

Article

Perception of the Transition to a Zero-Emission Economy in the Opinion of Polish Students

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Abstract: Renewable energy sources are an alternative to traditional sources and are based on inexhaustible and environmentally friendly supply. Various controversies have been stirred up by the development of energy production from renewable sources, e.g., due to the high cost of these investments or carbon footprint at the production stage of renewable installations, or later in the disposal process. However, they seem to be gradually offset by the numerous benefits that outweigh the initial costs of their support. Therefore, it is not surprising that European Union (EU) countries are at the forefront of the transition to a low-emission economy. This is evidenced, e.g., by a 22% reduction in greenhouse gas emissions in Member States, with gross domestic product (GDP) growth of 58% between 1990 and 2017. Nevertheless, the use of renewable energy sources such as sun, wind, water, etc. is much more expensive than burning fossil fuels. This argument of high investment costs can be decisive in decisions of both public debates and individual households. Therefore, education on renewable energy sources is needed to facilitate the process of transition to a zero-emission economy in the European Union countries. This education should, above all, be addressed to young people, who will be making these decisions in the future. Reduction of greenhouse gas emissions by 2050 will largely depend on the knowledge and awareness of young people. The aim of the paper is to diagnose the perception of the transition to a zero-carbon economy in the opinion of Polish schoolchildren. We put a particular emphasis on renewable energy sources as a key element shaping the security of the state in terms of sustainable ecology and friendly social development. We achieved the aim of the study through a research process with use of theoretical and empirical research methods. We analysed the literature on the subject and the current legal acts in the field of renewable energy sources. We also conducted a survey of high school students in Poland. The analysis of the research results allowed us to formulate recommendations on the possibility of shaping state security in the field of sustainable ecology and friendly social development.

Keywords: renewable energy sources; national security; ecology; social development; non-emission economy; high school students; European Union



Citation: Kaczmarczyk, B.; Urych, I. Perception of the Transition to a Zero-Emission Economy in the Opinion of Polish Students. *Energies* **2022**, *15*, 1102. <https://doi.org/10.3390/en15031102>

Academic Editor: Luigi Aldieri

Received: 28 December 2021

Accepted: 29 January 2022

Published: 2 February 2022

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1. Introduction

One of the most important challenges of the 21st century is avoiding a climate catastrophe. This can be achieved through climate neutrality, otherwise known as “net zero emissions”, which is a balance between emitting and sequestering greenhouse gases. This objective should be achieved by 2050 at the latest by reducing greenhouse gases to a level where the global temperature increase does not exceed 1.5 °C [1]. Without these measures, scientists believe, the increase in the average global temperature could reach 2 °C after 2060 and continue to rise. At the same time, such unrestricted climate change could turn Earth into a “greenhouse”, posing unpredictable threats to both humanity and the environment [2].

Implementing climate neutrality in as many countries of the world as possible is essential. The paradigm of change is emphasised especially by European Union countries [3]. The case for a process of transition to a zero-emission economy appears to be supportive in this respect. It is worth including, among others: using the bioeconomy to reduce CO₂ emissions by means of carbon capture and storage, the possibility of using renewable energy sources and electricity to fully decarbonise energy supply in Europe, developing smart grid infrastructure, and enhancing energy efficiency. In the European Union, these activities, consequently, imply individual and collective responsibility for shaping the economic, political and social environment [4]. At the same time, they are based on efficiency, decentralisation, individual and collective participation, creating a common legitimacy for the actions taken [5]. The implementation of a zero-emission economy is also the result of conscious citizen participation in environmental protection and in the implementation of the European Union's New Green Deal [3]. The role of the responsible citizen in ensuring the implementation of the European Union's New Green Deal is vital, especially in terms of young people who are still shaping their approach to a low-emission society in the European Union. It is "soft skills" rather than "hard skills" [6] that are crucial for future policy professionals dealing with low-carbon societies, and, therefore, an appropriately well-educated society [7].

This is why we need education about the emission-free economy and the use of renewable energy sources, which can facilitate the transition to "net zero carbon" for all European Union countries. This education should not only be directed at adults who are currently responsible for making decisions regarding the implementation of a zero-carbon economy but, above all, at young people who will be involved in these decisions in the future. It is upon their knowledge and awareness of sustainable ecology and its friendly societal development that the realisation of zero greenhouse gas emissions by 2050 largely depends. Therefore, it can be assumed that the knowledge of Polish pupils, in line with the awareness of pupils in EU countries, will have the greatest impact on the emergence of a zero-emission economy [7]. This situation implies the need for an assessment of the knowledge of Polish students on climate neutrality, which will make it possible to formulate recommendations for the implementation by Polish citizens of environmentally sustainable and climate-friendly social development to contribute to EU efforts to achieve climate neutrality by 2050. The aim of the paper is to diagnose the perception of the transition to a zero-carbon economy in the opinion of Polish schoolchildren.

The article consists of six substantive parts namely: introduction, theoretical framework, research methodology, results, discussion and conclusions. The introduction presents an overview of the topic of the zero-emission economy and the essence of the research problem undertaken. In the second part titled "Theoretical Framework", a review of the literature on the need for a zero-emission economy within the European Union and the need for the education of young people in this field is made. Then, the methodological assumptions of the conducted research are discussed, and the main results are presented, indicating the main trends in the empirical material obtained. In the discussion, the authors address the need to stimulate the global economy, which is in recession, not only through the policies of the Community countries adopted in this area but also the need for effective education enabling informed citizen participation in environmental protection. The conclusions, on the other hand, present the main findings of the conducted research in the areas of knowledge, awareness and opinions of the respondents on the topic of zero-emission economy and the need for the balanced development of young people in Poland. The existence of a knowledge gap among young Poles was identified. Educational needs in this area were also discussed.

2. Theoretical Framework

In accordance with a report prepared by the Intergovernmental Panel on Climate Change (IPCC), it can be shown that, compared to the pre-industrial era, the atmosphere and the ocean have warmed by an average of 1.5 °C. This has caused snow and ice masses to

diminish, ocean levels to rise, accompanied with an increased concentration of greenhouse gases in the atmosphere. In the Northern Hemisphere, the period 1983–2012 was probably the warmest 30-year period during the last 1400 years. As a result of global temperature increases, the Greenland and Antarctic ice sheets are losing their volume, adding to the rate of rise in ocean and sea levels. At the same time, the concentration of carbon dioxide (CO₂), nitrous oxide (NO) and methane (CH₄) in the atmosphere has risen to levels not seen on our planet for 800,000 years. The IPCC reports that such high levels of carbon dioxide are the result of the burning of fossil fuels (coal, lignite and oil), as well as changes in land use. Since the dawn of the industrial age, humans have been the dominant emitters of carbon dioxide and are, thus, responsible for increasing greenhouse gas emissions. This process contributes to global warming, decreasing glacier mass and rising sea levels. In the opinion of the report's authors, further forecasts in this area make it possible to formulate various scenarios for the future. Above all, global warming may have different manifestations in different regions of the world. In some, it will cause more frequent and more prolonged heat waves, in others, the likelihood of floods. Additionally, changes in the amount and pattern of precipitation, such as droughts or heavy rainfall, or changes in the frequency of adverse weather events, such as hurricanes and storms, will be observed. Climate warming will also have social, economic and political impacts, such as the problem of so-called climate refugees, economic burden caused by climate change mitigation, and conflicts over access to natural resources [8]. It is mass climate migration that could contribute to one of the darkest scenarios possible for the consequences of global warming, international political and even armed conflict. Not only may citizens of countries such as Iran, Iraq, Saudi Arabia, Kuwait, Bahrain, Oman and Qatar be forced to migrate but especially those of impoverished African countries who will no longer be able to feed themselves [9].

It is, therefore, necessary to limit the existing climatic effect and achieve climate neutrality. The Allied Transformation Command has said that efforts to reduce greenhouse gas emissions to “0” would take at least two decades. Restrictive measures will not have their first results until 2035. Until then, the warming of the oceans, the melting of glaciers and the rising of sea and ocean levels will continue. This means that humanity and the environment will face inevitable disasters [10]. Only adequate human intervention will reduce the negative changes occurring in the biosphere [11] but only to the extent practicable. More optimistic scenarios in this respect are feasible but require a longer timeframe and multidimensional, coherent action by many countries [12].

Due to the global climate recession, a discussion is now taking place in EU countries on creating a low-emission economy. In parallel, the European Commission is implementing measures under the Green Deal. Dynamic stimulation of the global economy caught in recession is necessary [1]. Achieving climate neutrality is one of the priorities of the European Union, and this can be termed “green capitalism” [13]. Measures aimed at its implementation revolve around decoupling the growing GDP of European Union countries from the growing and environmentally destructive energy consumption and implementing environmentally neutral technologies for the use of renewable energy in the Member States. There is also discussion of an EU-wide ban on environmentally harmful energy use [14].

The pursuit of a low-emission economy requires, first and foremost, reforms to promote renewable energy sources and, consequently, the implementation of a biofuels plan [15]. It is worth noting that there are many innovative proposals to reduce carbon dioxide emissions. One of these concerns is the use of a Doubly Fed Induction Generator (DFIG) targeting the Eco-Maximum Power Point Tracking (EMPPT) for environmental aspects. The controller consists of two clusters, which are the novel Artificial Immunity sensorless Eco-Maximum Power Point Tracking (AI EMPPT) and the asymptotic non-linear control techniques. The use of EMPPT will reduce carbon dioxide emissions by generating power from a renewable energy source such as wind power [16].

Researchers also stress that the superseding of conventional fuel generation requires the creation of virtually “green” societies, aware of the importance of individual and group decisions in energy production and consumption processes [17]. What is needed

in this area are measures that induce people to think, both in a forward-looking way and independently, about their immediate environment. However, as the results of empirical studies conducted in the European Union countries show, its citizens still have a “not in my backyard” mentality. For example, they tend to negatively perceive industrial carbon capture storage if it occurs anywhere close to where they live [18].

The promotion of a variety of activities supporting a zero-emission economy has resulted in the need for multidimensional initiatives, both in economic, political and social terms [4]. The reduction of greenhouse gas emissions should be evident in practical solutions incorporated into everyday life [19]. The choices that are made in favour of climate neutrality will have consequences for the future. Avoiding a climate catastrophe depends on the implementation of various measures in the energy, construction, forestry, agriculture and transport sectors, amongst others [1].

Nevertheless, the use of renewable energy sources such as the sun, wind and water is considerably more expensive than burning fossil fuels. This argument tends to be decisive not only in public debates but also when every individual on our planet is considering the choice to move to a zero-emission economy. Therefore, there is a need, for example, to develop future leaders in the implementation of zero-carbon policies at different decision-making levels in the Member States and the European Union institutions [20]. It is also essential to establish ideals and competencies that serve to shape civic attitudes and act for the public good [21]. These actions can be taken by every responsible EU citizen through their everyday consumer decisions [22]. Environmental education is, therefore, of fundamental importance here, providing guidance on reducing greenhouse gas emissions, conserving natural resources and adopting a carbon-neutral economy. Its essence is the formation of pro-environmental attitudes and, thus, an innovative approach to energy use [23].

In the above context, it is not only present-day actions to discontinue policies opposed to the achievement of the climate neutrality goal that are important [1] but equally important are the initiatives that will concern the actions taken by EU citizens in the future. Thus, it is possible to formulate the hypothesis that the knowledge and awareness of young people is crucial for delivering the Community’s main objectives for a zero-carbon economy, as it is this social group that will have the greatest impact on the emergence of the zero-emission economy in the future [24]. In accordance with the Paris Agreement, which culminated the 21st UN Climate Conference, the European continent is to be the first place on Earth to reduce or eliminate its carbon footprint in industry, agriculture, transport, services and the lifestyles of its inhabitants [25]. The planned transition period is from 2020 to 2050. The 30-year period is intended to accelerate the transition to renewable energy sources, reduce dependence on external sources and diversify supply. This paradigm shift is also expected to accelerate investment in solutions to ensure future mobility, improve air and water quality, promote sustainable agriculture, implement a European pillar of social rights at the Community Member State level, and strengthen climate action. This is supposed to result in climate neutrality for Community countries by 2050, meaning that they will only emit as much greenhouse gas as they are capable of absorbing [26]. This imperative sparked the research, the results of which are presented in the article. This research also assumed that the focus groups’ knowledge and awareness of climate neutrality mirrored that of other young people in Poland.

3. Research Methodology

The research undertaken in this study focused on two interrelated areas. The first is the changes in climate policy discourse and its understanding by a representative research sample of Polish secondary school students. Thus, this area was concerned with transitional thinking embedded in scientific innovation [22]. The second area of research undertaken focused on the preferred forms of energy generation, distribution and use within EU society. This identified the knowledge base of an informed citizen, ready to pursue their social, economic and political needs [6]. Although no direct reference was made to the institutions

of the European Union or to the organisation itself [23,27], it can be indicated that the preferences of the young Community citizens surveyed today portend certain behaviour in the future. In the context of the European Green Deal, it is assumed that the current high standard of living of Europeans will be improved by meeting life, environmental, individual, group and social needs [28]. It should be noted, however, that there is a lack of knowledge about the current preferences of the Community's young citizens in this regard, which led to the implementation of the research of the results of which are presented in the article.

The aim of the research conducted and presented in this article was to identify the ecological and energy awareness of secondary school students studying in the so-called military classes, their knowledge of renewable energy sources and their opinion on their usage in two contexts: at home and at work, and to compare it with the opinion of university students majoring in national security.

The preferences survey helped to fill the knowledge gap on the stimulus action model for future implementation of a zero-emission economy combined with environmental protection and climate change mitigation [29]. In the literature, there are many interdependent issues defining the relationship between climate change, environmental protection, economic development and the projection of changes in these areas resulting from European Union policies [30]. This analysis is based on climate change caused by human activity, carbon dioxide emissions, pollution of water resources and the ability to develop sustainable agriculture [31].

In order to fully explicate the research problems adopted, a quantitative—qualitative search strategy was used, which resulted in the research being diagnostic and explanatory in nature [32]. In the research process, the subject literature and the legal provisions in force were analysed, which made it possible to classify, generalise, describe and systematise the facts gathered during the research. Surveys were also carried out among secondary school students aged 15–19 years. The sampling was random and incidental.

The students surveyed belong to the so-called military classes. This term is used in Poland to describe secondary schools which implement a broadly defined programme of education for security, enriched with topics related to national defence, Polish military history and the shaping of patriotic attitudes among children and young people. The distinguishing features of the education of pupils in military classes can be defined as the theoretical and practice-based preparation of young people for conscious and effective participation in defence undertakings. In addition to the numerous strengths of the students studied, such as their patriotic, social and health-related approaches, it is important to stress the utilitarian nature of their education, which serves to impart knowledge, skills and habits of the “Basic Training Programme of the Armed Forces of the Republic of Poland”. Moreover, as the results of the empirical study indicate, the secondary school pupils surveyed are characterised by the following potentials: mobilisation, social and individual. The mobilisation potential of military classes is to be understood as the ability of citizen-students of military classes, predisposing them to defend the people and country and to maintain combat readiness, especially in times of military threat (conventional and unconventional), when state defence and security considerations require it. It is based on the indicated aspects of their life and life aspirations, setting their lifestyle, as well as on their specific knowledge, skills and attitudes. The societal potential of military classes is the capacity of citizen-students of military classes, in individual and group dimensions, to actively participate in social and economic life together with their civic duties, based on their school achievements, extracurricular activities and lifestyle-defining interests, as well as on their specific knowledge, skills and attitudes. The collective potential of military classes is distinguished by individual personality traits, abilities, values, experiences, skills, stimulating citizen-students of military classes to work and personal development, based on interests determining the lifestyle of the subjects, as well as their specific knowledge, skills and attitudes [33].

The survey had 581 respondents. The survey questionnaire included more than a dozen questions, eight of which allowed the respondent to express their own thoughts, opinions and preferences.

An important issue in the empirical research was to determine the minimum size of the research sample so that a fully representative study could be obtained. This could be determined using the following formula [34,35]:

$$n_b = \frac{N}{1 + \frac{4d^2(N-1)}{Z^2}} \quad (1)$$

where:

n_b = necessary sample size;

N —the size of the population of interest to the researcher;

Z —standard deviation for a given significance level p ($Z = 1.96$ for $p = 0.05\%$);

d —standard estimation error ($4\% = 0.04$).

The assumed research sample was 3600 individuals, as this was the number of students attending the latest form of the so-called military classes in 2021. The minimum sample size was $n_b = 515$ individuals, 581 were surveyed. The study population meets the requirements of a statistical minimum sample. However, it cannot be considered a sample representative of the wider population, although it can be assumed that the knowledge and awareness of the focus groups on climate neutrality reflects that of other young people in Poland.

During the study, the knowledge of secondary school pupils in Poland was contrasted with that of university students majoring in national security, who were surveyed in May 2021 based on the same set of questions. A total of 1106 students took part in the study, in various age groups (aged 15 to 18, 18 people; aged 19 to 25, 970 people; aged 26 to 30, 118 people) with gender distinction for 218 women and 888 men, of the following universities: AGH University of Science and Technology in Kraków, University of Land Forces in Wrocław, Military University of Technology in Warsaw, Rzeszów University of Technology, the Silesian University of Technology and the University of Warsaw took part in it. As part of the specialization and dedicated programs, the issues of renewable energy sources were addressed, including prosumer energy and the green capital economy. The study was also attended by members of the Youth Climate Council (Council), an opinion-making and advisory body operating at the Ministry of Culture and Environment [31,36].

This provided an opportunity to compare the knowledge of secondary school pupils and university students who are also citizens of the European Union. The closed- and open-ended responses of the research participants on the topic of a non-carbon economy created a field of research subject to interpretation. At the same time, a controlled study was conducted [32]. The research was practical in nature and aimed to produce relevant and value-adding findings and recommendations for change and improvement primarily in the current focus group education processes [32].

4. Results

The survey consisted of over a dozen questions. Nine of them were open-ended questions, eleven were ranking or optional questions. The responses of the two groups surveyed (secondary school class pupils aged 15–19 and university students aged 20–24) are presented and compared below (Tables 1–10).

Table 1. Question No. 1, research results.

			Response Options					
Question			photovoltaic	geothermal energy	wind energy	wave energy	water energy	biomass energy
No. 1	<i>Which forms of energy production do you think are the most environmentally, social and human friendly in Poland?</i>	University students	26.64%	21.86%	17.65%	16.87%	11.32%	5.66%
		Pupils of military classes	26.81%	13.11%	31%	11.70%	11.01%	6.37%

Table 2. Question No. 2, research results.

			Response Options						
Question			waste segregation	participation in “farm to table” food consumption	saving water	using recycled materials	living in an energy-efficient building	using biodegradable materials	saving electricity
No. 2	<i>How would you like to protect the environment?</i>	University students	35.4%	22.44%	13.7%	9.06%	7.8%	5.9%	5.7%
		Pupils of military classes	34.59%	13.96%	12.73%	23.4%	4.65%	4.65%	6.02%

Table 3. Question No. 3, research results.

			Response Options			
Question			very good	good	sufficient	insufficient
No. 3	<i>How do you assess your knowledge of renewable energy sources?</i>	University students	8.7%	26%	46.9%	18.4%
		Pupils of military classes	6.5%	31.5%	51.3%	10.7%

Table 4. Question No. 4, research results.

			Response Options				
Question			using dual-use water technology, e.g., by reusing water for hygiene purposes	living in an energy-efficient building	using energy-efficient heating	using energy-efficient lighting	using an energy-efficient building for people to work in.
No. 4	<i>How would you like to reduce your carbon footprint when using energy?</i>	University students	34.04%	31.28%	15.16%	14.21%	5.4%
		Pupils of military classes	30.47%	27.20%	15.75%	21.27%	5.31%

Table 5. Question No. 5, research results.

			Response Options						
Question			would share their electricity in a free wired and wireless	in a paid wired	in a paid wireless	in a free wireless	in a free and paid wired	in a paid wired and free wireless	in a free wired manner
No. 5.	<i>How would you like to share the electricity you generate?</i>	University students	42.37%	26.9%	9.48%	6.97%	6.23%	4.02%	4.03%
		Pupils of military classes	41.51%	8.23%	7.81%	7.36%	7.58%	6.02%	21.49%

Table 6. Question No. 6, research results.

		Response Options			
Question		using distributed free forms of energy	using grid centric free forms of energy	using paid wired and wired free forms of energy	
No. 6	Which energy-saving model would you and your family prefer?	University students	45.4%	38.2%	16.5%
		Pupils of military classes	35.6%	43.2%	21.2%

Table 7. Question No. 7, research results.

		Response Options		
Question			as active energy prosumers	as passive energy consumers
No. 7	How do you see your future in a zero-carbon society?	University students	60.8%	39.2%
		Pupils of military classes	45.4%	54.6%

Table 8. Question No. 8, research results.

		Response Options		
Question			financial incentives, e.g., discounts on energy-efficient manufactured goods	discounts on organic food
No. 8	How do we encourage society to eliminate its carbon footprint?	University students	91.5%	8.5%
		Pupils of military classes	55.86%	44.14%

Table 9. Question No. 9, research results.

		Response Options			
Question			financial savings	eco-empathy	eco-fashion
No. 9	What would convince you to introduce low-carbon technologies into your immediate environment?	University students	68.26%	21.96%	9.78%
		Pupils of military classes	54.37%	24.39%	21.24%

Table 10. Question No. 10, research results.

		Response Options			
Question			financial incentives to use public transport	financial incentives for using communal forms of feeding	subsidies and no restrictions on installing own renewable energy sources
No. 10	Which forms of incentives would you prefer most?	University students	65.6%	31.9%	12.5%
		Pupils of military classes	41.7%	57.8%	0.5%

The respondents of both groups expressed similar opinions regarding the types of renewable energy sources that are environmentally friendly (Table 1). The main difference

in perception is that secondary school pupils listed wind energy first, followed by photovoltaics. In contrast, the university students value photovoltaics the most, and ranked wind energy third (Table 2).

Both students and pupils share the same beliefs with regard to how the environment should be protected (Table 3). However, there were differences with regard to which method should be used first. In the opinion of the pupils, the use of recycled materials should come just after waste separation, while according to the university students it is ranked fourth after waste separation, participation in “farm to table” food consumption and water saving (Table 4).

The findings of the two groups are similar. Both university students and school pupils assess their level of knowledge at a comparable level. The noticeable difference is in the declaration of “insufficient”, as the difference covers almost 8%. This may be due to the fact that the military pupils’ core curriculum does not include content on renewable energy sources. Therefore, it can be concluded that the knowledge that pupils have is acquired from various sources such as the internet, television and ecological activities. For university students, the situation is slightly better (although not at a satisfactory level) due to greater participation in discussions held on social media or during academic activities.

Reducing the carbon footprint, according to respondents, should be done in the following order: using dual-use water technology, e.g., by reusing water for hygiene purposes; living in an energy-efficient building; applying energy-efficient heating; using energy-efficient lighting; an energy-efficient building in which people take up work.

Both pupils and students see the possibility of sharing energy as follows and in the following order: would share their electricity in a free wired and wireless; in a paid wired; in a paid wireless; in a free wireless; in a free and paid wired; in a paid wired and free wireless; in a free wired manner (Table 5).

Students ranked the use of free energy from distributed energy sources first, followed by the use of free energy from grid centric networks. The university students made the opposite choice. In third place, they unanimously chose the model using paid energy distributed either by wire or wirelessly (Table 6).

When asked how you see your future in a zero-emission society, university students and school pupils were of different opinions. The majority of the university students saw their future as active prosumers of energy, while the students in military classes saw themselves as passive consumers of energy (Table 7).

The majority of university students and school pupils see the issue of encouraging society to adopt a zero-carbon lifestyle in the same way, i.e., financial incentives in the form of discounts on energy-efficient industrial products are more important than discounts on organic food. However, it is worth noting that although the factor of energy-efficient industrial products is listed first by students at military schools, the discount on organic food is lower only by about 10%, and in the case of university students by as much as 80% (Table 8).

The most compelling factor for the introduction of low-carbon technologies for both groups surveyed is financial savings. In second place, in consensus, eco-empathy is listed, followed by eco-fashion (Table 9).

In response to the question “Which forms of incentives would you prefer most?”, it is noticeable that there is a divergence of opinion between the groups surveyed. According to the majority of university students, i.e., 65.6% preferred financial incentives for using public transport, while 31.9% favoured financial incentives using communal forms of catering. The opposite is true for students in military classes. Conversely, 12.5% of university students and only 0.5% of school pupils were in favour of subsidies and no restrictions on installing their own renewable energy sources (Table 10).

The questionnaire also contained a number of open questions. In the part below, the opinions of the pupils of the military classes will be contrasted with the students of the national security course of the universities.

Open-ended questions were put to the university students and the pupils of military classes:

- (1) *Which information activities regarding renewable energy sources have you encountered in the educational process?*
- (2) *Which education activities regarding renewable energy sources have you encountered in the educational process?*

When asked the question: *“Which information and education activities related to renewable energy sources have you encountered in the educational process?”*, they pointed out that there are already several initiatives aimed at promoting knowledge about renewable energy sources in which they have participated. 62.5% of university students and 42.84% of military class pupils indicate that information on renewable energy sources was given to them during school classes. 50.3% of university students and 34.08% of pupils in military classes took part in Earth Day. 26.9% of students and 11% of pupils have participated in environmental workshops. In comparison, 23.3% of students and 11.35% of pupils attended meetings with environmentalists.

In terms of educational activities, the situation is almost identical. Respondents (both groups) also indicated that they had experienced both educational and informational activities during classes in subjects such as biology, geography or physics, and during discussions with their closest environment (family, friends). Respondents also indicate that social media, the internet, radio and TV are important sources of information with a lot of content on renewable energy sources. They also pointed to the easy accessibility of this information. It was also highlighted that there are many initiatives to promote renewable energy sources, namely competitions, tree planting schemes, brochures and books. In terms of information and education activities, the respondents of both groups agreed in their opinions.

- (3) *What forms of information activities could increase public awareness regarding renewable energy sources?*
- (4) *What forms of education activities could increase public awareness regarding renewable energy sources?*

Both survey groups concluded that public awareness about renewable energy sources is not comprehensive and that there is room for improvement. In response to the question: *“What forms of information and education activities do you think could increase public awareness regarding renewable energy sources?”*, respondents said that social media would be helpful in this task. Both groups surveyed point to the potential of mass media as well as television, both public and private. Respondents point to such activities as conducting information activities, as part of educational campaigns, and that these activities should be presented in an interdisciplinary manner showing different aspects of the issues. Campaigns of this kind should involve experts in the fields of energy and the environment who, in addition to making expert statements, could organise demonstrations to show the benefits of introducing renewable energy sources in comparison to traditional energy usage. According to the respondents, presenting these phenomena in a visual way would increase understanding and awareness of the renewable energy adoption. In addition to this type of activity, it is also necessary to design leaflets and brochures explaining renewable energy sources, including the effects of their adoption or non-adoption. There still remains the question of their dissemination, which according to the respondents could be done during family events, church festivals or those organised for various occasions by local authorities. This would also enable the older generation, who do not use the internet much, to learn about this issue.

In addition, half of the surveyed military class pupils indicate the need to discuss this issue during the subject of geography backed with educational films. They also show willingness to participate in conferences and meetings with experts, while the university students indicate the need for academic discussions not only in the national but also in the international arena with the possibility of presenting the conclusions of scientific

conferences to politicians and authorities who have influence on the shaping of energy and environmental policy not only in the country but also within the European Union.

- (5) *What do you think renewable energy is used for at home?*
- (6) *What do you think renewable energy is used for at work?*

According to the university students, renewable energy sources are equally applicable at home and at work. The most common applications are photovoltaic, heat pumps and biomass energy. The most valuable, however, are photovoltaics, which produce energy from solar radiation because the use of solar collectors ensures lower operating costs for residential buildings by replacing a traditional heat source such as a coal or gas boiler or an electric heater for heating domestic water. Additionally, it reduces the household's dependence on energy suppliers. Using photovoltaic panels to generate electricity to run appliances, lighting and heat water, essentially replacing a furnace for heating the house and water reduces the level of pollutants produced during combustion; additionally, this generates savings over time [36]. The students surveyed also referred to the use of heat pumps as heating devices that extract renewable energy stored in the ground, water or air. Modern pumps perform a heating function and can also provide cooling for a building. In addition to the above, the low running costs of this device are an additional advantage. The students regard the burning of biomass as environmentally neutral, given that as much carbon dioxide is released into the atmosphere as the plants have absorbed during their growth, and argue that it is an ecological alternative to, for example, coal-fired boilers. In contrast, energy generated by windmills is used for lighting rooms or pumping water.

In turn, the surveyed military class pupils, in response to the question about the use of renewable energy sources at home, indicated only the use of photovoltaics and the benefits of this, namely financial savings and increased environmental protection. Here, a significant difference in knowledge of renewable energy sources is noticeable between the surveyed students and pupils. This is probably due to the lack of interest of younger respondents to the issue and the fact that there is a lack of information provided at different tiers of education.

Respondents also referred to *the use of renewable energy sources at work*.

The students interviewed emphasise that the use of renewable energy sources is a positive strategy with tangible benefits in the long term, such as: improved corporate image, financial savings on energy use, self-sufficiency, reduced carbon footprint, increased product competitiveness, etc. They also refer to corporate social responsibility. The most common applications according to the students surveyed are, for example, for space heating, sports halls and heating water in buildings. Wind energy can in turn be used in industrial facilities, for example, for lighting rooms or irrigating fields.

In contrast on the above issue, the surveyed pupils from military classes only identified financial and environmental benefits. This situation arises for the same reasons as for the question on the use of renewable energy sources in the home. In addition, it should be pointed out that the secondary school pupils, due to their age and their lack of discussion in this area, do not show interest in this issue, which is also confirmed by the survey.

- (7) *Which renewable energy sources can be found in Poland?*

Both survey groups showed very good knowledge of the existing renewable energy resources in Poland.

- (8) *Do you think that society can be encouraged to adopt a low-carbon lifestyle in addition to the suggestions made in the above question?*

In response to the question of *whether you think society can be encouraged to adopt a low-carbon lifestyle in addition to the suggestions already mentioned, respondents have a similar stance, although the student group's is slightly more elaborate*.

A total of 93.4% of the military class pupils surveyed felt that financial incentives, i.e., discounts on purchases of bio-food, energy-efficient manufactured goods, would be sufficient to encourage society to adopt a low-carbon lifestyle. The remaining respondents

indicate the following activities that could further improve this process, namely: raising national awareness, organising competitions in shops at bio food counters, programmes to subsidise the installation of renewable energy sources, educating the public about the effects of polluting the planet, introducing stricter laws against environmental polluters, introducing tax relief and additional discounts, cheaper electric cars and free charging, and switching modes of transport, e.g., from cars to bicycles.

Furthermore, 8.5% of the students surveyed, in addition to what was mentioned by the pupils of the military schools, stated that society can be encouraged to lead a low-carbon lifestyle by: government funding to replace energy sources, e.g., coal furnaces; lowering taxes for those who produce energy from renewable sources; abolishing taxes for electric vehicles and introducing privileges for those who use them, e.g., by introducing free charging networks (AC), allocating an expressway lane in Poland dedicated to family cars or electric cars, free parking, motorways, tax write-offs and reducing tax for bio food products.

Other suggestions from respondents include financial discounts on housing costs, tax breaks for low-carbon lifestyles, allowances for the purchase of electric cars, reductions in the cost of installing renewable energy sources and discounts for waste sorting (discounts for companies that do this). Plastic bags should also be taken out of circulation. Another element encouraging this lifestyle would be a reduction in car use through free public transport and by facilitating collective access to it.

5. Discussion

The global climate recession has made it imperative to discuss the introduction of a low-carbon economy in European Union countries. For the same reason, the European Commission is adopting measures under the framework of the Green Deal such as: the use of renewable energy sources and bio-economy, increasing energy efficiency, developing smart grid infrastructure or even creating “green” societies, aware of the importance of individual and group decisions in the processes of energy production and consumption [3,37].

However, the stimulation of a global economy in decline depends not only on the policies adopted by Community countries [38]. The implementation of a zero-emission economy is also the result of conscious citizen participation in environmental protection. It is upon their knowledge and awareness of sustainable ecology and its friendly societal development that the realisation of zero greenhouse gas emissions by 2050 largely depends. In addition, high self-knowledge makes it easier to predict that one will be successful in endeavours undertaken. This makes the knowledge of sustainable ecology and its sound social development among the Community’s young citizens all the more important. In view of the above, it can be assumed with a high degree of probability that the knowledge of Polish students, analogous to the awareness of students in other European Union countries, will have the most significant influence on the emergence of a zero-emission economy in the future.

Particular attention, therefore, needs to be paid to the individual, as the weakest and yet strongest link in the energy security system. Since everything that is important for the protection of well-being depends on one’s level of knowledge and awareness of what constitutes or may constitute a threat to a multidimensionally understood existence, it is from the individual, as a citizen of the European Union, that it is worth initiating efforts to establish carbon neutrality. However, the audience for this knowledge should not only be adults, who are currently making decisions on the utilisation of the carbon economy but, above all, young people, who will be making these decisions in the future. It is upon their knowledge and awareness of sustainable ecology and its conducive societal development that the realisation of zero greenhouse gas emissions by 2050 largely depends.

Meanwhile, the empirical research carried out indicates that there is a specific gap in the knowledge of secondary school students about the prevention of greenhouse gas emissions. Deficiencies in this knowledge can also be seen in university students. This assessment allows us to conclude that the limited scope of young Poles’ understanding

of energy transformations and the need for practical implementation of the Green Deal creates the need to change the content of education at each educational tier. It is also likely that this problem will affect not only Poland but also other European Union countries.

In this context, attention should be drawn to the issues affecting contemporary education. One of these may be the lack of or insufficient coverage given to educational content related to the climate recession, energy transition and the need to reduce greenhouse gas emissions [39]. On the other hand, another problem may also be related to the lack of teachers' own awareness concerning sustainable ecology and its favourable social development. Meanwhile, it is teachers, together with parents, who pass on knowledge, skills and models of behaviour to young people so that civilisational development can flourish. On the other hand, in the consciousness of this professional environment, it is difficult to see the imperative for didactic-educational interactions aimed at constructing and developing the personality of students towards their independence of thought and action [40]. Such an education would, in turn, give students the qualifications to participate fully in adult public life and, thus, make responsible decisions on, among other things, zero greenhouse gas emissions.

Moreover, state-of-the-art technology and the possibilities offered by the internet are no longer teachers' allies at work, as they allow the student to quickly verify the knowledge that is being taught to them [41]. In addition, the quantifiers of didactic value have changed. Appealing knowledge is not that which is widely available, even if only on the internet, but that which is inaccessible, niche or from the most up-to-date sources or unique experiences [42]. This makes it all the more important for teachers to ensure that the knowledge they pass on is not only the most up-to-date but also interesting to read and, therefore, better remembered. This knowledge should embody cognitive and practical values while taking into account and highlighting their actual relevance [43], which in this topic, relates to the need for a zero-carbon economy.

In the context of the research conducted, it is worth noting that the values chosen by the respondents reflect their attitudes towards a given good, which in this case, is climate neutrality. Since cultural goods are most often hierarchical, assigning value means determining the place occupied by that good in the hierarchy of both individuals and the group they represent. It can, therefore, be concluded that for the young people surveyed, who recognise renewable energy sources and the benefits of reducing greenhouse gases, which mainly revolve around financial savings and environmental protection, the values associated with zero emissions are clearly important. Although their knowledge of the subject is poorer than that of the university students, by advocating pro-environmental solutions in this area they bear witness to the importance of the issue. Therefore, teachers' efforts to ensure that these values are internalized by young citizens, recognized as their own and placed high in their hierarchy are all the more important here.

It should be added that it is precisely values that inspire people not only to set goals but also to a certain degree of activity and diligence in the implementation of actions taken. In other words, the axiology embraced prompts not only the actions themselves but also the achievement of a certain quality. Therefore, in the context of the empirical research conducted, it seems reasonable to impart to young people not only knowledge of the need for a zero-emissions economy but also to internalise in them the values with which this area of knowledge is associated. Recognising the values associated with the need for climate neutrality as one's own significantly increases the likelihood of taking individual action to achieve zero emissions.

6. Conclusions

The research presented in this article was undertaken to diagnose the perception of the transition to a zero-carbon economy in the opinion of Polish schoolchildren. The survey of secondary school pupils, so-called military classes in Poland, was designed to identify their environmental and energy awareness and knowledge of renewable energy sources and to obtain their opinions on their use in two areas: at home and at work. A further research

assumption was to compare the results of this research with the opinions of university students majoring in national security, which were obtained through surveys conducted in May 2021.

Thus, the knowledge, awareness and opinions of the two groups surveyed about the zero-carbon economy and the need for sustainable development were compared: secondary school students aged 15–19 and university students aged 20–24. Respondents are differentiated by age but have in common an educational programme “steeped” in content related to state security

The research results presented are ground-breaking. No research has previously been conducted in Poland or in other European Union countries to identify the environmental and energy awareness of secondary school pupils and university students. The knowledge of secondary school respondents on renewable energy sources and their opinions on its use in two areas: at home and at work, were compared with the opinions of university students majoring in national security. The research was of a practical nature and enabled the formulation of recommendations for change and improvement, especially in the current education processes of the focus groups.

Due to the COVID-19 pandemic, access to respondents was a research limitation. It was difficult to implement the study in Poland when young people were mostly studying remotely. Consequently, survey questionnaires were sent by post to randomly selected schools whose principals had agreed to participate in the study. Furthermore, it should be pointed out that it was not possible to carry out tests in other European Union countries either, because the national borders were closed to restrict the spread of the coronavirus. Thus, the prevailing epidemiological situation posed serious research limitations.

On the basis of the survey, it can be concluded that both university students and secondary school pupils assess their level of knowledge as “sufficient”. However, there is a difference of almost 8% in the declaration “insufficient”, which was more often identified by the university students. Both groups of young Poles surveyed are also familiar with the different types of renewable energy sources that are environmentally friendly. They also have similar opinions on how the environment should be cared for but with noticeable differences in the rankings of the responses.

Reducing the carbon footprint, according to respondents, should be done in the following sequence: using dual-use water technology, e.g., by reusing water for hygiene purposes; living in an energy-efficient building; applying energy-efficient heating; using energy-efficient lighting; an energy-efficient building in which people take up work. Both pupils and students see the possibility of sharing energy as follows and in the following order: would share their electricity in a free wired and wireless; in a paid wired; in a paid wireless; in a free wireless; in a free and paid wired; in a paid wired and free wireless; in a free wired manner.

Students ranked the use of free energy from distributed energy sources first, followed by the use of free energy from grid centric networks. The pupils made the opposite choice. In third place, they unanimously chose the model of using paid forms of wired and wireless energy.

Both groups of young Poles surveyed see the question of encouraging society to adopt a zero-emission lifestyle with no carbon footprint in the same way, i.e., financial incentives in the form of discounts on energy-efficient manufactured products are more important than discounts on organic food. Furthermore, the most convincing driver for the introduction of low-carbon technologies for both groups surveyed is financial savings. Both groups of young Poles place eco-empathy in second place and eco-fashion in third place.

The majority of respondents preferred financial incentives the most when using public transport, followed by communal feeding. Conversely, 12.5% of university students and only 0.5% of school pupils were in favour of subsidies and no restrictions on installing their own renewable energy sources.

The situation is almost identical with regard to education and information activities. Both groups of respondents indicated that they had encountered both educational and informational activities on environmental protection and a carbon-neutral economy during classes in subjects such as biology, geography or physics and during discussions in their immediate environment (family, friends). They also pointed to the easy accessibility of this information. It was also highlighted that there are many initiatives to promote renewable energy sources, namely competitions, tree planting initiatives, brochures and books.

Respondents also indicate that social media, the internet, radio and television, which broadcast a wide range of renewable energy content, were important sources of information. They indicated that educational campaign activities are carried out in their schools but they should be presented in an interdisciplinary way showing different aspects of the issue. Energy and environmental experts should also be involved in these campaigns. Experiments showing the effects of renewable energy sources could also be carried out, as the visual presentation of these phenomena will increase knowledge and awareness of the use of renewable energy sources. In addition to this type of activity, it is also essential to design leaflets and brochures providing information on renewable energy sources, including the effects of their use or non-use. Such leaflets, in the opinion of the respondents, could be distributed during family events, church festivals or those organised for various occasions by local authorities. This would also enable the older generation, who do not use the internet much, to learn about this issue.

In addition, half of the surveyed military school pupils indicate the need to discuss this issue during their geography lessons with the support of educational videos. They also show willingness to participate in conferences and meetings with experts, while the university students indicate the need for academic discussions not only at national level, but also internationally with the possibility of presenting their conclusions at scientific meetings with politicians and authorities who have significant influence on the shaping of energy and environmental policy not only in the country, but also in the European Union.

Based on the analysis of the survey results, there are certain dissimilarities in the awareness of the surveyed young Poles: military class pupils perceive themselves as passive consumers of energy, while university students mostly perceive themselves as active prosumers of energy. Here, a significant difference in knowledge of renewable energy sources is noticeable between the surveyed students and pupils. This may be due to the lack of comprehensive educational content on the subject in secondary schools. There may also be a lack of interest amongst younger respondents to the issue of a zero-carbon economy.

The vast majority of the military class pupils surveyed felt that financial incentives, i.e., discounts on purchases of bio-food, and energy-efficient manufactured goods, were sufficient to encourage society to adopt a zero-emission lifestyle. In addition, to what was mentioned by the military school pupils, some of the university students interviewed added that the public can be encouraged to adopt a zero-carbon lifestyle through other measures.

Analysis of the survey results allows for the conclusion that young Poles' knowledge of the necessity of a low-carbon society is at an inadequate level. Respondents recognise the need to protect the environment and take action to avoid a climate catastrophe, but only have a rudimentary knowledge of the need to introduce a low-carbon economy in EU countries. However, they lack a comprehensive approach on how to reduce greenhouse gas emissions. Nor do they have role models for such practices and values associated with sustainable ecology and environmentally responsible social development.

The preference survey helped to fill the knowledge gap on the stimulus model for future implementation of a zero-emission economy combined with environmental protection and climate change mitigation. The secondary school pupils and university students surveyed identify the precise actions that need to be taken to make the process of disseminating knowledge about the implementation of the idea of zero greenhouse gas emissions by 2050 effective.

To sum up the research, it should be noted that there is a gap in the knowledge of young Poles, as well as educational needs in this area. The paradigm of eliminating, or at least reducing, the carbon footprint of industry, agriculture, transport, services and the lifestyle of its inhabitants should begin with effective environmental education as an integral part of implementing the European Union's zero-carbon climate policy. What is important here is both the message conveyed and the internalisation of values relating to eco-empathy and everyday environmental action, which should reinforce the top-down climate action of all Community countries.

The research has identified a gap in the environmental knowledge of young Poles. This knowledge deficiency is apparent both at university and school level. We recommend further research to fully define this deficiency so that recommendations can be made to ensure that the education system fully prepares our young citizens for meaningful decision making in a world threatened by global climate change.

Author Contributions: Conceptualization, B.K. and I.U.; methodology, B.K. and I.U.; formal analysis, B.K. and I.U.; resources, I.U. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Conflicts of Interest: The authors declare no conflict of interest.

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