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ON ANALYSIS OF GREEN ENERGY PORTALS/APPLICATIONS IN PEOPLE'S REPUBLIC OF CHINA, SPAIN, POLAND AND TÜRKIYE FOR SUSTAINABLE DEVELOPMENT OF SOCIETY

Félix Puime GUILLÉN[1], Witold CHMIELARZ[2], Marek ZBOROWSKI[3*], Jin XUETAO[4], Mesut ATASEVER[5], Justyna SZPAKOWSKA[6]

[1] University of La Coruna, Spain; felix.puime@udc.es, ORCID: 0000-0001-7341-9134
[2] Faculty of Management, University of Warsaw, Poland; witek@wz.uw.edu.pl, ORCID: 0000-0002-9189-1675
[3*] Faculty of Management, University of Warsaw, Poland; mzborowski@wz.uw.edu.pl, ORCID: 0000-0003-4762-127X
[4] Faculty of International Media, School of Economics and Management, Communication University of China, Beijing, P.R. China; jinxuetao-cuc@cuc.edu.cn, ORCID: 0000-0001-6829-2036
[5] School of Applied Sciences, Usak University, Ankara, Turkiye; mesut.atasever@usak.edu.tr, ORCID: 0000-0002-7189-7551
[6] Faculty of International Media, School of Economics and Management, Communication University of China, Beijing, P.R. China; cuihua@funworld-media.com, ORCID: 0000-0003-2880-3887
* Correspondence author

Purpose: The primary goal of this article is to compare the role of green energy portals/applications in shaping sustainable societies in selected countries: the People's Republic of China, Spain, Poland, and Türkiye.
Design/methodology/approach: The comparisons were made for data collected at the turn of 2022/2023, in the PRC, Spain, Poland and Türkiye. The data was collected using a CAWI survey distributed in the academic environment of the countries analyzed in the study, supplemented by statements obtained through mailing lists and social media platforms. The study included 1209 people, of which a total of 608 individuals completed the entire survey questionnaire. Differences in the obtained results were evaluated using Euclidean distance. The hypothesis was made about the existing differences between the average ratings of attributes of individual green energy portals/applications and it was proven to be true for the Poland-Türkiye, Poland-PRC, and Poland-Spain relationships, but not for the pairs of other countries. Portal/application ratings were made using a scoring method and the proprietary conversion method.
Findings: Respondents in all analyzed countries use information technology infrastructure on a daily basis to communicate with the Internet (by smartphones and PCs): in the PRC, Türkiye, Poland and Spain, 53% of the surveyed people are very familiar with and well-versed in issues related to green energy, and they have the greatest knowledge about it.
Research limitations/implications: The limitation of the study was that it was mainly conducted in the academic environment of selected countries. Its most important achievement is the comparison of opinions on the use of green energy portals for countries that are so different culturally, economically, and demographically.

Practical implications: Practical implications of the study may be useful for business practitioners in selected countries to indicate possible strategies for designing green energy portals/applications that support the creation and development of a sustainable society as well as showing the method of using these results.
Originality/value: The value of the research was achieved by creating a pattern to follow, pre-design analyses, as a guideline for analysts and designers of portals, for establishing functionality and HCI techniques and for comparing methods used to evaluate modern ICT.

Keywords: green energy, sustainable society, green energy portals/applications, international comparative study, methods of evaluating services.

Category of the paper: Research paper.

1. Introduction

The main objective of the article is a comparative analysis of the potential role of portals/applications related to green energy in shaping a sustainable society in selected countries: the People's Republic of China, Spain, Poland and Türkiye. Sustainable social development refers to a situation where economic and social development is based on a balance between consumption and investment, with full awareness of the limitations of natural resources and the non-renewability, or difficult renewability, of some of them on a global scale. This leads to the support for real income growth, raising the level of education, and improving both public health and quality of life (Pearce et al., 1989). Sustainable development goals are therefore formulated for the three interconnected spheres related to economic, social and environmental dimensions (Keiner, 2005). At the same time, all these spheres should develop harmoniously, simultaneously and in an integrated manner, in order to meet social requirements and expectations, economic efficiency, and the highest possible level of environmental protection (The Future We Want, 2012). In the social sphere, such development aims to ensure universal prosperity (combating poverty, ensuring gender equality and intergenerational equality through economization and cooperation) and an increase in awareness, culture, and the need for pro-environmental action in the face of the increasing threat to life on Earth. In the economic sphere, efforts are focused on long-term economic profit and loss accounting in comparison to ecological solutions supported by the development of ecological technologies, eco-friendly economy, reducing waste (slow instead of fast economy) and financial burden for environmental pollution directed towards its remediation. In the ecological sphere, there is a focus on transforming technologies to be environmentally friendly and to support the conservation of its most valuable resources, limiting the extraction of non-renewable resources (alternative technologies - green energy or concessions), etc.

An ecological crisis occurs when changes in the environment (climate) or population (natural or social areas) begin to show symptoms that threaten their survival. The perceived impacts mostly refer to previously unnoticed intense heat waves, violent winds (cyclones, tornadoes), melting glaciers, rapid and prolonged rainfall and related flooding, massive deforestation, coral reef ecosystem degradation, food insecurity, species extinction, etc. Preventing these adverse changes (Climate Change…, n.d.) requires long-term economic and social policies. Counteracting these unfavorable trends is not easy and simple because it takes time, especially in terms of the general awareness. Such initial conditions as, for example, existing carbon dioxide emissions, or the lack of knowledge on the subject among the public, or the deliberate ignoring of it among a ruling class primarily interested in production efficiency, cannot be overcome overnight. The first serious warnings of the possibility of stunted development due to resource depletion from the 1970s (Meadows et al., 1972) have caused a shift towards the realization of sustainable development, but not for long. It seems that warnings about climate change still face obstacles regarding the policies of governments and corporations, in addition to the lack of awareness of its effects being undermined by a lack of knowledge and a lack of integration of environmental action. They are also sometimes countered by crises (where the economy seems more important), although, on the other hand, the reduction of oil supplies by Russia to Western Europe, after sanctions were imposed on that country following its attack on Ukraine, has led to an increase in interest in green energy sources. Therefore, any activity that raises awareness of this issue, especially on social media, most popular among the young Generation Z, is worth a thorough investigation and the results of such analyses should be presented and disseminated. One of the most commonly used tools for this purpose are portals/web applications. Their quality, measured according to various criteria, can attract or discourage users. Therefore, it is important that these tools meet users' requirements as much as possible, especially in such an important area as the promotion of the idea of green energy, which is the basis for the broadest current environmental activities. The patterns of portals/web applications in this field can be as varied as the cultural, social and economic conditions as well as the conditions directly related to crises or to health and political threats.

Do the existing and most popular portals/applications in the analyzed countries meet the identified criteria regarding their impact on informing and propagating green energy and sustainable actions for society? Are there methods to evaluate their usefulness that support decision-making in ways which are transparent and easy to accept in the pursuit of a sustainable society?

Analyses of their usefulness in this area are rarely found in the literature, since studies tend to focus on investigating the impact of ICT on the development of green energy (Collados-Lara et al., 2022). The research also focuses more on: comparisons of 'clean' energy suppliers (CleanTech…, n.d.), the use of renewable energy sources and strategies in the country in relation to the global economy or other countries (Arıoğlu Akan et al., 2015; Muhammed,

Tekbiyik-Ersoy, 2020; Effatpanah et al., 2022), comparison of renewable energy deployment options (Shatnawi et al., 2021). The importance of the methods used for analyzing the obtained results should not be underestimated. In a number of studies, simple scoring methods were used, while multi-criteria methods were only applied in a specific case of *comparative* evaluations of hypothetical nuclear *energy* system (NES) options (Application of Multi-Criteria…, 2019).

Therefore, a research gap arose, which this article partially attempts to fill in terms of comparative analysis of the usefulness and usability of internet portals/applications in shaping awareness of the need to use green energy and sustainable society in the selected countries.

To achieve this goal, the following structure of the article was adopted. The Introduction presents the essence of the research problem, identifies the research gap, and presents the article's objectives. The second section contains a literature review on green energy in a sustainable society and multicriteria comparative methods. The third section covers the research procedure and presents the sample. In the next part of the article, the analysis and discussion of the results are presented, abbreviated in the case of awareness research on the existence and use of green energy sources in the economy. The same part presents a full comparative analysis of the most popular and most frequently visited portals/applications for each of the selected countries. The Conclusions section contains conclusions and recommendations resulting from the research and discussion, as well as the limitations of the study and directions for further research.

2. Literature Review

The concept of striving for sustainable development of society in relation to information and communication technologies (ICT) sets goals in dimensions such as (Ziemba, 2016; Elliott, 2006; Hopwood et al., 2005):

- ecological dimension – ICT impacts the environment through a unique dematerialization of service and consumption processes, minimizing the use of natural resources, waste production and pollution,
- economic dimension – ICT enables increased production efficiency and productivity, optimization of distribution, generating higher incomes and reducing poverty,
- political dimension – ICT allows the entire society to enjoy civil, economic, political, and cultural freedoms through clearly and coherently specified procedures of state and territorial administration and unrestricted dissemination of information,
- social dimension – ICT provides wide access to information about healthcare, education, vocational training systems, high levels of ethical and non-exploitative employment, and participation in shaping a democratic society,

- cultural dimension – ICT presents a wide range of compromise choices among cultural diversity, and commonly recognized principles supported by ICT,
- technological dimension – refers to the efficient and rational use of ICT to integrate the remaining dimensions and support sustainable development of society.

Among such extensive ICT tasks, it plays a special role in creating and developing a sustainable society. Social transformations are a long-term, complex processes which have many, frequently conflicting goals. The subject of the article addresses the role of ICT in shaping awareness of the need for sustainable development, mainly in the field of energy transformation, i.e. replacing conventional sources of energy with so-called "green energy" sources - using typical tools of information dissemination, such as web portals/applications.

The term "green energy" refers to all sources of energy that do not pollute the natural environment and come from quickly replenishing (renewable) resources such as the sun, wind, water, biomass (Toombs, 2021). Their use for energy production does not cause the consumption of raw materials or the degradation of the environment, as during the use of conventional fuels. Therefore, it is classified as "clean" energy. Nuclear energy, which does not emit greenhouse gases, also does not pollute the environment, but it relies on rare and limited resources, making it clean but not renewable. The literature also mentions the category of sustainable energy sources, which create benefits not only ecological but also economic and social. However, not every green energy, or its use, is sustainable, as the conditions for balanced, integrated development in these three areas must also be met. All of these concepts are commonly used interchangeably, which stresses the role of web portals/applications in social education (Eco-Consciousness and Sustainability, n.d.).

The directions of development related to the replacement of conventional sources of energy by green energy depend on: geographical conditions, natural resources, economic conditions, geopolitical and often military alliances (Mont et al., 2021; Caballero-Morales, 2021; Stiglitz, 2021; Marttunen, Mustajoki, 2018). There are also differences during periods of crises, going through intermediate stages of rationalizing the structure of the energy "mix" from many different sources to optimizing effects, mainly economic ones (Hyman et al., 2021; Ibn-Mohammed et al., 2021). This is not always consistent with sustainable development.

The problem is becoming more and more serious, particularly given that, apart from Spain, which can be a positive benchmark for others (with 42.2% of energy from renewable sources in 2020), the other countries analyzed are not leaders in this area. In Poland, energy is obtained mainly from conventional sources (hard coal (50%), lignite (30%), gas (almost 4%)) - 84% in 2022, and energy from renewable resources is only less than 16% (Produkcja Energii…, n.d.; Produkcja Energii Elektrycznej…, 2022). In Türkiye, it looks very similar in 2021 - 84% of energy was sourced from coal and natural gas (Dierks, 2022), although other sources estimate this share much lower (Cetinkaya, 2022; Uğurlu, Gokcol, 2017). In the PRC, 78% (2021) was energy obtained from coal, gas and oil, and 22% from green energy (cycles & Text, n.d.).

Ecological topics are emerging more frequently in relation to individual countries, as well as at a regional level. They may concern the impact of obtaining energy from non-renewable resources and its effect on agriculture (Rohr et al., 2021), the influence of financial regulations on policies related to green energy (Yoshino et al., 2021), the logistics of the distribution of green energy sources (Wątróbski, 2016) minimizing environmental degradation (Zandi, Haseeb, 2019), or evaluating planning practices for shaping a strategy related to transforming energy into a form which is less harmful for the environment (Kabir, Morgan, 2021). Comparative analysis between countries is much less frequent (Chang et al., 2022) and mainly based on statistical and econometric analyses.

Currently, socio-economic development cannot be achieved without modern technologies. ICT development is particularly important in this regard. This also applies to the broadly understood ecology, as the third necessary "leg" for maintaining sustainable development in balance. This is due to the faster financial growth associated with information technology (Kaakeh et al., 2021) or the development of knowledge concerning new energy sources and optimal ways to use them (Kabir, 2021). The Internet has become one of the most important tools for disseminating this knowledge (Chien et al., 2021). In the online realm, portals and mobile applications are the fundamental tools for spreading information. Their usage may vary in different countries, depending on the path chosen for developing internet access. So far, the most popular method - via personal computers - is gradually being replaced by a cheaper and simpler option, but with more limitations - internet access through smartphones, as evidenced by recent studies. The increased interest in the Internet and environmental issues is also influenced by the recent recurring adverse weather conditions, scarcity of energy resources, or the energy and health crisis in general (COVID-19 pandemic) (Rempel, Gupta, 2021; Jia et al., 2021; Yoshino et al., 2021; Chmielarz et al., 2022b; Chmielarz et al., 2022a). Thus, times of crises are, on the one hand, favorable for the dissemination of the idea of 'green energy', but, on the other hand, due to economic constraints, they can also hamper it. Overcoming these trends is also, among other things, the role of the Internet - showing a reliable, long-term economic account of the advantages of green energy sources over conventional ones could change this situation. Overcoming these trends is also one of the Internet's roles - it could demonstrate the reliable, long-term economic advantages of green energy sources over conventional ones to change this situation.

The issue that remains is that of internet tools for user interaction. Undoubtedly, these include internet services and mobile applications installed on portable devices, primarily smartphones. They come in varying graphic forms, diverse functions, degrees of software complexity, etc. From the user's perspective, however, it is important whether they meet their requirements, interests, the need for knowledge, current trends, and color schemes associated with the content, as well as often such issues as ease of navigation, intuitiveness, user-friendliness, the convenience of use, etc. - attributes of good communication. Caring only about content does not guarantee success (User Experience…, 2019; Nielsen, 1999). This also applies

to green and sustainable portals/apps. A number of methods are used to assess mobile portals/apps, covering a range of attributes relevant not only to the "green energy" information placed on the site, but also to its possible search and a range of parameters that will prompt the user to revisit the site/use the application. In general, simple multi-criteria methods, based on a scoring method or a scoring method with preferences, or other more sophisticated methods are used for this purpose. A comprehensive overview of multi-criteria methods can be found in the publications (Wątróbski et al., 2019; Wątróbski, Jankowski, 2015). The authors, after their experience with multi-criteria methods (Chmielarz, Zborowski, 2020) applied their own Conversion Method based on the data collected in the scoring method in this study. This method is easy to apply in a mass survey (as compared to e.g., the AHP/ANP method) and easy to interpret.

3. Methodology

3.1. Research Procedure

Research on the role of green energy portals in sustainable societal development was divided into two stages. In the first stage, the level and conditions of awareness of the need to use green energy sources and the role of ICT in this process were determined among respondents from countries that are geographically and culturally distant. In the second stage, the most popular portals and applications related to this topic were identified, their most important attributes for users were specified, they were evaluated by respondents, and international comparisons were made.

Research into the use of ICT in raising awareness of the need for green energy were carried out according to the following procedure:

Stage I:

- agreeing the subject matter and specifics of the research in order to prepare a pilot study, taking into account the regional differences of the partners,
- conducting a pilot study that takes into account the clarity, comprehensibility and importance of survey questions according to the evaluation of a randomly selected group of respondents,
- random selection of student groups in which the survey was conducted,
- making the verified survey available to respondents in particular countries with a request to complete it, (CAWI method),
- analysis of differences in the views of respondents from individual countries and discussion of the obtained results regarding the determination of awareness of the need to introduce green energy sources into the economy.

Stage II:

- identifying the most popular portal/web applications in each of the countries analyzed,
- specifying the attributes of green energy portals/web applications relevant to their evaluation,
- calculating the differences in the respondents' attitudes to web portals/applications between pairs of individual countries and discussion of these differences,
- testing hypotheses concerning the differences in evaluations of web portal/application attributes based on Fisher-Snedecor statistics,
- summary and conclusions,
- description of the limitations and directions of future research.

The research was conducted from October 2022 to February 2023 simultaneously in four countries: the PRC, Spain, Poland, and Türkiye. The survey consisted of a total of twenty questions, including eighteen survey questions (related to: technical infrastructure for obtaining information about green energy, sources of obtaining information about green energy, awareness of the existence, benefits, and drawbacks of individual renewable energy sources, and two questions regarding knowledge and evaluation of the most popular green energy information portals) and two questions identifying the importance of portals/applications and evaluating the attributes of the most popular portals/applications. The survey included a section related to demographic data containing eight questions that characterized the research sample. The questions were formulated in English, translated into national languages, and then retranslated into English after the survey was conducted. The LimeSurvey tool was used to process the obtained results.

The response rate of the questionnaire reached 51%, which seemed a relatively low proportion, in view of the many prior agreements and the questionnaire being made fully comprehensible by being translated into the national languages.

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 (Hinton et al., 2004). The internal consistency measure of the 16 dependent variables for the three compared countries, which was based on Cronbach's coefficient alpha, amounted to 0.81 (and 0.88 for Cronbach's alpha calculated based on standardized items), for a total of 20 items.

International comparisons were made based on the Euclidean distance (squares of differences in percentage shares of responses to individual options within specific criteria). The sum of this distance indicated the degree of differentiation between individual countries.

Internet portals were evaluated according to 21 attributes (features of criteria) on a simplified, standardized Likert scale (Likert, 1932) from 0 – the absence of a particular criterion feature up to 1 – complete fulfilment of a particular criterion through intermediate values, divided incrementally by 0.25.

Additionally, the authors formulated the H_0 hypothesis about the existence of differences in the awareness of need for use of green energy between individual pairs of the three analyzed countries: Poland and Türkiye, Poland and the PRC, Poland and Spain, Türkiye and the PRC, Türkiye and Spain and the PRC and Spain in the values regarding individual criteria against the H_1 hypothesis concerning the lack of differences, with the assumed probability of 0.05.

To prove this hypothesis, the significance level of α was calculated for the probability distribution of the Fisher-Snedecor inverse (right-hand) value. It can be used in the Fisher-Snedecor test to compare the degree of variability of two data sets for two populations and to compare it with the p value determined based on test statistics. If $p \leq \alpha$, then we reject H_0 and adopt H_1, if $p \geq \alpha$, then we reject H_0 and take H_1.

3.2. Description of the research sample

All source data for the analyses were collected at the same time in four locations: University of Warsaw (Poland), Uşok University (Türkiye), University of La Coruña (Spain) and Communication University of China in Beijing (PRC). It was completed via mailing lists and social media platforms, as well as the distribution of paper copies (quick turnaround). The survey covered a total of 1209 people; with an average return rate of 51%, i.e. the results were obtained from 608 people: 99 from Poland, 227 from Türkiye, 162 from China and 120 people from Spain. On average, more than 50% of women and more than 47% of men participated in the survey in these countries and more than 2% declared a different gender or did not wish to declare it. The largest number of women, over 53%, completed surveys in Spain and slightly less in Poland. The largest number of men (55%) were among respondents in Türkiye. The second demographic factor of respondents was age. As the survey was mainly conducted in an academic environment, the age distribution varied, with most respondents (nearly 82%) aged 18-24 years old; over 10% aged 25-34 years old and almost 8% being over 34 years old. The academic community is undoubtedly the most active group of internet users and also the one which is most actively involved in environmental protection (Batorski, 2015). Regulations related to the COVID-19 pandemic have caused, and sometimes enforced, greater activity among older age groups, which is only minimally visible in this study. The age of the respondents, participating in the online survey, and the environment in which it was conducted also influenced their education. As many as 56% of the respondents indicated their education as being incomplete higher education or bachelor's degree, while 34% declared having secondary education level. Approximately 3.5% indicated primary or vocational education, and just under 6% declared having higher education. Analyzing the place of origin of respondents in the case of China required additional procedures. The concept of large, medium, and small cities was clear and equivalent in Poland, Türkiye, and Spain, but had to be adjusted for the PRC (respectively: more than 200 million, 21-200 million, 11-20 million, up to 5 million). The largest group consists of people from big cities (37%) and rural areas (21%). The participation of other groups of respondents is established at between 11-16%.

Social sciences (on average 55%) dominate among the fields of study, and there are also other fields (16%), mainly related to finance, banking, accounting, and logistics. The financial situation of more than half of the respondents is mostly good (32%) and sufficient (21%) or the responses spread between good (average 35%) and average (average 21%). More than 12% declare that they are students and are not financially independent. However, although an average of 66% of respondents declare that they are students or pupils, as can be seen from the above distribution, the majority have their own sources of income, so it appears that they work but they are not registered. Of the remainder, more than 25% of respondents work on a contract or casual basis, almost 4% are self-employed and more than 4% have other sources of income. They mainly work as, for example: office workers (e.g. secretary, clerk) - 9%; service workers (e.g. salesman, tour guide, sales representative) - 6% and 6% work as other professionals (e.g. IT specialist, engineer, doctor, teacher).

4. Analysis of the findings

4.1. Analysis and discussion of the findings

The survey, which was qualitative and quantitative in nature, was conducted in two stages and was divided into six sections.

Stage I (described in detail in (Chmielarz, Zborowski, 2022)):

- information on basic Internet communication tools,
- identification of general knowledge about green energy and its sources,
- review of selected elements of specialized knowledge related to green energy and the conditions for its application now and in the future,
- analysis of the possibilities of using ICT in information and promotion of principles and ideas related to green energy.

Stage II:

- a comparative analysis of the most popular and frequently visited websites and applications related to green energy, from the users' point of view.

The survey included also a section containing demographic data on respondents – including: gender, age, place of residence, education and specialization, professional and financial status.

Stage I – awareness concerning using green energy among respondents

The first section included infrastructural information introducing the survey topic. To determine the role of ICT in shaping awareness of the need and necessity to replace energy based primarily on "dirty" fuels (coal, oil, gas, etc.), it was necessary to find out how respondents interact with the Internet. The majority (60%) of respondents access green energy portals/applications using a combination of a smartphone and a laptop, followed by

a smartphone alone (28%). This is due to the adopted path of Internet communication development. European countries implemented the first option before the widespread use of smartphones. The distribution of the Internet via smartphones is now a faster and much cheaper strategy. Interestingly, the intermediate option - Internet communication using a tablet - did not prove to be effective (averaging at the level of nearly 4%). The greatest variation measured by Euclidean distance (54%) occurred between Poland and Türkiye, mainly due to the use of a combination of a laptop and a smartphone for Internet communication, as well as using a smartphone exclusively for this purpose. The smallest variation was recorded between Poland and Spain (Euclidean distance of 0.30%), due to cultural similarities and a similar path of ICT development. The next section included questions about respondents' interest in environmental protection. More than 51% of survey participants express an interest in this topic, the largest share (69%) in the PRC. However, some respondents (nearly 30%) are indifferent to the topic, although they have heard of it. The least interested survey participants (38%) were in Poland. The largest differences between the survey results in this regard were between Poland and the PRC (Euclidean distance amounting to 11%), mainly due to the statement *I am interested in it*, despite the generally high value of this option. The relatively smallest differences occurred between the PRC and Spain (Euclidean distance was established at 1.29%). Similar results were obtained in response to the question about interest in replacing 'dirty' energy with 'clean', renewable energy. More than 37% of respondents were interested in such a solution (most in Spain 58%), and 34% were moderately interested in it. The biggest difference in opinions was recorded between Poland and the PRC (Euclidean distance - 16%). Another question was related to where respondents first encountered the term *green energy*. Most of the respondents, 43% on average, had already encountered it at school (most in Poland 55% and in Spain 52%). In second place was the Internet (24% on average), which demonstrates the high position of ICT in disseminating the idea of renewable energy sources (most Poland 28%). In third place was the university (14% on average), with the highest percentage in Türkiye at 23%. The greatest difference (Euclidean distance - 5%) in terms of learning first about green energy was between Poland and Türkiye. To deepen their knowledge on green energy, respondents would mainly look for information on the Internet (21% of respondents on average, the highest number from Poland - 29%). Green literature on the subject came second with 19%, with most respondents choosing this answer in the PRC with 22%. The least attention is paid to colleagues and friends - 6% on average. As a source of information, environmental institutions (15%) and specialized literature (14%) are fairly valued. The largest differences (city distance 40%, Euclidean distance - 4%) occur between Poland and Türkiye, mainly due to the differential use of the Internet in this respect. Among knowledge of green energy sources, respondents' knowledge about hydropower is the highest (26% on average), mainly in Poland 34%, the survey participants know the least about obtaining energy from biogas (5% on average, the highest share - 6%, was recorded in China). Solid biofuels came second (average of 20%) and heat pumps third (average of 13%). In Spain, solar energy (24%) and hydropower and wind

energy (at the level of 18%) were the most widely known to respondents. In fact, the answers of respondents from Türkiye and Spain differed the most (Euclidean distance - 19%), mainly due to the difference in respondents' knowledge about hydropower. The last question to indirectly test respondents' knowledge of the practical applications of green energy solutions was the question about its share in total energy production in each country. Respondents did indeed mostly show a good understanding of this topic. In Poland, more than 70% correctly identified the share of green energy in the total energy production in the country (Produkcja Energii Elektrycznej…, 2022). Unfortunately, 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 (20-30%) almost equally with the correct answer (between 10% and 20%). In these two countries, ranges between 30% and over 50% were marked by Türkiye at 33% and the PRC at 35% respectively. In contrast, there was a significant underestimation in Spain, where only 7% of respondents marked the correct range for the share of green energy (42%). The largest difference was between Poland and Türkiye (Euclidean distance - 31%), with a slightly smaller difference between Poland and Spain (Euclidean distance - 28%). This part of the survey aimed to demonstrate whether respondents were aware of green energy issues and to what extent they were willing to broaden their interests in this area with the help of both electronic and traditional media. Additionally, it was revealed that respondents' perspectives on renewable energy can vary significantly across countries, despite similar economic development and political conditions, including the recent crises.

The following section of the survey aimed to systematize the general knowledge assessed in the previous section's questions and elicit respondents' perspectives on energy-related phenomena, particularly those related to green energy.

Initially, an effort was made to identify a shared definition of green energy among the countries included in the analysis. This was done by searching for "green energy definition" on the internet. Of the five definitions collected in this way: (What Is Green Energy?, 2023; What Is Renewable Energy?, n.d.; Green Energy, 2021; What Is Green Energy?, n.d.), the largest number of respondents (27%) selected the descriptive definition … *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)* ... (Energy Source, n.d.). All definitions were equally correct; however, this particular definition was chosen most frequently. It was primarily selected by respondents from Poland and China. The largest discrepancy was observed between Poland and Türkiye, with a Euclidean distance of 13%.

The next question inquired about the definitions mentioned earlier. Four statements were presented that referred to the relationship between clean energy and renewable energy sources. The respondents were asked to select the statement they believed to be the most accurate.

Their choice was largely dependent on the definition they selected earlier, especially that one definition in particular explicitly defined the relationship (...*all renewable energies are green, but not all green energies are renewable*...), thereby influencing the choice of respondents. As a result, the majority of respondents (32%) selected the first statement. Notably, 37% of Polish respondents also agreed with this statement. However, in Türkiye and China, slightly more respondents selected the third statement (...*all green energies are based on renewable and non-renewable sources (distinguished e.g. because of resource limitation or environmental damage)*...), which also corresponds to the broad discussion that takes place around the definition and classification of the term green energy. Overall, there was little variation in the distribution of responses across countries. The largest discrepancy was observed between Poland and Türkiye, with a Euclidean distance of just over 1%. A slightly smaller difference (less than 1% Euclidean distance) was observed between Poland and the PRC.

Next questions included in the survey concerned the advantages and disadvantages of green energy according to 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, 23% in Spain). 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. Ranked third at 18%, survey participants hold the belief that green energy reduces emissions of harmful substances and thus improves the environment as it does not lead to dust emissions. The smallest number of respondents (5% on average) indicated that the use of green energy from an economic point of view creates jobs for installers and manufacturers of green energy equipment and those that handle the disposal of used equipment and materials. There were also reservations about the fact that it reduces the number of jobs in mines, refineries, etc. The responses related to the criterion of optimizing distribution, also allowing the use of local energy sources were largely similar. The greatest variation (Euclidean distance of just over 1%) occurs between the assessments from Poland and the PRC.

In order to evaluate the drawbacks associated with the implementation of green energy technologies, a survey was conducted where respondents were presented with eight options and were asked to identify the most significant disadvantage from amongst them. The results indicated that the highest proportion of respondents (18%) highlighted the high costs associated with investing in renewable energy sources, the need for subsidies and grants from the government (photovoltaic panels, energy storage, etc.); the long payback period (16%), the difficult and underdeveloped ways of disposal (e.g. wind power plants or fissile materials) or the harmful impacts of the production and disposal of some green energy technologies (15%). The biggest differences, due to completely different approaches to green energy in Spain (preference for solar, wind and hydropower), occurred between this country and the other countries (Euclidean distance for PRC-Spain 11%, for Poland-Spain 9% and for Türkiye-Spain 7%). These countries are more dependent on weather conditions (sun, wind) or natural conditions (e.g. rivers with insufficient gradient).

Among widely held opinions, nuclear energy is considered to be green energy because it is decarbonized and does not emit greenhouse gases into the atmosphere. However, it should be taken into consideration that uranium, on which its emission is based, is a costly and limited resource and is dangerous to the environment in the case of an open fuel cycle (used fuel is stored). However, if there were significant investments made into extensive research on nuclear fuels and safe operational and disposal methods, nuclear energy could also be considered clean and renewable. Therefore, respondents were also asked questions about the advantages and disadvantages of atomic energy.

Among the advantages, the highest rating on average (22%), (highest in Poland 27% and the PRC 23%) was given to the lack of emissions of greenhouse gases, dust, sulphur oxides or heavy metals, which improves the health of the population and just behind (21%, highest in Türkiye), the relative safety of new technologies in this respect (compared, for example, to the occurrence of 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%) and independence from weather conditions and high independence from natural conditions (20%), in Türkiye to the lack of noise emissions (compared to e.g. wind power plants), and in Spain to the possibility of using nuclear waste in other areas of the economy e.g. in medicine and the possibility of using the land around nuclear power plants for agricultural purposes (13% each). The largest differences in the Euclidean distance in the responses (8%) were recorded between Poland and Spain.

Statements regarding the drawbacks of nuclear power plants focused on concerns over the possibility of reactor accidents, which pose a threat to life or health of the population (22% on average, highest in Türkiye - 25%), lack of safe methods of nuclear waste disposal (improperly stored may contaminate soil or water) - 18% on average, Poland 23%, and high and increasing costs of nuclear power plant construction - 17% on average, Türkiye 20%. The PRC also singled out technical, competence and construction problems during construction that could increase planned costs (23%), and Spain, similarly to Poland, lack of safe storage methods (16%). The largest, albeit small, difference in Euclidean distance - less than 4% - is between Poland and the PRC.

The previous results indicate that respondents are able to identify green energy, what it can be used for and why it should be used as well as its advantages and disadvantages. The next logical question seemed to be whether they themselves have participated in a green energy project (such as installing a heat pump, photovoltaic panels in the family home, a local hydroelectric plant, a wind turbine, etc.). The highest number of people (41% on average) reported that they have never participated in such a project and do not intend to participate in it in the future. In contrast, slightly fewer respondents (34%) indicated their intention to participate in a green energy venture in the future. Responses related to one-time participation were highest (23%) among respondents from Poland. The largest differences expressed in terms of Euclidean distance were observed between the PRC and Spain (68% of responses) and between Poland and the PRC (58% of responses).

The next question concerned opinions on the future of green energy. Most people (37% on average, most (43%) in the PRC) predicted that green energy would become commonplace in just 10 years. In second place (29% on average) was the answer in 20 years. The most optimistic were respondents from Türkiye (10%), who believe that green energy will be the dominant trend in just one year. The greatest differences in opinion occurred between Poland and Türkiye (Euclidean distance 11%), mainly due to the predominant answer in Poland stating that green energy will be common worldwide *in 20 years*.

The final, but most relevant, section of questions focused on the extent to which ICT can assist in the introduction of green energy, especially in a situation of already somewhat permanent crises. Among the answers given as to how ICT can best help disseminate and implement the idea of green energy, the predominant opinion (19% on average) was related to the role of ICT in informing the public about pollution problems and methods in which we can protect the environmental. A similar option – disseminating and popularizing the idea of green energy and informing about its principles - was chosen most frequently (19%) in Türkiye. In Spain, the most common response (18%) was the one focusing on *promoting the online sale of products and services to reduce environmental pollution through dust and greenhouse gas emissions*. In Türkiye, the predominant response (18%) was related to *producing software to monitor pollution and automate pollution reduction*. In the PRC, 19% of respondents chose the option of *intensive marketing of services and products related to green and clean ways of producing energy*. The differences between the statements of respondents from each country were small, i.e. a fraction of a percentage, the largest between Türkiye and Spain not exceeding 0.89% of the Euclidean distance.

The last question included in the section referred to whether the situation of crises (COVID pandemic, threat of armed conflict, energy crisis, internal political crisis, high inflation) influences the drive to promote and implement green energy through ICT and, if yes, how it is being implemented. On average, the largest number of respondents chose the option indicating *moderate influence so as not to upset the economic balance* (38% on average, Poland - 53%, PRC 46%). A similar magnitude was given to the answer indicating that *it could be a way out of the crisis* (average 31%, most Türkiye 39%). The opinion of *no action at all* is less than 2%. The largest differences measured in opinions on this topic occurred between Poland and Türkiye (Euclidean distance of 18%), mainly due to the option stating that ICT should support green energy in *a moderate way*, and the statement that *it can be a way out of the crisis*. A similar situation occurred in the Türkiye-China relationship (Euclidean distance of 12%).

4.2. Comparative analysis of green energy portals/web applications using the scoring method

In summary, the results of the qualitative analysis so far have shown that the respondents, regardless of the differences between them:

- use infrastructure that allows them to access the Internet on a daily basis,
- have a good understanding of environmental protection issues,
- are aware of the need to implement green energy and would like to have more knowledge about it, mainly obtained on the Internet,
- believe that in a situation of deep crisis, ICT should be allowed to moderately or fully support the idea of green energy and its implementation in a sustainable way because this can be a way out of crises, especially the energy crisis and the related economic crisis.

Following the research procedure, the evaluation by respondents of the most popular, frequently visited, and launched internet services and mobile applications related to green energy in Poland, Türkiye, the PRC, and Spain was then presented. Data for these calculations were collected through the last two survey questions. The first one concerned knowledge of eco-themed services/applications containing references to green energy, and the second one concerned a detailed evaluation according to the adopted rating scale.

Each website/application was rated using a simplified, normalized Likert scale (Likert, 1932), where:

- – meets all user requirements,
- 0.75 – meets most user requirements,
- 0.50 – moderately meets user requirements,
- 0.25 – minimally meets user requirements,
- – does not meet user requirements.

The sum of the average scores obtained was then related to the sum of the maximum scores that could be obtained in the evaluation of the website/application in two cross-sections (for each selected website/application and for each attribute).

A list of 9 to 14 of the most well-known and popular websites/applications was prepared for each country, from which the five most popular among respondents from that country (with over 20 indications) were then selected. The results of the average ratings of the surveyed individuals for the websites/applications, expressed as a percentage of the maximum possible score, are presented in Table 1. The highest ratings were given to the websites/apps in the PRC at 68.86%, 8% higher than the average rating of the countries analyzed. Portals/apps in Türkiye were rated the lowest (meeting only 55.76% of user expectations). The Chinese portal www.green-stone.org scored highest in the rankings (72.62%), while the Turkish portal www.tureb.com.tr scored worst with 47.40%. The difference between the national averages is 13.10%, between the worst and the best portal/application is 25.22%. Admittedly, these are averaged subjective results, but it is important to indicate that since green energy portals/applications are designed for users, it is only natural that they should be evaluated by them.

Table 1.
The most popular and frequently visited environmental websites/apps in Poland, Türkiye, PRC and Spain

Country	Link to a website/application	Share in the maximum value
Poland	http://gramwzielone.pl	52.01%
	http://zielonagospodarka.pl	58.20%
	http://wysokienapiecie.pl	57..74%
	http://globenergia.pl	67.52%
	http://wwf.pl	63.84%
	Average for Polish websites/application	**59.86%**
Türkiye	www.tureb.com.tr	47.40%
	www.zorluenerji.com.tr	52.65%
	www.enerjisa.com.tr	58.63%
	www.kocyigitenerji.com	59.42%
	www.borusanenbw.com.tr	60.71%
	Average for Turkish websites/applications	**55.76%**
PRC	www.cred.org.net	61.31%
	www.cegreen.org	67.56%
	www.eedu.org.cn	70.32%
	www.creia.net	72.47%
	www.green-stone.org	72.62%
	Average for Chinese websites/applications	**68.86%**
Spain	https://www.ree.es/es	53.61%
	https://www.appa.es	56.27%
	https://www.idae.es	56.58%
	https://energia.gob.es	58.93%
	https://www.cener.com	61.38%
	Average for Spanish websites/applications	**57.35%**
Average in total		**60.46%**
Variance		0.50%
Standard deviation		7.06%

Source: own work.

A list of twenty-one attributes has been prepared for evaluating the quality of each website, indicating whether and to what extent a given internet portal/application meets the requirements related to a properly designed and user-friendly website. This is because only such websites are able to attract users and make them return, and the content of the website sometimes plays just as important a role as the way in which it is communicated and the user-friendliness of the website. The list of attributes verified by the respondents is shown in Table 2.

Table 2 shows the results of calculations regarding the shares in the maximum possible score for the average ratings of websites/applications in Poland, Türkiye, the PRC and Spain. The first column lists the attributes according to which the services were evaluated by the respondents, and the following columns show the results for each country and the average.

Table 2.
Results of the comparison of the shares of the maximum possible scores for the average attribute scores of services/applications in Poland, Türkiye, the PRC and Spain

Attributes/Website/application	Poland % share max. score	Türkiye % share max. score	PRC % share max. score	Spain % share max. score	Average
Automated updates of the application	37.95%	72.50%	66.13%	54.74%	57.83%
Availability of content concerning green energy	75.86%	69.70%	71.88%	57.75%	68.80%
Catalog of cooperating companies, sponsors	56.48%	68.79%	72.50%	53.97%	62.93%
Color scheme	69.12%	66.67%	69.60%	57.84%	65.81%
Comfort	52.85%	68.57%	68.79%	54.70%	61.23%
Convenience of use	63.51%	68.14%	72.17%	57.82%	65.41%
Ease of navigation	74.15%	70.03%	69.70%	57.34%	67.81%
Ease of use of categories related to green energy	66.18%	69.60%	74.54%	57.75%	67.02%
Existence and number of offered products/service categories	40.62%	68.79%	67.47%	56.12%	58.25%
Filtering by national language	50.12%	71.88%	63.82%	58.18%	61.00%
Information on claims and returns	32.78%	67.51%	62.35%	53.31%	53.99%
Informative content on green energy	72.72%	62.35%	67.51%	57.68%	65.06%
Intuitiveness	70.87%	64.52%	68.57%	58.61%	65.64%
Legal aspects regarding the possibility of introducing green energy	64.63%	67.47%	72.63%	60.38%	66.28%
Main menu	71.45%	70.65%	70.03%	58.60%	67.68%
Payment methods for products or services	42.58%	72.63%	67.22%	57.77%	60.05%
Readability of text regarding green energy	74.90%	67.22%	71.07%	59.67%	68.21%
Search for green energy content	71.96%	72.17%	68.14%	57.66%	67.48%
System of ratings and comments on content related to green energy	31.46%	71.07%	70.65%	56.86%	57.51%
User-friendliness	72.15%	63.82%	64.52%	60.28%	65.19%
Visualization	64.73%	66.13%	66.67%	57.43%	63.74%

Source: own work

In Poland, the aspects which were rated highest in the considered websites and applications included: the availability of content regarding green energy (nearly 76%) and the readability of the text describing it (75%). The lowest rating was given to the rating and comments system (31%). In Türkiye, the highest rating (73%) was given to payment methods for or within services (delivery of content), and the lowest rating was given to informative content regarding green energy (62%). In the PRC, the highest rating in these portals/applications was given to the ease of use of the services (75%), the lowest (62%) to information about claims regarding the services provided. In Spain, the legal aspects of the possibility to introduce green energy and the user-friendliness of the website were rated highest (60% each). The lowest rating in the country - 53% was assigned for information about claims or complaints regarding the services provided. The largest spread between the highest and lowest ratings was in Poland (44%), with a 13% spread in the PRC and 11% in Türkiye. On average across the selected countries, the highest ratings were assigned for availability of content regarding green energy (69%), ease of navigation and readability of the text regarding green energy (68%).

The variation in ratings between portals/applications was examined using Euclidean distance. The calculations of Euclidean differences for all attributes are provided in Table 3.

The greatest variation occurred between the attribute ratings of portals/applications in Poland and the other three countries in the following categories:

- in the category of sum of attribute difference coefficients between Poland and Türkiye (40.12%) and Poland and Spain (39, 29%),
- in the category of attribute differences:
- in the case of the attribute rating and comment system of websites/applications in Poland and Türkiye; Euclidean distance (15.69%) and Poland and the PRC; Euclidean distance (15.26%),
- in the case of the attribute of *information about claims concerning services* provided by services/apps from Poland and Türkiye; Euclidean distance (12.06%) and Poland and the PRC; Euclidean distance (8.74%),
- in the case of the *automated update* attribute of services/applications from Poland and Türkiye; Euclidean distance (11.93%) and Poland and the PRC; Euclidean distance (7.94%).

The smallest differences were between Türkiye and the PRC - the sum of Euclidean differences is only 2.22%, and many attribute differences, especially technical attributes such as ease of navigation, main menu appearance, user-friendliness, comfort, rating and comment system and visualization take zero value.

Table 3.
Differences between average ratings of attributes of green energy websites/applications

Differences between countries/attribute	Poland-Türkiye	Poland - PRC	Türkiye-PRC	Poland-Spain	Türkiye-Spain	PRC-Spain	Average
Legal aspects regarding the possibility of introducing green energy	0.08%	0.64%	0.27%	0.18%	0.50%	1.50%	0.53%
Automated updates of the application	11.93%	7.94%	0.41%	2.82%	3.15%	1.30%	4.59%
Availability of content regarding green energy	0.38%	0.16%	0.05%	3.28%	1.43%	2.00%	1.22%
Filtering by national language	4.73%	1.88%	0.65%	0.65%	1.88%	0.32%	1.68%
Information on claims and returns	12.06%	8.74%	0.27%	4.21%	2.02%	0.82%	4.69%
Informative content on green energy	1.08%	0.27%	0.27%	2.26%	0.22%	0.97%	0.84%
Intuitiveness	0.40%	0.05%	0.16%	1.50%	0.35%	0.99%	0.58%
Existence and number of offered product/service categories	7.94%	7.21%	0.02%	2.40%	1.61%	1.29%	3.41%
Catalog of cooperating companies, sponsors	1.52%	2.57%	0.14%	0.06%	2.20%	3.44%	1.65%
Color scheme	0.06%	0.00%	0.09%	1.27%	0.78%	1.38%	0.60%
Comfort	2.47%	2.54%	0.00%	0.03%	1.92%	1.99%	1.49%

Cont. table 3.

Ease of use of categories related to green energy	0.12%	0.70%	0.24%	0.71%	1.40%	2.82%	1.00%
Ease of navigation	0.17%	0.20%	0.00%	2.83%	1.61%	1.53%	1.06%
Main menu	0.01%	0.02%	0.00%	1.65%	1.45%	1.31%	0.74%
User-friendliness	0.69%	0.58%	0.00%	1.41%	0.13%	0.18%	0.50%
Methods of payment for products or services	9.03%	6.07%	0.29%	2.31%	2.21%	0.89%	3.47%
System of ratings and comments on content related to green energy	15.69%	15.36%	0.00%	6.45%	2.02%	1.90%	6.90%
Visualization	0.02%	0.04%	0.00%	0.53%	0.76%	0.85%	0.37%
Convenience of use	0.21%	0.75%	0.16%	0.32%	1.06%	2.06%	0.76%
Search for green energy content	0.00%	0.15%	0.16%	2.05%	2.11%	1.10%	0.93%
Readability of text regarding green energy	0.59%	0.15%	0.15%	2.32%	0.57%	1.30%	0.85%
Total	40.12%	29.46%	2.22%	39.26%	29.37%	29.92%	28.39%
Variance	0.24%	0.17%	0.0003%	0.02%	0.01%	0.01%	
Standard deviation	4.92%	4.08%	0.17%	1.56%	0.80%	0.76%	
F-Snedecor Test	27.28	22.58	0.83	61.97	2.27	2.75	

Source: own work based on the survey results.

In addition, it was hypothesized that there was a significant average variation in services/applications between the countries analyzed according to a distinguished set of their characteristics (attributes). The differentiation was examined using the right-sided Fisher-Snedecor test $_{(20,3)}$. The obtained values for comparing the differentiation between: Poland and Türkiye (27.28), Poland and the PRC (22.58) and Poland and Spain (61.97), for a significance level of 0.05; respectively, are above the cut-off level of 8.66, so the H_0 hypothesis for these three differences was confirmed. However, it was not confirmed for the differences between Türkiye and the PRC (0.83), Türkiye and Spain (2.27) and PRC and Spain (2.75).

4.3. Quantitative analysis using the conversion method

The multi-criteria conversion method was developed for the evaluation of websites in order to make the collection of data from the average user as easy as possible (data are collected using the scoring method), while at the same time bringing the subjective results of the scoring method closer to reality by relating the results of the scoring analysis to the averages in the individual categories (attributes). A brief description of the method is presented below (Chmielarz, Zborowski, 2013).

This method consists in determining the relation of each criterion to other criteria, based on averaged distances from the maximum potential value established on the basis of previous scoring evaluation. Data received from scoring evaluation is the starting point for a conversion method. The steps of the conversion method are as fallow.

I. Established preference vector of the superior level criteria (first converter) constructing a matrix of distances from the maximum value for each criterion in every website, establishing the maximum value:

$$P_{i,max} = Max\{f_i(a_j), \dots, f_n(a_m)\} \text{ for } i = 1, \dots, n \text{ and } j = 1, \dots, m \quad (1)$$

1. establishing the matrix of the distances from the maximum value

$$\delta\left(f_i(a_j)\right) = P_{i,max} - f_i(a_j) \text{ for } i = 1, \dots, n \text{ and } j = 1, \dots, m \quad (2)$$

2. calculating the average distance from the maximum value for each criterion,

$$\overline{F_{i,j}} = \frac{\sum_{j=1}^{m} \delta\left(f_i(a_j)\right)}{m} \quad (3)$$

3. as a result of the above operation, constructing a matrix of differences in the distance from the maximum value and the average distance according to criteria,
4. for each website: constructing conversion matrices - modules of relative distances of particular criteria to remaining criteria (the distance from the same criterion is 0), the obtained distances below the diagonal are the converse of the values over the diagonal,
5. averaging criteria conversion matrices – creating one matrix of average modules of values for all criteria:

$$\overline{A}_{i,j} = \frac{\sum_{i=1,j=1}^{n,m}(\alpha_{i,j} - \alpha_{i+2,j})}{n} \quad (4)$$

6. transforming the conversion matrix of criteria into a superior preference matrix (calculating squared matrix, adding up rows, standardization of the obtained preference vector; repeated squaring, adding up rows, standardization of preference vector – repeating this iteration until there are minimum differences in subsequent preference vectors).

II. As a result of the above operations we establish a criteria conversion matrix Ta_{mx1}. Subsequently, the authors performed a transformation of the scores presented by experts on the level of a matrix specifying expert websites' evaluations for particular criteria (second converter). The results have been obtained in an analogical way:

1. constructing a matrix of distances from the maximum value for each criterion and each website:
   a. establishing the maximum value

$$P_{i,max} = Max\{f_i(a_j), \dots, f_n(a_m)\} \quad (5)$$
$$\text{for } i = 1, \dots, n \text{ and } j = 1, \dots, m$$

   b. establishing the matrix of distances from the maximum value

$$\delta\left(f_i(a_j)\right) = P_{i,max} - f_i(a_j) \text{ for } i = 1, \dots, n \text{ and } j = 1, \dots, m \quad (6)$$

2. calculating the average distance from the maximum value for each website,

$$\overline{F_i} = \frac{\sum_{j=1}^{m} \delta\left(f_i(a_j)\right)}{m} \quad (7)$$

3. constructing a matrix of the differences of deviations from the maximum value and the average distance of the features from the maximum,
4. for each criterion: constructing a matrix of transformations (conversions) of the differences of the average distance from the maximum value between the websites, analogically as presented above values below the diagonal are the converse of the values over the diagonal,
5. constructing a module matrix of transformations of the differences of average distance from the maximum value between the websites, for each criterion,

$$\overline{A}_{i,j} = \frac{\sum_{i=1,j=1}^{n,m}(\alpha_{i,j} - \alpha_{i+2,j})}{n} \quad (8)$$

6. for each module matrix of transformation of the differences of the average distance from the maximum value between the websites, squaring it, adding up rows, standardization of the obtained ranking vector and repeating this operation until the obtained differences between two ranking vectors for each criterion will be minimal,
7. As a result of the above presented operations we obtain a conversion matrix of websites' evaluations: Tf_{mx1}
    a. using the obtained vectors to construct a combined ranking matrix – returning to the matrix where in
    b. its side-heading there are criteria, in the heading names of bank websites by appropriate transfer of the obtained preference vectors for each criterion,
    c. multiplying the matrix obtained in such a way by the previously calculated preference vector,

$$T' = Tf \otimes Ta \quad (10)$$

    d. analysing final results and drawing conclusions note: the lowest distances in this case are the most favourable, comparability adjustments to other methods can be obtained by subtracting these values from 1 and their repeated standardization (details of the method see: (Chmielarz, Zborowski, 2013)),

In the case analyzed for Poland, Türkiye, the PRC and Spain, data on green energy portals/applications were collected by means of an online survey. Its results for average ratings were previously described using the scoring method. The same input data set was also used in the calculations in the conversion method.

In the course of data collection, this method is much more convenient for users as it allows them to answer survey questions in a more "user-friendly and comprehensible way than, for example, the ELECTRA or PROMETTEE methods, the TOPSIS method (giving similar results), and certainly than the AHP/ANP method" (Saaty, 2008). As shown in the previous

section, it also allows for an easy and broad interpretation of the results also in regional analyses. The subjectivity of respondents is reduced in direct proportion to the number of respondents, although it appears to be no greater than when comparing pairs of mismatched attributes in the AHP method. However, in the conversion method based on distances from the mean results in each category, the computational burden, as with other methods, is transferred to the software. The obtained results, similar to the AHP method, have a lower correlation coefficient R^2 than other multicriteria methods. Due to the adopted calculation algorithm, the results obtained also differ from those of scoring methods and their interpretation is more difficult and less obvious than in scoring methods.

Table 4 shows a cross-section of the average ratings of the characteristics of the examined portals in each country. It can be seen that different attributes are valued most highly in each of them. In Poland, it is the catalogue of cooperating companies and sponsors (14.37%), understood as forms that directly or indirectly support the idea of green energy, and the existence and number of offered product/service categories in the field of environmental protection (8.80%). In Türkiye, it is a system of ratings and comments on content related to green energy (9.99%) and for technical reasons - user-friendliness of the site for the user (11.40%). In the PRC, the best-rated features are: ease of use of categories related to green energy (7.90%) and the ability to filter by national language (8.16%). In Spain, the country with the most developed and used green energy technology, the issue is so well known that attention is mainly paid to the ability to filter by national language (7.87%) and the ease of site navigation (7.27%). Nevertheless, Spanish portals/applications are still rated highest by users. Above the average rating in Spain, there are 10 features out of 21, in the PRC - 7, in Poland - 8 and Türkiye - 9. On average, the lowest rated features are ease of use of categories related to green energy (1.28%) and the appearance of the Main menu (1.41%) and information on claims and returns (1.42%).

Table 4.
Average scores for the attributes of the portals/applications in the surveyed countries according to the conversion method and an assessment of their Euclidean distance

Measure/Country/Attribute	The average for each country			
	Poland	**Türkiye**	**PRC**	**Spain**
Legal aspects regarding the possibility of introducing green energy	4.49%	2.71%	2.81%	2.64%
Automated updates of the application	5.63%	4.51%	6.58%	6.01%
Availability of content regarding green energy	5.60%	3.67%	3.08%	3.78%
Filtering by national language	3.64%	4.28%	8.16%	7.87%
Information on claims and returns	1.68%	4.00%	4.62%	3.48%
Informative content on green energy	4.72%	7.72%	4.75%	4.16%
Intuitiveness	5.22%	4.20%	2.99%	6.30%
Existence and number of offered product/service categories	8.80%	3.57%	5.55%	4.69%
Catalog of cooperating companies, sponsors	14.37%	3.88%	4.01%	3.56%
Color scheme	4.49%	5.48%	4.34%	5.82%
Comfort	4.24%	4.00%	6.84%	3.32%
Ease of use of categories related to green energy	2.50%	2.64%	7.90%	6.32%

Cont. table 4.

Ease of navigation	2.82%	4.90%	3.04%	7.27%
Main menu	3.62%	2.00%	2.56%	2.45%
User-friendliness	4.46%	11.40%	4.38%	4.03%
Methods of payment for products or services	3.99%	3.00%	6.23%	4.96%
System of ratings and comments on content related to green energy	1.92%	9.66%	6.00%	6.52%
Visualization	5.42%	4.03%	3.71%	3.06%
Convenience of use	2.88%	5.03%	3.94%	4.48%
Search for green energy content	5.94%	5.54%	4.66%	5.78%
Readability of text regarding green energy	3.59%	3.78%	3.85%	3.51%
Standard deviation	2.71%	2.28%	1.65%	1.57%
Variance	0.07%	0.05%	0.03%	0.02%

Source: own work based on the survey results.

The differences measured by Euclidean distances between the responses of respondents from the countries analyzed are highest between Türkiye and Spain (5.80%), mainly due to the perception of the user-friendliness of the website (1.30%) and the quality of the system of ratings and comments on content related to green energy (0.93%). The differences between Poland and Türkiye are almost halved (2.85%), which was caused mainly by the catalogue of cooperating companies and sponsors (1.10%), and the system of ratings and comments on content related to green energy (0.60%). The results are presented in Table 5.

Table 5.
Evaluation of the Euclidean distance between the mean scores of the attributes of the portals/applications in the analyzed countries

Measure/Country/Attribute	Euclidean distance					
	Poland-Türkiye	**Poland-PRC**	**Poland-Spain**	**Türkiye - PRC**	**Türkiye-Spain**	**PRC-Spain**
Legal aspects regarding the possibility of introducing green energy	0.0317%	0.0283%	0.0001%	0.0082%	0.0732%	0.0003%
Automated updates of the application	0.0124%	0.0092%	0.0429%	0.0392%	0.2038%	0.0033%
Availability of content regarding green energy	0.0371%	0.0637%	0.0036%	0.0184%	0.1350%	0.0049%
Filtering by national language	0.0041%	0.2042%	0.1506%	0.0528%	0.1830%	0.0008%
Information on claims and returns	0.0541%	0.0866%	0.0038%	0.0667%	0.1602%	0.0130%
Informative content on green energy	0.0901%	0.0000%	0.0885%	0.2125%	0.5959%	0.0034%
Intuitiveness	0.0105%	0.0498%	0.0145%	0.0340%	0.1763%	0.1093%
Existence and number of offered product/service categories	0.2731%	0.1055%	0.0391%	0.0023%	0.1276%	0.0075%
Catalog of cooperating companies, sponsors	1.1001%	1.0715%	0.0002%	0.0047%	0.1503%	0.0021%
Color scheme	0.0098%	0.0002%	0.0128%	0.0891%	0.2999%	0.0218%
Comfort	0.0006%	0.0678%	0.0808%	0.0376%	0.1598%	0.1242%
Ease of use of categories related to green energy	0.0002%	0.2915%	0.2767%	0.0183%	0.0697%	0.0250%
Ease of navigation	0.0435%	0.0005%	0.0347%	0.0884%	0.2404%	0.1787%
Main menu	0.0263%	0.0112%	0.0032%	0.0035%	0.0399%	0.0001%
User-friendliness	0.4818%	0.0001%	0.4925%	0.5530%	1.3000%	0.0012%
Methods of payment for products or services	0.0098%	0.0498%	0.1040%	0.0157%	0.0901%	0.0161%

Cont. table 5.

System of ratings and comments on content related to green energy	0.5989%	0.1663%	0.1340%	0.4577%	0.9335%	0.0027%
Visualization	0.0192%	0.0292%	0.0011%	0.0279%	0.1626%	0.0042%
Convenience of use	0.0464%	0.0113%	0.0119%	0.0932%	0.2530%	0.0030%
Search for green energy content	0.0016%	0.0163%	0.0077%	0.0711%	0.3064%	0.0125%
Readability of text regarding green energy	0.0004%	0.0007%	0.0001%	0.0375%	0.1428%	0.0012%
Total	2.85%	2.26%	1.50%	1.93%	5.80%	0.54%
Standard deviation	0.27%	0.23%	0.12%	0.15%	0.31%	0.05%
Variance	0.00075%	0.00055%	0.00014%	0.00021%	0.00095%	0.00002%

Source: own work based on the survey results.

In general, there were also differences in the rankings determined by the conversion method and the scoring method, irrespective of the country involved (Figure 1). These mainly consist of a greater spread between the highest and lowest scores and a change in the order of the rankings.

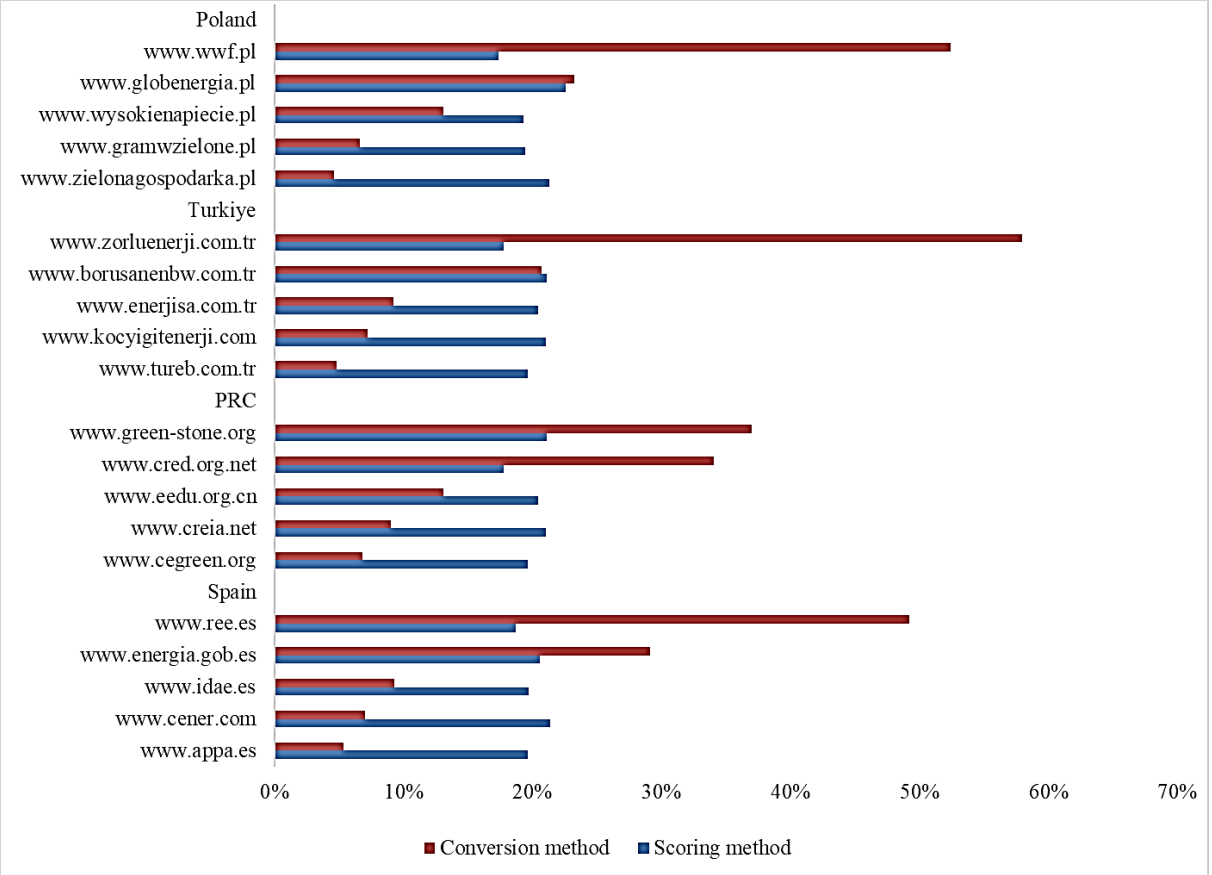

Figure 1. Assessment of the quality of services and applications using the conversion method and the scoring method.

Source: own work.

The difference concerning specific places in rankings was the highest among the portals/applications analyzed in Poland (10 points) and the lowest in PRC (6 points). In terms of Euclidean distance, the largest difference (16%) occurred in the evaluation of the Turkish portal www.zorluenerji.com.tr, and the smallest (0.001%) in the case of the Turkish portal www.borusanenbw.com.tr. Similar differences occurred in Polish portals - the largest

Euclidean difference (12%) in the evaluation of www.wwf.pl, and the smallest (0.005%) in the evaluation of www.globenergia.pl. The smallest variation in Euclidean scores obtained using both methods, just over 2%, is found in the assessment of Chinese portals/applications, a slightly larger 8.5% of Spanish portals/applications.

The differences in rankings according to the scoring method and the conversion method between the average attribute scores were greatest (19 items) for the user-friendliness of the website, and the methods of payment for products/services, automatic application updates and information about complaints and returns (12 items each). No difference occurred in the case of the search for green energy content and filtering by national language.

The conversion method is currently being tested for the banking sphere, in order to compare it with other multi-criteria methods and to modify the method in order to reduce the differences between the lowest and highest scores.

5. Conclusions

The conducted research justifies drawing the conclusions presented below.

Stage I was an introductory study on green energy awareness and the basis for conducting comparative research on the most popular and frequently visited websites related to this topic.

Stage I:

- respondents in all analyzed countries use information technology infrastructure on a daily basis to communicate with the Internet (mainly smartphones: the PRC, Türkiye), PCs, and smartphones (Poland, Spain);
- the majority (on average 53%) of the surveyed people are very familiar with and well-versed in issues related to green energy, and they have learned about it in school,
- respondents have the greatest knowledge about wind, solar, and water energy,
- the surveyed people are aware of the need to implement green energy, which is mainly expanded through knowledge obtained from the Internet; hence, the role of ICT in promoting green energy topic,
- websites and internet applications are perceived as the primary tools for propagating green energy,
- despite concerns about the lack of complete protection against disasters, nuclear energy is seen as a temporary alternative to green energy,
- the survey participants agreed on the role of ICT related to such activities as informing society about environmental pollution problems and methods of environmental protection, promoting green energy ideas and informing about its principles, and developing software for monitoring pollution and automating the reduction of its level,

- differences between responses obtained from the analyzed countries were not so significantly despite existing cultural and economic differences, although the greatest differences occurred mainly between Poland and the other countries.

Stage II:

The second stage involved the evaluation and comparative analysis of green energy services in the surveyed countries. The analysis was conducted for each country individually and by comparing the results from the selected countries. The analysis was carried out using two methods: a simple scoring method and a conversion method. Rankings were obtained for each country and across the evaluation of the attributes of the portals analyzed in the study.

Analyses are most commonly used for:

- determining the order of popularity of portals/applications in order to propagate the content analyzed in this study,
- assessing which criteria influence this popularity and to what extent,
- comparing portals/applications between countries in order to establish basic principles of cooperation between them, especially if they are culturally distant or currently at a different economic level,
- creating a template (pattern), as a guideline for analysts of the selected issue and designers of portals/web applications (a template to follow, material for pre-design analyses, for establishing functionality and HCI (Human-Computer-Interaction) techniques and for comparing methods used to evaluate modern ICT tools).

Given the results obtained, they can be used to:

- identify the top-rated portals and thus encourage visits to them,
- identify the characteristic features and content that are best developed on individual portals, which will ensure their popularity,
- provide guidance on what to pay attention to when addressing portals/applications related to environmental and green energy content in global markets,
- show which multicriteria evaluation methods can be used to solve problems with data collection and processing, especially in the field of green energy, in a rational way,
- create a mapping of the best-rated attributes found in the most popular portals/applications in a given country and internationally, and then use it as a basis for designing a new, competitive portal/application against existing ones.

An example of how to proceed is presented below based on information concerning selected portals/applications operating in Poland. The results obtained as a result of the study for individual attributes of the most popular portals/applications in Poland are shown in Table 6. All attributes whose value exceeds the average are marked with the letter G (Good), those whose results were the highest - with the letter B (the Best), results below the average with the letter - P (Poor), and the worst - W (the Worst).

Table 6.

Mapping of average results of evaluation of attributes of the most popular portals/ applications in Poland

Poland	gramwzielone.pl	zielonagospodarka	wysokienapiecie.pl	globenergia.pl	wwf.pl
Legal aspects regarding the possibility of introducing green energy	W	B	G	P	G
Automated updates of the application	B	P	P	P	W
Availability of content regarding green energy	G	B	W	P	P
Filtering by national language	W	G	G	P	B
Information on claims and returns	P	W	P	P	B
Informative content on green energy	W	P	B	P	P
Intuitiveness	B	G	W	G	P
Existence and number of offered product/service categories	G	B	P	W	P
Catalog of cooperating companies, sponsors	G	B	P	P	W
Colour scheme	P	W	B	P	P
Convenience	W	P	B	G	P
Ease of use of categories related to green energy	W	P	P	B	G
Ease of navigation	G	P	W	P	B
Main menu	W	P	G	B	G
User-friendliness	G	W	P	P	B
Methods of payment for products or services	W	P	B	G	G
System of ratings and comments on content related to green energy	P	P	W	P	B
Visualization	B	G	P	W	G
Convenience of use	P	W	P	B	G
Search for green energy content	P	W	B	P	P
Readability of text regarding green energy	W	P	P	B	P

Source: own work based on survey results.

With the above table, the portal/application designers can adopt the following procedures: in Table 6, obtained by the conversion method, take the highest values in each row (B) and analyze the reasons why they were considered the best by the respondents. On this basis, build a new portal/application, taking into account only the best results and using them as a model. If they wish to obtain even better knowledge then they should:

- check the average ratings among the respondents for the attributes to determine to what extent they fulfill their requirements (based on the scoring analysis),
- then it is necessary to familiarize themselves with the worst (W) characteristic features of individual portals and determine what can be improved in them, not just by modeling them on those that were defined as the best ratings (B). Of course, they can try to build a portal/application based on the principle that only those attributes that received the worst ratings in the rows are improved, but it appears to be a more challenging path than using the best ones as models,
- another approach could be to improve all "good" but not the best-rated attributes marked with the letter (G) and bring them up to the level of the best (W).

Naturally, this is just one of the possible directions for using the obtained results in the process of improving the design of web portals/applications. Nevertheless, in addition to typical applications, it can be helpful in project management.

The research encountered limitations that may affect the results and their generalizability:

- comparisons and analyses were conducted for four selected countries: Poland, Türkiye, the PRC, and Spain,
- a survey was conducted to obtain data mainly in academic environments, among online shoppers who are the most active Internet users, but with limitations regarding age groups and financial resources (Batorski, 2015). Surveys conducted outside of the university were also filled out primarily by young people who use the Internet on a daily basis and generally have a positive attitude towards environmental protection,
- the impact of selected attributes was analyzed only for the five most popular green energy websites and applications indicated by respondents in the analyzed countries.

The above-mentioned limitations can be minimized in future studies by:

- expanding the number of analyzed countries to include, for example, North or South American countries, or African countries,
- collecting data involving a research sample outside of the academic environment while still maintaining the database on university servers for security reasons,
- analyzing the ratings of attributes for websites and internet applications related to green energy in the analyzed countries using various multicriteria methods to obtain results that allow for more unambiguous decisions.

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