# Pro-Ecological Energy Attitudes towards Renewable Energy Investments before the Pandemic and European Energy Crisis: A Segmentation-Based Approach

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**Abstract:** The household as the primary decision-making unit is founded on classical and neoclassical economics. However, household behaviour changes have been noticeable in the last decade, moving towards more green and sustainable patterns, which have been pronounced in EU countries striving for a more significant share of renewable energy sources (RES) in energy consumption. These behaviours can be attributed to sustainable economics and are an essential part of energy transformation, as they are focused on pro-ecological attitudes, considering both financial activities and those related to caring for the environment and future generations. This article aims to segment energy consumers and to determine what attitudes prevailed in the selected segments and to what extent consumers were pro-ecologically oriented when making decisions regarding RES management before the pandemic and the energy crisis outbreak in Europe. We propose a three-segment model for archetyping household energy consumers in Poland by considering the following groups of factors: environmental and energy goods protection (F1), the mirror effect (F2), and energy and devices profitability (F3). The segments are distinguished based on factor analysis and the fuzzy $c$-means method. The number of segments is determined based on the cluster validity measure. The presented results prove that the F1 factor plays the leading role in each segment. The percentage of positive responses for each segment, including a migrating group of households, oscillates over 80%. It gives strong hope for retaining sustainable attitudes regardless of the pandemic and energy crisis that occurred in 2022 in the EU.

**Keywords:** households; renewable energy sources; energy attitudes; fuzzy segmentation; fuzzy $c$-means; energy behaviour; energy and pandemic crisis
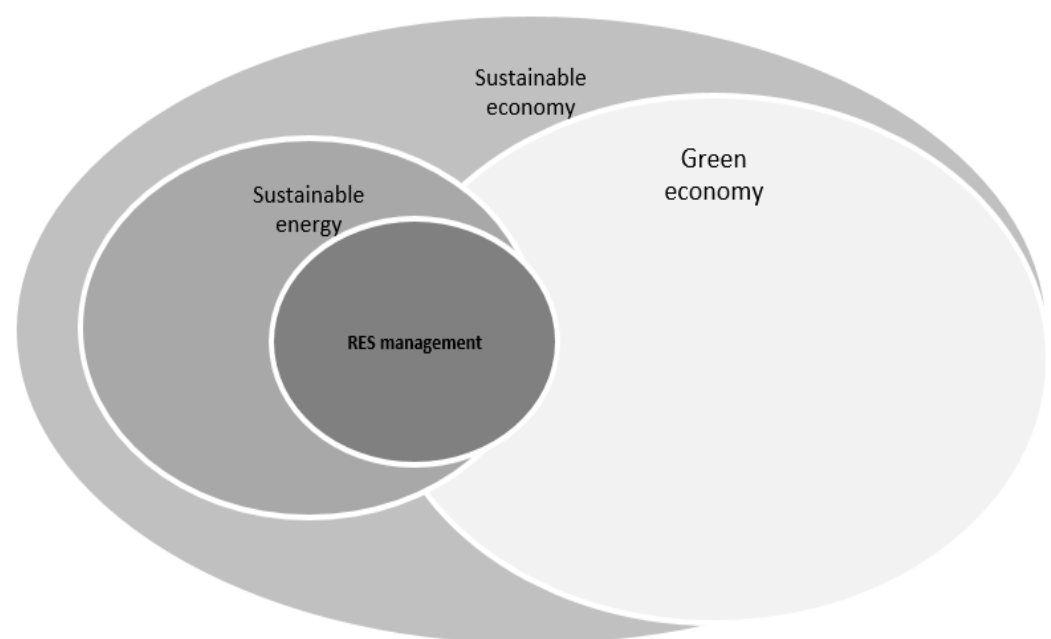
## 1. Introduction

The household is one of the individual decision-making units in economics [1] (pp. 1–2) [2] (pp. 84–85). Its decisions about what needs to satisfy and what goods to choose are important in energy management. Specific beliefs guide households in their actions and decisions, motives, and principles. On the one hand, they can be of an economic nature but also be related to tradition, habit, acquired knowledge, and ecological awareness. Consumers also appreciate other factors, such as air quality, environmental protection, and energy security. Domestic energy consumption research usually concerns behavioural patterns coupled with household profiles and archetypes [3–6]. Most of them analyse energy efficiency and energy-saving behaviours, taking into account socio-demographic variables and psychological variables in relation to household energy use and changes in

energy use [7–11]. Another rarely seen research trend concerns behavioural biases [12,13] and the attitudes–action gap of energy consumer behaviours [5].

This paper indicates three factors in the RES (renewable energy sources) decision-making process: environmental and energy goods protection, the mirror effect, and energy and devices profitability. The selected factors fill the existing research gap by considering research on household behaviours in the energy market; at the same time, they concern three factors related to environmental, financial, and special demand effects that have not been investigated. These three groups of factors that are connected to environmental issues, special demand effects, and energy goods profitability reflect a new concept of human behaviour named homo energeticus. This concept was created and more widely discussed by A.M. Graczyk [14]. Homo energeticus is an economic man involved in energy management who is compatible with the present economic, environmental, and social problems, particularly with the operationalisation needs of the sustainable development idea. The concept belongs to the school of sustainable economics [15–17]. It considers the variety of value systems associated with market choices and the psychosocial determinants of behaviour (behavioural economics [18–23]).

In accordance with the Polish National Science Centre classification [24], sustainable economics not only comprises issues in such areas as sustainable development, micro and macroeconomics (including consumption and consumer behaviour), institutional economics, behavioural economics, public management, social infrastructure, public administration, life conditions and life quality, income, and poverty, but also international economics, urban planning, and spatial planning. Concepts discussed in this paper are interdisciplinary in character.

Sustainable economics describes one of the sectors of sustainable management (see Figure 1). As such, it applies mainly (but without limitation) to green energy technologies; these also include low-emission technologies and those with higher environmental standards, such as the utilisation of residual and waste heat or the conversion of electric power from wind installations to gas or heat. RES is an indispensable element of the modern approach to sustainable consumption and sustainable energy production, utilising environmentally friendly sources to support effective economic and social development. This process occurs within the framework of both sustainable energy and green economy (as a shared element and a subset of each of the above categories).



**Figure 1.** Sustainable economy relations.

The object of this research is an average Lower Silesian household [25], defined in Polish law as a physical person maintaining himself/herself independently (a single-person household) or as a physical person together with related or unrelated persons who combine to occupy and jointly maintain a single housing unit (a multi-person household).

According to the current statistical data (2 June 2022), there were 15 million households in Poland as per the end of 2020 [26]. The results of the National Population and Housing Census 2021 indicate that there were 15,227,927 apartments in Poland (13,495,377 in 2011). Flats were located in 6,806,910 buildings, and their number in 2021 increased by 759,818, i.e., by 12.6%. More dwellings were in multi-family buildings (8,609,900) than in single-family buildings (6,681,600). More than 60% of places' total usable floor space, i.e., 696,662,100 m$^2$, belonged to dwellings in single-family buildings. In 2021, in the area of Lower Silesia, there were 436,784 buildings [27].

Our study was based on surveys taken in the Lower Silesia region (Dolnośląskie voivodship), ranked fourth in the number of households per region in Poland [26]. Taking into account the recent inflow of Ukrainian migrants in 2022, the region's capital city of Wroclaw can be ranked as the third largest municipality in Poland, with a population of 892 thousand [28] (p. 15). Electric energy consumption in Lower Silesia households is ranked second (for rural areas) and third (for municipal areas) [29] (see Figure 2).
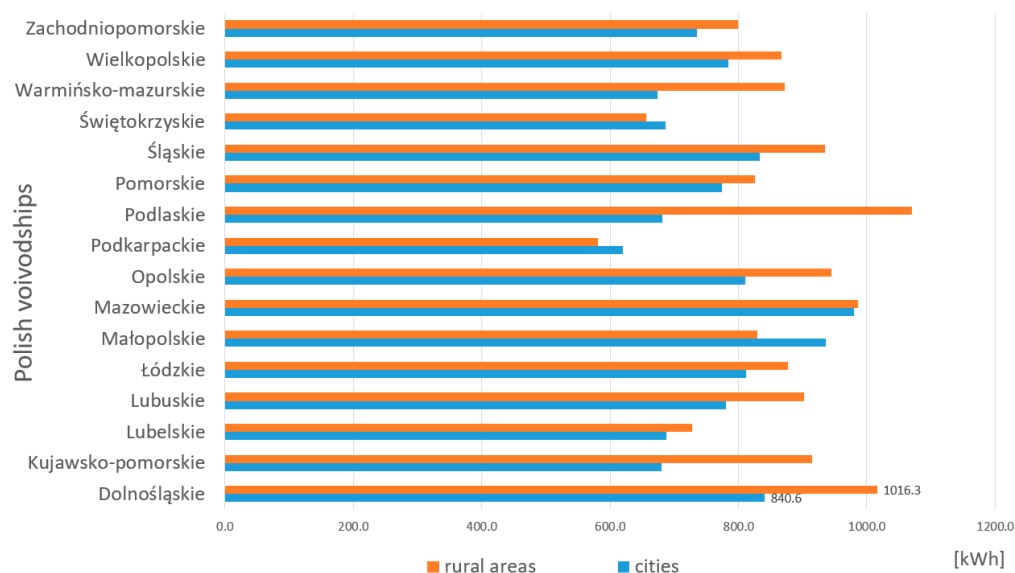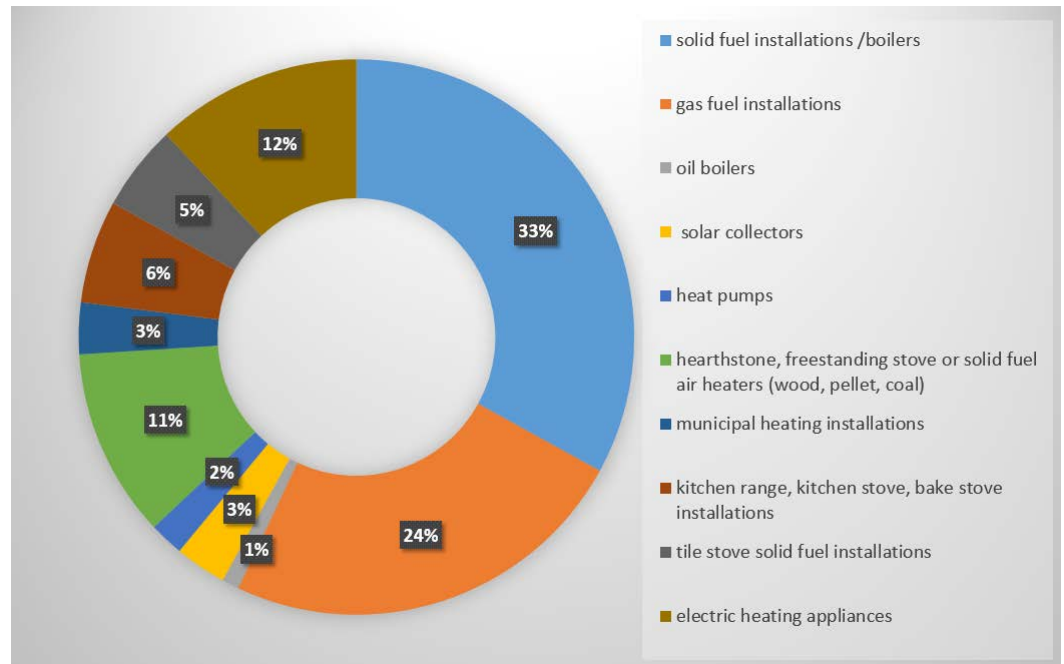


**Figure 2.** Electricity consumption in households per capita in 2021 [29].

Figure 3 concerns equipping buildings with heating installations in Poland. It is worth noting that only about 3% of buildings are supplied with district heating, and 40.4% of households have such a heat source (these households are located in multi-apartment buildings connected to the communal heating network). Individual families cannot decide to change the method of heating. The administrators of such buildings can do this, sometimes representing hundreds of households in such buildings. On the other hand, in the remaining buildings—most often occupied by only one or two households—power sources are varied. This differentiation determines the structure of heating installations, as shown in Figure 3. The structure and distribution of main heating sources in Polish households comprises the following [30]:

- 33% solid fuel installations (coal and carbon-based fuels, wood chunks and chips, pellets, and other biomass sources) burned in solid fuel boilers with manual or automatic feeders;
- 24% gas fuel installations;
- 1% oil boilers;
- 3% solar collectors;

- 2% heat pump installations;
- 11% hearthstones, freestanding stoves or solid fuel air heaters (wood, pellets, and coal);
- 3% municipal heating installations;
- 6% kitchen range, kitchen stove, and bake stove installations;
- 5% tile stove solid fuel installations;
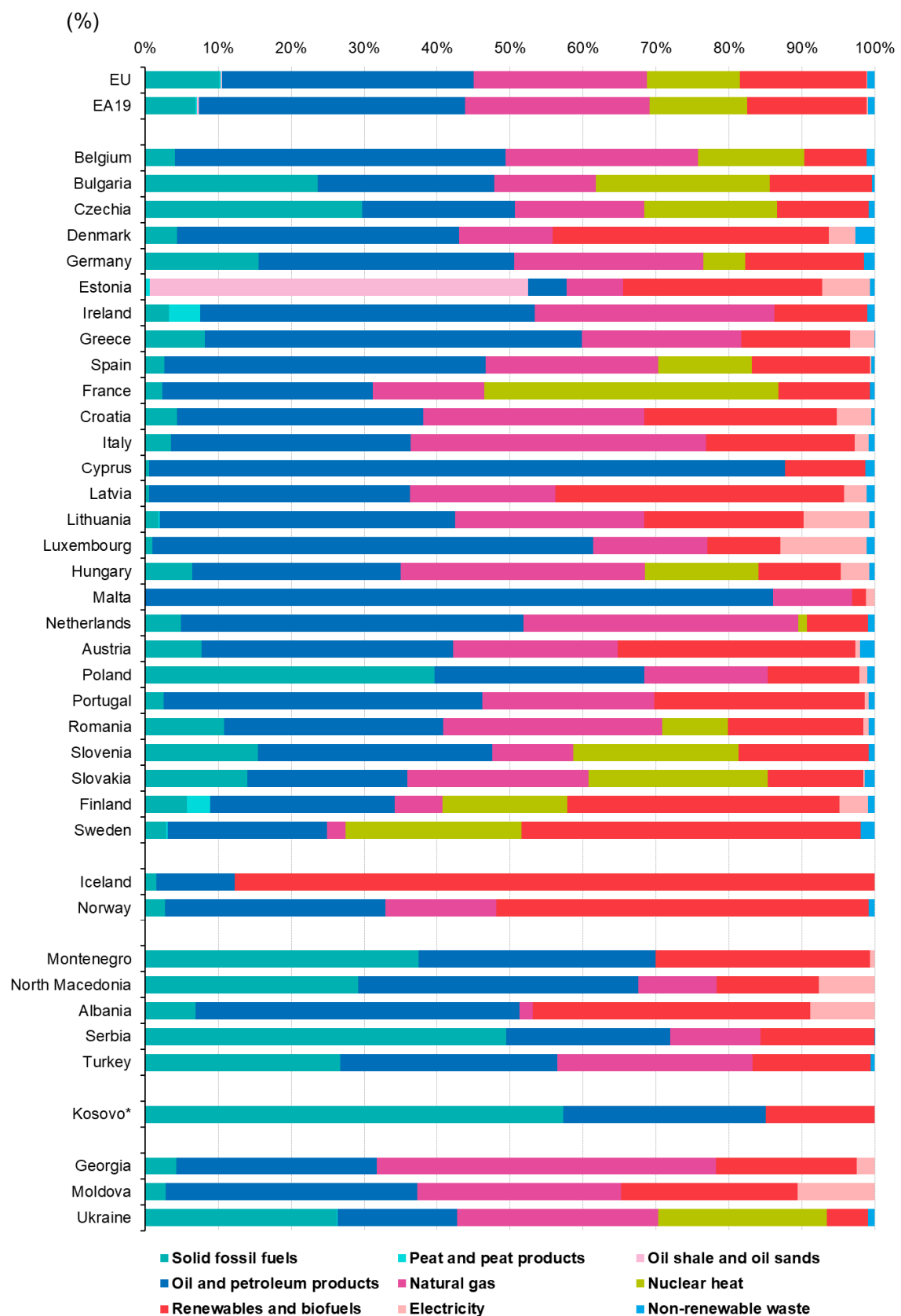- 12% electric heating appliances.



**Figure 3.** Structure and distribution of main heating sources in Polish households [%] [30].

More than 51% of boilers are below Class 3; 20% are Class 3 appliances; 10.4% are Class 4; 16.4% are Class 5; and only 1.9% are Ecoproject [30].

Considering the Eurostat data, it can be observed that Poland is the largest EU consumer of solid fossil fuels (see Figure 4) [31]. At present, approx. 70% of electric energy is produced from carbon fuel, with a similar percentage observed in district heating.

Summarising the data on gross available energy structure in 2020 (see Figure 4), 68.4% of all energy in the EU is produced from coal, crude oil, and natural gas. RES and nuclear heat account for 12.7% and 17.4% of the total, respectively [31]. In Poland, the main problem for improving air quality is exceeding the permissible levels for PM10 particulate matter and PM2.5 and exceeding the target level of benzo(a)pyrene, as determined by PM10 [32].

Wroclaw, the capital of the Lower Silesia region, is regularly ranked among the world's most polluted cities in winter seasons [33]. Poor breathable air quality results from poor-quality coal fuels and waste incineration. Transportation is responsible for more than 20% of air pollution, and heating appliances produce as much as 70% [34]. Poland introduced a parliamentary act [35] to introduce a national system for evaluating and managing breathable air, with regular monitoring and formal publications of Air Protection Programmes' reports [36]. Poland's air pollution scale is expected to rise in the current heating season considerably.

(%)



**Figure 4.** Gross available energy by fuel in 2020 [%] [31].

* This designation is without prejudice to positions on status, and is in line with UNSCR 1244 and the ICJ Opinion on the Kosovo Declaration of Independence.

As a result of the energy crisis related to Russian aggression in Ukraine and the penal restrictions and embargos imposed on Russia (as the main exporter of fossil fuels and gas on the EU market), fossil fuel prices have seen a rapid rise in all segments; in the third quarter of 2022, the price of natural gas rose by up to four times compared to last year's figures [37,38], that of electric energy rose by approx. 24% compared to last year's figures [39], and that of coal rose to prices per tonne between 4 and 5 times higher than those of last year [40]. Moreover, the availability of fossil fuels in Europe has dropped by a large margin. In the EU area, black coal is mined in only two Member States: Poland (96% of European supply) and the Czech Republic (4% of European supply), with an annual extraction of approx. 56 million tonnes (following a few fold decreases since the 1990s) [41].

The present situation places an immediate and extraordinary load on energy markets, producing the risk of a drastic shortage of fossil fuel supply to individual households and aggravating energetic poverty. To alleviate the supply risk, the Polish government drastically reduced the quality standards for fossil fuels, allowing for the incineration of lignite and poor-quality fine coal [42–44]. This decision will negatively aggravate air pollution during the oncoming season but will also alleviate the risk of energetic poverty in Poland. Households utilising solid fossil fuel boilers, LPG gas boilers, or oil boilers may apply for co-financing programmes for the duration of this heating season [25]. Maximum prices limiting household usage to 2 MWh in 2023 have also been set for electric energy (693 PLN/MWh) [45] and gas (approx. 200 PLN/MWh) [46].

The shock of declining activity due to the COVID-19 pandemic has severely impacted the EU economy and caused a social crisis [47]. It has been said the world economy is in one of the worst economic crises since the Great Depression (1929–1933) [48]. At the beginning of the pandemic crisis, Poland was called the "green island" because it had the fastest upward trend of GDP growth in the EU. The potential Polish GDP growth rate, meaning the long-term rate of development of the Polish economy, was almost unchanged from what came before the crisis erupted [49]. However, the optimistic forecast did not last long. After the pandemic, the energy crisis came, which was caused by the Russian attack in Ukraine. All these disruptions in economic activity (COVID-19 lockdowns, disrupted supply chains) and society (fear and deaths) and the energy shortage of coal and gas supply spread the above energy consumption attitudes in Poland.

The looming recession in Europe and the economic slowdown in 2023 seem imminent and unavoidable. Economic forecasts are far from optimistic [50,51]. The galloping inflation in the EU area (most notably in Poland in October 2022) was at a level of 17,9% from year to year for the gas and oil markets, as caused by the pandemic outburst, and the present energy crisis has drastically aggravated the economic situation of households [52,53].

RES management significance has seen a rapid increase, because households are more inclined to reach for green energy solutions as a way to limit their expenditures and to improve the quality of breathable air. These choices are largely affected by their previous attitudes towards pro-environmental solutions and the grounding of such solutions. For this reason, this study places focus on previous reports and studies conducted prior to the pandemic outburst to verify whether the past attitudes of households towards RES solutions were already pro-environmental.

In view of the above, the main research hypothesis was formulated as follows:

Prior to the pandemic outburst and the energy crisis in Europe, the majority of energy consumers had already been pro-environmental in their choices of energy sources.

The main objective of this paper was to prepare a segmentation of energy consumers and to study the prevalence of consumer attitudes in each segment with respect to their choices of pro-environmental sources in RES management decisions.

As mentioned above, Wroclaw, the capital of Lower Silesia, is regularly ranked among the world's most polluted cities. The Lower Silesia region is ranked fourth in the number of households per region in Poland and is ranked second (for rural areas) and third (for municipal areas) for electric energy consumption. These characteristics justify the need to research this region and emphasise its importance in Polish energy management.

To ensure the logic and clarity of the content, this article is divided into five main sections, beginning with the Section 1 providing the background and justification for undertaking the research and presenting the aim and the hypothesis. Section 2 is the Materials and Methods section and is divided into a Literature Review (Section 2.1), which provides an overview of energy consumer segmentation, and a subsection, the Methodology of the Survey (Section 2.2), which includes assumptions of the research and its methodology. Section 3 contains our segmentation results, introducing three factors (F1 environmental and energy goods protection, F2 mirror effect, and F3 energy and devices profitability), which together explain 70% of the total variability in the data set. Section 4 discusses the results in detail, indicating policy implications, future research, and our research limitations. Section 5 ends the paper with the most significant conclusions.

## 2. Materials and Methods

### 2.1. Literature Review

Market segmentation is a fundamental area of marketing research. It involves the division of the market into relatively uniform classes of purchasers based on similarities of criteria that characterise the customers and/or criteria of their reactions as products or services that are offered.

Segmentation analyses are also used in the study of energy markets. The results of segmentation analyses of electric energy market consumers help establish those variables—both the immediately observable and those escaping direct observation—which characterise various consumer segments. Based on the results, energy suppliers are able to adjust their offers of products to the needs of assorted segments of consumers.

Segmentation analyses also provide information on renewable energy production technologies' values or preferences according to various consumer segments. The results of these studies may also constitute a starting point for changes in legal regulations and the national energy policy, which are necessary to persuade consumers to change their preferences towards using energy from renewable sources.

Pedersen [54] classified BC Hydro's residential customers into six market segments, identified on the basis of their attitudes and behaviours towards electricity and conservation. Segments were identified using the *c*-means clustering method, belonging to a group of iterative optimisation methods of cluster analysis. Segment profiles were established, among others, on the demographic properties of consumers as well as on electricity consumption and other behavioural dimensions.

Cluster analysis was also applied in the study by Sütterlin et al. [55], resulting in the identification of six segments of energy consumers in Switzerland. In their approach, the authors adopted the Ward method—another subclass of cluster analysis. They adopted behavioural measures as well as energy-related psychosocial variables as segmentation variables.

Zhang and Wu [56] identified market segments based on residents' willingness to pay for green electricity. The authors conducted an online and paper-based survey among city residents in Jiangsu Province, China. The research was carried out in 2010 on a group of 1250 married urban residents between 18 and 60 years of age. A total of 1139 individual electricity consumers sent correctly completed questionnaires by e-mail or by post. The authors distinguished six segments of customers in terms of their bid amount.

Research by Tabi et al. [57] was designed to identify variables (sociodemographic, psychographic, and behavioural variables) that differentiate existing green energy consumers from those who are vitally interested in renewable energy sources but who are not yet using them (i.e., potential users). For this purpose, the authors adopted a choice-based conjoint analysis for the segmentation of energy consumers. The study was performed in 2009 on a sample of 414 respondents representing German recipients of electric energy that undertook the choice experiment on electricity products. Respondents were presented with a series of 12 choice tasks involving comparisons of different electricity products with varying levels of attributes. The authors identified five consumer segments: (1) adopters, (2) po-

tential adopters—truly greens, (3) potential adopters—price-sensitive greens, (4) potential adopters—local patriots, and (5) likely non-adopters. Individual segments of the consumer base were characterised using sets of variables of sociodemographics (e.g., gender, age, and education), psychographics (e.g., sensitivity to environmental issues), and behavioural variables (e.g., willingness to pay).

Yang et al. [58] analysed the preferences of individual consumers of electric energy in Denmark. Based on consumers' trade-off decision making, they distinguished three consumer segments: value seeking consumers, price sensitive consumers, and green consumers. In their paper, they implemented a discrete choice experiment (DCE), a commonly used multi-attribute valuation method for eliciting consumer preferences. The study was conducted using self-administered questionnaires in 2012 on a sample of 1012 Danish consumers who were residential electricity bill payers between 18 and 65 years old. Based on their research, the authors concluded that consumers are willing to pay extra for an increased share of renewable energy. Moreover, the authors confirmed that sociodemographic factors also influence consumer decisions related to energy use.

Issock Issock [59] identified four segments of households in South Africa based on their behaviours related to electric energy saving. The study used a wide range of complex measurement scales available in the professional literature (e.g., curtailment, efficiency, and behavioural intentions), which were then validated using confirmatory factor analysis (CFA). The segment identification procedure employed the Ward method and the *c*-means clustering method. The segments were profiled based on sociodemographic characteristics and some economic and psychological drivers of conservation behaviours.

Słupik, Kos, and Trzęsiak [60], based on survey studies conducted in 2018, identified and evaluated the most important motives for individual consumer behaviours on the market of energy in the Polish region of Silesia. Based on expert knowledge of 1237 respondent households, four consumer segments were identified, representing distinct approaches to household energy saving. The four segments were then described using classification trees. This approach also helped establish the ranking of factors influencing customer attitudes towards energy savings.

Słupik, Kos, and Trzęsiak [61] presented another approach to consumer segmentation on the energy market involving classification on the basis of distance between class centroid and characteristics of individual consumers. The method was applied to the segmentation of Germany, Spain, and UK consumers participating in the eco-bot project (Personalized ICT-tools for the Active Engagement of Consumers Towards Sustainable Energy). Segments were identified a priori based on motives for energy savings revealed by the respondents.

Energy saving motives were also applied as a basis for segmentation in another work by Słupik, Kos, and Trzęsiak [62]. Their study aimed to characterise segments of energy consumers (including the establishment of typical customer profiles in the identified segments) in terms of socioeconomic factors. To identify factors, the authors used survey results gathered among respondents from eight EU Member States. The study findings allowed for the identification of 10 socioeconomic variables that were statistically correlated with behavioural types of energy consumers.

Barjak et al. [63] based their work on three independent approaches: a systematic review of the literature, an expert workshop, and a survey of Swiss electricity customers, and they distinguished five segments of private electricity customers. They were as follows: (1) affluent and quality-oriented, (2) ecologically aware, (3) technophile, (4) regionally rooted, and (5) stable and uninterested. The study workshops were attended by energy market experts, managers of energy providers, and scientists representing various fields related to energy markets. Based on energy consumer analyses, 464 online questionnaires were performed. The research tool employed a number of socioeconomic variables, energy consumption data, and 22 queries addressing consumer attitudes towards the environment, major social issues, money, regional identification, and technology. The attitude exploration queries were based on a six-point Likert scale. In the study, regression and cluster analyses were used.

By analysing the above overview of market segmentation studies of energy consumers, it can be observed that they were applied on various levels, including national and regional levels, and they employed both multidimensional methods (cluster analyses, latent class analyses, and classification trees) and author methods (e.g., the identification of segments on the basis of selected combinations of user responses to queries of respondent attitudes, preferences, behavioural patterns, and others).
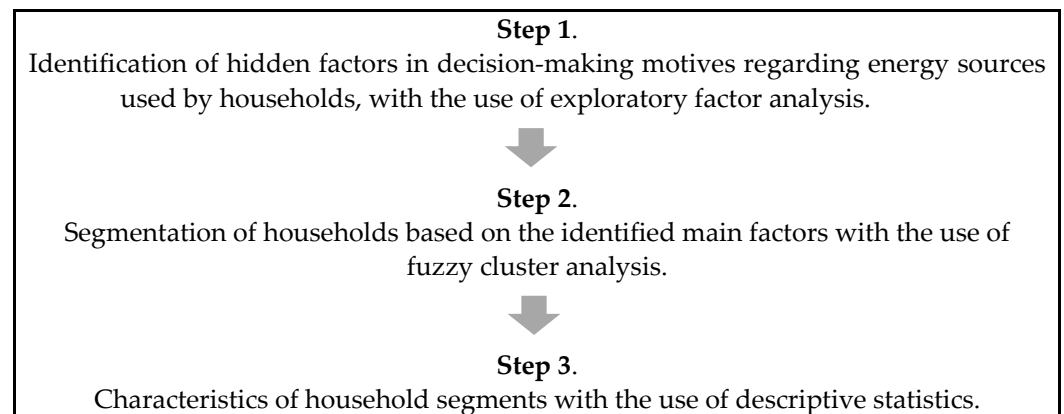
The above overview shows that cluster analysis is one of the most often applied methods for the identification of segments on the market of energy consumers. This method is often supported by other methods, such as factor analysis, mainly for reductions in large volumes of potential segmentation factors. This approach allows for considerable simplification of multidimensional analyses, and the findings are more easily interpreted and more useful for determining energy policies on national and regional levels. It must be emphasised that the wealth of studies presented herein is only a subset of the available literature on the market segmentation of energy consumers. For a broader overview, e.g., see the works of Słupik et al. [62] and Barjak et al. [63].

### 2.2. Methodology of the Survey

This article aimed to segment consumers on the renewable energy market. The segmentation was carried out using survey results, which included a sample of 500 households from the area of Lower Silesia (Poland), living in single-family houses or terraced houses. The owners of these households were able to independently decide on the source of heat and electricity used, and they had the option to install devices which use renewable energy inside and outside the building or on the property. A random sample selection was used, which was systematic within defined layers, i.e., with a division into urban, rural, and urban–rural communes. The sampling frame was the address database of the Lower Silesia Province, which was used to draw the starting addresses from which the interviewers began their research. The research technique of individual face-to-face interviews was used, which was conducted with the use of the paper version of the interview questionnaire (PAPI). The interviews were conducted in the period from April to May 2016 with the adults responsible for household charges. The main objective of the empirical research was to determine the behavioural pattern of households in the field of energy management/renewable energy sources. In one of the questions of the interview questionnaire, the respondents were asked to respond to the statements that defined their motives in making decisions about the energy sources that they used. The respondents' task was to determine on a scale from 1 to 4 (where 1 stands for "I strongly disagree", 2 is "I mostly disagree", 3 is "I mostly agree", and 4 is "I strongly agree") to what extent they agree with the statement. Based on a list of 13 statements used in the interview questionnaire, the following variables were adopted:

A1: The positive impact of renewable energy sources on the natural environment.
A2: The care for clean air and the improvement of its quality.
A3: The desire to increase energy efficiency in the household.
A4: The increase in the reliability of energy supply.
A5: The use of local resources in the commune.
A7: The benefit of future generations and concern for the environment in the future.
A8: The desire to show that the respondent can afford it.
A9: The desire to stand out and have something that others do not have.
A10: The desire to have a renewable energy source because others also have it.
B1: The payback period for incurred expenses.
B3: The price of the energy source.
B4: The opportunity to earn from the sale of electricity from RES.
B6: Attractive subsidies.

This article uses a research procedure consisting of three basic steps, as presented in Figure 5.

**Step 1**.
Identification of hidden factors in decision-making motives regarding energy sources used by households, with the use of exploratory factor analysis.

**Step 2**.
Segmentation of households based on the identified main factors with the use of fuzzy cluster analysis.

**Step 3**.
Characteristics of household segments with the use of descriptive statistics.

**Figure 5.** Research procedure.

Exploratory factor analysis for polychoric correlations was used to identify hidden motives for decision making about household energy sources. Polychoric correlations are suggested in factor analysis when the variables are measured on an ordinal scale. Factors were extracted using principal component analysis and were then subjected to VARIMAX rotation.

Estimated values of factor loadings for households constituted the basis for their segmentation. The segmentation used the fuzzy $c$-means method that was proposed by Dunn [64] and subsequently generalised by Bezdek [65] and Höppner [66]. The fuzzy $c$-means method is an extension of the classical $c$-means method. In the classic variant of the method, each of the objects is classified exclusively into one class. The fuzzy approach makes it possible to assign to the classified objects the degrees of belonging to each class. For this purpose, under the fuzzy $c$-means method, the goal is to minimise the following function [65]:

$$J_m = \sum_{i=1}^{c} \sum_{j=1}^{n} \mu_{ij}^m d_{ij}^2, \tag{1}$$

where $\mu_{ij}$ is the level of the $j$-th object membership in the $i$-th fuzzy class, $d_{ij}$ is the Euclidean distance between $i$-th fuzzy class gravity centre and $j$-th object, and $m$ is the fuzzification parameter, where $m > 1$.

The fuzzy $c$-means method is an iterative method consisting of the following steps [67,68]:

**Step 1**. Random membership matrix initiation $\mathbf{U} = \lfloor \mu_{ij} \rfloor$, where $\sum_{i=1}^{c} \mu_{ij}, \forall j = 1, 2, \ldots, n$.

**Step 2**. Calculating gravity centres of classes following the below formula:

$$c_i = \frac{\sum_{j=1}^{n} \mu_{ij}^m x_j}{\sum_{j=1}^{n} \mu_{ij}^m} \tag{2}$$

where

$$\mu_{ij} = \frac{1}{\sum_{k=1}^{c} \left(\frac{d_{ij}}{d_{kj}}\right)^{\frac{2}{m-1}}} \tag{3}$$

**Step 3**. Calculating the new $\mathbf{U}_{new}$ membership matrix. If $\|\mathbf{U}_{new} - \mathbf{U}\| > \varepsilon$, where $\|\mathbf{U}_{new} - \mathbf{U}\|$ represents the Euclidean distance, and $\varepsilon$ refers to the accepted convergence threshold, then $\mathbf{U} = \mathbf{U}_{new}$ should be accepted, and we should proceed to Step 2. The procedure is finalised in the situation when $\|\mathbf{U}_{new} - \mathbf{U}\| < \varepsilon$ or the set number of $k$ iterations is obtained.

The parameter $m$ determines the degree of blurring of the classification results. Its value should be greater than 1. As the value of $m$ comes closer to 1, the classification results

come closer to the classic variant. It should be emphasised that there are no indications in the literature as to the value of *m*. In this article, the value of *m* was assumed to be 1.3. The number of segments was determined using classification quality measures. The measure formulas with their desired values are listed in Table 1.

**Table 1.** Cluster validity measures.

| Name | Formula | Desired Value |
|---|---|---|
| Partition coefficient (PC) [65] | $PC = \frac{1}{n} \sum\limits_{i=1}^{c} \sum\limits_{j=1}^{n} \mu_{ij}^2$ | max |
| Partition entropy (PE) [65] | $PE = -\frac{1}{n} \sum\limits_{i=1}^{c} \sum\limits_{j=1}^{n} \mu_{ij}^2 \log_a \mu_{ij}$ | min |
| Fukuyama and Sugeno measure (FS) [69] | $FS = $ $\sum\limits_{i=1}^{c} \sum\limits_{j=1}^{n} \mu_{ij}^m \left\| x_j - v_i \right\|^2 - \sum\limits_{i=1}^{c} \sum\limits_{j=1}^{n} \mu_{ij}^m \left\| v_i - \overline{v} \right\|^2$ where: $\overline{v} = \sum\limits_{i=1}^{c} \frac{v_i}{c}$ | min |
| Xie and Beni measure (XB) [70] | $XB = \dfrac{\sum\limits_{i=1}^{c} \sum\limits_{j=1}^{n} \mu_{ij}^m \left\| x_j - v_i \right\|^2}{n \min_{i,j} \left\| v_i - v_j \right\|^2}$ | min |

## 3. Results

The use of exploratory factor analysis for polychoric correlations with VARIMAX rotation allowed us to distinguish three main factors. The factor loadings are listed in Table 2.

**Table 2.** Values of factor loadings for three factors.

| Variable | F1 | F2 | F3 |
|---|---|---|---|
| A1 | 0.88 | | |
| A2 | 0.89 | | |
| A3 | 0.90 | | |
| A4 | 0.86 | | |
| A5 | 0.73 | | |
| A7 | 0.68 | | |
| A8 | | 0.95 | |
| A9 | | 0.97 | |
| A10 | | 0.94 | |
| B1 | | | 0.77 |
| B3 | | | 0.78 |
| B4 | | | 0.60 |
| B6 | | | 0.50 |
| | RC1 | RC2 | RC3 |
| SS loadings | 4.34 | 2.85 | 1.87 |
| Proportion Var | 0.33 | 0.22 | 0.14 |
| Cumulative Var | 0.33 | 0.55 | 0.7 |

The three factors together explain 70% of the total variability in the data set. Factor F1 mainly includes motives that fit with the idea of caring about the natural environment, energy sources, common goods, and future generations. The variables that comprise this factor result from the respondents' knowledge, their ecological awareness, and their internal conviction as to which actions are good for others and the natural environment. Factor F1 was defined as environmental and energy goods protection and refers to the following:

- Variable A1: The positive impact of renewable energy sources on the natural environment.
- Variable A2: The care for clean air and the improvement of its quality.
- Variable A3: The desire to increase energy efficiency in the household.
- Variable A4: The increase in the reliability of energy supply.

■ Variable A5: The use of local resources in the commune.
■ Variable A7: The benefit of future generations and concern for the environment in the future.

Factor F2 groups themes related to the special demand effects, including the bandwagon effect, the snob effect, and the Veblen effect. In this case, the demand effects concern the orientation of the behaviour of energy consumers and the allocation of their consumption intentions. Factor F2 was defined as the mirror effect and refers to the following:

■ Variable A8: The desire to show that the consumer can afford RES.
■ Variable A9: The desire to stand out and have something that others do not have.
■ Variable A10: The desire to have a renewable energy source because others also have it.

The last factor, on the basis of which the households were segmented (F3), covers economic motives. Factor F3 was defined as energy and devices profitability and refers to the following:

■ Variable B1: The payback period for incurred expenses.
■ Variable B3: The price of the energy source.
■ Variable B4: The opportunity to earn from the sale of electricity from RES.
■ Variable B6: Attractive subsidies.

Based on the estimated values of three factors for each household, segmentation was used in accordance with the methodology and parameters described in the Methodology section. Three measures of classification quality indicated the presence of two household segments. One of the measures suggested a division into four segments. The decision to divide households into two segments was made on the basis of most indications. The values of the classification quality measures are presented in Table 3.

**Table 3.** Values of classification quality measures for different numbers of segments.

| Number of Segments | PC | PE | FS | XB |
|---|---|---|---|---|
| 2 | 0.932 | 0.123 | −375.866 | 0.0013 |
| 3 | 0.874 | 0.222 | −482.713 | 0.0014 |
| 4 | 0.874 | 0.230 | −650.701 | 0.0015 |

The cluster analysis using the fuzzy *c*-means method allowed us to distinguish two segments of energy management in households. Of the households, 27.8% were in the first segment (S1), and 62% were in the second segment (S2). In total, almost 90% of the units participating in the study belonged to both segments. In the research sample, there were also visible so-called migrating households, which, in a way, constituted the third segment (M). They accounted for about 10% of the research sample. A characteristic feature of these households was their location "between" the abovementioned segments. In the classic variant of cluster analysis, the position "between" the abovementioned segments is ignored, and the research objects are arbitrarily assigned to one of the segments. The application of the fuzzy *c*-means method made it possible to determine the degree of belonging to the first and the second segments for each migrating household. In order to identify migrating households, we applied the so-called critical value of the degree of affiliation with one of the two segments at the level of 0.7. Examples of migrating households are presented in a fragment of the data set that includes the degrees of belonging to the two segments (see Table 4).

**Table 4.** Degrees of affiliation of selected households with two segments.

| Household | S1 | S2 |
|:---:|:---:|:---:|
| ... | ... | ... |
| 96 | 0.997652 | 0.002348 |
| 97 | 0.933659 | 0.066341 |
| 98 | 0.884547 | 0.115453 |
| 99 | 0.650564 | 0.349436 |
| 100 | 0.146753 | 0.853247 |
| 101 | **0.403545** | **0.596455** |
| 102 | **0.649796** | **0.350204** |
| 103 | 0.065966 | 0.934034 |
| ... | ... | ... |

The presented example clearly shows that the households with IDs 101 and 102 belong to the group of migrating households. This is especially true of the first of the abovementioned households, which is difficult to unambiguously assign to separate segments.

Two segments and migrating households were characterised in terms of three factors (F1, F2, and F3), grouping the motives of household owners in making decisions about the energy sources that they used.

The highest value of the F1 factor was observed for the first segment, whereas the lowest was observed for the group of migrating households. Moreover, it can be noticed that individual segments and migrating households were characterised by a similar, relatively high value of factor F1.
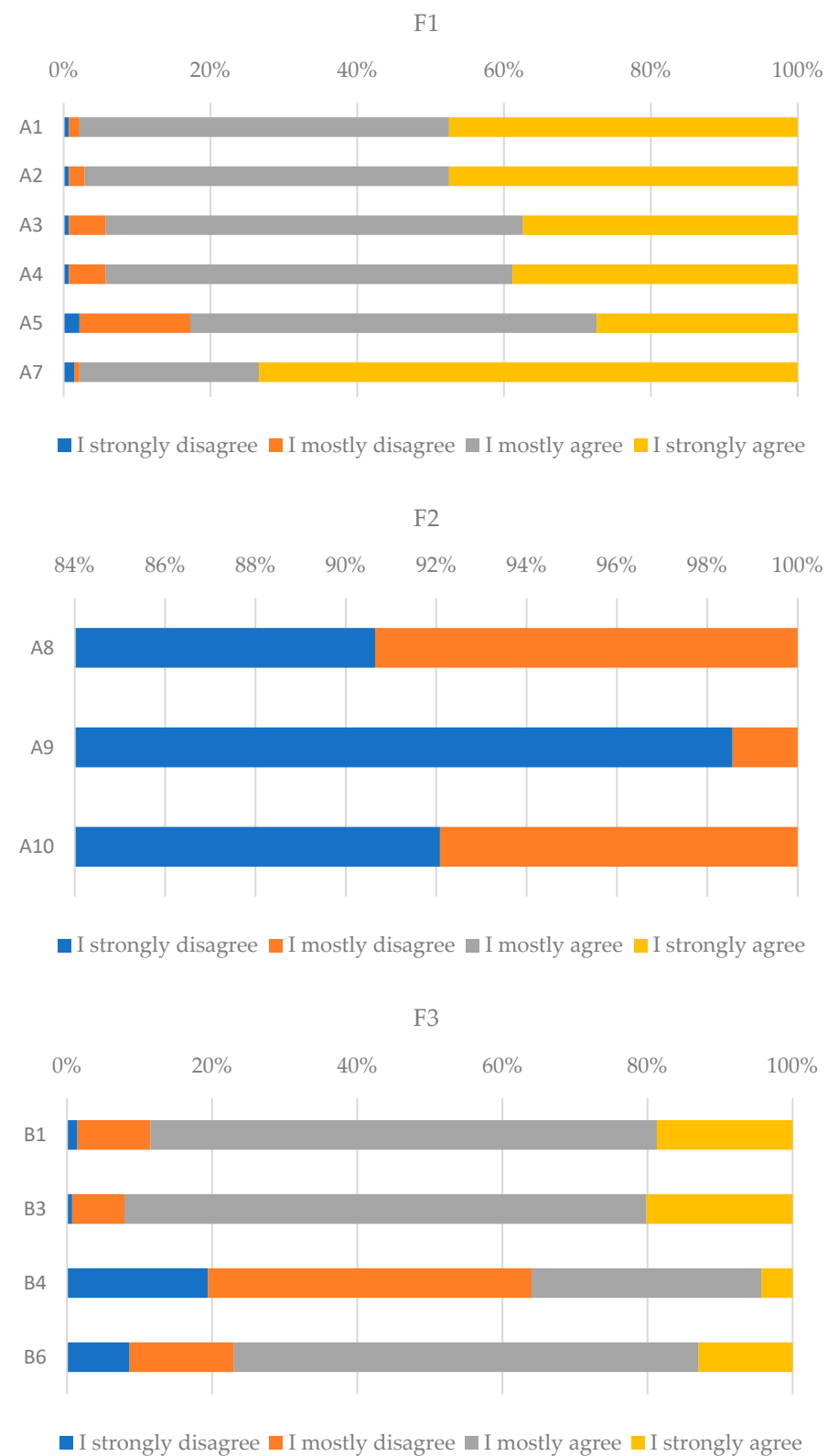
In further parts of this study, we analyse the distribution of responses to individual statements (variables), loading the F1, F2, and F3 factors. The distribution of all answers is presented in Figures 6–8.

By analysing the structure of responses within the F1 factor, it can be stated that, for each group (segment) under examination, the environmental and energy goods protection factors are typically met with a positive response. Respondents from segment 1 displayed decidedly more positive attitudes compared to those from S2. The ratio of "I strongly agree" responses in the migrant group lies between those recorded for S1 and S2.

The largest discrepancies between the segments and migrating households were observed in relation to variable A5. More than a quarter of the respondents in the first segment indicated the possibility of using local resources in the commune as a motive in making decisions about the chosen energy sources, whereas in the group of migrating households, fewer than 2% of respondents positively assessed this motive (answered "I strongly agree"). Many more positive answers expressed hesitation ("I mostly agree"). The percentage of positive responses for both the segments and the group of migrating households was similar and oscillated around a high level of over 80%.
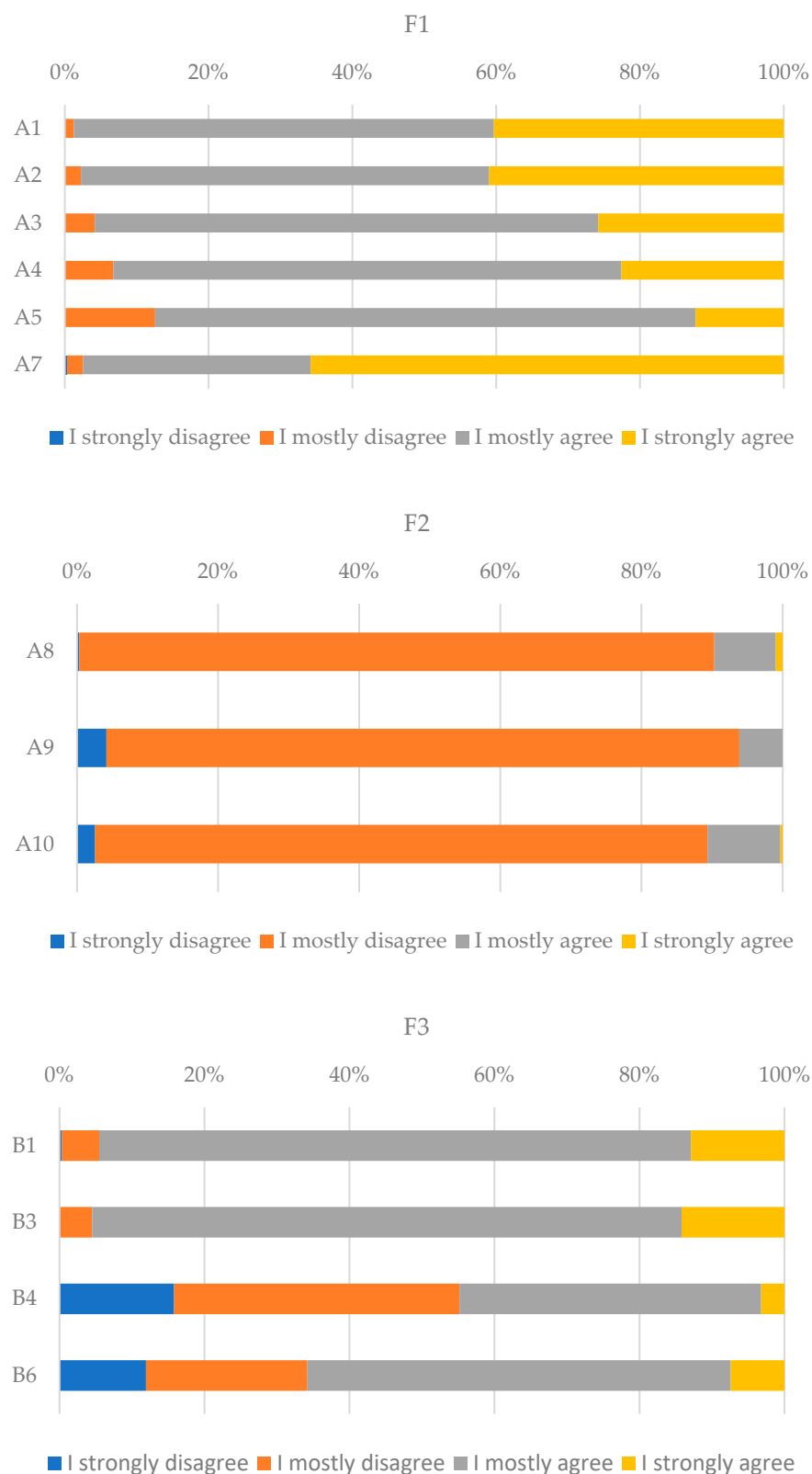
Factor F2 had the greatest variation between the segments. For each of the F2 response types, negative responses were dominant, which attests to the notion that the mean F2 for each segment is decidedly lower than the maximum value.

The highest value of the F2 factor was recorded in the second segment, whereas the lowest was observed in the first segment. It is worth noting that the lowest mean value was observed in S1 and constituted nearly half that of S2, with the latter comparable to that in the M segment. The response of "I rather disagree" was dominant in all F2 statements in groups S2 and M. On the other hand, the "I strongly disagree" responses were dominant in S1. The S1 group was characterised by a complete absence of responses confirming any of the F2 statements. Confirming responses were observed in S2 and M, but their share did not surpass the 12% margin for M and oscillated around 10% in S2. Migrating households maintained the value of the F2 factor at a level similar to that in the second segment.
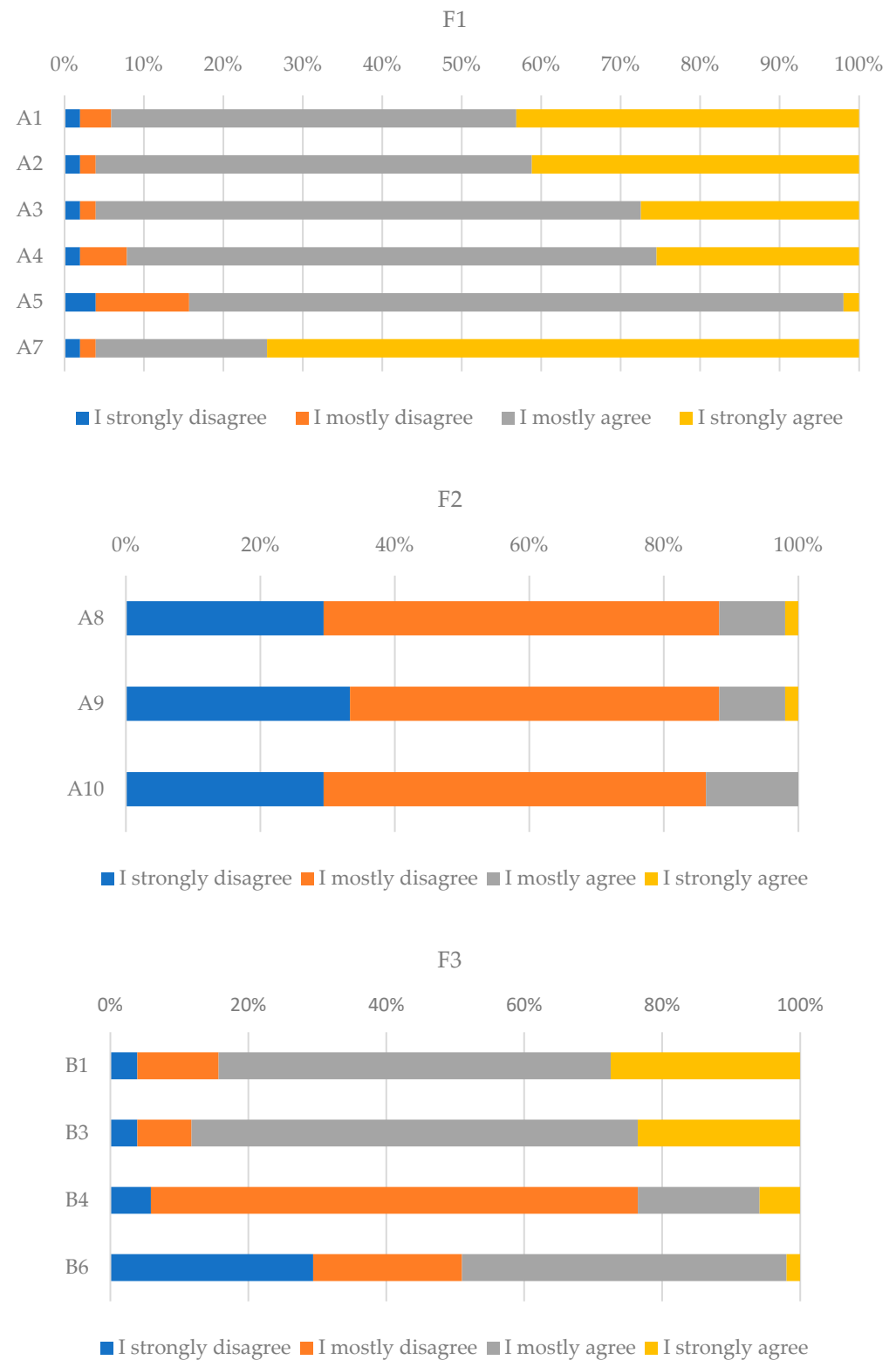
**Figure 6.** Distribution of answers in segment S1.

**Figure 7.** Distribution of answers in segment S2.

**Figure 8.** Distribution of answers for migrating households.

Factor 3 was defined as energy and devices profitability. F3 was loaded by four variables: B1, B3, B4, and B6. The B4 and B6 queries for the F3 variable attest to the impulse of gaining additional benefits by respondents, such as co-financing or becoming a prosumer, selling surplus energy to the regional or national grid. On the other hand, queries B1 and

B3 (price of the source and the average payback period) relate to the choice of energy source without the influence of any such additional benefits.

Regarding factor F3, slight differences in values were observed for the first and second segments. The lowest value of the factor grouping economic motives was observed in the group of migrating households.

In segments S1 and S2, responses to statements B1 and B3 had the highest share of "I mostly agree", which, along with the "I strongly agree" responses, constituted around 90% of the total. The ratio of confirming responses was even higher in the S2 group, surpassing the 95% margin.

In all segments, more than half of the recorded responses for B4 were negative. This was particularly evident in group M, with nearly 80% negative responses. More than half of the negative responses were also recorded in association with the B6 statement, and the remaining two segments had a higher ratio of positive responses (more than 3/4 in S1 and approx. 2/3 in S2).

## 4. Discussion

Of all three segments, S1 consumers were the most eco-aware and pro-ecologically oriented. Almost every other respondent from the first segment strongly declared (I strongly agree) that, in making decisions about chosen energy sources, they are guided by the positive impact of renewable energy on the natural environment as well as by care for clean air and the improvement of its quality. It can therefore be concluded that almost half of the consumers of the first segment were people with very high ecological awareness, who may be characterised by strongly pro-ecological attitudes in making decisions about energy sources. Consumers from this segment, compared to consumers from the second segment and migrating households, also cared about increasing energy efficiency, increasing the reliability of the energy supply, and using local resources.

It is worth mentioning here that the strategy of efficiency (increasing the efficiency of energy use), cohesion (RES are characterised by reduced externalities, i.e., they cause significantly less pollutant emissions in the whole LCA [71,72]), and sufficiency (resignation from the current level of consumption, in particular reducing electricity consumption) is described in the literature on the subject as strategic paths of the economics of sustainable development, in line with the idea of sustainable consumption choices [73].

Tier one consumers attached less importance to special demand effects compared to tier two respondents and migrating households. In the first segment, none of the respondents chose an affirmative answer ("I strongly agree" or "I mostly agree"), and the predominant answer (over 90% of indications for each of the three variables loading a given factor) was "I strongly disagree".

Demands' special effects can be explained by the difference between individual demand curves and collective market demand [74]. According to Lebenstein's definition, the bandwagon effect is a strong desire of some consumers to be in style and is recognised when one person buys because another is buying the same thing, i.e., the desire to have a renewable energy source because others also have it. The desire to show that a consumer can afford RES can be noted as the prestige effect (Veblen effect), and the desire to stand out and have something that others do not have can be noted as the snob effect.

These three theorised effects on material consumption were the research subject of product and brand choices [75,76], especially regarding marketing, economic, and psychological matters. Our research proves that the snob, bandwagon, and Veblen effects have little significance in choosing energy sources. However, the results are important because the special demand effects have not yet been investigated according to RES consumer behaviour. In summary, our research outcomes fill the research gap in this subject.

Completely different observations can be made regarding the group of migrating households. Almost 14% of respondents in this group, when deciding to choose an energy source, declared their willingness to have renewable energy because others also had it (bandwagon effect). Nearly 12% of respondents from this group wanted to stand out and

have something that others do not have (snob effect), or they wanted to show that they can afford RES (prestige effect). In the second segment, about 10% of households were those for whom it is important to imitate others or demonstrate their material status when making decisions regarding the choice of energy source.

The status quo behaviour discussed by Frederiks, Stenner, and Hobman [12] can be similar to bandwagon effect, which we have investigated already. This means that households stick to the default settings or defer their decision making entirely, especially as the amount or complexity of information increases [77,78]. Frederiks et al. [12] noticed that energy consumers tend to resist change and 'go with the flow' of pre-set options, even where alternatives may occur more financially rewarding or materially advantageous. Those three researchers also distinguished the bandwagon effect from household energy consumers by describing it as following the behaviour of others and conforming to social norms by following norms that reflect what is socially approved.

Using local resources in a commune as a motive in making decisions about chosen energy sources was the strongest factor, as confirmed by the respondents in the first segment. This variable (A5) had the largest discrepancies among all segments. The remaining respondents also perceived this need but chose not to accentuate it in a decisive manner. In Poland, the use of local energy resources has been propagated for many years, but the process is not intensive. There is no sufficient supervision over the utilisation of local RES on the parish level, and parish communities often lack formally established energy plans supported by the use of RES potential. Ecological education is not provided in a comprehensive fashion. This is likely why only the S1 respondents, as strongly pro-ecologically oriented people, perceived an urgent need for the adequate utilisation of RES in their local communities.

A good prognosis for the future, in the context of energy transformation, is undoubtedly responsible for the distribution of respondents' answers regarding variable A7. In the first segment and in the group of migrating households, nearly 3/4 of respondents declared that they care for the welfare of future generations and care for the environment in the future. In the second segment, the percentage of positive responses ("I strongly agree") was slightly lower and amounted to around 66%.

To summarize the clearly visible pro-ecological behaviours in segments S1 and S2, we can refer to other Polish research that was conducted nationwide and in the Lower Silesia Region, which all confirm our research hypothesis.

Lower Silesia research was conducted by Ropuszynska-Surma and Weglarz [79] in 2015 on the end user profiles of RES among 960 households (half a year before our research). The main segmentation criteria were determinants of willingness to install small-scale RES. The results proved that over 70% of respondents always behave pro-ecologically by using energy appliances and sources at home. However, the question that was asked did not concern care for future generations and concern for the environment.

CBOS research conducted in 2016 (the same year as ours) [80,81] strongly support the conclusion that behaviour related to renewable energy sources was green and visible on the Polish national scale. Both groups of respondents, ours and those of CBOS, displayed similar levels of emphasis on protecting the natural environment and declared interest in RES solutions and even in purchasing RES for their household needs. However, comparisons between these two studies should be taken with care, as they adopt different research methodologies and target profiles (nationwide vs. local perspectives).

Regarding factor F3 (energy and devices profitability), for all consumer groups, the most important variable that is taken into account in the decision-making process regarding energy sources is their price. The responses are not surprising in this regard, taking into account the relatively still high costs of investing in renewable energy sources.

The payback period landed in second place in the group of considered economic motives in the process of consumer decisions. All consumers, regardless of whether they belonged to the segment, took little account of the possibility of earning money from the sale of electricity from RES. The lowest interest in this aspect was recorded in the group of

migrating households (23.53%). Attractive co-financing was interesting only to every other consumer in the group of migrating households and to as many as 3/4 consumers in the first segment. This also attests to the fact that the most ecologically aware consumers of the S1 segment were also prosumers utilising RES in their installations. The rapid increase in the prosumer segment in Poland was facilitated by the introduction of governmental programmes (Mój prąd—My Energy) providing co-financing of PV for households. At present, the size of the group of prosumers in Poland is estimated to be more than 1 million. As of the end of July, the number of prosumers reached nearly 1.15 million, compared to slightly more than 4 thousand at the end of 2015. The target of one million prosumers set for the year 2030 was reached in the first quarter of this year [82].

Apart from present prosumers, S1 can be subdivided into two groups, namely those who can already afford to choose RES under the present co-financing policies, with state policies perceived as marginal in their purchase decisions, and those who cannot afford such purchases (the majority of Polish households have less than 5 thousand PLN of savings at their disposal [83]) and postpone their decisions in anticipation of more beneficial state policy support for RES investments.

In Siedlecka's and Graszko's [84] research conducted in 2015 on 50 households in Wisznice Municipality (Lublin Province in Poland), almost 90% of respondents expressed the opinion that, without the subsidy, they would not decide to buy solar collectors. Issues related to collector purchase costs were the factor that influenced the choice of a specific device to the greatest extent. When analysing the five criteria that the respondents took into account when choosing an installation, a low price was the most important.

This behaviour was also confirmed in research conducted by Ropuszyńska-Surma and Weglarz [79] (p. 17). Energy consumers divided into two segments indicated the reasons for reluctance to be a prosumer. In segments one and two, respectively, every fifth and every fourth consumer outlined high installation costs as the main barrier of having RES. They also noted the lack of financial and technical possibilities.

S1 and S2 had a high ratio of positive responses (more than 3/4 in S1 and approx. 2/3 in S2) to subsidies. Segments S1 and S2 were dominated by pro-ecologically oriented households (as attested by high scores in F1 variables), typically accentuating the weight of attractive RES co-financing. This leads to the conclusion that segments may easily be stimulated to increase their RES involvement by increasing the volume of co-financing support. This is an important clue for state administration. In fact, increased support would be an additional stimulus for segments to install RES solutions or supplement them with additional elements. In addition, the ecological effect would be immediate.

The findings of our study in this context seem particularly important in light of the apparent omission of segments with already established pro-environmental attitudes as targets for governmental support. For example, members of households fitted with energy-saving solutions that meet the current standards and that were introduced prior to the year 2021 are restricted in their access to heat pump co-financing. Thermo-modernisation programmes are also limited to households with high-emission heating sources. In Poland, the most pro-ecologically oriented consumers with long-time established attitudes are, sadly enough, restricted in their access to new co-financing or tax-exemption schemes, because the rulings of such programmes are applied to the years 2019–2020 and are not retroactive [85].

On the other hand, consumers with poorly established pro-environmental attitudes declaring no active interest in environmentally friendly solutions rarely display adequate support for the use of thermo-modernisation programmes of co-financing in Poland [32]. This is caused not only by their poor initiative and ecological judgement but also by inadequate education in this context.

Households do not utilise any formal accounts of economic effectiveness but rather make their judgements based on immediate investment costs. In effect, they perceive RES solutions as decidedly more costly compared to conventional gas furnaces or eco-pea coal installations. They are not equipped to properly judge immediate ecological external costs.

This is why, at the onset of the energy transformation in Poland, governmental support for pro-environmental installations was perceived as an attractive stimulus for investment, particularly in the first wave of the state co-financing programmes of investment support (i.e., solar thermal collectors). The enrollment period, spanning the first few months of 2010 [86], was met with enormous interest, but mainly due to sizeable financial incentives, short returns, and great profitability. The following years brought a further increase in the number of state support programmes and an equally rapid increase in pro-environmental attitudes in households.

The demand for RES is also influenced by the WTP of energy consumers. This factor is also important in the determination of the volume of state support for RES and conditions of RES co-financing programmes. This context is addressed and developed in Section 4.2, Future Research, in this article.

Other factors, including the impending rise of conventional energy prices in the EU, already play a crucial role in consumer decisions related to the choice of energy sources. At the time of this study, consumers were not influenced by risks associated with the pandemic threat (with its onset dating March 2020), the Russian attack in Ukraine (24 February 2022), and the energy crisis, related to the rise in conventional energy prices in the EU. Another risk is galloping inflation in Poland. Factors related to the above risks have coincided and accumulated over time, resulting in the reinforcement and overestimation of the need for a rapid departure from a strong dependence on conventional energy sources in the EU area.

The popularisation of pro-environmental attitudes, associated with the implication of the sustainable development idea, contributes to the so-called ratchet effect. Financial factors, energy pricing, and the elements of state support are typically shaped in accordance with the expectations of energy consumers (a rise in conventional energy prices results in an increase in state support for RES). Well-founded pro-environmental attitudes result in the reinforcement and sustenance of RES solutions among consumers, even when the negative trends lose their effect.

### 4.1. Policy Implications

An important indicator, as well as a recommendation for state authorities (both in Poland and in the EU area), is the fact that well-founded attitudes increase reluctance for the reinstalment of conventional energy sources in the future. More and more consumers have already become quite aware of the risks associated with air pollution and the deterioration of breathable air in their place in their immediate vicinity. Both the act of eliminating the sale of the most contaminating fuels to households (coal sludge and flotation concentrate) and the introduction of quality certificates for solid fuels (informing their calorific value and quality) were quite novel in the Polish legal system [87–89]. They had the effect of raising the environmental awareness of households and led to the elimination of the most harmful fuels from the housing sector. These regulations were supported by remote drone supervision of household emissions.

The energy crisis in Poland has resulted in a drastic limitation of coal supply to households that are still using it as their main source of heating energy, resulting in a herding run and possibly stifling the development of planned thermo-modernisation projects. In order to support and ground the demand for RES, it may be advisable to increase the number of support programmes for individual recipients, enterprises, and farming. Polish support programmes are mainly dedicated to offer financial assistance in RES investment over short periods. For instance, the support for individual consumers to purchase heat pumps was introduced in 2022 ("Moje Ciepło"-"My Heat"; duration period: 29 April 2022–31 December 2026 [90]), and the co-financing of solar energy collectors was only active in the years 2010/14 with no prospect of continuation [91,92].

It is essential that these measures are supplemented by intensive development of local grass-roots initiatives and education activities with the potential to reach households with poorly developed or freshly budding pro-environmental attitudes. Proper informing has the potential to dissuade these groups from the use of high-emission sources of heating.

Another significant measure is to induce thermo-modernisation and RES investment by directing them to the most profitable programmes of state support for household energy solutions based on locally available sources and conditions [93]. In particular, education efforts should be directed to members of multi-household units faced with energy poverty, as existing support for this segment lacks special mechanisms to induce environmentally friendly investments in this segment. At the present pace, the existing interest in the Clean Air Programme will take 12 years and will not be reached by the end of 2029 [32] (p. 23), as previously anticipated. As seen above, the intensification of legislative, organizational, and educational efforts in this respect is of the utmost importance at present.

It is important that political spheres perceive and support the need for further intensifying these efforts, including the need for the diversified use of energy sources. At present, the dominant model of the Polish energy mix is one based on coal, with renewable sources constituting a mere 16% of the total supply (2020) [94]. Poland has no atomic energy (it has only recently started to be planned [95]), and the development of large wind farms is still hampered by the 10 H act [96]. The theoretical potential of Polish wind farms in the Baltic Sea is 28 GW (with the possibility of producing approx. 140 TWh per year) by 2050 and 10 GW by 2030 [97].

In addition, the war in Ukraine has emphasised the awareness of the benefits offered by dispersed energy sources and departure from foreign supply. Therefore, the process of energy transformation to zero-emission models and green economy is expected to continue and gain pace.

### 4.2. Research Limitations

According to research limitations, it is worth remembering that the responsibility declared by respondents for future generations and the state of the environment in the future may, but does not have to, translate into specific pro-social and pro-ecological attitudes and behaviours, which are extremely important for the implementation of sustainable consumption. Behaviours that are defined in the psychology and behavioural economics literature include knowledge–action gaps [98–100], value–action gaps [101–103], attitude–action gaps [104], and/or intention–action gaps [105,106].

It is worth mentioning that some studies [5,107] found a weak correlation between consumers' positive attitudes towards environmental issues and their conversion. However, an upward trend of care for the environment and common goods for future generations is, after many years, still visible.

Another limitation is that the survey sample was affected by geographical limitations because respondents were recruited only from Lower Silesia in Poland. In this case, our results can be useful as a starting point for further research rather than as a generalisation.

### 4.3. Future Research Directions

The adopted methodology of dispersed cluster analysis allowed for the effective identification and characterisation of the segment of so-called migrant households. Future recapitulation of this study using the same formula would provide the potential for dynamic analysis to compare the following: changes in the composition of segments over time, capacities of segments, differences in the degree of households' affiliation with segments, and changes in behavioural profiles of segments.

For future research, we also plan to incorporate regional analyses of motives behind individual consumers' decisions to utilise renewable energy sources. Another interesting area is the analysis of the effectiveness of the various instruments and incentives offered to households to entice them to migrate from conventional to renewable sources.

An important direction for further research is to establish the willingness to pay (WTP) for renewable sources in the segment of consumers lacking such sources, particularly with respect to technologies that are relatively expensive compared to conventional solutions (such as heat pumps or gas installation investments). Proper research in this context

might provide important insight into the development of more adequate RES co-financing programmes in Poland.

WTP is the subject of much scientific research. The mainstream is based on meta-regression analysis (MRA) using the synthesis of the results of numerous studies by estimating the statistical indicators reported in these empirical studies [108]. By 2021, there were seven meta-analyses of consumer preferences for RES, which were conducted by Bigerna and Polinori [109], Ma et al. [110], Soon and Ahmad [111], Sundt and Rehdanz [112], Pokhrel [113], Grilli [114], and Chaikumbung [115]. These studies sought to identify the factors influencing the WTP for consumers of renewable electricity.

As evidenced by Ma et al. [110], consumers are more inclined to invest in energy produced from solar, wind, or broadly defined RES sources rather than those from conventional or biomass sources. Sundt and Rehdanz [112] argued that the WTP of electric energy consumers varies by source, with the least pronounced WTP for water-based sources deemed of poor value. Consumer preferences are significantly influenced by information regarding the source of the energy that is produced in power stations that are to be replaced by RES solutions. Soon and Ahmad [111] provided radically different observations; their research shows that RES does not influence WTP.

Soon and Ahmad [111] argued that the WTP for municipal areas is higher than that for rural areas. Another important factor is the size of disposable income. Consumers in affluent countries are more willing to pay than those in less affluent nations. The results of meta-analyses of Pokhrel [113], based on 21 original studies with 99 observations conducted in the first decade of the 21st century in 2000- 2013, confirm that a high disposable income is a significant factor inducing consumers to pay for RES. Consumers are willing to pay more if payments are due in monthly energy instalments compared to seasonal or annual payments.

Chaikumbung [115] observed that factors that influence WTP values include factors such as political and economic institutions, forms of renewable energy, and several country-specific and research-specific variables. Citizens of democratic and liberal nations place a higher value on renewable energy (excluding hydroelectric power stations) in total gross energy production. They are more willing to pay for the support of green energy. A negative impact on WTP was observed in countries emitting large amounts of carbon dioxide; their citizens are less inclined to support green energy solutions.

Our research confirms that the respondents displayed strong environmentally friendly behaviours. However, Lower Silesia, the region under study, is one of the world's most polluted areas. Poland is one of the leading countries in terms of their share of fossil fuels (carbon) in energy production. In light of the above, the gradual evolution and increase in environmental awareness in this region is apparent and also evidenced in research by Pokhrel [113]. The author argues that, with time, people have become more aware of the harmful effects produced by the excessive use of fossil fuels and—at the same time—more aware of the benefits offered by renewable energy sources. Moreover, as evidenced by Soon and Ahmad [111], more and more households have become willing to pay for the use of RES over time.
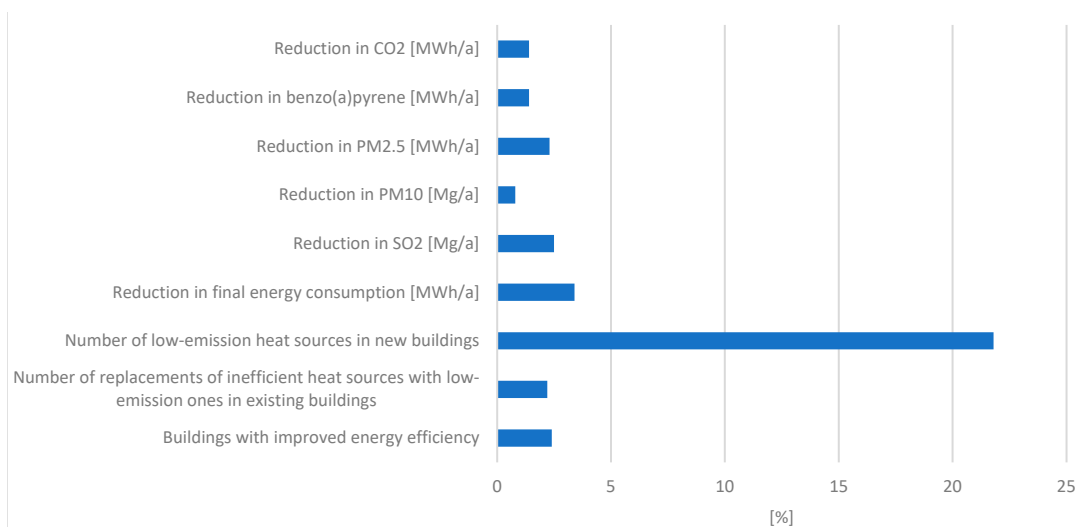
WTP is of key significance for the effective and efficient realisation of RES support programmes, with the potential to greatly intensify their use. At present, due to the lack of universal and perpetual campaigns of education and information, as evidenced in a survey study commissioned by the Supreme Audit Office in Poland, 95% of respondents were aware of the support programmes, with half of them declaring to know the details of such support. However, 45% declared their lack of knowledge on such details [32] (p. 12). Effective campaigns designed on the basis of sound survey studies might provide sufficient information on the social expectations of the co-financing threshold.

Between 19 September 2018 and 25 June 2021, out of a total of 16 cities, Wroclaw placed 13th in terms of the number of agreements (4985 agreements) held between the Regional Fund for Environmental Protection and Water Management and beneficiaries supporting the Clean Air Programme [32] (p. 100). This leads to the conclusion that the

Lower Silesia region under study requires increased and intensified educational efforts directed to households, as potential beneficiaries of other organisational activities can be designed to improve the effectiveness of state support programmes.

The Polish government has directed attention towards retrofitting programmes to improve the energy efficiency of residential buildings. Since 2021, there has been an obligation that every newly built house is energy effective and that the primary energy use of the building is no more than 70 kWh/m$^2$/year [116] and ([92], p. 69).

Figure 9 shows that every fifth newly built house has a low-emission heat source installed. This is the highest, though not impressive, indicator of the pace of the implementation of the Clean Air Programme, which is crucial in supporting the energy transformation of households in Poland.



**Figure 9.** Polish Clean Air Programme ecological outcomes 06.2021 [32] (p. 106).

A good implication for future research can be expressed in the following research question: to what degree do factors associated with the current energy crisis (rapid increases in prices for coal, energy, and gas, and the problems in their supply), including post-pandemic and economic factors (galloping inflation and imminent recession) and the Russian invasion in Ukraine (the risk of spreading the conflict, the risk of attacks on critical infrastructure, and the blockade of gas and coal supply), strongly influence consumer choices of energy sources in use within the next few years? It is crucial in this context to evaluate consumer attitudes towards these factors and their impact on consumer choices related to the use of energy sources.

This research is currently under way [47,117,118]. The results show a close link between energy consumption and the behaviour of household residents. Lockdowns have drastically changed the pattern of electrical energy consumption in favor of household consumption.

## 5. Conclusions

In summary of the conclusions, it is worth underlining that our hypothesis was verified.

It is evident that, at the time of the study—the year 2016—both S1 and S2 consumers were aware of and attentive to the environmental concerns and the need to preserve environmental values for future generations in their choices related to the use of energy sources. In total, almost 90% of the consumers participating in the study belonged to both segments S1 and S2 (27.8% of households belonged to the first segment (S1), and 62% belonged to the second (S2)). Taking into consideration both unambiguously positive responses (4: "I strongly agree") and positive responses (3: "I agree") to questions in F1, it can be said that the vast majority of consumers are guided by a positive impact on the environment, the care for clean air, and the improvement of its quality.

Summarising the considerations above, it can be concluded that consumers who are "the most sustainable" in terms of energy consumption, characterised by the highest environmental awareness and care for future generations, are concentrated in the first segment. It is worth recalling here that this segment accounts for less than 28% of all respondents participating in the survey. The vast majority of respondents involved households constituting the second segment. As many as 62% of respondents were in this segment. Interestingly, households in the second segment were characterised by a relatively high value of factor F1, similar to the first segment (oriented towards environmental protection and care for future generations), but in the case of the second segment, responses most frequently expressed hesitation ("I mostly agree") over definite responses ("I strongly agree").

Similar to migrating households, when making decisions about energy sources, households in the second segment follow the motives of the prestige, bandwagon, or snob of having RES. This is a feature that clearly distinguishes these households from first segment consumers. Manifesting one's financial capabilities, imitating others, or the desire to stand out is not what drives the purchasing decisions of a "sustainable consumer" from the first segment. It is worth noting that the "sustainable" first segment also includes households for which economic factors play an essential role in the decision-making process for energy sources. Those factors are mainly related to the price of investments in renewable energy, the payback period, and the possibility of obtaining attractive subsidies.

Household energy consumption is a complex issue related to macro and micro economic factors such as fuel prices and inflation; geopolitical factors such as war and the pandemic crisis; physical home attributes such as energy systems and appliances; and seasonal characteristics such as weather conditions. Considering people's behaviour regarding using energy sources as well as internal and external factors, we noticed that pro-ecological attitudes were evident before the war in Ukraine and the pandemic crisis. The open question is as follows: will those attitudes be sustained or discontinued in the next few years? Our outcomes have shown that Lower Silesia respondents display strong environmentally friendly attitudes towards energy sources. It is recommended to design future studies to establish the willingness to pay for renewables, especially concerning relatively expensive technologies compared to conventional solutions. In addition, future research may concern pattern changes in energy consumption caused by pandemic lockdowns and the energy crisis in Europe.

Poland is in a critical moment at present, where the intensification of energy transformation is of the utmost importance. Pro-environmental attitudes of the majority of households may aid the process but must be supported by effective national and local energy policies focused on managing residential energy consumption. These conclusions should be a precious guide to the local and federal government in order to strengthen environmental and energy policies to meet EU zero-emissions goals by 2050 [119].

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