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Are Greek Drivers Willing to Embrace V2G Technology? A Survey Research

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Abstract: According to the European Commission, electric vehicles (EVs) remain parked for 95% of their life, which makes them inefficient. In addition, EV sales are forecasted to rise over the following years, which will create additional electricity demand, especially during peak hours. This challenge coincides with the growing trend of homeowners installing renewable energy sources (RES) in their homes. Therefore, a potential solution to managing the increase in electricity costs and peak demand is the use of EVs as a flexible storage system by utilizing vehicle-to-grid (V2G) technology. The successful market penetration of V2G technology hinges significantly on the willingness of current and future EV drivers to participate. Hence, in the broader context of the promotion and transition to electromobility and related technologies (V2G), the main purpose of this paper was to shed light on the hitherto unknown attitudes of Greek drivers towards V2G technology. The adopted methodology involved a survey questionnaire with statements serving as indicators on a 5-point Likert scale. The results show that Greek drivers highly appreciate the positive environmental impact of EVs but are primarily driven by the potential economic incentives they might receive from engaging with V2G technology. In addition, they appear to be skeptical about both V2G technology and electromobility, mainly due to the increased upfront cost of EVs but also due to the immature V2G market.

Keywords: electromobility; vehicle-to-grid; Greek driver willingness; closed-type questionnaire

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1. Introduction

According to the European Commission, electric vehicles (EVs) remain parked for 95% of their life [1], which makes them inefficient. Furthermore, hybrid renewable energy installations are considered the main solutions to environmental problems, with wind and solar being the main energy sources. However, the high dependence of these installations on weather conditions, as well as the high initial investment costs, raise doubts about them [2]. According to the latest available data, more than 26 million electric cars (including battery electric vehicles (BEVs) and plug-in hybrid electric vehicles (PHEVs)) were on the world's roads in 2022, up 60% relative to 2021, and more than five times the stock in 2018 [3]. This will create additional electricity demand, thus weighing on electricity generation and transmission, especially during peak hours [4].

The contribution of EVs to tackling environmental pollution by decarbonizing the transportation sector is an unquestionable fact, according to recent evidence [5]. Apart from the announced political decisions aiming at zero emissions, such as that made by the European Union [6] proposing to ban the sales of internal combustion engine vehicles and electrifying all new vehicles by 2035, recent studies confirm the positive environmental benefits caused by EV adoption [7].

Furthermore, a possible solution to managing the increase in electricity costs (Figure 1) and peak demand [8] is using the electric vehicles themselves as a flexible storage system by utilizing vehicle-to-grid (V2G) technology. With this technology, maximum utilization

of electric vehicles, as they will then constitute a solution to increased power demand [9], can also be achieved. Since 1997, when the concept of V2G first emerged [10] as a way of utilizing EVs' stored energy to support the electricity grid, several studies, such as that in Ref. [11], have been carried out to show the benefits of this method. V2G technology enables electric vehicles to support flexibility services by discharging electricity back to the grid or by reducing their energy consumption when necessary. This capability is crucial for managing the increased load on the grid caused by the growing number of electric vehicles and addressing the supply fluctuations associated with renewable energy sources; furthermore, when deployed on a large scale, V2G technology could significantly increase the proportion of renewable energy within the overall energy mix, achieving the ambitious sustainability targets set by numerous cities worldwide [12]. The importance of the V2G system is increasingly recognized due to its distinct benefits for both electric vehicles and the power grid. For electric vehicles, V2G enhances functionality and cost-effectiveness. For the power grid, it provides notable advantages such as active and reactive power adjustments, load balancing, frequency regulation, and improvements in efficiency, stability, and reliability. Furthermore, the implementation of V2G technology can facilitate peak shaving, thereby enhancing self-consumption [13].

According to a recent review [14], range anxiety, a lack of understanding, and the cost of V2G chargers are some of the 23 potential barriers to the adoption of V2G technology. Finally, according to V2G hub [15], there are currently 148 registered projects, since 2009, related to V2G in 27 countries, which are either completed or ongoing, offering different services and involving vehicle manufacturers, EVSE manufacturers, DSO/TSO, and aggregators.

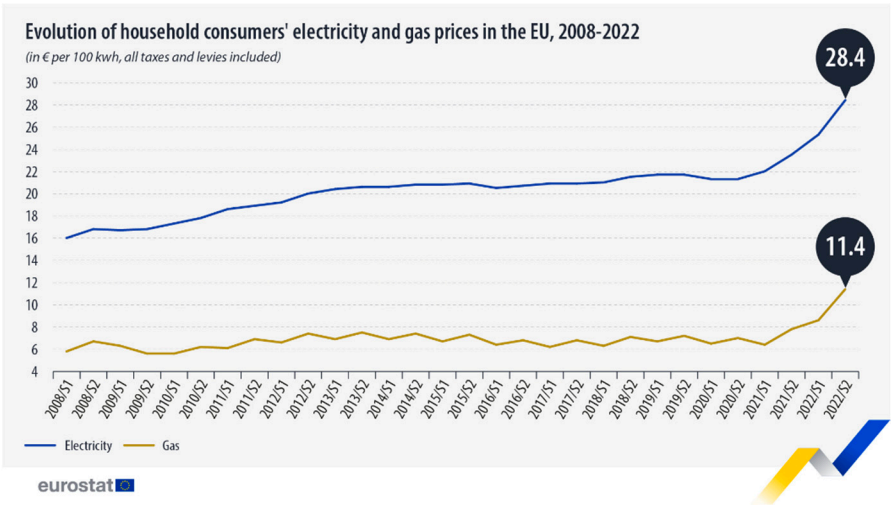


Figure 1. Evolution of household consumers' electricity and gas prices in the EU, "2008–2022" (Reprinted from Ref. [16]).

1.1. The Case Study of Greece

Electrification in Greece is a remarkable example of how the right policy decisions can change the energy profile of a sector in a relatively short time. According to the National Energy and Climate Plan (NECP), and, in line with the EU's Fit For 55 legislation, Greece aims at a total reduction in carbon emissions of 55% to that of 2005 levels by 2030, and carbon neutrality by 2050 [17]. It is therefore clear that electromobility is a high-priority issue for the Greek government.

Taking a brief look back to 2013, according to official data [18], only 3 battery electric vehicles (BEV) were registered, while by 2023, more than 15,000 EVs (BEV and plug-in hybrid electric vehicles (PHEV)) were on the road (Figure 2). Since that early state of electromobility in Greece, significant efforts have been made to drastically change the transport sector and especially the culture of Greek drivers. More specifically, the

EV market share in 2019 was less than 1%, while in 2023, it exceeded 11%, one of the largest increases in the European Union. Additionally, and according to the National Electrification Plan [19] of the Ministries of Environment and Energy, Development and Investments, and Infrastructure and Transport, in 2019, there were less than 100 installed public charging points and no substantial plan to promote electrification. On the other hand, in 2022, there were 3200 public chargers installed, the largest percentage of which was concentrated on the national road network. In addition, strategic actions have been put in place for the implementation of European and national targets for 2025, 2030 and 2050 on the electrification of road and maritime transport and the development of charging infrastructure. More precisely, through the "Charge Everywhere" [20] action, started in 2023 under the National Recovery and Resilience Plan "Greece 2.0", the installation of more than 8000 publicly accessible charging stations throughout the Greek territory is being subsidized.

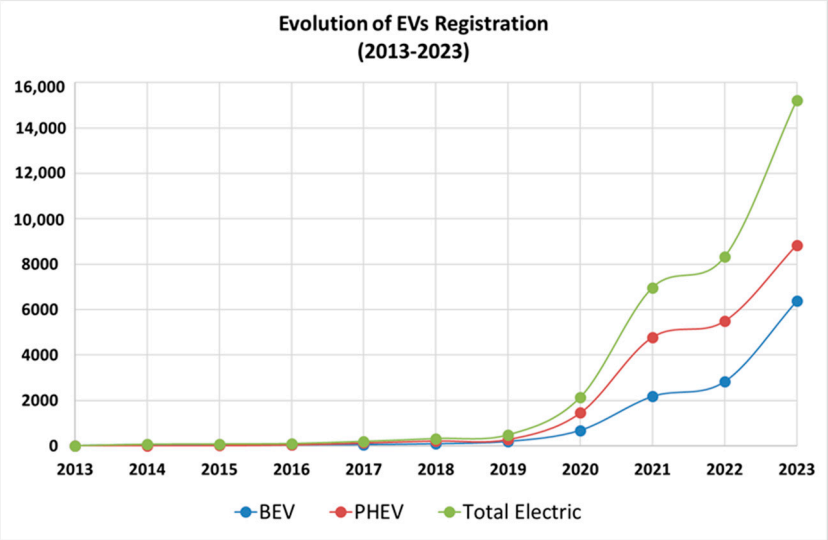


Figure 2. Evolution of EV registration in Greece ("2013–2023") (Adapted from Ref. [18]).

Regarding the incentives given by the Greek state for the promotion of electromobility, as of 2023, the action "I Move Electrically II" [21] offers, among other incentives, a 30% subsidy for the purchase of an electric car to a maximum amount of 8000 €; a withdrawal reward of €1000; and a €500 subsidy for the purchase of a smart charger for individuals. For legal entities, several subsidies and tax reliefs have been provided. Furthermore, a reduced VAT rate of 13% instead of 24%, and a yearly road tax exemption are additional incentives for the promotion of electromobility.

Finally, and according to the National Electrification Plan scenarios, it is estimated that by 2035, the Greek vehicle fleet will consist of almost 2.9 million EVs, mainly passenger cars and light commercial vehicles, while more than 100,000 public chargers will be installed by 2030. From the abovementioned data, it is obvious that the Greek EV market is in continuous development, with a positive outlook, and is a fertile ground for novel—to Greece—EV technologies such as V2G.

1.2. Literature Review

Previous studies in the literature regarding the V2G strategy are full of technical case studies [8,22], overviews [23], and techno-economic analyses [24,25] that provide crucial theoretical and applicable results to help in the application of V2G technology. Nevertheless, V2G's successful integration will depend on the opinion-awareness of the public, so that attitudes and perceptions of EV drivers can be determined [26]. Hence, the utilization of users' data through interviews and surveys is of the utmost importance.

Many of these studies examine the extent to which drivers are willing to pay–participate with regard to EVs that support V2G technology and the corresponding services through contracts, as well as the parameters that affect vehicle users' participation. By the term "contract", studies in the literature refer to EV users' compensation for the inconvenience they experience during V2G [27]. More precisely, Ref. [28], through an online stated-preference survey conducted in 2009 of 3029 U.S. householders, concluded that, due to their increased sense of inconvenience with V2G contracts, the high price demanded by drivers to make their vehicle available for V2G services will be an obstacle to the development of the EV market. The authors' suggestion, towards aggregators, was to adapt a pay-as-you-go contract model or provide drivers with upfront discounts on the price of EVs. Furthermore, in Ref. [12], an online survey conducted in 2013 among German drivers found that range anxiety and the minimum range of EVs, and not the amount of compensation, were the main factors determining whether EV users will participate in V2G or not. It is also interesting that only 1% of the participants knew the basic information about V2G, while users' willingness was the lowest when charging and discharging were controlled by the electricity grid operator via the vehicle (bidirectional charging). Finally, their study revealed that short-distance drivers found V2G transition less attractive than long-time conventional vehicle users.

By the same token, Ref. [9] discusses a survey conducted in 2019 via paper and pencil and online in the Netherlands to examine the willingness of EV drivers' preferences to participate in V2G contracts. The recharging time, even if reduced to 5 min, had a strong influence on the willingness of drivers to participate in V2G. In addition to this, a fixed monthly compensation had a positive effect on V2G contract participation, as long as the agreed plug-in time was not increased, as drivers felt it to be quite inconvenient to leave their EV plugged in for long time [28]. A similar survey that also took place in 2019 in the Netherlands was presented in Ref. [27], where the analysis of 96 completed surveys revealed that the number of discharging cycles and the guaranteed energy highly influence users' decision whether or not to participate in V2G schemes. Another online-based survey, discussed in Ref. [29], was conducted for a whole year between five Nordic countries with more than 4000 respondents. In accordance with a previous study, mutatis mutandis, only 10% had heard about V2G technology, although Nordic countries and, especially Norway, Iceland, and Sweden are among the top five countries with the highest share of EV sales [30]. Therefore, the lack of a clear V2G policy seems to affect the willingness of drivers to participate in such a scheme. Ref. [31], in 2019, conducted a stated choice experiment among 148 Dutch EV drivers to identify their preferences regarding their willingness to participate in V2G on the basis of an increased recharging speed. They found that more than 50 EV drivers would not choose any V2G contract based on conventional charging, while fewer than 38 participants would not choose it even with a faster charging speed.

Furthermore, other studies examined the adoption of V2G under a behavioral perspective to identify factors that affect the willingness of users to participate in V2G. Particularly, Ref. [32], in 2021, interviewed 20 Dutch EV drivers and concluded that remuneration, knowledge spillover regarding V2G, and a user-friendly interface are factors that will accelerate the adoption of V2G. On the other hand, battery degradation and range anxiety are factors that worry users and thus influence their willingness to participate. A recent online survey carried out by Ref. [33] in Norway among 929 car users showed that EV owners are more likely to participate in V2G technology than those who do not have an EV. On the other hand, both EV and non-EV users would have a positive view of V2G as long as there were incentives, minimum guaranteed charges, and an integrated education for the benefits of V2G. In accordance with previous surveys, two of the major obstacles to the development of V2G technology are battery degradation and range anxiety, which, with proper information from the state, will be overcome.

At this point it is worth noting that surveys based on questionnaires on the broader field of electromobility in Greece are few. A relevant study was conducted in 2023, investigating the factors influencing the adoption of EVs in Greece [34]. A more technical study

based on a questionnaire survey explored the development of a power supply network by utilizing EVs on the island of Skiathos [35].

As shown above, although there is an abundance of surveys regarding V2G technology in several European countries, there is no relevant research concerning this issue specifically in Greece. Despite the fact that there are many studies on the issue of electromobility using Greece as a case study, very few deal with technical issues, such as the impact of V2G on the national distribution network [36], and there are none about the public's willingness to participate in V2G. Therefore, this study aims to fill this gap by presenting, for the first time, Greek drivers' opinions on the upcoming technology of V2G.

1.3. Objective and Novelty

In the broader context of the promotion and transition to electromobility and related technologies (V2G) the purpose of this paper is, on the one hand, to contribute to the existing literature with a survey investigating the attitude of Greek drivers towards electromobility and, on the other hand, to shed light on the hitherto unknown behavior of Greek drivers towards V2G technology. Since the literature, especially concerning Greece, is incomplete on the part of V2G, the present study aims to highlight the factors that seem to influence the participation of drivers in this technology. The findings would be advantageous for stakeholders engaged in electric vehicle (EV) and vehicle-to-grid (V2G) projects, encompassing manufacturers, policymakers, and utility firms.

2. Materials and Methods

2.1. Methodology for V2G Surveys Based on Questionnaire in Greece

In order to identify studies relevant to our work in the literature, we performed a specific searching strategy by utilizing the Scopus database. According to our purpose, we tried to find if there were any surveys (i.e., interviews) that took place in Greece, irrespective of the period time, concerning V2G acceptance. Hence, we initially found every V2G research study concerning Greece by searching within Article title, Abstract and Keywords using Scopus' Operators as follows: vehicle AND to AND grid OR vehicle-to-grid OR v2g AND Greece OR Greek. Between 2004 and 2023, 42 documents were found concerning either a Greek island or the mainland that dealt with technical issues such as the impact of V2G on the national distribution network [36]. Based on our comprehensive literature review, we found that all the studies that were carried out in the form of questionnaires contained, either in their abstract or in their filed keywords, apart from V2G, the words "interview(s)", "survey", "choice experiment", "questionnaire", "willingness to pay", "acceptance" and "participate", respectively. Therefore, we decided to enrich Scopus' searching field as follows: in the Title search, we retained the (vehicle-to-grid OR v2g) form and separately in the Abstract search we added the (Greece OR Greek AND interview OR survey OR questionnaire) form; however, no documents were found. Then, we added, in the Abstract field, the (willingness AND to AND pay OR acceptance OR participate) form; however, again, no results were found. Hence, to the best of the authors' knowledge, no survey, in the form of a questionnaire, has been carried out in Greece, to date, regarding V2G technology.

2.2. Methodology for Electromobility Surveys Based on a Questionnaire in Greece

Following the same methodology, we tried to find any survey (i.e., interviews) that took place in Greece, irrespective of the period time, regarding electromobility. Therefore, we searched within the Article title, Abstract and Keywords using Scopus' operators as follows: Electric AND Vehicle OR EV AND Greece AND Survey AND Questionnaire. Between 2017 and 2023, seven surveys conducted with questionnaires were found concerning either the factors that affect EV adoption [34] or, from a more technical point of view, the development of sustainable power supply network for people and goods on the island of Skiathos [35].

2.3. Measures

The questionnaire, by using closed-type questions and statements (19 in total) as indicators, examined driving habits, was conducted to determine the usefulness and importance of electromobility and that of V2G, trust in V2G; and relative concerns and intentions to use it. Before dealing with the main part of the article, which is the willingness of drivers to participate in V2G and the recording of their general concerns about this technology, a brief description of bidirectional charging was given. More precisely, we explained the differences between normal charging, unidirectional charging, and bidirectional charging (V2G). Most of the indicators were rated on a 5-point Likert scale based on the importance of each indicator; for instance, 1 = not important at all, 2 = unimportant, 3 = neutral, 4 = important, 5 = extremely important.

2.4. Questionnaire Design

As previously stated, our research relied on an online survey aimed at gathering information from respondents. The survey consisted of three sections, as follows:

1. The first part focused on gathering socio-demographic details (age, gender, level of education);
2. The second part aimed to gather data on respondents' driving profile and examines how familiar are Greek drivers with EVs, the general perception of electromobility and drivers' willingness to buy EVs. For instance, to investigate the relationship of Greek drivers with electromobility, respondents were asked if they are aware of how EVs operate. Furthermore, their willingness to buy an EV in the next five years was measured (if you don't own an EV, how willing would you be to buy one in the next 5 years?) in order to determine the tendency towards electromobility. Finally, in order to find out the priority drivers set for buying an EV, respondents were then asked to evaluate the reasons why someone should buy an EV;
3. The third part aimed to gather information on respondents' familiarity with V2G technology and their charging preferences. By asking them "how likely is it that you will use the following strategies to charge your EV", we demonstrate their tendency towards bidirectional charging. The respondents were also asked to examine their main concerns, as well as their willingness to participate in V2G. Therefore, we asked them how concerned they were about specific issues, such as the immature market for V2G vehicles and chargers, battery degradation etc., in order to determine their main concerns. Finally, some crucial drivers for the embracement of the technology emerged.

2.5. Data Collection

Information was gathered via an online questionnaire survey conducted over approximately two months, spanning from April 2023, to May 2023. The participation was voluntary, and the questionnaire was anonymous. No foreseeable risks arose from their participation in this survey and their refusal to participate did not in any way adversely impact upon them. The main purpose of conducting the questionnaire was to gather a sufficient number of participants to enhance our research. The questionnaire was created using a free online platform, specifically Google Forms, and was distributed through social media channels and institutional emails to members of academic communities.

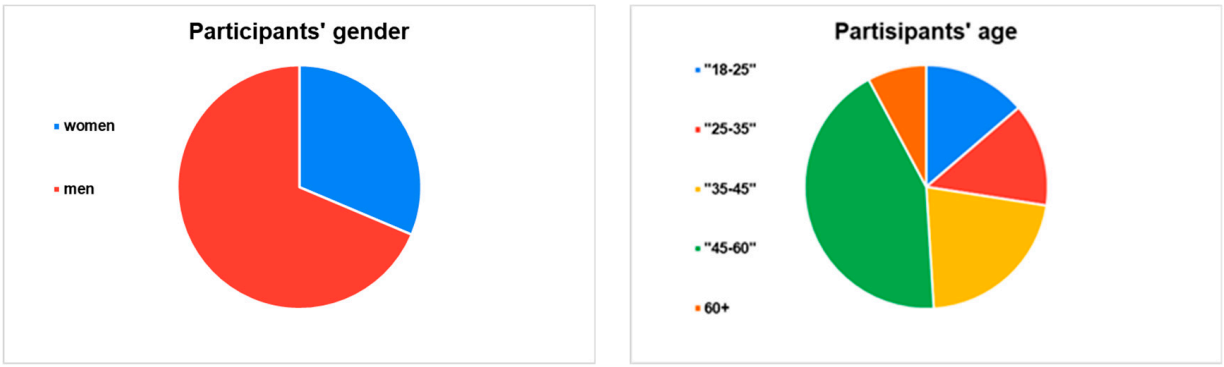
Ultimately, 216 questionnaires were gathered, after which a data-cleaning procedure was implemented. Questionnaires containing incomplete responses were excluded. More precisely, some questionnaires did not have enough answers while others had multiple options in a single-choice question. Consequently, 205 questionnaires were deemed valid for exploring the intention of Greek drivers to participate in V2G.

3. Results and Discussion

3.1. 1st Part of Analysis

Sociodemographic Results

In an attempt to capture the characteristics of the participants, we tried to collect information concerning gender, age, education level, occupation, annual income, and area of residence. As shown in Figure 3, 30% of the respondents were female and 70% were male. Over 40% belonged to the 45–60 age group, over 20% to the 35–45 age group, while the 18–25 and 25–35 age groups were evenly divided, with 14% each; only 8% represented ages over 60.



(**a**) (**b**)

Figure 3. (**a**) Participants' gender; and (**b**) participants' age.

Furthermore, as can be seen in Figure 4a,b, an interesting link can be made between educational levels and the respondents' occupations, as it appears that more than 30% have a PhD and about 50% are civil servants. This is probably due to the fact that the questionnaire was distributed through institutional emails to members of the academic community and that perhaps these percentages concern professors, researchers, and other staff. Consequently, the percentages related to the possession of a master's degree and a bachelor's degree are equally divided, with 30% each. As far as household income is concerned, the results (Figure 4c) are almost split between the three categories of 10,000 €–25,000 €, 25,000 €–40,000 € and over 40,000 €, with each having a percentage of about 30%. Finally, as shown in Figure 4d, only 13% appear to live in an urban environment, which indicates that the remaining 87%, who answered that they live in a province, probably live in the suburbs of the city.

3.2. 2nd Part of Analysis

3.2.1. Participants Driving Profile

In order to create driving profiles for the participants, questions were asked concerning their driving experience in years, their daily driving hours, and corresponding mileage, as well as the type of vehicle they used, based on fuel. The driving experience of 74% of the respondents, according to the results (Figure 5a), was more than ten years; a third these were EV owners. Only 5% of the respondents had been driving between 5 to 10 years. Combined with daily driving hours (Figure 5b), almost 60% of the respondents drove between 1 and 3 h, while 45% drove 10–30 km every day (Figure 5c). Regarding the fuel used, it can be seen in Figure 5d that half of the vehicles ran on gasoline, while hybrids and electrics made up 23%, compared to those using diesel at 19%. The remaining categories, LGS and natural gas, accounted for 8%. Although the proportion of conventional vehicles is large, it is remarkable that EVs occupy almost a quarter of the fuel types used.

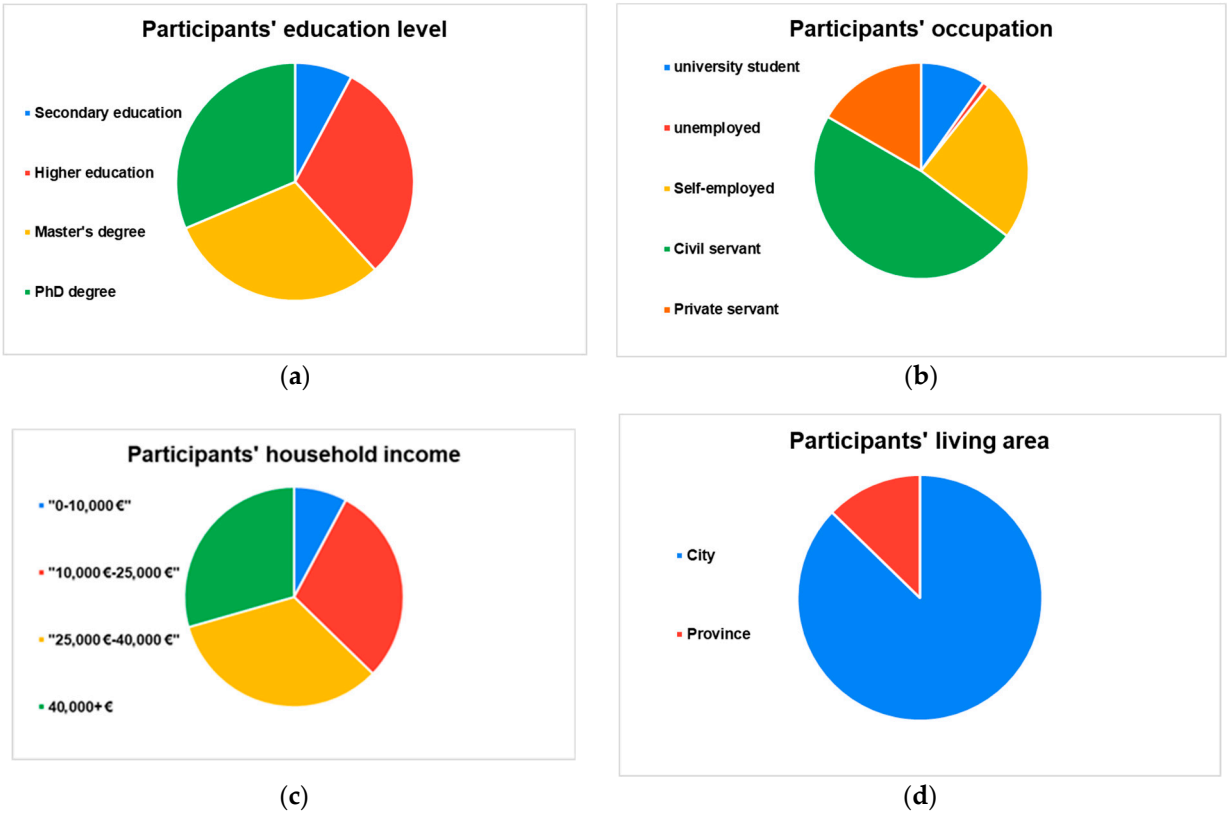


Figure 4. (**a**) Participants' educational level; (**b**) participants' occupation; (**c**) participants' household income; and (**d**) participants' living area.

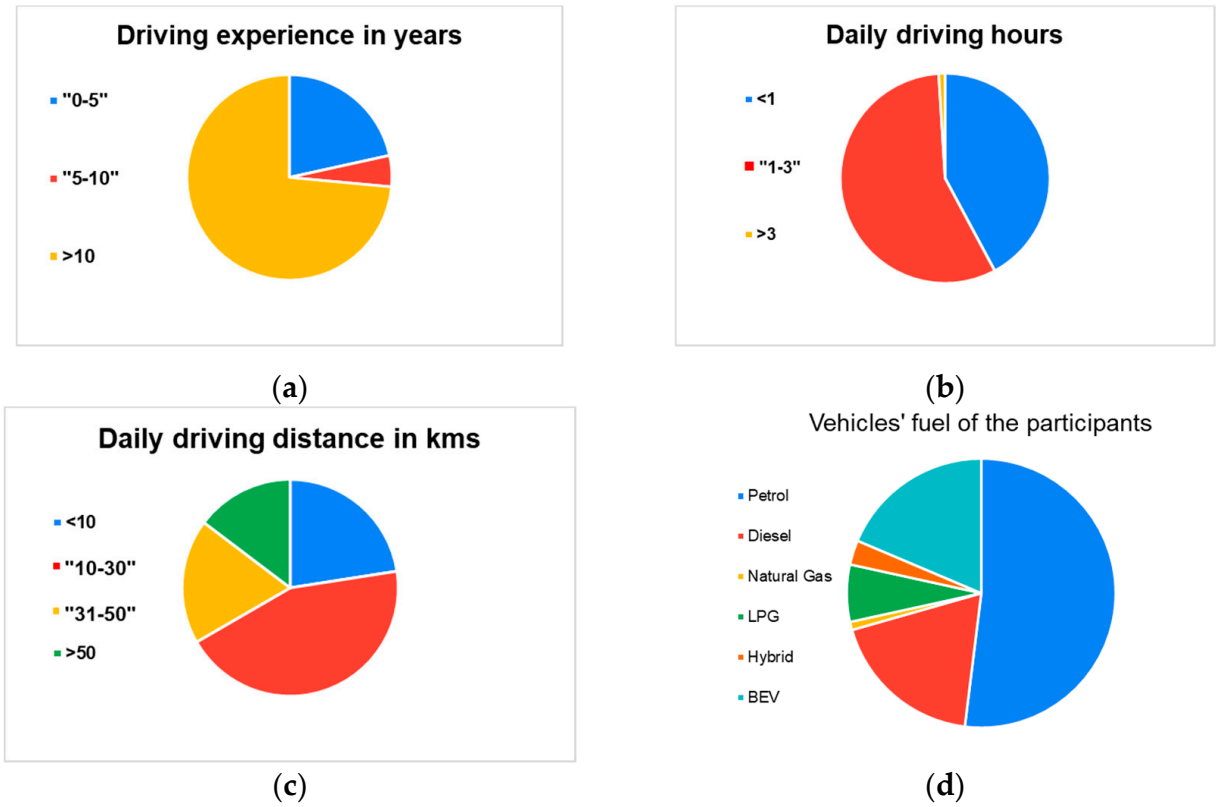


Figure 5. (**a**) Participants' driving experience in years; (**b**) participants' driving hours; (**c**) participants' driving distance in kms; and (**d**) vehicle fuel of the participants.

3.2.2. General Perspective about EVs

At this point, it is worth noting that the analysis is based on two axes: those who own an EV; and those who do not own an EV. The aim is to understand the general perception of the public regarding electromobility and the reasons why someone would buy an EV, or even participate in the technology of V2G.

Familiarity with EVs and Willingness to Buy One

As mentioned above, and since to participate in something let alone be willing to buy it you should be familiar with it, one of the aims of this research was to investigate the relationship of Greek drivers with electromobility. This is why an initial question was whether drivers know how an electric vehicle operates, which indicates their familiarity with EVs. More precisely, the question was "Are you aware of how EVs operate?". The reason why this question was not followed by any further explanation about the concept of "operates" is because we were now talking about electric vehicle users and not just drivers. EV owners must not only manage the information they receive about batteries and be able to understand how to utilize them, they should also be familiar with the optimum discharging and charging rates of their EVs. This is obvious from the literature, as articles such as those in Refs. [12,37,38] refer to EV users instead of EV drivers.

Participants' results are shown in Figure 6. In line with what was said above, 38% were not fully aware of how EVs work, 25% were not aware, while only 11% were fully aware. What is noteworthy here is that, after separating the responses of EV owners and non-EV owners, of those who said they were not aware of how EVs operated, almost 50% had an EV. This highlights the problem of the lack of awareness related to electromobility issues and the need for proper training in the use of an EV, which includes not only the process of discharging but also that of charging the EV, with the indirect purpose of extending the battery life.

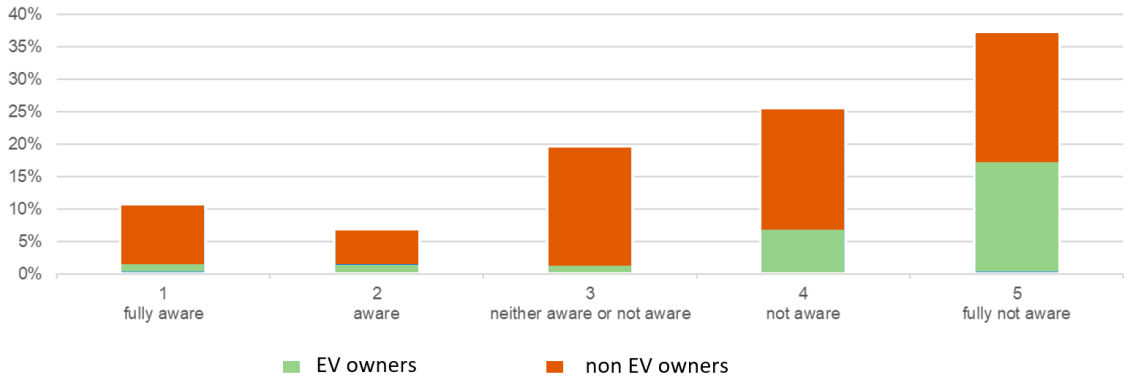


Figure 6. Familiarity with EVs (question: are you aware of how EVs operate?).

The desire of those who did not own an EV to buy one in the next 5 years was then studied. Figure 7 shows that 41% showed a particular desire to buy an EV (i.e., 23% were totally willing and 18% were willing), while 33% indicated an intermediate state, translated as a lack of interest. It is important to relate these results with the awareness of EV operation in the previous question. Here, it can be seen (Figure 8) that more than 50% of those who want to buy an EV (totally willing and willing) are not aware of how it operates, while 25–30% were neither aware or not aware. Future buyers who know something about the operation of EVs accounted for 12–27%. In those who were characterized by a neutral situation, the percentage who lacked any knowledge of EVs was 40%, while for those who would not buy an EV, the corresponding percentage reached 83%. In other words, those who were familiar with EVs would buy one much more readily than those who were not aware, which was also proven in Ref. [39]. Therefore, we conclude that the lack of knowledge about the use, operation, management, and the positive and negative aspects of EVs affects drivers' desire to invest their money in buying an EV, leaving a

feeling of distrust. It is also important to note that the prevalent age group of those who already owned an EV is the 45–60 age group while future buyers are among the 35–45 and 45–60 age groups, at 30% and 23%, respectively, according to our results.

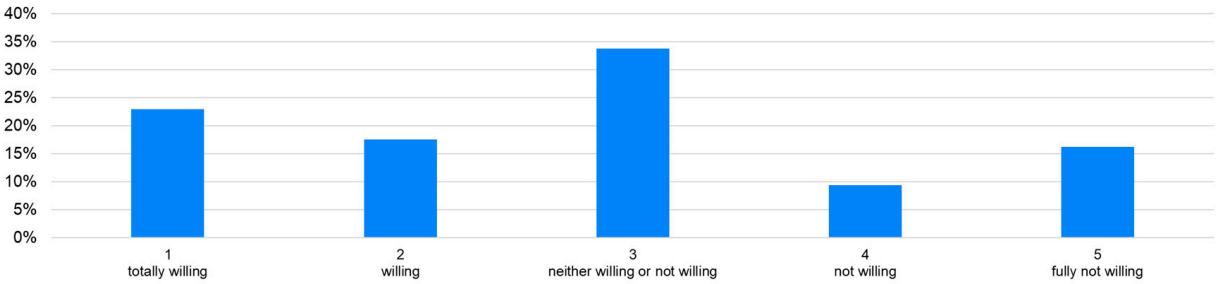


Figure 7. Willingness to buy an EV (question: if you do not own an EV, how willing would you be to buy one in the next 5 years?).

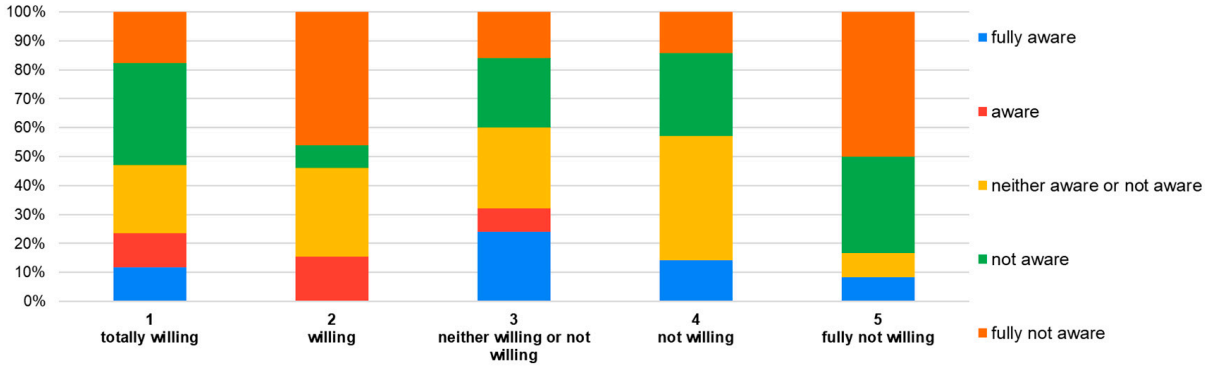


Figure 8. Familiarity with EVs and willingness to buy an EV.

To complete the analysis on participants' familiarity with EVs, both categories (EV owners and non-EV owners) were asked to indicate what type of EV they had, and, for those who did not, what type they would buy. Initially, as it can be seen in Figure 9, almost 27% were EV owners with BEVs accounting for 80%, hybrids 18%, and plug-ins accounting for 2%. In the same category, 93% of owners used an EV as their main commuting option. On the other hand, 73% would buy an electric vehicle in the near future, among which half would choose a BEV, 23% a plug-in, and 27% a hybrid.

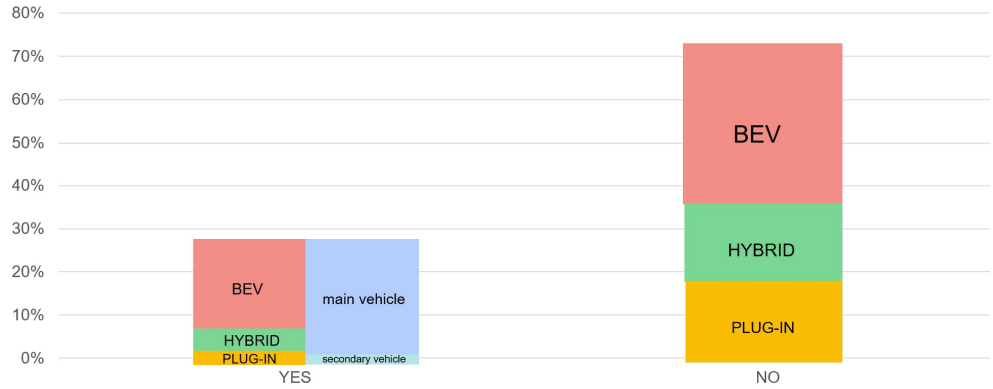


Figure 9. Vehicle type of EV owners and future EV owners (question: do you own an EV? if yes what type and if no what would you buy?).

Reasons to Buy an EV

Respondents were then asked to evaluate the reasons why someone should buy an EV, by rating them based on which reason they considered extremely important or not at all important. Initially, the analysis was for the whole population of respondents. Figure 10 shows that the public's priority is the protection of the environment, with 80% considering the contribution of EVs in reducing air pollution in urban environments as extremely important. Also of the utmost importance for more than 65% of the respondents was the reduction in noise pollution in urban environments and that of CO_2 in the transport sector, underscoring the strong public sentiment that cleaner transportation, particularly electric vehicles, are key to improving air quality in urban areas [40,41]. The low operating and maintenance cost was also considered an extremely important reason for purchasing an EV for 63% of respondents. Contrary to the previous results, technological issues, and the feeling of driving an EV were considered to be extremely important reasons for almost 30% of drivers, although BEVs were seen as more dynamic than the majority of comparable conventional models. These results are in line with previous research [42] in the UK, according to which the most important reasons for buying an EV, in order of decreasing significance, were the protection of the environment, the reduced running costs, and factors such as tax advantages and parking benefits. To sum up, the main priority for buying an EV, according to our study, is the environmental impact, followed by the operating and maintenance cost, and finally, driving performance.

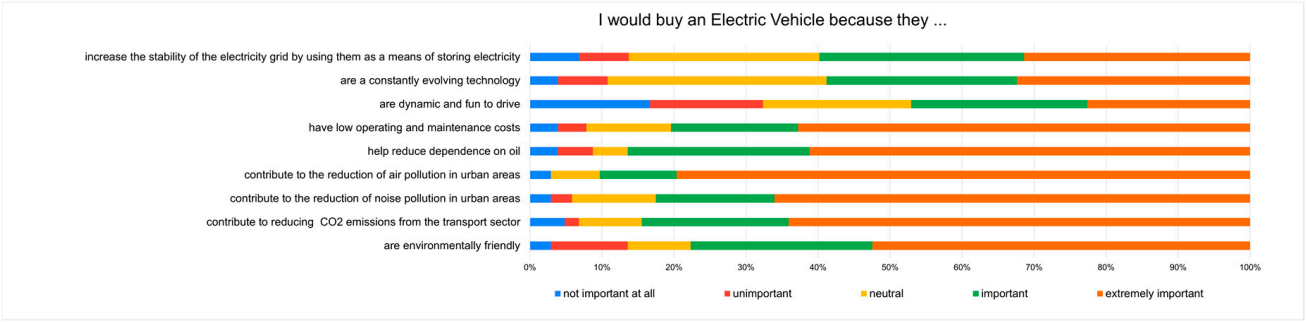
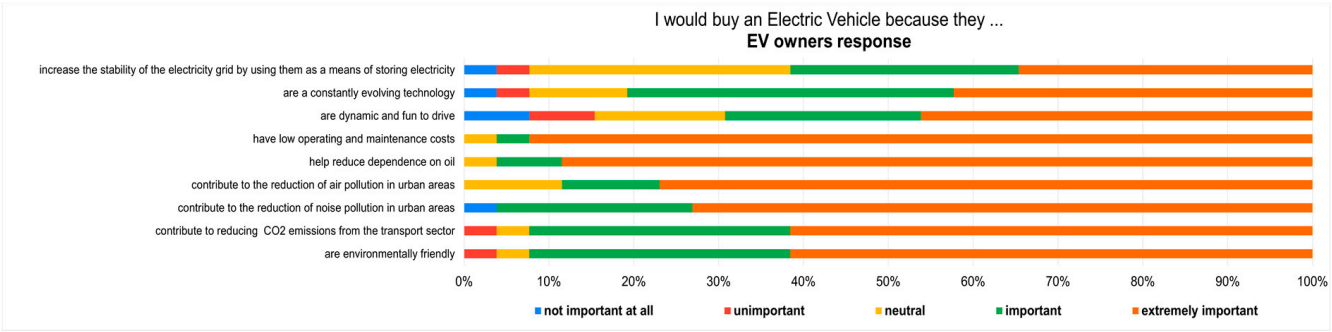
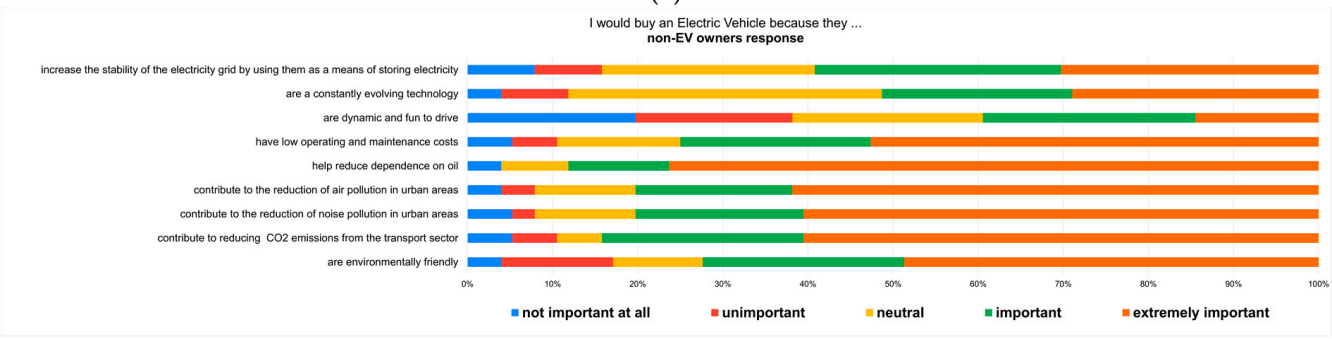


Figure 10. Evaluation of the reasons why someone should buy an EV.

Moving on to an analysis between the two categories of participants, the first differentiation appears in relation to the low operating and maintenance cost, and the environmental impact. More precisely, EV owners (Figure 11a) ranked the cost factor first in importance, and the environmental impact second, which is also supported by Ref. [43], where EV owners opted to purchase an EV primarily for the following three reasons: to cut costs (48%); protect the environment (27%); and save time (12%). Since non-EV owners (Figure 11b) are not familiar with, or properly informed about, the indirect economic benefit of EVs, it is logical that they do not consider it as important as EV owners do. This highlights, once again, the lack of awareness of electromobility issues by external stakeholders. Nevertheless, considering the total percentages regarding "extremely important" and "important" choices, one can conclude that EV owners are more environmentally aware than non-EV owners; this is supported by Ref. [44], where it is stated that EV owners generally care about the environment. By the same token, non-EV owners, who are not familiar with the vigorous driving performance of an EV, appeared to not care about its performance. The only common results among the two groups related to the extent to which it affects network stability, which is quite technical, even for EV owners.



(**a**)



(**b**)

Figure 11. Evaluation of the reasons why someone should buy an EV: (**a**) EV owners' responses; and (**b**) non-EV owners' responses.

3.3. 3rd Part of Analysis

3.3.1. Familiarity with V2G and Charging Preferences

As above, we first needed to determine what the participants' relationships were with V2G technology; for this reason, they were asked if, and to what extent, they had heard of this technology. The results, shown in Table 1, showed that 45% had not heard of this technology, while only 22% knew enough about it, which was expected, as V2G, especially in Greece, is new and people do not know about it. Analyzing the responses in each category, the relationship between those who had an EV and V2G is highlighted since, as shown in Figure 12, only 23% of EV owners did not know about the given technology, in contrast to almost double the amount of non-EV owners. It can be seen that those who knew enough about V2G were the EV owners, at 38%, which was twice the amount of those who did not have an EV.

Table 1. Participants' relationships, for both categories, with V2G technology.

Have You Ever Heard of the Term Vehicle-to-Grid (V2G)?	Percentage
No, I've never heard of it	45%
Yes, I ve just heard it	33%
Yes, I know enough about it	22%

In order to study EV users' willingness to participate in V2G, it is crucial to provide them with the necessary information regarding the technology. Therefore, participants were given the necessary information for each charging strategy, as shown in Table 2, (normal charging, unidirectional charging, and bidirectional charging) before assessing their willingness to use them in order to charge their EVs on a scale of 1 (=extremely unlikely to use it) to 5 (=extremely likely to use it). Results showed that willingness to participate in bidirectional charging (both the likely and extremely likely choices), which reflected participation in V2G, was the lowest, at 49%, which was lower than that for

normal or unidirectional charging, at 63% and 64%, respectively. These results are in line with the study in Ref. [12], where bidirectional charging had the lowest preference while normal and unidirectional charging were almost equal.

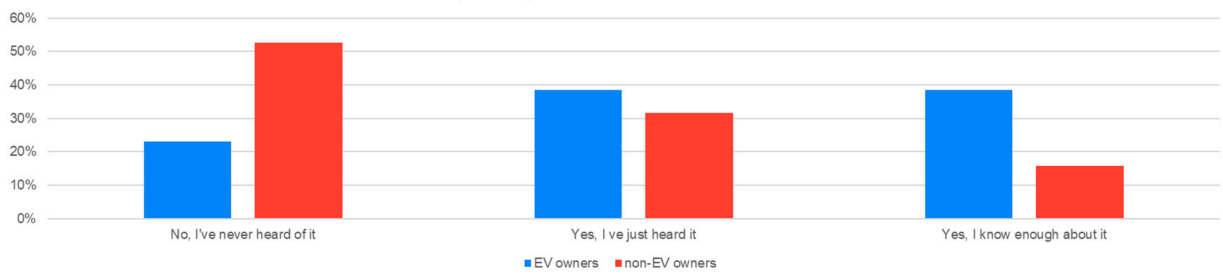


Figure 12. Participants' relationship, for each category, with the V2G technology (question: have you ever heard of the term vehicle-to-grid (V2G)?) depending on EV and non-EV owners.

Table 2. Explanation of vehicle-to-grid charging strategies.

Normal Charging
Your EVs battery will start charging as soon as you connect your car to the power grid
Unidirectional charging
You designate a specific time when your vehicle should be available with a fully charged battery. Typically, your vehicle will not charge immediately; instead, it will charge when there is an excess of electricity or when the demand for electricity is low. EVs battery is controlled and charged, but not discharged, by the power grid operator. This ensures that your EV's battery will be fully charged at the specified time.
Bidirectional charging
You designate a specific time when your vehicle should be available with a fully charged battery. Typically, your vehicle will not charge immediately; instead, it will charge when there is an excess of electricity or when the demand for electricity is low and discharged when the electricity demand is high. The power grid operator has the ability to independently control power generation and battery charging/discharging. This ensures that your EV's battery will be fully charged at the specified time.

Comparing the responses of the EV owners (Figure 13a) and those who do not own EV (Figure 13b), we see a cautious attitude of the former towards bidirectional charging compared to the latter, which is not consistent with the increased knowledge about V2G of those who have EVs. Of course, they could be intimidated by the full control given to the power grid for charging and discharging their vehicle. On the other hand, there is a greater willingness to use normal charging by EV owners compared to those who do not own an EV, which might reflect their daily experience with this charging strategy. It is noteworthy that both categories show similar rates of unwillingness to participate in bidirectional charging, which would be different if they were fully aware of the technology. Regarding unidirectional charging, more than 80% (both "extremely likely" and "likely") of EV owners would choose this method, compared to less than 60% of non-EV owners. A possible explanation of the above is that drivers who do not own an EV cannot understand the benefit of offering peak-shaving services to the power grid [45].

3.3.2. Concerns about V2G

In order to rate the concerns of the drivers concerning V2G, respondents were asked what worried them the most about this technology on a scale of 1 (=extremely unconcerned) to 5 (=extremely concerned). As far as the whole population surveyed is concerned, Table 3 shows that their biggest concerns were that there might not be enough compensation for the potential battery degradation, and that the market for V2G vehicles and chargers was immature. After these concerns, they worried that they might not have enough autonomy after V2G operation and that there is a lack of information about V2G. Finally, their fifth and

sixth concerns were EV battery life and the limited freedom and control over the vehicle for users, followed by the last worry, which was that their driving data might be used for several reasons.

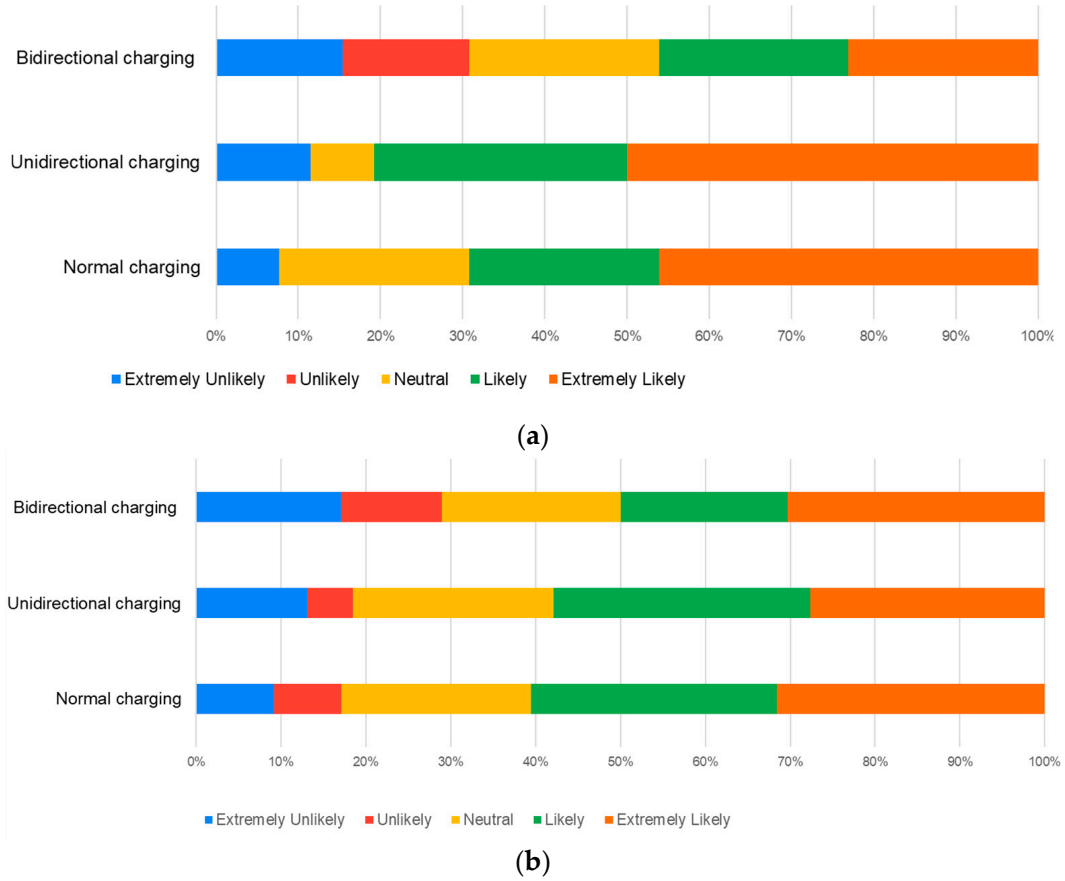


Figure 13. Participants' willingness to use each charging strategy: (**a**) EV owners' response (question: how likely is it that you will use the following strategies to charge your EV?); and (**b**) non-EV owners' response (question: how likely is it that you will use the following strategies to charge your (future) EV?).

Table 3. Participants' concerns regarding V2G technology.

How Concerned Are You about the Following Issues Regarding the Use of V2G	Percentage
Evs battery life	49%
the immature market for V2G vehicles and chargers	63%
Evs autonomy after V2G operation	56%
user's freedom and control over the vehicle is limited	49%
not enough compensation for potential battery degradation	65%
data security	25%
lack of information	54%

When concerns are checked from each category's point of view, the results are quite interesting. EV owners (Figure 14a) do not seem to be concerned about the lack of information about V2G and their vehicle's safety at 50%, contrary to the view of non-EV owners (Figure 14b) at 25%, which can be explained by the previous chart concerning their familiarity with V2G. With regard to battery degradation issues, in terms of the lack of any compensation, and the immaturity of EV charging market, 70% of respondents appeared to be highly concerned, which might reflect the daily challenges they face concerning the charging infrastructure and battery health. By the same token, more than 60% appeared to

worry about the remaining autonomy of their EV after the use of V2G, perhaps because they do not know that there is a guaranteed battery level or because the range anxiety phenomenon still worries them. Finally, it is surprising that 50% of EV owners are not concerned, in total (="extremely unconcerned", "unconcerned", "neutral") about their EV battery life, which is in contrast to their general concern about potential battery degradation. One reason for this might be that most of them lease their EVs, since the share of the electric fleet in business contract hire cars is growing quickly [46], accompanied by the fact that battery lifetime extension is not a user priority [47]. What can be said about non-EV owners is the almost equal share of indifference, contrary to those of EV owners, among all the responses, which might reflect their lack of knowledge on EVs generally.

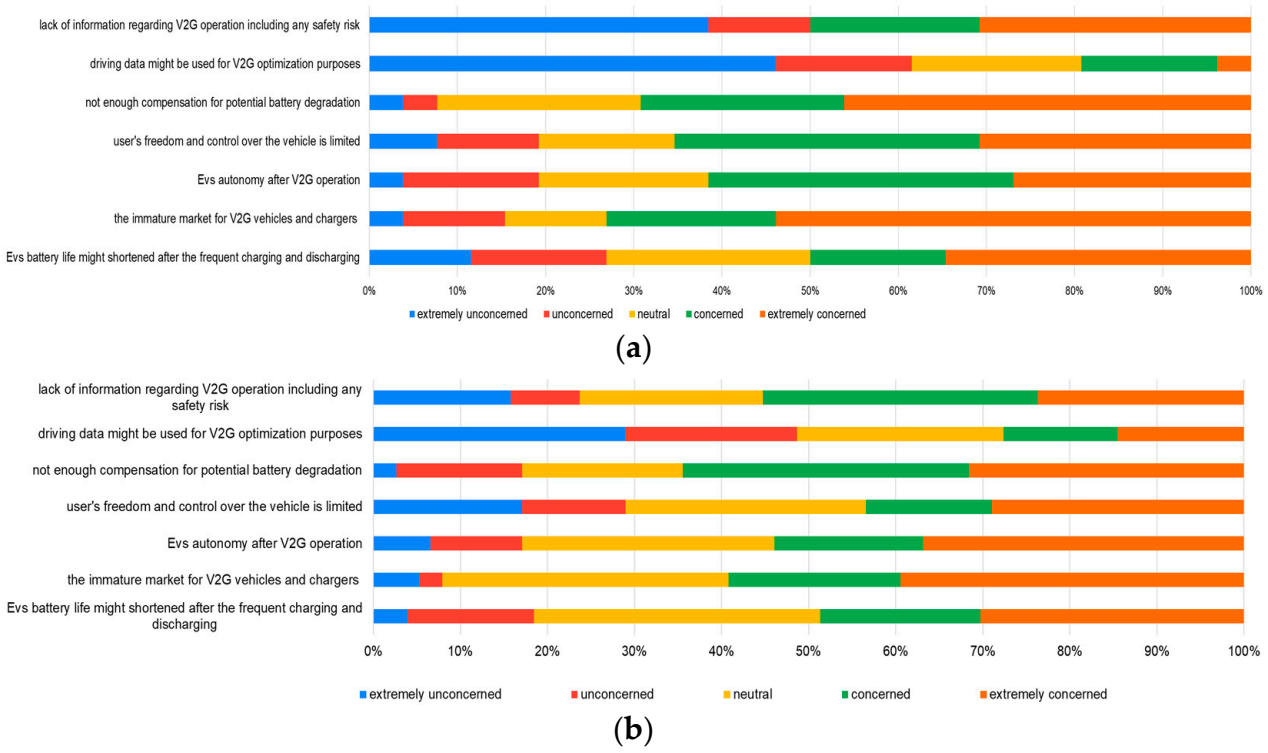


Figure 14. Participants' concerns about the use of V2G: (**a**) EV owners' response (question: how concerned are you about the following issues about the use of V2G?); and (**b**) non-EV owners' response (question: how concerned are you about the following issues about the use of V2G?).

3.3.3. Willingness to Be Part of It

To evaluate the willingness of Greek drivers to participate in V2G, specific statements were presented to reflect incentives, and respondents were required to express their agreement or disagreement based on a scale of 1 (=strongly disagree) to 5 (=strongly agree). In descending order, as it can be seen in Figure 15a, respondents agreed that the strongest incentives, based on "agree" and "strongly agree" responses, for their participation in V2G were: their control of the discharging procedure, the price of charging, the reduction in EV/charging station prices, and the assurance that EV charging originated from RES, which reflected the environmental awareness of respondents. Furthermore, the greatest incentives for EV owners (Figure 15b) were any reductions in EV or charging station prices, contrary to non-EV owners (Figure 15c), who would feel more willing to participate if they had control of the discharging procedure. One can see that EV owners consider financial incentives and environmental protection more significant than non-EV owners, which is in line with previous results.

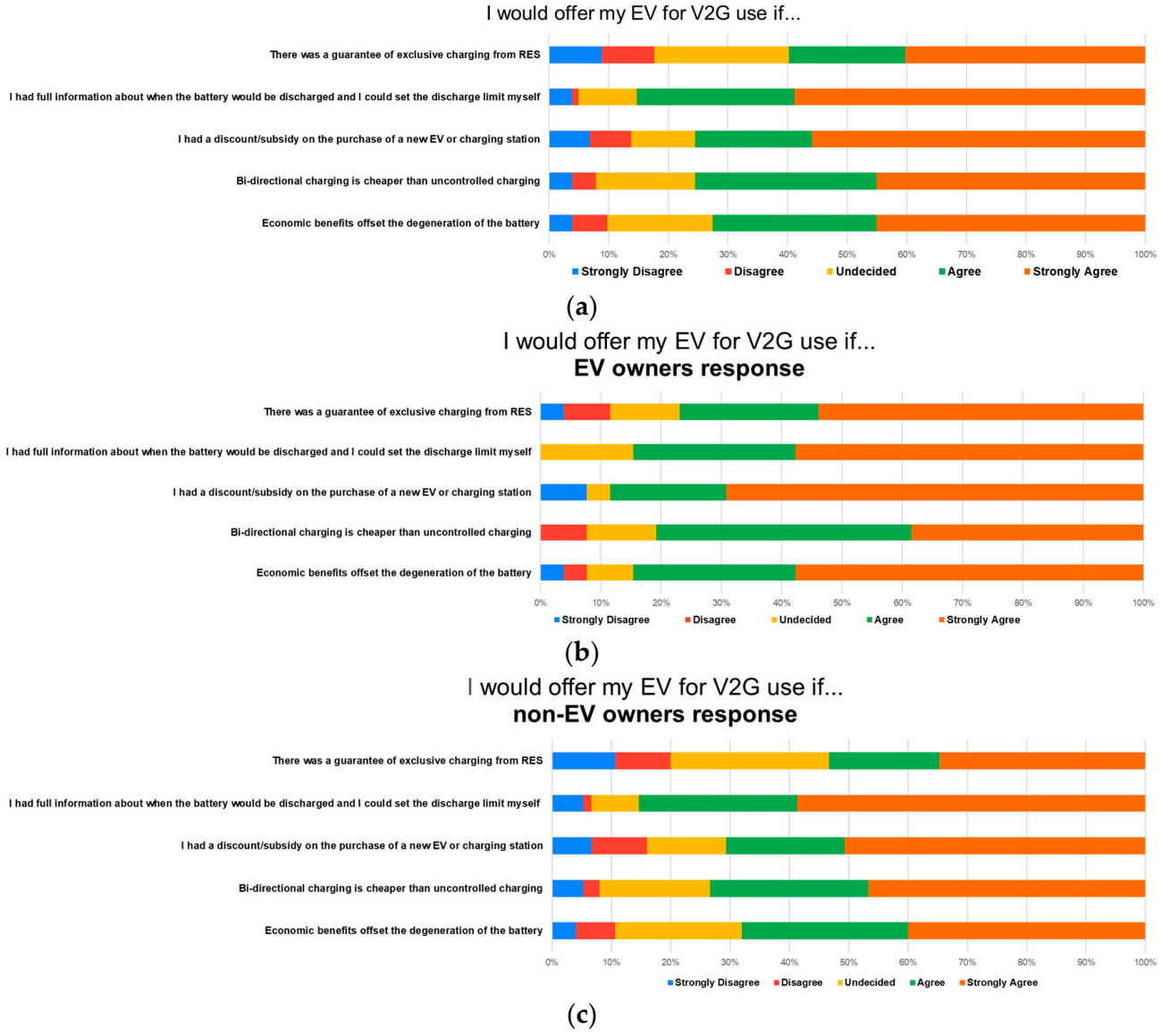


Figure 15. Participants' willingness to participate in V2G by offering their EV: (**a**) general population (**b**) EV owners' responses; and (**c**) non-EV owners' responses.

3.3.4. Drivers for the Embracement of V2G

In order to evaluate the factors driving users' decision to either participate or not in V2G, specific statements were presented and respondents' agreement, or disagreement, based on a scale of 1 (=strongly disagree) to 5 (=strongly agree), were measured. EV owners, as it can be seen in Figure 16b, set as their priority the environmental and economic benefits of V2G use and stressed the need for a legislation scheme concerning bidirectional charging, accompanied by a comprehensive briefing for the operators concerned in order to increase drivers' confidence with the grid operator and how it will manage their vehicles. On the other hand, although EV owners were encouraged by their participation in something innovative, they were not willing to change their daily driving habits for the maximum utilization of V2G. A different reaction was observed in the non-EV owner category (Figure 16c), where the largest percentage of the participants were undecided. Nevertheless, legislation and environmental impacts were of the utmost importance, followed by the lack of confidence and the maximizing of profits.

Figure 16. Participants' agreement on specific statements regarding V2G: (**a**) general population (question: how much do you agree with the following); (**b**) EV owners' responses (question: how much do you agree with the following); and (**c**) non-EV owners' response (question: how much do you agree with the following).

4. Limitations of the Research

At this point it should be stressed out that the authors realize that the current research is subject to certain limitations. In particular, although the questions were repeatedly checked to ensure that the wording was not confusing to the participants so that the answers were as valid as possible, no software was used to verify reliable completion of the survey questionnaire by respondents. This survey is the first attempt to record Greek drivers' perspectives regarding the upcoming V2G technology and represent a primarily qualitative analysis in order to identify and correct, in future work, any potential weaknesses and to continue this effort with a comprehensive statistical analysis. Additionally, a more focused questionnaire can be developed which will be distributed to a larger sample, perhaps in cooperation with Greek (vehicle) dealers in order to obtain even more accurate results. Nevertheless, the authors strongly believe that the present analysis adds value to the existing literature and its results can be utilized by all stakeholders.

5. Conclusions

This study was based on a comprehensive literature review and online interviews concerning the acceptance of V2G technology by Greek drivers. Participants were divided into two categories, EV owners and non-EV owners, in order to obtain a broader view of the

results. To the best of the authors' knowledge, the present study is arguably the first that sheds light on the behavior of Greek drivers towards V2G technology and electromobility in general, putting forward a pilot survey based on a closed-type questionnaire.

The engagement of Greek drivers towards electromobility was examined through the willingness to purchase an EV, with results showing that both categories, and especially EV owners, highly appreciate the positive environmental impact and low operating and maintenance costs of EVs. Regarding V2G, the increased environmental awareness of EV owners is again obvious, although this does not represent the most important component for the engagement of Greek drivers with this technology.

Despite recognizing the positive environmental impact of V2G, EV owners are primarily driven by the potential economic incentives they might have from engaging with V2G technology. In a decreasing order of importance, the incentives include either a discount for the purchase of the car/charger, or any profit that could be made to cover the vehicle's battery degradation, which represents the second biggest concern after the until now immature market for EVs and the chargers that support V2G, or the reduction in the cost of charging EVs compared to traditional charging methods.

A similar picture, mutatis mutandis, can be observed for future EV owners, with the economic factor outweighing the environmental one. An equally important incentive to the financial incentive, especially for EV owners, is the control they want to have over the battery's discharge procedure, which is related to the lack of trust towards the grid operator regarding the management of their vehicle; this was a valid concern for about 70% of the participants. This is in line with their third most important concern, the limited freedom and control of users over their vehicle.

Something that concerns EV users a great deal is that, after V2G operation, the vehicle's battery might not be sufficiently charged for a trip, even though EVs have average ranges of up to 380 km [48], which indicates the range anxiety experienced even now. This factor is inversely related to the willingness of Greek drivers to participate in V2G. The higher their concern for an insufficiently charged vehicle, the lower their willingness to offer their car for V2G services. It is also observed that concerns on practical issues, such as autonomy, the immature market of EVs and chargers that support V2G, and battery degradation, are related more to EV owners. In addition, although about 70% of EV owners are willing to participate in an innovative technology, such as V2G, they do not seem to be willing to change their daily driving habits, which is in line with a recent survey [49] in which Greece ranked last among 31 countries for EV adopters.

In order to answer the main question of this research, Greek drivers would offer their vehicle for V2G use as long as they had a financial incentive that would cover any future battery degradation, as well as a guarantee that the energy used for charging their car originated from RES. Lack of information around V2G appeared to be a concern for over 50% of the participants, in both categories, to such a degree that is comparable to battery degradation concerns. Therefore, and as a first step, the planning of an information campaign is suggested, highlighting the positive environmental and economic impacts of the use of EVs and V2G on the one hand, and explaining the operation of the technology on the other, in order to eliminate the aforementioned concerns of Greek drivers and to enhance their confidence in the management of their vehicle by a third party (i.e., the grid operator). Moreover, the State, with its respective bodies, should invest in the education of the public, especially between the ages 35 and 60, as the given group presented great interest in the future purchase of EVs. Greek drivers seem to be skeptical about V2G technology, as well as electromobility, mainly due to the increased upfront cost of an EV but also, as shown in the results, due to the immature V2G market, which, according to Ref. [50], represent some of the challenges that need to be tackled for the V2G transition.

This study sheds light on the unique perspective of drivers towards V2G technology, offering valuable insights for policymakers and industry stakeholders throughout Europe. The findings highlight the importance of economic incentives, particularly those that mitigate battery degradation concerns, in driving V2G adoption. Additionally, addressing

the knowledge gap surrounding V2G operation and environmental benefits through targeted information campaigns is crucial. Investing in public education, especially for the 35–60 age group with high EV purchase interest, can further accelerate market penetration.

Furthermore, this research emphasizes the need for a pan-European approach to V2G development. Therefore, to foster V2G adoption and realize its full potential, policymakers and industry stakeholders should:

- Implement comprehensive financial incentives that not only address battery degradation but also incentivize V2G participation;
- Prioritize the development of a robust infrastructure for V2G charging stations and grid integration;
- Strongly encourage the inclusion of V2G capabilities in new EVs;
- Develop and implement clear regulations governing V2G operations, including data privacy and security standards;
- Foster collaboration and knowledge sharing among European countries to accelerate V2G development and adoption.

By taking these actions, policymakers can create an enabling environment for V2G technology, contributing to a more sustainable and resilient energy system. This will not only benefit Greece but also accelerate the continent's transition towards a more sustainable and integrated energy future.

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