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Qualitative Analysis of Household Energy Awareness in Poland

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Abstract: Because of disruptive changes in energy businesses and services, as well as changes in people's lifestyles around the world, energy demand and consumption have risen quickly in recent decades. A household energy awareness literature review was conducted. The survey was conducted in Poland with over 1097 respondents. Additionally, it was given a qualitative analysis. At the same time, in order to consider why energy consumption in households is increasing, a traditional quality management tool was used—the Ishikawa diagram. The Pareto–Lorenz diagram was used to analyze the causes of the increase in energy consumption in households. A model of the causes of increasing energy consumption in households has been built. The researchers calculated the chi-square test, which allows them to determine Pearson's C coefficient. The C-Pearson coefficient can be calculated using the Chi square value. The results of the study clearly show that the respondents have knowledge of energy and the factors that influence the increase in its consumption but are not aware of why energy should be saved and what it means for the environment. The authors propose ways to build the awareness of household users through a modern quality management tool called the interrelationship diagram.

Keywords: customer awareness; energy; Ishikawa diagram; Pareto–Lorenz diagram; model of the causes of increasing energy consumption in households; interrelationship diagram

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1. Introduction

In today's world, energy conservation and renewable energy consumption are major concerns for both developed and developing countries [1]. The household energy consumption sector is changing as new technologies and regulations for transitioning to renewable energy emerge [2,3]. Global warming and technological improvements are driving the energy domain's renewal, which has the potential to transform the way we produce and consume energy. The role of awareness is important in affecting household energy consumption and pro-environmental choices [4–8]. Both accessibility and affordability of using energy improves social wellbeing in terms of health status. Awareness alone does not necessarily reduce energy consumption, but subjective factors can play important roles. Moreover, household's subjective attitude can significantly influence decisions to purchase more energy efficient products and encourage pro-environmental choices [5]. Research shows that most household consumers live in outdated buildings [9–13]; thus, energy awareness issues seem to be important. There are studies that have examined household energy issues and their awareness [9–14] but in terms of energy saving methods, energy efficiency or renewable energy sources. This case study aims at filling this research gap by examining qualitative consumer energy awareness by using chosen traditional and modern quality management tools in Poland [9,10]. Household consumers will become respondents (1097 of respondents have taken part in the survey) for the purpose of testing energy awareness.

2. Review of Literature

The European Union's energy policy emphasizes the importance of reliable energy supply, sustainable energy usage, and reduced reliance on fossil fuels as well as increased energy efficiency [11]. The world's current energy consumption is around 9000 MTOE, which has doubled between 1971 and 2014; however, total primary energy supply has increased by nearly 2.5 times during the same period, causing serious environmental consequences, particularly in heat and electricity production, which accounts for 25% of global greenhouse gas emissions [12]. The following development trends affecting global energy markets can be noticed in particular:

1. Electrification: The need for cleaner, more cost-effective energy as a result of global warming is driving the electrification of transportation and a number of other sectors. Power-to-X [13] is a major technology that supports this growing trend. As the amount of electricity transmitted and delivered increases, flexibility management will become increasingly important.
2. Renewable energy: Environmental and economic factors are driving an increase in the use of renewable energy sources. Solar and wind energy are already low-cost sources of new electricity generation capacity. Because solar and wind power output are fickle and cannot be managed in the same manner as fossil-fuel power plants, this development will make flexibility even more vital.

The trend toward embedded connectivity and processing in products and building automation systems is enabling real-time control of distributed energy resources such as freezers, refrigerators, water boilers, electric vehicle (EV) charging, and heating, ventilation, and air-conditioning systems (HVAC). The party in possession of these flexibility resources will be a crucial player in future energy markets, as demand-side flexibility will be the primary source of flexibility. The main hurdle to energy efficiency is always a lack of knowledge or awareness [14,15]. Dahle and Neumayer [16] identified a number of obstacles that can hinder the greening process, including financial, cultural, and urbanization issues. The second impediment to the greening process was lack of awareness. People cannot be expected to change their behavior, and thus their culture, unless they are conscious of the need to do so. This suggests that if individuals are unaware of the necessity of energy conservation, they will not take any steps to conserve it.

Many studies [17–25] have looked at the impact of information availability and energy awareness on consumers' intentions to engage in energy-related behavior. Due to increased digitalization [4–6,26–30], an increase in renewable energy sources, and rapid technological progress, energy markets are currently developing [30,31]. To adapt to these changes, energy companies are being driven to develop new business models and adjust their business practices. Together with rapid technological development, the ever-increasing amounts of energy data acquired from smart devices, appliances, and systems (hereinafter referred to as "devices") are enabling the emergence of new types of commercial prospects. Energy data can be used for a variety of purposes, including developing new products and services, monitoring and controlling devices and systems, and making real-time decisions. Artificial intelligence (AI) technologies, in particular, are enabling intelligent services as well as the automation of evidence-based business decision making. Smart and sensible data utilization allows for the emergence of new actors in the domain, as well as provides a competitive edge to existing actors playing new roles [31]. Many research studies have shown that how families respond to energy feedback varies greatly [32,33].

Research shows that household behavior affects energy consumption [34]. Many social and environmental psychological studies [34] have been conducted to better understand why this is the case and how such behaviors might be altered to minimize energy use.

There are no empirical studies investigating how household awareness influences on their energy consumption. This gap is also considered a further perspective of empirical research to identify awareness-building methods and tools. Three key outcomes of solar panel adoption, according to Claudy et al. [15], reflect customers' perceptions of their benefits: (1) energy cost savings, (2) environmental benefits, and (3) independence from

traditional energy sources. Socioeconomic parameters such as energy price, consumer attitude, economic position, and environmental issues such as ultrafine dust concentration were studied in order to find factors impacting household energy usage. According to Bhattacharjee and Reichard, it is vital to examine not only human behavior, but also non-human factors such as weather and energy pricing in order to improve energy efficiency and decrease the constant growth in household energy use [35]. A review of the effect of behavioral intervention on household energy savings [36], a review of the impact of the intervention, such as providing customized information and feedback, on changes in household energy consumption and energy-related behavior [37], and a study that examines which type of feedback is most effective in reducing household power consumption [38], are all examples of behavioral intervention research.

By engaging users with issues such as attitudes, knowledge, awareness, and skills [39], the behavioral approach to energy saving offers significant opportunity. However, raising awareness is the first step toward behavioral changes because it is the seed for future changes [40,41]. There will be no realistic action to conserve energy without awareness. According to one notable report [42], it is critical to raise awareness in the energy sector. The importance of awareness in influencing home energy use and pro-environmental choices cannot be overstated. In terms of health, both accessibility and affordability of energy use improve social wellbeing. Although awareness alone is not sufficient to reduce energy consumption, subjective variables can play a significant influence. Furthermore, a household's subjective attitude can have a big impact on whether or not they buy more energy-efficient products and support pro-environmental choices [3].

Energy conservation can be difficult to achieve without energy awareness, which can lead to energy waste [43]. The use of information to encourage energy conservation is widespread [44]. Various types of information can be presented. First, by giving information about energy-related issues, households can gain a better understanding of topics such as global warming. Second, by offering information about behavioral options for reducing energy use, households can gain a better understanding of how they might save energy. Geller (1981) [44] discovered that a workshop on energy conservation resulted in increased conservation knowledge but no behavioral changes. Staats, Wit, and Midden (1996) [44] reviewed a mass media campaign on global warming and found that public awareness of the issue had increased. Choong developed the Conceptual Model of Energy Awareness Development Process (CMEADP) as a tool for facilities and energy managers to increase energy awareness and behavior [43], while Mohammed et al. [45] created a development process model. Researches Keles et al., Cao et al., Jebaraj et al., Bhattacharyya et al., Droste-Franke et al., and Despréset et al. [46–51] formalized energy models, from which energy policy recommendations are derived, as useful for strategic decision making. However, developed awareness is insufficient because awareness and behavior do not occur simultaneously. Changing a participant's understanding about energy and conservation is easier than changing their attitudes [52]. Similarly, persons who understand the necessity of energy conservation and are aware of energy saving techniques may not put them into practice.

Between 2005 and 2017, home energy use fell by 0.6 percent per year. Improvements in household energy efficiency offset the increased number of appliances and the increased floor area of residences, resulting in this dropfina [53]. Figure 1 shows the evolution of energy consumption in households in 2017–2019. It can be seen from the picture that the most energy-intensive consumption in all years is space heating, followed by water heating and lighting. In most European Union nations (including Poland), transportation is the primary source of energy consumption. Industry consumes 24.6 percent of energy in the EU, followed by transportation (31.3 percent), services (13.9 percent), and households (26.7 percent).

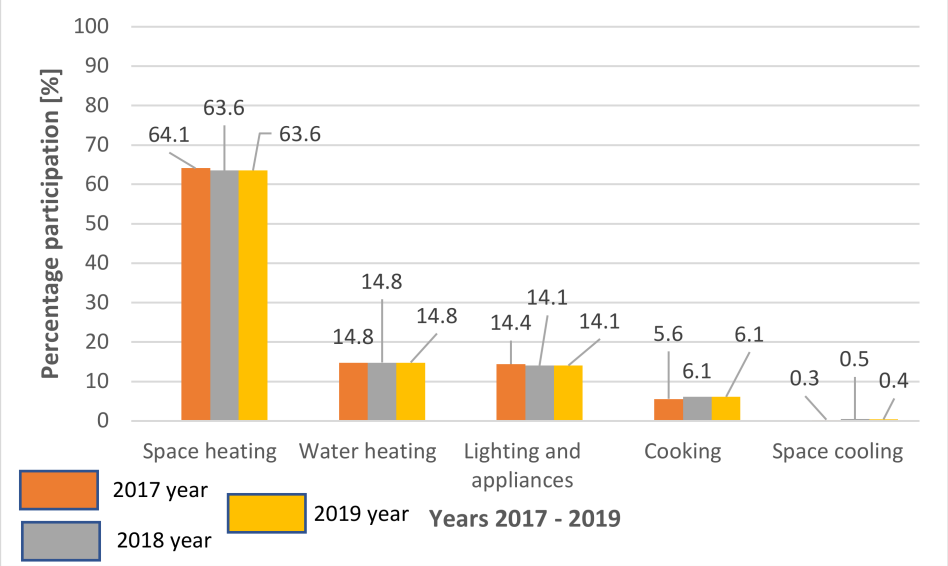

Figure 1. Energy consumption in EU households in 2017–2019 years. Source: own study, based on [54,55].

In 2019, homes accounted for 26% of final energy consumption in the EU, or 17% of gross inland energy consumption. In 2019, European homeowners used the bulk of their energy to heat their houses (64 percent of total residential energy consumption), with renewables accounting for more than a quarter (28 percent) of total residential energy consumption. Poland produced roughly 158 TWh of electricity in 2020, which is 4.0 percent less than in 2019. Coal was used to generate more than 70% of the electricity [11]. According to the OECD report Towards Sustainable Household Consumption Trends and Policies in OECD Countries, energy consumption in OECD countries increased by 36% between 1973 and 1998 and is expected to rise another 35% by 2020. Electricity usage for commercial and residential applications accounts for 30% of overall energy consumption, making it the two fastest expanding segments of global energy use, alongside transportation. It has also been projected that the amount of homemade food consumed by farms has increased, which has an indirect environmental impact in the form of mostly utilized energy and generated trash [56,57]. In addition, according to the OECD's Greening Household Behavior report in 2011, it was expected that public policy will play a significant impact in the years ahead [58]. Since 2006, coal's proportion of electricity production in Poland has been declining, with gas and renewable energy sources taking its place [59]. In Poland, transportation consumes 33% of total energy. Households are the second and third largest "consumers," respectively. The pandemic's impact on the energy system was felt in Poland, particularly in spring 2020; however, its economic and energy system effects faded subsequently. Market trends (energy, and technology prices) play an essential impact in the short term and will continue to do so. Technological trends related to the decarbonization of the sector will play a critical role in the evolution of the power system and its environment in the medium and long term. Renewable energy, energy storage, and electromobility all experienced rapid growth in 2021. In addition, new measuring methods were being tested and introduced, allowing for the use of high frequency data (HFD) and accuracy data. Hydrogen technology may become more popular in the long run [60,61].

3. Materials and Methods

The objective of this research is to build consumer awareness of energy consumption in households. This study concerned only the household approach [57,58], as consumers treat energy consumption quite differently in the workplace [59] and in public places than at home. Despite thinking about the sustainable development of the planet, the proper use

of resources, or the effective use of tools for energy resources, man will involuntarily place his own economic benefit in first place. The examination of the above hypothesis-based research question is warranted in light of the literature review and analysis. The conducted research shows that the structure of the analyzed attitudes [60], views, and behaviors [25,61] is derived from the knowledge about energy management [28,62].

The research used the CAWI [63] questionnaire, the aim of which was to examine the awareness of consumers in households in terms of energy consumption [28,64,65]. The minimum sample size was determined, and the method of communication with respondents was determined. Due to the timing of the pandemic and the size of the sample, the questionnaire was made available online [66,67]. The research was conducted over a quarterly period in 2021 in Poland. There were 1097 respondents, of which 20% were women and 80% were men. The gender analysis showed that men in Poland are responsible for managing household energy consumption [28]. After the research, the results were analyzed and conclusions were formulated. The research questionnaire contained 40 targeted questions, solving the research problem. The aim of the study is to conduct a qualitative analysis of the awareness of household consumers [68–70] in the field of energy consumption using the Ishikawa diagram [9,51], the Pareto–Lorenz chart [9,51], and the relationship diagram [9,51], and to build a model of the causes of the increase in energy consumption in households [51–53]. This paper poses the following research questions:

- Are people aware of how much energy they use?
- What is the model for the causes of rising home energy consumption?

The chi-square test was used by the researchers to determine Pearson's C coefficient. Calculating the C-Pearson coefficient is made possible by the Chi square value.

4. Results

The Ishikawa diagram is one of the traditional quality management tools [62–68], which is often also used by other management systems. Ishikawa is used to determine the cause and effect relationships of a given problem. It is based on a graphical representation of the analysis of the relationship between the causes that trigger a specific problem [69]. The tool helps to locate the cause of the problem [28,70]. The following question was analyzed: Why is energy consumption increasing among households? (Figure 2). The main factors influencing the increase in household energy consumption have been analyzed. The reasons for the increase in energy consumption are mainly related to: (1) remote work introduced in connection with the pandemic, (2) introducing innovations to the market by companies, (3) the desire of consumers to be modern, and lack of knowledge of the signs on the products (4). Most of the respondents' represented three or more in household size (42%). Other respondents represented single family (35%), two family (17%) and no family (6%).

The kind of lighting used in respondents' houses is presented in Table 1.

Traditional light bulbs are the most commonly used kind of lighting (58%). Table 2 shows elements decisive in choosing a light source.

It can be seen that the elements most often decided about choosing lighting are appreciation of the quality of traditional light bulbs-their color and natural (36.49%). After that, care about environmental aspects (34.94%) and the advantages of tradi-tional bulbs (22.37%). Table 3 presents energy eaters in respondents' homes.

The biggest energy consumers are the heater (42.26%), air conditioner (36.08%), and refrigerator (27.83%). Table 4 shows elements taken into account by respondents when reading energy labels. It can be seen that the most important labels are device energy class (47.01%) and water consumption (28.86%).

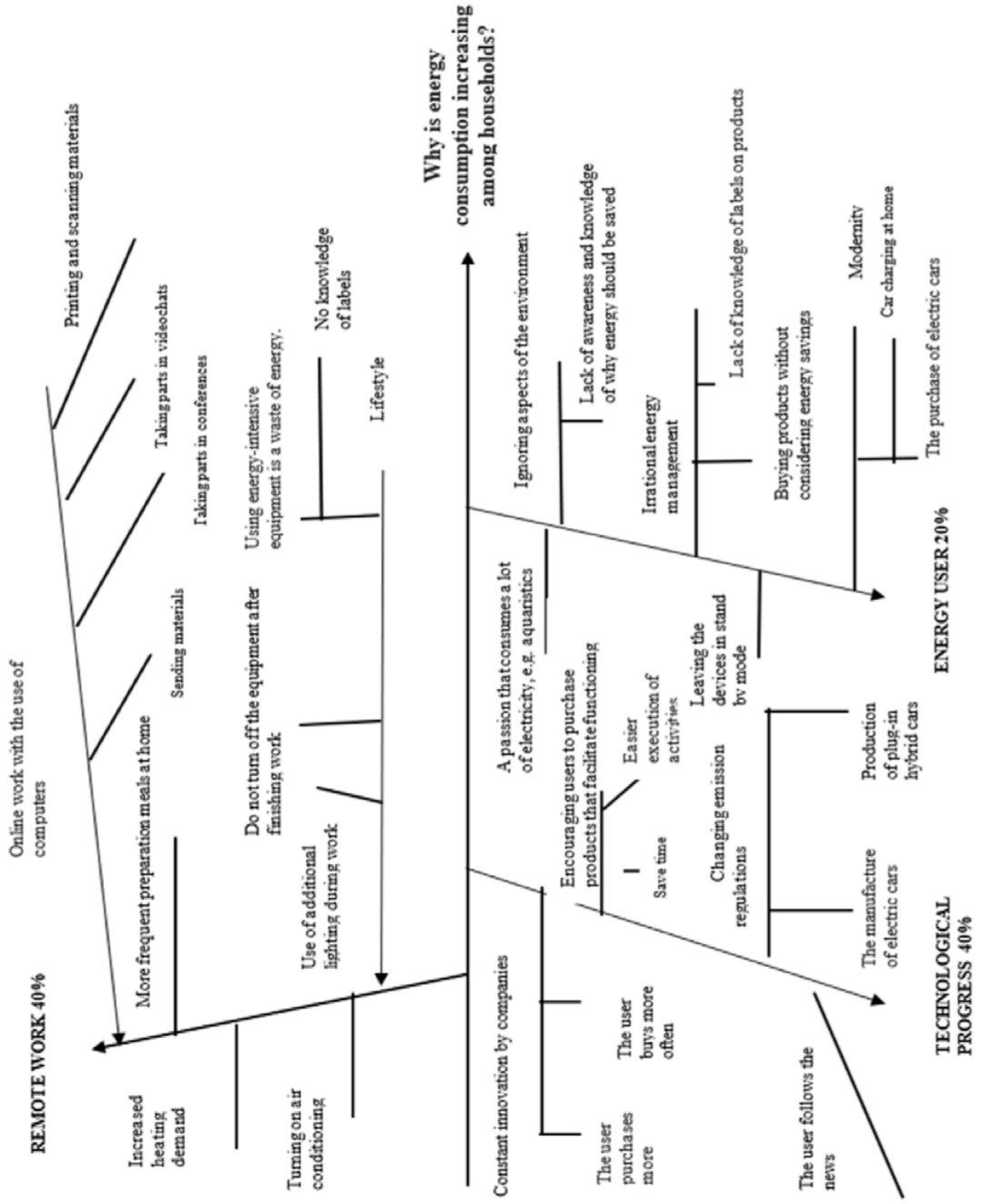

Figure 2. Ishikawa diagram base on the question: Why is energy consumption increasing among households?

Table 1. Kind of lighting using in respondents' home.

Kind of Lighting	Share
LED sources	34%
traditional light bulbs	58%
compact fluorescent lamps	8%

Source: own study.

Table 2. Decisive elements of a light source.

Elements	Share
taking care of environmental aspects	34.94%
appreciation the advantages of traditional light bulbs	22.37%
appreciation the quality of traditional light bulbs—its color and natural appearance of illuminated objects	36.49%
appreciation the natural color of traditional light bulbs	6.2%

Source: own study.

Table 3. Energy consumer in respondents' home.

Elements	Share
heaters	42.26%
refrigerators	27.83%
air condition	36.08%
kettles	18.55%
electric cookers	18.55%
heat blowers	10.3%
freezers	10.3%
coolers	17.52%
washing machine	10.3%
microwave	11.34%
computer	4.12%

Source: own study.

Table 4. Elements taken into account by respondents when reading energy labels.

Elements	Share
device energy class	47.01%
annual energy consumption	21.54%
water consumption	28.86%
noise level	2.59%

Source: own study.

In accordance with Table 5, the electricity consumption of respondents per annum in most cases is under 10,000 kW h (45.56%).

Table 5. Electricity consumption of respondents per annum.

Consumption/Year	Share
Under 10,000 kW h	45.56%
10,000–20,000 kW h	15.46%
20,000–40,000 kW h	6.18%
Over 40,000 kW h	4.12%
I do not know	28.68%

Source: own study.

Not many respondents reported having their own energy production, consisting mainly of solar panels (22.4%) and solar collectors (9.4%). Only 10.6% of respondents have electric cars (Table 6).

Table 6. Energy units use in respondents house.

Energy Units	Share
Electric car	10.6%
Solar panels	22.4%
Solar collectors	9.4%
Home automation system	32.9%
Other	24.7%

Source: own study.

The electricity consumption (kWh/year) of the respondents is presented in Table 7. Direct electrical heating was the most used heating method (38.7%), followed by gas (22.6%).

Table 7. Heating methods use in respondents house.

Heating Methods	Share
Direct electrical heating	38.7%
Storage electric heating	8.6%
Oil/wood/pellet	8.6%
Geothermal	4.3%
Exhaust air heat pump	1.1%
Air–water heat pump	4.3%
Hearth	2.2%
Gas	22.6%

Source: own study.

Table 8 shows smart grid solutions known to respondents. The table shows that the most known consumers are fiber optic (48.4%), public cellular networks (40%), and access to the public Internet via XDSL (30.5%).

Table 8. Smart grid solutions known to respondents.

Smart Grid Solutions	Share
Fiber optic	48.4%
Copper narrowband line carrier systems for transmitting matter	11.6%
Broadband power line support systems	22.1%
Wireless Mesh, Wimax	32.6%
Public cellular networks (GPRS, UMTS, LTE)	40%
Access to the public Internet via XDSL	30.5%
I do not know any of this	28.4%

Source: own study.

Table 9 presents the behaviors of respondents that increase energy consumption. These include primarily leaving the devices in stand-by mode (39.65%), forgetting about turning off the lights when leaving (22.5%), not using household appliances, and low-low electricity consumption (20%).

Table 9. Behavior of respondents that increases energy consumption.

Behavior	Share
Leaving the devices in stand-by mode	39.65%
Forget about turning off the light when leaving	22.5%
Not using energy-saving light bulbs	10.84%
Not using of households appliances and low electricity consumption	20%
Font cook energy-saving	7.01%

Table 10 shows the frequency of the increase in energy consumption in households.

Table 10. Reasons for increasing energy consumption by frequency of occurrence.

Reason Symbol	Reasons for Occurrence	Type of Reason	Percentage Share	Cumulative Value
P1	Leaving the devices in stand-by mode	Remote work	39.65	39.65
P2	Forget about turning off the light when leaving	Energy user	22.5	62.15
P3	Not using energy-saving light bulbs	Energy user	10.84	72.99
P4	Not using of households appliances and low electricity consumption	Energy user	20	92.99
P5	Font cook energy-saving	Energy user	7.01	100

Source: own study.

Based on Table 10, a Pareto–Lorenz diagram was built (Figure 3) that shows the reasons for the increasing energy consumption in households.

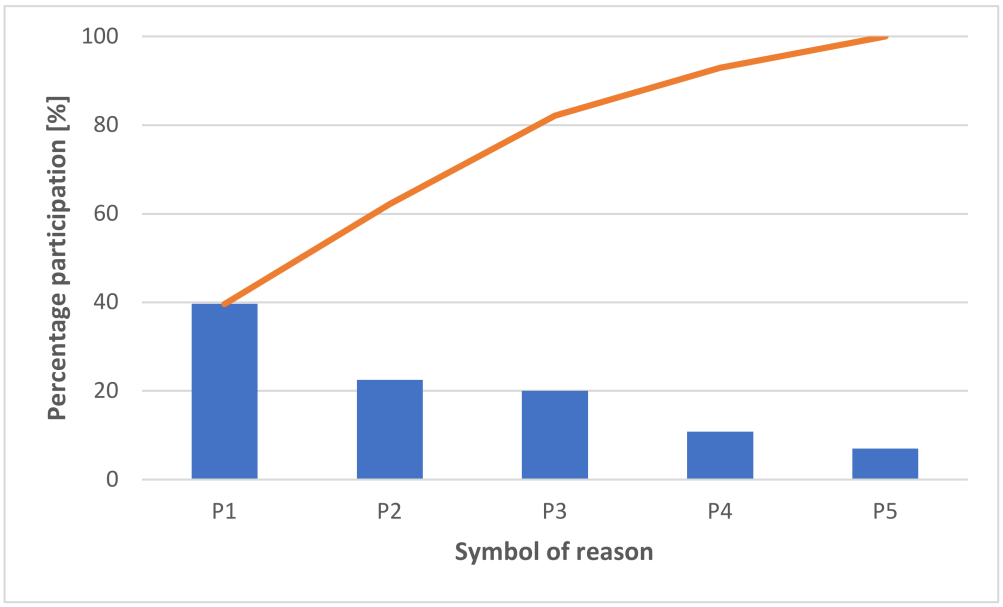

Figure 3. Pareto–Lorenz diagram causes of increasing energy consumption in household.

In order to determine how many reasons affect energy consumption, the Pareto–Lorenz diagram (Table 10) was used. The Pareto–Lorenz diagram is a tool that enables the scheduling of factors influencing the analyzed issue [61–65]. The analysis of Figure 3 shows that 21.94% of the reasons that include leaving the devices in stand-by mode (P1) and forgetting about turning off the lights when leaving (P2) affect 62.15% of the participation in the increasing energy consumption in households. It seems that these reasons may be caused by a lack of instilling in households the need for ecological thinking and concern for the welfare of the planet. Consumers are oblivious to the importance of ecology and energy conservation in today's fast-paced world. It turns out that simple activities such as turning off the lights and turning off standby mode devices are a challenge for households on the way to low energy consumption.

On the basis of the obtained results, we can observe that remote work is the reason that has the highest level of influence on increasing energy consumption in households. Another important factor is energy use. After data analysis, we can build a model of reasons connected with increasing energy consumption based on their importance. The model is in Figure 4.

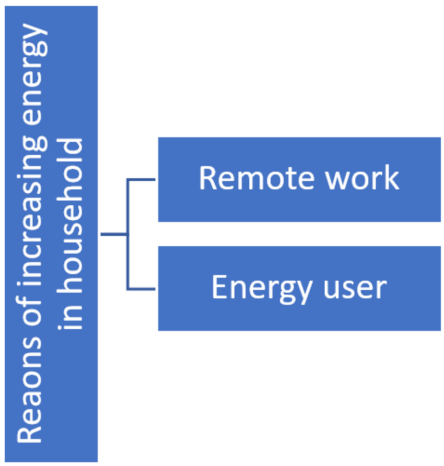

Figure 4. The model of reasons of increasing energy consumption in household.

Regarding the two main reasons mentioned in the previous analysis, for the increasing energy consumption in households, we can distinguish the two main groups in the model: remote work—highest importance, total value 39.65; and energy consumer—medium importance, total value of 62.15.

The next step of research is the calculation of the chi-square test, which allows for the determination of Pearson's C coefficient [71,72]. The Chi square value allows one to calculate the C-Pearson coefficient, which takes values from 0 to 1. The values mean:

0–0.2—an extremely weak relationship
0.2–0.4—weak relationship
0.4–0.6—moderate relationship,
0.6–0.8—a strong relationship
0.8–1.0—a strong relationship.

Table 11 presents the results of the C-Pearson coefficient at a significance level of 0.05.

Table 11. The results of the C-Pearson coefficient at a significance level of 0.05.

Dependences	C-Pearson Coefficient Value
type of lighting used/knowledge about intelligent energy systems	0.74
traditional lighting/price	0.62
energy efficiency/light source price	0.53
reading energy labels/energy consumption	0.8
energy class/knowledge of symbols	0.45
bad habits/energy efficiency	0.27
electric heating/annual consumption	0.46
support for renewable energy/familiarity with symbols	0.69

Source: own study.

The results presented in Table 11 show a strong relationship between the type of lighting used and the knowledge about intelligent energy systems, where the value of the C-Pearson coefficient is the highest and amounts to 0.74. The results also show a strong relationship between support for renewable energy and familiarity with symbols on products and between traditional lighting and the price paid for energy. The analysis of the results shows that a great influence on building consumer awareness of households is their desire to pay lower energy bills. In order to pay lower bills, they need to learn about technological innovations in the field of energy.

The last stage is to analyze the best way to build household awareness. It was made by an interrelationship diagram (Figure 5). A dependency diagram, relationship tree, or cause dependency diagram is another name for the diagram. It is a method of elucidating causal links. It was created to demonstrate logical links and interconnections among the various components that influence the issues under consideration. The relationship diagram resembles the Ishikawa Cause and Effect Diagram in that it not only specifies and depicts cause–effect linkages, but also cause–cause relationships [71].

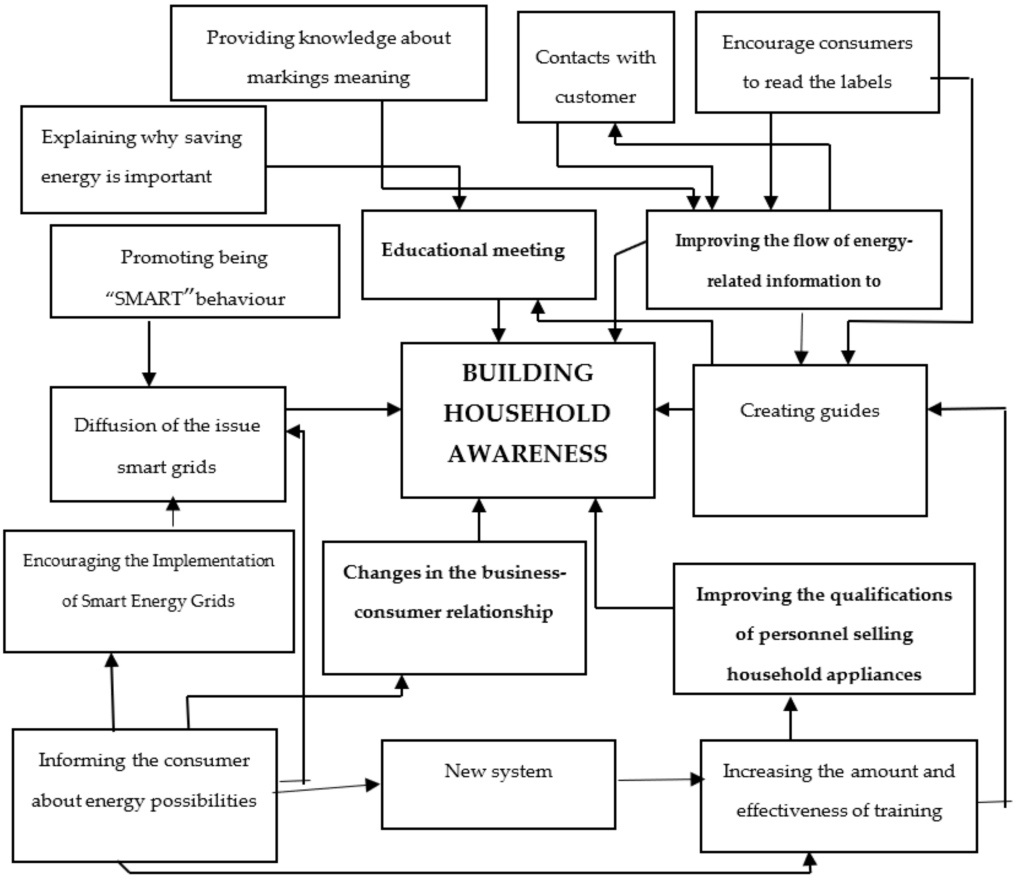

Figure 5. The interrelationship diagram for the problem: building household awareness.

Analysis of the diagram shows that in order to build awareness among households, service providers should act against them. Enterprises should change their approach to the customer in the enterprise–customer relationship to focus on informing the customer about the benefits of taking care of energy. The authors also believe that a new system should be implemented that will help consumers understand how to buy products that use as little energy as possible through educational activities and employees.

5. Discussion and Conclusions

In the modern economy, electricity has become the most important factor in ensuring any country's socioeconomic progress and improving the quality of life of its population. There is an essential component of life for every modern person. It improves society's functioning by providing adequate conditions for labor, development, and rest. People can live more comfortably and safely due to electricity. Electricity is used in all aspects of human existence to aid communication, transportation, and trade.

One of the biggest problems in the electricity market in Poland is the high level of so-called energy illiteracy, which is influenced by the significant technical, legal, economic, and organizational complexity of this market. Consumers have an average interest in the subject of electricity, as well as that they are not sure of their knowledge about their

rights. Awareness of the rights of energy consumers is also low. Households must adopt sustainable consumption patterns as a result of active government policy that is tailored to unique national, regional, and local circumstances. One must pay special attention to raising customer awareness and promoting energy usage behaviors. Inconsistent with the principle of balanced consumption, the major causes are a lack of understanding, submitting to stereotypes, as well as a lack of knowledge and comfortable life without considering the implications of one's actions on the environment.

Energy awareness is necessary for a person to understand his own motivations as well as activities in the natural world. Based on our examination of the current environmental threats, we may infer that one. The fundamental reason is that a big portion of the population is unaware of the problem. Indifference, recklessness, and a lack of sense of responsibility for the state of the environment are all manifestations of society, and often a lack of culture in this area. Electricity has become a critical aspect in the modern economy, ensuring each country's socioeconomic progress and improving the quality of life of its residents. There is an essential component of life for every modern person. It improves society's functioning by providing adequate conditions for labor, development, and rest. People can live more comfortably and safely due to electricity. Electricity is used in all aspects of human existence to aid communication, transportation, and trade. Consumers in the energy market lack the appropriate degree of economic and expert knowledge due to the scale and rate of change as a result of ongoing progress. Because the electrical market in its current form is unfamiliar to Polish consumers, they lack the necessary information.

In today's economy, the consumer is more likely to be confronted with an abundance of market information than with a scarcity of it. Quality, as well as the completeness of information reaching the consumer, is a major issue. As a result, in the decision-making process, the customer should actively seek and analyze market information. It is important to underline that this is a difficult process. Consumers are constantly bombarded with information from a variety of sources and in a variety of formats. The following questions were asked in the paper:

- Are people aware of how much energy they use?

Research shows that respondents have knowledge of how to conserve energy but are not fully aware of the consequences of neglecting the aspects of turning off the lights or not turning off the equipment when leaving the house. This is most likely related to a comfortable life and a fast-paced lifestyle that causes them to forget to conserve energy. Therefore, it seems that in order to reduce energy consumption, it is important to undertake educational activities that not only build awareness but also make people aware of the importance of creating good habits. When buying new devices, respondents pay attention above all to the price. Their awareness that the purchased device will work has been working in the household for years. That is why it is important in the purchase stage, as there is a conscious estimation of the total cost they include, apart from one-off expenses. In order to raise awareness, guides would be helpful, which could help consumers save energy. The purchasing of a device is an example: Select a device that is the appropriate size for your requirements. It is a waste of electricity to have a refrigerator that is too big. Note that the class (the letter on the energy label) is a combined indicator of annual energy usage and refrigerating plant capacity. This indicates that a large refrigerator with an energy class of A+ will use more energy than a small refrigerator with an energy class of A. As a result, when purchasing a device, consider its size first, and then compare devices of the same energy class with the same capacity. Based on data analysis, the authors claim that households should be aware of the necessity of energy conservation and that they will take steps to conserve it.

- What is the model for the causes of rising home energy consumption?

In the energy consumption model, it is worth paying attention to the times of the pandemic, which caused the consumer to spend more time at home (remote work), use the equipment more and cook more. The second element is the user himself, who, in pursuit

of an easier lifestyle, buys more equipment. According to studies, users are unaware of all the indicators on products. The introduction of Smart Energy Grids brings with it huge lifting opportunities and awareness of one's own household appliances' energy use in homes, and may lead to major cost savings for households as well as environmental benefits for the environment. Understanding and modifying home energy usage habits are thought to be effective approaches to boost energy efficiency and promote conservation. Traditional energy systems are being digitized as traditional and developing information and communication technologies (ICTs) gain traction in the energy sector. Energy big data offer a new way to evaluate and comprehend individual energy use patterns, allowing for greater energy efficiency and conservation [72–75]. Energy conservation is a cost-effective and critical method in light of the need for low-carbon society to combat global warming. This should be on the local government's priority list: local policymakers should start energy-saving awareness initiatives to close the gap between awareness and practice. The public sector should take a proactive role in influencing people's attitudes about energy conservation and renewable energy consumption, and employ mass media to effectively spread the message [1,76].

Researchers must determine what key concerns are related to household energy consumption and completely examine which issues are expected to gain attention in the future to contribute to research in the household sector in response to policy, environmental, and technology developments [2]. The amount of energy consumed by households accounts for a significant share of total energy consumption. Household energy use accounts for almost a third of global primary energy demand and has a considerable environmental impact [77]. Individuals, households, local communities, corporate environments, local governments, national governments, and international structures all experience changes in the domain of consumption [35,78,79].

The findings revealed a strong link between: the type of lighting used and understanding of intelligent energy systems; -support for renewable energy and familiarity with symbols on products; and conventional lighting and energy prices paid.

The examination of the data reveals that the desire to pay lower energy bills has a significant impact on raising consumer awareness in households. They must learn about technical developments in the sector of energy in order to pay lesser rates.

The problem presented in the introduction, described by a hypothesis and research problems, was supported by related research described in the literature. The conducted research allowed us to determine the reasons for the increase in energy consumption, and the construction of the energy consumption model allowed us to determine which factors influence the low awareness of households. Due to the use of a relationship diagram, actions were proposed that could raise the awareness of household. The research conducted fills the research gap, while previous research only indicated the level of awareness without giving a way to increase it. However, there is a lack of studies comparing the level of awareness in different countries. The selection of the research method and the use of quality management tools allowed us to determine which behaviors cause consumers to use more energy, what they know about energy saving, and what motivates them. The authors decided that the next step would be to compare countries to determine which country is more oriented toward the conscious use of water and energy resources in terms of sustainable development.

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References

1. Kim, S.; Lee, H.; Kim, H.; Jang, D.-H.; Kim, H.-J.; Hur, J.; Cho, Y.-S.; Hur, K. Improvement in policy and proactive interconnection procedure for renewable energy expansion in South Korea. *Renew. Sustain. Energy Rev.* **2018**, *98*, 150–162. [CrossRef]
2. Kim, M.; Park, C. Academic Topics Related to Household Energy Consumption Using the Future Sign Detection Technique. *Energies* **2021**, *14*, 8446. [CrossRef]
3. Tanner, C.; Wölfing Kast, S. Promoting sustainable consumption: Determinants of green purchases by Swiss consumers. *Psychol. Mark.* **2003**, *20*, 883–902. [CrossRef]
4. Lutzenhiser, L. A cultural model of household energy consumption. *Energy* **1992**, *17*, 47–60. [CrossRef]
5. Li, X.; Zhang, D.; Zhang, T.; Ji, Q.; Lucey, B. Awareness, energy consumption and pro-environmental choices of Chinese households. *J. Clean. Prod.* **2021**, *279*, 123734. [CrossRef]
6. Brandon, G.; Lewis, A. Reducing Household Energy Consumption: A Qualitative and Quantitative Field Study. *J. Environ. Psychol.* **1999**, *19*, 75–85. [CrossRef]
7. Steemers, K.; Yun, G.Y. Household energy consumption: A study of the role of occupants. *Build. Res. Inf.* **2009**, *37*, 625–637. [CrossRef]
8. Ekholm, T.; Krey, V.; Pachauri, S.; Riahi, K. Determinants of household energy consumption in India. *Energy Policy* **2010**, *38*, 5696–5707. [CrossRef]
9. Grossu-Leibovica, D.; Kalkis, H. Total quality management tools and techniques for improving service quality and client satisfaction in the healthcare environment: A qualitative systematic review. *SHS Web Conf.* **2022**, *131*, 2009. [CrossRef]
10. Daril, M.A.B.M. Rational Decision for Selection of Quality Tools and Techniques using Cosine Similarity. *Asia Proc. Soc. Sci.* **2022**, *9*, 273–274. [CrossRef]
11. Eurostat, M. *Energy, Transport and Environment Statistics*; Publications Office of the European Union Luxembourg: Luxembourg, 2019.
12. IEA. *Oil Crises and Climate Challenges: 30 Years of Energy Use in IEA Countries*; International Energy Agency: Paris, France, 2004.
13. Erlinghagen, S.; Markard, J. Smart grids and the transformation of the electricity sector: ICT firms as potential catalysts for sectoral change. *Energy Policy* **2012**, *51*, 895–906. [CrossRef]
14. Yik, F.W.H.; Lee, W.L. A Preliminary Inquiry into Why Buildings Remain Energy Inefficient and the Potential Remedy. *HKIE Trans.* **2002**, *9*, 32–36. [CrossRef]
15. Yik, F.W.; Lee, W.L.; Ng, C.K. Building energy efficiency and the remuneration of operation and maintenance personnel. *Facilities* **2002**, *20*, 406–413. [CrossRef]
16. Dahle, M.; Neumayer, E. Overcoming barriers to campus greening. *Int. J. Sustain. High. Educ.* **2001**, *2*, 139–160. [CrossRef]
17. Zainudin, N.; Siwar, C.; Choy, E.A.; Chamhuri, N. Evaluating the Role of Energy Efficiency Label on Consumers' Purchasing Behaviour. *APCBEE Procedia* **2014**, *10*, 326–330. [CrossRef]
18. Schwarzer, K.B.; Hansmann, R.; Popp, M.; Von Streit, A.; Binder, C.R. Energy efficiency standards of single-family houses: Factors in homeowners' decision-making in two Austrian regions. *Energy Environ. Res.* **2015**, *5*, 49–66. [CrossRef]
19. Dato, P. Investment in Energy Efficiency, Adoption of Renewable Energy and Household Behavior: Evidence from OECD Countries. *Energy J.* **2018**, *39*. [CrossRef]
20. Ma, G.; Andrews-Speed, P.; Zhang, J.D. Study on Chinese consumer attitudes on energy-saving household appliances and government policies: Based on a questionnaire survey of residents in Chongqing, China. *Energy Procedia* **2011**, *5*, 445–451. [CrossRef]
21. Zainudin, N.; Lau, J.L.; Munusami, C. Modelling household behavioural changes as an opportunity for sustainable home energy. *Environ. Econ. Policy Stud.* **2022**, *24*, 73–97. [CrossRef]
22. Schwarzer, K.; Da Silva, M.E.V. Characterisation and design methods of solar cookers. *Solar Energy* **2008**, *82*, 157–163. [CrossRef]
23. Tangari, A.H.; Smith, R.J. How the Temporal Framing of Energy Savings Influences Consumer Product Evaluations and Choice. *Psychol. Mark.* **2012**, *29*, 198–208. [CrossRef]
24. Claudy, M.C.; Peterson, M.; O'Driscoll, A. Understanding the Attitude-Behavior Gap for Renewable Energy Systems Using Behavioral Reasoning Theory. *J. Macromark.* **2013**, *33*, 273–287. [CrossRef]
25. Akroush, M.N.; Zuriekat, M.I.; Al Jabali, H.I.; Asfour, N.A. Determinants of purchasing intentions of energy-efficient products. *Int. J. Energy Sect. Manag.* **2019**, *13*, 128–148. [CrossRef]
26. Zywiolek, J.; Molenda, M.; Rosak-Szyrocka, J. Satisfaction with the Implementation of Industry 4.0 Among Manufacturing Companies in Poland. *ERSJ* **2021**, *XXIV*, 592–603. [CrossRef]
27. Rosak-Szyrocka, J.; Zywiolek, J.; Kulinska, E.; Matulewski, M. Analysis of Enterprises' Readiness in for Industry 4.0 Implementation: The Case of Poland. *ERSJ* **2021**, *XXIV*, 615–628. [CrossRef]
28. Rosak-Szyrocka, J.; Abbas, A.A.; Akhtar, H.; Refugio, C. Employment and Labour Market Impact of COVID-19 Crisis—Part 1—Analysis in Poland. *Syst. Saf. Hum. Tech. Facil. Environ.* **2021**, *3*, 108–115. [CrossRef]
29. Knez, M.; Jereb, B.; Jadraque Gago, E.; Rosak-Szyrocka, J.; Obrecht, M. Features influencing policy recommendations for the promotion of zero-emission vehicles in Slovenia, Spain, and Poland. *Clean Technol. Environ. Policy* **2020**, *23*, 749–764. [CrossRef]
30. Żywiołek, J.; Rosak-Szyrocka, J.; Mrowiec, M. Knowledge Management in Households about Energy Saving as Part of the Awareness of Sustainable Development. *Energies* **2021**, *14*, 8207. [CrossRef]

31. Immonen, A.; Kiljander, J.; Aro, M. Consumer viewpoint on a new kind of energy market. *Electr. Power Syst. Res.* **2020**, *180*, 106153. [CrossRef]
32. Nilsson, A.; Wester, M.; Lazarevic, D.; Brandt, N. Smart homes, home energy management systems and real-time feedback: Lessons for influencing household energy consumption from a Swedish field study. *Energy Build.* **2018**, *179*, 15–25. [CrossRef]
33. Mukai, T.; Nishio, K.; Komatsu, H.; Sasaki, M. What effect does feedback have on energy conservation? Comparing previous household usage, neighbourhood usage, and social norms in Japan. *Energy Res. Soc. Sci.* **2022**, *86*, 102430. [CrossRef]
34. Wood, G.; Newborough, M. Energy-use information transfer for intelligent homes: Enabling energy conservation with central and local displays. *Energy Build.* **2007**, *39*, 495–503. [CrossRef]
35. Bernard, J.; Delprat, S.; Guerra, T.M.; Büchi, F.N. Fuel efficient power management strategy for fuel cell hybrid powertrains. *Control. Eng. Pract.* **2010**, *18*, 408–417. [CrossRef]
36. Xu, Q.; Lu, Y.; Hwang, B.-G.; Kua, H.W. Reducing residential energy consumption through a marketized behavioral intervention: The approach of Household Energy Saving Option (HESO). *Energy Build.* **2021**, *232*, 110621. [CrossRef]
37. Abrahamse, W.; Steg, L.; Vlek, C.; Rothengatter, T. The effect of tailored information, goal setting, and tailored feedback on household energy use, energy-related behaviors, and behavioral antecedents. *J. Environ. Psychol.* **2007**, *27*, 265–276. [CrossRef]
38. Fischer, C. Feedback on household electricity consumption: A tool for saving energy? *Energy Effic.* **2008**, *1*, 79–104. [CrossRef]
39. Du, J.; Pan, W. Examining energy saving behaviors in student dormitories using an expanded theory of planned behavior. *Habitat Int.* **2021**, *107*, 102308. [CrossRef]
40. Chatterjee, C.; Halim, N.; Mozumder, P. Energy conservation and health risk reduction: An experimental investigation of punishing vs. rewarding incentives. *Environ. Econ. Policy Stud.* **2022**, 1–20. [CrossRef]
41. Wang, G. Evaluation and Analysis of High Quality Economic Development Indicators by the Analytic Hierarchy Process Model. *Sci. Program.* **2022**, *2022*, 1042587. [CrossRef]
42. UNEP. UN Environment Programme (NaN): Global Environment Outlook 4. UN Environment. Available online: https://www.unep.org/resources/global-environment-outlook-4 (accessed on 20 March 2022).
43. Wai, C.W. The Conceptual Model of Energy Awareness Development Process: The transferor segment. In Proceedings of the 2009 3rd International Conference on Energy and Environment (ICEE), Malacca, Malaysia, 7–8 December 2009; IEEE: Piscataway, NJ, USA, 2009; pp. 306–313, ISBN 978-1-4244-5144-9.
44. Winett, R.A.; Love, S.Q.; Kidd, C. The Effectiveness of An Energy Specialist and Extension Agents in Promoting Summer Energy Conservation by Home Visits. *J. Environ. Syst.* **1982**, *12*, 61–70. [CrossRef]
45. Mohammed, A.H.; Alias, B.; Wai, C.W. Energy awareness development process model. *Middle East* **2005**, *4*, 2–7.
46. Keles, D.; Möst, D.; Fichtner, W. The development of the German energy market until 2030—A critical survey of selected scenarios. *Energy Policy* **2011**, *39*, 812–825. [CrossRef]
47. Cao, K.-K.; Cebulla, F.; Gómez Vilchez, J.J.; Mousavi, B.; Prehofer, S. Raising awareness in model-based energy scenario studies—A transparency checklist. *Energy Sustain. Soc.* **2016**, *6*, 28. [CrossRef]
48. Jebaraj, S.; Iniyan, S. A review of energy models. *Renew. Sustain. Energy Rev.* **2006**, *10*, 281–311. [CrossRef]
49. Bhattacharyya, S.C.; Timilsina, G.R. A review of energy system models. *Int. J. Energy Sect. Manag.* **2010**, *4*, 494–518. [CrossRef]
50. Droste-Franke, B.; Paal, B.P.; Rehtanz, C.; Sauer, D.U.; Schneider, J.-P.; Schreurs, M.; Ziesemer, T. *Balancing Renewable Electricity*; Springer: Berlin/Heidelberg, Germany, 2012; Volume 40.
51. Després, J.; Hadjsaid, N.; Criqui, P.; Noirot, I. Modelling the impacts of variable renewable sources on the power sector: Reconsidering the typology of energy modelling tools. *Energy* **2015**, *80*, 486–495. [CrossRef]
52. Chen, C.; Nelson, H.; Xu, X.; Bonilla, G.; Jones, N. Beyond technology adoption: Examining home energy management systems, energy burdens and climate change perceptions during COVID-19 pandemic. *Renew. Sustain. Energy Rev.* **2021**, *145*, 111066. [CrossRef]
53. Final Energy Consumption by Sector and Fuel in Europe—European Environment Agency. Available online: https://www.eea.europa.eu/data-and-maps/indicators/final-energy-consumption-by-sector-10/assessment (accessed on 23 January 2022).
54. SEC(2011)1565 Impact assessment accompanying the Energy Roadmap 2050. Available online: https://ec.europa.eu/energy/sites/ener/files/documents/sec_2011_1565_part2.pdf (accessed on 4 January 2022).
55. Eurostat. Available online: http://ec.europa.eu/eurostat/ (accessed on 4 January 2022).
56. Paramati, S.R.; Shahzad, U.; Doğan, B. The role of environmental technology for energy demand and energy efficiency: Evidence from OECD countries. *Renew. Sustain. Energy Rev.* **2022**, *153*, 111735. [CrossRef]
57. OECD 2001. Environmental Outlook Report 2001. Available online: http://www.oecd.org/dataoecd/51/6/2088589.pdf (accessed on 2 January 2022).
58. OECD. *Greening Household Behaviour: The Role of Public Policy*; OECD: Paris, France, 2011; ISBN 9789264063624.
59. Lisowski, R.; Woźniak, M.; Jastrzębski, P.; Karafolas, S.; Matejun, M. Determinants of Investments in Energy Sector in Poland. *Energies* **2021**, *14*, 4526. [CrossRef]
60. Bergasse, E.; Paczynski, W.; Dabrowski, M.; de Wulf, L. The Relationship between Energy and Socio-Economic Development in the Southern and Eastern Mediterranean. *SSRN Electron. J.* **2013**, *76*, 112. [CrossRef]
61. Bukowski, M.; Majewski, J.; Sobolewska, A. Macroeconomic Electric Energy Production Efficiency of Photovoltaic Panels in Single-Family Homes in Poland. *Energies* **2021**, *14*, 126. [CrossRef]

62. Liliana, L. A new model of Ishikawa diagram for quality assessment. In *IOP Conference Series: Materials Science and Engineering*; IOP Publishing: Bristol, UK, 2016; Volume 161, p. 12099. [CrossRef]
63. Wong, K.C. Using an Ishikawa diagram as a tool to assist memory and retrieval of relevant medical cases from the medical literature. *J. Med. Case Rep.* **2011**, *5*, 120. [CrossRef]
64. Hidayah, E.N.; Veronica, G.; Cahyonugroho, O.H. Identification and Factors of Failure Risk in Refill Drinking Water Quality by Using Ishikawa Diagram. In *IOP Conference Series: Materials Science and Engineering*; IOP Publishing: Bristol, UK, 2021; Volume 1125, p. 12020. [CrossRef]
65. Idris, N.I.; Sin, T.C.; Ibrahim, S.; FadzliRamli, M.; Ahmad, R.A. Case Study of Coffee Sachets Production Defect Analysis Using Pareto Analysis, P-Control Chart and Ishikawa Diagram. In *Intelligent Manufacturing and Mechatronics*; Springer: Singapore, 2021; pp. 1295–1305.
66. Hisprastin, Y.; Musfiroh, I. Ishikawa Diagram dan Failure Mode Effect Analysis (FMEA) sebagai Metode yang Sering Digunakan dalam Manajemen Risiko Mutu di Industri. *Maj. Farmasetika* **2020**, *6*, 1. [CrossRef]
67. Leśniak, A.; Górka, M.; Skrzypczak, I. Barriers to BIM Implementation in Architecture, Construction, and Engineering Projects—The Polish Study. *Energies* **2021**, *14*, 2090. [CrossRef]
68. Goryńska-Goldmann, E.; Gazdecki, M.; Rejman, K.; Łaba, S.; Kobus-Cisowska, J.; Szczepański, K. Magnitude, Causes and Scope for Reducing Food Losses in the Baking and Confectionery Industry—A Multi-Method Approach. *Agriculture* **2021**, *11*, 936. [CrossRef]
69. Rosak-Szyrocka, J.; Knop, K. Quality Improvement in the Production Company. *Multidiscip. Asp. Prod. Eng.* **2018**, *1*, 521–527. [CrossRef]
70. Klimecka-Tatar, D.; Ingaldi, M.; Obrecht, M. Sustainable Developement in Logistic—A Strategy for Management in Terms of Green Transport. *Manag. Syst. Prod. Eng.* **2021**, *29*, 91–96. [CrossRef]
71. Chen, C.-K.; Salim, Y.; Reyes, L. Root Cause Investigation of Climate Change: A Two-Stage Interrelationship Diagram Analysis. In *Key Challenges and Opportunities for Quality, Sustainability and Innovation in the Fourth Industrial Revolution*; World Scientific: Singapore, 2021; pp. 393–417.
72. Zhou, K.; Yang, S. Understanding household energy consumption behavior: The contribution of energy big data analytics. *Renew. Sustain. Energy Rev.* **2016**, *56*, 810–819. [CrossRef]
73. Ingaldi, M.; Klimecka-Tatar, D. People's Attitude to Energy from Hydrogen—From the Point of View of Modern Energy Technologies and Social Responsibility. *Energies* **2020**, *13*, 6495. [CrossRef]
74. Nguyen, S.P. Mobile application for household energy consumption feedback using smart meters: Increasing energy awareness, encouraging energy savings and avoiding energy peaks. In Proceedings of the 2014 International Conference on Collaboration Technologies and Systems (CTS), Minneapolis, MN, USA, 19–23 May 2014; IEEE: Piscataway, NJ, USA, 2014; pp. 291–296, ISBN 978-1-4799-5158-1.
75. Björkskog, C.A.; Jacucci, G.; Gamberini, L.; Nieminen, T.; Mikkola, T.; Torstensson, C.; Bertoncini, M. EnergyLife. In Proceedings of the 12th ACM International Conference Adjunct Papers on Ubiquitous Computing—Ubicomp '10, Copenhagen, Denmark, 26–29 September 2010; Bardram, J.E., Langheinrich, M., Truong, K.N., Nixon, P., Eds.; ACM Press: New York, NY, USA, 2010; p. 361, ISBN 9781450302838.
76. Zhelykh, V.; Voznyak, O.; Yurkevych, Y.; Sukholova, I.; Dovbush, O. Enhancing of energetic and economic efficiency of air distribution by swirled-compact air jets. *Prod. Eng. Arch.* **2021**, *27*, 171–175. [CrossRef]
77. Han, X.; Wei, C. Household energy consumption: State of the art, research gaps, and future prospects. *Environ. Dev. Sustain.* **2021**, *23*, 12479–12504. [CrossRef]
78. Ghodsvali, M.; Krishnamurthy, S.; de Vries, B. Review of transdisciplinary approaches to food-water-energy nexus: A guide towards sustainable development. *Environ. Sci. Policy* **2019**, *101*, 266–278. [CrossRef]
79. Eid, M.; Nuhu, N.A. Impact of learning culture and information technology use on knowledge sharing of Saudi students. *Knowl. Manag. Res. Pract.* **2011**, *9*, 48–57. [CrossRef]