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An Innovative Approach to Energy Consumer Segmentation—A Behavioural Perspective. The Case of the Eco-Bot Project

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Abstract: Energy consumption impacts the environment, humans' well-being, comfort and quality of life. The article aimed to develop the original model of energy consumer segmentation, based on behavioural variables, which influence consumer decisions and motivations regardless of demographic, geographic and socio-cultural differences. The innovative contribution is the segmentation procedure, which fills the existing research gap and can be treated as a universal tool serving various groups of stakeholders for creating and implementing sustainable development policies. The methodology used for the segmentation is based on the original algorithm and involves classifying a consumer into the most appropriate group based on the measurement of the distance between the ideal class representative and a particular respondent. Several distance measures (e.g., Sokal–Michener, Goodall, Lin) were used, while the similarity of those classifications was verified using the adjusted Rand index. The segmentation involved adopting—a priori—five basic classes of consumers, varying in terms of motivation to save energy. The validation performed on a sample of 1606 respondents, carried out as part of the eco-bot project, verified both the classification approach adopted in the study and the accuracy of the assumptions. The application of the distance measures chosen for the study allowed for the assignment of 96.1% of the respondents to the appropriate classes, which yielded the following distribution: EI (33.9% of the respondents); DS (33.1%), AE (17.2%), O (7%) and I (4.9%).

Keywords: behavioural energy consumer segmentation; energy consumption; financial motivations; pro-environmental motivations; model segmentation

Citation: Słupik, S.; Kos-Łabędowicz, J.; Trzęsiok, J. An Innovative Approach to Energy Consumer Segmentation—A Behavioural Perspective. The Case of the Eco-Bot Project. *Energies* **2021**, *14*, 3556. https://doi.org/10.3390/en14123556

Academic Editors: Sergio Ulgiati and Marco Casazza

Received: 24 April 2021
Accepted: 10 June 2021
Published: 15 June 2021

1. Introduction

The contemporary socio-economic reality, in particular, one of the European Union countries where dynamic processes are underway and are shaped mainly by increasing globalisation and advancing climate change, requires a holistic approach to people and their needs. Particular emphasis is placed on the well-being of the consumer, while at the same time, the necessity for and importance of responsible actions aiming to ensure the best possible quality of life are also coming to the forefront. Consumption patterns have visibly evolved in the last two decades. Sustainable consumption [1–6] as a response to environmental and social problems is gaining significance. In contrast to overconsumption, perceived as a lack of environmental awareness [1], responsible, sustainable consumers are conscious of their impact on the environment and society and, while building their well-being, try to mitigate the threats resulting from their actions.

Micheletti [7] argues that attitudes are increasingly changing and individuals are becoming more sensitive to social needs and environmental problems, and these trends

are manifested in ethical consumption [8–10]. It stems partly from growing consumer knowledge and partly from choices determined by values, virtue and ethics [7].

In the literature, it is observed that sustainable consumption has developed into two approaches: weak (efficiency-oriented so as to improve the quality of life) and strong [1,11]. In the latter case, apart from adopting the greening of consumption [12,13], it is necessary to change its volume and patterns, link consumption decisions with social responsibility, transform lifestyles, and maintain a sense of community [1,11,14].

For many years, researchers have been asking the question about what characterises and differentiates individual consumers. What causes the consumer to behave in a particular way? What distinguishes green consumers from other consumers? Why do some consumers seem more rational than others, while still others are more environmentally conscious? Finally, what motivates consumers to act or fail to act?

When consumption is defined as a process of satisfying diverse and constantly changing human needs, the important role that economic, cultural, social and psychological factors play in consumer decision-making becomes evident. Energy consumption is equally strongly influenced by consumers' daily practices, routines, leisure activities and work [15]. Therefore, identifying these behavioural patterns and gaining insight into how attitudes and habits directly influence energy consumption and what motivates individual consumers are both crucial to achieving energy and climate efficiency targets and useful for consumer segmentation.

Segmentation studies have always aimed to identify particular patterns of consumption [16,17] as well as the diversity of behaviour, but it is the pursuit of clusters manifesting a relative homogeneity of characteristics that is increasingly becoming the subject of new studies [18–21]. However, in the case of energy consumers, segmentation studies that would account for a full range of variables are not conducted commonly or frequently, while the few existing publications do not provide a comprehensive answer to the questions concerning primary drivers determining pro-efficiency behaviour and affecting consumption. The authors perceive this as a research gap and intend to address it in this article. Furthermore, they recognise the importance of such research, not only for the marketing value of segmentation, but also because accurate segmentation can facilitate knowledge development and form desired attitudes in society [1,7]. Profiling is also helpful when communicating with and motivating consumers as well as in the situations when local and regional authorities seek to adopt appropriate intervention measures. Segmentation allows for targeted, individualized communication, tailoring tools encouraging energy-saving to particular groups of consumers. It can also be instrumental in developing long-term consumer engagement strategies, especially when it takes behavioural factors into account.

The main goals of the article can be formulated as follows:

1. The presentation of the authors' original model of the segmentation of energy consumers according to behavioural factors, developed as a result of the review of the reference literature and the findings of the study conducted as part of the eco-bot interdisciplinary research project funded by the EU Programme Horizon 2020 (more information on the project: www.eco-bot.eu accessed on 14 June 2021);
2. The analysis of the results obtained during the first stage of the empirical validation of the model and the discussion of general conclusions, laying the foundations for the evaluation of methodological assumptions aiming at the development of the universal model of behavioural segmentation.

The authors observed that previous studies on energy consumers focused mainly on geographical and demographical segmentation, with selected economic and social factors and were conducted on an area-limited population. Yet, studies adopting a comprehensive approach that takes into account behavioural and psychographic factors are largely lacking. During the study conducted as part of the project, the authors performed the in-depth analysis of the reference literature aiming to catalogue all possible variables that may affect the attitudes and behaviour of energy consumers (Section 3 outlines the stages of the study). The next step involved identifying a group of behavioural factors that are the most relevant

and universal. In other words, the authors searched for such factors that influence consumer decisions and motivations regardless of demographic, geographical and socio-cultural differences. The methodological assumptions of the presented segmentation underwent initial verification within the project, and its results clearly indicated that, as far as the motivation to save energy is concerned, non-behavioural factors do not play a role in distinguishing particular groups of consumers.

Therefore, the approach proposed in the article and the segmentation that the article presents, while initially developed for the eco-bot project, have evolved towards a universal tool, constituting the authors' original contribution to the extant reference literature and filling the research gap in the considerations into the behavioural patterns of energy consumers. Additionally, the approach proposed in the article may become a universal method used by different stakeholder groups to classify energy consumers, e.g., in the development and implementation of sustainable development policies [22–27] embracing the motivations of societies to save energy, or by other researchers in their studies.

To ensure the logic and clarity of the discussion presented in the article, it is divided into sections, starting with the introduction, where the purpose of the study and the relevance of the topic are highlighted. Section 2 includes the literature review concerning energy consumer segmentation, discussing the rationale behind the distinction of particular segments. The review was used to prepare the behavioural segmentation assumptions and methodology for the eco-bot project discussed in Section 3. In addition, Section 4 assessed the segmentation based on empirical data, and the discussion is presented in Section 5. The short conclusion closes the article.

2. Literature Review

The economic theory and psychological theory perceive the energy user as an individual—a person who makes individual choices in a rational or semi-rational way, just like other people [28]. The most important motivations determining choices are, therefore, the profitability of investing in energy efficiency and a reduction in costs. The analyses show, however, that consumers also appreciate other factors, such as improved health and energy security as well as the enhanced quality of energy products and services. These factors can be of equal [29] or even higher importance [30] compared to cost savings. Segmentation studies, therefore, play an important role in research concerning the consumer and their preferences [16,31–34]. Insight into people's purchasing behaviour and the understanding of the determinants and factors that affect decisions whether to act or not to act is important in times of change, especially environmental and climate change. For many years, researchers have been trying to answer the question of what drives people to act. In marketing, which first raised the issue of consumer segmentation, the answer to this question is also important, as it helps to understand customers better and, as a result, serve their needs more effectively. The observations pointed to the importance of finding common features and identifying relatively homogeneous groups [17]. The obtained information also allows for the definition of the behaviour, motivations and attitudes of energy consumers. The literature recognises the need to predict and control future and present behaviour [31] to determine the perceptions, expectations and values of people [35]. Segmentation, however, is a complex process, requiring the identification and in-depth analysis of consumer characteristics and behaviour. As Kotler et al. [36] argued, it is not an easy or simple process because they are rooted in the mind of the consumer.

Behavioural psychology and economics [37–39] are of particular relevance to the understanding of consumer motivations and behaviour in respect of energy saving. It is behavioural and psychosocial factors (and even psychographic factors based on personality-related variables [40]) that prove to be the most important in distinguishing between different types of energy consumers [37,39]. Frederiks argued [41] that consumers are becoming increasingly aware of the value of and demand for practices promoting sustainable energy and climate. Sütterlin et al. concluded [27] that behaviour and attitudes related to energy consumption provide a more effective basis for developing energy-saving strategies and

policies than information about general consumer characteristics. As many consumer decisions are directly or indirectly related to energy consumption [27], a number of studies adopt the following factors as a basis for segmentation: general values [42], lifestyle [43–45], general consumer behaviour patterns [45], attitudes towards the environment and environmental awareness [46], attitudes towards technology [19], contextual factors [39,47] and the rebound effect [48]. In many cases, however, the results of the studies that were designed in a similar manner led to entirely different conclusions. For example, Wiser [49] concluded that knowledge about the environment and strong environmental awareness are the drivers of green consumption and can increase the consumer's willingness to pay for green electricity [49,50]. This is in contradiction to the results of the studies conducted by authors such as [51,52], who argued that environmentally conscious attitudes do not necessarily lead to energy savings or even, in certain circumstances, contribute to increased energy consumption [53]. These discrepancies confirm that the segmentation of energy consumers is not an easy task, and the selection of both qualitative and quantitative criteria is instrumental in obtaining the most accurate answers [54]. Undoubtedly, the geographical and demographical variables proposed by [55] also differentiate energy consumers, but they prove to be insufficient and, as Black et al. [21] pointed out, in recent years, the approach to research on behavioural change has not been significantly modified, although it remains an area of interest for many researchers [21]. The authors of [21] also drew attention to the adoption of a fundamentally different or more effective approach and provided an up-to-date review of the variables used for segmentation based on behavioural factors, as did the authors of [56]. Some studies emphasise the need for the practice approach in energy consumer segmentation [21,51], pointing out that, in order to initiate behavioural change, the right combination of elements [57] is necessary so that they can form networks of interrelated practices [21], informing on the reciprocal nature of activities, materials and cultural influences, or socially accepted norms through which consumers organize their lifestyles [57].

Both the issue of energy consumption and the motivation of consumers to develop more energy-efficient behaviour are multifaceted and complex problems [58,59]. The range of factors that affect energy consumption and demand for energy is extensive [60,61] and concerns individual socio-economic characteristics of users [62–66] (e.g., income, education), external determinants that influence both the demand side (e.g., characteristics of the user's residence and electrical appliances owned by the user) [44,66–68] and the supply side (e.g., energy market regulations), [22,25–27,69] and finally, issues related to individual consumer behaviour, which are more difficult to measure (e.g., attitudes, values, habits) [59,63,70,71].

The multitude of factors reveals a considerable diversity of individual energy consumers and, in consequence, implies that a standardised and unified approach adopted in an attempt to change their behaviour as a result of external actions (initiated by administration or energy suppliers) may not be very effective. However, a fully individualised approach to each energy consumer (or end-user from the point of view of the supplier) is not possible either, due to the difficulties involved in obtaining necessary information and its further processing. Information needed for personalized approach to the end user in some respects may be at risk of intrusion, must be preserved and secured.

In order to gain a better understanding of energy behaviour and plan adequate interventions aimed at behavioural change, attempts are made to classify and segment users or households based on their characteristics [17,25,68,72]. Table 1 presents selected studies on energy consumer segmentation, taking into account behavioural and psychosocial factors, which, according to the authors, provided the strongest theoretical premises of the assumptions underlying the authors' original segmentation model discussed in this article.

Table 1. Overview of selected studies segmenting energy consumers based on behavioural and psychosocial factors.

Study	Segments	Motivations Behind Energy Saving	Factors	Approach	Location
Frankel et al. (2013) [18]	1. Green-advocate energy savers, GAES (19%) 2. Traditionalist cost-focused energy savers, TCFES (20%) 3. Home-focused selective energy savers, HFSES (25%) 4. Non-green selective energy savers, NGSES (17%) 5. Disengaged energy wasters, DEW (19%)	• perceived environmental benefits • saving money—cost savings • home improvement • actions "easy to implement"	Attitudes and behaviours (held or demonstrated)	Comprehensive ethnographic in-home interviews, along with a detailed, 2500-person national survey to quantify behavioural trends	The United State of America
Sütterlin et al. (2011) [27]	1. Idealistic energy savers, IES (15.6%) 2. Selfless inconsequent energy savers, SIES (26.4%) 3. Thrifty energy savers, TES (14%) 4. Materialistic energy consumers, MEC (25.1%) 5. Convenience-oriented indifferent energy consumers, COIEC (5.3%) 6. Problem-aware well-being-oriented energy consumers, PAWOEC (13.6%)	• idealistic thoughts • energy consciousness • financial considerations • society's expectations (social pressure) • personal comfort and convenience	Energy-related behavioural characteristics (purchase- and curtailment-related energy-saving behaviour, acceptance of policy measures and energy-related psychosocial factors)	Cluster analytic approach, energy-saving behaviour and energy-related attitudes as a basis for the classification, a mail-in survey on a random sample of Swiss households	Switzerland
Tabi et al. (2014) [37]	1. Adopters, A (7%) 2. Potential Adopters—Truly Greens, PA-TG (28.3%) 3. Potential Adopters—Price Sensitive Greens, PA-PSG (18.8%) 4. Potential Adopters - Local Patriots, PA-LP (26.1%) 5. Likely Non-Adopters, LNA (19.8%)	• sensitive to environmental issues • energy cost and price-sensitive • location of power generation (in favour of domestically-produced electricity)	Socio-demographic, psychographic and behavioural variables	Latent class segmentation analysis based on choice-based conjoint data, comparison customers who have already purchased a green product with three different potential adopter segments along with socio-demographic variables, psychographic and behavioural characteristics, 4968 experimental choices of a representative sample of 414 German consumers	Germany

Table 1. *Cont.*

Study	Segments	Motivations Behind Energy Saving	Factors	Approach	Location
Pedersen (2008) [73]	1. Tuned-Out and Carefree, TOC (12.7%) 2. Stumbling Proponents, SP (19.9%) 3. Comfort Seekers, CS (9.1%) 4. Entrenched Libertarians, EL (5.4%) 5. Cost-Conscious Practitioners, CCP (21.7%) 6. Devoted Conservationists, DC (25.6%)	• moral obligation • pro-environmental motives • maintaining comfort or lifestyle • individual motives that go beyond concern for the environment, finances and moral motives • saving money • doing things for a greater good • resource conservation and climate protection	Characteristics and features of customers' homes, the different ways in which electricity is used, opinions, attitudes and behaviours of residents relating to electricity, conservation and the environment	Quantitative end-use studies among BC Hydro residential customers across the British Columbia province/Canada sample—4191 completed surveys received cluster analysis	Canada
Yang et al. (2015) [42]	1. Value seeking consumers, VSC (53%) 2. Green consumers, GC (22%) 3. Price sensitive consumers, PSC (25%)	• moral obligation • the possibility of increasing the use of renewable energy sources • financial considerations	Individuals' perceptions, attitudes, values as well as socio-demographic variables	Danish households Latent class modelling, self-administered questionnaires, sample 1012 usable questionnaires among 7000+ Danish consumers	Denmark
Accenture end–consumer observatory on electricity management (2010) [20]	1. Proactives, PO (16%) 2. Eco-rationals, ER (12%) 3. Cost conscious, CC (17%) 4. Pragmatics, PA (21%) 5. Scepticals, S (21%) 6. Indifferents, I (13%)	• social pressure • pro-environmental motives • financial considerations	Attitudinal, demographic and behavioural factors on electricity consumption	Quantitative global survey of consumers' opinions and preferences toward electricity management programs, 9108 individuals, 17 countries conjoint analysis	Australia, Brazil, Canada, China, Denmark, France, Germany, Italy, Japan, Netherlands, Singapore, South Africa, South Korea, Spain, Sweden, United Kingdom, The United States

Table 1. *Cont.*

Study	Segments	Motivations Behind Energy Saving	Factors	Approach	Location
Han et al. (2013) [74]	1. Cost focused residents, CFR (20%) 2. Conscious residents, CR (43%) 3. Ease driven residents, EDR (18%) 4. Environment minded residents, EMR (19%)	• financial (highly sensitive to structural financial interventions and consequence interventions such as rewards and feedback) • saving money and environmental concerns • comfort of living • environmental concerns	context opportunity, motivation, knowledge, curtailment behaviour, investment behaviour, the social-demographic factors and the dwelling characteristic	Energy-saving behaviour—preferences for interventions latent class model analyses sample: Eindhoven region of the Netherlands—1500 households, an online questionnaire	The Netherlands

The studies presented in Table 1 primarily aimed to develop a better understanding of the behaviour of energy consumers and to examine their attitudes, motivations, views and preferences, as well as the factors that affect their willingness to adopt pro-efficiency actions. All authors cited in the article are in agreement concerning the scarcity of this type of scientific research. Still, few energy consumer segmentations are based on a comprehensive approach, taking into account and integrating not only demographical data but also behavioural and psychosocial factors as potential segment differentiators [26,75]. Research results confirm the thesis that a broader approach based mainly on behavioural factors is necessary to obtain an adequate and yet sufficiently clear classification of energy consumers [27]. Furthermore, the factors that play a key role in engaging consumers in initiatives related to improved energy efficiency, reduced energy consumption or renewable energy purchases are of a predominantly emotional nature.

Socio-demographic characteristics, such as gender, age, household net income and household size, were indicated by other researchers as having a marginal role in differentiating segments [37]. Very often, the respondents characterised by these features were evenly distributed in the identified clusters [37]; hence the emphasis is on emotional, behavioural and psychographic factors [59,66,76–79].

When the approaches presented in Table 1 are analysed in more depth, it becomes evident that the behaviour of energy consumers is characterised by significant complexity and the diversity of attitudes and preferences. The overview focuses particularly on major motivations, expressed by respondents, behind their decision to take or not take pro-efficiency actions, as these motivations differentiate the segments.

It is worthwhile to observe that the fundamental motivation of energy consumers has not changed significantly over time. Studies conducted from 2008 to 2015, or even after 2015 [19], indicate that the concern for the environment and the desire to reduce household budget expenditure remain the two strongest motivators for consumer behaviour and decisions. Undoubtedly, as researchers point out, the changing world, technological progress, increasing globalisation, as well as lifestyle changes and increased awareness of ecological threats cause new segments of consumers, including energy consumers, to

emerge. They can be distinguished, for example, based on their attitude to information technology [19], attitude to investing in renewable energy sources, lifestyle in different social contexts [43,44], the perception of comfort in the consumer's home [80] and others.

The analysis of the segmentation approaches presented in Table 1 reveals that consumers characterised by a pro-environmental attitude, who attach importance to environmental issues, constitute on average 20% of the entire research sample. A similar proportion concerns consumers driven by financial motivation in their energy-related behaviour and choices (on average, 20% of the total number of respondents). Finally, respondents who are not committed in any way also make up a separate cluster of approximately 20% of the entire sample. The question arises who the remaining 40% are. When developing a priori segmentation assumptions or identifying the factors that adequately characterise this 40%, it is difficult to achieve full homogeneity of the cluster.

It is, therefore, crucial to adopt as broad an approach to the consumer as possible. The researcher should propose an extensive range of motivators, as they will facilitate the individual assignment of consumers to a relevant segment. Frankel et al. argued [18] that the segmentation including behavioural and psychosocial, or even psychographic variables, is more difficult to perform than the one based exclusively on demographical factors, but its outcomes are better aligned with the adopted objectives.

The tabular summary does not comprise all the studies that produced the segmentation of energy consumers. It presents selected segmentations taking into account mainly psychosocial and behavioural factors. The authors intended to focus on the studies that influenced and inspired them to develop the original segmentation model for the eco-bot project. They endeavoured to select and present segmentation studies that were conducted in different geographical locations, included—in addition to demographical factors—behavioural factors, and used statistical tools and methods (e.g., taxonomic analysis).

3. Methodology, Theoretical and Design Assumptions of Behavioural Segmentation

The European Union, recognising the significant influence of the energy sector and energy consumption on the condition of the environment and the well-being of societies, promotes and supports a variety of initiatives aimed at reducing negative human impact in these areas. The eco-bot project ("Personalised ICT-tools for the Active Engagement of Consumers Towards Sustainable Energy"), co-funded under Horizon 2020: "Reducing energy consumption and carbon footprint by smart and sustainable use", is a good example of the EU's commitment in this respect. The project, implemented by a consortium of nine partners from five EU member states countries (Germany, Greece, Spain, Poland and the United Kingdom) based on grant no. 767625 from November 2017 to June 2021, aims to change energy consumer behaviour to more energy efficient with the use of modern technologies. The final outcome of the project is envisaged as a personalised virtual assistant (a chatbot application). It will play two roles: informative, as it will provide users with data on their current energy consumption (disaggregated to the level of individual electrical appliances), and advisory–educational, because it will deliver personalized recommendations motivating users to take energy-saving actions. It can be noted that self-determined energy-saving actions (taking into account such factors as a person's socio-economic status, type of housing, existing knowledge, motivation and ability to engage in energy conservation programs) are more likely to be sustained in the long term and may benefit from support by ICT solutions [81,82] or ICT-based interventions [83].

The basic idea behind the eco-bot project is presented in Figure 1.

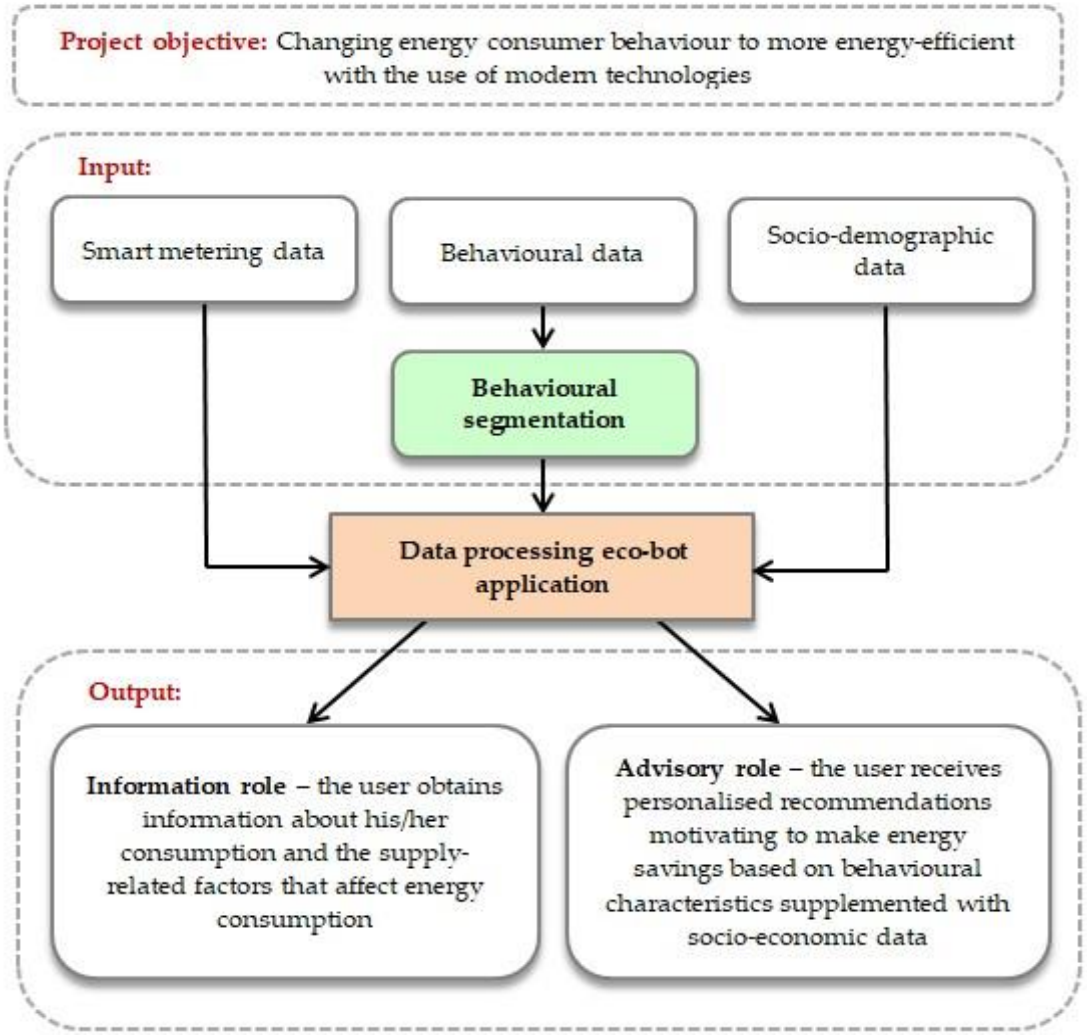

Figure 1. Main assumptions of the eco-bot project.

The article aims to present the most relevant, in terms of behavioural research, element of the eco-bot application—the model of consumer segmentation and its primary assumptions. As the project has not been concluded yet and the pilot stage of the application is still underway, it is impossible to assess its full functionality, including its informational and advisory roles

In the literature, the majority of the studies involving behavioural segmentation of energy consumers concern individualised situations, aimed at solving a specific problem/providing a specific service or checking how effective an instrument stimulating energy-saving behaviour is (e.g., issues related to the choice of the right tariff [84] or the right appliance [85], or the examination of the behaviour of residents of a specific region [86]). The authors' aspiration, on the other hand, was to create universal segmentation, taking into account motivations behind energy-saving consumer behaviour, where socio-economic and geographical differences will only play a supplementary role, useful for the creation of the information part in the application (energy consumption readings; the comparison of tariff offers or the appliances that help and encourage decreased energy consumption).

3.1. Justification/Motivation and Assumptions of a Priori Segmentation

The authors' attempt to identify universal energy-saving motivators necessary for the preparation of the segmentation turned out to be more complicated than initially assumed, even though it was limited to the EU member states. The project was divided

into stages, each of which was validated empirically. Table 2 shows the evolution of methodological assumptions underpinning the process leading to the development of behavioural segmentation.

Table 2. The evolution of behavioural segmentation.

Stage 1		Stage 2		Stage 3	
Action	**Outcome**	**Action**	**Outcome**	**Action**	**Outcome**
(1) Literature review (2) Preparation and the pilot run of the research survey: (a) Workshop in Barcelona (12.2017) (b) Pilot survey in Katowice (03-04 2018)	Adaptation of segmentation from Frankel et al. (2013) [18]	Preliminary empirical validation of methodological assumptions Analysis of the survey results (06–09 2018) Supplementary literature review	The authors' original behavioural segmentation—an attempt to create a universal model	Verification of segmentation: (1) As part of the pilot study among eco-bot application users who are customers of the energy providers in the consortium from ES and GE (in progress, ends 06 2021) (2) On energy consumers (quota survey sample on respondents not participating in the project) from: (a) Pilot countries (ES, GE, UK—03–04 2021) (b) Selected EU countries (CZ, FR, GR, PL, RO—in progress, ends 05 2021)	Verification of the validity and universality of the proposed behavioural segmentation Or Further research and modifications
Completed	Completed	Completed	Completed	In progress	Started

The review of behavioural theories and models (see [87–89]) allowed for the identification of relevant socio-economic and behavioural factors necessary for the conduct of the energy consumer segmentation. Triandis's Theory of Interpersonal Behaviour, which identifies the importance of attitude (i.e., the belief in the potential consequences of a behaviour and their evaluation), social factors (including norms, roles and an individual's perception and self-esteem), affect (emotions) and past behaviour, turned out to be of particular relevance. The selected factors accounted for both the determinants and constraints for changing the behaviour of eco-bot users, as well as potential motivations and reasons that can be used to encourage energy consumers to switch to more energy-efficient behaviour (which is the prime goal of the eco-bot project). Income and ownership of a place of residence (socio-economic factors) and past behaviour (behavioural factor) were identified as constraints and determinants of more energy-efficient consumer behaviour in the future. The other behavioural factors in Triandis's model—attitudes, social factors and affect [90]—were classified as factors motivating consumers to change to more energy-efficient behaviour.

As at that moment, it was only possible to obtain data on energy consumption (from three project partners who are energy suppliers), which was insufficient to determine the motivations or attitudes of the users, crucial for behavioural segmentation, the a priori approach was adopted [91]. A priori segmentation is based on the assumptions adopted in advance concerning the number of segments and the characteristics of each segment.

The literature review allowed for the identification of the energy consumer segmentation, which took into account the factors considered relevant from the point of view of the eco-bot project needs. The segmentation developed by [18], including energy-saving behaviour declared by respondents, revealed considerable alignment with the project assumptions. Additionally, the five proposed segments embraced the two approaches to

motivate consumers to save energy (financial and pro-environmental) that are the most common in literature and were mapped onto the assumptions of Triandis's behavioural model. The next step involved the preparation of a survey questionnaire to gather data that would allow assigning respondents to particular segments. The survey questionnaire contained questions both on energy consumption and energy saving (including questions concerning actions taken or planned, motivations behind and views on energy saving behaviours, among which segmenting questions were placed) and questions about socio-economic factors that were identified as those that hinder energy saving. The questions for both the original questionnaire and its subsequent iterations, together with detailed justification, are available in the project documentation [92].

The pilot survey questionnaire (which was distributed during the project workshops in Barcelona in December 2017 and in Poland in March–April 2018) was tested and reviewed, and then handed over to the project partners from Catalonia (Spain) and Germany, who made it available to their customers as an online survey (CAWI) during the holiday period, June–September 2018. Despite the low return of correctly filled questionnaires (81 respondents completed the questionnaire, but only 37 forms were verified as complete), it was possible to divide the respondents into five segments adopted in the project. The following segmentation of respondents was obtained: Green-advocate energy savers (GAES)—49.4%, Traditionalist cost-focused energy savers (TCFES)—37%, Home-focused selective energy savers (HFSES)—1.2%, Non-green selective energy savers (NGSES)—9.9%, Disengaged energy wasters (DES)—2.5%. The obtained data were insufficient to fully verify the segmentation and create a stable classification model. The examination of the relationship between particular questions led to the confirmation of the importance of the psychosocial and behavioural factors that were selected, while the auxiliary questions identified additional aspects relevant to the segmentation that had not yet been included.

The two most numerous segments (GEAS and TCFES) were characterised by a dichotomy between financial and pro-environmental motivation behind energy-saving measures adopted by consumers. Nevertheless, it should be noted that the two segments whose representatives dominated the survey comprise consumers manifesting strong awareness of the importance of energy-saving measures. The aim of the eco-bot project, however, is primarily to engage and motivate all consumers to change their behaviour into energy-efficient. Behavioural segmentation should support this goal, as it can only be achieved if all potential groups of energy consumers are identified.

In alignment with the project assumptions, the segmentation was modified. Based on the literature and the results of the preliminary survey, it was decided to include two primary motivation-related factors (environmental awareness and financial motivation) to diversify the potential users of the application. This distinction, identifying only two segments (under working labels of ecologists and money savers), was considered insufficient, and the search for factors that could further differentiate these types was pursued. Segmentations discussed in the literature were revisited (summarised in Table 1), and the distinction concerning sources of motivation into intrinsic motivation (moral obligation [42,73]) and extrinsic motivation (social pressure [20,27]) came to focus. The impact of the environment and the pressure of a social group also emerged in the results obtained during the first attempt to conduct a segmentation, which further supported the inclusion of this factor in the modification of the segmentation. The distinction applied to energy consumers sensitive to pro-environmental arguments caused that the type of "ecologist" was divided into two groups. One, the Ecological Idealist (EI), was mainly driven by a sense of inner responsibility (intrinsic source of motivation), while the other, the Aspiring Ecologist (AE), was influenced by the environment and social pressure, either experienced or perceived (extrinsic motivation). In the case of the other primary type of the "money saver", the factor related to the desire to increase the value of the property, as indicated by [18], was abandoned, and the factors related to perceived comfort [27,42,73] and simplicity in implementing energy-saving solutions [18,27] were included. This led to the distinguishing of the Opportunist (O) sub-segment from the type of "money savers", who

are, to a certain extent, responsive to pro-environmental and financial arguments, but limit their actions either due to aversion to change or fear of losing comfort and quality of life. This segment, however, can be motivated by simplicity in the adoption of potential energy-saving solutions. The fourth segment is the Dedicated Saver (DS). These consumers are motivated and willing to undertake energy-saving measures that require effort and may result in lowering their perceived comfort. Such a division of the two initial types allowed for a better differentiation of energy consumers into segments based on their behavioural and socio-psychological factors, while maintaining as large homogeneity as possible within segments. Additionally, the need to develop a universal typology—without accounting for geographical and country- or region-specific factors—was addressed and fulfilled. Finally, the assumption was adopted that consumers manifested varied levels of commitment stemming from other components of Triandis' model: norms and past behaviour/habits. To prevent the blurring of the clear differences successfully established between the segments, further division of the segments was not pursued.

In consequence, four types of eco-bot users were distinguished according to motivation and commitment. However, the division did not include the users who, at a given moment, are not interested in energy saving at all (total lack of commitment), although they are of particular importance in view of the project objectives. Hence, the division into five segments, also embracing uncommitted consumers, was the starting point for preparing the characteristics of particular groups (according to the assumptions of the a priori segmentation), which, at a later stage, would become the basis for developing dedicated recommendations and strategies for engaging particular groups of application users in actions aimed at more energy-efficient behaviour. The particular segments and their description are presented in Table 3.

Table 3. Description of the segments.

Segment	Environmental Awareness	Financial Motivation	Commitment	Description
Ecological Idealist (EI)	High	Low	High	• Consumers who are involved in various pro-environmental initiatives, not only those related to energy saving • Willing to commit financially to activities aimed at environmental protection • Strong environmental awareness usually translates into considerable relevant knowledge which they are willing to share with others • Likely to take on the role of leaders and ambassadors for various pro-environmental initiatives, inspiring others
Aspiring Ecologist (AE)	High	Low	Average	• Consumers who are willing to pay more for green products, especially if they notice such a trend in their environment • Less likely than EI to research potential solutions and pro-environmental behaviour on their own but willing to implement guidelines from others • Influenced to the actions of others, especially the groups they identify with, responsive to changing trends • Often young people with high socio-economic status (education, income, occupation)

Table 3. *Cont.*

Segment	Environmental Awareness	Financial Motivation	Commitment	Description
Dedicated Saver (DS)	Average	High	High	• Consumers who have extensive knowledge of ecology but are not interested in environmental protection • Not interested in environmental protection, but likely to take pro-environmental action if they may achieve specific financial benefits • Arguments promising reduced costs of energy consumption may encourage them to undertake pro-environmental actions • If sufficiently motivated, they can allocate considerable time and commitment to environmental protection activities • Seeing potential benefits, willing to invest in environmentally friendly solutions even if returns and benefits can only be expected in the long term
Opportunist (O)	Low	Low	Low	• Consumers who are unlikely to engage in pro-environmental activities unless these solutions are easy to implement and do not require excessive effort • Willing to save if it is easy and does not require excessive effort • If they do undertake pro-environmental activities, they do so sporadically and without a strong commitment • Usually satisfied with their low level of commitment and averse to change • Susceptible to both financial and environmental incentives, but to a limited extent
Indifferent (I)	None	None	None	• Consumers who do not show any interest in their energy consumption levels and do not consider environmental issues when making decisions • Unlikely to respond to financial incentives in return for a commitment to pro-environmental actions • The segment that is the most difficult to motivate and as such requiring particular attention if it were to change behaviour towards more energy-efficient

The inclusion of the level of knowledge and willingness to pursue guidelines obtained from external sources in the descriptions of particular segments is important for achieving the project goals and the designing of functionalities of the application. Following the consultation with the partners, the new version of the segmentation questions and survey questionnaire was prepared and used to verify the modified behavioural segmentation.

Additionally, the decision was made to extend the research sample, which should contribute to the more comprehensive empirical verification of the methodological assumptions of segmentation. The survey was planned to be performed in other selected EU countries (presented in Table 2). The rationale included the following arguments:

- a small research sample in the project, insufficient for the purpose of developing universal segmentation;
- the absence of the indifferent segment during empirical validation, which made it impossible to evaluate the functionality of the created segmentation fully;

- verification performed only in the partner countries participating in the pilot study (2 countries) cannot identify the entire array of energy consumer behaviours and attitudes.

3.2. Procedure for Energy Consumer Segmentation—A Statistical Approach

In line with the theoretical assumptions of segmentation presented in Section 3.1, the methodology was developed to classify energy consumers into particular segments.

The analysis discussed in the article is based on the data collected in the CAWI survey conducted on a representative sample (in terms of age, gender and place of residence) of 1606 respondents from the project partners participating in the pilot study, i.e., from Germany (572 respondents), Spain (522 respondents), and the UK (512 respondents). The survey was carried out within the eco-bot project in March–April 2021 as the first of the two stages of a broader empirical validation of the behavioural segmentation model for energy consumers. The survey questionnaire consisted of both segmentation questions and respondent information questions, and the consecutive stages of its preparation are discussed in detail in Section 3.1., while Table 2 offers the outline of the entire process.

Based on the characteristics of the ideal representative of each class (Table 3), it was possible to prepare relevant and adequate questions in the survey questionnaire. The purpose of those questions was to assign respondents to appropriate segments. The response to each question involved selecting the statement that was the most relevant to the respondent. The answers corresponded closely with the characteristics of the segments. For example, answer "a" to question 1 corresponded most closely to the Ecological Idealist, answer "b" was indicative of the Dedicated Saver, answer "c" related to the Aspiring Ecologist, answer "d"—the Opportunist, while answer "e" identified the Indifferent user.

In practice, four questions were proposed ($Q_1 - Q_4$). Each question has five possible answer categories, which represent five types of energy users (see Table 3), e.g., the ideal representative of the 1st class Ecological Idealist (EI) is the respondent who selects the answer labelled "a" to questions 1 and 3, and also selects answer "b" to question 2, and answer "d" to question 4 (see Table 4). The class that is positioned at the other extreme is the Indifferent. The ideal representative of the 5th class Indifferent (I) is the respondent who selects "e" as the answer to three questions (1, 2 and 4) and "c" as the answer to question 3. Due to ongoing work on the eco-bot project, which also involves the next stage of the survey, it is not possible to quote the complete segmentation questions in this article. The publication of the questions at this stage may distort the results of the segmentation of the eco-bot project customers at a later stage of the study.

Table 4. Response labelling of the five segments of energy consumers.

Segment	Answer to Q_1	Answer to Q_2	Answer to Q_3	Answer to Q_4
Ecological Idealist (EI)	a	b	a	d
Aspiring Ecologist (AE)	c	a	b	b
Dedicated Saver (DS)	b	d	d	c
Opportunist (O)	d	c	e	a
Indifferent (I)	e	e	c	e

As one would expect, the answers given at least by some of the respondents did not indicate clearly only one type of the energy saver, because for instance, the respondent might have given answer "a" to question 1 (indicative of class EI), but answer "d" to questions 2 and 3 (indicative of class DS) and answer "b" to question 4 (indicative of class AE). In such cases, it is necessary to determine the best class assignment for each particular case.

The solution to this problem is the approach based on defining ideal energy consumers for each segment. Every segmentation question (Q_j for $j = 1, \ldots, 4$) can be treated as a variable measured on a nominal scale, where the answers "a", "b", "e" are the categories of this variable. This way, the model class representatives are associated with points, the

coordinates of which are the answers given to the segmentation questions. For example, the representative of the Ecological Idealist segment can be identified with the point:

$$\mathrm{EI} = (\mathrm{a}, \mathrm{b}, \mathrm{a}, \mathrm{d}) \tag{1}$$

whereas the model Dedicated Saver can be described as:

$$\mathrm{DS} = (\mathrm{b}, \mathrm{d}, \mathrm{d}, \mathrm{c}) \tag{2}$$

As it can be seen easily, the points representing the ideal representatives of each segment can be read from the rows of Table 4.

The respondent who answered the questions in the survey questionnaire is assigned to the right segment using the methodology based on a distance measure. As in the case of the ideal consumers, other respondents can be represented as points, the coordinates of which are the answers to the segmentation questions. Each respondent should be assigned to the group where their answers differ the least from the answers given by the ideal representation of the class. In practice, this means that the respondent will be assigned to the segment for which the distance between them and the ideal is the shortest. In the analysis, we used distance measures dedicated to the nominal variables [93].

The segmentation algorithm for the ith respondent R_i can be presented in the following steps:

Step 1. For every kth class ($k = 1, \ldots, 5$), define the description of the ideal representative I_k. This representative would also be called "class centroid". The descriptions of the ideal representatives I_k are presented in Table 4. The ideal representatives are aligned with the theoretical assumptions presented in Section 3.1.

Step 2. Based on the description obtained from the questions ($Q_1 - Q_4$) for every respondent R_i compute its distance to the centroid of each of the classes:

$$\bigwedge_{k=1,\ldots,5} d(R_i, I_k). \tag{3}$$

Step 3. Identify which of the distances computed in the previous step is the shortest—it indicates the class the respondent should be assigned to:

$$\min_{1 \le k \le 5} d(R_i, I_k) \rightarrow k, \tag{4}$$

where d is the distance measure dedicated to the nominal variables.

Step 4. In the case of ties in step 3, when two or more centroids have the same minimal distance to the given respondent, this person cannot be unambiguous classified. In such a situation, answers to other questions can be used as additional descriptions that should help in classifying the respondent.

For illustration, the segmentation algorithm is presented in Figure 2.

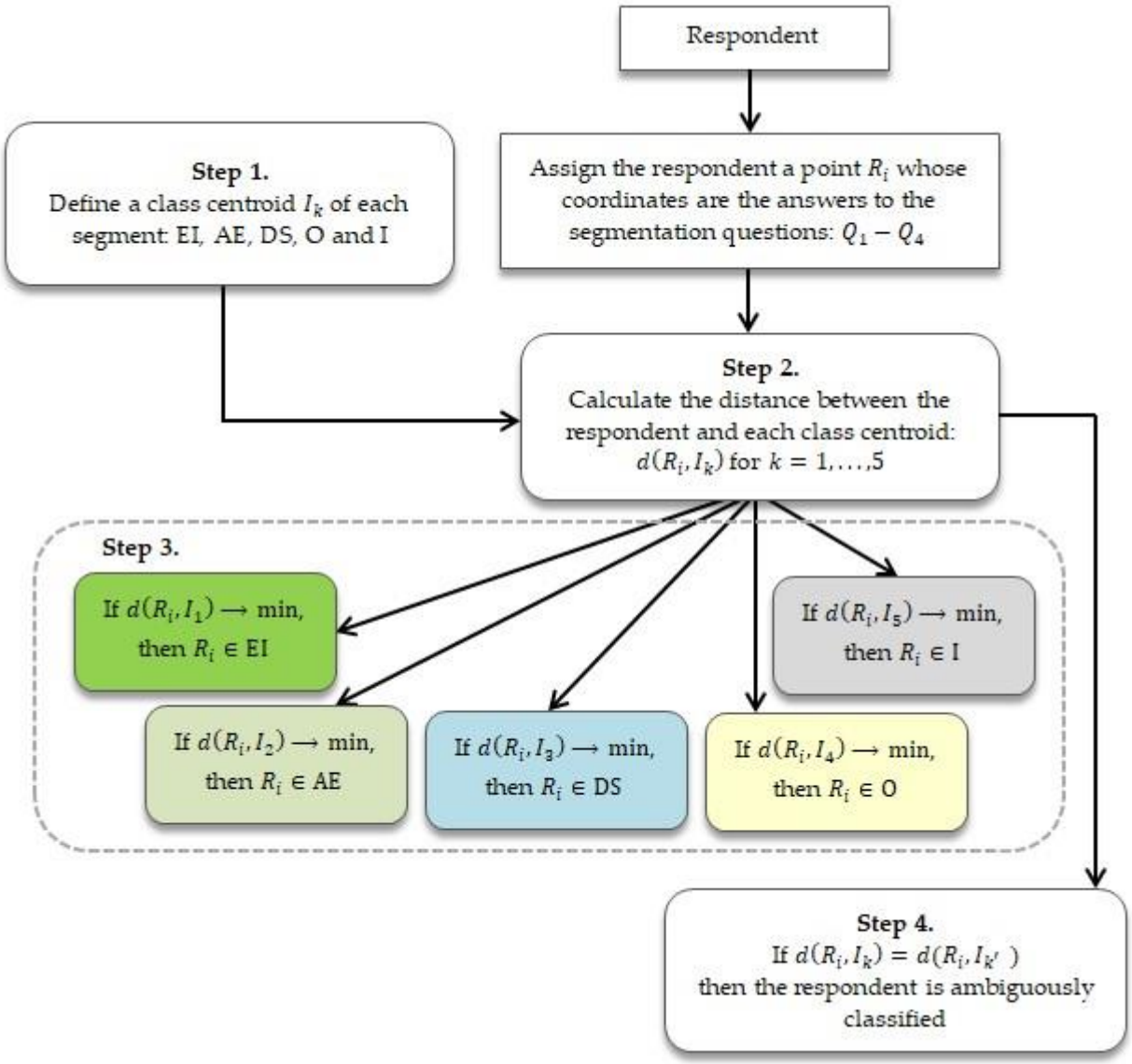

Figure 2. The diagram illustrating the segmentation procedure.

In conclusion, the methodology used to assign energy consumers to an appropriate segment is the authors' original proposal based on distance measurement. Due to the theoretical assumptions adopted in the eco-bot project, an approach different from classical taxonomic analysis (e.g., hierarchical methods or the k-means method) was introduced. Based on the literature review discussed in Section 2, the solutions developed by other researchers were generalised. The aim was to create universal segmentation in the broadest possible sense, so the focus was on identifying common segmentation characteristics presented in the literature (see Table 1). This way, it was possible to identify clear differences between the energy consumers' classes that were used in the eco-bot project and to determine the characteristics of the ideal representatives of these segments. Finally, the theoretical assumptions were aligned with adequate methodology, and the authors proposed the original algorithm for classifying users into appropriate segments. It is possible, however, to point out some similarities of this algorithm to the k-means method [94,95], where, in a similar manner, objects are assigned to the clusters the class centroid of which lies closest to them. The main differences consist in the fact that the solution presented in the article determines the number of classes and the ideal representatives of these classes a priori, while the k-means method involves selecting these elements simulationally, during the execution of the algorithm.

4. Results

The algorithm presented in Section 3.2 was used to conduct the classification of respondents participating in the pilot stage of the eco-bot project. The determination of the number of classes and the characteristics of the ideal representative of each segment were based on the theoretical assumptions discussed in Section 3.1., where the division into five classes of energy consumers was adopted.

The segmentation algorithm proposed by the authors involves the choice of the measure d which allowed to calculate the distance between points representing respondents and ideal class representatives. The literature offers several measures dedicated to nominal variables. The first and probably most intuitive proposal is the Sokal–Michener measure (*sm*) [96]. The other measures that are also in use comprise:

- measures introduced by [97] *good1*, *good2*, *good3* and *good4*;
- Inverse Occurrence Frequency (*iof*) and Occurrence Frequency (*of*) Measure [98];
- Lin's measures [99]: *lin* and *lin1*;
- Variable Entropy (*ve*) Measure [100].

The study used each of these measures, obtaining 10 different segmentations. Calculations and analyses were performed in the R programme, with the use of the functions implemented in the nomclust package [101]. Table 5 presents selected fragments of the results—classifications of each respondent to the particular segment, determined for each of the 10 measures. The distances calculated using one of these measures (*good3*) between the points representing sample respondents and every centroid of the segments are shown in Table A1 in Appendix A (both the supplementary data and detailed calculations are available).

Table 5. Classification results using 10 different distance measures for 12 selected respondents.

ID	*sm*	*good1*	*good2*	*good3*	*good4*	*iof*	*of*	*lin*	*lin1*	*ve*
1	DS	DS	DS	DS	DS	DS	DS	DS	DS	DS
2	DS	DS	DS	DS	DS	DS	DS	DS	DS	DS
3	EI	EI	EI	EI	EI	EI	EI	EI	EI	EI
4	AE	AE	AE	AE	DS	AE	AE	AE	EI	AE
5	EI	EI	EI	EI	EI	EI	EI	EI	O	EI
6	EI DS O I	I	DS	O	EI	I	DS	O	O	DS
7	EI AE DS O	O	EI	O	DS	DS	EI	O	I	EI
8	EI	EI	EI	EI	EI	EI	EI	EI	AE	EI
9	DS	DS	DS	DS	DS	DS	DS	DS	DS	DS
10	EI	EI	EI	EI	EI	EI	EI	EI	EI	EI
11	EI AE DS O	AE	EI	AE	DS	O	EI	AE	DS	O
12	O	O	O	O	AE	O	O	O	I	O

The analysis of the classification results reveals that the definite majority of distance measures allow for the conclusive classification of respondents to particular segments. Only the Sokal–Michener measure yields an ambiguous result. In the examined data set, this concerned 19.9% of respondents.

Furthermore, in many cases, the results of the segmentations, carried out using different distance measures, are very similar, although not identical. The consistency of these classifications was examined using the adjusted Rand index [102], which measures the similarity between two segmentations of the same set of objects. The results are presented in Table 6. The closer the value of the Rand measure is to 1, the more similar the results of the two classifications. It can be observed that the most similar segmentations are those obtained using the measures: *good1*, *good3* and *ve*. The classification using *good3* is the most consistent with the classification using the Sokal–Michener (*sm*) measure.

Table 6. Adjusted Rand index values—the consistency of classifications obtained for 10 different distance measures.

ID	*sm*	*good1*	*good2*	*good3*	*good4*	*iof*	*of*	*lin*	*lin1*	*ve*
sm	1	0.849	0.717	0.853	0.430	0.827	0.688	0.791	0.244	0.793
good1	0.849	1	0.745	0.990	0.369	0.792	0.685	0.829	0.221	0.856
good2	0.717	0.745	1	0.749	0.420	0.705	0.675	0.645	0.181	0.826
good3	0.853	0.990	0.749	1	0.371	0.796	0.680	0.832	0.224	0.862
good4	0.430	0.369	0.420	0.371	1	0.486	0.509	0.391	0.206	0.399
iof	0.827	0.792	0.705	0.796	0.486	1	0.647	0.681	0.241	0.769
of	0.688	0.685	0.675	0.680	0.509	0.647	1	0.658	0.262	0.690
lin	0.791	0.829	0.645	0.832	0.391	0.681	0.658	1	0.273	0.741
lin1	0.244	0.221	0.181	0.224	0.206	0.241	0.262	0.273	1	0.198
ve	0.793	0.856	0.826	0.862	0.399	0.769	0.690	0.741	0.198	1

The adjusted Rand index can be used to assess the similarity of the classifications, but it does not identify the best one. Accordingly, the decision was made to use all the results instead of seeking a criterion for the selection of the best segmentation. The majority rule (majority voting rule) was applied, which involves the final selection of the segment that is most frequently indicated for a given respondent. Table 7 shows the results of this procedure for the sample 12 respondents. The final segment to which the respondent will be classified is the one dominant over the previously indicated results.

Table 7. Classification results and the final segmentation.

ID	*sm*	*good1*	*good2*	*good3*	*good4*	*iof*	*of*	*lin*	*lin1*	*ve*	*final segment*
1	DS	DS	DS	DS	DS	DS	DS	DS	DS	DS	**DS**
2	DS	DS	DS	DS	DS	DS	DS	DS	DS	DS	**DS**
3	EI	EI	EI	EI	EI	EI	EI	EI	EI	EI	**EI**
4	AE	AE	AE	AE	DS	AE	AE	AE	EI	AE	**AE**
5	EI	EI	EI	EI	EI	EI	EI	EI	O	EI	**EI**
6	EI DS O I	I	DS	O	EI	I	DS	O	O	DS	**DS O**
7	EI AE DS O	O	EI	O	DS	DS	EI	O	I	EI	**EI O**
8	EI	EI	EI	EI	EI	EI	EI	EI	AE	EI	**EI**
9	DS	DS	DS	DS	DS	DS	DS	DS	DS	DS	**DS**
10	EI	EI	EI	EI	EI	EI	EI	EI	EI	EI	**EI**
11	EI AE DS O	AE	EI	AE	DS	O	EI	AE	DS	O	**AE**
12	O	O	O	O	AE	O	O	O	I	O	**O**

It is evident that this procedure also fails to allocate each respondent to the particular segment conclusively. However, due to the small number of inconclusive cases (63 out of 1606 respondents, which accounts for approximately 3.9%), it was decided those respondents would remain without a definitive class assignation.

Eventually, with 1543 respondents conclusively assigned to a particular segment, the results of the segmentation procedure revealed that the largest segments were the Ecological Idealists (544 persons, 33.9% of respondents) and the Dedicated Saver (532 persons, 33.1%), followed by the Aspiring Ecologists (276 persons, 17.2%) and the Opportunist (113 persons, 7%). The smallest segment was the Indifferent (78 persons, 4.9%).

The distribution of the respondents in the segments is shown in Figure 3.

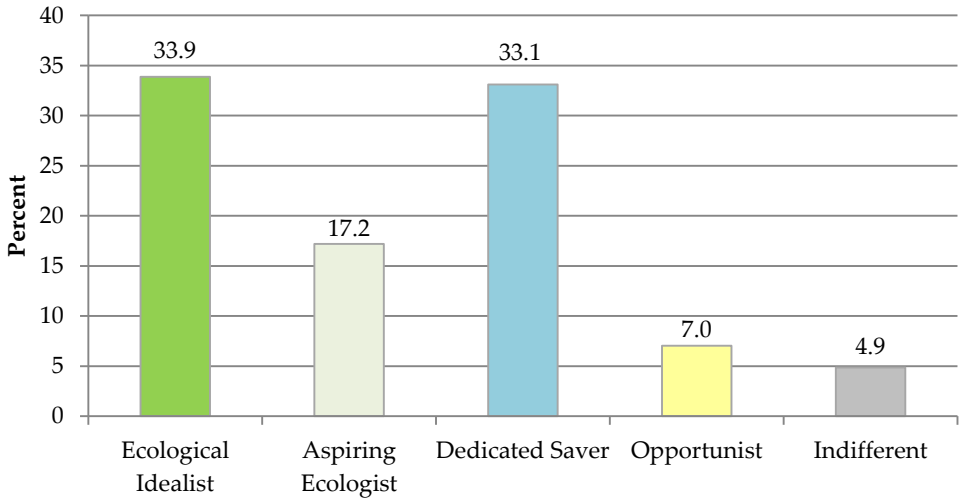

Figure 3. The respondents of the survey by the final segment membership.

5. Discussion

The results of the empirical verification of the proposed method, performed in a group of users from three EU countries, identified the representatives of the five classes adopted in the first survey, which may imply the intended effect of universality was achieved. In order to avoid premature conclusions, however, the authors decided to compare the numbers/share of particular segments to the results of the earlier works in this area. Table 8 includes all segments identified in the segmentations, which were taken into account in the preparation of the assumptions for the behavioural segmentation proposed by the authors. All the segments were analysed in terms of similarities that could be observed, with a focus on the dominant motivations for particular segments. Then, all the segments (including those proposed by the authors) were allocated to one of the five groups: (1) segments with mostly pro-ecological motivation with different levels of knowledge and dedication, (2) segments with mostly financial motivation with different levels of knowledge and dedication, (3) segments in which comfort and/or ease of implementation were identified as potential drivers/barriers, (4) segments of people that are not interested in energy-saving and (5) other motivations. In the case of most classifications, with the exception of [42], despite the different number of segments (from 3 [74] to 6 [27,73]), classes were successfully assigned to at least three of the five groups distinguished above according to motivation (with the reservation that the fifth group "other motivations" contained the segments only from segmentations [37,73]). Some of the classifications identify more than one segment with the same dominant type of motivation (such as the segmentation proposed by the authors, which distinguishes two "pro-environmental" types). This is marked in the table with different background colours—where the more intense denotes the "pure" type distinguished by the dominant motivation, while the lighter background indicates the segment where, apart from a given type of motivation, other factors were important (e.g., social influence, see the Aspiring Ecologist (AE)). Table 8 uses the abbreviations from Tables 1 and 3 to identify particular segments.

Table 8. Comparison of the different segments with the proposed segmentation.

Motivations	Frankel et al. (2013) [18]	Sütterlin et al. (2011) [27]	Tabi et al. (2014) [37]	Pedersen (2008) [73]	Yang et al. (2015) [42]	Accenture end–Consumer Observatory on Electricity Management (2010) [20]	Ha et al. (2013) [74]	Proposed Segmentation
Mostly pro-ecological motivation with different levels of knowledge and dedication	GAES (19%)	IES (15.6%) SIES (26.4%) PAWOEC (13.6%)	PA-TG (28.3%)	DC (25.6%) SP (19.9%)	GC (22%)	ER (12%) PO (16%)	EMR (19%) CR (43%)	EI (33.9%) AE (17.2%)
Sum	(19%)	(55.6%)	(28.3%)	(45.5%)	(22%)	(28%)	(62%)	(51.1%)
Mostly financial motivation with different levels of knowledge and dedication	TCFES (20%) H-FS-ES (25%)	TES (14%) MEC (25.1%)	PA-PSG (18.8%)	CCP (21.7%)	PSC (25%) VSC (53%)	CC (17%) PA (21%)	CFR (20%)	DS (33.1%)
Sum	(45%)	(39.1%)	(18.8%)	(21.7%)	(78%)	(38%)	(20%)	(33.1%)
Comfort/ease of implementation as a potential drivers/barriers	N-GSES (17%)	COIEC (5.3%)	-	CS (9.1%)	-	S (21%)	EDR (18%)	O (7%)
Not interested/Not engaged	DEW (19%)	-	LNA (19.8%)	TO C (12.7%)	-	I (13%)	-	I (4.9%)
Sum	(36%)	(5.3%)	(19.8%)	(21.8%)	-	(34%)	(18%)	(13.9%)
Other Motivations	-	-	PA-LP (26.1%) A (7%)	EL (5.4%)	-	-	-	-
Sum	-	-	(33.1%)	(5.4%)		-	-	-
Total	(100%)	(100%)	(100%)	(94%) *	(100%)	(100%)	(100%)	(96.1%) **

* 6% of customers are unclassified due to identification as outliers or intermediates [73]. ** 3.9% of respondents (63 people) were not assigned to the segments.

The straightforward comparison of the proposed segmentation with the literature, taking into account the methodologies, assumptions and purpose, is not possible. Nevertheless, based on the similarities between segments presented in Table 8, the authors attempted to determine how the sizes of the proposed segments compared in particular categories with the average size of the seven segmentations used to define the assumptions of the authors' segmentation (Table 9).

Table 9. Comparison of the shares of respondents in particular segments.

Motivation	Average Share for Segments from the Compared 7 Segmentations	Proposed Segmentation
Mostly pro-ecological motivation with different levels of knowledge and dedication	37.2%	51.1%
Mostly financial motivation with different levels of knowledge and dedication	37%	33.1%
Comfort/ease of implementation as a potential drivers/barriers	8%	7%
Not interested/Not engaged	19%	4.9%
Other motivations	5.50%e	-

The comparison should be considered with caution for several reasons, including the difference already indicated in the number of segments or the absence of certain motivations in the assumptions classifying respondents into segments. Nevertheless, the disproportion, visible upon analysis, in the share of energy consumers with pro-environmental motivation should be observed and, perhaps, inform the hypothesis that it is caused by growing awareness and initiatives undertaken at various levels to promote sustainable consumption (including energy consumption). However, such hypotheses should be formulated with extreme caution because the share of segments with this motivation in previous studies

is not the highest value (higher for [27,74]). The same reasoning could be pursued in the considerations into the difference between the average share of consumers without commitment to energy saving and their share in the proposed segmentation, but again it can be argued that some of the earlier segmentations [27,42,74] did not include them at all. Despite the results obtained in the study, it is clear that further research is required into consumer energy behaviour motivations.

6. Conclusions

The behavioural segmentation of energy users performed as part of the eco-bot project contributes to and aligns with the current state of knowledge, complementing previous studies and filling the gap concerning the inclusion of behavioural and socio-psychological factors. Based on the literature review and taking into account the application requirements of the eco-bot project, the article presents the generalization of the existing segmentations aiming to obtain distinctive and, simultaneously, relatively universal types of energy consumers. The a priori segmentation is an approach that has been rarely adopted in the literature; however, it should be stressed that most segmentations performed to date have focused on clearly defined groups of energy consumers. The authors' goal was for their segmentation to be universal and, as such, applicable to energy consumers from different countries (the project requirements for the eco-bot application), varying in the energy mix and climate conditions, the dominant type of residential development. The definition of universal types of energy users required that the factors common to the existing segmentations were identified and, as a result, a new approach could be created. It is worthwhile to stress that previous behavioural segmentations of energy consumers did not jointly consider intrinsic motivation and the impact of the external environment (social pressure) in their models. The clear distinction of the five proposed segments was the result of the in-depth literature review, consultations with the project partners and the pilot survey. Further division aiming to identify more segments was considered, but it was not pursued as not to risk blurring the criteria and potentially reduce the universality of the segmentation model. In line with theoretical concepts, an energy consumer segmentation algorithm was developed based on the definition of the ideal representatives and distance measurement. This solution was intended to verify the project assumptions. The authors argue that the approach adopted was also more adequate to the implicated assumptions of the proposed than the application of taxonomic methods, which determine, for example, the number of classes in a simulational manner. In this case, the five segments of energy consumers were adopted a priori to be later verified by the survey.

The authors are convinced that the segmentation presented in the article can contribute to a better understanding of the needs and behaviours of energy consumers and provide support and reference to:

- central and local authorities—in their efforts to create effective tools promoting sustainable consumption and encouraging the adoption of energy-saving measures;
- energy providers—to adopt their energy products and services so that they include renewable energy sources and to identify the needs of their customers more effectively;
- NGOs—to target their campaigns promoting sustainable lifestyles more adequately;
- consumer organisations—to be able to adapt information and communication to specific consumer groups, also for educational purposes;
- scientific institutions and research centres—as the starting point for further empirical research.

The authors are aware of the limitations of the analysis presented in the article. The results are a starting point for further research rather than conclusions that can be generalized.

The presented validation of segmentation is not free from several constraints, especially as in the case of other studies [27,37,42,73,74], the survey sample is affected by geographical limitations. At this stage, the respondents were recruited only from three countries—Germany, Spain and Great Britain, which makes it difficult to conduct the synthesis of the results at this stage of the research. Additionally, as in [27,42,74], due to its

limited length, the survey questionnaire did not contain the complete list of behaviours that respondents may manifest in relation to energy saving. Moreover, the contextual factors, to which the survey refers indirectly through the attitudes and beliefs of respondents, were reduced to a few selected ones. The final limitation of the verification presented in the article is the fact that the respondents self-assess their energy behaviour. The verification is based on the opinions expressed by the respondents; hence the survey results may be biased because the respondents may wish to reveal socially desirable behaviour (as indicated by [103]) and hide or downplay socially undesirable behaviour (as in [27]). As in [41,104], the results obtained are declarative, i.e., they are a reflection of the respondents' beliefs and perceptions of their own behaviour and not necessarily their actual behaviour.

It should be emphasised, however, that the measurement of actual behaviour is difficult to perform, especially if a researcher wants to adopt a comprehensive approach accounting for a wide range of factors. The authors are in agreement with Boudet et al. [75], who argued that, in order to fully understand the behaviour of energy consumers and adequately promote energy-saving actions, the interplay between different sets of factors—demographic characteristics, individual values and beliefs, contextual factors and behavioural attributes—should be examined and may be the area of further research.

Due to these limitations, the authors are aware of the need to verify their segmentation on a larger and more diverse sample. Such a verification has been planned and is currently underway following two paths: as part of testing the eco-bot application by the customers of the project partners from Catalonia and Germany and in the course of a large-scale survey carried out in additional five EU member states of different profiles (the Czech Republic, France, Greece, Poland, and Romania). The expected results should lead to the final verification of the proposed behavioural segmentation and/or its modification to fulfil the needs of entities interested in promoting more energy-efficient attitudes among energy consumers.

Author Contributions: Conceptualization, S.S., J.K.-Ł. and J.T.; methodology, S.S., J.K.-Ł. and J.T.; formal analysis, S.S., J.K.-Ł. and J.T.; investigation, S.S., J.K.-Ł. and J.T.; data curation, J.T.; writing—original draft preparation, S.S., J.K.-Ł. and J.T.; writing—review and editing, S.S., J.K.-Ł. and J.T.; funding acquisition, S.S. All authors have read and agreed to the published version of the manuscript.

Funding: This research was funded by European Union's Horizon 2020 research and innovation program: "Reducing energy consumption and carbon footprint by smart and sustainable use", as a part of the currently implemented project "Personalised ICT-tools for the Active Engagement of Consumers Towards Sustainable Energy. Eco-bot" under grant agreement No. 767625.

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Data Availability Statement: Supplementary data to this article can be found online at: https://web.ue.katowice.pl/trzesiok/data_for_analysis_Innovative_approach_energy_consumer_segmentation.csv (accessed on 14 June 2021).

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

Appendix A

Table A1. The *good3* distance calculated between points representing sample respondents and every centroid of the segments: EI, AE, DS, O and I.

ID	*good3* Distance to Centroid of Class EI	*good3* Distance to Centroid of Class AE	*good3* Distance to Centroid of Class DS	*good3* Distance to Centroid of Class O	*good3* Distance to Centroid of Class I	Segment
1	1	0.773	0.358	1	1	DS
2	1	1	0.784	1	0.253	I
3	0.782	0.773	0.559	1	1	DS
4	0.360	0.765	1	1	1	EI
5	0.360	1	0.784	1	1	EI
6	0.780	1	0.799	0.518	1	O
7	0.360	1	0.784	1	1	EI
8	1	0.773	0.574	0.766	1	DS
9	0.751	1	0.337	1	1	DS
10	1	1	0.121	1	1	DS
11	0.798	0.290	1	1	1	AE
12	0.580	0.773	0.784	1	1	EI
13	0.580	0.773	0.784	1	1	EI
14	0.780	0.765	1	0.504	1	O

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