

Electromobility research: the impact of using renewable energy solutions on the development of electromobility

Abstract: *The paper presents the results of research in which the main question was what is the consumer relationship between the owners of an alternative energy source and their decision to invest in new solutions in this field - electromobility. Responses were received regarding relations, social awareness, investment opportunities as well as willingness to develop and forecast demand for electric vehicles, as well as conclusions were drawn that with a photovoltaic installation and energy storage, charging the car will become free and access to own energy will be unlimited in time, which will reduce the amount of investment in an electric vehicle*

Streszczenie: *W pracy przedstawione zostały wyniki badań w których głównym pytaniem było to jaki jest związek konsumencki między posiadaczami alternatywnego źródła energii a ich decyzją o chęci inwestycji w kolejne rozwiązania z tej dziedziny – elektromobilność. Otrzymano odpowiedzi odnośnie relacji, świadomości społecznej, możliwościach inwestycyjnych oraz chęci rozwoju i prognozowanemu popytowi na pojazdy elektryczne, jak również m.in. wysnuto wnioski, że przy posiadaniu instalacji fotowoltaicznej i magazynu energii, ładowanie auta stanie się darmowe, a dostęp do własnej energii nieograniczony czasowo co wpłynie na zmniejszenie wysokości inwestycji w pojazd elektryczny (**Badanie elektromobilności: wpływ posiadania rozwiązań z dziedziny odnawialnych źródeł energii na rozwój elektromobilności**).*

Keywords: electric vehicle, photovoltaic, electromobility, development of electromobility,

Słowa kluczowe: samochód elektryczny, fotowoltaika, elektromobilność, rozwój elektromobilności,

Introduction

They refer to the Directive 2014/94/EU of the European Parliament and of the Council on the development of alternative fuels infrastructure, which imposes an obligation on Member States (including Poland) to implement it and sets the "framework for measures regarding the development of alternative fuel infrastructure", including electromobility in the European Union (EU) [1,2] that electromobility is one of the fundamental assumptions for the development of the Polish economy. Depending on the perspective and adopted point of view, electromobility is perceived as an opportunity to create a new reality of the road transport market, and thus increase the share of renewable energy sources in the country's energy mix.

We can perceive electromobility and thus electric cars (EV) as an incredible opportunity to reduce transport costs, reduce CO₂ emissions and other harmful gases into the atmosphere, prevent smog but, above all, create demand for a new product. Therefore, in recent years, interest in electromobility has been growing dynamically all over the world [3, 4, 5].

Nevertheless, the aforementioned Directive of the EU Parliament refers not only to electromobility but to all alternative fuels. Photovoltaics (PV), because we are talking about it, is slowly and permanently inscribed in the image of Polish roofs, mainly as a prosumer¹ installation. More and more private people are investing in this type of energy source and using the "own" power supply with the possibility of storing it in the power grid. According to the source, as of September 1, 2020, the installed photovoltaic capacity in the National Power System was 2,528.371 MW and is 267.024 MW higher than a month earlier. This means an increase of 168.7% year on year. However, throughout August 2020, the increase in the capacity of photovoltaic installations amounted to 11.08% compared to July 2020. Although the above data includes all PV installations reported to distribution companies, connected to both medium and low voltage networks, it can be seen how much demand this alternative energy source has [6,7]. Solutions in the field of photovoltaics are not only supplying single-family houses, but also energy produced for the

needs of enterprises and for public purposes (parking meters, information boards). One of the most popular applications combining PV and EV are carports, used to charge electric vehicles with energy produced from photovoltaic panels usually located on the roofs of parking lots [8].

There are many common areas for both of these technologies, in addition to the carports mentioned, it is mainly about the implementation of the charging process. As the market shows, the ten largest networks in Poland by the end of December 2020 will enable the simultaneous charging of nearly 2.8 thousand. electric cars at over 1,000 charging stations throughout the country [9]. These figures thus show that electric cars are slowly but steadily increasing their share in transport. Of course, there are barriers that inhibit EV expansion, but thanks to modern technologies they also facilitate development for the market. We are talking mainly about the lack of charging infrastructure, prices of electric cars, battery life and cooperation with the power grid. Photovoltaics quite strongly begins to correspond with electromobility - the implementation of the charging process seems to be the first thought where both technologies can look for a mutual correlation. By carrying out the charging process with energy produced from the installation, we lower the process price and we are able to use the surplus energy produced during the day. But can the possession of an installation contribute to the development of electromobility? The study focused on the aspect of decision-making and by answering the questions asked, an attempt was made to discover the mutual correlations and dependencies between the solutions.

Research goal

The paper presents research results in which the main question was what is the consumer relationship between owners of an alternative energy source and their decision to invest in further solutions in this field - electromobility. Testing about 450 independent respondents from three groups, we received answers regarding relationships, public awareness, investment opportunities as well as the desire to develop and projected demand for electric vehicles. All results and answers were properly analyzed and presented in the further part of the work.

¹ a private person who simultaneously produces electricity and uses for their own needs (here in a photovoltaic installation)

The willingness to conduct the research was dictated not so much by the "boom" of solutions from the photovoltaic industry, but by the development of the electromobility sector, directions, government guidelines in this area as well as the increasing number of electric vehicles on Polish roads every year. Currently, according to the Central Vehicle Register data, at the end of 2019 the number of electric cars traveling on Polish roads exceeded 10 000 pieces. The total number of passenger cars and vans with electric drive, plug-in hybrids and one hydrogen powered model is 10 232 pieces (data for Poland) [10]. From a total of 10 232 vehicles, as many as 4322 units were registered last year, which represents 42.2% share in this market segment. 2 775 pieces are new cars, straight from dealerships. Sales growth compared to 2018 was 95.5% [10].

As the numbers show, this type of transport is slowly becoming more popular, it is very young, it is still developing, which is why the percentage increase in the number of electric cars in Poland is so dynamic. But objectively it still concerns a small number of copies [11]. The electromobility revolution is only the future with us. What affects the sale of electric cars? Is this at some degree dictated by previous experience in the field of renewable energy sources? What is the person making the decision to buy an electric car guided by? How big is the awareness of ecology and energy?

An important highlight is also the fact that the increasing amount of EV is also a growing demand for electricity [12]. Under government assumptions and market speculation, the energy needed to use electric vehicle (EV) is over 800GWh forecast for 2025 [3]. Thus, the cooperation of individual solar installations producing energy to power car batteries seems to be inevitable. Of course, there can be many ways to meet such energy demand, the already known and repeatedly described solution treating an electric car as an energy storage (Vehicle to Grid (V2G), Vehicle to Home (V2H)) [13] seems to fit perfectly into this type of concept. It uses the car as a mobile energy storage, which gives the unused energy to current needs at a time when the more expensive price of energy from the grid applies.

Assumptions, research process and results

As mentioned above, the main goal of the research was to learn about the decision mechanism referring to previous experience in the field of alternative fuels. It was assumed that due to the dynamic increase in the number of solar prosumers installations it will be a good mapping of the market. The survey was carried out on three groups of respondents: prosumer - having a functioning solar installation, interested - people who do not have an installation but interested in investing in this type of energy source in the future, and uninterested - people who do not have a PV installation and have no plans to invest in the installation. In total, 459 database records were examined, where the percentage distribution of each of the three groups is presented in Fig. 1. People to conduct the survey were selected randomly from each of the three groups described. No selection of respondents was taken into account, for example in terms of the installed photovoltaic capacity. The process of collecting responses took place over the phone, all the information provided was tabulated and later mathematically processed.

There were 8 total questions asked to the respondents. Nevertheless, some of them were resultant (in the form of a tree) and only the expected answer resulted in the next question being asked. The respondents were required to provide a very precise and short answer - some of the questions were closed questions. Strength of interest or

willingness, respondents were asked to rate on a scale (from 1 to 10) with an explanation of the extreme values. The first and main question that was asked was: "If an electric car costed like a car of the same class and a sufficient number of chargers were available in Poland at a normal price for charging, would you prefer buying an electric or petrol?"

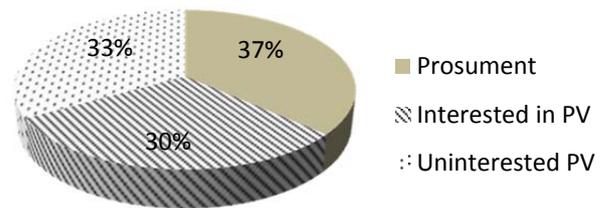


Fig. 1. Division of respondents

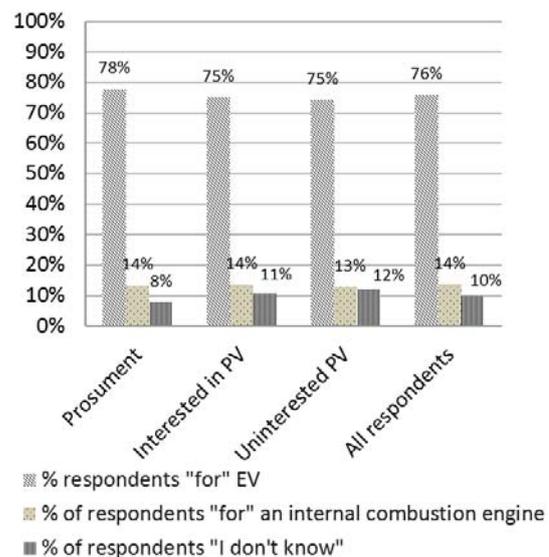


Fig. 2. Picture of willingness to buy an electric car, broken down into the statuses of the respondents

The collected and compiled data show that the percentage of people interested in an electric and internal combustion car is similar for all statuses. However, it is optimistic that, assuming the equalization of costs and charging possibilities, the absolute majority of respondents were in favor of buying an electric car. This may be related to the desire to learn technology, the possibility of using "own" produced energy for the charging process (for the "Prosumer" group), and the desire to raise social status by having a luxury good that EV is considered to be, thus adversities in buying an electric car should be sought elsewhere. Of course, the first unfavorable aspect is the cost - probably for many years it will be the main criterion for the purchase decision, prices of electric cars are high, there is no secondary market, lack of adequate charging facilities, small EV range, high cost of possible battery replacement. It can be assumed that these arguments will scroll most often when it comes to justifying the decision to buy a car with an internal combustion engine. Nevertheless, the equalization of values in all the aforementioned groups also proves that, regardless of previous experience with renewable energy sources, the desire to have an electric car in the near future will certainly have a very strong impact contributing to the development of electromobility. The "Prosumer" group compared to the "interested" / "uninterested" by 3 percentage points above was in favor of an electric car, which may be a sign of greater awareness

when it comes to renewable energy sources, and of previously collected positive experiences regarding the operation of a solar installation (for "Prosument" group). Nevertheless, the difference is so small that it is difficult to draw the conclusion that having a renewable energy source defines the desire to have an electric car. It can be said that this can be an incentive but not a leading factor.

Another question that appeared in the survey was related to clarifying the power of interest in an electric and combustion car. The analysis of the data showed that customers in the "Uninterested" status preferring an internal combustion car are more strongly confirmed in their beliefs. Customers from the "Interested" group opting for a petrol car are less confident in their belief, which may be due to insufficient knowledge in the subject. The biggest discrepancy in determining the strength of preferences appeared in the case of the status of "Interested", in other words, the most expressive in the responses were respondents in the status "Interested".

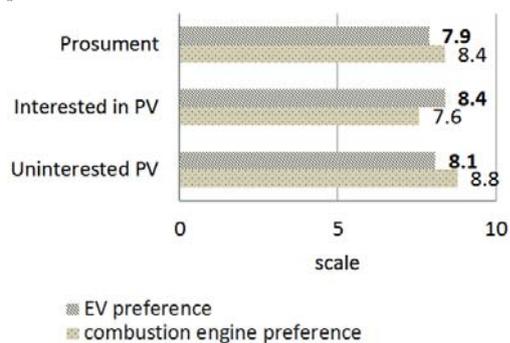


Fig.3. Level of interest in the type of car. Average rating on a scale of 1-10.

Still remaining on the subject of questions about electric car, respondents were asked about preferences regarding the method of charging, the question was "Would you prefer to charge slower and cheaper, or faster and more expensive when charging an electric car in a shopping mall. Please rate on a scale of 1-10 where 10 means fast and more expensive (0 means I don't know). " Working out the results, it was easy to come to the conclusion that this was the most problematic question for the respondents. It caused the most consternation and additional questions. Respondents, regardless of the group, most often used the answer "it depends" - which indicates the answer is not obvious only multidimensional. This is evidenced by the fact that the most frequently appearing answer to "5" - representing 27% of those surveyed.

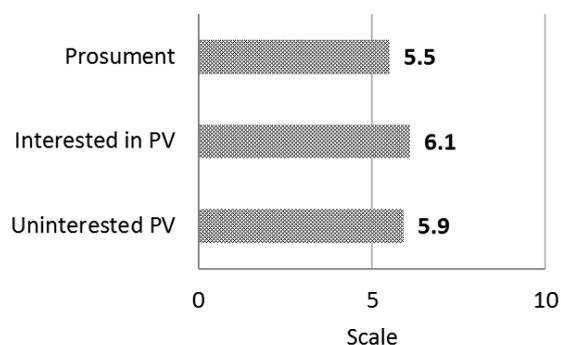


Fig.4. Average rating of EV charging preferences. Where 10 means fast and more expensive, 1 - cheap and slow.

Electromobility is not only electric cars but also the whole process associated with their landing. Currently, the most popular and the most common way to charge an

electric car is self-charging at home. Using night electricity sales tariffs, this is also the cheapest way to recharge your battery. Therefore, another question addressed to the "Prosument" group and the "Interested" group was to learn about the preferences regarding the possibility of having an energy warehouse cooperating with your PV installation or planned PV installation.

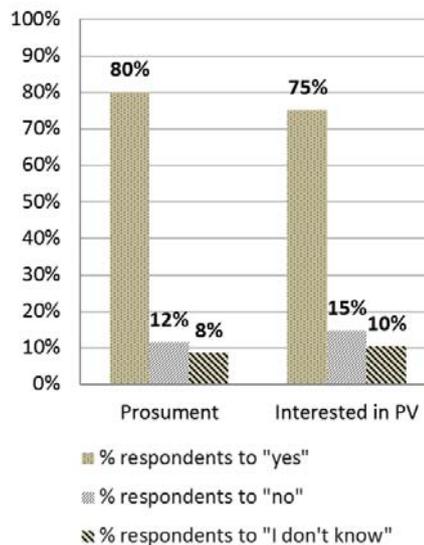


Fig.5. Respondents' interest in energy storage

Although, as can be seen in the chart, the vast majority of respondents were in favor of having an energy store (including additional costs), this question also gave rise to a number of accompanying questions, from queries to battery life, their capacity, efficiency or subsequent disposal. Thus, it can be concluded that this aspect of technology related to electromobility requires a deeper study of knowledge in the field of technology and operation. Determining the power of desire to have - the most frequently appearing answer to the question "how much you are interested / interested in the possibility of storing energy" the most common answer was 10 - constituted about 45% of all answers.

Conclusion

Electromobility, as you can see, has very optimistic forecasts regarding public perception. More and more drivers are convinced of modern solutions in this field. Of course, the bottleneck in the first place is still the price of the car, nevertheless, from year to year it is much lower, and the good of EV is becoming more available to the public. When analyzing the presented results, it is also important that the development of the electromobility sector should have a multi-level character - not only the financial availability of the car, but also the largest possible range of batteries and the possibility of charging are important. While in the largest cities in Poland there is no major problem with this (currently there are about 1,500 publicly available charging points in Poland), in smaller towns and on transit routes it is difficult to look for this type of solutions.

Mapping the situation to the solar market, one can conclude that time is also needed here. Not so much to increase public awareness but to show the possibilities of becoming more independent of external electricity supplies and the cost of liquid fuels. The impact of renewable sources on electromobility is so large that if you own a solar installation and produce your own energy, charging your car will become free, adding energy storage, access to it will become unlimited and personal transport costs will cease to exist. Thus, in this aspect, electromobility corresponds

strongly to renewable energy solutions. Prosumers will be the first to experience a positive drop in the cost of moving, because due to their own electricity produced in the photovoltaic installation and used to charge the electric car, they will even forget about the costs of refueling with traditional fuel known to them so far.

As the charts show, it is difficult to clearly show that having a renewable source determines the decision-making nature of an investment in an electric car. The reason for this may be the fact that regardless of the solar plant you own or not, there is a great desire to have the latest technologies, including those related to the automotive industry. Nevertheless, in each of the questions asked, the advantage for having EV were those surveyed who had or were interested in investing in PV. These results give an optimistic vision of the future that society is inclined to a multi-dimensional approach to ecological solutions. The fact of energy demand for the growing market of electric cars and their cooperation with the power grid, emphasized earlier, is also important [14]. More EV means greater energy demand, which can easily be met by solar farms - photovoltaic installations. Generally speaking, depending on the point of view, electromobility is perceived as an opportunity for: creating demand for a new product, reducing transport costs, reducing air pollution or increasing the share of renewable energy in the total pool of energy produced.

Therefore, it will be true that electromobility is a multi-stakeholder issue: EU, central, regional and local - it requires the cooperation of many diverse entities, i.e. public entities (central and local government), private entities (technical sector), as well as business entities and science [1]. Nevertheless, the market's response to the desire to develop in this direction is unequivocal and only time will show how quickly electromobility will replace traditional previously known solutions.

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