment of EVs.

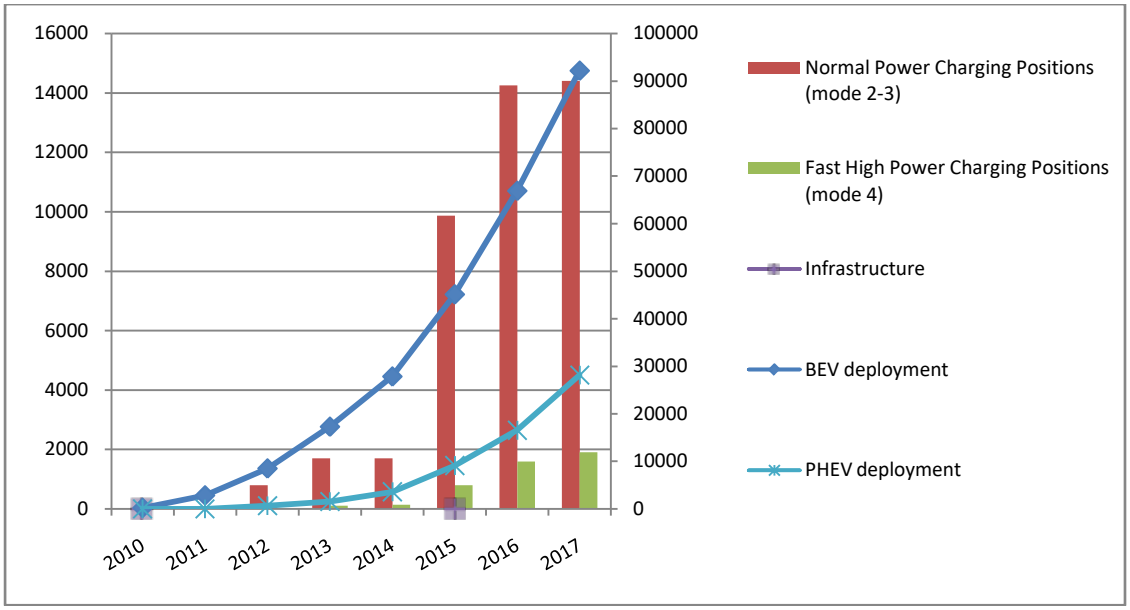

Figure 7 development of public charging position availability - the study case of France
Note: + Denotes the infrastructure framework change in 2010 making the charging infrastructure mandatorily included in public parking spaces and the 2015 Announcement of various municipalities investing in their publicly accessible local charging infrastructure. (Data derived from EAFO [4])

b.vi. Electric Range.: One significant technical boundary for EV adoption is the limited electric range of the vehicle fleet increasing the dependency of the EV deployment to the public charging position availability.

b.vii Economic Situation: The economic situation of the country is deemed to be a significant parameter influencing, the capability of each economy to provide fiscal incentives for the development of the EV market, as well as the consumer's willingness to pay for EVs. The fit indicators to express the economic situation with regards to the transportation market are considered to be GDP/capita and the average household income.

c. Results

Multi-regression analysis was tested as a statistical tool for determining the leverage of each parameter on the deployment of electric vehicles showing non-significant statistical correlations of EV deployment based on the historical data sets of the EU markets that were tested on. Advanced econometric forecasting tools and large data sets of more advanced EV markets are deemed necessary to determine a correlation between EV deployment and the tested parameters. With a more simplified approach we can observe that the EV market in Greece is not very well established, thus very volatile with non identifiable trends in the introduction of EVs. Specifically as shown on figures 8 and 9 the only year that we can observe a significant increase in EV introduction was 2017 and thus we cannot extract a trend out of one year market performance.

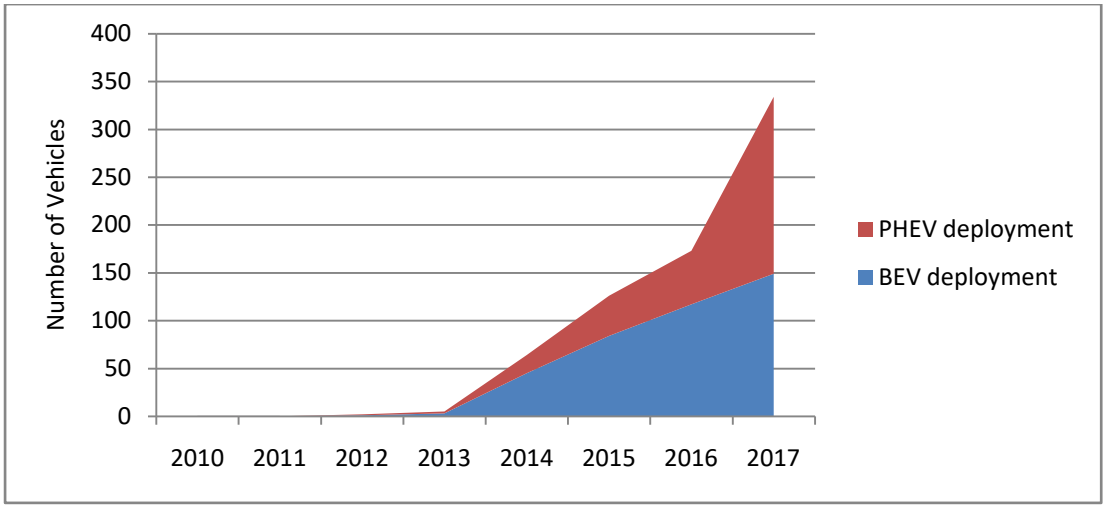

Figure 8 Plug-in Electric Vehicle Deployment in Greece.

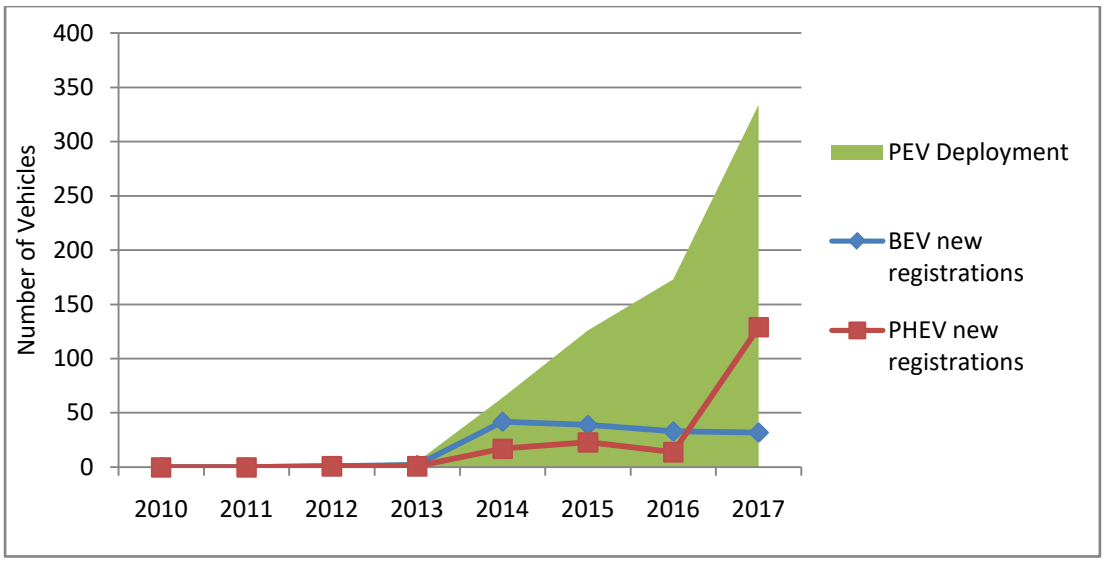

Figure 9 New registration of plug in electric vehicles in Greece.

d. Discussion and Conclusions

Concluding, the global EV market has shown promise and it seems that, unlike the market failures of the past, the renewed interest in EVs is backed by a rapidly developed industry. In Greece the steps of adopting electric mobility have been slow but it is expected that the rapidly escalating development of the EV market globally will drive Greece along to the electric mobility race. 2020 is a landmark year for Greek EV market as we expect the rapid increase of the number of installed charging stations nationwide following the implementation of the HEDNO's plan. Greece is also expected to proceed further with the establishment of the legal framework for EV charging that is expected to prompt new opportunities for investment and to increase the interest towards electric mobility. With regard to the statistical forecasting using correlation of the crucial parameters with EV deployment, the historical data utilized by various EU markets proved to be limited, due to the early stage of development of the EV market.

Therefore, no concrete results leading to meaningful correlations for the Greek EV market could be extracted. For future related work consumer behavior and driving behavior studies are deemed crucial so as to ensure data validity, and also avoid rough estimations and assumptions.

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