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The Role of ICT in Creating the Conscious Development of Green Energy Applications in Times of Crisis: Comparison of Poland, Türkiye and People's Republic of China

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Abstract:

Purpose: *The main purpose of this article is to analyze and compare the role of Information and Communication Technologies (ICT) in creating awareness of the possibility to obtain and use green energy sources in the era of ecological, health, economic and political crisis in selected countries, Poland, Türkiye and the People's Republic of China (PRC).*
Design/Methodology/Approach: *The comparative analysis was carried out at the turn of October and November 2022, i.e., during the period of the Covid-19 pandemic crisis in the first two countries and the return of the pandemic in China, in the situation of the growing economic crisis in Poland and Türkiye, intensified by worsening political crises and the war in Ukraine. The data was collected by means of a questionnaire distributed using the CAWI method on the servers of the Faculty of Management of the University of Warsaw. The survey covered a group of 1,101 people, with the total of 483 participants.*
Findings: *The results of the study may be useful for practitioners to show possible strategies for the development and implementation of green energy in culturally diverse countries, located in different geographical regions.*
Practical Implications: *The conclusions can be used by organizations that want to promote or sell green energy solutions as an alternative to traditional energy sources.*
Originality/Value: *The value of the study is related to the fact that, for the first time in the literature, the authors carried out a comparative analysis of respondents' opinions on the use of ICT technologies in disseminating the idea of using green energy in place of traditional energy sources for countries which are culturally different and experience diverse crises conditions.*

Keywords: *Green energy, awareness of the need for green energy, the consciousness of green energy, energy responsibility, energy sustainability, location distance, international comparative study, crisis.*

JEL Classification: *M15, Q27, O33, L86.*
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1. Introduction

The present environmental crisis is no less important than the recent health, economic and political, etc., crises which occur around the world. It is related to other types of crises; however, in view of the economic problems caused by the Covid-19 pandemic, the war in Ukraine and related sanctions, the environmental crisis appears to be one of the most relevant issues today.

It is of primary importance because overcoming it can, directly and indirectly, reduce or even eliminate the effects of the existing crises by providing energy based on renewable (clean, green) sources available to the public, rather than relying on scarce (dirty and difficult to access) sources such as, for example, lignite and hard coal, oil or nuclear energy. The issue is particularly relevant as in the last few decades energy demand has increased (Su *et al.*, 2021) and is still growing (Khan *et al.*, 2021).

The primary aim of this article is to identify the role and place of ICT in shaping the awareness of the need to obtain and use green energy in times of health, economic, climate and political crises in selected countries, Poland, Türkiye and the PRC.

This phenomenon was studied against the background of the assessment of environmental awareness of respondents, which was understood as an attitude characterized by rational responsibility for the state of the natural environment. The latter is important in the context of the pursuit of sustainable economic development, both in industry and agriculture, based on the active protection of man and nature with a view to counteracting the threats posed by the excessive exploitation of natural resources.

In order to actively counteract environmental threats, it is first necessary to establish the level of public awareness of green energy, identify the challenges, and then methods and new technologies to help counteract the identified threats. The state of public awareness of green energy is influenced by economic factors (high costs of green energy investments), insufficient scientific development and low technological development, lack of expertise or access to information on green energy as well as common difficulties in accessing funding for this type of investment (Wang *et al.*, 2021a; 2021b).

Counteracting the major issues through technology should be considered in:

- a social dimension - raising awareness through education, acquiring knowledge about environmental threats as well as environmental protection, innovativeness in this area, etc.,
- a technical dimension - supporting the social dimension and taking action to minimize or eliminate existing risks.

In the first dimension, ICT technologies, especially web-based solutions, may be seen as the most important tool used to inform the public about risks as well as promote, disseminate and explain the concepts related to sustainable ecological development. They may play an important role and provide educational and scientific support as regards environmental protection.

In the second case, related to the technical dimension, technologies may be applied in the area of environmental hazard monitoring and alerts; use of alternative energy sources, supporting full recycling; minimizing production waste; reduction of unfiltered wastewater; reduction of exhaust gases, etc. Activities indicated in the second dimension cannot fully succeed without public support for such tasks, especially at a time of economic, political and health crises.

The recent shift of many companies toward online activities during the Covid-19 pandemic, due to the development of ICTs, can also create new growth opportunities for green energy (Olanipekun and Alola, 2020). In addition to improving economic performance, increasing efficiency and reducing costs, which is inherent to e-commerce and related to the wide scope of its activities, ICTs can potentially raise awareness of the need to protect the environment.

This, in turn, may help government administration to introduce, if they have the intention to do so, practical solutions in this regard (Bakirtas and Akpolat, 2020), (Paul *et al.*, 2021). Notably, the number of ICT customers in all countries examined in this study has increased significantly (Genc, 2017; McCartney *et al.*, 2021).

The literature on green energy is extensive. However, the studies are mainly concerned with the specification of equipment for the generation or storage of green energy and green energy enterprises, the issue of substitutability of energy sources as a way to achieve a less environmentally hazardous mix of energy sources (Hanssen *et al.*, 2018), the issue of psycho-social barriers to the implementation of green energy solutions (Paillé and Mejía-Morelos, 2014; Kaakeh *et al.*, 2021), economic barriers (Shaktawat and Vadhera, 2021), geographical considerations (Sironen and Mononen, 2018; Tiitu *et al.*, 2018), their importance for agricultural development (Zandi and Haseeb, 2019) or political aspirations and plans (Winfield and Dolter, 2014).

There have also been (Rempel and Gupta, 2021; Jia *et al.*, 2021; Wang and Zhang, 2021) studies on the impact of crises, especially the Covid-19 pandemic, on green energy development. The term green energy is used here in a broad sense as a current symbol of the environmental strategy implemented in the field of power generation and energy. In the context of counteracting pollution effects, it appears to be one of the most important areas at present.

There are few studies (Chien *et al.*, 2021; Kabir and Morgan, 2021; Kong and Liu, 2014; Chang *et al.*, 2022) that comprehensively examine and present the impact of

ICT on the development of green energy, especially in terms of analyses conducted by geographical area. The present study aims to fill, or at least reduce, the resulting research gap.

Therefore, in their study on the role of ICT in shaping the conscious use of green energy, the authors adopted the following approach:

- the authors established the scope and extent of the study by identifying how users access the Internet,
- then the authors explored the respondents' general knowledge of environmental protection and its source, and they specifically addressed the topic of replacing environmentally hazardous energy with so-called green energy,
- they identified the state of awareness of the term green energy and the advantages and disadvantages of its use,
- they assessed the status of the most popular portals and applications dealing with environmental issues regarding the use of green energy in the analyzed countries,
- based on the results, they established recommendations for improving the performance of ICT tools in promoting the use of green energy.

In order to achieve the main objective of the study, the following structure of the paper was adopted. The Introduction presents the essence of the research problem, identifies the research gap and presents the objectives of the study.

The next section provides a literature review on green energy issues and the impact of ICT tools on the dissemination and implementation of this idea. The third section characterizes the research procedure and the sample examined in the study. The fourth section contains an analysis of the findings and their discussion. The last section presents conclusions and recommendations, limitations and further directions for the development of research work in this area.

2. Literature Review

The term *ecological awareness* generally refers only to education and knowledge, *ecological consciousness*, in addition to the perception of the phenomenon, it also refers to ecological action (Toombs, 2021).

The term green energy refers to clean energy that, unlike fossil fuels, does not pollute the environment and comes entirely from renewable sources such as water, wind, sun, and biomass, also being considered sustainable energy. Energy sources are regarded as renewable when natural resources do not diminish during energy production, or they recover very quickly. At the same time, their use does not cause a deficit of raw materials and the impact on environmental degradation is lower

than with traditional energy sources. Renewable energy differs from clean energy in that it comes from resources provided by nature such as wind, sun or water.

Although, here too, the definitions include the restriction that they should not significantly damage the environment (Three Gorges Dam in China, Itaipu Dam - Brazil/Paraguay, Grand Coulee Dam - USA, Sayan-Shushan Hydroelectric Power Plant in Russia and many others).

Clean energy includes, in addition to renewable energy, also nuclear energy, which does not emit greenhouse gases. In contrast, it is not renewable because it is based on rare and limited uranium resources. Green energy is commonly associated with clean energy, although many uninformed people attribute it to renewable energy.

Hence, education related to environmental protection is important *(Ertör-Akyazı et al.,* 2012), ("Turkey Renewable Energy Market Analysis - Industry Report - Trends, Size & Share," n.d.), (Mundaca and Luth Richter, 2015).

In recent years, the category of sustainable energy sources, i.e., energy that generates not only environmental but also social and economic benefits, has gained importance. Green energy does not automatically mean sustainable, because if a lot of energy has been used to produce and transmit it, and there is also, as yet, no possibility of complete disposal, then it is not considered sustainable ("Eco-Consciousness and Sustainability," n.d.).

On the other hand, in times of crisis, aiming at achieving sustainable energy goals is important. This can be done by optimizing the structure of the energy sources produced in a country and gradually increasing first the share of renewable energy and then clean energy in the overall production volume. This approach makes it possible to rationalize the short-term tendency to minimize costs, which is, as it were, natural during crises, and move towards the long-term maximization of effects, including environmental and social benefits (Hyman *et al.,* 2021; Caballero-Morales, 2021; Ibn-Mohammed *et al.,* 2021).

Green energy development strategies in different countries depend on geographical conditions (number of days of sunshine, strong winds, rivers with high gradients), natural resources (coal, lignite, oil, gas, radioactive raw materials). They are also related to the direction of economic development to date, which is based on existing resources or resources that are cheap to obtain.

The energy policy and currently implemented actions are related more to politics rather than the strategy of the current state administration; other factors which are important in this context include geopolitical considerations and economic alliances (Kabir *et al.,* 2022; Mont *et al.,* 2021; Stiglitz, 2021; Lansana, 1992; Marttunen and Mustajoki, 2018).

Each of these determinants can apply to any type of green energy source: the energy which comes from water (river flow, sea waves, thermal energy of the seas and oceans, ocean currents, tides, diffusion due to concentration differences, thermal energy from geothermal sources), from the air (wind power, heat pumps), from the ground (ground source heat pumps), from the sun (photovoltaic panels, thermal collectors), or biomass and biogas energy (waste materials transformed after combustion, drying, pressing, gasification or esterification (heat from a chemical reaction) (Gürlek and Tuna, 2018; Pop, 2022; Kapoor *et al.,* 2021).

The issue needs to be addressed because in the countries considered in the article, green energy production does not account for a very large share of total energy production. In Poland, the acquisition of energy from polluting sources is by far dominant - 84% in August 2022 (including hard coal (50%), lignite (30%), gas (almost 4%)), and energy from renewable resources accounts for less than 16% (including the share of wind - 5%, hydropower - 1%) ("Produkcja energii elektrycznej w Polsce | Rynek Elektryczny," 2023), ("Produkcja energii elektrycznej z OZE - podsumowanie roku 2021," 2022).

In Türkiye, the trend was very similar, in 2021, still, 84% of energy was obtained from coal and natural gas (Dierks, 2022), although opinions from various data sources estimate this share to be much lower (Sahin and Esen, 2022; Todorović, 2022; Cetinkaya, 2022; Uğurlu and Gokcol, 2017). In the PRC at the beginning of 2021, 78% of energy was derived from coal, gas and oil ("2020 electricity & other energy statistics (preliminary)," 2021), and 22% from green energy sources ("2019 detailed electricity statistics (update of Jan 2021)," 2021), including less than 5% of nuclear energy (cycles and Text, n.d.).

The cited data shows that green energy is not yet a priority in energy development practice in the analyzed countries. The dominance of fuels based on coal, oil and gas leads to serious environmental problems (Kamyk *et al.,* 2021; Zandi and Haseeb, 2019). In addition, countries possessing these resources may - as the example of Russia shows - use the restriction to access them for political blackmail. Therefore, green energy sources that reduce CO2 emissions have become a clear alternative to conventional fuels (Song, 2020; Drachal, 2021).

Modern economic growth strategies point to the importance of technological progress in economic development. ICT has the potential to stimulate it in both the social and technical spheres. This may be due to its positive impact on financial development (Kaakeh *et al.,* 2021) or intellectual development concerning knowledge of energy resource sources and how to use them (Kabir, 2021).

Green energy issues also occur regionally but are significantly differentiated. It may concern oil extraction in the Canadian shelf and its impact on agriculture (Rohr *et al.,* 2021), the relevance of green energy consumption for agriculture and minimizing environmental degradation in sub-Sahara African countries (Zandi and

Haseeb, 2019), the assessment of planning practices and their impact on the environment in Australia and New Zealand (Kabir and Morgan, 2021), the impact of the carbon tax on the energy balance in Japan (Yoshino *et al.,* 2021).

Analyses of liquid fuel demand in China (Norouzi and Fani, 2020; He and Guo, 2021). Comparative analyses involving many countries are rare (Chang *et al.*, 2022) and are mostly based on statistical data applied for building comparable econometric models.

Environmental issues have become widely recognized with the increasing climate change, which adversely affects atmospheric phenomena (tornadoes, tsunamis or melting ice). These are now being publicized not only by environmental organizations but also by spontaneous social movements, specialist groups and scientists, etc. The Internet (Chien *et al.,* 2021), with its basic solutions: websites and mobile applications, is one of the tools allowing the dissemination of ecological ideas and concepts related to green energy.

The role of the Internet has increased dramatically during the Covid-19 pandemic, not only in the area of e-commerce or e-banking (Chmielarz *et al.,* 2022a; 2022b) but also in spheres related to ecology (Sharma *et al.,* 2021; Rempel and Gupta, 2021; Jia *et al.,* 2021; Hyman *et al.,* 2021; Wang and Zhang, 2021). The health crisis has had a directly proportional impact on the potential for green energy propagation.

Adverse weather conditions caused by climate change (e.g., last year's droughts in Europe, and this year's hurricanes and snowstorms in the USA) have had the same effect. The economic crisis has also played its part since the services provided and products distributed via the Internet are relatively cheaper and more easily and widely available than in the traditional economy, as indicated in the authors' previous studies (Chmielarz *et al.,* 2022a; 2022b).

Therefore, the time of crisis may be seen as a factor contributing to the accelerated growth of all Internet-related phenomena, including, of course, the increase in environmental awareness and the spread of green energy ideas that support and facilitate it.

3. Research Methodology

3.1 Research Procedure

The research on the use of ICT in raising awareness of the need for green energy was conducted in the following stages:

- agreeing on the topic and specifics of the research in order to create a pilot survey, taking into account the regional differences of the

partners involved in the study,
- conducting the pilot survey taking into account the comprehensibility and relevance of the questions as assessed by the respondents,
- selecting on a random basis a research sample group in each of the cooperating universities,
- conducting research (CAWI method) using a verified questionnaire,
- analyzing differences between the views of respondents from each country and discussing the obtained results,
- summarizing the findings and drawing conclusions,
- describing the limitations and directions for future research.

The survey was conducted between 26 October and 11 November 2022 in three countries in parallel, Poland, Türkiye and the PRC. The survey contained 18 questions concerning, the devices (i.e., technical infrastructure) used for obtaining information related to green energy, sources of information concerning green energy, awareness of the existence, benefits and drawbacks of different renewable energy sources, two questions related to knowledge and evaluation of the most popular green energy information portals, and eight questions characterizing the research sample.

The questions were formulated in English, then translated into national languages and, after the survey, translated back into English. The LimeSurvey tool was used to process the obtained results.

Despite the previous reconciliations and agreement as well as the detailing of the questions and translating them into national languages, there appeared some problems related to the full understanding of the survey questions, the comparability of the demographic data and the specific characteristics of the activities promoting the use of green energy in each country. As a result, the data obtained from the surveys had to be adjusted for subsequent analyses.

The Cronbach's alpha coefficient was applied for the reliability analysis. In all analyzed key questions, Cronbach's alpha coefficient indicates the internal consistency and reliability of the sample (cycles and Text, n.d.). The internal consistency measure of the 16 dependent variables for the three compared countries, which was based on Cronbach's coefficient alpha, amounted to 0.85 (and 0.89 for Cronbach's alpha calculated based on standardized items), for a total of 20 items.

International comparisons were made on the basis of city distance and Euclidean distance (absolute differences in the percentages of responses to individual options within each criterion or the square of the differences). In both cases, their sum indicated the strength of the variation between countries.

3.2 Description of the Research Sample

All primary data for the analyses were collected at the same time in three locations: Warsaw University in Warsaw (Poland), Uşak University (Türkiye) and Communication University of China in Beijing (PRC). The survey covered a total of 1101 people with an average return rate of 43%. The results were finally obtained from 483 individuals, 94 from Poland, 227 from Türkiye and 162 from the PRC. The characteristics of the research sample are presented in Table 1.

Table1. *Characteristics of the research sample*

Characteristics	Poland	Türkiye	PRC	Average
Gender				
Women	53.13%	45.00%	48.72%	48.28%
Men	46.88%	55.00%	51.28%	51.72%
Age				
> 18	1.56%	10.00%	15.38%	8.37%
19 - 24	95.31%	81.00%	46.15%	78.82%
25 - 34	3.13%	9.00%	17.95%	8.87%
35 - 55	0.00%	0.00%	20.51%	3.94%
55 +	1.56%	10.00%	15.38%	8.37%
Education				
Bachelor's degree, undergraduate	29.69%	97.00%	58.97%	68.47%
Primary	1.56%	1.00%	0.00%	0.99%
Secondary, basic vocational	67.19%	1.00%	10.26%	22.66%
Higher	1.56%	1.00%	30.77%	6.90%
Place of origin*				
A town with 21-50 thousand residents (PRC 6-10 million)	6.25%	5.00%	7.69%	5.91%
A big city with 51-200 thousand residents (PRC 11-20 million)	1.56%	19.00%	2.56%	10.34%
A small town with up to 20 thousand residents (PRC up to 5 million)	3.13%	7.00%	15.38%	7.39%
A large city with over 200 thousand residents (PRC 20+ million)	85.94%	60.00%	30.77%	62.56%
Rural areas	3.13%	9.00%	43.59%	13.79%
Field of study				
Humanities, including philology, history, cultural studies, art history	0.00%	3.00%	12.82%	3.94%
Medical sciences	0.00%	12.00%	7.69%	7.39%
Social sciences, including psychology, sociology, economics, pedagogy, administration, law, management	85.94%	17.00%	33.33%	41.87%
Science, including mathematics, computer	0.00%	5.00%	7.69%	3.94%

science, physics, chemistry				
Natural sciences, including biology, environmental protection, geography	0.00%	4.00%	15.38%	4.93%
Agricultural, forestry and veterinary sciences	0.00%	4.00%	0.00%	1.97%
Arts, including music, visual arts, theatre	0.00%	1.00%	5.13%	1.48%
Technical/Engineering studies	1.56%	8.00%	7.69%	5.91%
Other	12.50%	46.00%	10.26%	28.57%
Financial situation of respondents				
Very good (I can afford everything I need, and I have some savings)	18.75%	7.00%	5.13%	10.34%
Good (I have no reason to complain but it could be better)	60.94%	16.00%	41.03%	34.98%
Sufficient (I can still make ends meet)	1.56%	22.00%	7.69%	12.81%
I am a student, and I am not financially independent	7.81%	18.00%	15.38%	14.29%
Average (I have enough money to lead a frugal life)	9.38%	25.00%	30.77%	21.18%
Bad (barely enough to buy basic products and services)	1.56%	12.00%	0.00%	6.40%
Occupational status				
Other	4.69%	2.00%	0.00%	2.23%
Student/pupil	28.13%	84.00%	58.97%	57.03%
Contract of employment or casual work	65.63%	8.00%	28.21%	33.94%
Own business	1.56%	6.00%	12.82%	6.79%

Note: **data from the PRC were adjusted to the regionalization typology of other countries*.
Source: *Own work based on questionnaires.*

4. Research Results and Discussion

The qualitative-quantitative survey was conducted in four sections:

- information on the devices used to access the Internet (technical infrastructure),
- general knowledge about green energy,
- expertise related to green energy and conditions for green energy applications and their potential or future prospects,
- analysis of possibilities of the use of ICT in terms of information search and dissemination of green energy principles and ideas.

The questionnaire also included questions concerning demographic data (gender, age, place of residence, education and field of study, occupational and financial status).

The first section of the survey was related to the devices used by respondents to access the Internet (i.e., introductory infrastructural information). In order to be able to determine the role of ICT in creating awareness of the need to replace mainly carbon-based energy with green energy, it is necessary to find out if and how respondents access the Internet.

The largest number of respondents (53% on average) access the Internet and, as a consequence, green energy services and applications using their smartphone and laptop. Poland is a leader in the ranking with 68% of respondents choosing this method. The second place was taken by the option - I mainly use a smartphone (36% on average). Türkiye is leading in the case of this option with a score of 57%.

The greatest overall variation occurred in both city distance (82%) and Euclidean distance (28%) between Poland and Türkiye, mainly due to the use of a combination of laptop and smartphone to connect with the Internet and the use of only a smartphone for this purpose. This is due to the adoption of a slightly cheaper ICT variant in Türkiye (mainly smartphones) than in Poland.

The **second section** began with questions concerning general environmental knowledge. In line with popular opinions, an average of 53% of respondents confirm their interest in this topic, most (69%) in the PRC. The other extreme view, reflected by the opinion: *I have heard about it, but I am not interested in it,* was pointed to by an average of 30% of respondents (highest in Türkiye - 35%).

In Poland, the option *I am somewhat interested* was indicated in the second place (33%). Only less than 3% on average are not interested in environmental protection at all. The biggest differences between the survey results in this respect were between Poland and the PRC (city distance 63%, Euclidean distance 16%), mainly due to the statement *I am interested in it*, despite the generally high average value of this option.

Relatively the smallest differences were between Türkiye and the PRC (city distance - less than 1%, Euclidean distance - 4%). A more specific question about the interest in the possibility of replacing 'dirty' energy with 'clean' renewable energy, yielded similar results overall.

Another question asked was related to where respondents first encountered the term green energy. Most, 43% on average, had already discovered it at school (the highest share (55%) in Poland). In the second place, the survey participants pointed to the Internet (24% on average), indicating the high position of ICT in disseminating the idea of renewable energy sources.

The biggest differences (city distance 53%, Euclidean distance - 8%) regarding learning first about green energy occurred between Poland and Türkiye (mainly due to options *at school* and *university*).

In order to obtain more information on green energy, respondents would mainly look for it on the Internet (on average 21% of respondents chose this answer, the highest share in Poland - 29%). Green literature on the subject came second with 19%; most PRC respondents (22%) selected this answer. The biggest differences (city distance - 40%, Euclidean distance - 4%) are between Poland and Türkiye, mainly due to differences in the use of the Internet in this respect.

Among green energy sources, respondents have the widest knowledge about hydropower (29% on average), the highest in Poland, amounting to 34%. They generally know little about obtaining energy from wind power (the lowest scores: 3% on average, the highest, estimated at 5%, in China). Solid biofuels came second in the ranking related to respondents' knowledge about such solutions (24% on average), with heat pumps in third place estimated on average at 16%. Interestingly - in all these categories, respondents from Poland know the most.

In contrast, 12% of Chinese respondents know 10 times more than Polish respondents, and twice as much as Türkiye respondents about liquid biofuels. In terms of knowledge of renewable fuels, the differences between questions were not considerable.

The greatest benefits (29% on average) of green energy were attributed to hydropower. Respondents from Türkiye were most positive about this (31%), with slightly fewer enthusiastic responses indicated among Polish respondents (29%).

Solid biofuels came second (21% on average). In third place, there were heat pumps (14%). Interestingly - despite an average of 7% of respondents claiming to know the most about geothermal energy - they did not consider it to be the most efficient source of green energy. The largest variability, although also related to overall small differences of 20% city distance (less than 1% Euclidean distance), occurred between Türkiye and the PRC.

The last question, which was applied to indirectly test respondents' knowledge related to the practical applications of green energy solutions, was the question concerning the share of green energy in the total energy production of specific countries. Indeed, respondents did mostly show good knowledge of this topic. In Poland, more than 70% correctly identified the share of green energy in the country's total energy production to be between 10% and 20%.

Unfortunately, many respondents from Türkiye and the PRC probably either remembered data from previous years or overestimated the share of energy obtained from water and marked the range between 20% and 30% as the correct answer. A similar share chose the right answer which was the level of 10%-20%. The greatest variation occurred between Poland and Türkiye (city distance 95%, Euclidean distance - 32%%).

The second section of the survey was designed to show whether and to what extent its participants are aware of green energy issues and are willing to broaden their interests in this area with the help of both electronic and traditional media. It turned out that their views on renewable energy can vary widely in the analyzed countries, despite largely similar conditions in terms of economic development risks, health risks (pandemic) and certain political perturbations.

The **third section** of the survey questions required the structuring of respondents' general knowledge and identifying their views on green energy phenomena and conditions for their implementation and development.

First of all, respondents were asked to select the definition of green energy which, in their opinion, is the most comprehensible and best reflects the essence of the phenomenon. As it was difficult to identify the literature related to environmental issues which would be widely accessible and shared in all the examined countries, the authors applied definitions from the Internet resources. These were finally obtained from an internet search using the keyword 'green energy'. On this basis, Table 2 was created.

Table 2. *Assessment of the relevance of the 'green energy' definition by respondents in particular countries*

Definitions	**Poland**	**Türkiye**	**PRC**	**Average**
…Green energy is any energy type that is generated from natural resources, such as sunlight, wind or water. It often comes from renewable energy sources although there are some differences between renewable and green energy…	9.38%	14.00%	12.82%	12.32%
…Green energy is energy derived from natural sources that are replenished at a higher rate than they are consumed. Sunlight and wind, for example, are such sources that are constantly being replenished…	10.94%	34.00%	10.26%	22.17%
…"Green" energy is clean energy that, unlike fossil fuels, is non-polluting and comes from 100% renewable sources, which means that it does not harm the environment and is more sustainable. We tend to confuse clean energies with renewable energies. The key difference is that all renewable energies are clean, but not all clean energies are renewable.…	14.06%	18.00%	31.24%	19.21%
…Green energy is a term for energy that comes from renewable sources. Green energy is often referred to as clean, sustainable, or renewable energy. The production of green energy doesn't release toxic greenhouse gases into the atmosphere, meaning it causes little or no environmental impact…	28.13%	22.00%	15.38%	22.66%

…Green energy is only energy obtained from renewable energy sources, such as: sun, wind, water (rivers, tides and sea waves), nuclear energy in a closed fuel cycle (used fuel is recovered unburned fissile materials, reused to produce nuclear fuel), biomass, biogas, bioliquids and biofuels, as well as heat obtained from the ground (geothermal energy), air (aerothermal energy) water (hydrothermal energy)...	37.50%	12.00%	30.30%	23.65%

Source: *Own work based on: ("What is Green Energy?," 2023), ("What is renewable energy?," n.d.), ("Renewable energy sources," 2021), ("Energy source," n.d.)*

Most Polish respondents (37.50%) chose the descriptive, most developed and longest definition of green energy (…*Green energy is only energy obtained from renewable energy sources, such as: sun, wind, water (rivers, tides and sea waves), nuclear energy in a closed fuel cycle (used fuel is recovered unburned fissile materials, reused to produce nuclear fuel), biomass, biogas, bioliquids and biofuels, as well as heat obtained from the ground (geothermal energy), air (aerothermal energy) water (hydrothermal energy)...* ("What is Green Energy?," 2023)).

Respondents from the PRC (30.30%) found this definition adequate, but in the end, a slightly higher number (31.24%) chose a definition highlighting the differences between green energy and renewable energy *(..."Green" energy is clean energy that, unlike fossil fuels, is non-polluting and comes from 100% renewable sources, which means that it does not harm the environment and is more sustainable. We tend to confuse clean energies with renewable energies. The key difference is that all renewable energies...* ("What is renewable energy?," n.d.)).

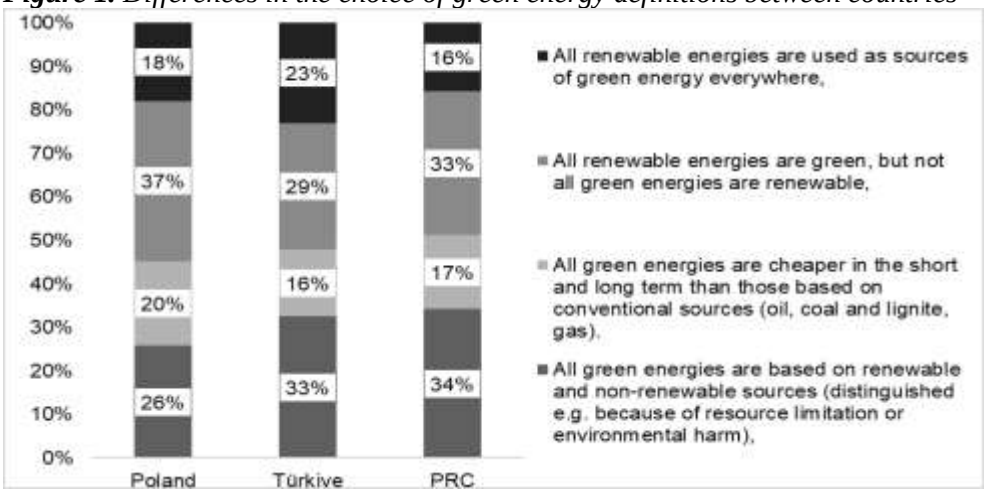
Turkish respondents (34.00%), on the other hand, chose a definition focusing on the sources that are replenished faster than they are consumed *(…Green energy is energy derived from natural sources that are replenished at a higher rate than they are consumed. Sunlight and wind, for example, are such sources that are constantly being replenished…* ("Green Energy," 2021)).

Nobody prefers definition *(…Green energy is any energy type that is generated from natural resources, such as sunlight, wind or water. It often comes from renewable energy sources although there are some differences between renewable and green energy…* ("What is Green Energy?," 2023)). The differences in the choices are shown in Figure 1. The biggest differences here were between Türkiye and the PRC (average city distance 63.08%; Euclidean distance 11.19%) and Poland and Türkiye (average city distance 60.17%, Euclidean distance 12.57%).

The next question was related to the above definitions. The choice basically depended on the definition adopted previously, especially as this was explicitly presented in one of them. Respondents who recognized this in the previous question marked the first answer.

Therefore, on average, the highest share (32%) of respondents selected the first statement (37% of responses from Poland also confirmed this trend). On the other hand, slightly more people in Türkiye and the PRC indicated the third answer, which also corresponds, as it were, to the broad discussion that takes place around the definition and classification of green energy (Figure 1).

Figure 1. *Differences in the choice of green energy definitions between countries*



Source: *Own work.*

Overall, the distribution of responses points to minor differences between countries. The largest (18% city distance, just over 1% Euclidean distance) are connected with the differences between Poland and Türkiye, and slightly smaller differences (17% - city distance, less than 1% - Euclidean distance) were observed between Poland and the PRC.

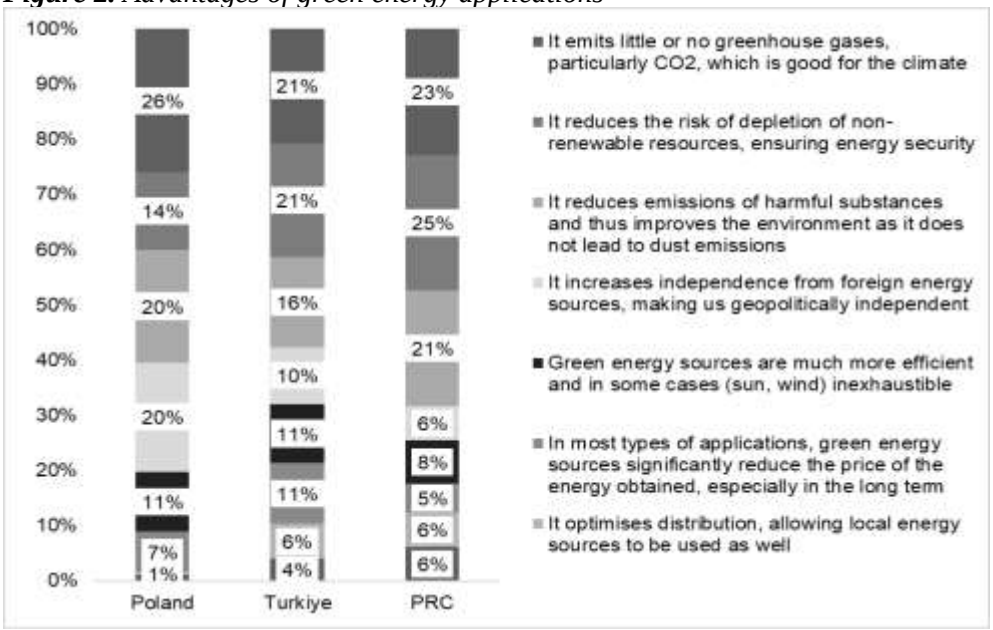
The following questions concerned the advantages and disadvantages of green energy in respondents' opinions. Among the advantages, undoubtedly the largest number of respondents highlighted the reduction or elimination of greenhouse gases (23% on average, 26% in Poland). The results are shown in Figure 2.

In the PRC, the largest number of respondents (25%) believe that green energy reduces the risk of depletion of non-renewable resources, ensuring energy security. In third place, (18%) respondents believe that green energy reduces emissions of harmful substances and thus improves the environment as it does not lead to dust emissions.

The smallest share of respondents (3% on average) indicated that, from an economic point of view, the use of green energy creates jobs for installers and manufacturers of green energy equipment as well as those involved in the disposal of used equipment and materials. The reservation they expressed in their comments was that at the same time it reduces the number of jobs in mines, refineries etc. related to

producing raw materials for so-called 'dirty' energy. In assessing the advantages of using green energy sources, the greatest variation (average city distance estimated at 43.91%; Euclidean distance at 3.79%) occurs between assessments of survey participants in Poland and the PRC.

Figure 2. *Advantages of green energy applications*



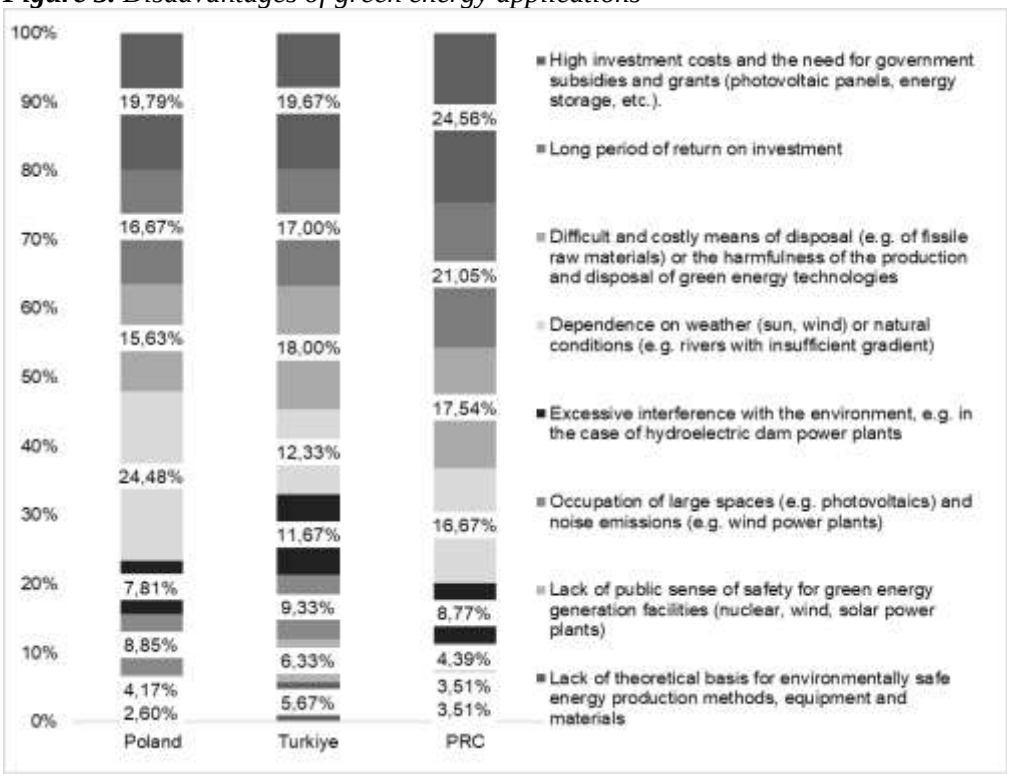
Source: *Own work.*

The evaluation of the disadvantages of green energy applications was carried out in a similar way. Respondents were asked to select from previously established eight options indicated as the most important features of green energy application that could be considered negative. In Poland, dependence on weather conditions (sun, wind) or natural conditions (e.g., rivers with insufficient natural gradient) was highlighted as one of the most important factors (24%).

In the other two countries, the high cost of investing in clean energy sources and the need for subsidies and government subsidies (photovoltaic panels, energy storage, etc.) was considered to be the biggest disadvantage of such solutions (PRC: 25% of respondents; Türkiye: 20%).

In Poland, this disadvantage was ranked second and was indicated by 20% of respondents. In third place (with an average of almost 18%), the survey participants pointed to the long period of time related to return on investment, followed (with an average of more than 17%) by the difficult and incompletely developed method of disposal (e.g. of wind power plants or fissile materials) or the negative environmental effects of the production and disposal of some green energy technologies. Detailed results are shown in Figure 3.

Figure 3. *Disadvantages of green energy applications*



Source: *Own work.*

The largest differences occurred between the ratings in Türkiye and the PRC (city distance 27%, Euclidean distance 1%), but these were evenly distributed between categories. In the specific categories, the largest difference (city distance 12%; Euclidean distance 1, 48%) occurred in the category of dependence on weather conditions (sun, wind) or natural conditions (e.g. rivers with insufficient gradient). However, the differences between the overall green energy disadvantage scores were not very high (0.3% to 1.5%).

In many studies (Hinton *et al.*, 2004; "6 reasons why nuclear energy is not the way to a green and peaceful world," 2023), nuclear energy is considered green energy because it is decarbonized and does not emit greenhouse gases into the atmosphere.

However, this energy is not renewable because uranium, its fuel, is a finite resource and it is not environmentally safe if an open fuel cycle is used in the production process (used fuel needs to be stored) and it is not the cheapest. Nevertheless, if there were a large-scale search for nuclear fuels, better methods of operational safety than before (e.g., Chernobyl) and safe disposal methods, nuclear energy could also be considered as fully clean and renewable.

In this connection, respondents were also asked questions about the advantages and disadvantages of nuclear energy. The results partially confirmed the above opinions. Among the advantages, the highest average rating (22%, highest in Poland and the PRC) was given to the absence of emissions of greenhouse gases, dust, sulphur oxides, or heavy metals, which improves the health of the population, followed closely (19%, highest in Türkiye) by the relative safety of the new technologies in this respect (compared, for example, to accidents in mines).

In Poland, attention was also drawn to the much higher efficiency of obtaining energy from one physical unit of raw material (23%). In Türkiye - the absence of noise emissions (compared to e.g. wind power plants), and in the PRC - the relative safety of new technologies in this regard - 18% (compared to e.g. the number of accidents in mines).

Among the highlighted disadvantages, the predominant ones are the fear of possible reactor failures or related accidents - a threat to the life or health of the population (22% on average, Türkiye 25%), the lack of safe methods to dispose of radioactive waste (improperly stored can contaminate soil or water) - 18% on average, 23% in Poland, and the high and ever-increasing cost of building nuclear power plants - 17% on average, and 20% in Türkiye.

The PRC also singled out technical and competence-related problems during construction that could increase the initial costs (23%), and in Poland location problems - the public's reluctance to locate a nuclear power plant in a nearby area (12%).

The next question included in this section followed logically from the previous answers of the respondents. They previously showed awareness as to what green energy means, what it is used for and what its advantages and disadvantages are. It is a natural consequence to ask survey participants whether they themselves are participating, have participated or will participate in green energy ventures (e.g., installing photovoltaics in their home, setting up a heat pump, installing a wind turbine, installing a local hydroelectric plant, etc.).

The dominant response was the intention to participate in such a project in the future (38% on average, highest in the PRC estimated at 67%, Türkiye at 41%). The biggest difference was between Poland and the PRC (city distance 135%; Euclidean distance 58%).

The last question concerned respondents' opinion on when green energy will become a common solution worldwide. Most people (34% on average, 43% in the PRC) predicted it would happen in the next 10 years. An equally popular timeframe was *in 20 years* (45% of respondents from Poland, 23% from the PRC and 23% from Türkiye). The greatest differences in opinions occurred between Poland and China (city distance: 61%; Euclidean distance: 9%), mainly due to the dominant

response that green energy will be common worldwide *in 20 years*, which was pointed to by respondents in Poland.

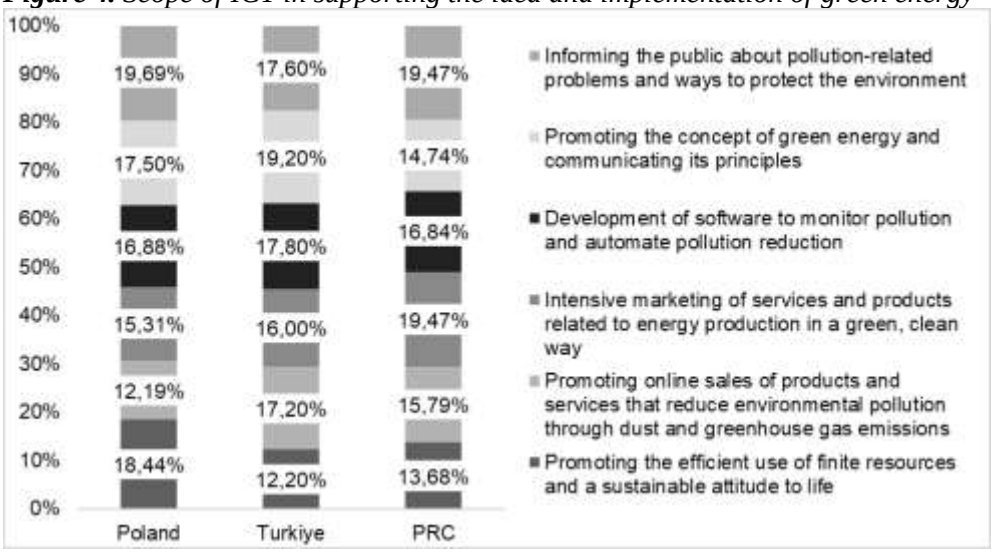
Section four focuses on the extent to which ICT can be used in the introduction and application of green energy solutions and whether crises can accelerate this process. The first question addressed the issue of how ICT can best help spread and implement green energy.

The responses were distributed fairly evenly. It appears that services and applications are credited, albeit to varying degrees, with the potential to influence society in terms of promoting and implementing green energy sources in all the areas examined in the study. There were only minor differences in the statements selected by respondents.

In Poland, *informing the public about pollution-related problems and methods of protecting the environment* was considered the most important contribution (20% of statements). In second place (18% on average, the highest in Türkiye - 19%) was *the promotion of the idea of green energy and information about its principles*. In the PRC, *informing the public about pollution-related problems* and *intensive marketing of services and products related to producing energy in a green and clean way* (19%) were regarded as equally important ICT contributions.

The distribution of answers also influences the degree of differentiation. This variability is in this case the smallest observed so far, and it amounts to an average city distance estimated at 15% and Euclidean distance established at 0.6%. Detailed results can be found in Figure 4.

Figure 4. *Scope of ICT in supporting the idea and implementation of green energy*

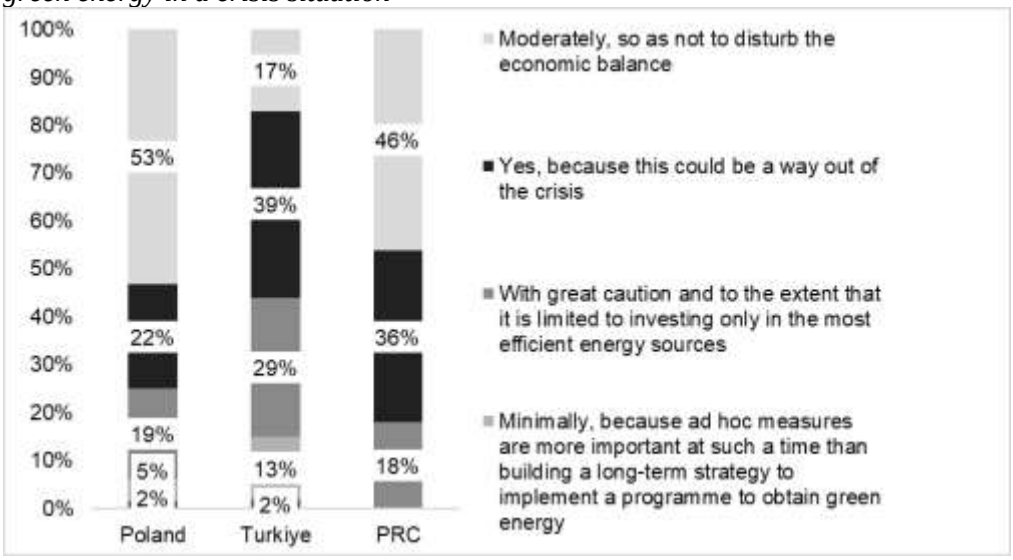


Source: *Own work.*

The last question dealt with the issue of promoting and implementing green energy through ICT technologies in a high-risk situation (pandemic, threat of armed conflict, energy crisis, internal political crisis, high inflation). The largest number of respondents indicated that it should be pursued in *a moderate way, so as not to upset the economic balance* (34% on average, Poland - 53%, the PRC 46%).

Nearly the same number of respondents stated that *it could be a way out of the crisis* (average 33%, Türkiye 39%, the PRC - 35%, Poland 22%). The implementation of other *ad hoc* tasks was pointed to by only 8% of respondents on average, and no action at all by a marginal number, not exceeding 2% (Figure 5).

Figure 5. *Recommendations for ICT to support the idea and implementation of green energy in a crisis situation*



Source: *Own work.*

The biggest differences recorded with regard to opinions on this topic were between Poland and Türkiye (city distance 36%, Euclidean distance 18%). This was mainly due to the option of ICT supporting green energy *in a moderate way so as not to upset the economic balance* and the statement that *this could be a way out of the crisis*. A similar situation occurred in the Türkiye-PRC relationship (city distance 29%, Euclidean distance 12%).

A summary of the differences between the responses to the individual questions is provided in Table 2. The average value of city distance (46%) for all the attributes of the assessment shows the greatest variation between the results of respondents from Poland and Türkiye. This was mainly due to the high participation rates in estimation of the share of green energy in energy production and in the differences with regard to the devices used to access the Internet. Slightly smaller (41%) are the differences between Poland and the PRC, in terms of the interest in introducing

green energy and in the devices used to access the Internet. Slightly smaller are the differences between Türkiye and the PRC (37%) in this case, where the largest differences of just over 50% occurred in the assessment of the participation in green energy projects and in defining the term.

***Table 2**. Average differences between responses to individual survey questions between Poland and PRC, Poland and Türkiye and Türkiye and the PRC*

	City distance				**Euclidean distance**			
Problems assessed in the survey	Poland-Türkiye	Poland-PRC	Türkiye-PRC	Average	Poland-Türkiye	Poland-PRC	Türkiye-PRC	Average
Devices used to access the Internet	81,69%	50,26%	57,08%	63,01%	27,89%	6,84%	8,79%	14,51%
Interest in introducing green energy	37,08%	63,46%	36,97%	45,84%	11,88%	15,62%	4,29%	10,59%
Possibility of replacing dirty energy with clean energy	27,67%	53,37%	32,31%	37,78%	4,71%	8,99%	3,41%	2,92%
Initial source of knowledge about green energy	52,67%	48,80%	43,33%	48,27%	8,23%	4,73%	4,34%	5,77%
Sources of information about green energy	40,25%	36,29%	39,47%	38,67%	4,07%	2,91%	2,80%	3,26%
The level of knowledge about green energy sources	22,77%	48,45%	34,74%	35,32%	0,97%	3,89%	1,97%	2,28%
Identification of green energy definitions	60,17%	41,24%	63,08%	54,83%	12,57%	5,22%	11,19%	6,20%
Relation of green energy to renewable resources	18,35%	16,86%	14,42%	16,54%	1,46%	0,96%	0,73%	1,05%
Advantages of green energy	34,58%	43,91%	25,79%	34,76%	2,34%	3,79%	1,05%	2,39%
Disadvantages of green energy	24,46%	25,88%	26,56%	25,63%	1,82%	1,29%	1,05%	1,39%
Advantages of nuclear energy as a source of clean energy	57,88%	36,79%	31,23%	41,96%	7,07%	2,53%	1,66%	3,75%
Disadvantages of nuclear energy as a source of clean energy	39,13%	37,88%	23,16%	33,39%	2,90%	3,50%	1,16%	2,52%

Estimation of the share of green energy in energy production	94,96%	84,21%	33,69%	70,96%	31,52%	22,30%	2,44%	18,75%
Efficiency of green energy applications	19,92%	19,52%	21,77%	20,40%	1,56%	0,70%	0,78%	1,01%
Participation in green energy projects	63,33%	34,86%	65,23%	87,81%	16,25%	57,93%	13,11%	29,10%
The perspective of the dissemination of green energy	61,42%	44,47%	36,62%	47,50%	9,06%	6,87%	4,14%	6,69%
Impact of ICT on the dissemination of green energy	15,26%	15,53%	13,66%	14,82%	0,73%	0,61%	0,41%	0,58%
Implementation of green energy in times of crises	65,42%	28,04%	58,31%	50,59%	17,73%	2,70%	11,55%	3,31%
Average	45,39%	40,55%	36,52%	42,67%	9,04%	8,41%	4,16%	6,45%

Source: *Own work.*

The results, assessed by Euclidean distance, generally confirm the previous results, with a slight shift of the emphasis to the individual attributes for assessing awareness of the propagation and dissemination of green energy ideas.

5. Conclusions:

In summary, setting aside the differences between the respondents' opinions, the analysis so far has shown that the survey participants:

- use an IT infrastructure (devices and relevant ICT solutions) which allows them to access the Internet on a daily basis,
- there are three main strategies related to accessing the Internet based on:
- mainly smartphones (the PRC), due to relatively late involvement in online activities and the relative cost-efficiency of this solution,
- mainly personal computers and smartphones (Poland), due to the earlier development of e-commerce and e-banking using mainly personal computers,
- primarily smartphones and personal computers (an intermediate strategy, being a compromise between the previous two options).
- more than half (53% on average) of the respondents are very well or well versed in environmental issues, especially with regard to the issue of obtaining green energy,

- most survey participants first encountered the term green energy at school and on the Internet,
- most respondents are able to choose the most descriptive, appropriate definition of green energy and then use this definition to complete subsequent questions included in the survey concerning e.g. differences between green energy and renewable energy,
- respondents are most knowledgeable about wind energy (in Poland, which has been a controversial topic in this country for almost a decade) and hydroelectric energy (the PRC and Türkiye, which is in line with the long-standing policy of developing renewable energy sources - hydroelectric plants),
- survey participants generally overestimate the importance of renewable energy supply in the general energy source mix (Türkiye, China), the most correctly estimated share was pointed to by respondents in Poland,
- respondents are deeply aware of the need to implement green energy and want to have more knowledge on the subject, gained mainly on the Internet, which stresses the role of ICT in promoting the issue of green energy,
- survey participants believe that in a situation of deep crisis, ICT should, moderately or fully, support the idea of green energy and its role in the implementation of sustainable development, mainly because this can become one of the ways out of the economic crisis,
- the primary tools for this are web-based services and applications that are very popular in the academic circles where the study was carried out, which will be the subject of subsequent analyses),
- among the advantages of green energy, the largest share of respondents highlighted the reduction or elimination of greenhouse gases and the reduction of the risk of depletion of non-renewable resources,
- among the disadvantages of green energy – the largest share of respondents pointed to dependence on weather conditions (sun, wind) or natural conditions (e.g. rivers with insufficient natural gradient) and high costs of investing in clean energy sources, together with the need for subsidies and grants from the government,
- despite concerns about the lack of total protection against disaster (especially following the events which occurred during the war in Ukraine), nuclear energy is considered by respondents to be a secure temporary alternative to clean energy,
- most respondents declared their willingness to participate in green energy projects, although its widespread implementation was foreseen to take place in 10 or more years,
- regarding the role of ICT in the processes of implementing green energy, despite cultural differences, respondents were unanimous and attributed the greatest importance to such activities as: informing the public about pollution-related problems and methods of protecting the environment, promoting the idea of green energy and informing about its principles, and producing software allowing for pollution monitoring and automation of pollution reduction,

- as far as green energy solutions are concerned, the participants of the survey propose to implement them gradually and with caution, so as not to upset the economic balance, in accordance with the principles of sustainable economy,
- differences between the answers obtained from the analyzed countries were not as spectacularly significant (see Table 3) as assumed by the authors of the study; nevertheless, the biggest differences occurred between Poland and the other countries.

In the course of conducting the research, there were limitations that may have affected the generalizability of the results:

- the first limitation was related to conducting comparisons on the use of e-commerce devices in only three selected countries, Poland, Türkiye and the PRC,
- the second was associated with conducting a survey in an academic environment, among the most active e-commerce customers, but limited in terms of both age and financial resources,
- the study did not consider the impact of specific attributes of green energy websites and applications on their popularity in the examined countries, and therefore their influence and role in disseminating environmental ideas were not analyzed.

These limitations can be minimized in future studies by:

- expanding the number of countries analyzed to include also Western European countries. This would allow establishing whether the differences observed in the assessment of the phenomenon by respondents from Poland in relation to those in Türkiye and PRC are confirmed in relation to other European countries,
- extending the research sample beyond academia,
- analyzing the ratings of attributes of green energy websites and applications in the analyzed countries using multi-criteria methods and drawing conclusions for the dissemination of alternative energy sources.

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