Renewable and Sustainable Energy Reviews 155 (2022) 111776

Contents lists available at ScienceDirect

Renewable and Sustainable Energy Reviews

journal homepage: www.elsevier.com/locate/rser

Consumer preferences towards alternative fuel vehicles. Results from the conjoint analysis

Anna Kowalska-Pyzalska [a,*], Rafał Michalski [b], Marek Kott [c], Anna Skowrońska-Szmer [a], Joanna Kott [a]

[a] Department of Operations Research and Business Intelligence, Faculty of Management, Wrocław University of Science and Technology, 50-370 Wrocław, Poland
[b] Department of Management Systems and Organization Development, Faculty of Management, Wrocław University of Science and Technology, 50-370 Wrocław, Poland
[c] Department of Electrical Power Engineering, Faculty of Electrical Engineering, Wrocław University of Science and Technology, 50-370 Wrocław, Poland

ARTICLE INFO

Keywords:
Consumer preferences
Electric vehicles
Plug-in electric vehicles
Hybrid electric vehicles
Conjoint analysis
On-line survey
Sustainable transport

ABSTRACT

Alternative fuel vehicles (AFVs) are an important element of sustainable development and electromobility. Even though the analysis of consumers' preferences towards AFV has already been done in various countries, the point of view of consumers from the country representing Central and Eastern Europe was missing. 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. The study is conducted on a large group of Polish respondents (N=1002 and N=500), and the choice of factors is based on a broad CATI survey. 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.

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 [1]. 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 [2–5]. The general differences between most popular types of AFV and their structure are presented in Fig. 11 in Appendix and in [6].

In Poland the presence of AFV is still very limited [6,7]. 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 [8]. As the European Automobile Manufacturers' Association (ACEA) indicates, Poland is nowadays, one of the EU countries with the highest sales rates of HEVs [9].

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. [4,10–12], a very few were focused on the Central and East European (CEE) countries, where the market of AFV is much less matured [6,13,14]. 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

* Corresponding author.
E-mail addresses: anna.kowalska-pyzalska@pwr.edu.pl (A. Kowalska-Pyzalska), rafal.michalski@pwr.edu.pl (R. Michalski), marek.kott@pwr.edu.pl (M. Kott), anna.skowronska-szmer@pwr.edu.pl (A. Skowrońska-Szmer), joanna.kott@pwr.edu.pl (J. Kott).

https://doi.org/10.1016/j.rser.2021.111776
Received 4 February 2021; Received in revised form 16 August 2021; Accepted 13 October 2021
Available online 25 November 2021

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 and contribution 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 general idea of applying conjoint analysis in examining preferences 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. In particular this Section provides the rationale for designing and conducting six different conjoints, which were based on outcomes resulting from T0 study. It also presents the overall scheme of the whole experimental procedure, as well as details of performed conjoints and conjoint types.

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.

2. Literature background

2.1. Conjoint analysis in empirical studies

The principles of the conjoint analysis were provided by Luce & Turkey [15] and Krantz & Tversky [16]. All variants of the conjoint approaches are theoretically and methodologically based on the utility theory which is used to describe and explain customers' behavior. 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 judgments about assessed variants having different properties [15,17]. 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 [18]. 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 [19] 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 [20].

A number of conjoint analyses were also performed for environmental evaluations such as ecosystem management, forestry, pollution [21], or waste management [22].

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. [24] examined hospital's innovativeness reputation whereas Weernink et al. [25] provided an extensive review of conjoint applications in medical decision making.

In the tourism domain, e.g. Kim et al. [26] studied performing arts product preferences of Japanese tourists, Eriksson & Fagerstrom [27] 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. [28] to investigate hotel reviews' heuristic attributes.

A quantity of papers concerned food, for instance, Lima et al. [29] focused on strawberries packaging, Tekień et al. [30] examined consumers preferences towards animal origin food products. Lately, an adaptive version of the conjoint was employed by Sulistyawati et al. [31] to learn about preferences towards quality attributes of dried mango among subjects from China, Indonesia, and the Netherlands, whereas Anabatwi et al. [32] investigated perceived healthiness of food items.

Graphical usability aspects of graphical interfaces were, for instance, investigated by Myung [33] who used the conjoint method for determining Korean typography guidelines in web environment. Michalski [34] analyzed users' preferences towards vertical graphical toolbars, Kim et al. [35] studied graphical symbols for fighter aircraft cockpit displays, while Michalski & Staniów [36] 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 [17,18,37–39], or lately [40].

2.2. Implementation of conjoint approach to the analysis of AFV

The report of Graham [41] 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 [42]. 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 [43]. 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 [44] 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 form 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 [45]. 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 [46] 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) [47] 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 [48], 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. [49] 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. [50] 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. [51] 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. [2] 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], labeled choice experiment [52], discrete choice model [52–55], mixed logit or nested logit models [53,54] or latent class models [4,55,56] can be mentioned.

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 [53], leading to openness to electric mobility [52], as well as on the analysis of barriers to widespread adoption [58].

The surveys reveal that price and financial incentives still are the most vital factors influencing the demand [4,53,54,58]. Consumers expect proper public policies, such as tax exemptions and/or reductions, free parking, bus lane access and others [53,54]. 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 [53,54,58]. Finally emission reduction seems to be important for the consumers [53]. 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 [5,7,10,12,56,58].

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 [4,54,60].

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	[53]
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	[54]
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	[57]
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	[55]
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	[52]
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	[58]
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	[4]
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	[59]

3. AFV market in Poland

There have been major changes in the European new passenger car registration market in recent years. Sales of AFVs are systematically increasing at the expense of vehicles with conventional engines. In 2020, electric cars (BEV and PHEV) increased their market share to 10.5% (in 2019 the share of BEV was only 3.0%) according to ACEA [61]. The registration of new hybrid electric vehicles (HEVs) is on the similar level. Overall, in 2020 HEVs accounted for 11.9% of total EU passenger car sales, compared to 5.7% in 2019. While the overall 3 million decline in car registrations as a result of COVID-19 hit diesel and gasoline powered vehicles the hardest, in 2020 EU car sales continued to be dominated by conventional fuel vehicles in terms of market share (75.5%) [61].

Currently there are over 23.4 million passenger cars registered in Poland, which accounts for 8.7% of all cars registered in the EU [62, 63]. 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 Fig. 1.

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, 8834 PHEV and 10,041 BEV were registered in Poland. In the 2020, 9879 PHEV and BEV vehicles were added — 140% more than in the corresponding period of 2019 [67]. PHEV enjoyed 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.

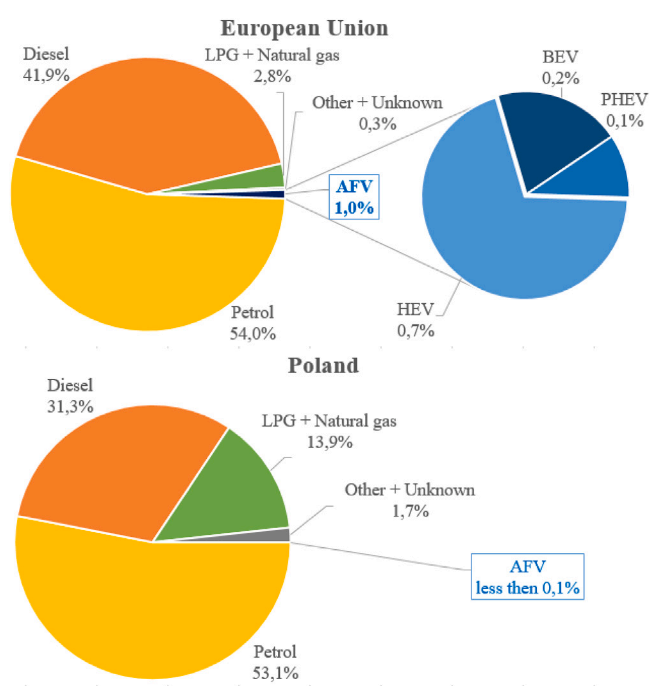

Fig. 1. Passenger cars market by fuel type [9,64,65].

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

Table 2
Number of newly registered AFVs [66,67].

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%

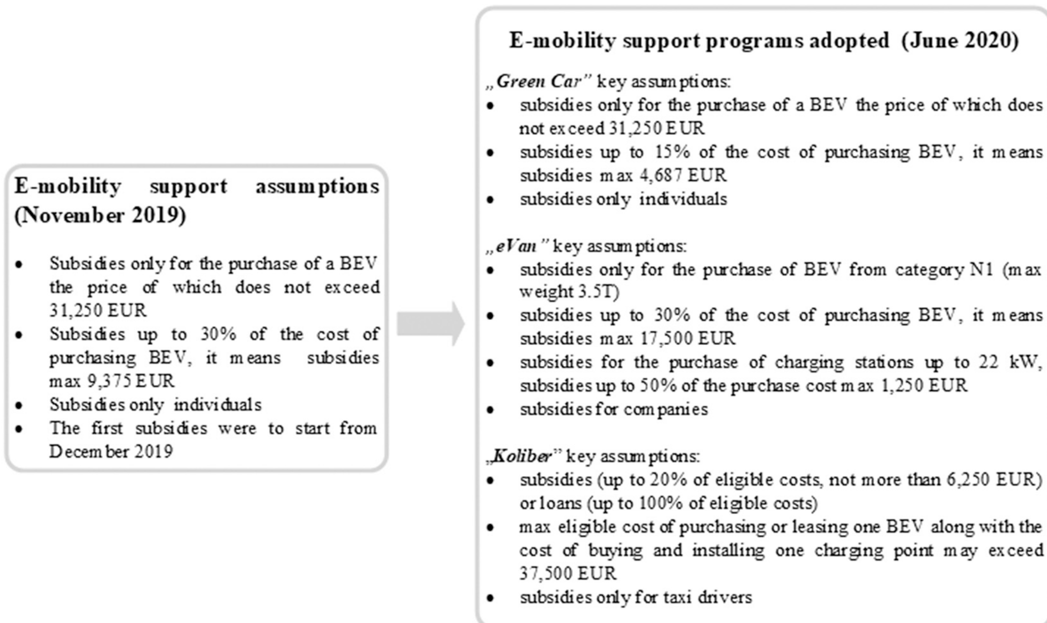

Fig. 2. Changes in the conditions of AFV funding in Poland.

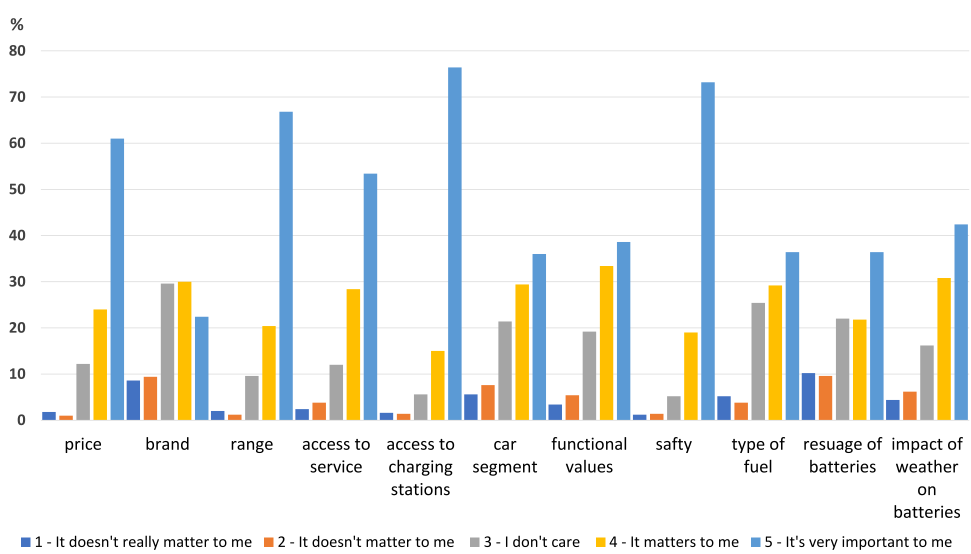

Fig. 3. Assessment of importance of the key factors that may affect the choice of AFV (N=1002).

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 Fig. 2. Additionally, detailed changes to the AFV market legislation are described in [6].

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.

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 (2258 points) in Poland. 33% of them were fast DC charging stations and 67%

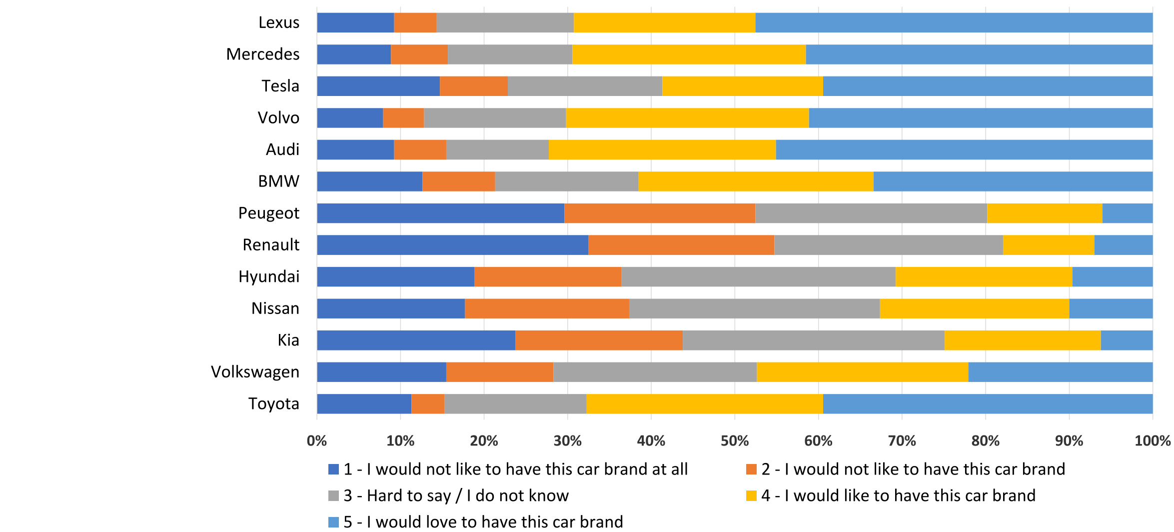

Fig. 4. Assessment of the importance of the respondents' preferences as to the brand of a potentially purchased AFV (N=530).

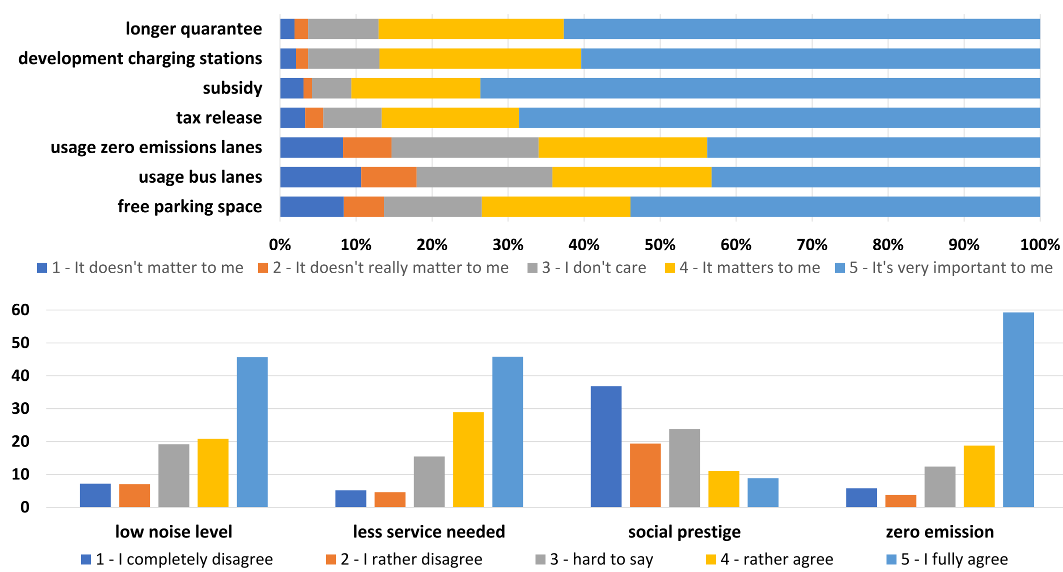

Fig. 5. Assessment of the importance of benefits (upper panel) and advantages (bottom panel) that would encourage to purchase of BEV in the future (N=1002).

Table 3
Model offers of vehicles eligible for the "Green Car" program [68–75].

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

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 [67].

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

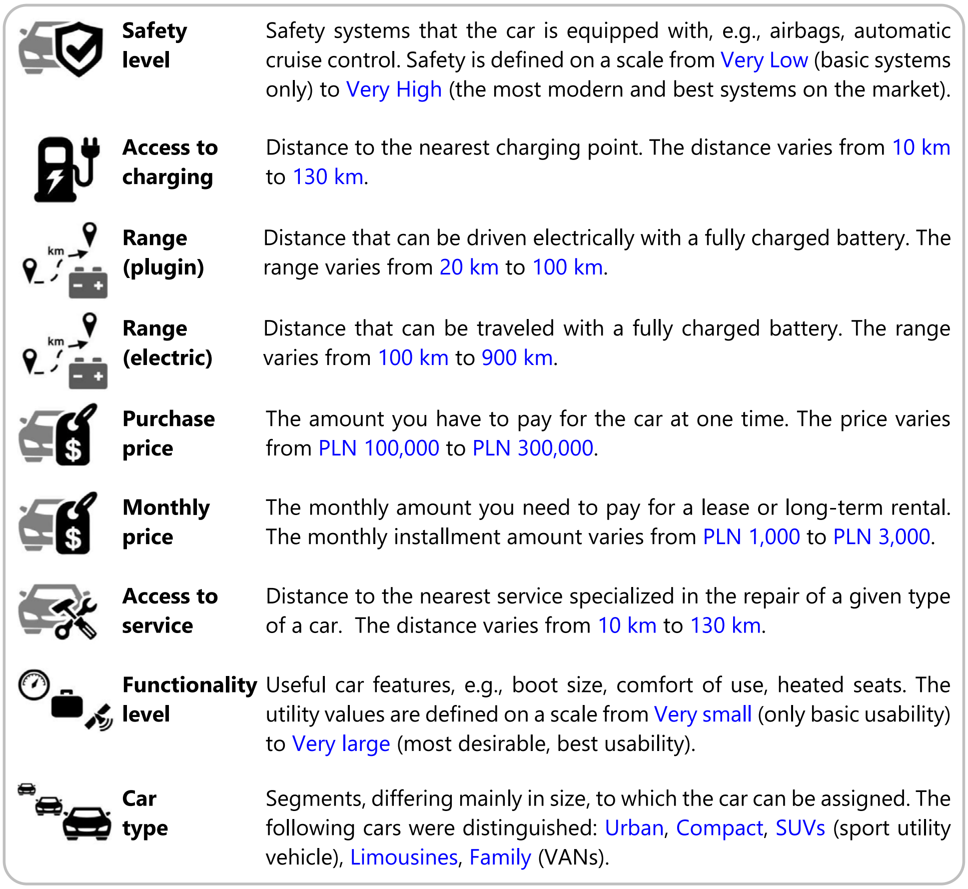

Fig. 6. Conjoint attributes' descriptions along with the used pictograms.

(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, Fig. 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).

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

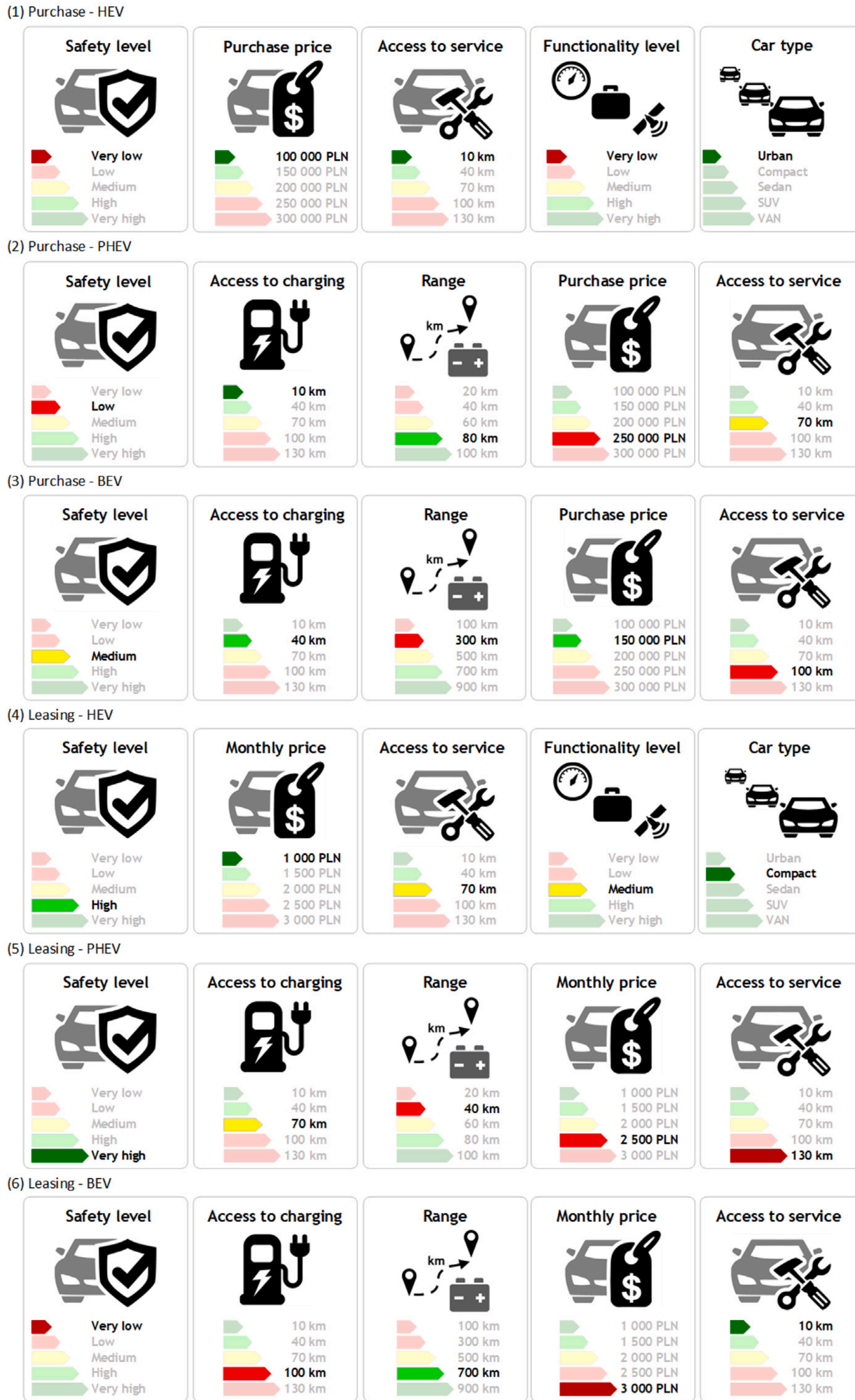

Fig. 7. Cards samples for all conjoint types.

(Table 6) or leasing it (Table 7) is higher for respondents running a business.

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 2000 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 2000 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.

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

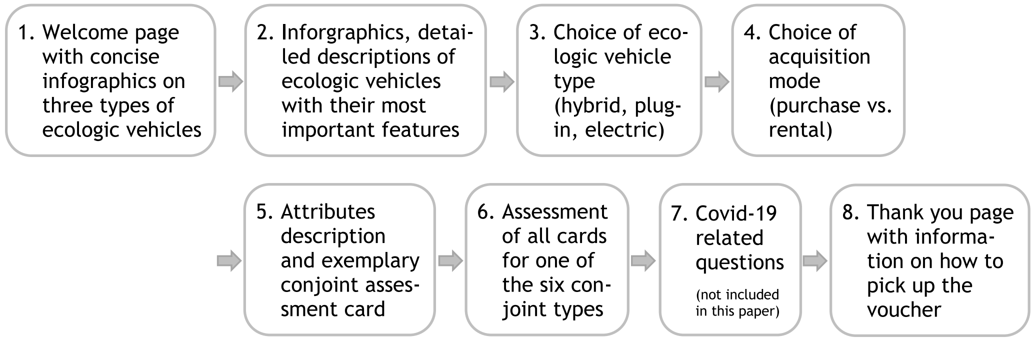

Fig. 8. Conjoint overall procedure.

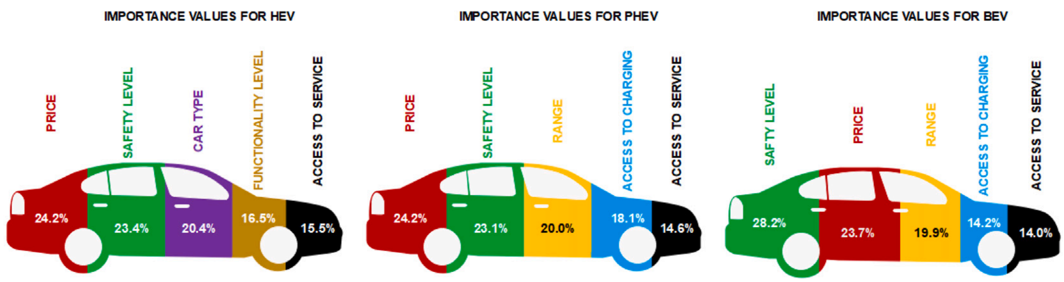

Fig. 9. AFV features according to the type of vehicle by purchase buyers.

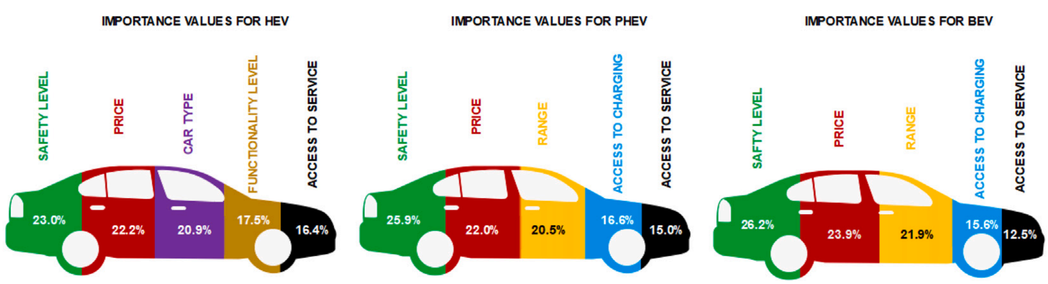

Fig. 10. AFV features according to the type of vehicle by leasing buyers.

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%	Female 42.4%
	Male 60%	Male 57.6%
Age	M = 36.26, SD = 11.15	M= 35.59, SD = 10.51
Education	Primary school 1.0%	Primary school 0.8%
	Basic vocational 4.6%	Basic vocational 2.4%
	Secondary vocational 21.2%	Secondary vocational 14.2%
	Secondary education 14.5%	Secondary education 17.4%
	Higher education 56.7%	Higher education 65.1%
Material situation	Very bad or rather bad 2.0%	Very bad or rather bad 1.4%
	Moderate 33.8%	Moderate 35.2%
	Rather good or very good 63.4%	Rather good or very good 63.3%
Place of a living	Village 32.4%	Village 30.7%
	City up to 30,000 inh. 18.6%	City up to 30,000 inh. 17.8%
	City 30,000 to 100,000 inh. 15.6%	City 30,000 to 100,000 inh. 12.4%
	City 100,000 to 500,000 inh. 10.9%	City 100,000 to 500,000 inh. 12.4%
	City more than 500,000 inh. 21.8%	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

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%

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)

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%)

of respondents declared that they would decide to buy HEV, 19.2% BEV and 32.9% PHEV.

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);
- 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 characterized in Tables 9–11.

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 Fig. 3, indicate the accuracy of the selected factors as all of them were considered by the respondents as very important or important.

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 Fig. 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 Fig. 4. The list of the car brands was built on the basis of the ranking of the best-selling electric cars in Poland[2].

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 Fig. 5.

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.

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;

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

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

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

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

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)

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

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

- 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 (Fig. 6). Each of all five factors included in the examination was treated as a discrete variable with five levels. Conjoint attributes' descriptions along with the used pictograms are presented in Fig. 6.

The selected influence factors and their order 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 x 5 x 5 x 5 x 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 (the remaining 5 orthogonal plans are provided in Tables 16–20 in the appendix), whereas sample cards used in all types of conjoints are presented in Fig. 7[3].

[3] zł is the same as PLN depicting Polish currency.

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 Fig. 8. Screenshots from the consecutive steps of the procedure are provided in Figs. 18–25 given in Appendix.

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 Fig. 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).

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 Figs. 12, 13, 14, 15, 16, 17 in Appendix. In our study, the respondents were divided into two groups. The adopted division criterion was the method of financing the car. The

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

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

$^*SE$ - standard error for all levels; $^{**}C$ - constant (standard error for the constant).

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 Section 5.1 and for the respondents choosing leasing as a form of acquisition (Section 5.2).

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 Figs. 12–14.

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 a 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). Fig. 9 lists the features that an AFV should consist of, according to the surveyed 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 [64]. 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

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

$^{*}SE$ - standard error for all levels; $^{**}C$ - constant (standard error for the constant).

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 conjoints are also shown on Figs. 15–17.

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 Fig. 10.

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).

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.

6.1. 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 Figs. 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, [77]).
- ***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.

6.2. Contribution of the paper

The contribution and 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. It is a novel approach and an important contribution to the existing 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 has 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.

6.3. 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.

6.4. 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 [3,4,78]. 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.

Our survey could be followed and extended by the market segmentation of customers depending on their preferences towards AFV. It would allow to propose more precise business models and marketing strategies. Moreover the future research could pay attention to the point of view of the supplier side of the market. In particular some research regarding energy management, including vehicle to vehicle (V2V) communication as well as the investigation of the preferences towards charging infrastructure by both consumers and suppliers could be suggested [79]. It would be also interesting to check what key factors are taken into account by the manufacturers when creating an alternative fuel vehicle for our Central and Eastern European market. Are the features and parameters of these cars consistent with the preferences, needs and expectations of customers?

6.5. 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.

CRediT authorship contribution statement

Anna Kowalska-Pyzalska: Conceptualization, Investigation, Supervision, Project administration, Funding acquisition, Writing – original draft, Writing – review & editing. **Rafał Michalski:** Conceptualization, Methodology, Investigation, Data curation, Formal analysis, Visualization, Writing – original draft, Writing – review & editing. **Marek Kott:** Conceptualization, Investigation, Data curation, Formal analysis, Visualization, Writing – original draft, Writing – review & editing. **Anna Skowrońska-Szmer:** Conceptualization, Investigation, Data curation, Formal analysis, Writing – original draft, Writing – review & editing. **Joanna Kott:** Conceptualization, Investigation, Writing – original draft, Writing – review & editing.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgment

This work was supported by the National Science Center (NCN, Poland) by grant no. 2018/29/B/HS4/00069.

Appendix

See Tables 16–20 and Figs. 11 and 25.

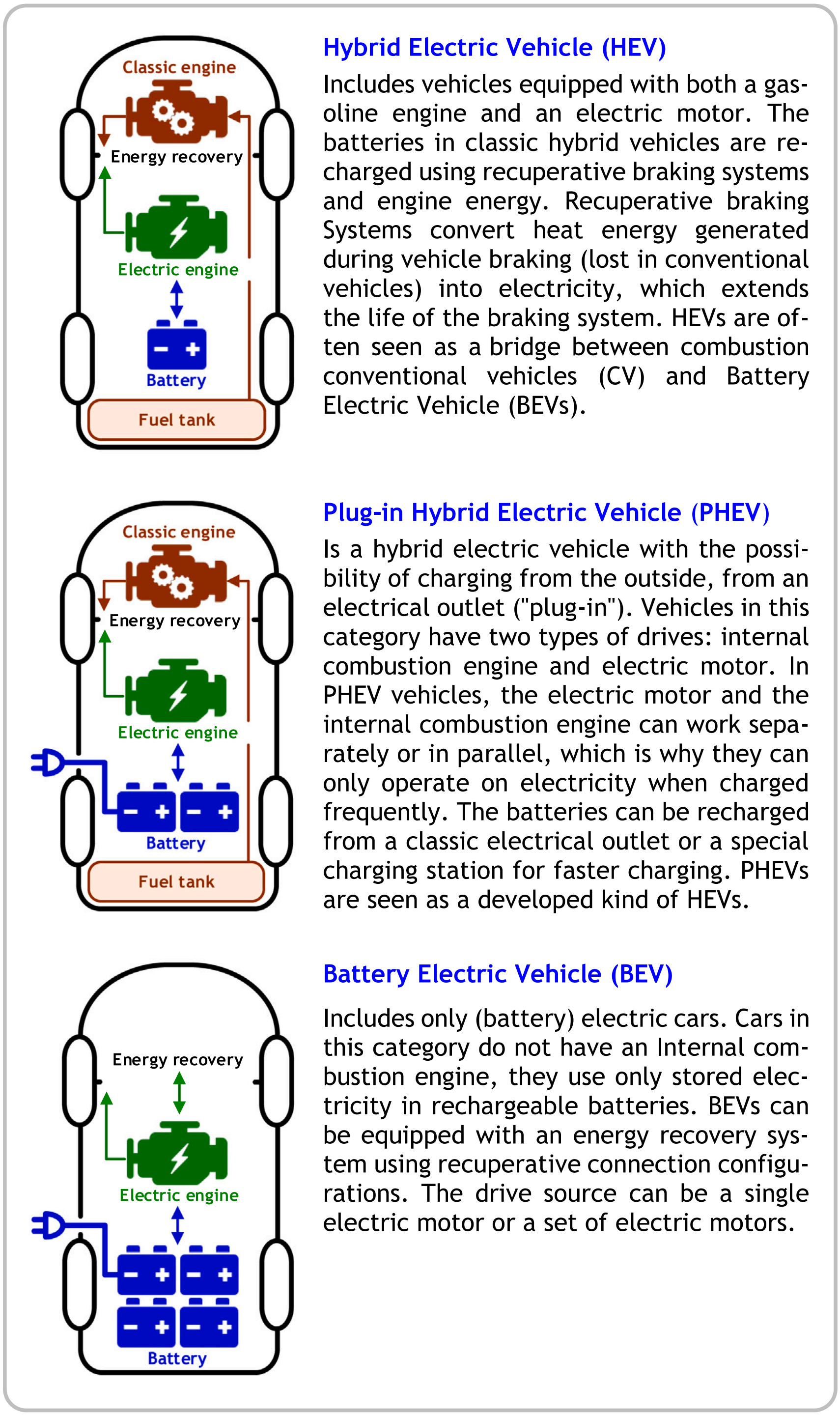

Fig. 11. The description of main differences between AFV: BEV, PHEV and HEV (a guide for the project participants).

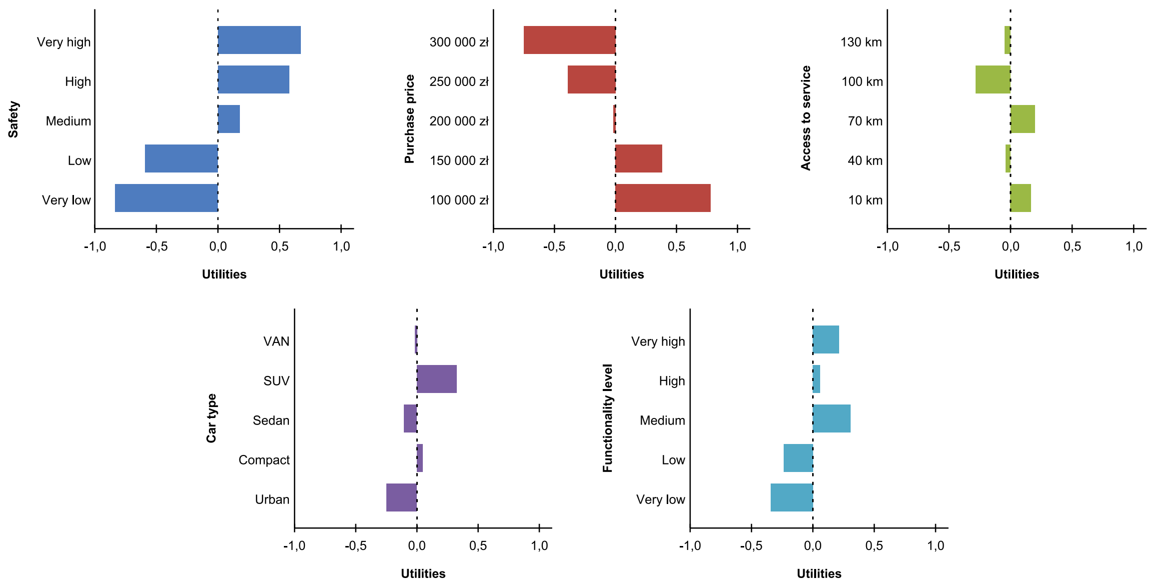

Fig. 12. Partial utilities for factors in the purchase-HEV conjoint.

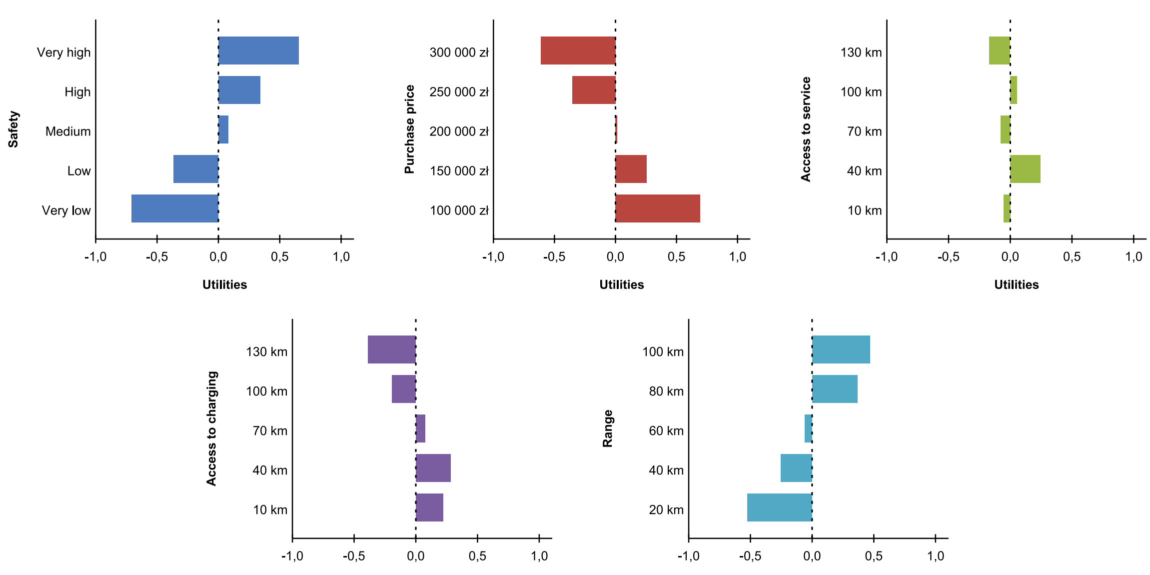

Fig. 13. Partial utilities for factors in the purchase-PHEV conjoint.

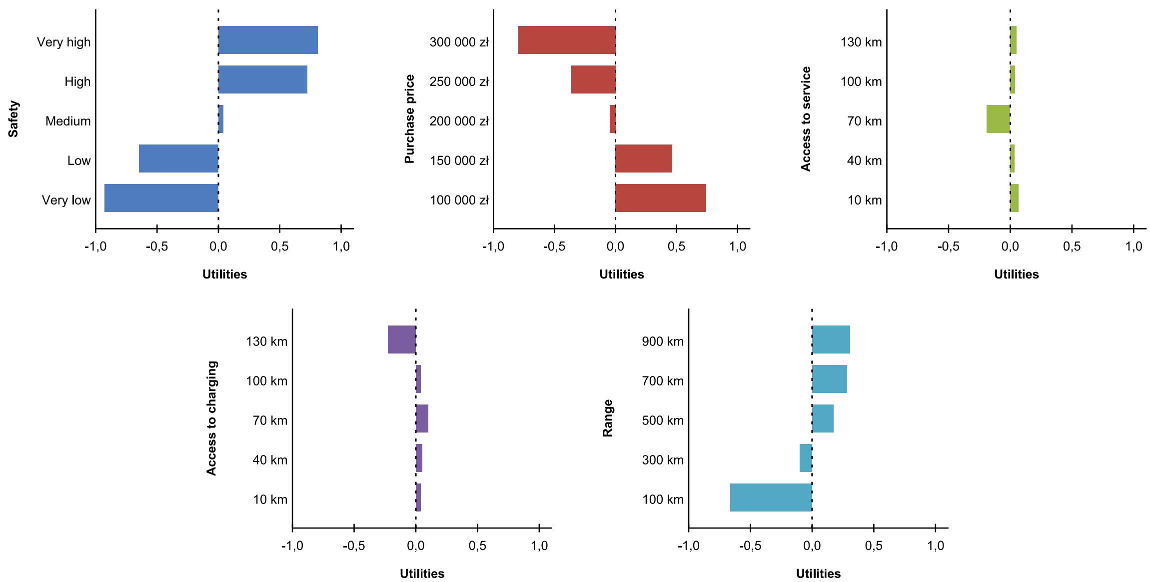

Fig. 14. Partial utilities for factors in the purchase-BEV conjoint.

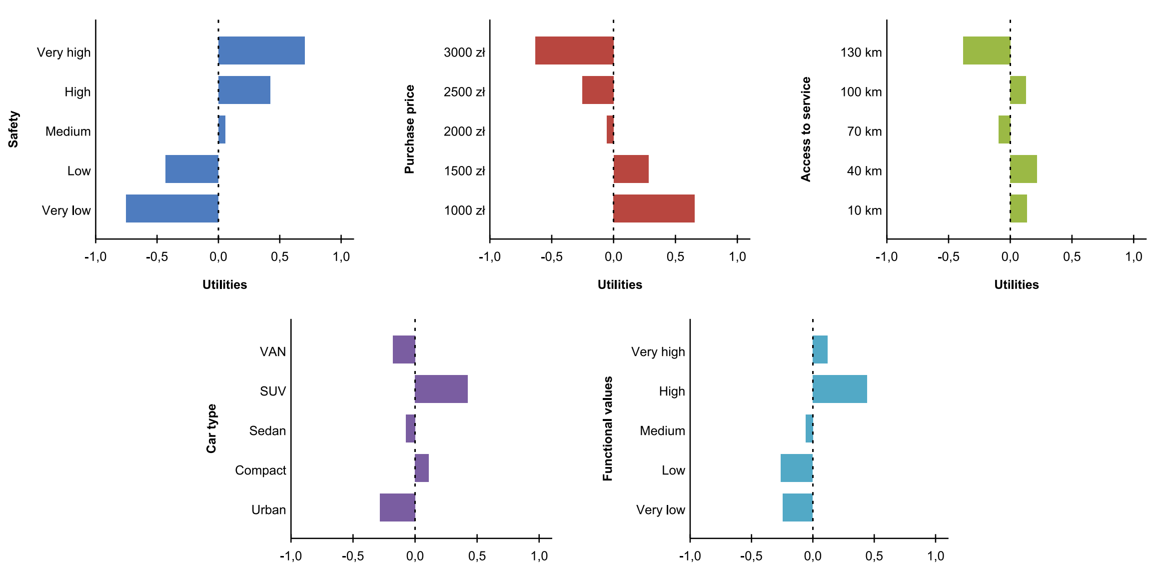

Fig. 15. Partial utilities for factors in the leasing-HEV conjoint.

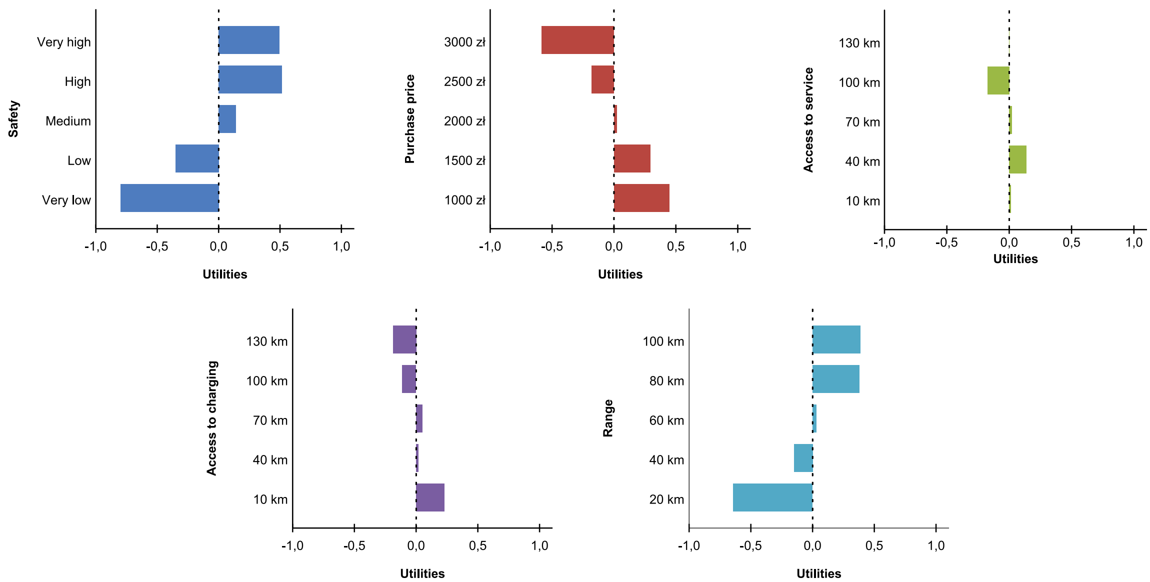

Fig. 16. Partial utilities for factors in the leasing-PHEV conjoint.

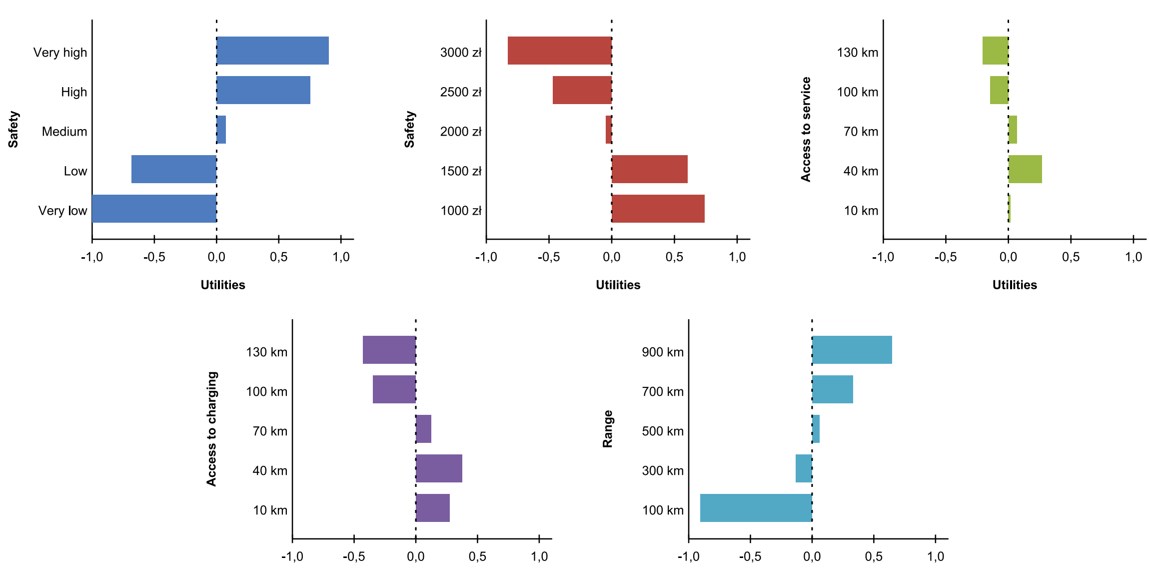

Fig. 17. Partial utilities for factors in the BEV-leasing conjoint.

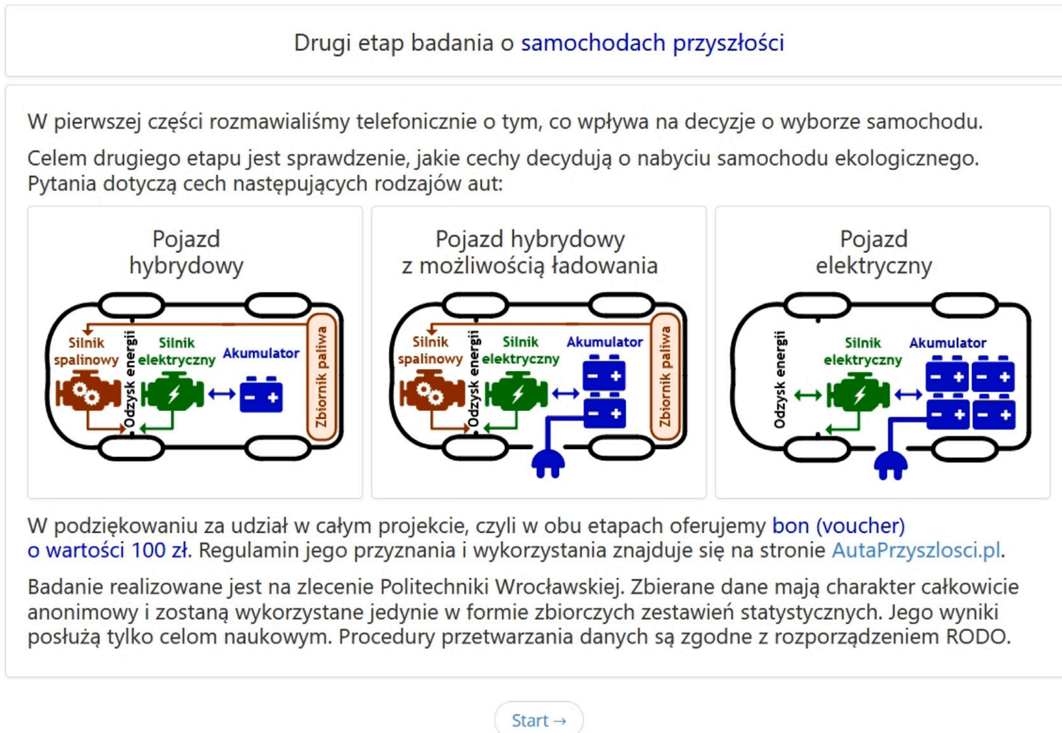

Fig. 18. Study T1 procedure — step 1 sample.

Table 16
An orthogonal plan for the purchase-PHEV conjoint type.

ID	Safety level	Access to charging	Range	Purchase price	Access to service
01	Medium	40 km	60 km	300 000 zł	70 km
02	Very high	100 km	20 km	150 000 zł	70 km
03	Very high	70 km	100 km	250 000 zł	130 km
04	Very low	70 km	60 km	150 000 zł	40 km
05	Low	100 km	40 km	200 000 zł	40 km
06	Medium	130 km	20 km	250 000 zł	40 km
07	Medium	70 km	80 km	200 000 zł	10 km
08	Very high	10 km	60 km	200 000 zł	100 km
09	Low	70 km	20 km	300 000 zł	100 km
10	Low	10 km	80 km	250 000 zł	70 km
11	Low	130 km	60 km	100 000 zł	130 km
12	Medium	10 km	40 km	150 000 zł	130 km
13	Very high	130 km	40 km	300 000 zł	10 km
14	High	10 km	100 km	300 000 zł	40 km
15	Medium	100 km	100 km	100 000 zł	100 km
16	High	70 km	40 km	100 000 zł	70 km
17	Very low	10 km	20 km	100 000 zł	10 km
18	Very high	40 km	80 km	100 000 zł	40 km
19	Very low	40 km	40 km	250 000 zł	100 km
20	High	40 km	20 km	200 000 zł	130 km
21	High	130 km	80 km	150 000 zł	100 km
22	High	100 km	60 km	250 000 zł	10 km
23	Very low	100 km	80 km	300 000 zł	130 km
24	Very low	130 km	100 km	200 000 zł	70 km
25	Low	40 km	100 km	150 000 zł	10 km

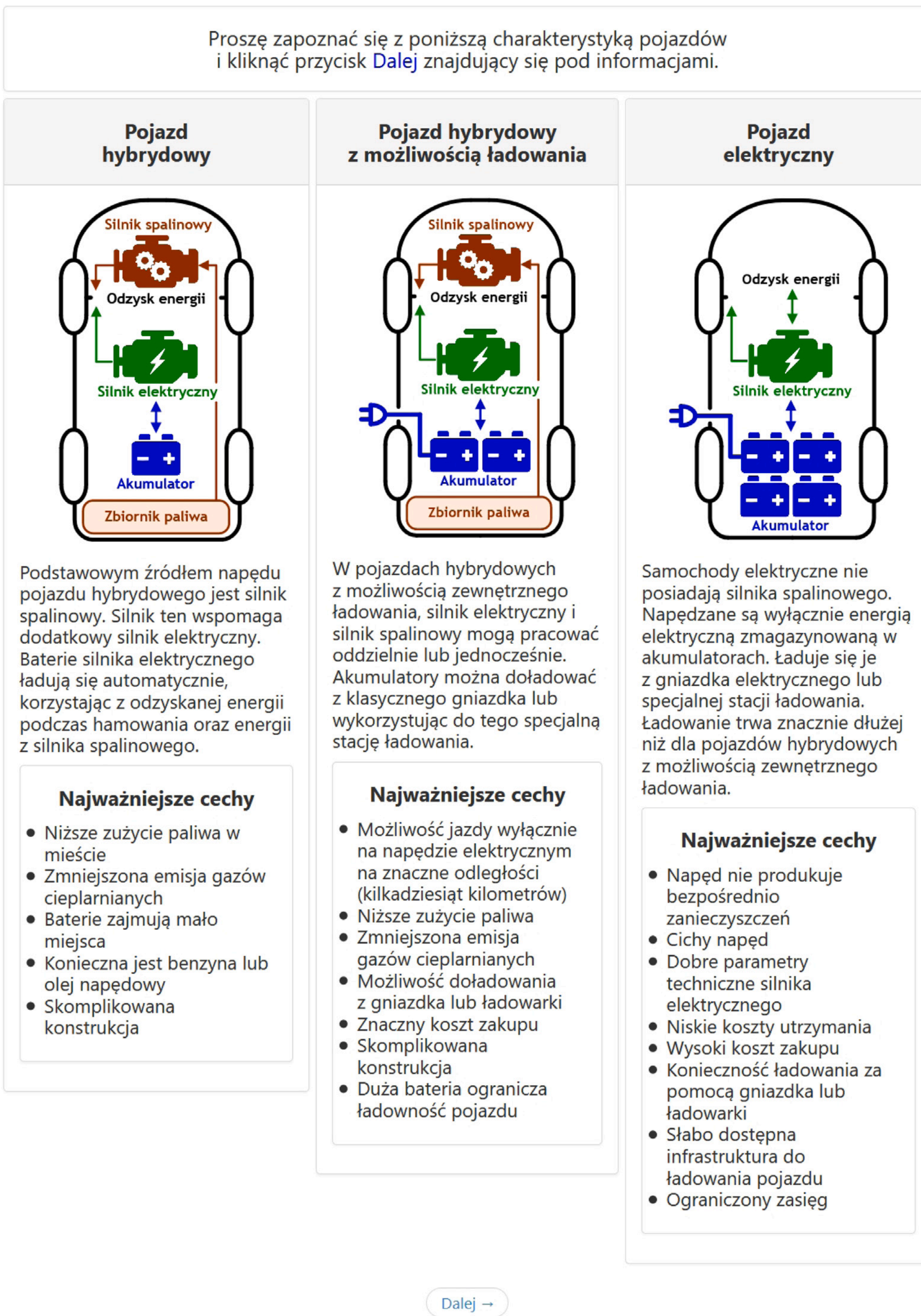

Fig. 19. Study T1 procedure — step 2 sample.

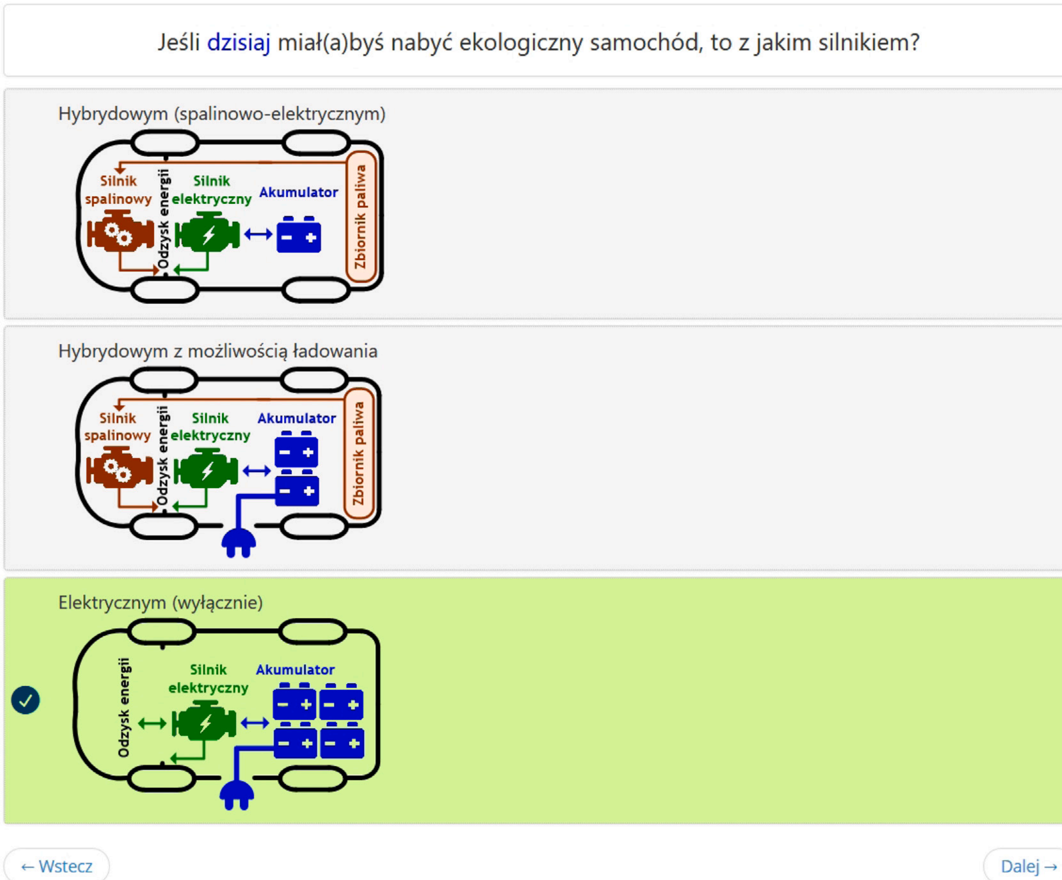

Fig. 20. Study T1 procedure — step 3 sample.

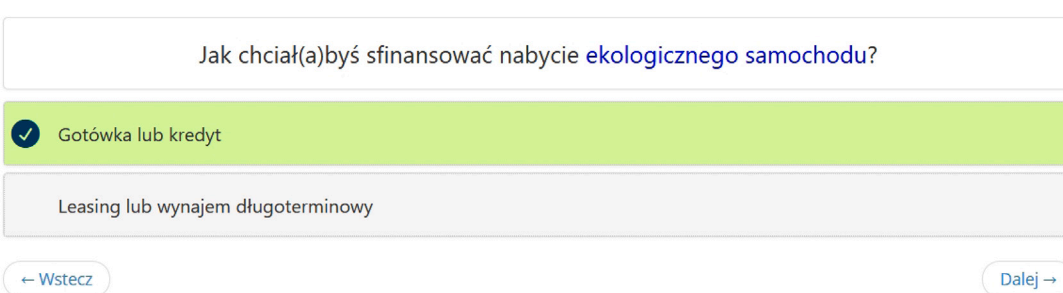

Fig. 21. Study T1 procedure — step 4 sample.

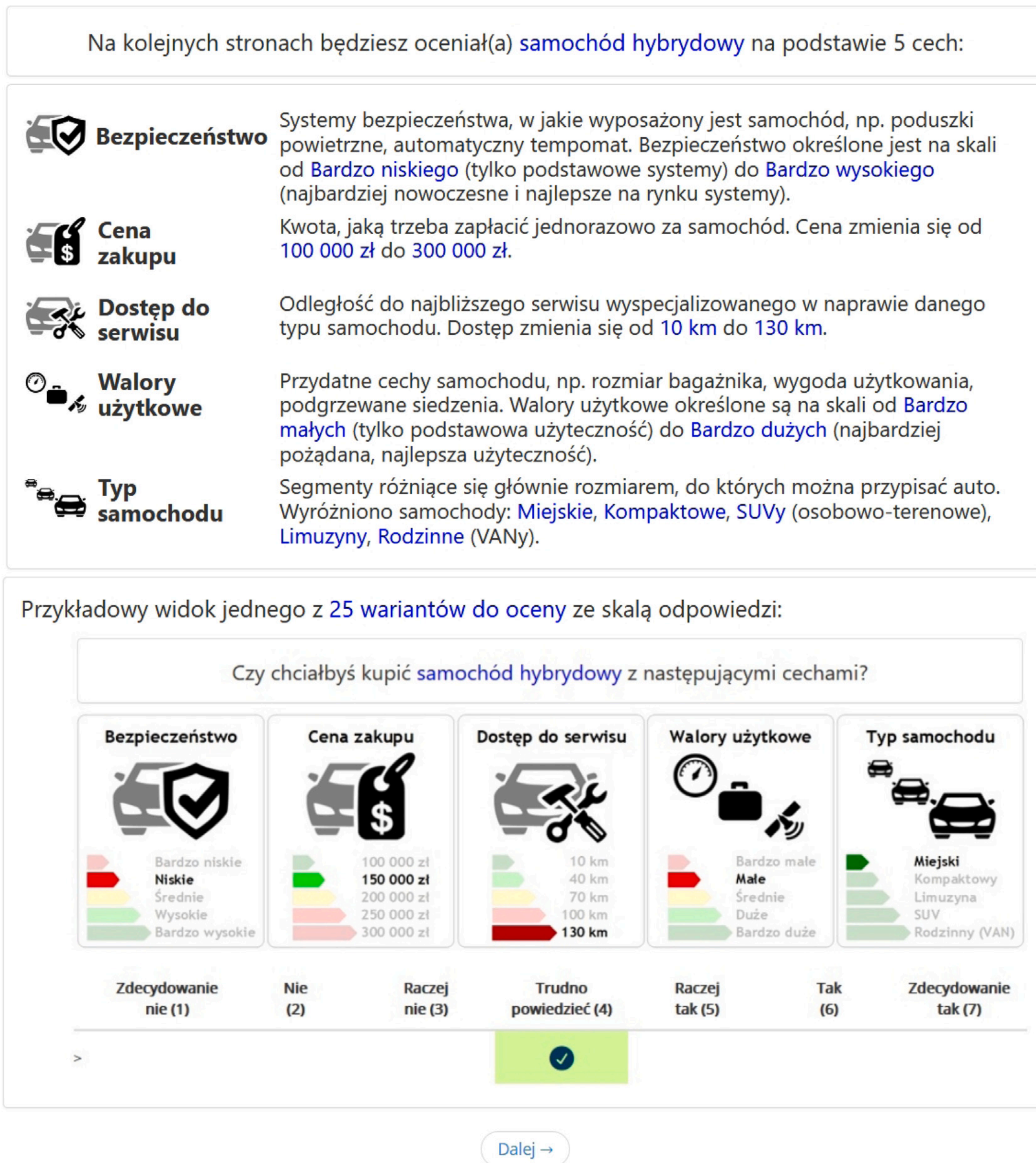

Fig. 22. Study T1 procedure — step 5 sample.

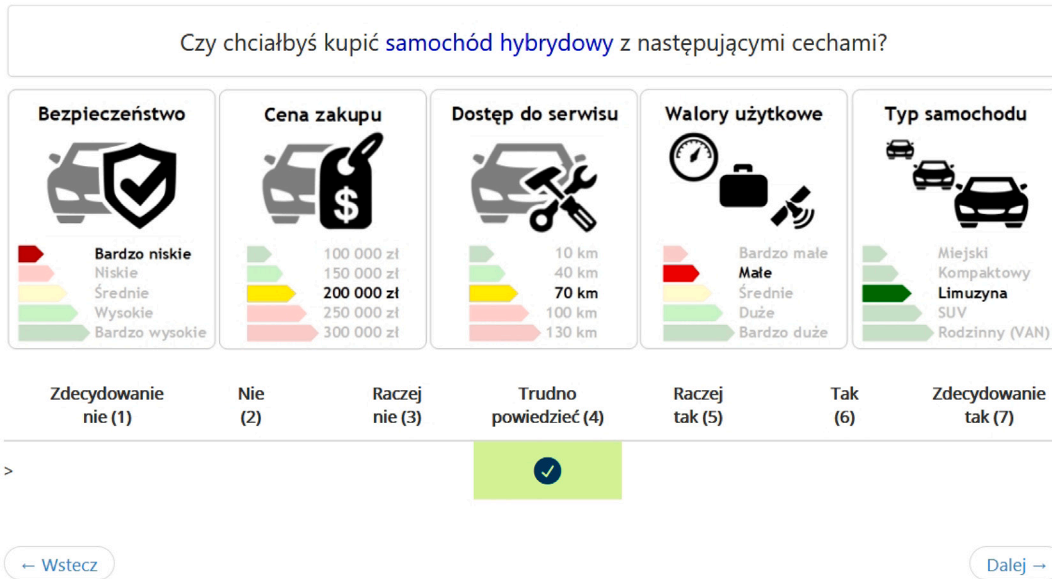

Fig. 23. Study T1 procedure — step 6 sample.

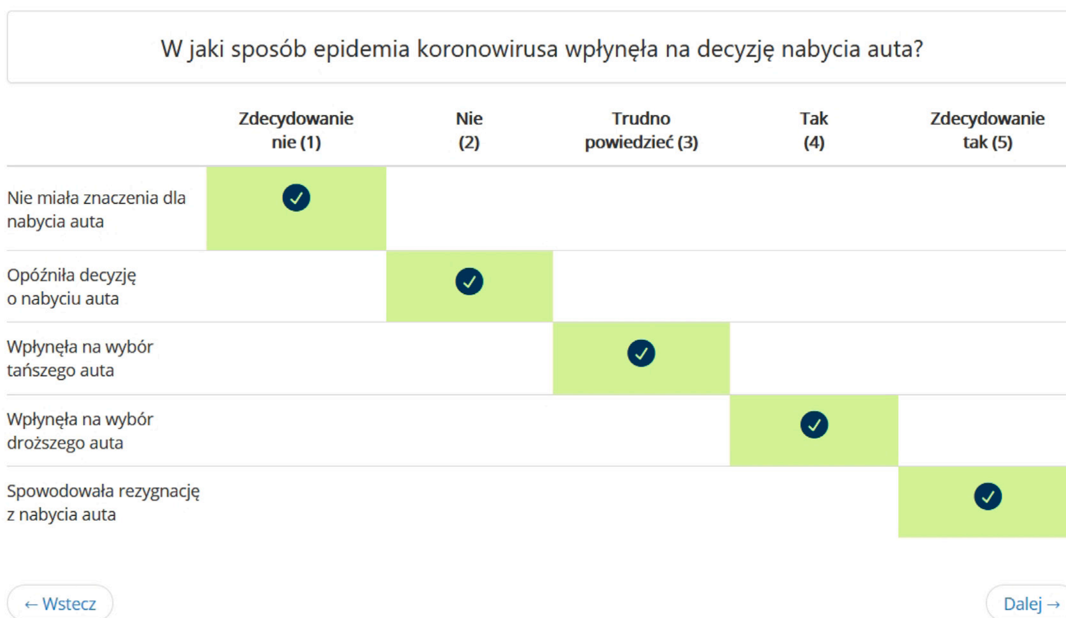

Fig. 24. Study T1 procedure — step 7 sample.

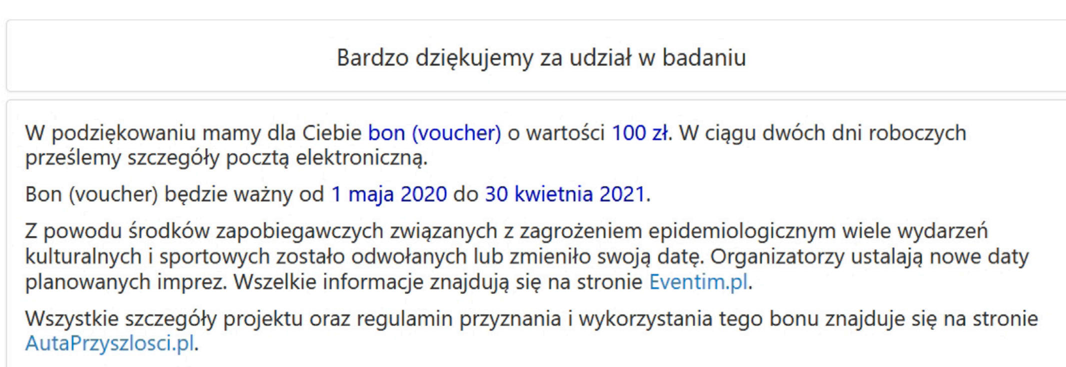

Fig. 25. Study T1 procedure — step 8 sample.

Table 17
An orthogonal plan for the purchase-BEV conjoint type.

ID	Safety level	Access to charging	Range	Purchase price	Access to service
01	Very low	100 km	500 km	250 000 zł	100 km
02	Medium	100 km	700 km	300 000 zł	40 km
03	Very high	70 km	100 km	300 000 zł	100 km
04	Very high	40 km	300 km	250 000 zł	70 km
05	High	130 km	100 km	250 000 zł	40 km
06	Low	100 km	100 km	150 000 zł	70 km
07	Low	70 km	300 km	100 000 zł	40 km
08	Very low	40 km	900 km	150 000 zł	40 km
09	Low	10 km	700 km	250 000 zł	130 km
10	Medium	10 km	300 km	150 000 zł	100 km
11	Low	40 km	500 km	300 000 zł	10 km
12	Low	130 km	900 km	200 000 zł	100 km
13	High	10 km	900 km	300 000 zł	70 km
14	High	100 km	300 km	200 000 zł	10 km
15	Very low	10 km	100 km	100 000 zł	10 km
16	Very low	70 km	700 km	200 000 zł	70 km
17	Medium	70 km	900 km	250 000 zł	10 km
18	Very high	130 km	700 km	150 000 zł	10 km
19	Very high	10 km	500 km	200 000 zł	40 km
20	Medium	130 km	500 km	100 000 zł	70 km
21	High	40 km	700 km	100 000 zł	100 km
22	Very high	100 km	900 km	100 000 zł	130 km
23	High	70 km	500 km	150 000 zł	130 km
24	Medium	40 km	100 km	200 000 zł	130 km
25	Very low	130 km	300 km	300 000 zł	130 km

Table 18
An orthogonal plan for the leasing-HEV conjoint type.

ID	Safety level	Monthly price	Access to service	Functionality level	Car type
01	Medium	3000 zł	70 km	Medium	Compact
02	Very high	1500 zł	70 km	Very low	SUV
03	Very high	2500 zł	130 km	Very high	Sedan
04	Very low	1500 zł	40 km	Medium	Sedan
05	Low	2000 zł	40 km	Low	SUV
06	Medium	2500 zł	40 km	Very low	VAN
07	Medium	2000 zł	10 km	High	Sedan
08	Very high	2000 zł	100 km	Medium	Urban
09	Low	3000 zł	100 km	Very low	Sedan
10	Low	2500 zł	70 km	High	Urban
11	Low	1000 zł	130 km	Medium	VAN
12	Medium	1500 zł	130 km	Low	Urban
13	Very high	3000 zł	10 km	Low	VAN
14	High	3000 zł	40 km	Very high	Urban
15	Medium	1000 zł	100 km	Very high	SUV
16	High	1000 zł	70 km	Low	Sedan
17	Very low	1000 zł	10 km	Very low	Urban
18	Very high	1000 zł	40 km	High	Compact
19	Very low	2500 zł	100 km	Low	Compact
20	High	2000 zł	130 km	Very low	Compact
21	High	1500 zł	100 km	High	VAN
22	High	2500 zł	10 km	Medium	SUV
23	Very low	3000 zł	130 km	High	SUV
24	Very low	2000 zł	70 km	Very high	VAN
25	Low	1500 zł	10 km	Very high	Compact

Table 19
An orthogonal plan for the leasing-PHEV conjoint type.

ID	Safety level	Access to charging	Range	Monthly price	Access to service
01	Low	10 km	100 km	1500 zł	70 km
02	Medium	10 km	80 km	2000 zł	130 km
03	Very high	70 km	100 km	2500 zł	130 km
04	Medium	100 km	20 km	2500 zł	100 km
05	High	100 km	100 km	3000 zł	10 km
06	Very low	100 km	60 km	1500 zł	130 km
07	Low	70 km	60 km	1000 zł	100 km
08	Very low	130 km	40 km	2500 zł	70 km
09	Very low	70 km	80 km	3000 zł	40 km
10	Low	130 km	20 km	3000 zł	130 km
11	Very high	100 km	80 km	1000 zł	70 km
12	High	10 km	60 km	2500 zł	40 km
13	Very low	10 km	20 km	1000 zł	10 km
14	Very high	10 km	40 km	3000 zł	100 km
15	Very low	40 km	100 km	2000 zł	100 km
16	High	40 km	40 km	1000 zł	130 km
17	Medium	40 km	60 km	3000 zł	70 km
18	Low	40 km	80 km	2500 zł	10 km
19	Medium	130 km	100 km	1000 zł	40 km
20	Very high	130 km	60 km	2000 zł	10 km
21	Very high	40 km	20 km	1500 zł	40 km
22	High	130 km	80 km	1500 zł	100 km
23	Medium	70 km	40 km	1500 zł	10 km
24	High	70 km	20 km	2000 zł	70 km
25	Low	100 km	40 km	2000 zł	40 km

Table 20
An orthogonal plan for the leasing-BEV conjoint type.

ID	Safety level	Access to charging	Range	Monthly price	Access to service
01	High	70 km	900 km	1000 zł	70 km
02	High	130 km	100 km	2500 zł	40 km
03	Medium	130 km	900 km	3000 zł	10 km
04	High	10 km	700 km	2000 zł	100 km
05	Low	40 km	900 km	2500 zł	100 km
06	Medium	100 km	300 km	1000 zł	100 km
07	Medium	40 km	100 km	2000 zł	130 km
08	Low	130 km	700 km	1000 zł	130 km
09	Low	10 km	300 km	3000 zł	40 km
10	Very high	100 km	700 km	2500 zł	10 km
11	High	100 km	500 km	3000 zł	130 km
12	Very high	40 km	500 km	1000 zł	40 km
13	Low	70 km	500 km	2000 zł	10 km
14	Low	100 km	100 km	1500 zł	70 km
15	High	40 km	300 km	1500 zł	10 km
16	Very low	70 km	300 km	2500 zł	130 km
17	Very low	130 km	500 km	1500 zł	100 km
18	Medium	10 km	500 km	2500 zł	70 km
19	Medium	70 km	700 km	1500 zł	40 km
20	Very high	70 km	100 km	3000 zł	100 km
21	Very low	40 km	700 km	3000 zł	70 km
22	Very low	100 km	900 km	2000 zł	40 km
23	Very high	130 km	300 km	2000 zł	70 km
24	Very low	10 km	100 km	1000 zł	10 km
25	Very high	10 km	900 km	1500 zł	130 km

References

[1] Mazza S, Aiello D, Macario A, De Luca P. Vehicular emission: Estimate of air pollutants to guide local political choices. a case study. Environments 2020;7:37.

[2] Czakon W, Niemand T, Gast J, Kraus S, Frühstück L. Designing competition for radical innovation: An experimental study of managers' preferences for developing self-driving electric cars. Technol Forecast Soc Change 2020;155:119992. http://dx.doi.org/10.1016/j.techfore.2020.119992.

[3] Long Z, Axsen J, Kormos C, Goldberg S. Latent demand for zero-emissions vehicles in Canada (part 1): Insights from a design space exercise. Transp Res D 2019;67:51–66.

[4] Kormos C, Axsen J, Long Z, Goldberg S. Latent demand for zero-emissions vehicles in Canada (part 2): Insights from a stated choice experiment. Transp Res D 2019;67:685–702.

[5] Kowalska-Pyzalska A, Kott M, Kott J. How much consumers know about alternative fuel vehicles. Impact of knowledge on the willingness to buy. Energies 2021;14:1438.

[6] Kowalska-Pyzalska A, Kott J, Kott M. Why polish market of alternative fuel vehicles (AFVs) is the smallest in europe? SWOT analysis of opportunities and threats. Renew Sustain Energy Rev 2020;133:110076.

[7] Skowrońska-Szmer A, Kowalska-Pyzalska A. Key factors of development of electromobility among microentrepreneurs: A case study from Poland. Energies 2021;14:764.

[8] EDP. Electromobility development plan in Poland: Energy for the future. Council of ministers 16th march 2017. 2017.

[9] ACEA. European automobile manufacturers' association, report vehicles in use: Europe 2019. 2020, https://www.acea.be/publications, [Accessed January 2021].

[10] Axsen J, Langman B, Goldberg S. Confusion of innovations: Mainstream consumer perceptions and misperceptions of electric-drive vehicles and charging programs in Canada. Energy Res Soc Sci 2017;27:163–73.

[11] Melton N, Axsen J, Goldberg S. Evaluating plug-in electric vehicle policies in the context of long-term greenhouse gas reduction goals: Comparing 10 Canadian provinces using the "PEV policy report card". Energy Policy 2017;107:381–93.

[12] Jin J, Slowik P. Literature review of electric vehicle consumer awareness and outreach activities. Working paper for the international council of clean transportation. 2017.

[13] Romejko K, Nakano M. Portfolio analysis of alternative fuel vehicles considering technological advancement, energy security and policy. J Cleaner Prod 2017;142:39–49.

[14] Raslavicius L, Azzopardi B, Kersys A, Starevicius M, Bazaras Z, Makaras R. Electric vehicle challenges and opportunities: Lithuanian review. Renew Sustain Energy Rev 2015;42:786–800.

[15] Luce RD, Tukey JW. Simultaneous conjoint measurement: A new type of fundamental measurement. J Math Psych 1964;1(1):1–27. http://dx.doi.org/10.1016/0022-2496(64)90015-X.

[16] Krantz D, Tversky A. Conjoint-measurement analysis of composition rules in psychology. Psychol Rev 1971;78(2):151–69. http://dx.doi.org/10.1037/h0030637.

[17] Cattin P, Wittink DR. Commercial use of conjoint analysis: A survey. J Mark 1982;46(3):44–53. http://dx.doi.org/10.2307/1251701.

[18] Green P, Krieger A, Wind Y. Thirty years of conjoint analysis: Reflections and prospects. In: Wind Y, Green P, editors. Marketing research and modeling: Progress and prospects: A tribute to Paul E. Green. International series in quantitative marketing, Springer US; 2004, p. 117–39. http://dx.doi.org/10.1007/978-0-387-28692-1_6.

[19] Grobelny J, Michalski R. Various approaches to a human preference analysis in a digital signage display design. Hum Factors Erg Manuf Serv Ind 2011;21(6):529–42. http://dx.doi.org/10.1002/hfm.20295.

[20] Grobelny J, Michalski R. The role of background color, interletter spacing, and font size on preferences in the digital presentation of a product. Comput Hum Behav 2015;43(6):85–100. http://dx.doi.org/10.1016/j.chb.2014.10.036.

[21] Alriksson S, Öberg T. Conjoint analysis for environmental evaluation: A review of methods and applications. Environ Sci Pollut Res 2008;15(3):244–57. http://dx.doi.org/10.1065/espr2008.02.479.

[22] Mishima K, Nishimura H. Requirement analysis to promote small-sized E-waste collection from consumers. Waste Manag Res 2016;34(2):122–8. http://dx.doi.org/10.1177/0734242X15615424.

[23] Flood EM, Ryan KJ, Rousculp MD, Beusterien KM, Divino VM, Block SL, et al. Parent preferences for pediatric influenza vaccine attributes:. Clin Pediatr 2010;50(4):338–47. http://dx.doi.org/10.1177/0009922810391247.

[24] Gurtner S, Hietschold N, Vaquero Martín M. Do patients value a hospital's innovativeness reputation? A multi-method approach to assess the relative importance of innovativeness reputation in patients' hospital choice. Health Ser Manag Res 2018;31(3):138–53. http://dx.doi.org/10.1177/0951484817748157.

[25] Weernink MGM, Til JAv, Witteman HO, Fraenkel L, IJzerman MJ. Individual value clarification methods based on conjoint analysis: A systematic review of common practice in task design, statistical analysis, and presentation of results:. Med Decis Making 2018;38(6):746–55. http://dx.doi.org/10.1177/0272989X18765185.

[26] Kim SS, Chung JY, Petrick J, Park JW. Determination of preferred performing arts tourism products using conjoint analysis. J Vacat Mark 2018;24(1):44–61. http://dx.doi.org/10.1177/1356766716679484.

[27] Eriksson N, Fagerstrøm A. The relative impact of Wi-Fi service on Young consumers' hotel booking online. J Hosp Tour Res 2018;42(7):1152–69. http://dx.doi.org/10.1177/1096348017696844.

[28] Yang S, Shin S, Joun Y, Koo C. Exploring the comparative importance of online hotel reviews' heuristic attributes in review helpfulness: a conjoint analysis approach. J Travel Tour Mark 2017;34(7):963–85. http://dx.doi.org/10.1080/10548408.2016.1251872.

[29] Lima Filho T, Della Lucia SM, Lima RM, Minim VPR. Conjoint analysis as a tool to identify improvements in the packaging for irradiated strawberries. Food Res Int 2015;72:126–32. http://dx.doi.org/10.1016/j.foodres.2015.03.023.

[30] Tekień A, Gutkowska K, Żakowska-Biemans S, Jóźwik A, Krotki M. Using cluster analysis and choice-based conjoint in research on consumers preferences towards animal origin food products. Theoretical review, results and recommendations. Animal Sci Pap Rep 2018;36(2):171–84.

[31] Sulistyawati I, Dekker M, Verkerk R, Steenbekkers B. Consumer preference for dried mango attributes: A conjoint study among Dutch, Chinese, and Indonesian consumers. J Food Sci 2020;85(10):3527–35. http://dx.doi.org/10.1111/1750-3841.15439.

[32] Anabtawi O, Swift JA, Hemmings S, Gertson L, Raaff C. Perceived healthiness of food items and the traffic light front of pack nutrition labelling: choice-based conjoint analysis and cross-sectional survey. J Hum Nutr Diet 2020;33(4):487–95. http://dx.doi.org/10.1111/jhn.12741.

[33] Myung R. Conjoint analysis as a new methodology for Korean typography guideline in web environment. Int J Ind Ergon 2003;32(5):341–8. http://dx.doi.org/10.1016/S0169-8141(03)00074-X.

[34] Michalski R. Examining users' preferences towards vertical graphical toolbars in simple search and point tasks. Comput Hum Behav 2011;27(6):2308–21. http://dx.doi.org/10.1016/j.chb.2011.07.010.

[35] Kim S-H, Jang W-S, Kim H-S, Chung H-S, Kim Y-D, Lee W-J, et al. Ergonomic design of target symbols for fighter aircraft cockpit displays based on usability evaluation. In: Stephanidis C, editor. HCI International 2018 – Posters extended abstracts. Communications in computer and information science, Springer International Publishing; 2018, p. 176–82. http://dx.doi.org/10.1007/978-3-319-92270-6_24.

[36] Michalski R, Staniów M. Subjective preferences towards various conditions of self-administered questionnaires: AHP and conjoint analyses. In: Marcus A, Wang W, editors. Design, user experience, and usability: Theory and practice. Lecture notes in computer science, Springer International Publishing; 2018, p. 439–50. http://dx.doi.org/10.1007/978-3-319-91797-9_32.

[37] Green P, Srinivasan V. Conjoint analysis in consumer research: Issues and outlook. J Consum Res 1978;5(2):103–23. http://dx.doi.org/10.1086/208721.

[38] Green P, Srinivasan V. Conjoint analysis in marketing: New developments with implications for research and practice. J Mark 1990;54(4):3–19. http://dx.doi.org/10.2307/1251756.

[39] Lohrke FT, Holloway BB, Woolley TW. Conjoint analysis in entrepreneurship research: A review and research agenda. Organ Res Methods 2009;13(1):16–30. http://dx.doi.org/10.1177/1094428109341992.

[40] Agarwal J, DeSarbo WS, Malhotra NK, Rao VR. An interdisciplinary review of research in conjoint analysis: Recent developments and directions for future research. Cust Needs Solut 2015;2(1):19–40. http://dx.doi.org/10.1007/s40547-014-0029-5.

[41] Graham R. Comparing the benefits and impacts of hybrid electric vehicle options. 2001, Publisher: ERPI, 2000439, 264.

[42] Ahn J, Jeong G, Kim Y. A forecast of household ownership and use of alternative fuel vehicles: A multiple discrete-continuous choice approach. Energy Econ 2008;30(5):2091–104. http://dx.doi.org/10.1016/j.eneco.2007.10.003.

[43] Kudoh Y, Motose R. Changes of Japanese consumer preference for electric vehicles. World Electr Veh J 2010;4(4):880–9. http://dx.doi.org/10.3390/wevj4040880.

[44] Orbach Y, Fruchter GE. Forecasting sales and product evolution: The case of the hybrid/electric car. Technol Forecast Soc Change 2011;78(7):1210–26. http://dx.doi.org/10.1016/j.techfore.2011.03.018.

[45] Eggers F, Eggers F. Where have all the flowers gone? Forecasting green trends in the automobile industry with a choice-based conjoint adoption model. Technol Forecast Soc Change 2011;78(1):51–62. http://dx.doi.org/10.1016/j.techfore.2010.06.014.

[46] Bohnsack R, Van den Hoed R, Oude Reimer H. Deriving vehicle-to-grid business models from consumer preferences. World Electr Veh J 2015;7(4):621–30. http://dx.doi.org/10.3390/wevj7040621.

[47] Bennett R, Kottasz R, Shaw S. Factors potentially affecting the successful promotion of electric vehicles. J Soc Mark 2016;6(1):62–82. http://dx.doi.org/10.1108/JSOCM-08-2015-0059.

[48] Rudolph C. How may incentives for electric cars affect purchase decisions? Transp Policy 2016;52:113–20. http://dx.doi.org/10.1016/j.tranpol.2016.07.014.

[49] Khan N, Fatmi M, Habib M. Type choice behavior of alternative fuel vehicles: A latent class model approach. In: World Conference on Transport Research, 25, 2017, p. 3299–313. http://dx.doi.org/10.1016/j.trpro.2017.05.188.

[50] Muslim E, Moch BN, Lestari RA, Shabrina G, Ramardhiani R. Ergonomic design of electric vehicle instrument panel: a study case on universitas Indonesia's national electric car. IOP Conf Ser Mater Sci Eng 2019;508(1):012109. http://dx.doi.org/10.1088/1757-899X/508/1/012109, Publisher: IOP Publishing.

[51] Philipsen R, Haverkämper I, Biermann H, Brell T, Ziefle M. Semi-charmed life - willingness to use and related contributing factors regarding semi-public charging infrastructure for electric cars. In: Stanton N, editor. Advances in human aspects of transportation. Advances in intelligent systems and computing, Springer International Publishing; 2020, p. 340–53. http://dx.doi.org/10.1007/978-3-030-50943-9_43.

[52] Ferguson M, Mohamed M, Higgins C, Abotalebi E, P. K. How open are Canadian households to electric vehicles? A national latent class choice analysis with willingness-to-pay and metropolitan characterization. Transp Res D 2018;58:208–24.

[53] Potoglou D, Kanaroglou P. Household demand and willingness to pay for clean vehicles. Transp Res D 2017;12:264–74.

[54] Hackbarth A, Madlener R. Consumer preferences for alternative fuel vehicles: A discrete choice analysis. Trans Res D 2013;25:5–17. http://dx.doi.org/10.1016/j.trd.2013.07.002.

[55] Axsen J, Bailey J, Castro M. Preference and lifestyle heterogeneity among potential plug-in electric vehicle buyers. Energy Econ 2015;50:190–201.

[56] Long Z, Axsen J, Kormos C. Consumers continue to be confused about electric vehicles: comparing awareness among Canadian new car buyers in 2013 and 2017. Environ Res Lett 2019;14:1–11.

[57] Anable J, Skippon S. Who will adopt electric vehicles? A segmentation approach of UK consumers. 2011, European Council for an Energy Efficient Economy 2011, Energy Efficiency First: The foundation of a low-carbon society, 1015–1026.

[58] Wang F, Yu J, Yang P, Miao L, Ye B. Analysis of the barriers to widespread adoption of electric vehicles in Shenzhen China. Sustainability 2017;9:522.

[59] Kurani K, Caparello N, TyreeHageman J. New car buyers' valuation of zero-emission vehicles: California. 2016, Plug-in Hybrid & Electric Vehicle Center, Institute of Transportation Studies, University of California, Davis.

[60] Fanchao L, Molin E, van Wee B. Consumer preferences for electric vehicles: a literature review. Transp Rev 2017;27:252–75.

[61] ACEA. ACEA - Press releases 4.02.2021-new passenger car registrations in the EU by alternative fuel type. 2021, European Automobile Manufacturers' Association, https://www.acea.be//, [Accessed May 2021].

[62] Eurostat. Road transport infrastructure. 2020, https://ec.europa.eu/eurostat/data/[Accessed January 2021].

[63] Eurostat. Road transport equipment. 2020, https://ec.europa.eu/eurostat/data[Accessed January 2021].

[64] ACEA. European automobile manufacturers' association, pocket guide 2019–2020. 2020, https://www.acea.be/publications, [Accessed January 2021].

[65] ACEA. European automobile manufacturers' association, making the transition to zero-emission mobility - 2020 progress report. 2020, https://www.acea.be/publications, [Accessed January 2021].

[66] SAMAR. Ranking TOP 50. 2020, Automotive Market Research Institute SAMAR, https://www.samar.pl/ [Accessed January 2021].

[67] PSPA. Polish alternative fuels association: Polish E-mobility index. 2020, http://pspa.com.pl/en/ [Accessed January 2021].

[68] Renault. Renault Zoe catalogue. 2019, https://cdn.group.renault.com/ren/pl/.

[69] VW. Vw up! prices list. 2019, http://cenniki.konfigurator-vw.pl/.

[70] Opel. Opel corsa-e catalogue and prices list. 2019, https://www.opel.pl/.

[71] Peugot. Peugeot 208e prices list. 2019, https://media.peugeot.pl/.

[72] Smart. Smart EQ for two: Catalogue and prices list. 2019, https://www.smart.com/pl/pl/.

[73] Smart. Smart EQ for four: Catalogue and prices list. 2019, https://www.smart.com/pl/.

[74] Skoda. Skoda CITIGOe iV catalogue and prices list. 2019, https://az749841.vo.msecnd.net/.

[75] Nissan. Nissan LEAF catalogue and prices list. 2019, https://www-europe.nissan-cdn.net/.

[76] Wisniewski J, Kania A, Witkowski L, Pieriegud J, Zawieska J. Raport Barometr Nowej Mobilnosci 2019/20 (in Polish). 2019, p. 84, https://pspa.com.pl/assets/uploads/2020/01/barometr_nowej_mobilnosci_2019_raport_S.pdf [Accessed July 2020].

[77] ElectroMobility. The home page of the electromobility SA company. 2021, AccessedJanuary2021.

[78] Long Z, Axsen J, Miller I, Kormos C. What does Tesla mean to car buyers? Exploring the role of automotive brand in perceptions of battery electric vehicles. Transp Res A 2019;129:85–204.

[79] Hu X, Zou C, Tang X, Liu T, Hu L. Cost-optimal energy management of hybrid electric vehicles using fuel cell/battery health-aware predictive control. IEEE Trans Power Electron 2020;35(1):382–92.