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Abstract

Alternative fuel vehicles (AFVs) are an important element of sustainable development and electromobility. Within our complex, two stages survey (CATI and CAWI) we used the conjoint method to compare and balance the important factors responsible for consumers' preferences towards AFV, in one study, allowing a relative assessment to be made. As a result, we got 6 separate conjoints (depending on the type of purchase: direct purchase or leasing) and the type of vehicle (HEV, PHEV and BEV). Although each conjoint contains different sets of factors, the methodological regime is followed. Our results indicate that surprisingly safety is the most important feature of a good AFV car. Then, the price, range and type of the car also matter. These findings recommend car manufactures and policy makers what they should focus on while designing and promoting AFV.

Keywords: consumer preferences; electric vehicles; plug-in electric vehicles; hybrid electric vehicles; conjoint analysis; on-line survey; sustainable transport

1. Introduction

In recent years, most European governments have clearly stated their aims to promote the production and sale of alternative fuel vehicles (AFVs), which are seen to be an environmentally-friendly means of transport. AFVs have the potential to reduce gasoline consumption as well as resulting greenhouse gas emissions and air pollutants [48]. Successful diffusion of these vehicles will depends on the readiness of the consumer market, which in turn, depend on consumer awareness, attitudes and interests, travel patterns and access to charging infrastructure [14, 36, 38, 45].

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In Poland the presence of AFV is still very limited [37, 68]. According to the Polish Alternative Fuels Association (PSPA) the number of battery electric vehicles (BEV) registered in Poland has doubled between the third quarters of 2019 and 2020 (but BEV's market share is still very low. On the other hand, Polish consumers are mainly interested in hybrid electric vehicles (HEV), so far not included in the subsidizing scheme of the Polish government [15]. As the European Automobile Manufacturers' Association (ACEA) indicates, Poland is nowadays, one of the EU countries with the highest sales rates of HEVs [3].

To understand the reasons of the limited market share of AFV and to propose appropriate and reasonable marketing strategies, consumers' preferences towards AFV must be explored. Although a lot of studies have already investigated consumers' preferences and points of views in different parts of the world, mainly in Canada, in the U.S. and in the U.K. [10, 32, 36, 49], a very few were focused on the Central and East European (CEE) countries, where the market of AFV is much less matured [37, 62, 64]. Because of the relatively lower purchasing power of the CEE inhabitants, less developed system of charging stations and sometimes less attractive incentives programs, the preferences towards AFV may be different.

Within our survey by the means of the two-part empirical survey on the representative sample of Poles we want to investigate and explore consumers' social and technical readiness to adopt AFV, including battery electric (BEV) that run only on electricity, plug-in hybrid (PHEV) that run on both electricity and gasoline and standard hybrid electric vehicles (HEV). In particular we want to find out what are the most important factors that might encourage consumers to buy one of AFV in the future.

The originality of this study concerns the complexity and two stages of the survey (CATI and CAWI) leading to the final conclusions. To explore consumers' preferences towards AFV and the key factors responsible for their willingness to buy one of these cars in the future, we use the conjoint method. This method compares and balances factors in one study, allowing a relative assessment to be made. As a result, we get 6 separate conjoints (depending on the type of purchase: direct purchase or leasing) and the type of vehicle (HEV, PHEV and BEV). Although each conjoint contains different sets of factors, the methodological regime is followed. Moreover, the survey is conducted on a large group of respondents, and the choice of factors is based on a broad CATI survey.

The remainder of the paper is as follows. In Section 2 the usage of conjoint analysis in empirical studies in general and in the investigation of AFV preferences in particular has been described. This Section also analyzes the main findings with regard to consumer preferences for AFV. Further, in Section 3 the AFV market in Poland is briefly described. Then, in Section 4 the survey framework, methodology and methods are elaborated. Here also descriptive statistics of the collected data are shown. Next, in Section 5 the results of the conjoint analysis are presented and discussed. The last Section 6 provides some conclusions and policy recommendations. The additional iconography and diagrams of utilities are given in Appendix 6.3.

2. Literature background

2.1. *Conjoint analysis in empirical studies*

The principles of the conjoint analysis were provided by Luce & Turkey [47] and Krantz & Tversky [39]. All variants of the conjoint approaches are theoretically and methodologically based on the utility theory which is used to describe and explain customers' behaviour. According to the utility theory the customer's overall utility of a given product or service depends on the sum of individual utilities of these goods' components. It is also assumed that customers make such decisions that maximize their benefits.

Unlike expectancy-value methods which are compositional in nature, conjoint analysis is decompositional. This means that the knowledge about preferences components is derived from the customers' global judgements about assessed variants having different properties [13, 47]. In compositional approaches, in turn, the overall utility is computed by aggregating evaluations of individual components.

Throughout years conjoint analysis has become more and more popular, mostly to its practical applications concerning day-to-day decisions. It simply helps to answer the extremely important question why customers choose one product or service over the other [25]. The overall conjoint goal is primarily to obtain preferences towards studied variants and then to calculate partial contributions of their attributes. One of the strong advantages of this method is the possibility to calculate relative importances for attributes and the so called part worths for all factor levels.

Within this general framework, a number of conjoint variants can be identified. They mainly differ in types of data collection (e.g. full profile assessment, adaptive approaches), applied models of preferences (e.g., linear, ideal point, discrete), stimulus presentation (e.g., paragraph description, terse descriptions, graphical material), measurement scale of the dependent variable (e.g., rating, ranking, pairwise comparisons), and estimation procedures (e.g., least squares, log-likelihood, Bayesian).

Various types of the conjoint approaches were applied successfully in different areas for examining people's preferences. For example, Grobelny & Michalski [28] showed how various approaches to a human preference analysis including the conjoint technique can facilitate interpretation of the data for the digital signage display design. Their another study concerning human visual perception used binary pairwise comparisons for investigating smartphone package design preferences [29].

A number of conjoint analyses were also performed for environmental evaluations such as ecosystem management, forestry, pollution [6], or waste management [52].

A significant amount of research involving conjoints was devoted to medical and health aspects. For instance, Flood et al. [23] analyzed parent preferences towards influenza vaccine attributes, Gurtner et al. [30] examined hospital's innovativeness reputation whereas Weernink et al. [75] provided an extensive review of conjoint applications in medical decision making.

In the tourism domain, e.g. Kim et al. [35] studied performing arts product preferences of Japanese tourists, Eriksson & Fagerstrom [18] focused on the relative impact of Wi-Fi service on online hotel booking among young consumers, and similar conjoint approach was applied by Yang et al. [77] to investigate hotel reviews' heuristic attributes.

A quantity of papers concerned food, for instance, Lima et al. [42] focused on strawberries packaging, Tekieñ et al. [72] examined consumers preferences towards animal origin food products. Lately, an adaptive version of the conjoint was employed by Sulistyawati et al. [71] to learn about preferences towards quality attributes of dried mango among subjects from China, Indonesia, and the Netherlands, whereas Anabatwi et al. [8] investigated perceived healthiness of food items.

Graphical usability aspects of graphical interfaces were, for instance, investigated by Myung [54] who used the conjoint method for determining Korean typography guidelines in web environment. Michalski [50] analyzed users' preferences towards vertical graphical toolbars, Kim et al. [34] studied graphical symbols for fighter aircraft cockpit displays, while Michalski & Staniów [51] examined the electronic versions of self-administered questionnaires by incorporating AHP-based weights into the conjoint framework.

For extensive reviews in numerous area please refer to [26, 27], [13], [25], [43], or lately [4].

2.2. Implementation of conjoint approach to the analysis of AFV

The report of Graham [24] is one of the first papers devoted to alternative fuel vehicles where the conjoint approach was used. The authors examined such options of the hybrid electric vehicle as performance, energy economy, fuel-cycle emissions, costs, consumer acceptance, and commercialization. Their comprehensive research included two phases. First, they interviewed 70 persons from Los Angeles and Orlando after educating them about plug-in and non-plug-in HEVs. The results were used to determine which attributes/benefits should be included in the second part of the study. In the following computer-administered conjoint they examined such attributes as price, fuel cost savings, environmental benefits, reliability and maintenance costs, government incentives, special additional features and functionalities. The obtained results are based on the responses from more than 400 subjects from Atlanta, Boston, Los Angeles, and Phoenix who had acquired a new car within the last 5 years. It occurred that 65% of participants would potentially choose one of the HEV variants while the vehicle transaction price had the biggest negative impact on respondents' preferences.

Next study was conducted in South Korea [5]. They surveyed 500 residents on how such attributes as fuel type, body type, maintenance cost, engine displacement, fuel efficiency, and fuel price influence their preferences for hypothetical alternative vehicles. The conjoint analysis showed the gasoline and CNG-powered cars were the most attractive for respondents whereas hybrid cars were the least preferred. Vehicles with the ordinary body type were better perceived than multipurpose-types such as RV and SUV. The higher maintenance and fuel costs negatively influenced the preferences while bigger engine displacement had positive impact on them. It is worth noting that authors assumed that all hypothetical cars had the same price.

Japanese consumer preferences towards electric cars in light of a changed governmental subsidy rules were, in turn, investigated by [40]. A choice-based conjoint was carried out via internet survey and showed that lower ranges of battery electric vehicles decidedly decreased preferences. Potential customers perceived passenger capacity as an important factor and would rather not accept fewer seats caused by mounting additional components for electric driving. Respondents also exhibit strong preferences towards hybrid electric cars.

Then, Orbach & Fruchter [57] proposed a model allowing for forecasting sales and evolution of the hybrid/electric car. For this purpose, they collect information on preferences and purchase intention by means of a conjoint approach before the product appears on the market. They directly took an inspiration from the work of Graham (2001) and focused on four hybrid configurations, that is, hybrids where the electric motor is used solely for acceleration assist, hybrids that allow for up to 20 or 60 miles drive on electricity, and fully electric cars with a range of up to 200 miles. Additionally, they extended the number of examined prices, and included another factor, i.e., availability of hybrid equivalents for popular car models. The results show how attributes and, as a consequence market demands, are changing over the years.

Another study that tries to take advantage of individual preferences obtained by the conjoint method for predicting the alternative fuel vehicle adoption rate was conducted by [16]. They analyzed compact and subcompact cars differing in the drive train technology (7 levels) and price compared to gasoline driven cars (4 levels). Based on the results from 242 persons they found that respondents exhibit strong acceptance for hybrid but not for all-electric cars. Subjects' opinions were strongly influenced by prices. The authors also showed in a sensitivity analysis that electric vehicles range has to be larger than 150 km if they are to be chosen.

The conjoint method in the work of [12] was employed to examine customers' preferences in vehicle-to-grid business models. They examined three factors, that is, ownership (4 levels), location to charge (4 levels), and aggregator (6 levels). The study involved 189 Dutch respondents who considered the ownership factor as the most important (45%) one and the aggregator type as the least important (19%). The study revealed higher preferences for private than community ownership of an electric car and a bidirectional charger. The subjects also preferred utility over car companies as aggregators, and they required both home and public charging.

In the study on 645 drivers of combustible fuel vehicles from Greater London (UK) [11] used the conjoint technique for determining characteristics of electric cars that are important while buying such a vehicle. They examined four factors: great driving experience (3 levels), economical (2 levels), reassurance about range anxiety (3 levels), preserves the environment (2 levels). Obtained results indicate that the great driving experience is the most important (38%), next comes the reassurance about range anxiety factor (29%). The preserving the environment aspect was rated the third (20%), whereas the economical issues, somewhat surprisingly, were perceived as the least important (13%).

In Rudolph conjoint [65], to assess how incentives can influence electric cars purchase decisions, the following seven attributes were taken into consideration: the propulsion technology (4 levels), price (4 levels), fuel/charging costs (3 levels), CO_2 tax (4 levels), direct subsidy (5 levels), parking fee (4 levels), and distance to charging point (7 levels). The research was based on 875 subjects and revealed that cyclists and public transport users were considerably more prone to choose electric cars than classic vehicles owners. The results also showed that all examined incentives positively affect the intention of choosing zero emission vehicles, however the scale depends on the degree of possible benefits.

Khan et al. [33] devoted their work to the alternative fuel vehicle type choice behavior. The author assumed an 100% increase in gas prices, and under this supposition they examined the inclination to purchase five different types of vehicles: regular gasoline, diesel, hybrid electric, plug-in hybrid electric, and plug-in all electric. The results divided the respondents into two classes. The

first one included older suburban dwellers with shorter commute distance and low car ownership whereas the second one consisted of younger urban dwellers with longer commute distance and higher car ownership. Given these categories the authors carefully examined propensities of choosing the above mentioned alternative fuel cars.

Muslim et al. [53] employed the conjoint analysis preceded by the questionnaire survey to determine the key characteristics of the dashboard of an electric car being developed in Indonesia. They examined six factors. The highest combination of factors' levels was obtained for layout A, a digital graph with text for speedometer, analogue symbol and text indicators of battery capacity, digital text for the ecometer, and digital symbols with text for ready to drive and driving range indicators.

Lately, Philipsen et al. [59] paid attention to semi-public charging stations, their perception, and possible usage. They analyzed two scenarios: charging an e-car after the work and searching for the charging station during a day off. The results from 147 respondents show that station's distance to the destination and its temporal availability the most important there are in both scenarios, though the temporal availability was of decidedly greater importance for workday situations. Obligation to re-park, cost of charging, surrounding areas, as well as charging strategy had much less impact on the selection process of semi-public charging stations.

Finally, Czakon et al. [14] examined a sample of 160 top-level managers from four German-speaking countries by means of a choice-based conjoint analysis, which focused on coopetition-shaping decisions in a radical innovation project regarding self-driving electric cars. They included four factors, all on 2 levels, that is the number of partners, governance type, market conditions, and knowledge management. The results indicate that managers prefer multiple over dyadic partnerships, tend to share knowledge, are more inclined to formal agreements in coopetition that should preferably take place in an uncertain market environment.

2.3. Consumers' preferences towards AFV

Apart from the usage of conjoint analysis to investigate the consumers' approach and preferences towards AFV, many other methods have been used. Among these methods semi-structured interviews [10], labelled choice experiment [22], discrete choice model [9, 22, 31, 60], mixed logit or nested logit models [31, 60] or latent class models [9, 36, 44] can be mentioned.

Table 1: Comparison of research questions and main findings in the examples of AFV preferences and perceived consumer value analysis

Research questions (RQ), Sample (N), Country (C), Main findings (MF)	References
RQ: The factors and incentives most likely to influence households' choice for cleaner vehicles N: 902; C: Canada; MF: The choice of the car segment depends on the respondent's gender, age and level of education as well as the size and type of household	[60]
RQ: Consumer preferences for AFV N: 711; C: Germany MF: Young, well-educated people, environmentally aware, undertaking numerous urban trips with the possibility to plug-in their car at home are most interested in AFV adoption	[31]
RQ: Segmentation of UK to electric vehicle consumers N: 2729; C: UK MF: Providing information about PHEV increase limited knowledge and influence the preferences of consumers, significantly improving their attitude towards PHEV	[7]
RQ: Market segmentation of PHEV potential users based on their lifestyle and preferences N: 1754; C: Canada MF: The main sources of AFV knowledge are education, social campaigns, advertisement, test drives, and social influence	[9]
RQ: Mainstream consumer perceptions and misperceptions of electric-drive vehicles and charging programs in Canada N: 22; C: Canada MF: Great importance in supplementing knowledge gaps and negative perceptions related to PHEVs have industry and government by providing information and marketing campaigns	[10]
RQ: Willingness-to-pay and metropolitan characterization of Canadian households N: 20520; C: Germany MF: The number of alternative cars will change with improvement of batteries, their electric range and with increase of knowledge about these cars	[22]
RQ: The main barriers to widespread adoption of EVs in Shenzhen N: 500; C: China MF: The key factors influencing the development of the BEV market are full-charge range, price, operational costs and public policy	[74]
RQ: Respondents preferences and motivations affecting the latent demand for zero-emissions vehicles N: 2123; C: Canada MF: Interest in AFV grows with purchase incentives and widespread charging stations deployment among younger, more highly educated and environmentally conscious respondents	[36]
RQ: How consumers respond to new technology vehicles and new fueling behaviors N: 5654; C: USA MF: There is a correlation between knowledge about BEV and positive attitudes towards this new technology	[41]

Table 1 summarizes the most common research questions and provide the main findings regarding consumers' preferences towards AFV. A lot of current research is focused on factors and incentives that influence demand for AFV [60], leading to openness to electric mobility [22], as

well as on the analysis of barriers to widespread adoption [74].

The surveys reveal that price and financial incentives still are the most vital factors influencing the demand [31, 36, 60, 74]. Consumers expect proper public policies, such as tax exemptions and/or reductions, free parking, bus lane access and others [31, 60]. Charging infrastructure, and the public access to the charging stations as well as driving full charge range are the next most often mentioned issues that matter [31, 60, 74]. Finally emission reduction seems to be important for the consumers [60]. Limited awareness of AFV types, differences between them, the way they are charged etc. seems to be also a vital barrier of their market penetration [10, 32, 38, 44, 68, 74].

The current findings indicate that young, well-educated, environmentally aware consumers with a possibility to plug-in their cars at home are mostly interested in the purchase of AFV [21, 31, 36].

3. AFV market in Poland

There are over 23.4 million passenger cars registered in Poland, which accounts for 8.7% of all cars registered in the EU [19, 20]. A characteristic feature of the Polish passenger car market is a large share of LPG-powered cars and a negligible percentage of AFV. The full division of cars according to the fuel used is presented in Figure 1.

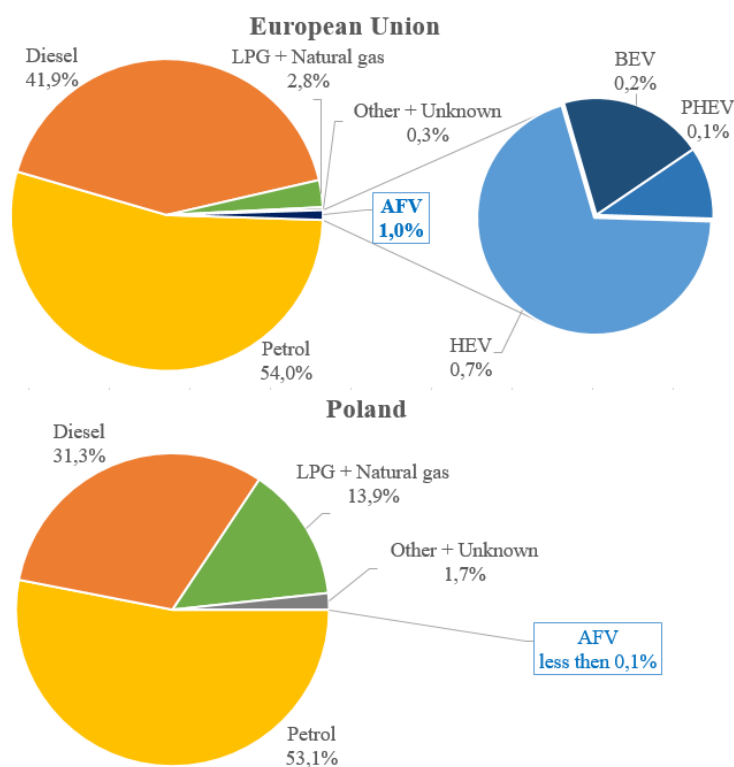


Figure 1: Passenger cars market by fuel type [1–3]

However, it should be emphasized that the AFV market in Poland in 2020 is developing dynamically, despite a significant slowdown in the entire automotive sector related to the COVID-19

pandemic. In 2020 there were about 158,000 HEVs on Polish roads (acc. to [66]).

Additionally, according to data from the end of 2020, 8,834 PHEV and 10,041 BEV were registered in Poland. In the 2020, 9,879 PHEV and BEV vehicles were added - 140% more than in the corresponding period of 2019 [61]. PHEV enjoys a great increase in popularity, which proves that customers are willing to buy cars that can have the advantages of an electric car in the city - environmentally friendly - but at the same time provide full comfort of traveling on long distances. Detailed data on the development of the AFV market are presented in Table 2.

Table 2: Number of newly registered AFVs [61, 66]

Vehicle type	Sales vol. 01-06.2020	Sales vol. 01-06.2019	Notes
HEV	25 041	19 853	Sales increase by + 26%
PHEV	1 609	704	Sales increase by + 228%
BEV	1 666	1 286	Sales increase by + 29%
Whole market	200 981	320 232	Sales drop by -37%

One of the reasons for the growing interest in AFVs were certainly the government's announcement of significant funding for the purchase of BEVs. Initially, a subsidy of 30% (EUR 9,375) was assumed for the purchase of BEV, the price of which does not exceed EUR 31,250. At the time of the announcement of this proposal, it was one of the highest funding in Europe. However, in the final version of the regulation, three e-mobility support programs were created in Poland, and the funding for the purchase of BEV was reduced by half. A comparison of the assumptions and implemented regulations for supporting the development of AFV in Poland is shown in Figure 2. Additionally, detailed changes to the AFV market legislation are described in [37].

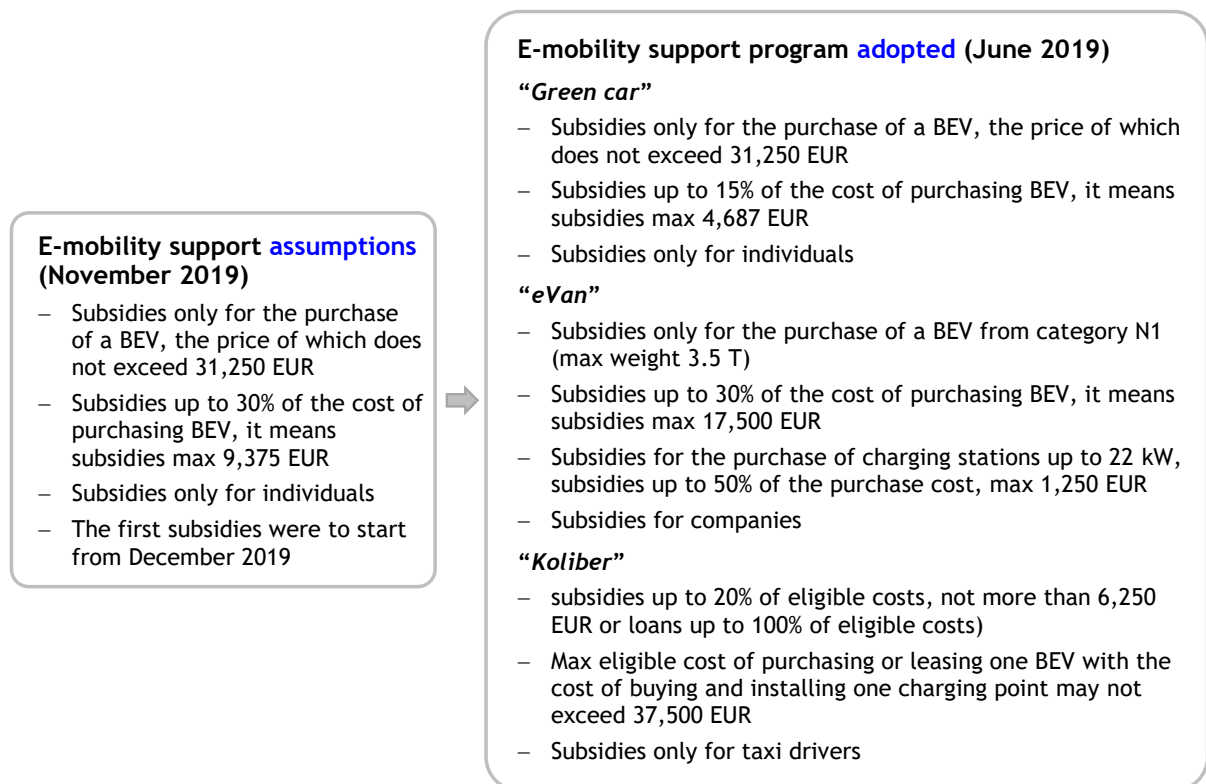


Figure 2: Changes in the conditions of AFV funding in Poland

Unfortunately, the implemented programs have a disturbingly weak effect. For example, for the "Green Car" program, the price limit of EUR 31,250 is set so that mainly buyers of city cars will benefit from the funding. There are currently only eight fixed-price models available on the Polish market. A detailed list of models is presented in Table 3.

Table 3: Model offers of vehicles eligible for the "Green Car" program [55, 56, 58, 63, 67, 69, 70, 73]

Vehicle model	List price(EUR)	Price after subsidies(EUR)	Co-financing value
Smart EQ fortwo	24 225	20 591	3 634
Volkswagen e-up!	24 498	24 498	3 675
Smart EQ forfour	24 600	20 910	3 690
Smart EQ fortwo cabrio	27 675	23 524	4 151
Nissan LEAF	29 500	25 075	4 425
Opel Corsa-e	31 123	26 454	4 668
Peugeot e-208	31 225	26 541	4 684
Renault ZOE	31 225	26 541	4 684

It should be noted that the availability of the models described in Table 3 is significantly limited. The situation is similar for other e-mobility support programs in Poland. As the number of electric vehicles increases, the charging infrastructure is also developing. The average growth rate

of the charging point network in 2020 is 2% on a month-to-month basis. At the end of the first half of 2020, there were 1,194 publicly accessible charging stations for electric vehicles (2,258 points) in Poland. 33% of them were fast DC charging stations and 67% were slow AC chargers with a power less than or equal to 22 kW. In June, 21 new, generally accessible charging stations (50 points) were launched [61].

To summarize, the AFV market in Poland is still in the very early stage. Many of the consumers have limited knowledge in terms of fueling of AFV or the brand names. AFVs are still too expensive to most of the average citizens. Also the limited system of the charging stations raise doubts among potential customers.

4. Survey

4.1. Survey design

The survey was built of two empirical parts, whereas the first (T0) aimed to explore consumers' knowledge, awareness about AFV, and willingness to buy AFV on the Polish automotive market, and the second (T1) by means of the conjoint analysis investigated consumers' preferences towards AFV. T0 part of the study was run by means of a telephone survey (CATI method), whereas T1 was conducted online (CAWI method). Between T0 and T1 a two months time lag was assumed. During this time lag respondents received a short instruction showing the basic differences between AFV types of vehicles available in market in Poland (BEV, HEV and PHEV), see Appendix 6.3, Figure 11. The respondents were compensated for the participation in the whole study with a 100 PLN (c.a. 25 Euro) voucher to be used when purchasing on the *eventim.pl* platform, (e.g., for a ticket for a selected artistic or sporting event). To make the research fully transparent (especially the rules for awarding prizes for participating in the project), the website www.autaprzyszlosci.pl was previously designed.

4.2. Data collection and the sample

The data was collected between January and April 2020. The selection of respondents for the study was nationwide and purposeful. The sampling frame was based on the database consisted of registered people declaring the purchase of a car in the near future (or declaring the purchase of a car in the last 6 months). Based on the data provided by database company, a sampling frame containing 26,568 records was built. Assuming the following assumptions: the level of confidence ($\alpha = 0.95$; giving us confidence in the results at the level of 95%), the size of the 0.5 fraction and the sample size at the level of $N=1002$ in T0 and $N=500$ in T1, allows to consider the study as a representative. At a given confidence level and fraction size, the maximum error for the entire sample was less than 3%. The data collection was conducted by a professional polling agency selected in a public tender.

4.3. Step first: classic questionnaire – T0

4.3.1. Sample characteristics

In this paper we focus on the respondents who have completed both stages of the survey T0 and T1, that is $N=500$ respondents. Among these respondents 408 represented households and 92 represented enterprises. In both cases these were people who bought a car in the last 6 months or

intend to buy it in the next 12 months. Table 4 compares the basic statistical frequencies for the whole sample N=1002 (T0) with the N=500 (T1).

Table 4: Sociodemographic variables for N=1002 (T0) and N=500 (T1)

Variable	Frequencies for N=1002 (T0)	Frequencies for N=500 (T1)
Gender	Female 40% Male 60%	Female 42.4% Male 57.6%
Age	M = 36.26, SD = 11.15	M = 35.59, SD = 10.51
Education	Primary school 1.0% Basic vocational 4.6% Secondary vocational 21.2% Secondary education 14.5% Higher education 56.7%	Primary school 0.8% Basic vocational 2.4% Secondary vocational 14.2% Secondary education 17.4% Higher education 65.1%
Material situation	Very bad or rather bad 2.0% Moderate 33.8% Rather good or very good 63.4%	Very bad or rather bad 1.4% Moderate 35.2% Rather good or very good 63.3%
Place of a living	Village 32.4% City up to 30,000 inh. 18.6% City 30,000 to 100,000 inh. 15.6% City 100,000 to 500,000 inh. 10.9% City more than 500,000 inh. 21.8%	Village 30.7% City up to 30,000 inh. 17.8% City 30,000 to 100,000 inh. 12.4% City 100,000 to 500,000 inh. 12.4% City more than 500,000 inh. 26.7%
Household size	M = 3.36, SD = 1.54	M = 3.34, SD = 1.47
Driving licence	M = 2.15, SD = 0.97	M = 2.15, SD = 0.93
Running business	M = 0.197, SD = 0.4	M = 1.82, SD = 0.39
Number of employees	M = 3.9, SD = 12.74	M = 2.03, SD = 4.13
How long the company exists	M = 8.8, SD = 7.13	M = 7.58, SD = 7.23

The sample N=500 consisted mostly from the households who were represented mainly by men. The vast majority was aged 19 to 40 (71.7%). At the same time over 70% of the owners of the surveyed companies were men as well (81.7%) aged 24 to 50 (87.7%).

The vast majority of people, both representing households and firms have finished either technical and general secondary school or had higher education completed. More than half of the respondents declared that they had technical education.

The majority of firms represented microenterprises with at least one employee (52 companies), whereas the rest of the companies represented sole proprietorship with no employees (36% - 33 firms), and the segment of small companies with up to 50 employees (7.6% - 7 companies).

4.3.2. Current usage of a car

At the moment of running the survey only 0.7% of the respondents did not possess a car. The majority had at least one (45%), two (35.5%) or even three cars (11.3%). In case of companies over 61% of them use only one car for business purposes. Two cars were used by almost every fifth surveyed organization (22.7%), and only 2 companies did not have any car.

4.3.3. Purchase of the future car

Unfortunately, only 10.9% of people running a business and 15.6% of households considered buying an alternative fuel vehicle (Table 5). The amount that respondents were willing to spend on buying a car (Table 6) or leasing it (Table 7) is higher for respondents running a business.

Table 5: With what engine the respondents plan to buy a car, depending on whether they run a business or not (N=500)

Engine type	Running business	
	Yes (N=92)	No (N=408)
Internal combustion engine	89.1% (82)	83.6% (341)
PHEV engine	1.1% (1)	3.9% (16)
HEV engine	8.7% (8)	8.3% (34)
BEV engine	1.1% (1)	3.2% (13)

Table 6: The amount that the respondents plan to spend on a car purchase depending on whether they run a business or not (N=338)

Purchase amount	Running business	
	Yes (N=41)	No (N=297)
1000 - 10 000 PLN	4.9% (2)	15.8% (47)
11 000 - 20 000 PLN	19.5% (8)	21.9% (65)
21 000 - 30 000 PLN	12.2% (5)	14.5% (43)
31 000 - 40 000 PLN	9.8% (4)	11.8% (35)
41 000 - 50 000 PLN	17.1% (7)	9.8% (29)
51 000 - 80 000 PLN	17.1% (7)	17.5% (52)
More than 80 000 PLN	19.5% (8)	8.8% (26)

Table 7: The amount that the respondents plan to spend on leasing a car depending on whether they run a business or not (N=108)

Leasing amount	Running business	
	Yes (N=43)	No (N=65)
300 - 1000 PLN	32.6% (14)	46.2% (30)
1100 - 2000 PLN	58.1% (25)	40.0% (26)
2100 - 3000 PLN	7.0% (3)	13.8% (9)
More than 3000 PLN	2.3% (1)	0% (0)

53.7% of business owners and 36.1% of households were ready to spend over 40,000 PLN ¹ for a car. At the same time only 20% of those who run business and only 8.8% of households intended to allocate more than 80,000 PLN. Only 65 individuals (17.9%) considered leasing as a form of financing the purchase of a car, and the leasing amount for most of them (86.2%) should not exceed 2,000 PLN. More than half of those who run a business (51.2%) declared that they want to buy a car using leasing, and for the overwhelming majority (90.7%) the lease amounts should not be higher than 2,000 PLN. The respondents' willingness to pay was certainly not high enough to cover the cost of even the cheapest alternative fuel vehicle, especially the battery electric one.

4.3.4. Hypothetical purchase of the AFV

Among 500 respondents who have completed the whole survey (T0 and T1) 447 people declared the choice of a hypothetical car with a non-combustion engine (Table 8). The vast majority of them declared that they would purchase a car for cash (74.4%) and only less than 20% would decide to lease such a car (17.7%). At the same time, almost 50% of respondents declared that they would decide to buy HEV, 19.2% BEV and 32.9% PHEV.

Table 8: Breakdown of respondents according to the choice of engine type and the form of purchase of a hypothetical car (N=447)

	Purchase	Leasing	Long-term rent
Hybrid car	159 (35.6%)	41 (9.2%)	19 (4.0%)
Plug-in hybrid car	108 (24.2%)	26 (5.8%)	9 (2.0%)
Electric car	67 (15.0%)	12 (2.7%)	7 (1.6%)

4.3.5. Preferences towards AFV

A part of the questionnaire was purposely designed to identify potential factors and their possible levels that constituted the basis for designing the follow-up conjoint experiment. They involved the following aspects:

- key factors by choosing one of AFV (such as price, brand name, range, access of service or charging stations, car segment, safety, type of fuel and others);

¹ 1 PLN = 0.22 Euro, acc. to the exchange rate from October, 30, 2020

- motivations for choosing BEV (such as usage of bus lanes, free parking, tax relieves, development of charging stations and others);
- benefits of using BEV (such as low noise level, social prestige, zero-emissions).

These questions were assessed on the 5-point Likert scale, where 1 meant "it would not matter to me", and 5 meant "it would be of great importance to me", 3 - "hard to say/ I don't know". The obtained results for the whole sample N=1002 were characterised in Tables 9, 10 and 11.

Table 9: Variables describing most important factors inducing respondents to purchase AFV (N=1002)

Variable	Mean	Std. dev.	Skewness	Kurtosis	Median	Quartile 25%	Quartile 75%
Price	4.37	0.94	-1.581	2.245	5.00	4.00	5.00
Brand	3.51	1.22	-0.523	-0.523	4.00	3.00	4.25
Range	4.47	0.89	-1.982	3.970	5.00	4.00	5.00
Access to service	4.29	0.96	-1.470	1.892	5.00	4.00	5.00
Access to charging	4.59	0.85	-2.394	5.688	5.00	5.00	5.00
Car segment	3.94	1.12	-0.931	0.188	4.00	3.00	5.00
Functional values	4.02	1.06	-1.009	0.436	4.00	3.00	5.00
Safety	4.64	0.73	-2.499	7.168	5.00	4.00	5.00
Type of fuel	3.86	1.14	-0.901	0.200	4.00	3.00	5.00
Reuse of batteries	3.66	1.36	-0.660	-0.777	4.00	3.00	5.00
Impact of weather on batteries	4.08	1.12	-1.160	0.602	4.00	3.00	5.00

The first set of questions concerned the determination of importance for the 11 factors which could possibly be of significant in selecting AFV. The obtained results presented in Figure 3, indicate the accuracy of the selected factors as all of them were considered by the respondents as very important or important.

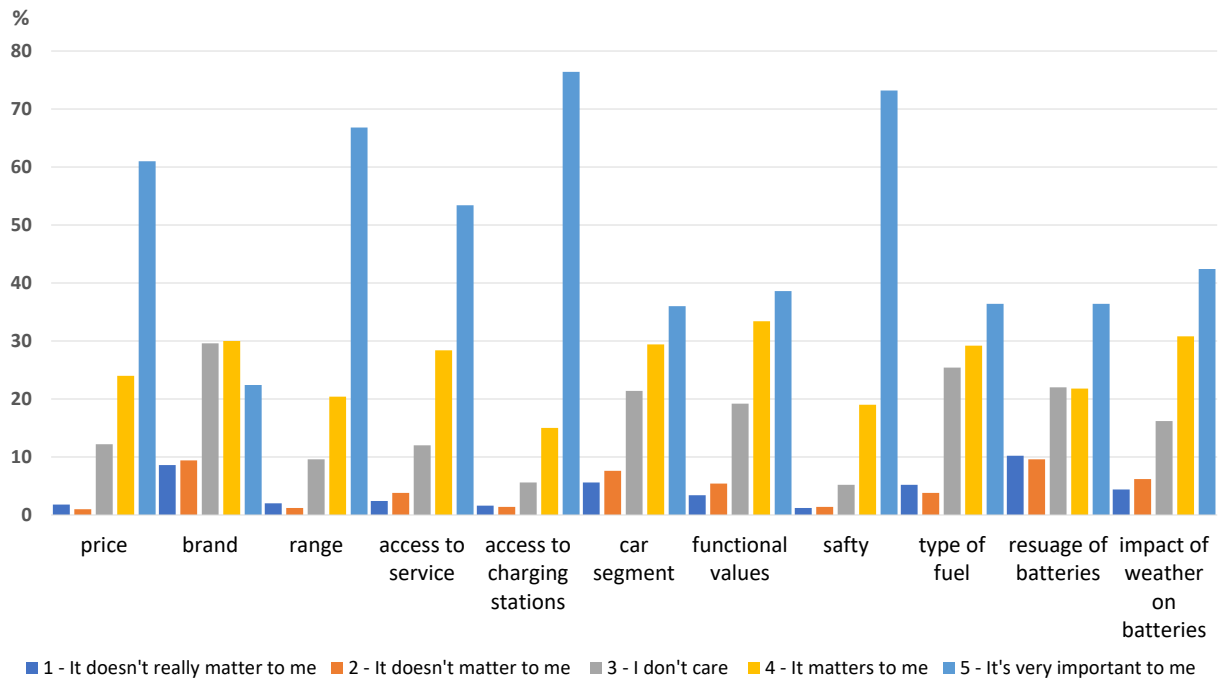


Figure 3: Assessment of importance of the key factors that may affect the choice of AFV (N = 1002)

Three factors have occurred to have a priority for the respondents, namely: the expansion of the charging stations, the safety of driving a car, and the range of the battery. Next, price and access to the service were also important for the respondents. The management of used batteries has been noticed as a big problem for a little bit more than half of the respondents. Surprisingly the car brand has turned out to be the least important factor. It was very important only for 25%, for 27.9% it was important, and at the same time most of the respondents did not have an opinion on this subject (29.3%).

Then, the respondents who indicated in Figure 3 that the car brand is important to them (answers 4 and 5, N = 530) were asked to rate which car brands they would be more likely to purchase or lease, and which less if they were to choose to buy an alternative fuel vehicle, see Table 10 and Figure 4. The list of the car brands was built on the basis of the ranking of the best-selling electric cars in Poland ².

²based on the current data regarding sales from www.samar.pl (accessed October 2019)

Table 10: Variables describing preferred car brands (N=530)

Variable	Mean	Std. dev.	Skewness	Kurtosis	Median	Quartile 25%	Quartile 75%
Toyota	3.81	1.31	-0.969	-0.127	4.00	3.00	5.00
Volkswagen	3.26	1.35	-0.312	-1.045	3.00	2.00	4.00
Kia	2.64	1.21	0.126	-0.949	3.00	2.00	3.25
Nissan	2.88	1.23	-0.011	-0.950	3.00	2.00	4.00
Hyundai	2.85	1.23	-0.015	-0.908	3.00	2.00	4.00
Renault	2.38	1.24	0.498	-0.718	2.00	1.00	3.00
Peugeot	2.44	1.22	0.386	-0.829	2.00	1.00	3.00
BMW	3.61	1.36	-0.697	-0.710	4.00	3.00	5.00
Audi	3.93	1.29	-1.090	0.073	4.00	3.00	5.00
Volvo	3.91	1.22	-1.040	0.202	4.00	3.00	5.00
Tesla	3.61	1.44	-0.638	-0.939	4.00	3.00	5.00
Mercedes	3.86	1.27	-0.982	-0.092	4.00	3.00	5.00
Lexus	3.93	1.29	-1.046	-0.021	4.00	3.00	5.00
Others	10.18	5.97	1.066	0.502	8.00	5.00	13.00

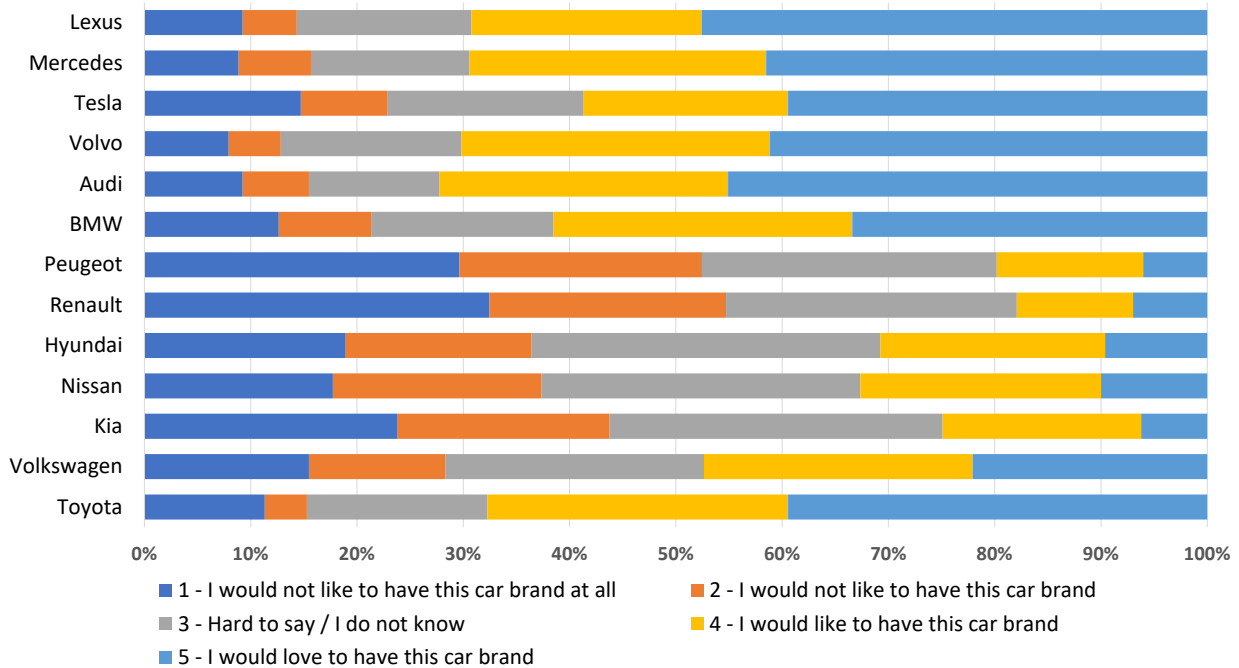


Figure 4: Assessment of the importance of the respondents' preferences as to the brand of a potentially purchased AFV (N = 530)

Here, too, a 5-point Likert scale was used, where 1 meant "I would not like to have this car brand at all", and 5 - "I would love to have this car brand". Some people presented their own suggestions for the car brands they would like to buy. The clear favorites of the respondents were three brands: Audi, Lexus and Toyota. To the least popular brands belonged Renault and Peugeot. Interestingly, there is also a large group of car brands about which, in over 30% of cases, the

respondents had no opinion, and these are: Hyundai, Kia, and Nissan.

Next, the respondents were asked to rate the importance of the benefits and advantages of possessing BEV in the future, see Table 11 and Figure 5.

Table 11: Variables describing most important benefits and advantages (N=1002)

Variable	Mean	Std. dev.	Skewness	Kurtosis	Median	Quartile 25%	Quartile 75%
Free parking space	4.05	1.28	-1.219	0.321	5.00	3.00	5.00
Usage bus lanes	3.79	1.35	-0.835	-0.518	4.00	3.00	5.00
Usage of zero-emission lanes	3.87	1.27	-0.908	-0.231	4.00	3.00	5.00
Tax release	4.46	0.97	-2.057	3.831	5.00	4.00	5.00
Subsidy	4.57	0.89	-2.540	6.526	5.00	4.00	5.00
Development of charging stations	4.42	0.88	-1.787	3.386	5.00	4.00	5.00
Longer guarantee	4.44	0.88	-1.822	3.419	5.00	4.00	5.00
Low noise level	3.91	1.25	-0.920	-0.214	4.00	3.00	5.00
Less service needed	4.06	1.12	-1.187	0.725	4.00	3.00	5.00
Social prestige	2.36	1.21	0.558	-0.828	2.00	1.00	3.00
Zero-emissions	4.22	1.156	-1.478	1.257	5.00	4.00	5.00

Respondents strongly opted for financial privileges such as government subsidies for a purchase of a new car and tax exemption. Equally important was the extended warranty and the availability of places to charge the car. Every fifth respondent had no opinion whether the possibility of using bus lanes and lanes intended only for zero-emission vehicles is an advantage or not.

For most of the respondents (over 78%) zero-emission of BEV was important or very important for them. The respondents appreciated silence resulting from driving BEV and almost half of them considered the extended periods between mandatory inspections to be very beneficial. Surprisingly, social prestige turned out to be the least important factor (for 56.2% of respondents) but at the same time almost every fourth respondent did not have an opinion on this subject (23.9%).

4.3.6. Conjoint types

Based on these outcomes resulting from T0 study, we have decided to design six different conjoint analyses differentiated by two aspects. The first one included 3 types of AFV cars, i.e., classic hybrid HEV, then hybrid with the possibility of charging, the so-called plugin hybrid PHEV, and fully electric BEV. The second dealt with the declared way of financing the car acquisition. We focused on two major possibilities here: either paying the full price at once (called later in the document purchase) or a specific monthly amount in a form of loan installments or leasing fees referred to later as leasing. All combinations of these two features resulted in 6 distinctive conjoints varied in factors and their levels. The conjoint types are given in Table 12.

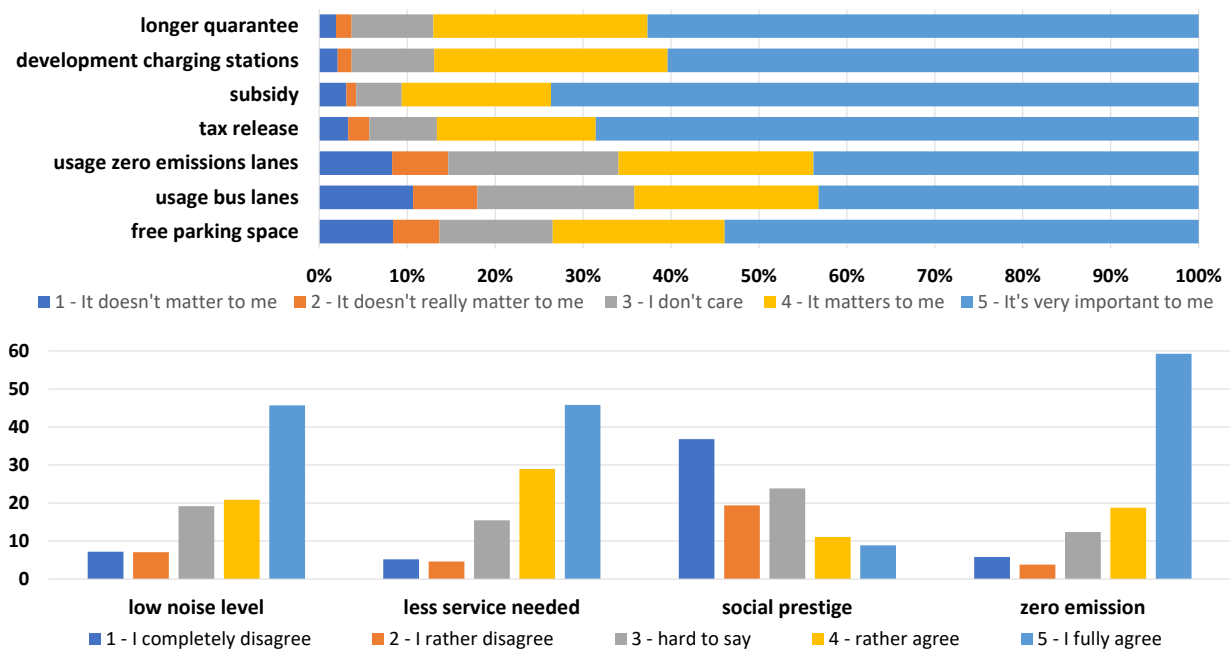


Figure 5: Assessment of the importance of benefits (upper panel) and advantages (bottom panel) that would encourage to purchase of BEV in the future (N = 1002)

Table 12: Specification of six conjoint analysis types conducted in this study

No	Acquisition form	Car type	Examined factors
1	Purchase	HEV	Safety level, Purchase price, Access to service, Car type, Functionality level
2	Purchase	PHEV	Safety level, Purchase price, Access to service, Access to charging, Range (PHEV)
3	Purchase	BEV	Safety level, Purchase price, Access to service, Access to charging, Range (BEV)
4	Leasing	HEV	Safety level, Monthly price, Access to service, Car type, Functionality level
5	Leasing	PHEV	Safety level, Monthly price, Access to service, Access to charging, Range (PHEV)
6	Leasing	BEV	Safety level, Monthly price, Access to service, Access to charging, Range (BEV)

4.3.7. Profile cards design

The selection process of factors to be examined in conjoints was not easy due to:

- a big number of possible factors and levels and methodological limitations of the conjoint

analysis;

- partially illogical answers from T0 respondents; e.g. they indicated the BEV brand names from companies that are not manufacturing such cars at all;
- the danger of the respondents being weary and tired by the excessive number of conjoint cards to score.

Based on the data from study T0 regarding potential customers' preferences we have selected five factors for every conjoint type (Table 6). Each of all five factors included in the examination was treated as a discreet variable with five levels. Conjoint attributes' descriptions along with the used pictograms are presented in Figure 6.










	Safety level	Safety systems that the car is equipped with, e.g., airbags, automatic cruise control. Safety is defined on a scale from Very Low (basic systems only) to Very High (the most modern and best systems on the market).
	Access to charging	Distance to the nearest charging point. The distance varies from 10 km to 130 km .
	Range (plugin)	Distance that can be driven electrically with a fully charged battery. The range varies from 20 km to 100 km .
	Range (electric)	Distance that can be traveled with a fully charged battery. The range varies from 100 km to 900 km .
	Purchase price	The amount you have to pay for the car at one time. The price varies from PLN 100,000 to PLN 300,000 .
	Monthly price	The monthly amount you need to pay for a lease or long-term rental. The monthly installment amount varies from PLN 1,000 to PLN 3,000 .
	Access to service	Distance to the nearest service specialized in the repair of a given type of a car. The distance varies from 10 km to 130 km .
	Functionality level	Useful car features, e.g., boot size, comfort of use, heated seats. The utility values are defined on a scale from Very small (only basic usability) to Very large (most desirable, best usability).
	Car type	Segments, differing mainly in size, to which the car can be assigned. The following cars were distinguished: Urban , Compact , SUVs (sport utility vehicle), Limousines , Family (VANs).

Figure 6: Conjoint attributes' descriptions along with the used pictograms

The order of factor attributes corresponded to the importance level obtained for the equivalent factor in the T0 study. The intensity of a given attribute was denoted by the length of the bar. The bar colors were inspired by energy usage information labels popular in household appliances. The color order depended on the nature of the given attribute. If lower values were potentially better perceived by subjects then shortest bars were green, and the longest red (e.g., car price). If bigger levels of a given feature were logically better for participants then the colors were reversed: the shortest bars were red whereas the longest – green (e.g., safety level). Since for the car type attribute it was hard to tell which option is better or worse, all bar lengths were green. Card and bar dimensions along with colors were consistent in all conjoint types and card profiles.

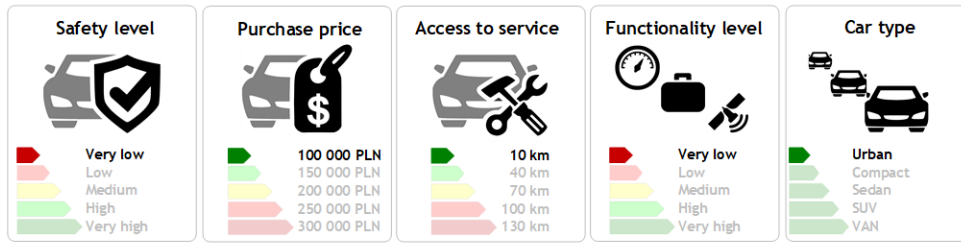
Since the full factorial design for such a number of factors and their levels would result in 3125 ($5 \times 5 \times 5 \times 5 \times 5$) conditions, it was necessary to reduce this number to a manageable level. The conjoint cards were prepared according to the orthogonal design sufficient to estimate part worths and significantly diminishing the number of necessary responses. For each conjoint type, 25 variants were generated. A sample of such a list of cards for one of the conjoints is given in Table 13, whereas sample cards used in all types of conjoints are presented in Figure 7 (³).

³zł is the same as PLN depicting Polish currency

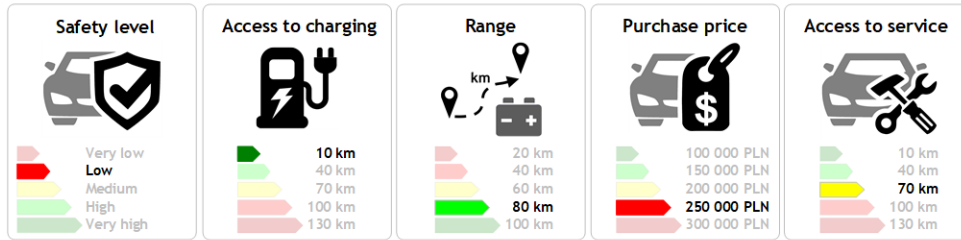
Table 13: Sample orthogonal plan for the purchase-HEV conjoint type

ID	Safety level	Purchase price	Access to service	Car type	Functionality level
01	Low	150 000 zł	130 km	Urban	Low
02	Very high	300 000 zł	40 km	Urban	Very high
03	Medium	250 000 zł	130 km	Compact	Very low
04	Very high	150 000 zł	100 km	Sedan	Very low
05	Very low	300 000 zł	130 km	VAN	Medium
06	Very high	200 000 zł	130 km	SUV	High
07	Low	100 000 zł	100 km	VAN	High
08	Medium	150 000 zł	70 km	VAN	Very high
09	Medium	100 000 zł	40 km	SUV	Low
10	Very low	100 000 zł	10 km	Urban	Very low
11	High	100 000 zł	130 km	Sedan	Very High
12	High	150 000 zł	10 km	SUV	Medium
13	Low	300 000 zł	70 km	SUV	Very low
14	Very low	250 000 zł	100 km	SUV	Very high
15	Very high	100 000 zł	70 km	Compact	Medium
16	Medium	200 000 zł	100 km	Urban	Medium
17	High	250 000 zł	70 km	Urban	High
18	Very low	200 000 zł	70 km	Sedan	Low
19	Medium	300 000 zł	10 km	Sedan	High
20	Very low	150 000 zł	40 km	Compact	High
21	Low	250 000 zł	40 km	Sedan	Medium
22	High	200 000 zł	40 km	VAN	Very low
23	Low	200 000 zł	10 km	Compact	Very High
24	Very high	250 000 zł	10 km	VAN	Low
25	High	300 000 zł	100 km	Compact	Low

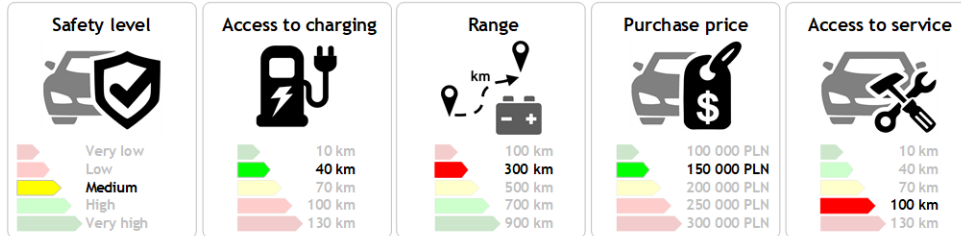
(1) Purchase - HEV



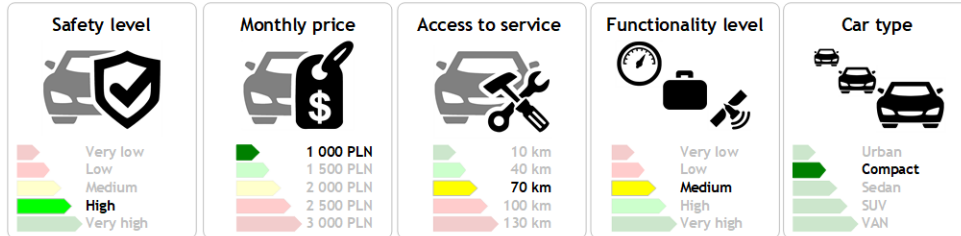
(2) Purchase - PHEV



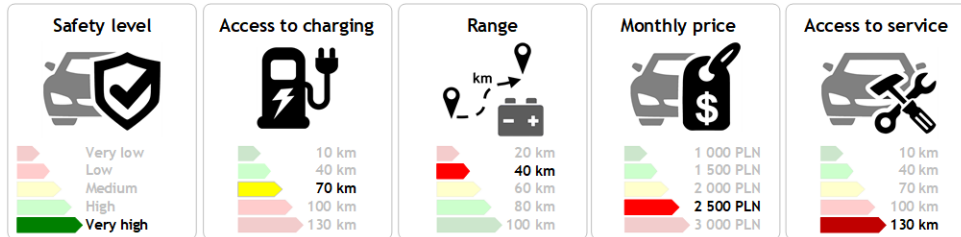
(3) Purchase - BEV



(4) Leasing - HEV



(5) Leasing - PHEV



(6) Leasing - BEV

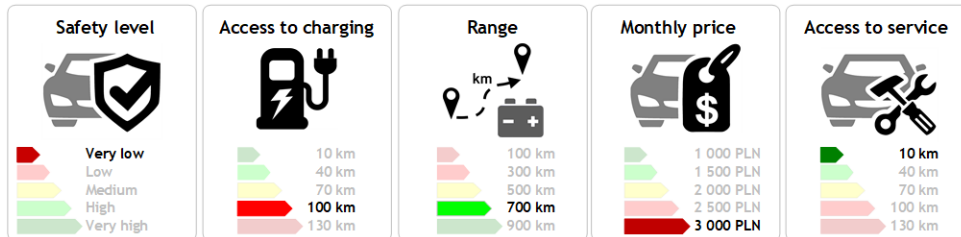


Figure 7: Cards samples for all conjoint types

4.3.8. Procedure

After two months of the first study T0, an email was sent to all participants taking part in the first step of the survey. Persons willing to participate in the second part were either to click on the hyperlink from the email, or copy and paste it directly to the web browsers. Subjects were instructed to avoid using smartphones or small tablets. The whole second part of the investigation was conducted in a custom-made web pages prepared in the Surneo environment (www.surneo.pl, dodać do referencji). All steps of the second study are presented in Figure 8. Screenshots from the consecutive steps of the procedure are provided in Figures 18 - 25 given in Appendix 6.3.

After the initial two web pages introducing participants into the topic (steps 1 and 2) , they made decisions on which type of ecologic vehicles they would acquire today and in what way (paying by cash or leasing or long-term rental). The fifth page included a description of car attributes for the selected earlier options. English translations of the descriptions used are provided in Figure 6.

Depending on the participants answers (steps 3 and 4), an appropriate type of the conjoint examination was chosen by the software. In the main sixth phase, subjects were to answer the following question “Would you like to buy (lease or rent for a long term) a hybrid (plug-in, electric) car with the following features:” for all 25 profile cards prepared for the given conjoint type. The exact question wording also reflected participants’ choices. The responses were given on a 7-point Likert scale: 1 – Definitely not, 2 – Not, 3 – Rather not, 4 – Hard to say, 5 – Rather yes, 6 – Yes, 7 – Definitely yes.

After completing all profile cards assessments, the subjects were asked five questions related to the COVID-19 situation (step 7), not included in the analysis in this paper. Finally, a thank-you web page with information on how to pick up the voucher for a cultural event appeared, which finished the entire procedure (step 8).

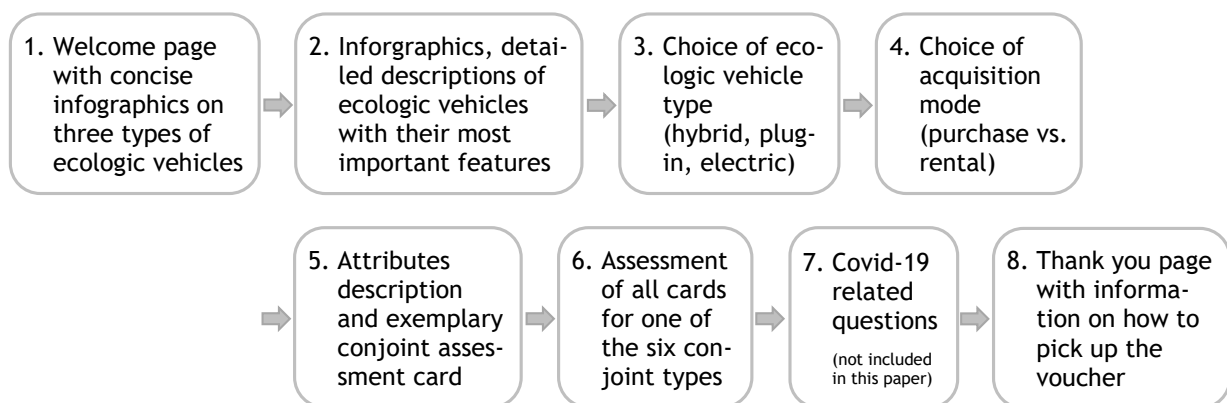


Figure 8: Conjoint overall procedure

5. Results and discussion

The main results for all types of conjoints performed in this study are provided in Tables 14 and 15, and in Figures 12, 13, 14, 15, 16, 17 in Appendix 6.3. In our study, the respondents

were divided into two groups. The adopted division criterion was the method of financing the car. The respondents chose between purchase or leasing a vehicle, as mentioned before. Hence the results are presented separately for the respondents willing to purchase a car (by cash or a loan) in subsection 5.1 and for the respondents choosing leasing as a form of acquisition (subsection 5.2).

Table 14: Factors and their levels in the performed conjoint analyses for purchase variants

Conjoints	Factors (Importances)		Levels and Partial utilities				
1. Purchase HEV $SE^* = 0.035$ $C^{**} = 3.16 (0.017)$	Safety level	(23.4%)	Very low -0.834	Low -0.591	Medium 0.175	High 0.577	Very high 0.672
	Purchase price	(24,2%)	100 000 zł 0.782	150 000 zł 0.382	200 000 zł -0.018	250 000 zł -0.392	300 000 zł -0.753
	Access to service	(15,5%)	10 km 0.166	40 km -0.037	70 km 0.197	100 km -0.281	130 km -0.045
	Car type	(20.4%)	Urban -0.247	Compact 0.047	Sedan -0.105	SUV 0.324	VAN -0.018
	Functionality level	(16.5%)	Very low -0.345	Low -0.237	Medium 0.307	High 0.061	Very high 0.214
2. Purchase PHEV $SE = 0.156$ $C = 3.32 (0.078)$	Safety level	(23.1%)	Very low -0.706	Low -0.366	Medium 0.077	High 0.341	Very high 0.653
	Purchase price	(24.2%)	100 000 zł 0.694	150 000 zł 0.257	200 000 zł 0.014	250 000 zł -0.353	300 000 zł -0.612
	Access to service	(14.6%)	10 km -0.055	40 km 0.247	70 km -0.078	100 km 0.056	130 km -0.17
	Access to charging	(18.1%)	10 km 0.223	40 km 0.283	70 km 0.076	100 km -0.194	130 km -0.388
	Range	(20.0%)	20 km -0.524	40 km -0.254	60 km -0.058	80 km 0.365	100 km 0.47
3. Purchase BEV $SE = 0.146$ $C = 3.51 (0.073)$	Safety level	(28.2%)	Very low -0.927	Low -0.644	Medium 0.039	High 0.722	Very high 0.81
	Purchase price	(23.7%)	100 000 zł 0.741	150 000 zł 0.463	200 000 zł -0.049	250 000 zł -0.361	300 000 zł -0.795
	Access to service	(13.9%)	10 km 0.068	40 km 0.034	70 km -0.19	100 km 0.039	130 km 0.049
	Access to charging	(14.2%)	10 km 0.039	40 km 0.049	70 km 0.098	100 km 0.039	130 km -0.224
	Range	(19.9%)	100 km -0.663	300 km -0.098	500 km 0.171	700 km 0.283	900 km 0.307

* SE - standard error for all levels; ** C - constant (standard error for the constant)

5.1. Acquisition form by purchase

Table 14 presents the importance of the included factors (safety level, purchase price, access do service, car type and functionality level) together with levels and partial utilities. The partial utilities are also shown of Figures 12, 13 and 14.

Price and safety are the key features of the respondents planning to purchase AFV for cash. However, the AFV range in zero-emission mode for PHEV should be at least 80 km, and in the case of BEV it is at least 500 km. Due to the significantly limited zero-emission capability of the HEV, the type of car is an important feature. The respondents would prefer to drive a hybrid SUV or a compact, and would not be looking for a new AFV among city cars. The respondents also expect HEV to have at least medium or higher functionality. For vehicles with a plug (PHEV, BEV), the availability of charging points is a less important feature. The respondents found that for vehicles with smaller batteries (i.e. PHEV) an extensive system of charging points is more important than for BEV. In the list of the five most important features for each type of vehicle, access to the service turned out to be the least important feature (Table 14). Figure 9 lists the features that an AFV should consist of, according to the surveyed purchase buyers.

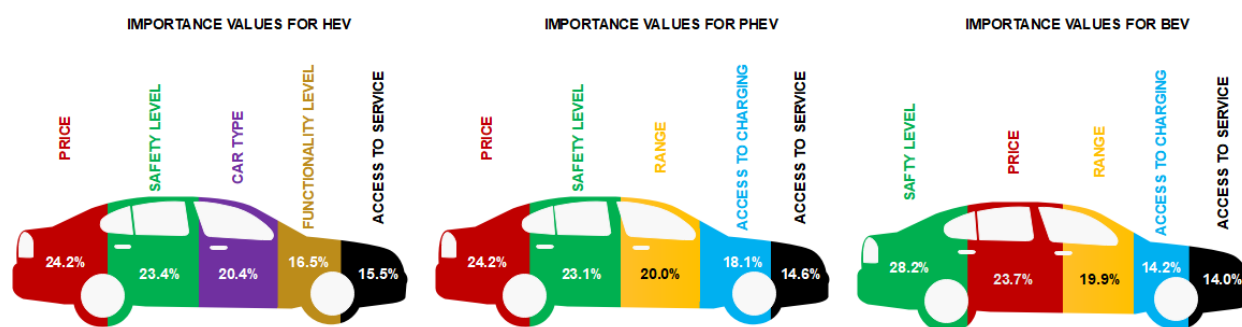


Figure 9: AFV features according to the type of vehicle by purchase buyers

The respondents considered the price to be the most important feature for two of the three vehicle types (HEV and PHEV). According to the research of [76], acceptable prices should be 20-30% lower than the list prices, so that buyers would be really interested in buying AFV. It can therefore be concluded that lowering the prices would significantly affect the popularity of AFV in Poland. Only for BEVs, the respondents indicated price as the second most important feature. This may result from the fact that people with a very good financial situation decide to purchase BEV, which is still expensive in Polish conditions.

Safety was by far the most important feature for respondents to BEV. BEV are perceived as modern, and therefore equipped with the latest technologies related to active and passive safety. At the same time, many BEV manufacturers (e.g. VW, Tesla, Audi, Nissan) offer new functionalities available only in BEV, such as semi-autonomous driving, new ways of communication between the driver and the vehicle or between vehicles, complex safety assistant systems, which make these vehicles considered to be safe.

For vehicles that can move using energy stored in batteries (PHEV and BEV), another important feature is range. It should be noted that the respondents declared much higher range values

than the technical capabilities of the currently offered eclectic vehicles. This means that a fairly large barrier to the development of AFV in Poland is their range.

The range is related to another feature which is access to the charging network. The data presented in the chapter "AFV market in Poland" shows that the development of the network of charging points in Poland is lower than the development of the electric vehicle market itself - 2% vs. 5% month to month. It should also be mentioned that in Poland there are only 0.2% of all charging points in Europe [2]. In the case of HEV, other important features are the type of the car and its functionality. Currently on the market, the most popular among individual customers in Poland are SUVs, perceived in the eyes of potential customers as universal vehicles with quite significant functionality. ([66]) This is the reason why a significant number of manufacturers in this segment of the automotive market offer not only conventional internal combustion vehicles (CV), but also hybrid versions (HEV). These vehicles sometimes differ in style or are equipped with accessories available only for AFV versions.

The feature closing the list is access to the car service. Despite the fact that this feature is at the end of the list, the authors of the research consider it important for several reasons. The new technologies used in AFVs mean that not every car service has the appropriate knowledge and tools (including IT) to repair such a vehicle. A relatively small number of specialized AVF car services can extend the repair time. The negligible number of service bases and the difficult availability of spare parts may constitute a significant barrier to the development of AFV in Poland.

5.2. Acquisition form by leasing

Table 15 focuses on the importance of the factors, such as safety level, monthly price, access to service, car type and functionality level in case of leasing a specific type of AFV. Levels and partial utilities are given. Partial utilities for leasing type of cojoints are also shown on Figures 15, 16 and 17.

Table 15: Factors and their levels in the performed conjoint analyses for leasing variants

Conjoints	Factors (Importances)		Levels and Partial utilities				
4. Leasing HEV $SE^* = 0.091$ $C^{**} = 3.11 (0.046)$	Safety level	(23.0%)	Very low -0.751	Low -0.431	Medium 0.056	High 0.423	Very high 0.703
	Monthly price	(22.2%)	1000 zł 0.656	1500 zł 0.283	2000 zł -0.054	2500 zł -0.251	3000 zł -0.634
	Access to service	(16.4%)	10 km 0.136	40 km 0.216	70 km -0.094	100 km 0.126	130 km -0.384
	Car type	(20.9%)	Urban -0.284	Compact 0.109	Sedan -0.074	SUV 0.426	VAN -0.177
	Functionality level	(17.5%)	Very low -0.244	Low -0.261	Medium -0.057	High 0.443	Very high 0.119
5. Leasing PHEV $SE = 0.119$ $C = 3.33 (0.060)$	Safety level	(25.9%)	Very low -0.8	Low -0.351	Medium 0.141	High 0.513	Very high 0.496
	Monthly price	(22.0%)	1000 zł 0.447	1500 zł 0.292	2000 zł 0.022	2500 zł -0.178	3000 zł -0.583
	Access to service	(15.0%)	10 km 0.013	40 km 0.137	70 km 0.022	100 km -0.174	130 km 0.003
	Access to charging	(16.6%)	10 km 0.228	40 km 0.02	70 km 0.051	100 km -0.112	130 km -0.187
	Range	(20.5%)	20 km -0.642	40 km -0.151	60 km 0.03	80 km 0.377	100 km 0.386
6. Leasing BEV $SE = 0.160$ $C = 3.34 (0.080)$	Safety level	(26.2%)	Very low -1,047	Low -0.683	Medium 0.074	High 0.753	Very high 0.903
	Monthly price	(23.9%)	1000 zł 0.739	1500 zł 0.603	2000 zł -0.047	2500 zł -0.469	3000 zł -0.826
	Access to service	(12.5%)	10 km 0.017	40 km 0.267	70 km 0.067	100 km -0.147	130 km -0.204
	Access to charging	(15.6%)	10 km 0.274	40 km 0.374	70 km 0.124	100 km -0.347	130 km -0.426
	Range	(21.9%)	100 km -0.904	300 km -0.133	500 km 0.06	700 km 0.331	900 km 0.646

* SE - standard error for all levels; ** C - constant (standard error for the constant)

Responses for this group of respondents largely coincide with the responses of people buying for cash. The list of features that an AFV should consist of, according to the respondents choosing acquisition of AFV by leasing, is presented in Figure 10.

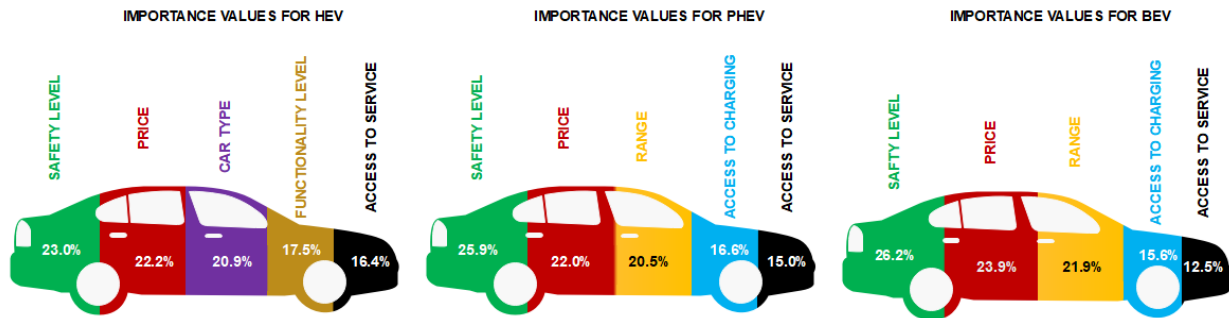


Figure 10: AFV features according to the type of vehicle by leasing buyers

The most important difference is the fact that safety is the dominant feature, followed by price (expressed in a monthly fee for this group of respondents). The change of importance of features may result from the fact that people with significant income may apply for leasing. However, in the case of companies, AFVs are often chosen as representative cars, emphasizing the ecological and modern character of the company. In both cases, the price is not crucial.

Another slight difference is the fact that respondents consider the PHEV zero-emission range of 60 km to be acceptable - one level lower than for the surveyed purchaser. For BEV, the minimum range should be at least 500 km (Table 15). In the entire research, the least important feature was the service access for BEV, both for the surveyed. AFV buyers for cash and for leasing. The share of this feature was respectively 14.0% and 12.5%. This may be due to the fact that BEV cars are perceived as failure-free and do not require complicated servicing (e.g. no need to blame oils and filters).

5.3. Characteristics of the features of the AFV

The division adopted in the research into 2 groups of respondents (purchase or leasing) and 3 AFV types (HEV, PHEV, BEV) allowed to obtain 6 unique sets of AFV features presented in Figures 9 and 10. The conducted research shows that:

- **Safety** - is the most important feature of a good AFV car. The respondents expect the AFV to provide active and passive protection of passengers by numerous systems monitoring the car's surroundings and technical improvements that increase its safety.
- **Price** - is crucial when buying HEV and PHEV for the surveyed cash buyers. The alarmingly weak effect of electromobility support programs in Poland: "Green car", "eVAN" and "Koliber" (Fig. 2) is a very clear sign for the authors of the projects that it is necessary to correct their assumptions. Above all, however, when introducing a program for people who want to buy AFV in the near future, the limit of the vehicle price and the amount of the subsidy must be increased, which will result in the program covering a greater number of models offered on the market by manufacturers.
- **Range** - an important, but not the key attribute when purchasing a PHEV or BEV. The respondents require significant coverage in the zero-emission mode. There are few offers on the market that meet the requirements of those interested in buying PHEV and BEV (see, [66] for more details).

- ***Access to charging points*** - is not a direct feature of AFV. A well-developed network of charging points would certainly contribute to the faster development of AFV in Poland.
- ***Vehicle type*** - research has shown that customers are primarily looking for an SUV. The demand for this type of vehicles has been noticed by manufacturers, which means that the offer in this market segment is constantly expanding (see, [66]). The Polish think-tank called ElectroMobility Poland S.A., supported by the Polish government, also forecasts that the production of electric SUVs will be launched in the coming years to meet the market expectations of the consumers (see, [17]).
- ***Functionality level*** - the AFV should offer at least average functionality expressed not only through high utility values (e.g. trunk capacity), but also through access to additional options such as navigation or extensive multimedia systems.
- ***Access to car service*** - is the last feature taken into account by the respondents. It should be noted that with the increase in the electrification of the vehicle, this feature plays less and less importance.

6. Conclusions and policy recommendations

Within our complex survey the respondents were firstly asked about their choice regarding the future car (its type, frequency of use, etc.), the hypothetical choice of AFV (including preferences and knowledge about the brand names, type of fuel etc.). Based on the answers, 6 separate conjoint analysis have been prepared taking into account the form of purchase (either the direct purchase or leasing). The respondents were evaluating the broad set of attributes, such as for example the price, the segment of the car or the access to the service. They had to evaluate how the given attributes are important to them in a relative assessment.

The originality of the paper includes not only the complexity of the two-stage empirical study, consisting of CATI and CAWI methods, but also on the usage of the conjoint method and keeping the methodological regime throughout the survey. Moreover, the survey is conducted on a large group of respondents, and the choice of factors in the conjoint analysis is based on a broad CATI survey. Finally the study is performed in Poland, one of the largest countries from Central and Eastern Europe, which represents different segment of consumers in comparison to the Western European or American markets being usually explored in the literature.

Our findings fit well to the current scientific knowledge about consumers' preferences towards AFV, shedding additional light into the points of view and perspectives of the consumers with a relatively lower purchasing power and currently lower exposure to the AFV. Surprisingly for these consumers safety turned out to be the most important feature, even more important than the price of the car and the range of the battery. Also the access to the service points have occurred to matter. It may reveal the relatively low level of knowledge and experience with AFVs, mixture of facts and myths about them present in social consciousness, and the lack of broader experience with this segment of the automotive market. This lack of knowledge and experience may lead to fear and anxiety observed among the respondents.

6.1. Policy recommendations

Based on our findings in order to increase sales of AFVs, car manufacturers should take into account two factors such as safety level and range. Vehicle safety is equated with systems such as Lane Keeping Assist, Adaptive Cruise Control, Traffic Jam Assist, Blind Spot Monitor and so on. Moreover, the research shows that the acceptable range for BEVs is min. 500 km, and in the case of the PHEV it is around 80 km. The meaning of range is certainly connected with the broad access to the charging stations and the easy access to the service, which both have occurred to be seen as an incentive to buy AFVs.

Secondly, if the government wants to increase the share of AFVs on the Polish market, it must abolish the purchase price limit for subsidized vehicles and extend the subsidy program to PHEV vehicles as well. The current level of funding is too low, which limits the choice to the smallest and cheapest BEV car models offered on the Polish market. In addition, it is also necessary to create an appropriate development plan for the infrastructure for charging electric vehicles in the coming future.

6.2. Future work

Based on this complex survey, we may recommend this kind of methodology. The complexity of the survey (conjoint analysis based on CATI questionnaire) allows to include a reflexive approach suggested by [36, 45, 46]. Within this approach raising of awareness and knowledge among the respondents during the stages of the survey is enabled. It is a great advantage in comparison to one-stage surveys with a simple evaluation of various option on the Likert scale.

6.3. Limitations

The groups of participants for various conjoints consisted of different number of people. It is certainly a disadvantage, but on the other hand as the participants were assigned to a certain conjoint based on their preferences regarding the form of purchase and the type of a vehicle, it was not feasible to guarantee a balance between the group size. In the future work the survey could be planned in advance in such a way, to control the allocation of respondents between the groups.

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Appendix

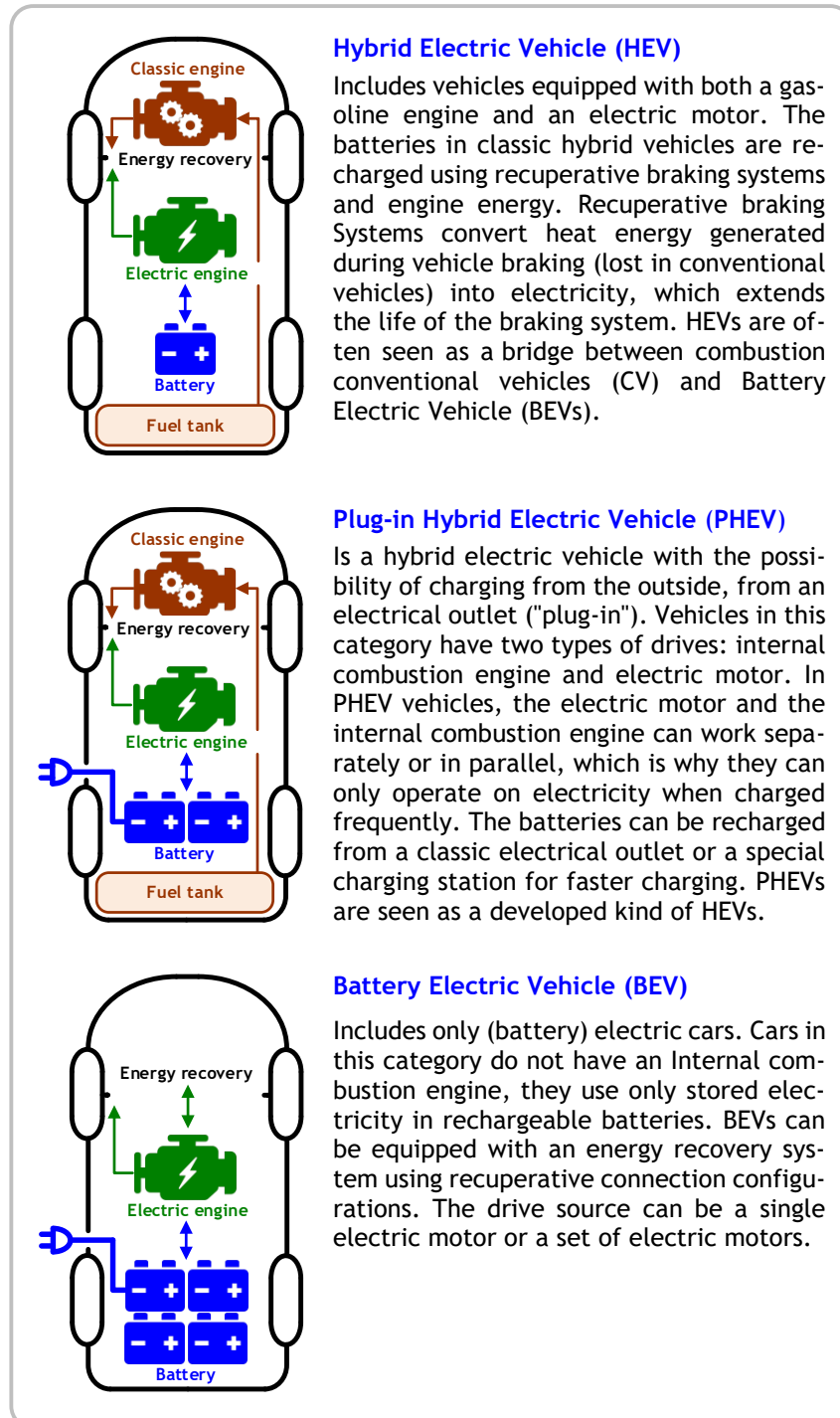


Figure 11: The description of main differences between AFV: BEV, PHEV and HEV (a guide for the project participants)

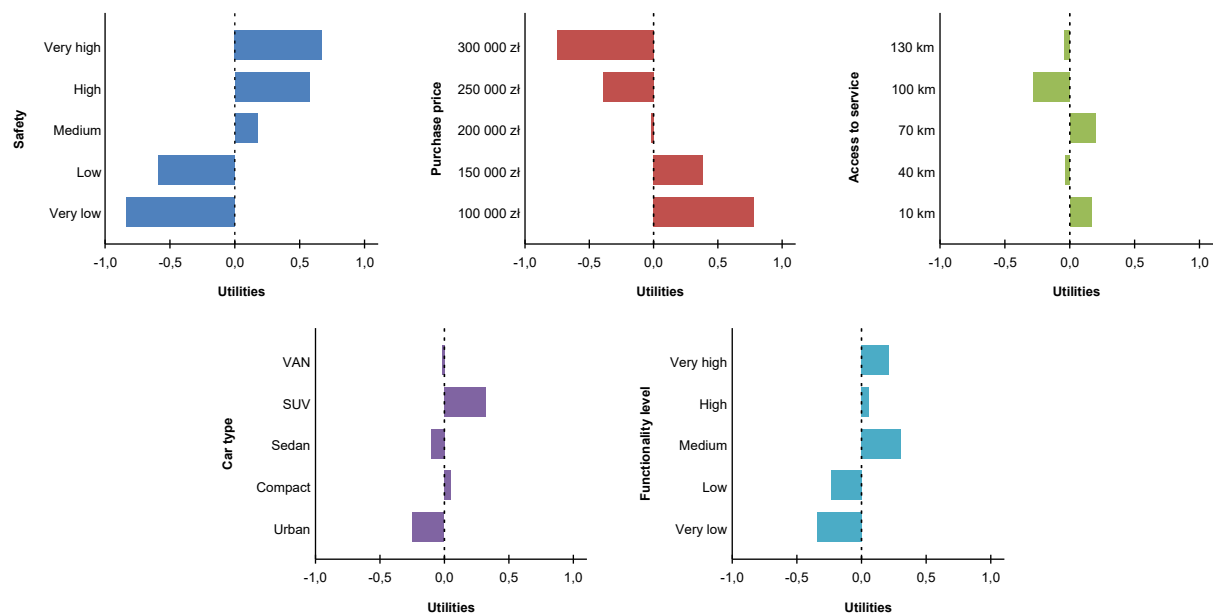


Figure 12: Partial utilities for factors in the purchase-HEV conjoint

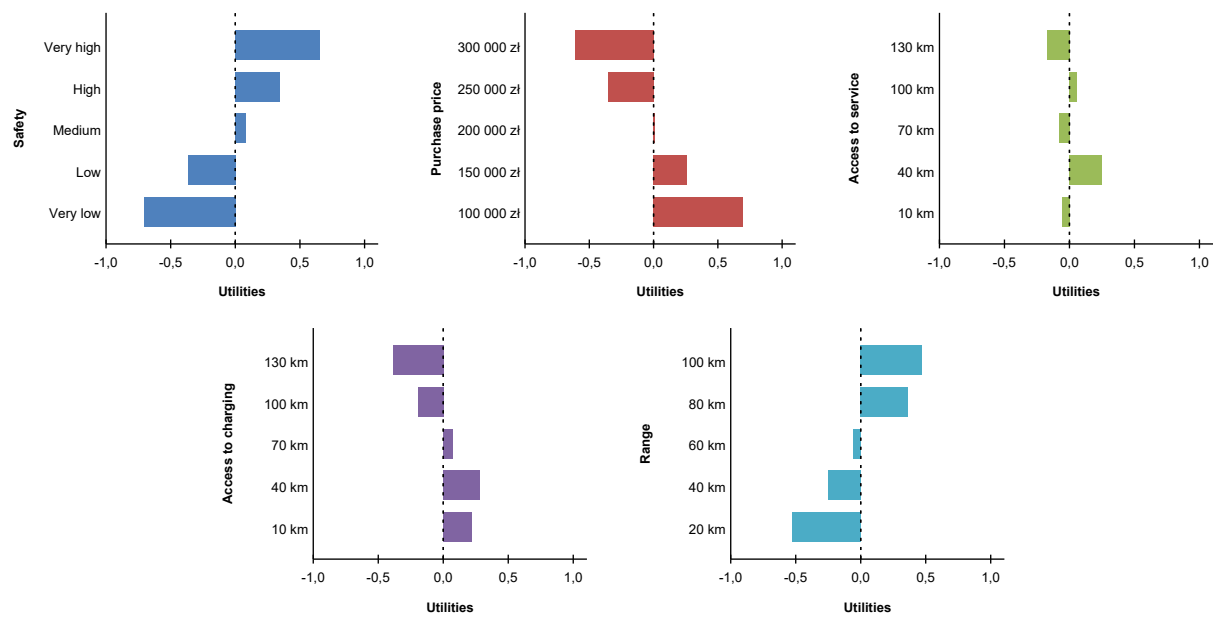


Figure 13: Partial utilities for factors in the purchase-PHEV conjoint

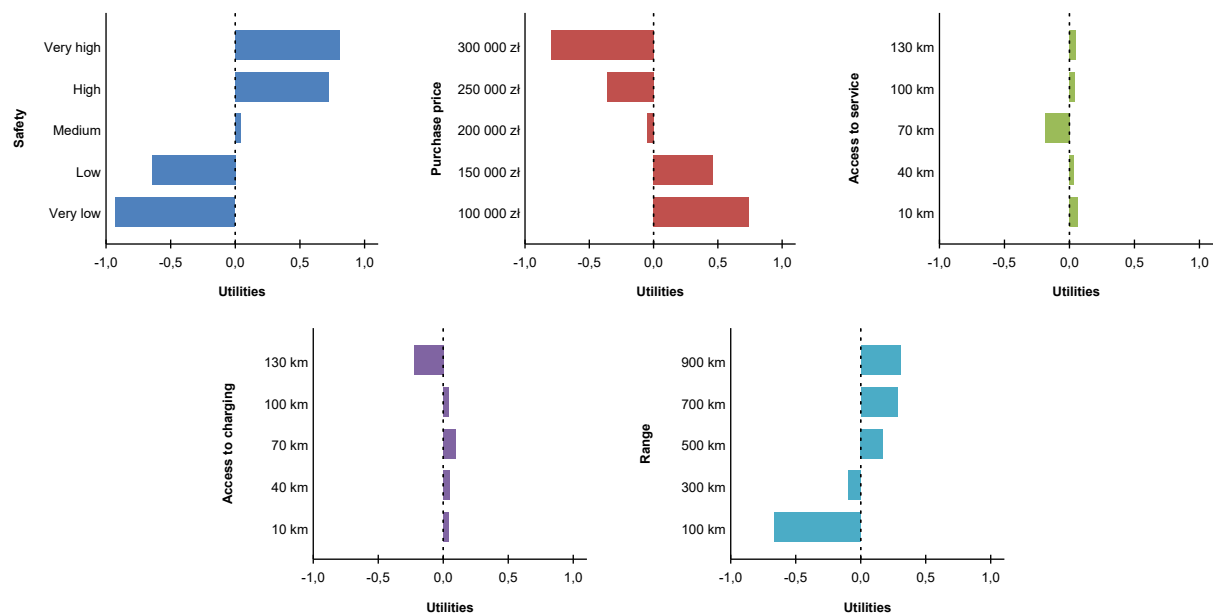


Figure 14: Partial utilities for factors in the purchase-BEV conjoint

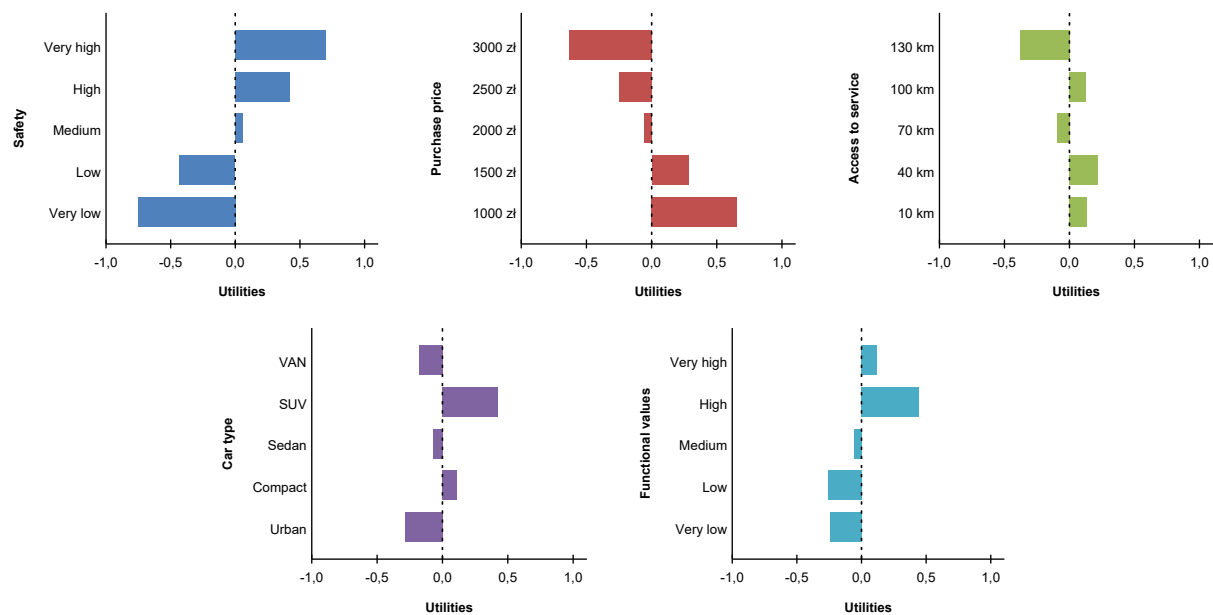


Figure 15: Partial utilities for factors in the leasing-HEV conjoint

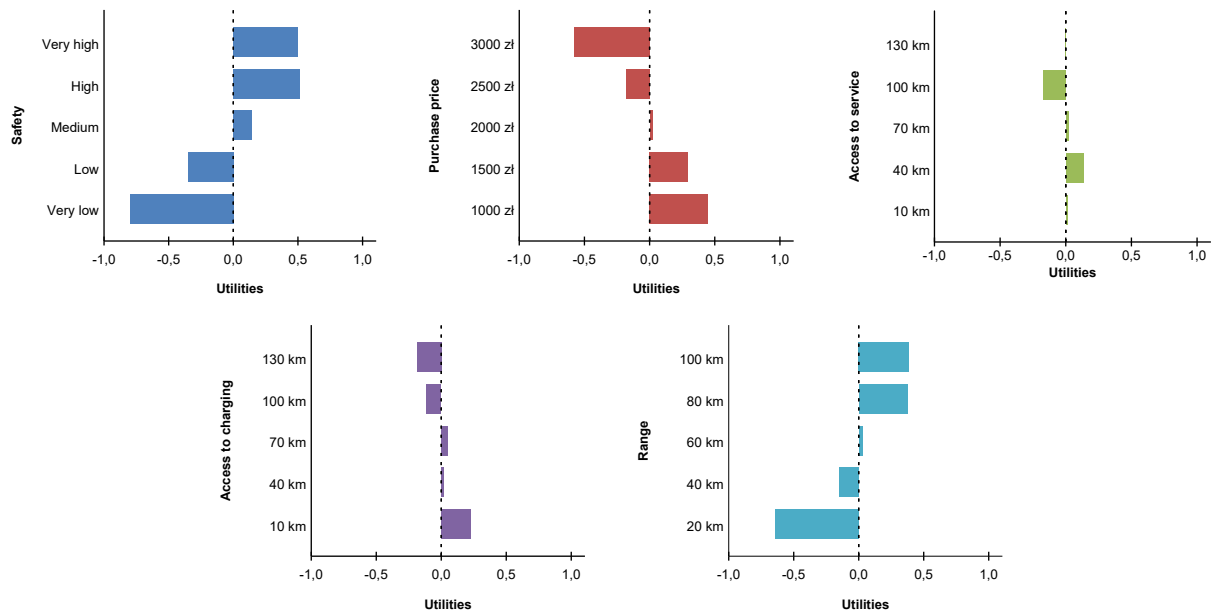


Figure 16: Partial utilities for factors in the leasing-PHEV conjoint

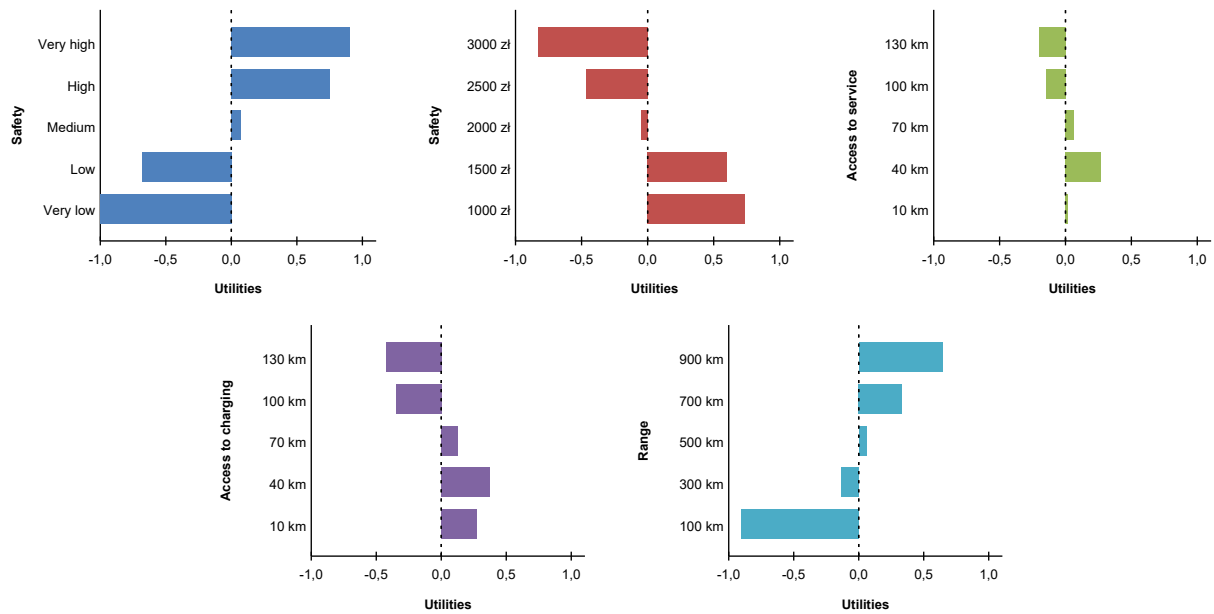
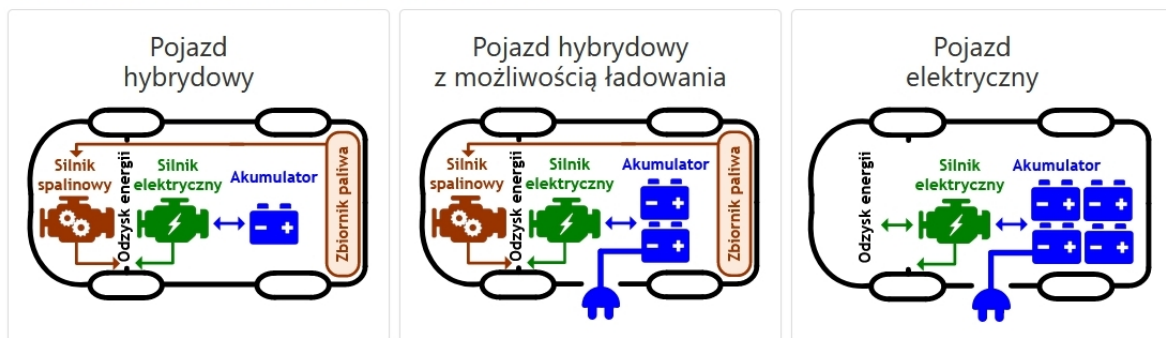


Figure 17: Partial utilities for factors in the BEV-leasing conjoint

Drugi etap badania o samochodach przyszłości

W pierwszej części rozmawialiśmy telefonicznie o tym, co wpływa na decyzje o wyborze samochodu. Celem drugiego etapu jest sprawdzenie, jakie cechy decydują o nabyciu samochodu ekologicznego. Pytania dotyczą cech następujących rodzajów aut:



W podziękowaniu za udział w całym projekcie, czyli w obu etapach oferujemy [bon \(voucher\)](#) o wartości 100 zł. Regulamin jego przyznania i wykorzystania znajduje się na stronie [AutaPrzyszlosci.pl](#).

Badanie realizowane jest na zlecenie Politechniki Wrocławskiej. Zbierane dane mają charakter całkowicie anonimowy i zostaną wykorzystane jedynie w formie zbiorczych zestawień statystycznych. Jego wyniki posłużą tylko celom naukowym. Procedury przetwarzania danych są zgodne z rozporządzeniem RODO.

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Figure 18: Study T1 procedure - step 1 sample

Proszę zapoznać się z poniższą charakterystyką pojazdów i kliknąć przycisk [Dalej](#) znajdujący się pod informacjami.

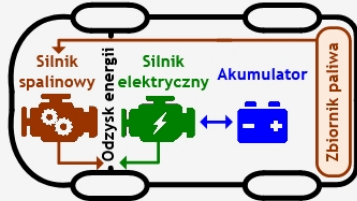
Pojazd hybrydowy	Pojazd hybrydowy z możliwością ładowania	Pojazd elektryczny
<p>Podstawowym źródłem napędu pojazdu hybrydowego jest silnik spalinowy. Silnik ten wspomaga dodatkowy silnik elektryczny. Baterie silnika elektrycznego ładują się automatycznie, korzystając z odzyskanej energii podczas hamowania oraz energii z silnika spalinowego.</p>	<p>W pojazdach hybrydowych z możliwością zewnętrznego ładowania, silnik elektryczny i silnik spalinowy mogą pracować oddzielnie lub jednocześnie. Akumulatory można doładować z klasycznego gniazdka lub wykorzystując do tego specjalną stację ładowania.</p>	<p>Samochody elektryczne nie posiadają silnika spalinowego. Napędzane są wyłącznie energią elektryczną zmagazynowaną w akumulatorach. Ładuje się je z gniazdka elektrycznego lub specjalnej stacji ładowania. Ładowanie trwa znacznie dłużej niż dla pojazdów hybrydowych z możliwością zewnętrznego ładowania.</p>
<p>Najważniejsze cechy</p> <ul style="list-style-type: none"> • Niższe zużycie paliwa w mieście • Zmniejszona emisja gazów cieplarnianych • Baterie zajmują mało miejsca • Konieczna jest benzyna lub olej napędowy • Skomplikowana konstrukcja 	<p>Najważniejsze cechy</p> <ul style="list-style-type: none"> • Możliwość jazdy wyłącznie na napędzie elektrycznym na znaczne odległości (kilkadziesiąt kilometrów) • Niższe zużycie paliwa • Zmniejszona emisja gazów cieplarnianych • Możliwość doładowania z gniazdka lub ładowarki • Znaczny koszt zakupu • Skomplikowana konstrukcja • Duża bateria ogranicza ładowność pojazdu 	<p>Najważniejsze cechy</p> <ul style="list-style-type: none"> • Napęd nie produkuje bezpośredniego zanieczyszczeń • Cichy napęd • Dobre parametry techniczne silnika elektrycznego • Niskie koszty utrzymania • Wysoki koszt zakupu • Konieczność ładowania za pomocą gniazdka lub ładowarki • Słabo dostępna infrastruktura do ładowania pojazdu • Ograniczony zasięg

[Dalej](#) →

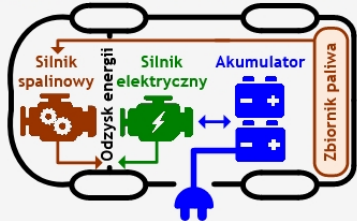
Figure 19: Study T1 procedure - step 2 sample

Jeśli **dzisiaj** miał(a)byś nabyć ekologiczny samochód, to z jakim silnikiem?

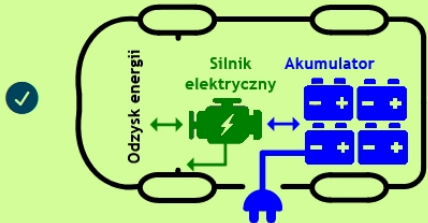
Hybrydowym (spalinowo-elektrycznym)



Hybrydowym z możliwością ładowania



Elektrycznym (wyłącznie)



← Wstecz

Dalej →

Figure 20: Study T1 procedure - step 3 sample

Jak chciał(a)byś sfinansować nabycie **ekologicznego samochodu**?

✓ Gotówka lub kredyt






Leasing lub wynajem długoterminowy

← Wstecz

Dalej →

Figure 21: Study T1 procedure - step 4 sample

Na kolejnych stronach będziesz oceniał(a) **samochód hybrydowy** na podstawie 5 cech:

	Bezpieczeństwo	Systemy bezpieczeństwa, w jakie wyposażony jest samochód, np. poduszki powietrzne, automatyczny tempomat. Bezpieczeństwo określone jest na skali od Bardzo niskiego (tylko podstawowe systemy) do Bardzo wysokiego (najbardziej nowoczesne i najlepsze na rynku systemy).
	Cena zakupu	Kwota, jaką trzeba zapłacić jednorazowo za samochód. Cena zmienia się od 100 000 zł do 300 000 zł .
	Dostęp do serwisu	Odległość do najbliższego serwisu wyspecjalizowanego w naprawie danego typu samochodu. Dostęp zmienia się od 10 km do 130 km .
	Walory użytkowe	Przydatne cechy samochodu, np. rozmiar bagażnika, wygoda użytkowania, podgrzewane siedzenia. Walory użytkowe określone są na skali od Bardzo małych (tylko podstawowa użyteczność) do Bardzo dużych (najbardziej pożądana, najlepsza użyteczność).
	Typ samochodu	Segmenty różniące się głównie rozmiarem, do których można przypisać auto. Wyróżniono samochody: Miejskie , Kompaktowe , SUVy (osobowo-terenowe), Limuzyny , Rodzinne (VANy).

Przykładowy widok jednego z **25 wariantów do oceny** ze skalą odpowiedzi:

Czy chciałbyś kupić **samochód hybrydowy** z następującymi cechami?

Bezpieczeństwo	Cena zakupu	Dostęp do serwisu	Walory użytkowe	Typ samochodu		
 <div style="display: flex; justify-content: space-between; padding: 0 5px;"> Bardzo niskie Niskie Średnie Wysokie Bardzo wysokie </div>	 <div style="display: flex; justify-content: space-between; padding: 0 5px;"> 100 000 zł 150 000 zł 200 000 zł 250 000 zł 300 000 zł </div>	 <div style="display: flex; justify-content: space-between; padding: 0 5px;"> 10 km 40 km 70 km 100 km 130 km </div>	 <div style="display: flex; justify-content: space-between; padding: 0 5px;"> Bardzo małe Małe Średnie Duże Bardzo duże </div>	 <div style="display: flex; justify-content: space-between; padding: 0 5px;"> Miejski Kompaktowy Limuzyna SUV Rodzinny (VAN) </div>		
Zdecydowanie nie (1)	Nie (2)	Raczej nie (3)	Trudno powiedzieć (4)	Raczej tak (5)	Tak (6)	Zdecydowanie tak (7)

>

✓

Dalej →

Figure 22: Study T1 procedure - step 5 sample

Czy chciałbyś kupić **samochód hybrydowy** z następującymi cechami?

Bezpieczeństwo	Cena zakupu	Dostęp do serwisu	Walory użytkowe	Typ samochodu		
<ul style="list-style-type: none"> Bardzo niskie Niskie Średnie Wysokie Bardzo wysokie 	<ul style="list-style-type: none"> 100 000 zł 150 000 zł 200 000 zł 250 000 zł 300 000 zł 	<ul style="list-style-type: none"> 10 km 40 km 70 km 100 km 130 km 	<ul style="list-style-type: none"> Bardzo małe Małe Średnie Duże Bardzo duże 	<ul style="list-style-type: none"> Miejski Kompaktowy Limuzyna SUV Rodzinny (VAN) 		
Zdecydowanie nie (1)	Nie (2)	Raczej nie (3)	Trudno powiedzieć (4)	Raczej tak (5)	Tak (6)	Zdecydowanie tak (7)

> ☒ ☐ ☐ ☐ ☐ ☐ ☐

[← Wstecz](#) [Dalej →](#)

Figure 23: Study T1 procedure - step 6 sample

W jaki sposób epidemia koronawirusa wpłynęła na decyzję nabycia auta?

	Zdecydowanie nie (1)	Nie (2)	Trudno powiedzieć (3)	Tak (4)	Zdecydowanie tak (5)
Nie miała znaczenia dla nabycia auta	<input checked="" type="radio"/>				
Opóźniła decyzję o nabyciu auta		<input checked="" type="radio"/>			
Wpłynęła na wybór tańszego auta			<input checked="" type="radio"/>		
Wpłynęła na wybór droższego auta				<input checked="" type="radio"/>	
Spowodowała rezygnację z nabycia auta					<input checked="" type="radio"/>

[← Wstecz](#) [Dalej →](#)

Figure 24: Study T1 procedure - step 7 sample

Bardzo dziękujemy za udział w badaniu

W podziękowaniu mamy dla Ciebie **bon (voucher)** o wartości **100 zł**. W ciągu dwóch dni roboczych prześlemy szczegóły pocztą elektroniczną.

Bon (voucher) będzie ważny od **1 maja 2020** do **30 kwietnia 2021**.

Z powodu środków zapobiegawczych związanych z zagrożeniem epidemiologicznym wiele wydarzeń kulturalnych i sportowych zostało odwołanych lub zmieniło swoją datę. Organizatorzy ustalają nowe daty planowanych imprez. Wszelkie informacje znajdują się na stronie [Eventim.pl](#).

Wszystkie szczegóły projektu oraz regulamin przyznania i wykorzystania tego bonu znajduje się na stronie [AutaPrzyszlosci.pl](#).

Figure 25: Study T1 procedure - step 8 sample