Article

Energy Conservation Behaviors and Awareness of Polish, Czech and Ukrainian Students: A Case Study

Zofia Gródek-Szostak 1,*1, Mateusz Malinowski 2, Marcin Suder 3, Klaudia Kwiecień 2, Stanisław Bodziacki 2, Magdalena D. Vaverková 4,5, Alžbeta Maxianová 4, Anna Krakowiak-Bal 2, Urszula Ziemiańczyk 2, Hrihorii Uskij 2, Karolina Kotulewicz-Wisińska 6, Rafał Lisiakiewicz 6, Agata Niemczyk 7, Anna Szelaż-Sikora 8 and Marcin Niemiec 9

1 Department of Economics and Enterprise Organization, Cracow University of Economics, ul. Rakowicka 27, 31-510 Krakow, Poland
2 Department of Bioprocess Engineering, Energetics and Automationization, Faculty of Production and Power Engineering, University of Agriculture in Krakow, Balicka Street 116b, 30-149 Krakow, Poland; mateusz.malinowski@urk.edu.pl (M.M.); klaudia.kwiecień.96@gmail.com (K.K.); stanislawbodziacki@gmail.com (S.B.); anna.krakowiak-bal@urk.edu.pl (A.K.-B.); urszula.ziemianczyk@urk.edu.pl (U.Z.); hrihorijuiskij@gmail.com (H.U.)
3 Department of Applications of Mathematics in Economics, Faculty of Management, AGH University of Science and Technology, 30-067 Krakow, Poland; msuder@agh.edu.pl
4 Department of Applied and Landscape Ecology, Faculty of Agronomy, Mendel University in Brno, Zemědělská 1, 613 00 Brno, Czech Republic; magda.vaverkova@uake.cz (M.D.V.); alzbeta.maxianova@gmail.com (A.M.)
5 Institute of Civil Engineering, Warsaw University of Life Sciences, Nowoursynowska 159, 02-776 Warsaw, Poland
6 Department of Political Science, Cracow University of Economics, 31-510 Krakow, Poland; kotulewka@uek.krakow.pl (K.K.-W.); lisiakir@uek.krakow.pl (R.L.)
7 Department of Tourism, Cracow University of Economics, ul. Rakowicka 27, 31-510 Krakow, Poland; agata.niemczyk@uek.krakow.pl
8 Department of Production Engineering, Logistics and Applied Computer Science, Faculty of Production and Power Engineering, University of Agriculture in Krakow, Balicka 116b, 30-149 Krakow, Poland; anna.szelaż-sikora@urk.edu.pl
9 Faculty of Agriculture and Economics, University of Agriculture in Krakow, ul. Mickiewicza 21, 31-121 Kraków, Poland; Marcin.Niemiec@urk.edu.pl
* Correspondence: grodekz@uek.krakow.pl

Abstract: Energy education of the younger generation, who are the future decision makers, investors, consumers, scientists, or skilled labor force in new energy technologies, is crucial for the future of Europe and the world. However, beyond the long-term goals of energy education policies, the short-term effects on energy conservation and the promotion of renewable energy sources are equally as important. The main purpose of the paper is to identify and analyze the behavior of students (who study the issues related to energy saving and RES), in terms of energy conservation. The conducted analysis focused on examining and comparing the scope of responses of the surveyed students in individual countries, especially in the Czech Republic, Poland, and Ukraine. The survey was carried out using the computer-assisted web interview (CAWI). Descriptive and graphical methods were used to present the results. Statistical analysis of the collected data included basic measures of descriptive statistics and the chi-square test. The main results of the study are as follows: Almost 60% of the surveyed students follow the principles of energy conservation; however increased educational activities on eco-energy behaviors is recommended. The share of RES in the heating systems of the studied residential buildings is 9%, on average, with the highest percentage of houses in Poland (14%) and the lowest in Ukraine (only 2.6%). When compared with literature reports, the collect data show that educational activities can be as effective as a tool in implementing RES and pro-environmental behaviors as the government’s environmental policy and household subsidies.

Keywords: energy consumption; energy conservation; higher education; management
1. Introduction

As part of the broader EU Energy Union strategy [1], on 30 November 2016 the European Commission published a legislative package entitled “Clean Energy for All Europeans” [2]. It includes a proposal to recast the directive on the promotion of the use of energy from renewable sources [3] to make the EU a world leader in renewable energy and to ensure that by 2030 the target of at least 32% of renewable energy in total energy consumption is met in the EU. The EU has adopted an energy policy to maximize the use of renewable energy sources (RES), in order to reduce the dependence on fuels from third-party countries, and to minimize the use of fossil fuels and emissions from coal-based energy systems, including decoupling energy costs from oil prices. In addition, the EU’s policy objectives include reducing the demand by promoting energy efficiency in both the energy sector itself and in end-use [4]. The above are also in line with the transformation of the national economies of the member states towards a circular economy [5].

The postulate of the Europe 2027 strategy [6] is economical innovation, founded on the ability to think outside the box and go beyond the well-known patterns. Today, the goal of formal and non-formal education is not only to acquire knowledge and skills, but also to build creative attitudes and promote independence, boldness, entrepreneurship, focus on self-development, and continuous education. The aforementioned building of attitudes is a much more complex process, forged in various types of activities, the effects of which should be essentially consistent. Please note the multiplying effect of non-formal education (for example, the attitude of acceptance for diversity), through subsequent experiences of a similar or even completely different nature, which reinforce the attitude and build a permanent predisposition to certain behaviors/actions [7].

The use of new technologies in RES in economic and domestic practice requires efforts to educate qualified personnel [8–14]. Overcoming the socio-cultural, mental and institutional barriers that hinder the popularization and use of renewable energy technologies can only occur if potential end-users, policy makers, and other stakeholders are “energy-aware”. In fact, the attitudes and preferences of the general public, as well as policy makers, need to be changed to increase the acceptance of renewable energy technologies. Energy education and training in general, and RES in particular, is therefore of paramount importance [15–18]. Limited staff resources with the required knowledge and skills are often cited as one of the main reasons for the poor diffusion and use of renewable energy technologies [19–21]. In this context, education plays a special role, moderating social discussion and building consensus in the following three key areas:

1. Individual responsibility for curbing the effects of climate change [22,23];
2. A significant market share of energy related to the promotion of the so-called “bottom-up energy model”, i.e., the opportunity to invest in and produce renewable energy (prosumerism), or involvement as key stakeholders in making decisions regarding the development and implementation of RES projects [24,25];
3. Social inclusion, since all citizens must be able to benefit from the functioning of the energy market, i.e., from active participation in forging RES regulations [26–28].

What can contribute to transforming passive consumers into active citizens is creating conditions for a better social understanding of the seriousness of the energy situation, raising environmental awareness of broadly understood local, regional, national, and global energy challenges, and providing relevant information on emerging RES technologies [18,19].

Youth-oriented energy education is extremely important for the future of Europe and the world, as it is they who will grow up to be the future decision makers, investors, consumers, scientists, or a skilled workforce in the field of new energy technologies. However, apart from the long-term goals of energy-related education policies, the short-term effects of preserving energy and popularizing renewable energy sources (RES) are equally important.

Higher education and high energy conservation awareness can be a more effective tool than various economic measures (regulations, information campaigns, subsidies) that
governments use to convince their citizens to invest in RES and in the environmentally friendly lifestyle.

The strong need and importance of providing renewable energy education at all levels has been recognized worldwide [29–35]. Over the past three decades, a number of countries have implemented renewable energy education programs [36–40], mostly independent graduate programs, or optional courses in conventional engineering/applied science curricula. Efforts have also been made to introduce energy-related topics into school and undergraduate curricula [41–47].

The main research problem addressed in this paper is whether energy education and its problems (including RES) at the university level could significantly influence the behavior presented by a selected social group in the context of energy conservation (both personal and per household).

The legitimacy of the research is in the creation of an educational strategy aimed at conscious environmental decision making, selection of energy sources, and energy conservation by young adults. Currently, the need for shaping environmental awareness and energy knowledge is increasingly observable. However, one should strive to ensure that these activities are not only the result of a social fad, but an expression of responsibility for one’s own actions towards one’s environment [48]. As one of the few social groups, students have not yet been the subject of targeted studies on their awareness and behavior consistent with the circular economy, especially in terms of energy conservation [49].

The above study has a number of political and practical implications, as it provides guidance to local, regional and national authorities who are responsible for developing/updating strategies for RES education and promotion. To promote and popularize mass investments in RES, each of the studied countries needs to ensure quality education, which is crucial for the implementation of the European Green Deal.

According to the strategy, cooperation of the EU, in terms of renewable and hydrogen power with its southern and eastern neighbors and the energy community, especially with Ukraine, will be promoted. Therefore, the cooperation of Poland (and EU member states) with Ukraine (an EU-associated country) is important, in terms of building the framework for educational cooperation for the implementation of the Green Deal.

The following sections describe the goals and scope of the study, the method of selection of the research sample, as well as the applied research and statistical analysis methodology. Since the study covered a very narrow scope of students from different countries, Section 3 describes the energy education models in force in the analyzed countries. The Results section characterizes the group of respondents, then their households, e.g., in terms of power supply systems and RES, and, lastly, describes the differences and similarities in individual behaviors of respondents. The discussion of the results constitutes a separate section. The Conclusions section presents a summary of key insights from the collected data, and relates the results to the education levels and systems in the studied countries.

2. Materials and Methods

2.1. The Aim of Research

The main purpose of the paper is to identify and analyze the behavior of students (who study energy conservation and renewable energy) in terms of energy conservation. It discusses the following research questions:

1. What percentage (share) of randomly selected students from Poland, Ukraine, and the Czech Republic follow the principles of energy conservation?
2. What are the individual behaviors declared by the students regarding “green” energy?
3. Are there significant differences in student behavior depending on the country of origin?
2.2. The Scope and Method of Research

The results presented in this paper concern the environmental awareness and behavior of students, with particular emphasis on their handling of electrical equipment and energy conservation. The scope of the research included developing and conducting a dedicated online computer-assisted web interview (CAWI). The questionnaire was addressed to students of natural science universities from Poland (University of Agriculture in Krakow), Ukraine (Lviv National University of Agriculture) and the Czech Republic (Mendel University in Brno), holding courses in environmental protection devices, eco-energy, or waste management.

The survey was divided into four sections related to eco-energy, eco-mobility, food waste and waste prevention. The eco-energy issues were then divided into two types of survey questions. The first concerned the data sheet and the characteristics of the respondent’s place of residence in terms of fuels used to heat the building and the necessity of conducting thermal renovation works (the current or past condition of the respondent’s place of residence).

The data constitute a background and a prerequisite for an in-depth analysis. Please note that the survey participants are young adults and the answers provided do not necessarily reflect their own behavior or awareness, but those who manage their households (usually their parents). The questionnaire was also to identify the respondents’ gender, age, level of education, as well as type and name of their place of residence.

The second group of questions related to individual behaviors regarding energy conservation that could result directly from the beliefs and knowledge of a young person. Therefore, in terms of pro-ecological behavior, the answers to these questions were related to the personal choices of the respondents.

2.3. The Formulation of Samples and the Course of Study

The countries (nationalities) analyzed as part of the research differ in terms of the number of population and the number of students, but they are characterized by a similar share of youth studying at universities (Table 1). This percentage ranges from 3.16% (in Poland) to 3.98% (in the Czech Republic). In addition, engineering studies, including those related to energy production and conservation, enjoy unflagging interest. The analyzed countries have similar and significant economic and social potential, but also serious environmental problems, including high air pollution (smog). While the Czech Republic and Poland are similar in light of this research, Ukraine is definitely not also due to legal regulations and the current directions of energy and economic development. Ukraine was included in the research due to the fact that the results of Poland and the Czech Republic are impacted by EU’s legal conditions, while Ukraine depends on the Russian Federation, e.g., in terms of limiting gas supplies or increasing its price.

Table 1. Total no. of students and total population in the analyzed countries in 2020.

| Variable          | Unit | Czech Republic | Poland | Ukraine |
|-------------------|------|----------------|--------|---------|
| Population        | Million | 10.50               | 37.97             | 44.29               |
| No. of students   | Million | 0.42               | 1.20       | 1.54     |
| Percentage of students | %    | 3.98               | 3.16     | 3.47     |

Source: own elaboration based on the European Statistical System, populationof.net, GUS and www.statista.com, accessed on 12–13 July 2021.

The group of respondents was selected purposely and the respondents were anonymous. The initial criteria were as follows:

- The status of student of energy and broadly understood environmental engineering in one of the 3 universities;
- First degree (engineering or BS, at least 2nd year graduates) and MS students,
- age of the respondents (21–24 years).
The sample size for the student community at each university was calculated using the following formula [50]:

\[ n = \frac{N}{1 + \frac{d^2(N-1)}{z^2pq}} \]  

(1)

where the following applies:

- \( z_\alpha = 1.64 \) for \( \alpha = 0.1 \)
- \( z_\alpha = 1.96 \) for \( \alpha = 0.05 \)
- \( z_\alpha = 2.28 \) for \( \alpha = 0.01 \)
- \( N \) — population size;
- \( p \) — expected order of magnitude of the estimated fraction;
- \( q = 1 - p \);
- \( d \) — permissible estimate error of the fraction \( p \) (given in a decimal fraction).

The sampled population included 209 students from Poland, 124 students from Czech Republic and 495 students from Ukraine. All of them had at least basic education on issues related to eco-energy, waste of energy, and environmental protection devices with particular emphasis on RES. All in all, 538 completed questionnaires were received, and the response rate in the study was 65%. The obtained number of questionnaires from individual countries exceeded the number required for this research.

In December 2019, a pilot study was carried out to verify the correctness of the prepared interview questionnaire and data sheet. The preliminary research was conducted in Poland among students and academics of the Faculty of Production and Power Engineering at the University of Agriculture in Krakow.

The final survey was made available online between 17 January and 17 April 2020. The questionnaire was published in Polish, Czech and Ukrainian. Access to the questionnaire was limited only to students at the universities selected for research. The conducted analysis focused on examining the scope of responses of the surveyed students in individual countries, especially in the Czech Republic, Poland, and Ukraine. These results were compared and whether the structure of the distribution of answers to individual questions differs significantly for individual countries was additionally verified.

The research did not limit itself to the graphical presentation of the results (bar charts), but also verified whether the obtained results for individual countries differ significantly. The hypotheses regarding the dependence between individual features, or lack thereof, were verified using the chi-square independence test included in the Statgraphics Centurion package. Chi-square test statistics were used to verify the impact of respondents’ nationality on their views and actions. The chi-square independence test is used to verify the independence of immeasurable (qualitative) features or when juxtaposing the independence of a qualitative feature with a quantitative one. Assuming that the subject of the study is the general population, an \( n \)-element sample was taken from this population (it is important that \( n > 30 \)). The results were classified in a table, per one feature in \( k \) rows and per second feature in \( k \) columns. The content of the independence table consists of the numbers representing \( n_{ij} \) elements of the sample that simultaneously meet the criteria contained in \( i \)-th line and \( j \)-th column. The table of independence is the foundation for the verification of the nonparametric null hypothesis that there is no relationship between the features (variables) in the population \( X \) and \( Y \).

This hypothesis can be described as follows, according to the concept of independence of random variables:

\[ H_0 : P(X = x_i, Y = y_i) = P(X = x_i) \cdot P(Y = y_i) \]  

(2)

that is, the features \( X \) and \( Y \) are independent and the following applies:

\[ H_1 : P(X = x_i, Y = y_i) \neq P(X = x_i) \cdot P(Y = y_i) \]  

(3)

i.e., the features \( X \) and \( Y \) are dependent, at the adopted level of significance \( \alpha \).
Statistics chi-square is used to verify the above hypotheses, the value of which is calculated from the following formula:

\[ \chi^2 = \sum_{j=1}^{k} \sum_{i=1}^{r} \frac{(n_{ij} - \hat{n}_{ij})^2}{\hat{n}_{ij}} \]  

(4)

where the following applies:

- \( n_{ij} \) — observed cardinality;
- \( k \) — no. of columns in the independence table;
- \( r \) — no. of rows in the independence table;
- \( \hat{n}_{ij} \) — theoretical quantity, determined according to the following formula:

\[ \hat{n}_{ij} = \frac{\sum_{j=1}^{k} n_{ij} \cdot \sum_{i=1}^{r} n_{ij}}{n} \]  

(5)

where \( n \) is the sample size.

After determining the appropriate values from Formulas (2) and (3), in the next step, the value of the statistics is read from the chi-square distribution tables, \( \chi^2_{\alpha; (r-1)(k-1)} \), i.e., the value of this statistic at the significance level \( \alpha \) and at \((r-1)(k-1)\) degrees of freedom.

The final decision to reject or to accept the adopted hypothesis is made by an appropriate comparison of statistics, according to the following principle:

- if \( \chi^2 \geq \chi^2_{\alpha; (r-1)(k-1)} \) then \( H_0 \) is rejected in favor of an alternative hypothesis;
- if \( \chi^2 < \chi^2_{\alpha; (r-1)(k-1)} \) then there is no grounds to reject \( H_0 \) on the independence of characteristics.

In this paper, the decision to reject or not to reject the hypothesis \( H_0 \) was made based on the \( p \)-value test statistic. The \( p \)-value is a boundary significance level, the lowest level at which the observed value of a test statistic leads to the rejection of the null hypothesis. The \( p \)-value allows the direct assessment of the reliability of the hypothesis. Knowing \( p \)-value allows testing at any level of significance:

- The null hypothesis \( H_0 \) is rejected when \( p \)-value \( \leq \alpha \);
- There are no grounds to reject the null hypothesis \( H_0 \) when \( p \)-value \( > \alpha \).

In the present discussion a significance level of 0.05 was applied in all tests.

3. Energy Education in the Studied Countries

Pursuant to Directive 2006/32/EC of the European Parliament [51], energy efficiency means the ratio of the obtained results: services, goods, or energy to the energy input, i.e., the relation between the energy obtained and supplied. The energy conservation ratio is the total of saved energy measured and/or estimated based on the consumption prior and after applying one or more energy efficiency measures. Energy producers, and governmental and non-governmental organizations run information programs and campaigns, especially regarding energy efficiency programs. The education includes many forms and methods, such as the following: classes on energy production from various sources and its safe use at different school levels, free energy audits, workshops, as well as clarifying labeling and certification systems for energy-consuming devices and energy efficiency regulations for erected buildings. The education is provided both through direct contact with the audience, as well as through dedicated portals, brochures, books, and TV programs [52].

The scope and number of executed energy efficiency projects are still growing. An important element in providing appropriate information to recipients are standards and eco-label systems [49,51]. Research indicates that the most effective methods of education include the following [53]: education and information workshops and courses (22.1%), introducing a standard code system for buildings (19.8%), energy audits (15.9%), thermal
renovation of buildings (10.9%), and technical support of energy recipients in selecting and installing devices (7%).

Energy education started to develop rapidly as a discipline in the 1990s. It comprises the following two main directions: the first is professional education and the second is related to developing energy skills, mainly in children and adolescents [48,49,51–56].

3.1. Forms and Methods of Energy Education: An Overview

3.1.1. Energy Education in Poland

The increasing interest in the energy sector requires the professional training of experts. This is why Polish universities offer new education programs, and high school graduates consider renewable energy studies as a possible path to professional stabilization in the future. Renewable energy subjects are taught at many universities and colleges. Renewable energy sources are the foundation of the curricula in renewable energy and waste management, eco-energy, renewable energy and energy management, energy efficiency, ecological energy sources, renewable energy engineering, renewable energy technologies, electromobility and renewable energy, as well as power engineering faculties, both in full-time and part-time courses. As a standard, first-cycle engineering studies last 3.5 years, and BS studies—3 years; postgraduate studies are also available [57].

Apart from formal college-level education, educational and popularizing activities related to RES are offered as part of informal education, e.g., by capital groups. For example, to promote the education of power industry staff in cooperation with universities, TAURON [58] takes measures to agree research topics for diploma theses and scientific research, to organize student internships, to mutually present and promote achievements, and to update the teaching processes and curricula. The company cooperates to employ students and graduates, organize and participate in postgraduate and doctoral studies, train specialists, and engage in other forms of improving qualifications and initiatives that encourage participation in joint research projects.

3.1.2. Energy Education in the Czech Republic

University-level studies in the Czech Republic train specialists in energy efficiency. Students learn about RES and how to reduce the amount of energy used by communities. Energy studies teach students the processes of generating, transmitting, and distributing electricity. Energy education projects that are implemented in the Czech Republic, co-financed by the HORIZON 2020 program, such as CraftEdu [59], are also worthwhile. As part of the project, common curricula for four targeted craftsmen training programs, and four national curricula on energy efficiency (EE) and the use of renewable energy sources (RES) in construction, were developed and disseminated. Qualification and education programs have also been established in the Czech Republic in EE, and the use of RES in buildings for target craftsmen and professionals in the construction sector. In turn, the ingREEs [60] project introduced a qualitative, pivotal change in lifelong learning in the Czech construction sector, determining the increasing participation rates and the effectiveness of educational activities. As part of this project, industry chambers and associations have organized a training system for mid- and senior-level engineers and construction specialists. The system teaches knowledge and skills corresponding to European standards and the requirements of modern Europe. The ingREEs training participants have obtained full qualifications in energy efficiency and the use of renewable resources in buildings.

3.1.3. Energy Education in Ukraine

With dynamic technological development and the constantly increasing requirements for energy efficiency in view, there is a growing demand for technical specialists who can use the latest technologies and are able to implement them. In Ukraine, the lack of such specialists is particularly acute in the energy and construction sectors, especially in terms of RES. The effective execution of energy efficiency reforms require not only modern technologies and materials, but also the knowledge and experience of qualified specialists.
Unfortunately, the educational infrastructure in this sector is very underdeveloped and hinders the rapid success of the energy efficiency reform. Moreover, depending on the university and the field of study, bachelor-level education lasts 6–7 months, and master’s studies 3–4 months (both full-time and part-time). The most popular energy-related study programs in Ukraine are the following: mechanical engineering, oil and gas production engineering, environmental technology and ecology, and energy management.

To solve the problem of access to eco-energy education, the non-governmental organization “School of Energy Efficiency” launched the project “Promotion of professions and education in the field of energy efficiency”. The project is implemented as part of “Professional Qualifications” under the “Promotion of energy efficiency professions and education” program for the years 2020–2025, run in Ukraine by Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH on behalf of Germany and Switzerland [61].

As part of the EU-funded Twinning project, energy experts train the staff of the National Agency for Energy Efficiency and Energy Saving of Ukraine (SAEE) in the field of renewable energy. The project also helps the agency to amend national legislation on RES, to bring it into line with EU legislation, and to raise public awareness of RES. Ukraine’s 2035 energy strategy, adopted in August 2017, has ambitious goals to halve its economy’s energy intensity by 2030, and to increase the distribution of Ukrainian energy production to 50% from nuclear energy, 25% from RES, 13% from hydropower, and the rest from thermal power by 2035 [61]. Importantly, in contrast to the above described countries, the electricity consumption in Ukraine decreases every year. In 2019, the electricity consumption in Ukraine decreased by 0.3%, to 80,264 billion kWh [62]. The largest electricity consumer, i.e., industry, reduced electricity consumption by 0.6%, to 34,311 billion kWh, and consumers reduced their energy consumption by 0.6%, to 23,387 billion kWh [63].

4. Results

The results presented in the article refer only to the behavior of the surveyed students and their households (dedicated respondent samples were used).

4.1. Characteristics of the Respondents and Their Household Equipment

One hundred and fifty-six students from Poland, 107 students from the Czech Republic, and 275 from Ukraine participated in the study. Table 2 presents the general characteristics of the studied groups. The following socio-demographic variables were specified: gender, education, and place of residence.

| Variables                  | Poland | Czech Republic | Ukraine |
|----------------------------|--------|----------------|---------|
| Gender                     |        |                |         |
| Women                      | 59.0%  | 74.8%          | 56.7%   |
| Men                        | 41.0%  | 25.2%          | 43.3%   |
| Education                  |        |                |         |
| Secondary (1st-degree)     | 68.6%  | 46.7%          | 20.7%   |
| Higher (2nd-degree)        | 31.4%  | 53.3%          | 79.3%   |
| Rural area                 | 48.1%  | 35.5%          | 39.3%   |
| Place of residence         |        |                |         |
| City up to 50,000          | 17.3%  | 24.3%          | 40.0%   |
| City 50,000–500,000 residents | 14.8%  | 26.2%          | 20.4%   |
| City over 500,000 residents | 19.9%  | 14.0%          | 0.4%    |

Source: own study.

The group of respondents was dominated by women, graduate students (except Poland), and residents of rural areas.

Figure 1 provides information on the respondents’ household heating systems. As the diagram analysis shows, Czechs mainly use natural gas, wood/biomass, and electricity to heat buildings. This is slightly different among the respondents from Poland. Coal (24.6%), natural gas (23%), and wood/biomass (22.1%) were most often indicated as the heating fuel. In the case of Ukraine, natural gas definitely prevails in the analyzed aspect, as it is
used for heating by over 40% of the respondents. This situation could result from the costs of using gas in Ukraine, where this fuel is cheaper than in Poland or the Czech Republic. The other indicated energy sources are wood/biomass (27.25%) and electricity (14.7%).

![System of heating in household (central heating and domestic hot water)](image)

**Figure 1.** Heating system in the household. Source: own study.

A common feature of all the analyzed households in the surveyed countries is that 48–56% of them have only a single heat source. The complementary heat sources are most often wood/biomass and RES systems. Nevertheless, the potential for implementing RES devices in each of the analyzed countries is still huge.

Less than 3% of the respondents from the Czech Republic declared that they used coal for heating. This is due to the fact that in the Czech Republic there is a restriction in using coal in boilers with a capacity under 300 kW. In Poland, the number of owners of coal heaters is much greater (approx. 25% of the respondents). Nevertheless, one should expect a gradual decrease in the number of coal heaters in Poland and Ukraine, including through the introduction of anti-smog laws in municipalities or the implementation of
the Czyste Powietrze (Clean Air) program (Poland), and the increasing interest in RES systems (Ukraine).

Among the answers, there is also a noticeable share of RES in the heating systems of residential buildings in Poland and the Czech Republic (solar panels and collectors, heat pumps). On the other hand, in Ukraine, the share of these sources in heating buildings is still negligible, mainly due to the price and availability of the raw material in the selected market, as well as the availability of infrastructure (gas, district heat) and institutional support for the expansion of alternative systems (solar panels and collectors, heat pumps).

The question that directly relates to the implementation of circular economy (which aims to protect the environment and respect natural resources) is the incineration of waste in households. This question was aimed at determining the environmental awareness of the respondents’ household managers. Figure 2 shows the distribution of answers to the question about waste incineration in domestic heaters. Most of this type of detrimental activity is carried out in Ukraine, as municipal solid waste is burned in almost every other of the surveyed households. In the case of respondents from the Czech Republic and Poland, this value is at the level of several percent. However, please note that in the past this was practiced in many of the households in Poland and the Czech Republic. Over 45% of the respondents from Poland and 57% from the Czech Republic gave this answer. The analyzed distribution of answers to the question turned out to be statistically significant (chi-square = 79.7, p-value < 0.001). Households that incinerate waste are located mainly in rural areas (Ukraine—62%, Czech Republic—63%, Poland—77%).

![Figure 2. Burning paper, wood or plastic in households. Source: own study.](image)

A thermostat optimizes the cost of bills and unnecessary heat loss in the household. When asked about it to regulate the water or air temperature (Figure 3), the Czechs gave the highest percentage of positive answers, as over 52% of the respondents from this country have a thermostat installed. In the case of Poland and Ukraine, this percentage is 40%. In both of these countries, more respondents do not have a thermostat. The Czechs, on the other hand, showed the greatest lack of knowledge in this area. Almost every fifth respondent was unable to answer this question. Every seventh person showed a lack of knowledge in this respect, among both Poles and Ukrainians. The indicated differences in answers to the question turned out to be statistically significant (chi-square = 12.4, p-value < 0.05).
Another question was related to the necessity of thermal renovation of the building where the respondent resided. The answers to this question also indicate whether the building has been renovated, or not. Analyzing the structure of the answers in Figure 4, it can be concluded that the greatest need for thermal renovation was observed by students from Ukraine (over 60% of the respondents in this group). For students from the Czech Republic, this percentage is at 40%, and the lowest is for Poland, amounting to 30%. In Poland, relatively more buildings (compared to other countries) have already undergone thermal renovation, which could be confirmed by the fact that nearly 55% of Polish students believe that there is no need to insulate the building. Polish students showed the greatest ignorance in this regard, because every 10th respondent is not interested in this issue. The distribution of answers to the question turned out to be statistically significant (chi-square = 51.13, p-value < 0.01). It can therefore be concluded that the level of advancement in the thermal renovation of buildings and awareness of the need of this treatment differs in individual countries.

Sixty percent of the respondents from Poland, 64% from Czech Republic, and 80% from Ukraine, living in rural areas, declared that their households require thermal renovation. Fortunately, in each of the surveyed countries, less than 5% of the respondents do not see any benefits from thermal renovation.
4.2. Analysis of the Respondents’ Behavior in Terms of Energy Conservation

As noted in the methodological part, the second part of the analysis included questions in which the respondents defined their behavior proving their eco-energy awareness.

The first question concerned preferences in the purchase of electronic devices and household appliances. The energy class of the device is important when making a choice for over 83% of Czech students, but only 8% considered it to be the main factor of choice (Figure 5). Among the surveyed Poles, 73% pay attention to the appliance’s energy class upon purchase, and it is a decisive factor for over 16%. On the other hand, in the group of Ukrainian students, only 50% of them pay attention to the energy class of the device they are buying (for approx. 16% of them, it is a decisive factor).

The importance of energy efficiency, and thus cheaper operation, is noticed by a significant number of respondents, but only 14% of the students consider it to be the main factor when choosing a device.

The noticed significant differences in the answers to the question in individual national groups turned out to be statistically significant (chi-square = 53.06, \( p \)-value < 0.01).

Another question was related to the use of the electric kettle by the respondents. In this respect, the highest percentage of positive answers was obtained for students from the Czech Republic (Figure 5), i.e., approx. 90%. In the case of Poland and Ukraine, this result is much lower and amounts to 60–70%. Moreover, in this case, the differences are statistically significant (chi-square = 21.17, \( p \)-value < 0.01).

The use of electric kettles positively impacts energy bills. Boiling a small amount of water in the kettle shortens the time of this process and, as a result, the consumption of electricity. Having an electric kettle in itself does not determine the pro-environmental attitude of the respondents, but conscious use of the device does. It is important, however, that the use of this kettle is the most eco-energetic way of boiling water.

The results of answers to the question about the use of LED lighting are presented in Figure 7. The lowest percentage of respondents using this type of lighting can be found among students from Ukraine. In this group, precisely 30% of the students do not use this type of lighting. On the other hand, the highest percentage of LED lighting is used by students from Poland, i.e., 85.5%, with 22.6% indicating that they use solely LED lighting. Moreover, in this case, the differentiation of answers to the question, between students from different countries, is statistically significant (chi-square = 13.837, \( p \)-value < 0.01).
The distribution of responses of the surveyed students from individual countries regarding the use of rechargeable batteries is presented in Figure 8. It shows that over 36% of the respondents from the Czech Republic and Ukraine use only rechargeable batteries. Among Polish students, this percentage is lower and amounts to 29%. In turn, students from Ukraine are most likely to use only disposable batteries. In this group, over 13% of the respondents indicated this answer. In Poland and the Czech Republic, every tenth student uses only disposable batteries. In this analysis, the differences in the distribution of responses were relatively small and it can be presumed that they are statistically insignificant. This is confirmed by the performed independence test, in which the chi-square value was 4.9 and p-value was 0.2972.

The last question regarded the use of additional artificial lighting when working at a computer or watching TV. The results of this analysis are presented in Figure 9.
It turns out that it is the respondents from Poland who always use an additional light source; more than 28% of them answered this question positively. In the case of their peers from the Czech Republic and Ukraine, this value is at 21–23%. In turn, every sixth respondent of the surveyed students from Ukraine never uses additional lighting, and this is the highest percentage among the three analyzed countries. In this respect, the lowest value was obtained for students from Poland (6.3%). However, the differences shown are not statistically significant as \( p \)-value = 0.1054 and chi-square = 7.6.

5. Discussion

The pro-ecological attitudes of students of various nationalities are the subject of many studies. In the research conducted by Ropuszyńska-Surma and Węglarz [64], it was found that only 5% of students from Wrocław-based universities used LED lighting only. The conducted survey showed that 22.6% of Polish respondents use LED lighting. Exactly 62% of students from Wrocław say that they only partially use LED lighting, which corresponds to the declarations of the respondents of this research.
In studies by Bednarek-Gejo et al. [65], every second person sometimes checked the energy class when purchasing a device (42.4% of students who were city residents, and 51.5% of country residents), and less than 20% always checked the energy class (15.3% of city residents and 17.8% of country residents). Equipment of the highest energy class ensures lower energy consumption, allows for saving resources and work, and protects the environment. The results of this study show that for over 83% of Czech students, energy efficiency is important. For Polish students, 73% of them find energy efficiency important, and for over 16% of them, it is a decisive factor (in the case of Czech students, it is only 8%). Fifty-two percent of the Ukrainian student group pay attention to energy class when purchasing an appliance, and for 15.8% of them, it is the decisive factor. Upon comparing the obtained results with those available in the literature, it can be concluded that the growing awareness of the importance of the energy class of electrical appliances is part of their rational and efficient use.

The proper use of electric kettles allows energy to be saved. It was found that 88.8% of students from the Czech Republic, 63.4% from Poland, and 68.1% from Ukraine declared the use of this device. The article [65] demonstrated that 85% of Britons use an electric kettle, but three out of four respondents boil more water than they need. As shown by the survey results, the use of electric kettles is popular among students in the studied countries; over 60% of respondents in Poland and Ukraine, and over 80% in the Czech Republic appreciate the pro-environmental features of the device. Rational boiling of water at single consumption remains a separate problem.

A report on the heating source of households in the Małopolskie Province, prepared by the CEM Market and Public Opinion Research Institute [66], showed that 70% of respondents use coal-fired boilers/furnaces. The rest of the respondents use the following energy sources: 18% gas, 7% wood/biomass, under 2%—electricity, and 3% use fuel oil, the municipal heating network, and ecological sources. As shown in the survey, in Poland, the most commonly used heating fuel is coal (24.6%), natural gas (23%), and wood/biomass (22.1%). In Ukraine, natural gas is by far the most dominant fuel, used by 40% of the respondents, followed by wood/biomass (27.25) and electricity (14.7%). The main heating source for Czechs is natural gas (30.3%), wood/biomass (22.1%), and electricity (21.6%). The changes in the structure of the used heating sources may be influenced by the public policies implemented in the studied countries, to improve the air quality and to counteract the ongoing climate changes.

Bieniek et al. [67] showed that 20% of respondents admit to burning plastics in domestic heating systems. Research carried out in 2016 in Krakow showed that as much as 60% of the households burned waste, and in Poland, as a country, the percentage is estimated at 30%. The results of the research conducted by the IPC Research Institute [68] in the Mazowieckie Province indicate that nearly half of the respondents (48%) burn waste in household furnaces [69]. The research showed that 16.4% of Poles, 10.3% of Czechs, and as many as 46.7% of Ukrainians burn waste in households. According to the authors, intensifying educational activities, as far back as kindergarten, is necessary to eliminate this practice. Burning waste also has a negative impact on the condition of chimney ducts, causing the accumulation of so-called “wet” soot in chimneys, which can result in chimney fires. What is more, the thermal processing of waste in an installation not intended for this purpose is liable to criminal sanctions, in accordance with national and local legislation.

Based on their research, Dzikuć et al. [70] stated that 11% of the respondents did not plan thermal renovation, since they believed that such a procedure is not necessary. In a survey conducted by the Public Opinion Research Center [71], as many as 2/3 of the respondents from Poland declared that they did not need thermal renovation of their residences, because it has already been done. In this study, half of the respondents in Poland (53.3%) and the Czech Republic (59.1%), as well as over 30% of the students from Ukraine, stated that their households do not require thermal renovation because the buildings are new or sufficiently insulated.
The use of a thermostat helps to save both heat and electricity. Currently, this device is used by 40% of student households in Poland, by 52% in Czech Republic, and by approx. 40% in Ukraine. Further, 11.6% of Poles declared that they owned a thermostat [72]. However, in 2012, the Central Statistical Office [72] published information that only 8% of households in Poland have a thermostat.

To increase awareness and improve the pro-ecological social behavior, above all in young people (students), the emphasis on ecological education and renewable energy should be increased [73]. This is particularly important for the representatives of “Generation Z”, i.e., people between 18 and 24 years old, as described by Parzonko et al. [74]. Their study showed that the representatives of generation Z are less engaged in pro-environmental behaviors than people from the older age group (25–60 years). The pro-environmental activities of young people consisted mainly of switching off the lights when they left the room and choosing public transport as the primary means of transportation. The main motivating and demotivating factors determining pro-environmental behavior among young people in general were mainly economic [74].

The results of the research of students presented in this article correspond with the nationwide research carried out by the Polish Ministry of Environment and Climate [75], in which over 95 percent of Polish residents declare that they save energy at home. The most frequently indicated energy-saving methods are the following: turning off lights in unused rooms, using energy-saving light sources, or purchasing energy-saving household appliances.

One third of the respondents plan to take additional measures to increase energy efficiency and reduce energy bills, most often by using RES. More than 3/4 of the respondents are willing to spend more on “clean” energy; this percentage is almost four times higher than the one obtained in 2018. The residents of Poland want to rely on RES more often, and on the thermal renovation of buildings and the use of energy-saving lighting less often, as confirmed by the research presented in this paper [76].

6. Conclusions

The above article is a part of a major project related to the introduction of circular economy (CE) and its problems, especially related to energy saving, waste management, and the impact of youth education on the future of circular economy. The project comprises the following three stages: (1) a survey of students of energy-related majors; (2) students of all majors; and (3) all people aged 16–65 in a selected country.

This article only presents the results from the first stage of the project, and they do not relate to environmental engineering—all fields of study of the subjects are related to energy conservation and RES. Moreover, the article presents the characteristics of energy education in selected (analyzed) countries.

Based on the research on a group of selected students from Poland, the Czech Republic and Ukraine, the following was found:

1. The share of RES in the heating systems of the analyzed residential buildings is 9%, on average, with the highest percentage of houses in Poland (14%) and the lowest in Ukraine (only 2.6%);
2. Currently, 84% of the respondents from Poland, 89% from the Czech Republic, and 53% from Ukraine do not burn waste in home furnaces any more, but in 1/3 of respondent’s households it was done so in the past;
3. Twenty-eight percent of surveyed Czechs, 45% of Poles, and 47% of Ukrainians declared having no thermostat installed in their households;
4. The energy class of household appliances/audio/video devices is considered prior to purchase by 73% of Polish respondents, 82% of Czechs, and 55% of Ukrainians;
5. Nearly 65% of student respondents use rechargeable batteries to power a low-voltage receiver;
6. Approx. 60% of the surveyed students follow the principles of energy conservation; however eco-energy behaviors (such as using LED lights, paying attention to the energy
class of the device, using rechargeable batteries instead of disposable for low-voltage devices, using thermostats, etc.) should be subject to increased educational activities;

7. Most of the studied behaviors showed significant variation between students from each country; no significant variation was obtained for the last two questions.

As emphasized by Paraschivescu et al. [77], education for sustainable development is not just a simple extension of environmental education with additional social and economic content. Education for sustainable development should constitute a strong pillar, connecting global education, environmental education, technical education, and health education. In the early 21st century, global education for sustainable development could be insufficient. Therefore, as stated by Acikgoz [78], in the era of dynamically growing energy demand, energy education or even RES education [79] will be a new compulsory discipline, both formal and informal, in all the countries of the world.

As a goal, sustainable education should be systematically and consistently developed. If the communication on sustainable development is sporadic and marginal, citizens are unlikely to change their attitudes to global climate change, global warming, and similar issues. The public should be regularly informed on the risks and threats related to traditional fossil fuels and the new, environmentally friendly use of RES, at all stages of education.

At the same time, sustainable education should aim to support the recognition of risk and resilience, and to encourage the society to take action for welfare, addressing the issue of social responsibility. Accordingly, universities play a key role in implementing and promoting sustainable development initiatives.

Building eco-energy awareness among the young is particularly important, because it is they who will be responsible for implementing energy-saving solutions in their households and the entire economy in the near future. These activities are in line with the circular economy system. Educating students in environmental consciousness will allow the building of power-generating farms, using solar power, water, and wind, and to increase the share of RES in energy consumption in the future [80,81]. As the conducted research shows, there is a lot to improve in this respect, because this awareness among the surveyed students is average.

Energy education is extremely important in the context of EU and national energy efficiency improvement projects. If there is no pro-ecological awareness, projects for the expansion of RES energy and increasing energy efficiency, e.g., Polish gasification projects, aimed at limiting the use of traditional energy sources, such as coal, will be incumbered.

As part of the research laboratory, the authors plan to investigate the impact of socio-demographic factors on the eco-energy behavior of students in individual countries. In subsequent research, they intend to formulate a number of research hypotheses, including that the higher the education of the respondents, the more frequent the use of electricity for heating buildings, and that the female residents of Ukraine pay less attention to the energy class of the device to verify it than the female residents of the Czech Republic and Poland.

Author Contributions: Conceptualization, Z.G.-S. and M.M.; methodology, M.M., M.S., K.K., S.B., M.D.V., A.M., H.U., A.K.-B. and U.Z.; software, M.S.; validation, Z.G.-S., M.M., M.S. and A.K.-B.; formal analysis, M.M., S.B., H.U., K.K. and A.M.; investigation, M.M., S.B., H.U., K.K. and A.N.; resources, M.M., S.B., H.U., K.K., A.M., M.D.V., A.K.-B., K.K.-W. and R.L.; data curation, Z.G.-S., M.M., M.S. and A.S.-S.; writing—original draft preparation, Z.G.-S., M.S., M.M., A.K-B., K.K-W., R.L.; A.N. and M.N.; writing—review and editing, A.N., Z.G.-S., M.S., M.M. and A.K.-B.; visualization, M.S.; supervision, A.S.-S. and A.N.; project administration, Z.G.-S. All authors have read and agreed to the published version of the manuscript.

Funding: This publication was financed by a subsidy granted to the University of Agriculture in Krakow. This publication was financed by a subsidy granted to the Cracow University of Economics (DOSKONALOŚĆ BADAWCZA nr 69/ZZE/2021/DOS). The publication was financed by a subsidy for the Faculty of Management of AGH University for the maintenance and development of research potential.
Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Data Availability Statement: Not applicable.

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

References

1. COM(2015)0080. Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee, the Committee of the Regions and the European Investment Bank, a Framework Strategy for a Resilient Energy Union with a Forward-Looking Climate Change Policy. Available online: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52015DC0080 (accessed on 10 May 2021).

2. COM(2016)0860. Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee, the Committee of the Regions and the European Investment Bank, Clean Energy for All Europeans. Available online: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52016DC0860 (accessed on 10 May 2021).

3. Directive (EU) 2018/2001 of the European Parliament and of the Council of 11 December 2018 on the Promotion of the Use of Energy from Renewable Sources. Available online: https://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX:32018L02001&from=PL (accessed on 10 May 2021).

4. COM(2008) 781 Final Second Strategic Energy Review. Available online: http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=COM:2008:0781:FIN:EN:PDF (accessed on 10 May 2021).

5. Głowiakci, J.; Kopyciński, P.; Mamica, L.; Malinowski, M. Identyfikacja i delimitacja obszarów gospodarki o obiegu zamkniętym w ramach zrównoważonej konsumpcji. In Gospodarka o Obiegu Zamkniętym w Polityce i Badaniach Naukowych; Kuleczka, J., Ed.; Instytut Gospodarki Surowcami Mineralnymi i Energią Polskiej Akademii Nauk: Krakow, Poland, 2019; pp. 167–179.

6. EU Cohesion Policy 2021–2027. Available online: https://ec.europa.eu/regional_policy/pl/2021_2027/ (accessed on 10 May 2021).

7. Szelag-Sikora, A.; Sikora, J.; Niemiec, M.; Gródek-Szostak, Z.; Suder, M.; Kubori, M.; Borkowski, T.; Malik, G. Solar Power: Stellar Profit or Astronomic Cost? A Case Study of Photovoltaic Installations under Poland’s National Prosumer Policy in 2016–2020. Energies 2021, 14, 4233. [CrossRef]

8. Kandpal, T.C.; Broman, L. Renewable energy education: A global status review. Renew. Sustain. Energy Rev. 2014, 34, 300–324. [CrossRef]

9. Keser, O.F.; Özmen, H.; Akdeniz, F. Energy, environment, and education Relationship in developing countries’ policies: A case study for Turkey. Energy Sources 2003, 25, 123–133. [CrossRef]

10. Vanegas Cantarero, M.M. Of renewable energy, energy democracy, and sustainable development: A roadmap to accelerate the energy transition in developing countries. Energy Res. Soc. Sci. 2020, 59, 101716. [CrossRef]

11. Alawin, A.A.; Rahmeh, T.A.; Jaber, J.O.; Loubani, S.; Dalu, S.A.; Awad, W.; Dalabih, A. Renewable energy education in engineering schools in Jordan: Existing courses and level of awareness of senior students. Renew. Sustain. Energy Rev. 2016, 65, 308–318. [CrossRef]

12. Nevesa, D.; Baptista, P.; Piresa, J.M. Sustainable and inclusive energy solutions in refugee camps: Developing a modelling approach for energy demand and alternative renewable power supply. J. Clean. Prod. 2021, 298, 126745. [CrossRef]

13. Buldur, S.; Bursali, M.; Erikk, N.Y.; Yucel, E. The impact of an outdoor education project on middle school students’ perceptions and awareness of the renewable energy. Renew. Sustain. Energy Rev. 2020, 134, 110364. [CrossRef]

14. Ott, A.; Broman, L.; Blum, K. A pedagogical approach to solar energy education. Sol. Energy 2018, 173, 740–743. [CrossRef]

15. Dias, R.A.; de Paula, M.R.; Rocha Rizol, P.M.S.; Matelli, J.A.; Rodrigues de Mattos, C.; Ferrella Balestieri, J.A. Energy education: Reflections over the last fifteen years. Renew. Sustain. Energy Rev. 2021, 141, 110845. [CrossRef]

16. Berkovski, B.; Gottschalk, C. Strengthening human resources for new and renewable energy technologies of the 21st century: UNESCO engineering education and training programme. Renew. Energy 1997, 10, 441–450. [CrossRef]

17. O’Mara, K.L.; Jennings, P.J. Innovative renewable energy education using the World Wide Web. Renew. Energy 2001, 22, 135–141. [CrossRef]

18. Jaber, J.O.; Mamlook, R.; Awad, W. Evaluation of energy conservation programs in residential sector using fuzzy logic methodology. Energy Policy 2005, 33, 1329–1338. [CrossRef]

19. Zyadin, A.; Puhaakka, A.; Ahponen, P.; Cronberg, T.; Pelkonen, P. School students’ knowledge, perceptions, and attitudes toward renewable energy in Jordan. Renew. Energy 2012, 45, 78–85. [CrossRef]

20. Cuppen, E. The value of social conflicts. Critiquing invited participation in energy projects. Energy Res. Soc. Sci. 2018, 38, 28–32. [CrossRef]

21. Keramitsoglou, K.M. Exploring adolescents’ knowledge, perceptions and attitudes towards Renewable Energy Sources: A colour choice approach. Renew. Sustain. Energy Rev. 2016, 59, 1159–1169. [CrossRef]

22. Halder, P. Perceptions of energy production from forest biomass among school students in Finland: Directions for the future bioenergy policies. Renew. Energy 2014, 68, 372–377. [CrossRef]

23. European Commission Profiting or Astronomic Cost? A Case Study of Photovoltaic Installations under Poland’s National Prosumer Policy in 2016–2020. Profit or Astronomic Cost? A Case Study of Photovoltaic Installations under Poland’s National Prosumer Policy in 2016–2020. May 2021).
78. Acikgoz, C. Renewable energy education in Turkey. *Renew. Energy* 2011, 36, 608–611. [CrossRef]
79. Karabulut, A.; Gedik, E.; Keçebaş, A.; Alkan, M.A. An investigation on renewable energy education at the university level in Turkey. *Renew. Energy* 2011, 36, 1293–1297. [CrossRef]
80. Dawid, L. German support systems for onshore wind farms in the context of Polish acts limiting wind energy development. *J. Water Land Dev.* 2017, 34, 109–115. [CrossRef]
81. Dawid, L. Current status and perspectives on offshore wind farms development in the United Kingdom. *J. Water Land Dev.* 2019, 43, 49–55. [CrossRef]