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Exploring the Potential of Energy Consumers in Smart Grid Using Focus Group Methodology

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Abstract: The socio-technological transition towards smart grids is an on-going process requiring adaptive behaviour by consumers. It is commonly assumed that consumer's attitudes and behaviours need to be modified to secure a sustainable energy future. This paper aims at exploring the influence of energy behaviours on smart grid processes, by contributing to the characterisation and systematisation of energy behaviours for specific segment of Croatian residential sector and proposing an integrative focus group methodology. Results show that participants have a positive predisposition towards smart technologies and home demand-side-management, but are less likely to accept automation system controlled by a supplier. We propose that smart grid designs must look beyond only the technology and recognise that a smart user who is actively engaged with energy is critical to much of what is proposed by demand-side-management. In the future, new innovative business models should be developed to explore different options to involve consumers to become smart users.

Keywords: energy behaviour; prosumers; demand-side-management; smart grid; focus group

1. Introduction

The term "smart grid" generally refers to the larger grid that integrates microgrids. A microgrid is a model for making a generation of electricity from resources, placed close to end-users making them competitive with central generation. The first power plants in the late 19th century were microgrids, so actually they have a long history. Microgrids enable the production and storage of renewable energy, as well as the exchange of electricity, between energy providers and consumers, to take place locally. Consumers are small-scale co-providers of energy reducing their dependence on the public grid. The social acceptance has to be ensured, providing them with an option to be more self-sufficient by becoming co-producers of electricity and forming their demand in the household. The residential sector is the major contributor to the global energy balance, so efficient demand management mechanisms are promising technique and proactive method to make users energy-efficient in the long term. Correspondingly, the attitudes and behaviours of energy consumers need to be modified, taking account of physical, social, cultural and institutional context, that shape and constrain people's choices [1,2].

Broad social acceptance issues largely determine the implementation of the smart grid. Today's focus is more on the technology than on general social acceptance issues. Consequently, the smart grid is a sociotechnical network, characterized by the active management of both information and energy flows, to balance energy supply and demand. Replacing conventional consumer–producer relationship with multiple relationships, where the consumer is co-producing and supplying for partners in the microgrid, as a distributed generation and vice versa. Other relationships, "consumer to utility", "consumer to grid manager" and "consumer to partners", are also changing. However, these relationships are not supported by existing institutions in energy provision. Accordingly, the attitudes and behaviours in the context of energy in microgrids need to change fundamentally, since it is the combination of new scientific and technical, as well as socioeconomic and organisation components [3].

Scientific research reveals that this field is enormous and has a potential to be applied in the area of energy and environmental issues. In the field of domestic energy consumption, a significant influence on consumer behaviour includes disciplines such as sociology, social psychology, human geography and anthropology, as well as a lack of information. The behaviour of energy consumers is influenced in complex ways by factors such as price, awareness, trust and commitment, including a sense of moral obligation [4]. The relationship between socioeconomic development and energy consumption is bi-directional. The availability of electricity allows the application of modern technologies, which improve the productivity and increase economic welfare. Therefore, the increase in electricity consumption is the consequence of economic growth and development. The energy policy, the delivery price and available technology all affect individual energy consumption. The energy policy usually has an influence on the human behaviour in an institutional and impersonal form. The tariff policies represent consumer expenses and modification, which are assimilated by population in time. However, if a consumer is used to technology, it is not comfortable in changing equipment, especially if facing higher cost.

To summarise, the sociotechnical transition towards smart grids is an on-going process which requires adaptive behaviour by consumers, so focus group methodology was used to explore characteristics of energy. In this respect, it is essential to understand and involve consumers to successfully assume their new role as active participants in the electric power system. For energy providers, it is critical to developing a closer relationship with their consumers during the new service development process to ensure excellent performance of new services [5].

Many studies have recently published results where consumers have been involved in interviews and surveys to assess their perceptions, understanding and willingness to pay for the development of smart grid technologies. These studies acknowledge a positive consumer attitude towards smart grid technologies. However, they also recognise the need to address beliefs and misunderstandings that new technologies are not reliable, transparent and do not provide feedback [6]. Even acknowledged by the European commission, a lack of consumer confidence or choice in the new systems will fail to capture all of the potential benefits of the smart grid, building a social roadmap for the smart grid [7]. As argued by [8], the only aspect of the smart grid that can be smart are the people within it, so if consumer's behaviour will not understand at these early stages, smart grid initiatives risk failing to realise their full potential. Observing of consumers in their social context has to start at an early stage of smart grid implementation and be included in the development process, to deliver the expected goals.

This study explores current and potential energy behavioural adaptions in Croatia during the smart grid transition period. A focus-group methodology was made to a reprehensive sample of the particular segment of Croatian residential consumers, evaluating current energy behaviours and questionable future actions for three different scenarios of the smart grid. This study uses empirical research methods to explore behavioural potential, rather than experimental approaches based on analysing pilot projects. The study examines characteristics and the willingness of consumers, regarding the different level of engagement in the smart grid environment. The central research questions are: What is the current involvement of Croatian consumers in energy consumption? What are relevant factors for adopting further behavioural adoption in Croatia? What are the preferences towards the different levels of engagement in smart grid environment? The aim of the research is to make a useful contribution to help utilities, policy makers and other various stakeholders involved in smart grid transition process.

The research has been carried out at the Polytechnic of Međimurje in Čakovec during April and May 2016. Four groups participated in the study, highly qualified consumers, categorised due to the status of involvement regarding involvement in education process at the Polytechnic. A group of full-time students (R) with eight participants, a group of part-time students (I) with seven participants, a group of teaching staff (N) with four members and administrative and support staff (A) with four participants, altogether 23 persons. As today's students will be users of the smart grid, the emphasis is put on student population. However, another reason why the research was carried out within higher education is, as mentioned in [9], they will be the first community to adopt the smart grid technology.

The research consisted of three sections. In the first part, participants filled in an entry form with basic socio-demographic characteristics, habits linked to energy consumption and the impact of the present economy on their usage of energy [10]. The second part included a short presentation on three different models of the future grid and ways of using energy in a household and its distribution. Model A, as shown in Figure 1, represents uncontrolled consumption in a household consisting of home automated appliances enabling remote control, an electric vehicle and a small PV power plant. The house is supplied with electricity from a PV power plant or the grid. In the case of surplus electricity production, electricity is sent back into the grid, while in the event of lack of electricity, a shortage is compensated from the grid. The consumption of electricity for household appliances and charging the electric vehicle is not controlled.

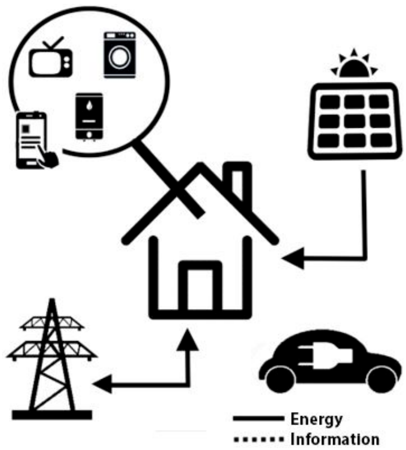

Figure 1. Model A—Uncontrolled load.

Model B, as shown in Figure 2, represents controlled consumption without an energy storage system. The previous model is updated in the way that the consumption of household appliances is optimised due to the production of PV power plant. In the case of surplus or shortage, electricity is sent to or taken from the grid. The electric vehicle is uncontrolled load, charged when connected to the grid. Model C, as presented in Figure 3, represents controlled consumption integrating an energy storage system, meaning that the electric vehicle, when connected to the house grid, can behave like a load or storage unit. The flow of energy from the battery will be determined by the household automation system, so that dependence on the grid will be decreased. In the case of a surplus of production, electricity will be stored in the battery of the electric vehicle or sent back to the grid. The consumer will personally set the settings, depending on the level of engagement in the electricity market. It can be concluded that, by using different approaches, the level of consumer engagement in the smart grid will be increased. Afterwards, a discussion with consumers was continued about their electricity usage, existing electric grid, topics about new technologies which will be integrated into the smart grid and preferences about the level of their engagement regarding different models and possibilities.

The third part consisted of filling in the exit questionnaire in which participants had evaluated their level of engagement due to a different situation, based on the Likert scale with five levels for further research necessities.

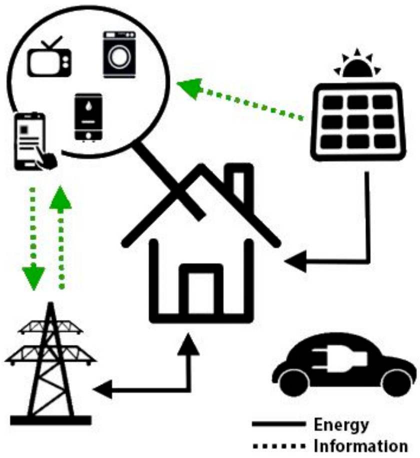

Figure 2. Model B—Controlled load without energy storage system.

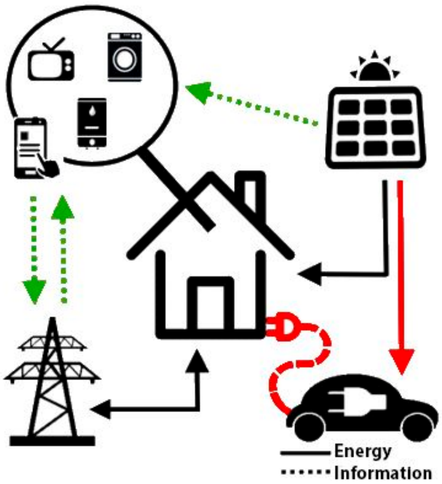

Figure 3. Model C—Controlled load with integrated energy storage system.

2. Review

Upgraded electric grid will become smart grid, enabling a two-way flow of energy and information, from production to consumers, and vice versa. This bidirectional flow will not only be necessary to dispatching grid for grid operators but also for consumers since their role will not be passive consuming of electricity but also they might become producers, titled as prosumers. Prosumers will have to deal and decide whether to consume, store or sell electricity back to the grid, depending on their consumption and dynamic prices, weather conditions, comfort requirements and power availability [11–13]. It is clear that technologies will have to provide support to consumers with applications of smart metering, energy management systems, and smart appliances to help consumers to manage their consumption. Traditionally, consumers are only focused on investment, maintenance and usage [14]. Depending on their behaviour, their consumption will be created. However, it is evident that most of the field studies and pilot projects are limited in the sample size and are often addressed to early adopters that are not representative of the population as a whole. This highlights how crucial it is to further research on human behaviour and psychological aspects in sustainable energy system acceptance. If society wants to change to an entirely new energy system, people will have to change their behaviour. Indeed, energy use is all about human behaviour: it is the consumer who determines what energy to use, how much energy to consume and if to consume it in an efficient way [15–17].

The theory of planned behaviour [18] is considered an example of an adjusted expectancy- value theory [19]. In an expectancy-value construction, people behave according to their beliefs about the outcomes of their behaviour and the values they attach to those outcomes. The behaviour is determined by the particular intention to perform it. In turn, the behavioural intention is driven by attitudes, subjective norms and perceived behavioural control. Attitudes towards a given behaviour depend on the beliefs about and evaluation of the outcomes of that behaviour and rely on the weighing of various costs and benefits, regarding time, money, effort and social approval. Subjective norm refers to the perceived social pressure to perform or refrain from that particular behaviour. The subjective norm is constructed as an individual belief about what other people who are important to me think of that specific behaviour, rather than the own personal belief about the behaviour (referred to as personal norm) [19]. Perceived behavioural control refers to people's perception of their ability to perform a given behaviour.

Stern and colleagues [20,21] proposed the value-belief-norm theory. The theory postulates that environmental behaviour results from pro-environment personal norms, i.e., a feeling of moral obligation to take pro-environmental actions. These personal norms are activated by beliefs that adverse consequences threaten things that the individual values (awareness of impact for valued objects, AC) and believes that the individual can act to reduce this threat (ascription of responsibility to self, AR). The value-belief-norm theory proposes that awareness of consequences and ascription of liability beliefs are dependent on general beliefs on human–environment relations (as the new environmental paradigm (NEP) whiting which human activity and a fragile biosphere are seen as inextricably connected) and on relatively stable value orientations. Typically, three general value orientations are distinguished: an egoistic value orientation, where people try to maximise individual outcomes; an altruistic value orientation, reflecting concern for the welfare of other human beings; and a biospheric value orientation, reflecting a concern with non-human species or the biosphere. Self-enhancement (egoistic) and self-transcendent (altruistic and biospheric) values seem to be particularly relevant to understand beliefs, preferences, attitudes, norms and behaviour in the environmental domain [20]. The stronger the biospheric and altruistic values, the more likely the person will accept the new environmental paradigm; the stronger the egoistic value, the less likely the person will take this model. The causal chain proposed in value-belief-norm theory moves from relatively stable and general values to beliefs about human–environment relations (NEP). These ideas about human-environment relations lead to awareness of the environmental consequences of one's actions and this, in turn, leads to awareness of one's responsibilities to reduce those effects. Based on this, the person develops a personal norm to engage in pro-environmental action [19].

The Integrated Framework for Encouraging Pro-Environmental Behaviour in [22], suggests two basic strategies to support pro environmental actions. The first approach focuses on reducing the conflict between hedonic and egoistic goals on one hand and normative goals on the other end; the second strategy focus on strengthening normative goals, therefore weakening the relative strength of hedonic and gain goals. Though the first strategy is important when pro-environmental behaviours are costly, it may not lead to sustained pro-environmental actions (people will act pro environmentally only as long as it is pleasurable and profitable to do so). On the other hand, strengthening normative goals can encourage pro environmental actions even when these actions can be somewhat costly. Steg et al. propose that the strength of normative goals depends on which values people endorse as well as on situational factors/cues that activate and support the accessibility of these values.

Research and studies in psychological aspects of energy system and on how to motivate sustainable and pro-environmental behaviour have increased in recent years. They explore that human behaviour and perception are the bottlenecks for many changes, yet researchers were typically focused on efficient energy use, addressing consumer as passive precipitant. Little is known how to change and shape active role of consumer in future grid [16]. Residential consumers accept smart technologies and support related investments, but are uncertain about their social and individual benefits [9]. Improving communication to residential consumers on the benefits of smart technologies is a fundamental aspect of their deployment [23]. Consumers adopt smart home technologies, not only depending on their price, savings and payback, but also on their convenience, ecological footprint, transparency and data privacy, the sense of control they provide and design other attributes [24,25]. Consumers often mistrust full automation and prefer controllable levels of automation, so they accept these technologies as long as they do not interfere with their daily activities, habits and routines [26]. In addition, according to smart grid projects in Europe and their research, they revealed that in the process of turning consumers into more active players in the energy system it is important to tailor and diversify strategies based on consumers' segmentation according to attitudes, motivations towards energy usage and values [5,27].

Social norms can facilitate consumer engagement in sustainable technology. Condelli [28] researched that social network plays an influential role in innovation diffusions, more than mass media. Interview results from Alolayan [29] found that some participants' intentions to use smart fridge are influenced by their friends, colleagues and community. Kranz [30] explored that groups like family members or friends significantly affect the intention of smart meter adoption. Axsen, according to [31], found that, among interested households, only those who found positive support through interpersonal interactions were willing to shift toward pro-environmental lifestyle. For PV diffusion, social influence was recognized as an important driver. As solar panels are visible, one sees neighbours benefiting from PV installations and becomes more aware of the available and viable option, and then the person is more likely to install a PV system [32].

Differences in behaviour of consumers have been found to contribute to the variability in household energy consumption levels. The research result found that more than 40% of the electricity consumption in households could be linked to lifestyle factors; approximately 12% of the variation in energy user for space heating could be explained by occupant behaviour; approximately 20% reduction in household carbon emissions could be achieved by behavioural changes [16]. It is suggested that future research should focus more on the household and more on the individual energy consumer as key unit of analysis. The private area comprises habits, current practice, experience and attitudes, while the contextual field focuses on both individual and collective variables (e.g., technical skills, know-how, social norms and expectations) [33,34].

Opposite perspective of the previous models, sociology approaches argue that energy use is not a consequence of individual choices, but it results from social context. Needs, attitudes and expectations are not individual, yet are part of a complex relationship between social norms and relations, technologies, infrastructures and institutions. Energy consumption is not the result of quick personal decisions. Therefore, it is the product of a long and complicated process. The energy provides useful services that enable normal and socially acceptable activities to be carried out as part of normal daily life. Some authors argue that fostering cooperative and energy savings household dynamics can have better results than educating people [35]. In recent years there has been an increasing trend of using agent based simulation in residential energy research [36,37] to approach the complexity of the problem. The idea is to model in a virtual environment the electricity prosumers who, while acting in a smart grid context, behave and interact with other actors at household, community and societal level. According to [38], several energy frameworks are explored from the point of view of the energy consumption process components:

- consumer choice—procedural rationality, behaviour economics and hierarchy of needs theories;
- needs and desires—personality, control, self-discrepancy, prosocial behaviour, perceived consumer effectiveness, collective action dilemma, willingness to pay and value belief norm theories;
- learning—cognitive consistency, balance, consistency, cognitive dissonance and relation discrepancy theories;
- buying—rational choice, the theory of reasoned action, theory of planned behaviour, hierarchy of effects and innovation decisions theories;
- categorisation of consumers—behavioural economics and diffusion methods; and
- product attributes and classification—distribution process.

The process of electricity consumer engagement is tightly related to the evolution of the electricity networks. Empowering the consumers to manage their electricity consumption, while enabling them to actively contribute to the operation of the distribution network, requires taking full advantage of the capabilities of smart grid technologies. Figure 4 depicts the level of consumer engagement in line with the evolution of the smart grid potential. The initial level of consumer involvement takes place through the provision of certain house electricity bill as a result of advanced metering infrastructure (smart metering) installed in the customers' premises. This indirect feedback does not necessarily motivate consumers to reduce energy consumption or trigger energy efficiency [6].

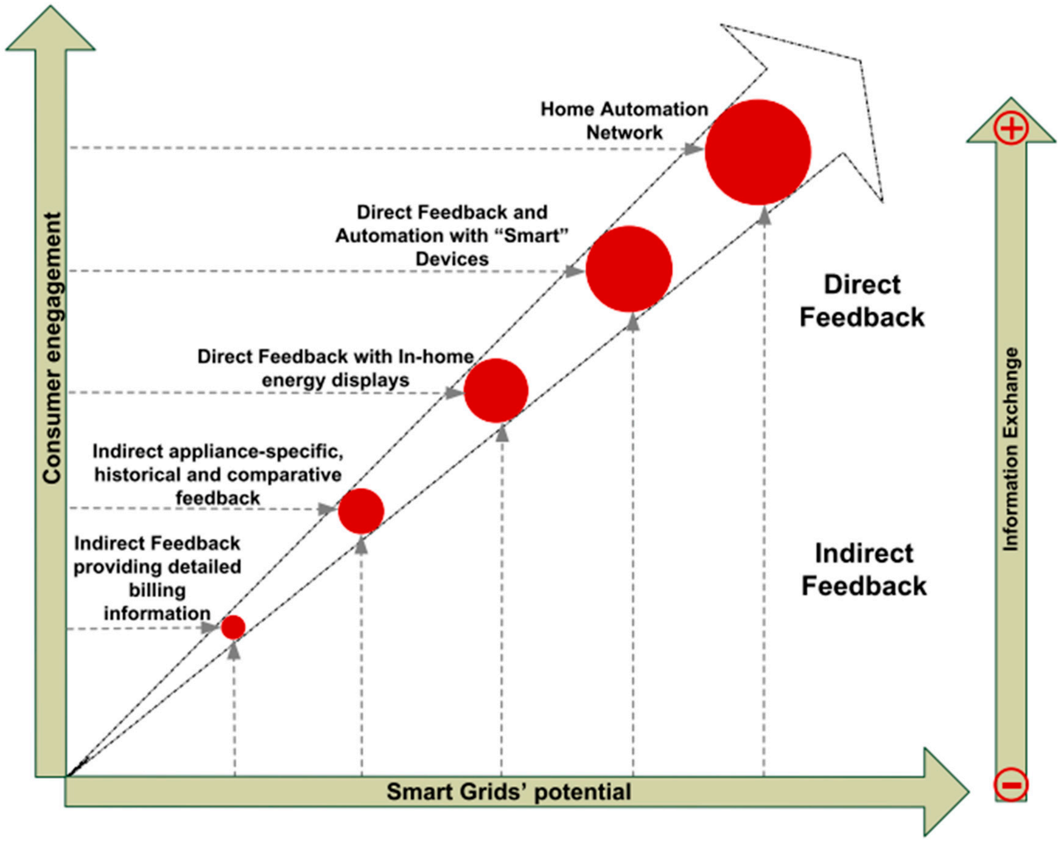

Figure 4. Consumer engagement and smart grids' potential.

To summarise, the socio-technological transition towards smart grid is an on-going process requiring adaptive behaviour by consumers. According to [39], the behaviour is influenced by the interactions between cognitive norms (e.g., beliefs and understandings), energy practices (e.g., activities and processes) and the material culture (e.g., technologies and buildings). Its four key features are:

- it is change-oriented rather than deterministic since it proposes social, environmental and economic forces, but do not determine person's cognitive norms, practices and material cultures;
- it accounts for the context through its modelling of the interactions between the three core components of behaviour, and between these and wider societal and structural influences;
- it is mainly designed to characterise variability in behaviours, enabling segmentation of the population regarding different clusters of similar patterns of norms, practices and material culture; and
- it works at different scales and in different sectors, applying to understanding an individual household, business, neighbourhoods, industries or regions.

Although being a conceptual model, it was developed from a case study using a multi-disciplinary research design approach.

3. Research Methodology and Objectives

The study was developed in the context of a multidisciplinary project of developing a demand-side-management system to be used to control, manage and optimise smart grid technologies and electricity consumption. Proposed models aim to autonomously coordinate and optimise electricity management in households, including storage and selling electricity back to the grid. For this purpose, consumers' preferences needed to be properly understood and addressed, including constraints associated with behaviour, usage of appliances, possibility to shift their working period, using electric vehicles as a storage system and decentralised renewable generation of electricity. Quantitative and qualitative methods were used to measure their level of motivation and perspective for smart grid technologies and services [40]. The knowledge of behaviour from social science has to be integrated, along with technological aspects [9].

The research is a foundation for further studies. Energy patterns and behaviours are used as an orientation for designing of input data of optimisation model. Members of the focus group will be energy consumers in the self-sustainable house, based on Croatian concept Membrain, designed for international student competition Solar Decathlon Europe.

Due to a previous survey [40], the classification regarding the status at the Polytechnic of Međimurje is the same. Full-time students are energy consumers who are still living with parents or renting an apartment where they study. It is expected that they use energy following their parent's patterns. Since they are still in the process of education, their level of experience of new technology is higher, so they will adopt it easier. Part-time students are consumers of various age groups, employed and interest groups, so their energy consumption is mixed. However, they are still in the process of education, willing to improve knowledge, which means that they are going to accept new technologies. The administration staff is employees from whom it is expected to behave with regards to economic incentives. Teaching staff are an academically highly responsible cluster and, since they are already taking part in research in their field, will be willing to contribute to science, additionally guided by economic incentives as well. Lastly, it is expected that consumers will be socially responsible for the establishment of a sustainable society.

In Figure 5, basic socio-economic characteristics of participants are presented: about 60% of participants are students, younger than 25, with an income less than 3000 kn; 73.9% of participants are women; and 56% are unemployed. Almost 70% of them live in a family house and the majority in a household with more than three members. The research was carried out on a large proportion of students, since, as previously mentioned, they will be users of future smart grid technologies. Additionally, students are a new generation, with a different view on the world and consumers who still have not developed their attitudes of energy usage, so they will probably be willing to use different tariff systems.

4. Results and Discussion

4.1. Behaviour of Energy Consumers

The discussion with participants started with topics concerning basic energy consumption issues. Participants had different viewpoints on energy consumption since the differences between groups were obvious. Teaching and administration staff members have provided information about their electricity expenses, but only a few of them had expressed it in kWh. As expected, groups of full-time and part-time students were uninformed, since their parents have been paying for electricity. When asked if they think that energy in their household is efficiently used and if they use the privilege of lower priced tariffs, most of the participants had concluded that energy is being utilised efficiently, but that they are aware that it can be used more effectively. Teaching and administration staff used the term of energy classes of their appliances in the household. The majority of participants were not informed if they had a multiple tariff system, especially full-time and part-time students.

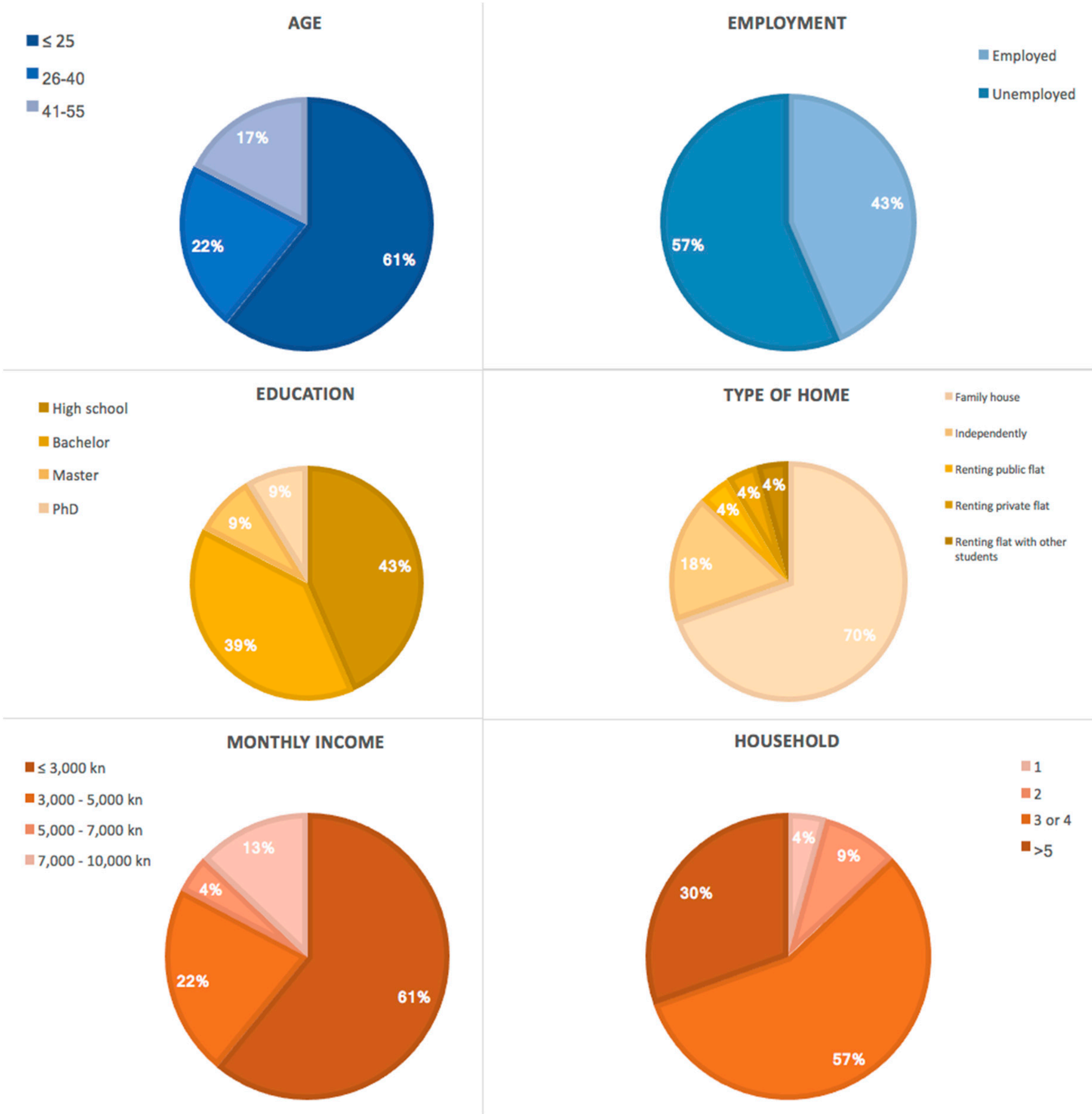

Figure 5. Socio-economic characteristics of participants.

(R): *I was never informed about prices, I did not even see our electricity bills, so I do not know.*

(N): *My monthly consumption is about 130 kn (20 €), for an apartment of 55 m*^{2} *and I think it could be decreased. For example, I have an old freezer, which could be replaced with a new, more energy efficient one and I could use the washing machine during the lower tariff period.*

Just one participant of the teaching staff is monitoring energy consumption on the meter in the case of a significant deviation of the electricity bill. The majority of participants have mentioned that they do not agree with meter reading in a six-month period, so they would like to be aware of consumption in a shorter period.

(N): *Occasionally, when I get a bill that burns my eyes, then I do some control.*

Participants have been asked if they can imagine life without energy and how they feel in the case of blackouts. All participants answered that they think we became dependent on energy since our daily activities are based on its presence.

(N): *I believe that all life is built on and depends on electricity.*

4.2. Opinion on Existing Electric Grid

Participants were asked about electricity suppliers and their satisfaction with provided services of the existing electric grid. When asked about their opinion about electricity prices, answers were divided, and one of them was following:

> (N): *I think it could be lower if HEP (Croatian Utility Company) was more efficient in managing the company*.

When talking about tariff models, some of the participants pointed out that they could not change their tariff models, even if they wanted, since their building infrastructure does not allow it.

> (A): *We did not have a choice*.

From the moment of energy market liberalisation and new suppliers, energy consumers still stayed at HEP supply. Just one household of 23 had changed the electricity supplier, but they pay the same for the electricity as before. The reasons why many energy consumers do not switch to another supplier are fear and lack of trust in prices and available models, resulting from media reports on some cases of similar negative experience with the telecommunication sector.

> (I): *I think it is about the same. When it was first offered, it looked a lot cheaper on paper, but it isn´t a big difference*.

Participants have confirmed that they are not aware of the items on the electricity bill, so they do not know that they pay separately for the usage of the grid, for energy consumption, a fee for investments in new renewable technologies, etc. Participants are satisfied with the reliability of the power system since they are informed about electricity grid maintenance work in time.

> (I): *I agree; it can be said that we are used to having it. And the media informs us when and in what period the electricity will be gone so that we can prepare*.

4.3. Opinion on Smart Grid Technology Adoption

The smart grid will be based on an integration of new technologies, such as renewable energy, automation system in a household and electric vehicles. In this part, participants were asked if they are interested in using this kind of system. They answered that they are aware of the potential this kind of technologies can offer, but they think that, at a national level, the potential has to be used more. The majority of participants answered that, if they could, they would install renewable energy sources immediately, while one of the participants from the group of administration staff reported on building a new house in which new technologies are used. In the design phase, the participant consulted technology experts. The new technique has not yet been subsidised.

> (A): *I am in the phase of moving to my own house and, we worked a lot on the sources of energy storage, solar systems and collectors and pyrolysis furnace*.

Reasons, why some participants did not implement similar projects in their households, are following: some of the participants have indicated that in the present building, they do not have the opportunity to integrate some of the new technologies since they have problems with building co-ownership.

> (A): *Actually, I can not afford it, because the building is common property and I am just a co—owner, so without the consent of the rest of the owners we can not put panels on the roof, the majority has to agree*.

Another problem is an initial investment that is too high for a majority of participants, in particular for the group of full-time and part-time students, who still do not have their household. It has to be mentioned that their level of motivation to possess new technologies is high. Nonetheless, some of the participants think that financial incentives are necessary.

> (N): *I would love to have the passive house, to supply myself. The only problem is the necessary starting capital.*

One of the participants interested in the integration of a solar system could not carry out the project because the bidder and the exponent were not behaving professionally.

> (I): *I know that in my household, my family has already asked for an offer and they came by. But it did not happen, it was quite expensive, and that was a few years ago*.

Household automation systems are attractive to the majority of participants, especially because their aim is to simplify daily activities and increase life quality. The listed advantages inevitably include remote control of household appliances, individual settings of working period, constant and real-time monitoring of consumption, etc.

> (A): *I think that automation system is a good thing*.

> (A): . . . *it will increase the quality of living*.

> (R): *I believe that automation makes the life easier*.

The increase in the number of electric vehicles is expected, and will thus cause a change in the traffic system. Participants answered that for a faster integration of electric vehicles infrastructure is necessary and that, today, the lack of charging stations is evident. However, some participants were wondering if this technology is just transitional, while others think the electric car will develop to an entirely self-sustainable system, able to supply itself with energy.

> (N): *I believe that it is a matter of infrastructure, i.e., electric vehicle charging station*.

> (N): *I think there will be an increase of such vehicles because they are ecologically more acceptable and trendy*.

It will be necessary to provide all relevant information to consumers so that could decide for their best solution, probably led by economic incentives.

> (N): *I think everything would be solved with a real economic incentive*.

Education for consumers would be useful for future smart grid users, with the aim to introduce different models and possibilities.

> (I): *I think so, yes, because, in the households here, parents do not use new media like the internet, maybe through television, it would reach the population that manages the home*.

> (I): *Maybe that would be good to a certain age group, but it would be difficult to get the younger people to a seminar about saving*.

Consumers can also be informed by contacting the producer, seller, or installer of the technology directly so that adequate information would be provided.

> (R): *The way that people could get informed is simply by a call to a supplier*.

A participant in the group of full-time students mentioned that maybe some online application, such as calculators, where you can enter basic information, would be useful. Another member suggested that this has to be already included in the education system, so, even from school period, you could act sustainably.

> (R): *It would be useful if some education would be implemented in the education system*.

4.4. Potential of Future Energy Consumers

Participants agreed that an automation system would be widely accepted and a part of daily activities. Remote control of the automation system is necessary, and will also serve as an initial help in the use of new technologies. The automation system has to provide useful information to customers, offering different options with economic calculations.

> (N): *I think that process automation would help, especially for people who will have difficulties in understanding how to convert to a smart system*.

> (A): *To suggest an option because you have to make decisions which you have not thought about before*.

The motivation of participants for engagement in the energy market was high, and even some of them suggested that they would like to exchange energy with their neighbours, forming a microgrid.

> (N): *Yes, I am more interested in micro network*.

Decisions about selling, storing, or buying electricity will be mostly led by economic profit of the consumer. A minor part of participants has made the statement that saving, if small, was not attractive to them.

> (A): *Yes, but I think there is a lot of combination. Again, you should make decisions that are best for you*.

Participants are assuming that electric vehicles will take a significant part in the transport sector and replace conventional vehicles. Consumers find a secondary use of electric vehicles, especially as electricity storage, attractive. One of the participants has predicted the possibility of using electricity stored in the electric vehicle in remote locations.

> (N): *It would be funny when, ok, I fill the car tank, I have a vacation house somewhere, and then I plug it in there... It would be my power plant and enable me to use the energy* . . .

A minor part of participants are not interesting in using the electric vehicle for other purposes, but, if necessary, the vehicle would have to fulfil its primary function, namely mobility.

> (N): *I do not know, for now, I am only interested that the vehicle is electrical and that I can reach some place. The rest is an upgrade that, at the time being, does not matter to me*.

However, participants who were not interesting in using the battery of the electric vehicle, consider the secondary function a risk for the battery system and lifetime.

> (I): *It would bother me, I think I would feel unsafe. The question is how long can I drive this car, how much do I have to the next charging station. I would maybe give up because of it*.

However, participants who were not interesting in using the battery of the electric vehicle, consider the secondary function a risk for the battery system and lifetime.

> (I): *I think that is adequate for someone who lives in a city because they do not drive longer distances. I believe it would be ok because it would preserve nature*.

Charging stations for electric vehicles should enable fast charging, to satisfy mobility needs of consumers.

> (R): *I would use an electrical vehicle under the condition that there is at least one charging station in every city so that the range would not be a big problem*.

The integration of home automation system with demand-side-management was acceptable to participants. It is important to members that the used equipment is sophisticated. However, they are aware that even that can fail. Just a few participants expressed fear of system intrusion.

> (A): *About hacker invading the system—I am a little sceptical there, but I would agree to it and use it*.

Information of home demand-side-management has to be exact and transparent for consumers to decide how they will use electricity. Participants concluded load shifting would be more attractive if the economic profit was higher.

> (R): *I would agree in the case that I do not need this at the moment, that I can postpone it for an hour, two or three, depends on how much is necessary, but if I need it right now and the price difference is not big, I would use it*.

Participants are aware that they can achieve significant economic benefit with small savings in the long term, so this is the primary motivation. When asked about their vision of sustainable development, they expressed their concern about Croatia and that it is evident that the rest of Europe is a step forward, mostly due to government decisions, laws, and regulations.

> (R): *I agree that we are lagging behind the rest of the world*.

Participants are aware that change can happen from individuals, creating their vision and being an example to the rest of the population.

> (R): . . . *every change starts with yourself...*

4.5. Self Evaluation of Energy Consumers

In further work, entrance and exit questionnaires were carried out on participants who had been part of the research. The results show that some habits of consumers are efficient. For example, 90% of participants always or very often turn the lights off in rooms where they do not stay. In addition, almost 90% of participants always or very often close doors in heated or cooled rooms and 80% of participants turn off the TV when nobody is watching. However, some of the consumers' habits have to be more efficient, such as avoiding the standby mode of appliances, which is only practised by 20% of participants.

The results linked to household demand-side-management show that the majority of the sample has a positive opinion about it and they think this kind of technology contributes to the environment, national economy, and a decrease of energy resources and facility fees in the household. Participants assume the acceptance of energy management system is a social responsibility and that it starts with individuals. Additionally, the majority of participants consider that their daily household activities will not be negatively influenced and that this kind of system will not take up their time and 68% of participants would accept this sort of system.

As a consequence of the state of the economy, more than a half of participants have changed their opinion about using electricity, especially on using the concession of lower priced tariffs and buying energy efficient appliances. Some of the participants think their consumption is lowered and their way of energy consumption was influenced by the state of the economy in the country.

Characteristics of the automation system relevant to consumers are related to access to information about energy use, costs and savings in real time. Other important features are the possibility of a simple change of the working period of appliances and remote control. All participants in the research want to possess an automation system to control household appliances, but the essential characteristics are reliance on technology, the possibility of savings, a simplicity of the system and user friendliness.

Participants have mentioned that they are ready to change their daily pattern of using appliances in a household and, surely, economic incentives are the most important factor which would contribute to it. Appliances whose working period can be postponed are dishwashers, washing machines, dryers, etc.

Only 26% of participants would accept an automation system managed by the supplier, while the other 74% think this kind of system would disturb their privacy, so they would like to be able to control their system. Participants think the possibility of damaging appliances, in this case, is high and, in their opinion, the relationship with the supplier needs to be based on trust.

As part of the research, hypothesis testing has been carried out. The mean value of consumers accepting the centralised automation system was tested. For testing the hypothesis, due to the small sample, the *t*-test was used. The hypothesis is next: H_0: $\mu \leq \mu_0$; H_1: $\mu > \mu_0$, where $\mu_0 = 3$.

Results are shown in Tables 1 and 2. The mean value and standard deviation can be seen in Table 1. The average value refers to the extent to which the average participant will accept a central automation system in the household. The standard deviation is representing that there is not any scatter. Table 2 shows that the significance of the level of *t*-test is 0, which means that zero hypothesis is rejected. This proposes that the assumption that consumers will accept centralised automation system is confirmed.

Table 1. One-Sample statistics.

	N	Mean	Standard Deviation	Standard Error
We will accept centralised automation system	23	3.9130	0.73318	0.15288

Table 2. One-Sample test.

	Test Value = 3					
	t	df	Sig. (2-Tailed)	Mean Difference	95% Reliability Index	
					Low	High
We will accept centralised automation system	5.972	22	0.000	0.91304	0.5960	1.2301

5. Conclusions

The decrease of electricity consumption through measures of energy efficiency in future smart grid will not be enough due to the significant role of intermittent production capacity based on distributed energy resources. To satisfy consumers' energy demands, they will be enabled to control their consumption with the aim of balancing production and consumption. Consumers will play a vital role in the realisation of the smart grid. Therefore, infrastructural and institutional support is necessary. It is important to understand that without a smart user, there will not be a smart grid [41]. Economics, behavioural and social psychology and technology diffusion focus on the individual as a decision maker, sociology questions the relevance of individually framed decision theories and highlights the social and technological construction of behaviour.

Terms related to energy efficiency were familiar to participants. Hence, some positive impact in this field can be seen. From existing technologies used, the integration of the solar system is the most popular one, especially the solar water heating system. Participants revealed they are not informed about their energy consumption, especially new generations of students. Thus, this can be used as an advantage, since their concept of energy consumption can be modified, especially in further stages of their lives, when they will build their houses. The majority of the teaching and administration staff is using advantages of lower priced tariffs, especially for significant loads. The research affirmed that it would not be possible to control habits related to food preparing and cooking, and therefore, loads in a kitchen, except dishwashers, will be categorised as uncontrolled loads.

The focus group methodology has confirmed that participants reacted positively on presented smart grid technologies. As an advantage of upgraded electric grid, the majority of participants would accept using the automation system to the level where they could control the settings independently from the central system. The smart home system, due to research, was familiar mostly to students and they were highly motivated to use this kind of system. The data privacy, storage, and user friendliness of the system are important categories of smart grid systems. The members expressed they expect to be educated in some way so that they would be familiar with all kinds of possibilities of smart grid systems. The research represented that just one of 23 households have changed its energy supplier due to the liberalisation phase of the energy market. However, in the case of possessing the distributed energy resource, participants showed their motivation to be engaged in the energy market. They think that individuals can set an example to grid users and motivate them to act sustainably.

To sum up, this research has contributed to the current literature by exploring Croatian residential users, especially potential future smart grid users, identifying the most relevant factors and strategies for facilitating the behavioural change and detailing preferences towards smart grid technologies according to presented models. Although these results apply to a particular segment of Croatian population, they are not generalised to the overall population. Since the focus group research mainly assessed the willingness to engage in certain actions, future research should also include the evaluation of practical activities with real-world smart grid projects.

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