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The State of Knowledge and Attitudes of the Inhabitants of the Polish Świętokrzyskie Province about Renewable Energy Sources

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Abstract: One of the ways to achieve an energy transformation is to reduce environmental degradation through the use of, among other things, renewable energy sources (RES). The widespread use of RES depends not only on economic and technical aspects, but also on societal acceptance. The aim of this research was to find out the attitudes and the state of knowledge of residents of Świętokrzyskie province regarding RES. This aim was further specified through five research questions. The research used a diagnostic survey method, and respondents' opinions were gathered through an author's survey. This survey included open-ended questions on solar energy (solar panels and photovoltaic panels separately), wind power, hydropower, geothermal energy (ground source heat pump and other sources separately), biomass and biogas. The research sample was selected based on data availability. Econometric modeling was used to analyze the results. The freedom in responding allowed for the exploration of a wide range of respondents' opinions. The results confirmed the positive attitude of residents towards RES and the influence of education level on their self-assessment. Residents of Świętokrzyskie province, in comparison to residents of Poland, stand out for their high level of acceptance of the use of hydropower in their neighborhood. The opinions of the residents of Świętokrzyskie province on the impact of wind power and heat pumps on the environment did not align with the opinions of the residents of Poland.

Keywords: renewable energy sources; surveys; knowledge; environment; social acceptance

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1. Introduction

Poland is obliged to implement Directive 2018/2001 of the European Parliament and of the Council, the main goal of which is to increase the share of renewable energy sources in the EU energy mix to at least 32% by 2030 and for individual member states to achieve so-called total national targets in gross final energy consumption [1]. In Poland, the framework for action on the national energy policy adopted by the Council of Ministers on 2 February 2021 assumes the following [2]:

- increase the share of RES in all sectors and technologies;
- in 2030, the share of RES in gross final energy consumption should be at least 23% with respect to primary energy consumption in 2020, including no less than 32% in electricity (mainly wind and PV) and 28% in heating;
- cover the heating needs of all households by 2040 via system heat and zero- or low-carbon individual sources.

At the same time, further development of photovoltaics, onshore wind farms and the growth of biomass, biogas, geothermal in district heating and heat pumps in individual heating are expected. Distributed energy based on RES power generation will also develop.

By 2030, the number of prosumers is expected to increase about fivefold, and the number of locally sustainable energy areas is expected to increase. There will be increased monitoring in single-family homes and consequences for those responsible for pollution. The energy sector should use waste biomass, in particular, including biodegradable municipal waste, sewage sludge, residues from the agro-food industry and agricultural waste, among others. The use of PV could reach an installed capacity of about 5–7 GW combined in micro and large installations in 2030 and as much as 10–16 GW in 2040. The installation of photovoltaic panels is an alternative to the use of brownfields and poor-quality land, as well as the roofs of buildings, including private ones. The construction of wind power plants is fraught with the risk of social disapproval, generating potential social conflicts [2,3].

In Poland, in 2021, the share of renewable energy in total electricity production was 17% and in Świętokrzyskie province—25.8%. Thus, it is significantly lower compared to Warmińsko-Mazurskie (90.7%), Podlaskie (73.9%) and Pomorskie (60%) provinces [4].

An important factor influencing the development of RES, both in Poland and around the world, is society's attitude to these energy sources. Cases of local communities effectively blocking new RES investments are not uncommon, and residents' reluctance and resistance, along with the NIMBY syndrome, in many cases, prolongs the investment process by up to 7–10 years [5–11].

Public interest in and attitude toward renewable energy sources is one of the key factors in the development and an element of success of the energy transition [12–14]. The level of knowledge about RES, as well as the main motives of individual RES buyers, are important in identifying barriers. Learning about public attitudes, levels of knowledge and even reproduced and perpetuated beliefs can be important in taking action on RES.

Research indicates that residents of Poland have a positive attitude toward RES. Poles expect RES to bring tangible benefits to the average citizen (87%). They perceive RES as the most modern and future-oriented type of energy (82%), capable of ensuring national energy security (76%) and reducing global warming (69%) [15,16]. Poles' positive attitude toward RES is accompanied by a lack of sufficient knowledge about RES [15]. High appreciation for the implementation of RES does not translate into acceptance of these energy solutions in the immediate vicinity [16]. At the same time, public acceptance of RES varies, with 66% accepting offshore wind farms in the Baltic Sea, 75% accepting geothermal sources (i.e., drilling and energy extraction from hot springs) and 76% accepting photovoltaic farms [16].

Poland stands out in comparison to other countries in the region and Europe for its declining population [17]. The 1.7 million increase recorded in the EU in 2022 was not a consequence of Poland's positive population balance. During this time, the population of Poland decreased by 2.4% [18]. Świętokrzyskie province is the region with the lowest natural population growth in Poland. Simultaneously, Świętokrzyskie province is characterized by one of the largest overall migration balances and a dramatically aging population [18,19]. In the context of demographic changes, finding out the current state of knowledge and social acceptance of RES is a tool that facilitates further stimulation of the development of these energy sources. The acceptance of RES by the residents of Świętokrzyskie province, as well as their knowledge of RES, has not been the subject of research and analysis to date. The purpose of this article was to analyze the state of knowledge and attitudes of the residents of Świętokrzyskie province regarding RES and their impact on the environment, human life and health. To achieve the set goal, the following research questions were adopted:

- What is the self-assessment of the respondents regarding their knowledge and utilization of RES?
- What is the awareness of the respondents regarding the necessity of implementing RES?
- What is the awareness of the respondents regarding the impact of RES on the environment?
- Is there acceptance among the respondents for all types of RES in their neighborhood?
- Is there a relationship between the knowledge of the respondents about RES and their level of education?

- Is there a relationship between the knowledge of the respondents about RES and their utilization of RES?

These research questions align with the search for solutions that enable the effective implementation of Poland's energy policy in line with EU priorities.

2. Literature Review

The knowledge and attitudes of residents towards RES are multifaceted [11,20]. A review of the literature has shown that research in this area has been focused on one or at most a few types of renewable energy sources. Most studies did not consider all types of renewable energy simultaneously. Klepacka et al. [21] surveyed owners of passive solar panels in rural areas, with the aim of finding out the importance of selected reasons for households' decisions to participate in a solar panel subsidy program. Meanwhile, Mroczek [22] examined the knowledge of respondents exclusively about wind power. The study by Us et al. [23], despite its focus on self-assessment of knowledge about wind power, solar energy, hydropower, biogas and biofuels, had limited territorial coverage. The respondents were residents of villages in the Lubelskie province [23]. Also, residents of villages who participated in the 2010 conference titled Odnawialne źródła energii dla domu i biznesu [Renewable Energy Sources for Home and Business] were survey participants. The purpose of this research was to determine knowledge and attitudes toward RES. The majority of respondents rated their knowledge as low, with a score of three on a five-point scale. Only one in ten individuals rated it as five. The majority of respondents expressed interest in attending more seminars, workshops and training sessions on RES topics [24].

Surveys on RES knowledge were also conducted as part of an assessment of the ecological awareness of Poles [25]. Although it was a series of surveys carried out in 2008, 2009 and 2010, the set of questions varied and did not always cover topics strictly related to RES [25–27]. Respondents answered closed-ended questions in a telephone survey. One of the questions asked in 2010 was as follows: "With what term do you associate the concept of renewable energy?". Respondents answered "yes", "no" or "hard to say" to 12 statements. Most respondents (85%) indicated that "it is energy based on, for example, solar energy, wind power, wave energy and geothermal energy". 19% of respondents indicated that "it is expensive energy." Respondents also expressed opinions about the type of energy considered the most environmentally friendly. 75% of respondents considered wind power the most environmentally friendly, 63%—hydropower and 61%—solar energy. According to the respondents, the least environmentally friendly were energy sources using biogas (2%), biofuels (5%) and heat pumps (4%). Traditional coal power, gas power and nuclear power were also deemed environmentally unfriendly. Noteworthy is the fact that respondents were characterized by a high consistency of views. 88% of those surveyed who found wind power friendly would agree that wind power plants should be built near their place of residence. A similar percentage of respondents (87%) who considered hydropower environmentally friendly would agree to the construction of a hydroelectric power plant in their neighborhood. Also, there was a high percentage (89%) of respondents who would agree to the construction of a solar energy installation [25]. In addition, the results of this survey showed that the strongest supporters of RES development in Poland were individuals with higher education, aged 35–44 and rural residents. Solar energy elicited the least concern and fear among respondents. Hydroelectric and wind power plants were next in line. In light of the results of this survey, educational efforts regarding RES should primarily target individuals over 54 years of age, women, those with primary education and residents of northern and southeastern Poland [25].

The issue of RES knowledge resonated in closed-ended questions asked in January 2016 to a representative group of Poles [28]. At that time, respondents expressed their opinions on the impact of energy sources/methods of energy production on the climate. Respondents were asked to select one of four given answers: "high carbon dioxide emissions, harmful to the climate", "low carbon dioxide emissions, climate-neutral", "no carbon dioxide emissions, climate-friendly" and "hard to say". Respondents separately assessed

the impact of hard coal, brown coal, oil, natural gas, nuclear energy, biofuels, hydro energy, wind energy, solar energy and geothermal energy [28]. However, options for obtaining energy from a source were not included in the above question; for instance, for solar energy, there were no separate questions about solar panels and photovoltaic panels.

From 24 February 2020 to 6 March 2020, a nationwide "Polish Public Opinion Survey on Various Energy Sources" [original title "Badanie opinii Polaków na temat różnych źródeł energii"] was conducted on behalf of the Polish Photovoltaic Association [29]

The survey consisted of 14 closed-ended questions and exclusively focused on two types of RES, i.e., solar energy—ground-based photovoltaic farm and wind power plant and conventional energy sources—nuclear, coal and gas [29]. With such a mix of energy sources, it is not surprising that respondents clearly preferred a ground-based photovoltaic farm [29].

In the majority of the surveys, respondents answered closed-ended questions [23–26,29]. This could potentially distort the results. To eliminate the influence of "predefined" responses, this study adopted the principle that the author's survey would contain only open-ended questions.

3. Characteristics of Świętokrzyskie Province

Świętokrzyskie province is one of the 16 regional units of Poland's administrative division. Świętokrzyskie province consists of 14 counties, including 13 terrestrial counties (covering rural areas and smaller towns) and 1 urban county (Kielce—a city with county rights, which is the capital of the province). Świętokrzyskie province includes 102 municipalities [30].

Świętokrzyskie province has a population of 1.1782 million people, or 3.12% of Poland's population. It is one of the provinces with a smaller population. The average rate of population loss in Świętokrzyskie province, with a value of −0.8% for 2022, was more than double the national average (−0.37%). The population density in Świętokrzyskie province is 100.6 people/km^2, thus lower than the national average (120.8 people/km^2) [18,19]. A total of 46% of the province's population is affected by energy poverty [31]. The land use structure in Świętokrzyskie province is dominated by agricultural land, 64.7%, and forested and wooded land accounts for 28.8% [18,19,32]. Biogas, biomass, solar energy, wind power and hydropower are used in Świętokrzyskie province (Table 1).

Table 1. Types of RES used in industrial installations in Świętokrzyskie province (own elaboration based on [4]).

Type of RES	Biogas	Biomass	Solar Energy	Wind Power	Hydropower
Number of installations	4	4	106	20	17
Total plant capacity, MW	3.8	243.169	98.84	26.462	2.295

4. Methods

Solving the established scientific problem requires conducting sound research, where the selection of appropriate methods, techniques and research tools is crucial. This will allow us to realize the stated goal of this study. The choice in question depends primarily on the people or phenomena that have been subjected to the research procedure. The criteria for selection should be the applicability and effectiveness of the chosen method, as well as its relevance to the concept of the work and the stated research problem [33].

The first step in the implementation of the research process is the selection of the research method, which is the concept of empirical activities. It is defined as "general, insufficiently detailed ways of arriving at reasonable and testable claims about teaching and learning phenomena and processes" [34]. In the concept of A. Kamiński, the research method is "a set of theoretically grounded conceptual and instrumental procedures covering, most generally, the entirety of the researcher's conduct aimed at solving a specific

scientific problem" [35]. Hence, the research method is such a research procedure, which is characterized by a well-defined research procedure, along with the use of appropriate research tools. Based on an analysis of the literature, the following research methods can be distinguished [36]: observational method, monographic method, document research methods, scientific experiment methods, expert methods, heuristic method, literature analysis and criticism method, individual case method (so-called case study) and diagnostic survey method, which was used in this research [37,38]. It allowed us to gather knowledge about the structure and directions of the research problem, taking into account the opinions of a specially selected group representing the population for which the research problem in question was carried out. It should be remembered that in order to achieve the highest possible reliability of studies, it is advisable to use several methods in a single study [39].

In the subsequent stage, a research technique was selected. It is defined by A. Kamiński as "practical activities, regulated by carefully worked out directives, allowing obtaining optimally verifiable information, opinions, facts" [40]. M. Łobocki puts it similarly, stating that "research techniques are more closely particularized ways of carrying out the intended research" [34]. Research techniques are subordinate to research methods, play a subservient role and constitute a cognitive activity by means of which the stated objectives can be achieved. The most commonly used research techniques include observation, interviewing, surveying and sociometric techniques.

Next, it is necessary to select a tool with which to conduct the research. It is understood primarily as a way of technically collecting information that comes from research. According to T. Pilch, "a research tool is an object used to implement a selected research technique" [41]. The most important research tools include a survey questionnaire, an observation sheet and a test. The present study used a questionnaire of the author's survey completed by households. It is one of the most common ways of obtaining information, used in surveys of people's opinions and attitudes and in mass surveys. Survey material is collected by gathering responses to a deliberate and predetermined set of questions, aimed at a selected group of respondents, which can be a wide range of people interested in a particular issue [42]. Surveys are also one of the main ways to conduct own studies, as they allow the adaptation of the scope of questions and topics to the author's needs for the research work in progress.

A group of 150 households was surveyed. For the purpose of achieving the goal of this research work, the author's research on the state of knowledge and attitudes of the residents of Świętokrzyskie province about renewable energy sources and their impact on the environment, human life and health was carried out. This research was conducted between 5 June and 31 July 2023. The sample was selected based on data availability. The online survey was conducted on the webankieta.pl platform, which is dedicated to conducting surveys. A diagnostic survey method was used to collect empirical material, which was conducted online. Surveying was adopted as the empirical data collection technique, while the survey questionnaire was the research tool. The author's prepared survey questionnaire was divided into two parts. The first part of the survey concerned the questionnaire proper, i.e., it contained developed sets of questions on the following aspects:

- knowledge of renewable energy sources, directions for their use and the benefits and drawbacks of renewable energy production;
- the relation to renewable energy sources located in the vicinity of the respondent's residence;
- the identification of factors influencing decisions on the choice of energy source at the place of residence;
- the impact of renewable energy production on human health, life and the environment;
- determining the impact of increasing the use of renewable energy sources on the natural environment in Świętokrzyskie province.

The second part is a classic metric that allowed the collection of basic household data, such as gender, age, education, places of residence, occupational situation, total number of people in the household and net income per person in the surveyed household. The

selection of the research unit was based on data availability. The research collective was made up of residents of Świętokrzyskie province. After the survey had been conducted, an electronic database was developed. The collected empirical material was subjected to quantitative and qualitative analysis. The results of the study are presented in descriptive and graphical form. They were the basis for the formulation of the final conclusions.

5. Results

5.1. Characteristics of Respondents

150 respondents took part in the survey, of which 54.0% of the total were women (81 people), while 42.67% were men (64 people). 3.33% (5 people) of respondents refused to provide information about their gender. The predominant part of the study population was young people between the ages of 21 and 40 (46.0%; 69 people). A fairly large group was represented by those aged 41–60: 32.0% (48 people). In contrast, the group of 20-year-olds was the least numerous: 2.0% (3 people).

Considering the education of the respondents, the largest group of respondents were those with higher education—70.0% (including higher education with a master's degree—30.0% of the total, higher education with a PhD or higher—26.0% of the respondents and higher education with an engineering/bachelor's degree—14.0% of the total, i.e., respectively, 45, 39 and 21 people). The smallest group was those with basic vocational or trade education—0.67% of the total, or 1 person. General secondary education and vocational education were represented by 28 respondents, or a total of 18.66%. Only 3 people or 2.0% were characterized by primary education.

The largest group among the households were those living in cities with a population of 15,000 or more, i.e., 52.0% of the total respondents (78 people), and rural residents—32.67% (49 people). Only 2 respondents resided in a city with a population of 5000 to 9999, which accounted for 1.33% of the total respondents.

Considering their work situation, 80 respondents indicated employee status (53.33%), and 42 were students (28.0%). The surveyed group included 13 retirees, 9 self-employed and 1 pensioner, who represented, respectively, 8.67%, 6.0% and 0.67% of the total.

In addition, the largest number of people who responded to the survey questions were from four-person households—50 (33.33%) and two- and three-person households—a total of 65 people (43.33%). Respondents constituting households of 5 or more persons accounted for about 15.0% (22 persons). Only 13 respondents said they constituted a single-person household (8.67%).

Respondents in the metric were asked to specify per capita net income. The largest number of surveyed residents of Świętokrzyskie province indicated that their net income per person in the household is between PLN 2501 and PLN 3000—21.33% (32 people). Income above PLN 5000 was indicated by 18.0% (27 people). In contrast, the lowest per capita net income of less than PLN 800 was declared by 6.67% of respondents, i.e., 10 of the total number.

5.2. Knowledge and Attitudes of Residents of Świętokrzyskie Province about RES

In the main part of the questionnaire, respondents were first asked to assess their knowledge of renewable energy sources (Figure 1). Half of the respondents rate the knowledge in question as very good and good, respectively: 14.67% (22 people) and 35.33% (53 people). As many as 53 people assessed their knowledge of RES at a sufficient level, which accounted for 35.33% of those surveyed. 22 households rated their knowledge of RES as poor and very poor, respectively: 16. (10.67%) and 6. (4.0%) of the province's population.

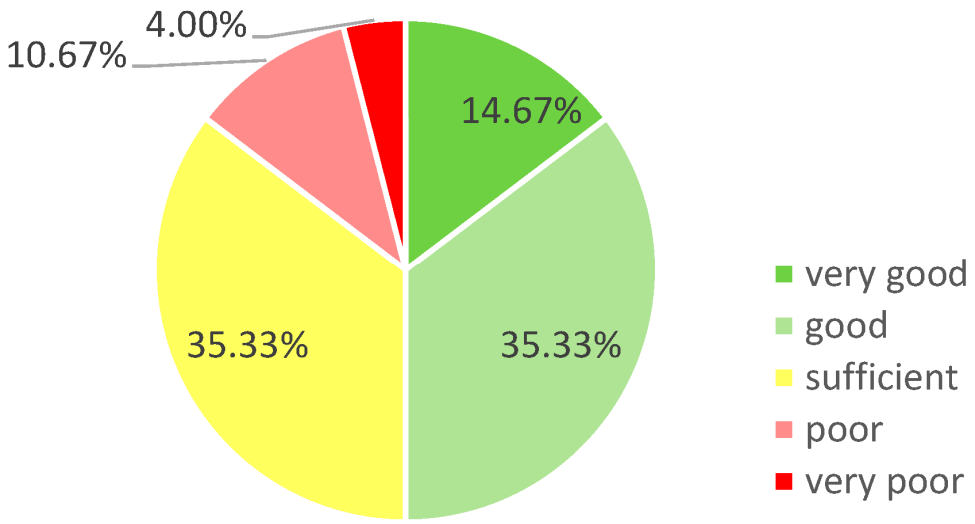

Figure 1. Assessment of households' knowledge of renewable energy sources. Source: own research. N = 150.

36.0% of respondents answered in the affirmative regarding the use of renewable energy sources at their place of residence (54 people), while 64% of respondents do not use RES (96 negative responses; Figure 2). Of the province's residents surveyed, 81.82% use photovoltaic panels, 30.91% use solar panels and 10.91% use ground source heat pumps. A small percentage—9.09%—uses biomass. Respondents do not use water, wind and biogas for energy.

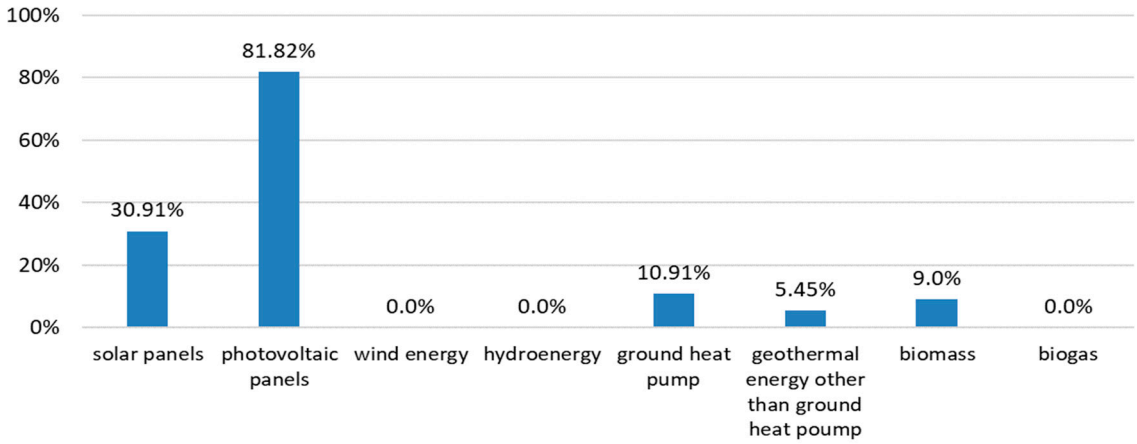

Figure 2. Renewable energy sources used by respondents at their place of residence; possibility to indicate more than one renewable energy source. Source: own research. N = 150.

The 54 people taking part in the survey use RES directly for their own needs. The majority of respondents use RES in single-family buildings (94.44%). 3.7% of respondents use RES in multi-family buildings, and 1.85% in an apartment in a multi-family building. In only two cases did respondents indicate the use of RES in buildings of a different nature, i.e., a commercial and residential building and a service building.

The survey shows that 77.78% of households use RES to obtain electricity, 70.37% to heat hot water, 37.04% for heating and 20.37% for cooling. Seven respondents use RES simultaneously for hot water heating, heating, obtaining electricity and cooling. Ten respondents indicated that they use RES in three manners. In this group of respondents, only three respondents indicated that they use RES to obtain cooling. Eleven respondents indicated that they use RES in two manners.

Respondents indicated that more than 30% of people use RES for heating hot water in single-family, multi-family and other (service and residential, commercial; Figure 3) buildings. The multi-family building is dominated by obtaining energy from renewable sources for electricity generation (66.6%). In apartments, multi-family buildings use RES for heating, obtaining electricity and obtaining cooling at comparable levels (33.3%). The least amount of energy obtained from renewable sources is used in single-family buildings for cooling—about 8.7%.

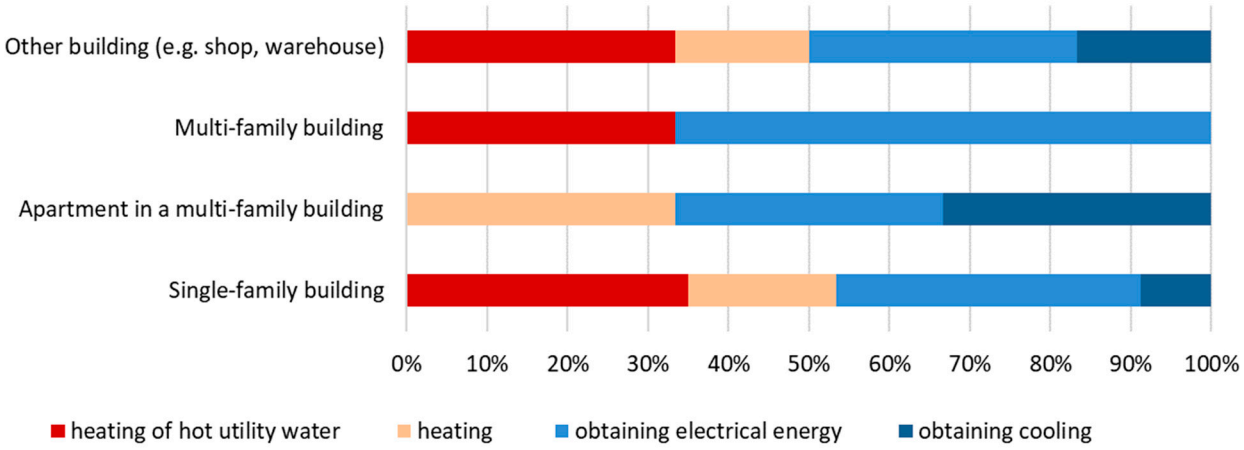

Figure 3. Purpose of RES use vs. nature of building used by respondents. Source: own research. N = 54.

Among the respondents, the vast majority believe that energy production from renewable sources is necessary—a definite yes and a yes were answered by 123 people, which accounted for 82.0% of the respondents (Figure 4). Only 14 people responded negatively to the aspect in question (9.33%). Thirteen respondents had no opinion on the necessity of using RES (8.7%). Respondents indicated various reasons in the surveyed area. They can be grouped as follows:

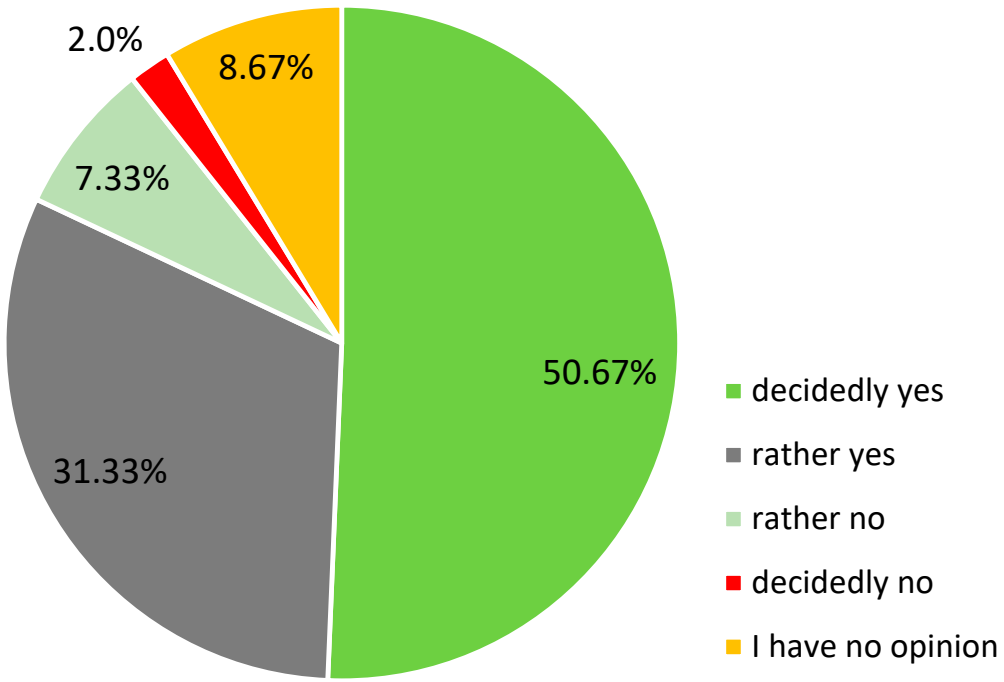

Figure 4. The question of the necessity of renewable energy production according to respondents. Source: own research. N = 150.

- environmental protection (the dominant reason among the responses);
- economic considerations (including cheaper green energy and lower maintenance costs);
- diversification of energy sources and depletion of energy resources (among other things, independence from fossil sources, depletion of non-renewable energy sources, energy security and their use does not involve a deficit),
- other reasons mentioned by respondents (direction of zero emissions and renewable energy sources, saving energy, benefiting the planet and using the potential of the sun, wind and water).

Equally important are the benefits of renewable energy production (Figure 5). The predominant responses include reduced air pollution (76.7%), reduced electricity costs (70.0%), saving other natural resources (58.7%), reduced heating costs (56.0%) and energy independence (54.0%). The smallest number of respondents indicated a benefit in terms of job creation (20.7%). Among other benefits of renewable energy production, one person cited "increased resilience to price fluctuations and energy availability dictated by the global energy lobby" (0.66%). In addition, 2 people responded that they did not know the benefits in question (1.33%).

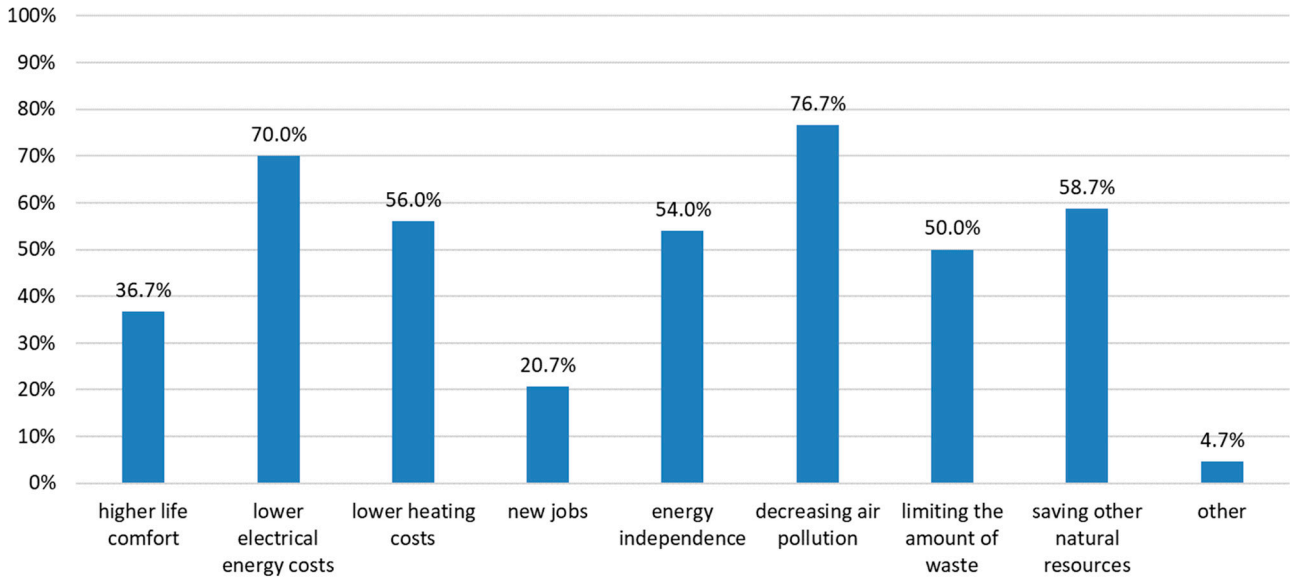

Figure 5. Benefits of renewable energy production; possibility to indicate more than one benefit. Source: own research. N = 150.

As can be seen, more than 60% of respondents say that the location of the renewable energy generation facility in relation to where they live does not matter to them, and they are positive about such an investment (32.0%). 4.67% would think about relocating, and only 2.67% would protest against such an investment. Among the arguments for a positive approach to the RES project were care for the planet, proximity to the workplace, reduced energy costs, opportunities for regional and economic development, reduced environmental pollution, better air quality and cheaper electricity, which could translate into lower prices for products and services, etc.

'In the subsequent question, respondents were asked to indicate the type of RES they disapprove of in the vicinity of their residence (Figure 6). The responses show that a large majority of respondents (55.3%) accept all sources. Significantly fewer respondents disapprove of wind power (24.7%) due to "noise, interference with natural air intake, adverse effects on health in the immediate vicinity and on birds, disfigurement of the landscape, disruption of spatial order, and nuisance to living comfort". A comparable number of respondents—16.7%—disapprove of biomass ("possible odor emissions") and biogas ("possible odor, risk of failure, risk of explosion"). 10% of respondents disapprove

of photovoltaic panels due to the inconvenience to living comfort. More than 6.7% of respondents disapprove of ground source heat pumps ("noise"), and 5.3% of respondents disapprove of solar panels (no justification) and hydropower ("noise").

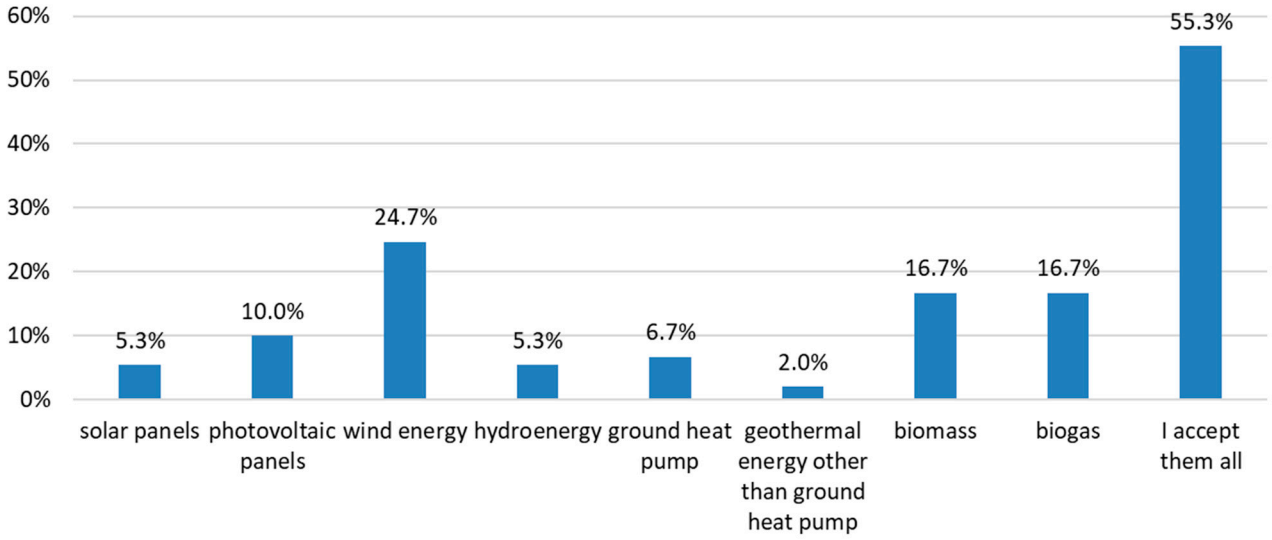

Figure 6. RES not accepted by respondents in the vicinity of their residence. Source: own research. N = 150.

Respondents were asked to identify the disadvantages of renewable energy production. The largest number of respondents cited the disadvantages of using photovoltaic panels and wind power (45.33% each). This was followed by solar panels with 26.67% of respondents, biomass with 24.0% and biogas with 22.67%. The disadvantages of hydroelectric energy and geothermal energy other than ground source heat pump were indicated, respectively, by 16.0% and 10.0%. In contrast, the disadvantages of using ground source heat pumps were identified by 7.33% of respondents—11 people. The disadvantages of obtaining energy from renewable sources as indicated by respondents are shown in Table 2.

Table 2. Disadvantages of renewable energy production indicated by respondents.

Disadvantages of Renewable Energy Production	
Solar panels *:	Photovoltaic panels *:
- high installation costs; - high cost of disposal of used panels; - hard-to-treat waste; - possibility of fire; - difficulties in disposal; - too much dependence on weather conditions; - the state is unable to store the energy generated on sunny days and shuts off electricity when there is excessive production; - frequent service; - lack of production during the winter period; - uneven amount of energy extracted depending on the season/day; - mismatch with the power grid.	- recycling problem—the need to dispose of used components of RES installations; - interruptions due to low capacity of power lines; - are subject to overheating which consequently carries the risk of fire; - occupation of agricultural land for photovoltaic farms; - panel production involves a heavy burden on the environment; - problems with transmission of excess energy produced; - decrease in the efficiency of the panels after a few years, the rate of their pollution and the lack of collection points for used panels, which consequently leads to environmental pollution; - there is no nighttime energy production or when snow covers them; - overloading of the power grid—urgent modernization of the power grid and energy storage facilities is needed; - decline in performance over time; - threat to animals and harmful to nature; - mismatch with the power grid and voltage spikes.

Table 2. *Cont.*

Disadvantages of Renewable Energy Production	
Wind energy *:	Hydropower *:
- noise generation and danger to birds; - problem of disposing of used components; - there is not always enough wind; - problem with worn propellers, as manufacturers do not disclose what the tripods and propellers are actually made of; - material life; - unstable energy source; - costly source; - landscape degradation; - risk of a turbine fire; - low efficiency; - apparently, there are scientific studies confirming the negative effects of turbines on bees; - drop in land prices in the neighborhood.	- inundation of inhabited areas and changes in the biosphere; - requires the construction of water reservoirs and flooding of a significant area; - the bang, the noise and the hum of water flowing with high intensity; - the destruction of aquatic ecosystems, reducing their biodiversity; - not everywhere can this system be applied; - few bodies of water and droughts; - declining groundwater levels and low rainfall; - reducing fish populations and regulating the riverbed can lead to the drying up of groundwater and the river itself, as well as the death of marine animals; - water problems; - high installation costs; - high investment costs, long ROI period and negative environmental impact; - small amount of energy in Polish conditions; - requires a water current of sufficient strength; - electromagnetic field; - lack of a fish ladder and too high a water level.
Ground source heat pump *:	Geothermal energy other than ground source heat pump *:
- high drilling costs; - poor performance; - requires the installation of a horizontal or vertical loop in the ground, which incurs additional costs; the construction of these loops can be time-consuming and expensive, especially in areas with limited accessibility or difficult ground; - the efficiency of a ground heat pump depends on the thermal properties of the ground, such as thermal conductivity and heat capacity; hence, some soils may be unsuitable for efficient heat uptake and transfer, which can affect system performance. - installing a heating loop in the ground can require a significant area; for small plots of land or urban areas where space is limited, it can be difficult to find a suitable place to install a ground source heat pump; - large financial outlay associated with the purchase of a heat pump; - failure rate and numerous fires in the installation.	- high cost of drilling and the uncertainty of its effectiveness; - not everywhere can it be applied; - large expenditures to reach the sources; - requires a lot of exploration; - geothermal sources are not stable (can move) and can only be used in certain locations; - possible contamination of the soil, water and atmosphere with extracted gases and minerals; - poor availability in Poland; - need to drill deep wells.
Biomass *:	Biogas *:
- possible unpleasant odor; - high investment costs; - low productivity; - biogas plants cannot be built everywhere, costs are high and there is a lack of state aid; - problems with storage, transportation and combustion; - emission of carbon dioxide and other combustion products into the atmosphere. - low energy value;	- unpleasant odor; - methane is a dangerous gas; - low productivity; - high cost of building a biogas plant; - biogas—necessary tightness of the processing plant; - low efficiency (high utilization costs compared to the benefits obtained); - possibility of unsealing the network; - risk of explosion and high cost; - can be intrinsically explosive in nature; care should be taken when storing it.

* Taken from among the responses; those that represented non-response or ignorance of the respondent about the disadvantages of RES types were eliminated. Source: own research. N = 150.

Only 7.33% of respondents gave an affirmative answer to the question of incurring higher energy costs if it came from renewable sources. 52.67% of respondents conditioned their decision on the issue in question on their financial situation. The remaining group, accounting for 40.00%, gave a negative answer.

The most important factors influencing households' decisions to choose an energy source at their place of residence are economic (70.0%) and practical (52.67%; Figure 7). Respondents attribute high importance to ecology and convenience, with 40.0% of respondents giving this response in both cases. In contrast, trend was the least important, indicated by one respondent (0.67%). 48.67% of respondents expressed the opinion that, given a choice in their consumer decisions, they are guided by the source of energy.

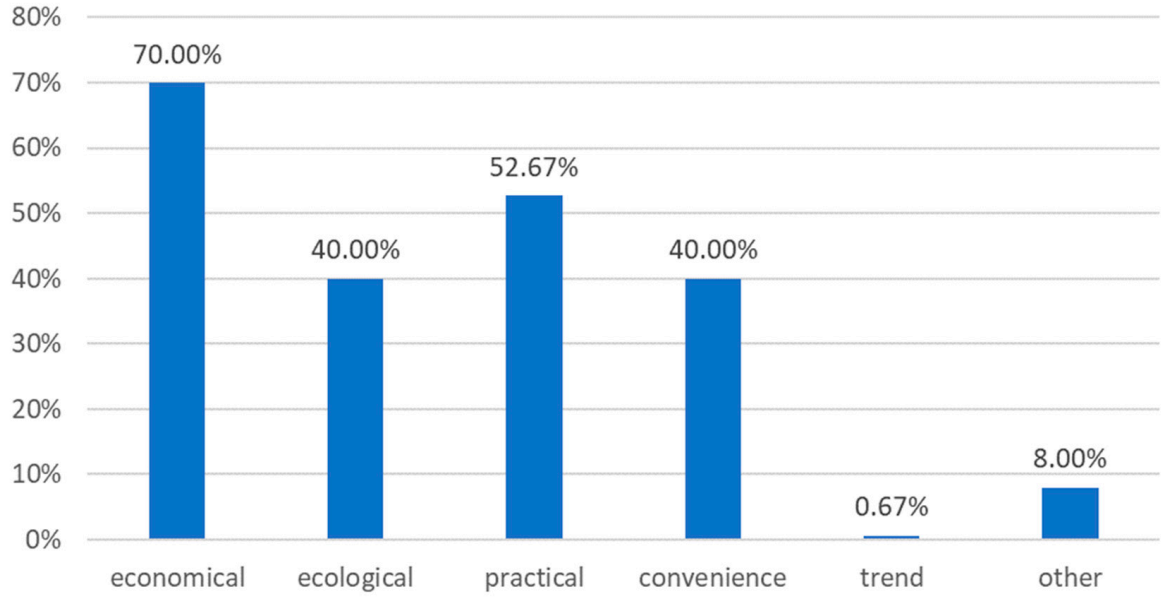

Figure 7. Factors influencing households' decisions to choose an energy source at their place of residence. Source: own research. N = 150.

When asked "If there was a choice of building a renewable energy source in the vicinity of your residence, would you choose from the list?" the largest percentage of people surveyed leaned toward photovoltaic panels—39.33% (59 people; Figure 8). The use of energy from solar panels and ground source heat pumps would be opted for, respectively, by 16.67% and 14.0% of respondents. The fewest respondents would opt for biogas and biomass—0.67% (one person).

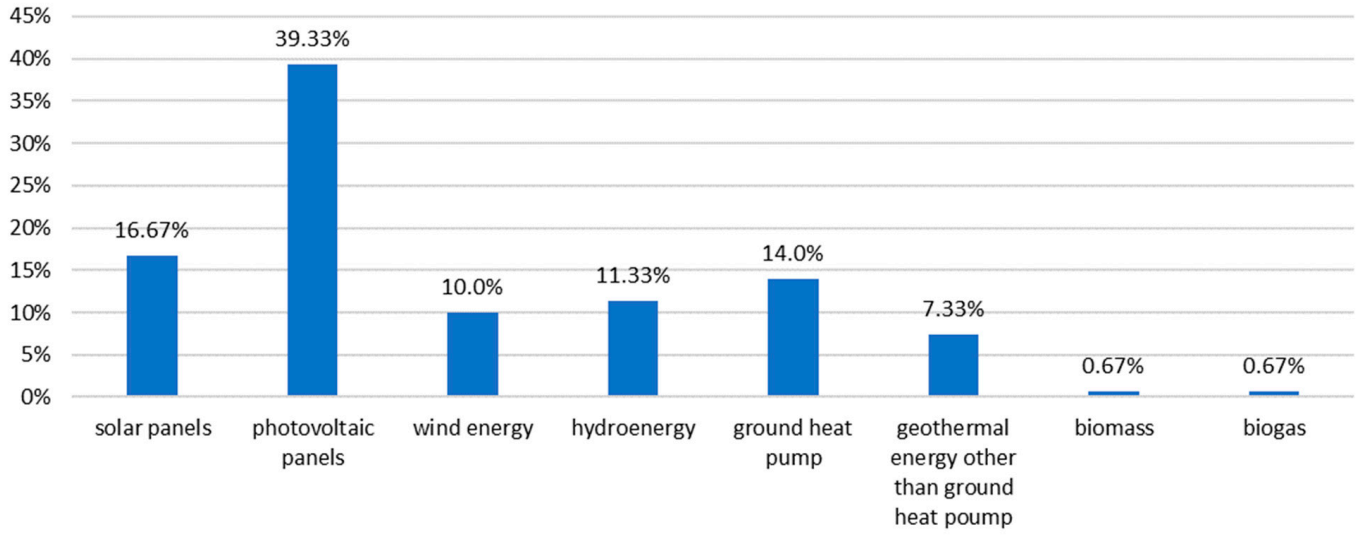

Figure 8. Respondents' choice of a source of renewable energy in the vicinity of their place of residence, if such a possibility existed. Source: own research. N = 150.

Among those surveyed, 95 people said that renewable energy production affects human health and life—63.33%. In contrast, 19 people gave a negative answer (12.67%). In contrast, 36 people surveyed said they did not know whether renewable energy production affects human health and life (24.0%). According to 44 respondents, i.e., 80%, renewable energy production has a positive impact on human health and life (N = 55). The remaining group—11 people (20.0%)—gave a negative answer.

Respondents considered hydropower (52.67%), photovoltaic panels (34.67%), wind power (32.67%), ground source heat pumps (32.67%) and solar panels (31.33%) to be the most environmentally friendly. The least environmentally friendly, according to respondents, are geothermal energy, other than ground heat pump (25.33%), biomass (12.67%) and biogas (6.0%; N = 150).

In turn, respondents identified solar, hydroelectric and geothermal energy as the most efficient sources of renewable energy, with indications, respectively, by 21.19%, 19.87% and 19.21% (N = 150). The least efficient, according to respondents, are wind power (8.61%) and biomass energy (3.31%). 42 people had no opinion on the issue (27.81%).

Hydropower (22.52%), geothermal (19.87%) and solar (14.57%) have the highest reliability, according to respondents. Biomass energy has the lowest reliability (5.3%). 30.46% of respondents had no opinion on the subject (Figure 9).

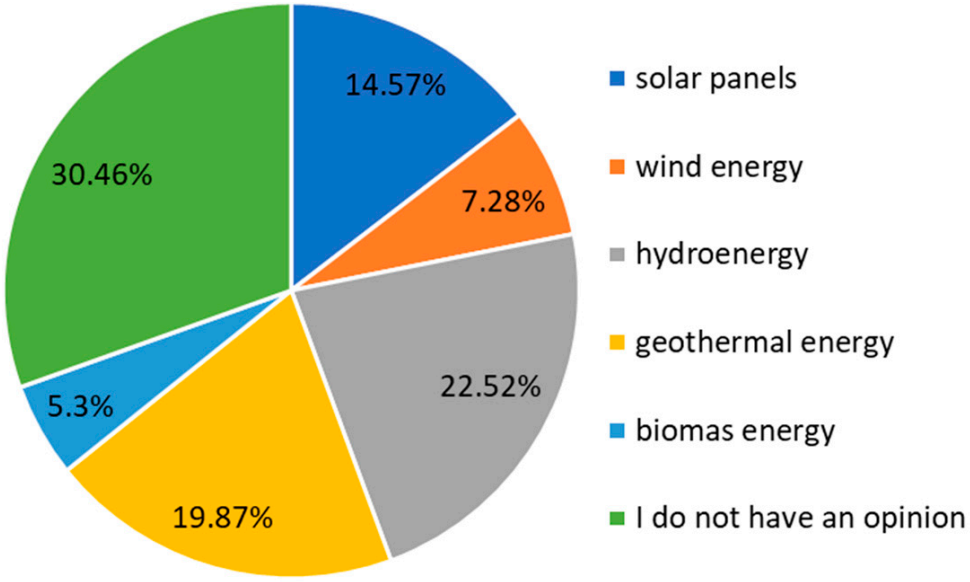

Figure 9. RES considered by survey respondents as the least reliable. Source: own research. N = 150.

There is optimism that, according to 84.11% of respondents, an increase in the use of RES will have a positive impact on the natural environment in Świętokrzyskie province. Only 15.89% of respondents do not see a positive impact of increasing the use of RES on the natural environment in the analyzed province. Consequently, the impact will not only be felt in the studied territorial unit but will also translate to the national level.

Respondents who rated their knowledge of RES as very good and good presented higher education with a master's degree (32.0%; Figure 10). Similarly, respondents with a university degree and a doctorate (or higher) rated their knowledge as very good and good (29.3%). A sufficient level of knowledge is represented by respondents with general secondary education (16.9%). In contrast, those with primary education (16.6%; 1 person), post-secondary or a high-school diploma education (16.6%; 1 person), higher education with an engineering/bachelor's degree (16.6%; 1 person) and higher education with a master's degree (50.0%; 3 people) rated their knowledge in the subject area very poorly. Of the surveyed population, 50.0% rated their knowledge of RES as very good and good, 35.33% rated it as sufficient and 14.6% rated it as poor and very poor.

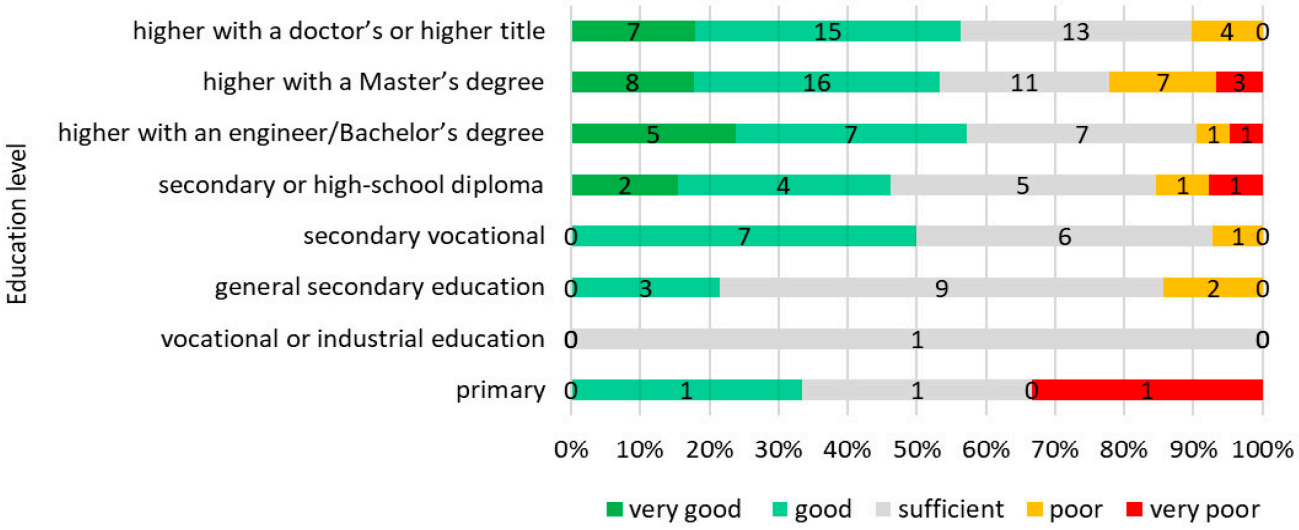

Figure 10. State of knowledge of RES according to respondents' education. Source: own research. N = 150.

In this study, a comparison was made between the respondents' knowledge status and their age (Figure 11). Quite a large group that assessed their knowledge of RES as very good and good were respondents aged 21–40 (45.3%). At the same time, 56.6% in this age group described their knowledge of RES as sufficient. 41.0% of respondents in the 41–60 age range indicated knowledge of RES to be very good, 30.2% to be good, and 68.75% to be poor. In the 60+ age group, the highest percentage of respondents indicated their knowledge of RES to be poor. No one stated that they had very good knowledge in the studied area in the age group <20 years.

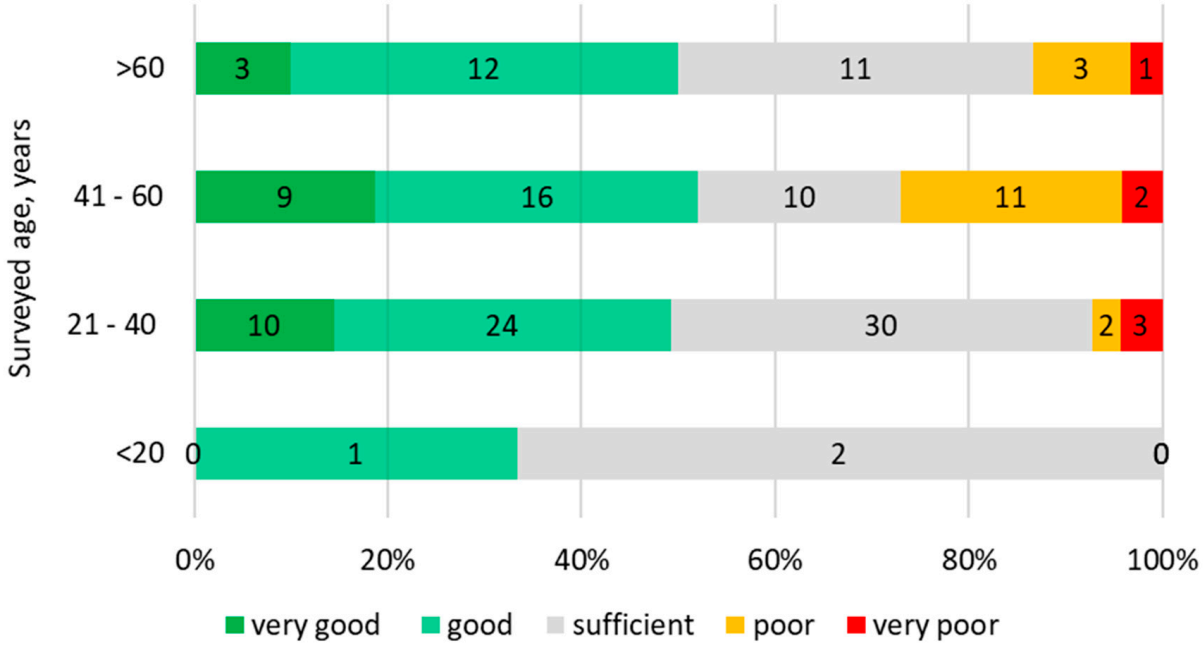

Figure 11. The state of knowledge about RES according to the age of respondents. Source: own research. N = 150.

To complement the scope of analysis based on clustering statistics, an attempt was made to use an econometric model as a research tool. This approach is much more versatile, as it not only involves the evaluation of correlation (coefficient of determination) but also

takes into account ANOVA analysis, and its results allow the discovery of cause–effect relationships between the key areas under investigation. An additional aim of the paper is to identify the determinants of the knowledge and attitudes of residents in Świętokrzyskie province regarding renewable energy sources. Table 3 shows the aggregate results of the final forms of the models, where a set of statistically insignificant variables has been removed. Basic statistics characterizing each of the studied relationships have been taken into account, such as the coefficient of determination and significance tests F and t. In Table 3, for the sake of clarity, the following notations have been adopted:

Table 3. Results of econometric modeling.

	Y1	Y2	Y3	Y4	Y5
R2	53.21%	36.19%	46.97%	39.19%	21.30%
F stat.	83.5848	41.6802	65.1114	95.3839	19.8893
Intercept (value)	2.3258	−0.6098	−0.3803	−0.2778	0.1191
(stat. sign. t)	24.9789	−5.2842	−3.7214	−2.6778	0.9657
X3 (value)	0.8892	−0.1841	0.1532		0.2754
(stat. sign. t)	7.8091	−2.3452	2.2036		3.2832
X6 (value)		0.3440	0.2886	0.2979	0.1167
(stat. sign. t)		8.6933	8.2344	9.7665	2.7598
X7 (value)	0.9870				
(stat. sign. t)	8.6933				

Source: own research. N = 150.

- Y1—self-assessed knowledge of respondents;
- Y2—use of RES;
- Y3—awareness of the need for RES;
- Y4—awareness of the positive impact of RES on the environment;
- Y5—acceptance of all types of RES in their surroundings;
- X1—income level;
- X2—place of residence (rural);
- X3—higher education;
- X4—gender;
- X5—age;
- X6—self-assessed state of knowledge of respondents;
- X7—use of RES.

Indicators such as level of knowledge and use of RES were used both as endogenous and exogenous variables. In order to avoid collinearity and an excess number of regressors, only rural residents (in contrast to residents of small and large cities) and people with higher education were included in the model as explanatory variables, as a result of the sparse representation of people with primary and vocational education (which could affect both the approximate collinearity and reduce the model's transparency). It is worth noting that the respondents' state of knowledge was treated as a quantitative variable, which was made possible using a Likert scale. The remaining determinants are dichotomous (binary) variables.

To verify the significance of the parameters, a 5% significance level was assumed, a value commonly used in economic and sociological research. The results proved to be relatively reliable. First of all, it was found that the level of knowledge (in the area of respondents' self-assessment) is statistically significantly influenced by higher education and the use of RES for one's own purposes. This relationship is strong, as it explains 53.21% of the knowledge level. A significantly lower (36.19%) level of explanation characterizes the aspect of respondents' use of renewable energy sources. Factors such as the level of higher education and the respondents' knowledge status in the field of RES have a significant influence here. However, it is worth noting the unique nature of the estimate concerning higher education—individuals with higher education were less inclined to use RES for their own purposes than those with a lower level of education. The third factor for which

an attempt was made to determine the influencing determinants was the awareness of the need to introduce renewable energy sources. In this case, the quality of the model turned out to be average, with a coefficient of determination of 46.97% and significant factors such as higher education and the respondents' knowledge status. To assess the factors shaping the awareness of the positive impact of RES on the environment, only the respondents' knowledge status was indicated. The model is characterized by a relatively low level of phenomenon assessment, amounting to 39.19%. However, the lowest coefficient of determination (21.3%) was observed when attempting to explain the factors influencing the acceptance of all types of RES in one's neighborhood. Education level and the respondents' knowledge status were again found to be statistically significant determinants.

6. Discussion

Respondents with a declared low and very low level of knowledge about RES represent a smaller percentage (<15%, Figure 1) than respondents with a lack of information in this area and taking part in surveys conducted in 2010 on a nationwide sample of Polish adults. Then, 16% of respondents indicated that they definitely lacked knowledge about RES. In contrast, 30% of the respondents believed that they mostly lack knowledge about RES [43]. The relative increase in knowledge about RES may be a consequence of the impact of information provided in the media [28] and advertising campaigns, e.g., about the Mój Prąd [44], Czyste Powietrze [45] and Prosument [46] programs.

The knowledge rating depended on the age of the respondents (Figure 11). Respondents between the ages of 21 and 40 declared the greatest knowledge, while those under 20 and over 60 declared the least knowledge. The high and very high self-assessment of knowledge about RES in the first-mentioned age group of respondents is not unusual. According to [25], the youngest people (18–24 years old) who consider themselves the best informed about RES constituted the largest group (68%) of Poles surveyed in 2010. Thus, it can be assumed that these are currently respondents under the age of 40.

The survey shows that respondents with higher education are the largest group with the most declared knowledge of RES (Figure 10). A similar relationship was noted in the results presented by Krzyzanowska et al. [43]. The research results presented in [25] also confirm that the level of education plays an invaluable role in self-assessment of knowledge about RES.

The clear prevalence of photovoltaic panel use by surveyed residents of Świętokrzyskie province (Figure 2) was potentially influenced by local and global factors. Local factors include the implementation of the nationwide Mój Prąd Program starting in 2019. The goal of the Mój Prąd Program is to subsidize expenses related to the purchase and installation of photovoltaic micro-installations [45,47,48]. Global factors, on the other hand, include the ongoing war across the country's eastern border since 2022 and the COVID-19 pandemic [49]. Positive attitudes toward the use of photovoltaic panels and solar panels to produce heat and electricity were already evident in a 2016 survey of a representative sample of Polish residents [28].

Information gaps about RES were demonstrated by respondents taking part in the survey analyzed. When answering open-ended questions, respondents said they had no knowledge of the subject of the question. For example, to the question "why do you think energy production from renewable sources is necessary?" 7.33% of respondents did not provide correct answers. Also, according to the report by [50], Poles have shown low awareness about renewable energy sources.

The high proportion of responses indicating a reduction in air pollution from renewable energy production (Figure 7) is not unique. The aspect of reducing air pollutant emissions through renewable energy production was also pointed out by a majority of surveyed Poles in a 2016 study conducted by the Center for Public Opinion Research [28].

A clear disapproval of living in the vicinity of wind power generation (Figure 8) is a popular attitude among surveyed residents of Świętokrzyskie province. Also, according to [51], 45% of Poles surveyed would not want to live near a wind farm. At the same time,

the prevalence of disapproval of wind energy procurement over reluctance to use solar energy is also an attitude of Swiss residents, further influenced by the size of solar and wind installations [52].

Acceptance of the use of hydropower in the neighborhood distinguishes the residents of Świętokrzyskie province compared to the residents of Poland as a whole. According to [25], the percentage of Poles strongly in favor of building hydroelectric power plants (41%) is comparable to those in favor of building wind power plants (39%). In contrast, in Świętokrzyskie province, there are 19% more residents accepting the use of hydropower in their neighborhood compared to those accepting wind power. This attitude is influenced by the fact that there are 17 small hydroelectric power plants in Świętokrzyskie province. The attitudes of the respondents from Świętokrzyskie province about energy costs are in line with those of Poles, who in a survey on the priorities of the European Energy Union, ranked guaranteeing reasonable energy prices first ([5], Figure 10). There is a clear reluctance among Europeans to bear higher heating and food costs as a consequence of rising energy prices. According to [51], this attitude does not depend on the wealth of the state. Disapproval of paying higher costs for renewable energy is also demonstrated by [53] in residents of the UK, US and Australia.

The percentage of the respondents from Świętokrzyskie province ranking wind energy as the most environmentally friendly was significantly lower (32.67%) compared to the respondents taking part in the nationwide survey (75%; [25]). The residents of Świętokrzyskie province also expressed a different opinion from surveyed Poles regarding the environmental friendliness of heat pumps. 32% of the surveyed residents of this province regarded this energy source as environmentally friendly, while only 4% of surveyed Poles shared this view [25]. The significant difference in opinions can be attributed to the increased availability and frequency of heat pump utilization over the past 12 years since the aforementioned survey of Polish residents [54].

From the perspective of the agricultural nature of Świętokrzyskie province, the classification of biomass and biogas (6%) as environmentally friendly energy sources by 12.67% of the residents surveyed is moderately satisfactory, even when compared to the opinion of surveyed Poles, among whom only 2% considered energy utilizing biogas to be environmentally friendly [25].

Asking respondents to indicate the disadvantages of all types of RES in an open-ended question was expedient (Table 2). This ensured that the responses were not influenced by a subjective and confrontational comparison with other sources of energy, such as fossil fuels. The confrontation of RES with nuclear, coal and gas power is noticeable in the research presented by [29].

The freedom in responding allowed for the exploration of a wide range of respondents' opinions (Table 2.). The variety of the drawbacks indicated stems from concerns but also probably from negative personal experiences, especially among users of photovoltaic panels. Over 65% of surveyed users of photovoltaic panels listed one or more disadvantage, both related to photovoltaic panels and other types of RES. Finding out respondents' views on the disadvantages is a valuable resource for decision makers and those undertaking RES-based investments. It serves as the basis for defining the substantive content directed at residents through social communication means to combat stereotypes (e.g., "problem with worn propellers").

The issue of high costs raised by the province's respondents (Table 2) corresponds with the high level of energy poverty among residents [31]. Therefore, it is a signal to decision makers about the justification of continuing and expanding the financial support system for residents to increase the use of RES.

7. Conclusions

The development of RES is one of the ways to achieve the EU's energy policy goals. At the same time, RES are part of sustainable development. Sustainable energy development incorporating RES generates environmental, economic and social benefits. Additionally,

environmental concern and efficient resource utilization align with the goals of another economic concept, namely, a circular economy.

The results of this survey indicate a positive attitude of the surveyed residents of Świętokrzyskie province toward RES. Thefavorability for the choice of RES in the vicinity of the residence is clear for solar energy, i.e., solar panels and photovoltaic panels. The aforementioned attitude of respondents is important not only because of the realization of the energy transformation but also because of the tourist and spa nature of Świętokrzyskie province.

Half of the respondents rate their knowledge of RES as very good or good, while the remaining describe their knowledge as sufficient, weak, or very weak. Unfortunately, 64% of the surveyed individuals do not utilize renewable energy sources in their place of residence. Among those using RES, just under 95.0% use it in single-family buildings, including for generating electricity, heating domestic hot water, heating and cooling. The dominant group of surveyed residents of Świętokrzyskie province emphasized the necessity of producing energy from renewable sources, citing reasons such as environmental protection, economic considerations (including cheaper green energy), diversification of energy sources and the depletion of energy resources.

The majority of respondents showed awareness of the disadvantages and limitations of using RES while recognizing their benefits and advantages. At the same time, the majority of respondents indicated the positive impact of RES on people's lives and the environment.

It should be noted that a relationship was observed between the respondents' knowledge and their age and education. The attitudes and knowledge of the surveyed residents of Świętokrzyskie province do not differ from previous results of surveys conducted at the national and regional levels. The econometric model further revealed the leading role of respondents' education and self-assessment of the state of their own knowledge as a factor influencing most endogenous variables. This is in line with expectations and confirms the conclusions drawn from descriptive statistics analysis.

The strength of this study is the results of the research conducted, which can be used to prepare programs and strategies to promote and educate residents about RES. The information obtained from this survey, indicating that a small percentage of respondents consider biomass and biogas to be the most environmentally friendly energy sources, is highly important. It should be a signal to policymakers organizing educational campaigns to include issues of the beneficial environmental impact of biomass and biogas energy. This will help offset the protests and reluctance of residents to new investments using these renewable energy sources, especially considering the agricultural nature of the province, which ensures ample access to resources for energy generation through biological conversion in anaerobic conditions.

In pursuing this research goal, particular attention was paid to the varied responses in relation to the knowledge and attitudes of the respondents regarding RES, especially since respondents were given the freedom to respond in open-ended questions.

The advantage of this study lies in the applied econometric modeling. Identifying the relationships shaping the key research areas addressed in this paper contributes to its cognitive value and further increases the reliability of the estimates confirmed by statistical tests. Another added value of this study is the regional perspective on renewable energy sources. Rational utilization of energy from renewable sources is one of the important components of the sustainable development of the studied province and can bring tangible ecological and energy-related effects in the near future.

Further research may focus on comparing the level of RES development in Poland with other European Union countries. There is also room for in-depth analyses of the impact of RES on the socio-economic development of Polish provinces. In the long-term perspective, the conducted research can be seen as a contribution to existing research and may serve further comparative analyses.

Accessibility to respondents and their willingness to complete the survey on RES was a significant limitation of the completed surveys in terms of the number of surveys returned. There is an unsatisfactory response to some survey questions. Hence, it is

reasonable to continue further research in the discussed area, which would include the use of the Likert scale to measure the degree of acceptance of RES by the community of Świętokrzyskie province and the comparison of the level of development of renewable energy in Poland with other European Union countries. There is also room for an in-depth analysis of the impact of RES on the socio-economic development of Polish regions, including Świętokrzyskie province, as they are a factor in its development.

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