Acceptance of Aggregators in Demand Response Programs During the Age of Renewable Energy

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Abstract

These days electricity supply and trading are developing quickly due to the digitalization of the energy industry. This development is also generated by the evolution of many new business models in the field and also by new technologies in form of smart grids, smart meters, demand response, smart homes peer-to-peer trading, blockchain, Internet of Things and not the least artificial intelligence. These technologies altogether have a great contribution to the field of electricity, furthermore conjointly make the digitalization of the electricity supply, trading, generation and transportation. The objective of the research is to determine the degree to which consumers agree to work with an aggregator to implement demand response programs. Additionally, there is an interest to research those services what makes these programs more attractive to electricity prosumers and consumers (both households and industry) as well to identify those triggers which make electricity consumers or prosumers to start utilizing them. We have to keep in mind that demand-side management beside offering monetary benefits and incentives, also assists final consumers and prosumers in energy management in the meaning of increasing the level of optimal generation and consumption and decreasing energy wastes. Beyond the abovementioned facts, the aim is on the decrease of carbon dioxide emissions generated by pollutant fossil fuel electricity generation and positively affecting global warming, without endangering the good functioning of electricity systems. Awareness and education have a greater role in achieving a more rational, conscious and optimal consumption of electricity though demand response programs. The issue has to be raised to the level of acceptance and importance similar to what recycling of other recyclable materials have these days, such as plastic, paper, various glass and metals.

Keywords: aggregator, demand response (DR), energy supply, energy trading, Internet of Things (IoT), smart meters.

1. Introduction

In recent years the evolution of electricity smart meters and the dynamics with which they were installed pushed forward and supported profoundly Demand Side Management (DSM) to pass through very powerful development and evolution. Nowadays in the electricity industry we can observe different types of challenges such as high energy losses, low efficiency and high emissions issues. Since there are differences between retail and wholesale prices, and also for the reason of flat electricity traditional prices there is no incentive for end consumers to modify or fine-tune their electricity consumption to supply costs. Demand side management has two big roles in the energy field. The first role is highlighted through the optimization what it offers to the evolution, innovation and modernization of electricity markets, aiding the process of electricity generation, consumption, transportation or even the storage. The second role - which is even more important than the first one - is when demand side management is offering solutions in the decrease of carbon dioxide emissions generated by pollutant fossil fuel electricity generation and positively affecting global warming.

A very efficient strategy for dealing with all of the above-mentioned challenges in power systems is to utilize demand side management programs. Demand side management offers all the necessary instruments concerning the improvement of the features of a power system from the demand side. It can be classified in two sub-categories as Energy Efficiency programs and Demand Response (DR) programs. We can describe demand response as modifications made by the electricity consumers in their usual electricity consumption patterns as a response to receiving incentives and to electricity price fluctuations over time. Incentives are mostly offered in order to increase electricity consumption when prices are low and decrease their consumption when electricity prices are expensive (electricity price behaves in the same way as any other commodity price, driven by the demand and supply curves), but all these also for the proper functioning of the electricity systems (Jordehi, 2019).

Usually electricity prices are lower when the renewable electricity generation is high and they are expensive when the renewable electricity generation is missing from the grid. It is necessary to underline that electricity generation from polluting fossil fuels is carbon intensive, furthermore they are much more expensive than electricity production from renewables.

In order for electricity end consumers to be able to use demand response, the electricity distribution industry should be digitalized as much as possible, because all component parts of energy supply, distribution, trading, generation and storage should be well coordinated in real time. This can be done with the help of smart meters, artificial intelligence, machine learning, huge data storage and analytics, as well as fast transmission of these. For the reason that electricity is produced as much as it consumed in a given timeframe and its storage can be expensive, it is a slightly different commodity from the rest of the same category.

Digital technologies have become parts of our modern lives and are affecting most domains. Through digitalization we will be able to improve sustainability, productivity, efficiency and safety of energy systems worldwide, taking into consideration questions of privacy and security. There is a continuous growth in the application of information and communications technologies (ICT) across energy systems, which can be identified as the digitalization of energy systems. The increasing convergence and interaction between the physical and digital worlds can be a different definition of digitalization. Three main elements define the digital world. The first element is digital information or the data. The second element is analytics - when using data we can create useful insights and information. The third element is connectivity through which the exchange of data between humans, machines and devices is made. As these three elements develop and

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advance, the trend to a greater digitalization is enabled. The evolution of these elements is a result of declining costs of data storage and sensors, more efficient machine learning, better connectivity of devices and people, cheaper and faster data transmission. “Internet of Things” (IoT), artificial intelligence and the Fourth Industrial Revolution are a range of concepts, trends and digital technologies contained in digitalization. According to the IEA 90% of the data in the world were created between the years 2015 and 2017. In addition, investments related to digital electricity infrastructure and software increased by 20% yearly during this period (International Energy Agency, 2017).

Until we have achieved the current utilization and acceptance of new technologies in the field of electricity distribution, supply and trading as smart meters, demand response, peer-to-peer trading, blockchain and artificial intelligence, the industry had to pass through several changes during the years. Council of the European Union (EU) together with European Parliament had to adopt a succession of law packages in order to reach the modern electricity trading of today (European Parliament, 2020).

Members States and EU came to a decision to gradually open these markets in the direction of free competition. In 1996 was adopted the First Energy Package for electricity and in 1998 for gas, the Second Energy Package was adopted in 2003 (European Parliament, 2020). At this time the electricity supply could be made by a larger number of companies, households and industrial consumers were able to freely choose their electricity supplier. The Third Energy Package which helped future liberalization of internal electricity and natural gas markets was adopted in April 2009. The electricity market rules from the Fourth Energy Package, from June 2019, offer support to attract investments and on renewable energy (European Parliament, 2020).

As a short review, security of supply, free access to electricity networks, transparency and free competition were the main focal points of the first package. The mandatory establishment of National Energy Regulators and the separation of the medium and low voltage from high voltage electrical networks (the separation of the transmission from distribution) were in the centre of the second package. Internal electricity and natural gas markets, competition, harmonizing the power of independent Regulators from different countries, better cross-border regulation, more efficient transparency, separating supply and production activities from transmission and distribution operations (so-called Ownership Unbundling) have particular attention in the third package (European Commission, 2019). Figure 1. below show how developed classic electricity markets worked in the past in the EU, when these new technologies were not available (e.g. smart cities, smart grids, prosumers Demand Response, or Aggregators):

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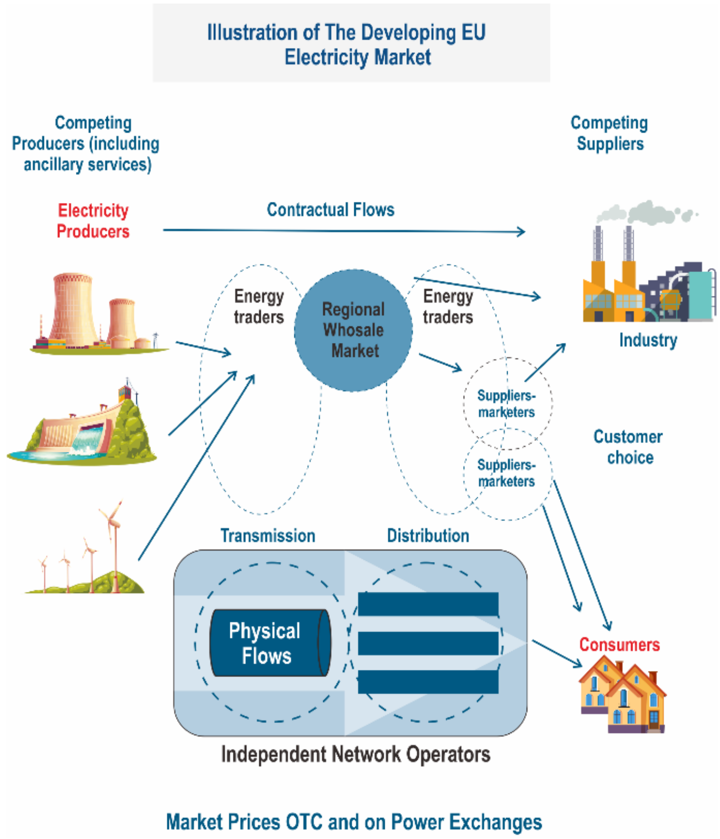

Figure 1. Illustration of classic electricity flow without Demand Response, aggregators, and prosumers.
Source: Adapted from Towards a single European energy market, EFET 15 years Edition, 2012, page 4:
https://www. efet.org/Files/Documents/Energy%20Background/Highlights-II-Final.pdf.

The objective of the research is to determine the degree to which consumers agree to work with an aggregator to implement demand response. In addition, we have an interest to search what determines them more attractive to electricity prosumers and consumers (both households and industry) as well as identifying the set off which makes electricity consumers or prosumers to start to take advantages of them. End consumers find it hard to learn how to work with these new technologies and their utilization creates difficulties, making them difficult to change from the convenient classic electricity supply (in the purchase of electricity), regardless of the time of consumption with fixed price to new models of optimized electricity consumption, even if this leads to an additional financial benefit. Furthermore, beyond these benefits, the increase of awareness regarding more rational, optimal and conscious electricity consumption, but also final consumer education is in the centre of attention. The outcome will be the reduction of pollutant fossil fuel electricity generation, lower carbon dioxide emissions and a more optimal use of renewable energy all these without endangering the proper functioning of the electricity systems

2. Literature Review

Because of the fact that demand response is voluntary, electricity consumers and prosumers should be convinced to participate. Participation in these programs means to accept home automation, to predictably respond to price signals, to participate in predictable and planned household activities that facilitate this kind of programs, this is also what modellers and analyst expect. As we have mention before, we would like to research the fact if end consumers are more attracted to DR through an aggregator (or Resource Aggregator) than participating by themselves.

2.1 Definition of aggregator in the scientific literature

The role of the aggregator as a market participant includes the following activities starting with registration and communication with consumers, calculation of consumption and savings, real time metering and forwarding of these data, calculation of user participation based on consumption and metered data. Furthermore, implementations of standards regarding metering and consumption verification, implementation of standards for data security, in the end consumer compensation. The aggregator, in addition to above mentioned, should obey to local regulations and comply with the particularities of the local electricity market where he operates. (Radenkovic et al., 2020)

A different approach for the aggregator as resource aggregator, defines it as an intermediator company between distributed energy providers, electricity end-users and participants to power system, which wants to utilize these services. According to the different types of resources it allocates, different types of aggregators exist. The role of the demand aggregator collects DR resources of all end consumers, the load aggregator accumulates the load flexibility of residential end consumers and the production aggregator gathers small generators as virtual power plant works (Lu et al., 2020).

An interesting recent study describes the operational model called day-ahead dynamic pricing-based DR. The core of this model is that each night end consumers receive dynamic electricity prices for the next day, from different aggregators. Each aggregator has different pricing scheme (dynamic pricing scheme), prices calculated in order to optimize its smart grid's total profit. The next morning the consumer can choose from these offers and pick which aggregator it works with (Tsao et al., 2021). As well we can classify the resources what manages an aggregator in consuming resources (CL), producing resources (DG) and bi-directional resources (ESS). Consuming resources (CL) describes those loads which have a certain flexibility, even if traditionally they are considered differently. These flexible loads could be aggregated and provide various configurations of ancillary services. Producing resources (DG) usually contains renewable electricity generation, as well as small traditional generation units which are installed close to end users. These production units could provide emergency power supply. Bi-directional resources (ESS) contains movable energy storage devices and static energy storage devices, which will represent a very important part of future power systems operation. Aggregators relation with end consumer can be classifies in analysing customers' DR potential, scheduling ahead of time, installing control and communication equipment, and providing economic incentives to customers. Analysing customers' DR potential is necessary in order that the aggregator could offer a customized service for a given end consumer and could correctly evaluate its profitability. It is important to find out for each end consumer which factors are influencing its responsiveness. Scheduling ahead of time describes the action of informing in time end consumers about possible interruptions or about when they have to reduce their electricity consumption. Installing control and communication equipment necessary for implementing DR and for the interaction between end consumers and aggregator. The control and communication are made through different types of devices, which can be also smart meters with load control. The aggregator makes installation and maintenance of these equipment. It also provides economic incentives to customers through incentives or price reductions. These financial motivations and their level can attract end users to active participation in DR programs (Lu et al., 2020).

2.2 Adoption of IoT technologies in the process of energy supply

Internet of Things (IoT) or smart devices define those objects and devices, which are connected to the internet. These Things which can send and receive data include smart phones, home assistants, cars, smart watches, home security, appliances and many other similar gadgets (U.S. Department of Commerce, 2019).

IoT is based on the fact that people and devices are connected to the internet. These devices collect, generate, exchange and process very large amounts of data. IoT have become a very popular topic in many fields of matter such as network technology, computational science, embedded system and in many other areas. IoT has influenced various industries, including also the electricity industry. The progress in the field of IoT itself and also that of electricity generation has led us to the emergence of the field of Internet of Energy (IoE). IoE is described as all linked energy sources from a given grid connected through the internet, by which electricity distribution, storage and generation are kept under control in a smart way. Further, we arrive to the notion of Internet of Renewable Energy (IoRe) system that is able to gather only renewable electricity for the support of the grid (Famous et al., 2019)

In developing countries, which do not have implemented yet the high-end energy infrastructure, new technologies such as smart grid systems and IoT, demand response can become very popular (Hanger et al., 2016).

Aggregator models, on technical aspects could significantly differ, but their objectives are to simplify the participation in demand response of individual users, by measuring their real consumption against their forecasted consumption. A usual practice is to meter consumers' energy consumption that is usually made through a smart meter, whether it is a building or a household (Mahmoudi et al., 2017).

One recent study describes an alternative to smart metering, as how IoT technologies can be used for metering the consumption of individual devices. These technologies can help end consumers with an easy way to be able to take part in demand response programs. IoT can be a possible alternative to sophisticated metering infrastructure in several developing countries. This is also because of smaller costs of implementation and better scaling. It is expected to reduce the complexity of business models in a more distributed and decentralized system. Beyond that IoT makes the required investments for demand response to be cheaper. In addition, it provides all necessary intelligence needed for such a program. The IoT approach can offer significant market participation as these days smart plugs have become commonplace and can already be found in many consumers' homes and can be used to perform the most primary form of demand response (Radenkovic et al., 2020).

Summarizing this section, our research analyses how aggregators' roles and responsibilities in DR programs are described in the scientific literature. We also researched how Demand Response through aggregators can be utilized in countries which at this moment lack the high-end energy infrastructure and whose grids are not well equipped with new generation of smart meters. In these countries a viable solution can be the adoption of IoT in the process of electricity supply. Further, our research consists in the analysis pointing out in which way end consumers could be attracted to DR programs through an aggregator.

3. Methodology

The main objective is to determine the degree to which consumers agree to work with an aggregator to implement demand response. The survey method was used for collecting data, from experts that operate in different fields related to energy trading, supply, generation and distribution, as well from subjects who do not have experience related to the energy field. Respondents which work in the energy sector are traders, sale agents, supply, and sale directors, portfolio managers, analysts, experts from innovation department, journalist, advisors to CEO and energy company owners, subjects located in Romania, Hungary and Serbia.

The previous research objective was to identify and improve business models in energy trading in the Digital Era (Energy Trading Perspectives in the Digital Era, Puskás-Tompos, 2019). We had analysed and described main innovations in the field, through which the final consumers are attracted to energy trading on web platforms or mobile applications. In addition, through these they can properly control their electric appliances and self-generation units in their homes.

For this research our hypothesis was that end consumers do not want to work with an aggregator to implement demand response. The questionnaire contains 10 questions about the subjects' demographic data and 13 questions (grouped in four questions) about the aggregator and services offered by this. This was made through Likert scale survey questions (Tullis and Albert, 2013). Table 1. presents the structure of the questionnaire:

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Table 1. Structure of the questionnaire.

A. Questions about the aggregator and about the services offered by this

1. My level of knowledge about Aggregators is:
    1) Very low
    2) Relatively low, I know only vague aspects, heard on the news, read in newspapers or on websites that do not belong to experts in the field
    3) Average
    4) High, because I am interested in the subject and I want to be always up to date with relevant information
    5) Very high, I am always informed because I am active (in various ways) in the field
2. My attitude towards the Aggregator is:
    1) I strongly oppose it
    2) I oppose it
    3) I would accept with reservations a contract with an Aggregator
    4) I want to sign a contract with an Aggregator
3. If the Aggregator offers me (e.g.: a., b., c., d., e., f., g., h., i., j.) I consider that I am:
    a. qualitative technical and IT support;
    b. specific legal support for my supply contract;
    c. repair and maintenance services of electrical household appliances;
    d. an electrician's service (e.g. electrical installations and lighting);
    e. home security and protection services;
    f. home insurance in case of damage and burglary;
    g. new solutions and equipment for my smart home;
    h. information and keeps me up to date about investment possibilities in renewable generation for my home;
    i. broadband internet access.

Answer options: 1) Very disinterested, 2) Disinterested, 3) Neutral, 4) Interested, and 5) Very interested

4. For a certain incentive, I would agree that the Aggregator could directly control (shift or curtail) the active usage interval for certain electrical appliances (boiler, heating, dishwasher, washing machine, etc.)
    a. The Aggregator could control the electrical equipment only by prior approval and the incentive value should represent a percentage of........ of the value of the current electricity bill:
    b. The Aggregator could control the electrical equipment by the type of contract or subscription and the incentive value should represent a percentage of........ of the value of the current electricity bill:

Answer options: 1) Less than 3%, 2) Between 3%-10%, 3) Between 10%-20%, and 4) More than 20%

B. General questions about the respondent

1. What is your monthly average electricity consumption?

0-150kWh	150KWh – 300 KWh	300KWh – 450 KWh	more than 450 KWh/month

2. What percentage of total income does your household spend on electricity and gas bills?

less than 3%	between 3%-6%	between 6%-10%	more than 10%

3. What gender do you identify as?	male female prefer not to answer
4. What is your age?	18 – 30 31 – 40 41 – 50 50+
5. What is the highest degree or level of education you have completed?	High School Bachelor's Degree Master's Degree Ph.D.
6. What is your annual household income?	less than €15000 €15000 - 25000 €25000 - 35000 more than €35000 prefer not to answer
7. Competencies in the energy sector. Have you worked in the energy sector?	0 years less than 2 years 2-5 years 5-10 years more than 10 years
8. Do you live in a house or in a flat?	house flat
9. Is the property owned or rented?	owned rented
10. Are you living in a city or in the country side?	city small city country side

Source: Authors' own research.

Through these questionnaires at first, we wanted to research and find out what is the subjects' knowledge level and attitude towards aggregator. Answer options for the level of knowledge were very low, relatively low, average, high and very high. Regarding the attitude towards the aggregator, response options were as follows strongly oppose it, oppose it, they would accept with reservations a contract with an aggregator and they want to sign a contract with an aggregator. Further, our research analyses those elements which are to the liking of consumers and through which an aggregator could attract end consumers to its portfolio, represented in matrix questions. We wanted to find out which of the following services are mostly preferred by clients, when it comes to choosing to work with an aggregator, as technical and IT support, specific legal support in regards of electricity supply contract. Furthermore, we received information regarding repair and maintenance service of electrical household appliances, electrician service (e.g. electrical installations and lighting), home security and protection service and home insurance in case of damage and burglary. Additionally, we enquired about their interest in an aggregator in case it is offering solutions and equipment for smart home and home renewable generation, as well as broadband internet access. Response variants were as follows very disinterested, disinterested, neutral interested and very interested. The last question was about what amount should be the level of incentive, in percentage from current bill value, in case the aggregator could directly control some electrical equipment only by prior approval or through the type of contract or subscription. This was a multiple-choice question with the response variants as follows less than 3%, between 3%-10%, between 10%-20% and more than 20%.

Regarding the general demographic information about the subjects, we were interested in gender, age, in their monthly average electricity consumption, annual household income and what percentage of total income is spent on electricity and gas bills. In addition, respondents were asked about the place of living. If the respondents are living in a city, small city or in the country side, as well if they live in a flat or a house and if this is rented or owned. Competencies in the energy sector and the highest level of education also was asked in the questionnaire.

4. Results and discussions

Part of interviewed subjects work in the energy sector and they are located in Romania, Hungary and Serbia. Their knowledge in the field is above average and they understand how the process of electricity generation, distribution and supply works. In addition, they are already informed about flexible contracts and Demand Response, and also have above basic knowledge of electricity supply contracts. In many developed countries, flexible contracts, Demand Response and aggregators, in one form or another, are already utilized to some extent, and the vast majority of end consumers understands better these concepts. The other part does not have knowledge about the matter, they are usual end consumers.

In order to select and access the audience, a workshop with experts was organized. Most of the inexperienced subjects were contacted through consumer associations, as well as a questionnaire was sent online. Experienced respondents from the author's field of activity were selected. The questionnaire was distributed to more than 250 people during the mentioned period.

The survey involved 141 respondents and was done between November – January 2021. Their demographic data presented in Table 2., as well data regarding electricity consumption and households' incomes in Table 3.

Table 2. Subjects' general demographic data.

Category	Variable	Value	Frequency	%
General demographic data	gender	male	87	62%
		female	53	38%
		preferred not to answer	1	1%
	age	18–30	39	28%
		31–40	65	46%
		41–50	29	21%
		50+	7	5%
	living in a city or countryside	city	90	65%
		small city	33	24%
		countryside	16	12%
	living in a house or in a flat	house	43	31%
		flat	94	69%
	the property owned or rented	owned	114	81%
		rented	26	19%

Source: Authors' own research.

Table 3. Subjects' incomes and electricity consumption.

Category	Variable	Value	Frequency	%
Incomes and electricity consumption	annual household income	less than €15000	34	24%
		€15000–25000	34	24%
		€25000–35000	8	6%
		more than €35000	10	7%
		prefer not to answer	53	38%
	monthly average electricity consumption	0–150 kWh	27	19%
		150–300 kWh	76	55%
		300–450 kWh	32	23%
		>450 kWh/month	4	3%
	household expenditure on electricity vs. total income (%)	less than 3%	55	41%
		between 3–6%	45	33%
		between 6–10%	20	15%
		more than 10%	15	11%

Source: Authors' own research.

Regarding the consumer profile, we can state that almost two thirds of respondents were male, their age mostly between 31-40 years, living in cities, in their own flats. More than half have monthly electricity consumption in the interval of 150–300 kWh and the household expenditure on electricity from total incomes represents for the majority less than 3% from total incomes.

In Table 4. from below can be found information related to subjects' competencies in the energy sector and the highest level of education. Subjects with competencies in the energy sector are referred those subjects who have experience in the field as traders, sale agents, supply and sale directors, portfolio managers, analysts, experts from innovation department, journalist, advisors, and energy company owners.

Table 4. Subjects' competencies in the energy sector and level of education.

Category	Variable	Value	Frequency	%
Competencies and level of education	competencies in the energy sector	no experience	65	46%
		less than 2 years	3	2%
		2–5 years	8	6%
		5–10 years	24	17%
		more than 10 years	40	29%
	highest degree or level of education	High School	46	33%
		Bachelor's Degree	45	32%
		Master's Degree	50	35%

Source: Authors' own research.

With regards to respondents' competencies and level of education we can affirm that respondents in 46% are without experience, on the other hand 29% have experience more than 10 years. In regards of the level of education we can state that both three levels of education (participating in our survey) are well represented.

Regarding the EU28 states, in 2019 more than half of the Member States have reached the 10% rate concerning the installation of electricity smart meters. Seven out of these countries already reached 80%, or even finished, as Sweden, Finland, Italy, Estonia, Malta and Spain (European Commission, 2019). In Finland all suppliers offer dynamic pricing contracts and they have very developed smart meter infrastructure. According to above mentioned, 11% of consumers already have contracts with hourly prices linked to the day-ahead market. Explicit utilization is also available, through 20 aggregators both suppliers and independent, so clients are paid for the generation provided to the grid and for flexibility (smartEn.eu, 2020).

In our questionnaire we wanted to find out what is the subjects' level of knowledge about aggregator. According responses, 9% have very high, 12% have high, 34% have average, 23% relatively low and 22% have very low level of knowledge. We can observe that 55% of respondents have average or above average level of knowledge about aggregator, fact that enforce further results in our study. Results represented below in Figure 2.:

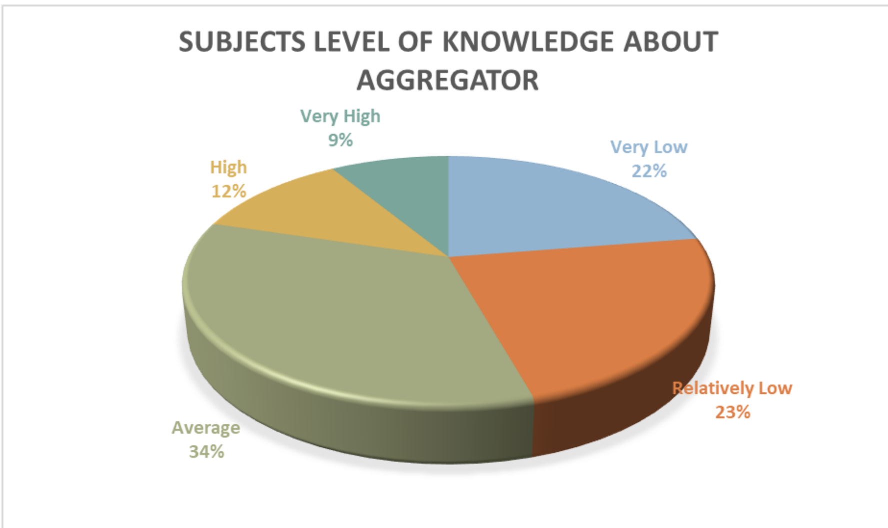

Figure 2. Subjects level of knowledge about aggregator.
Source: Authors' own research.

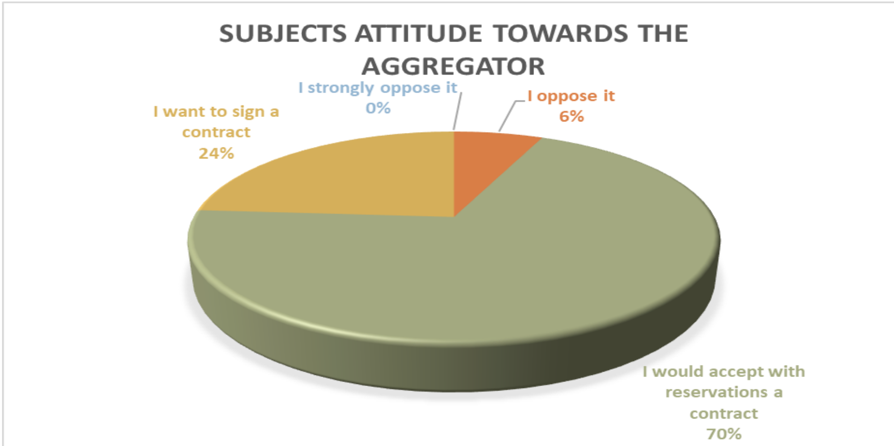

Figure 3. Subjects attitude towards the aggregator.
Source: Authors' own research.

Current research started from the hypothesis that end consumers do not want to work with an aggregator to implement Demand Response. In order to research if our hypothesis was right, subjects were asked about their attitude towards the aggregator.

The results show that 24% of subjects would like to sign a contract with an aggregator and 70% would accept with reservation a contract. None of subjects strongly oppose aggregators and only 6% of them opposes them. Correspondingly, our hypothesis is disproved because 24% of subjects want to sign with an aggregator to implement DR programs and none strongly oppose it. We also have to admit and it support our findings the fact that 70% would accept with reservation a contract. Once more, we have to take in consideration the fact that 54% of subjects have experience in the field or related fields to energy, with above average knowledge on the field of mater. Results are represented in details above in Figure 3.

In previous sections we mentioned a recent study about how can be utilized IoT technologies on metering the consumption of individual devices as an alternative to smart metering and to sophisticated metering infrastructure. One part of this paper was analysing the trust in the service operator. For the DR aggregator three possibilities of organization type was valued as follows, when the aggregator is a non-profit organization, as a profit organization or as a public enterprise. The results indicate that respondents have the highest trust in the operator as public enterprise, followed by profit organization and the least confidence when the operator is a non-profit organization (Radenkovic et al., 2020).

Furthermore, in our research we found out that 72% of respondents (47% are interested and 25%) are very interested) in information and update about own renewable investments, 74% of respondents (50% are interested and 24% are very interested) in new solutions and equipment for smart home. As well, 71% of subjects (51% are interested and 20% are very interested) are interested in qualitative technical and IT support end consumers. In Figure 4. below you can find a more detailed presentation of the obtained results:

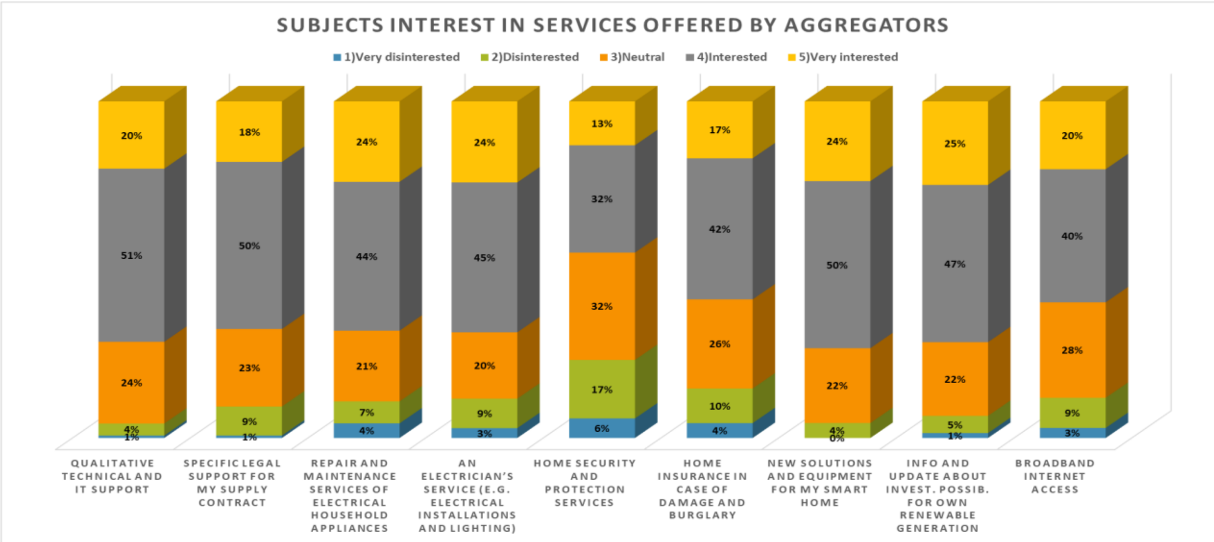

Figure 4. Subjects interest in services offered by Aggregators.
Source: Authors' own research.

An important stage of the research was to analysed the level of incentives for which end consumers would allow the aggregator to control directly their electric appliances. In the first case the direct control is resulting from the contract or registration. In the second case the aggregator must obtain end consumers' prior approval to control their electric appliances. In the first (direct control from the contractual condition) case 36% of respondents affirmed that incentive levels have to be more than 20% and 22% affirmed should be between 10%-20% of their electricity bills. In the case of prior approval, 30% of respondents affirmed that levels have to be between 10%-20% and 30% of respondents affirmed that levels should be more than 20%. Figure 5. shows detailed results for both cases:

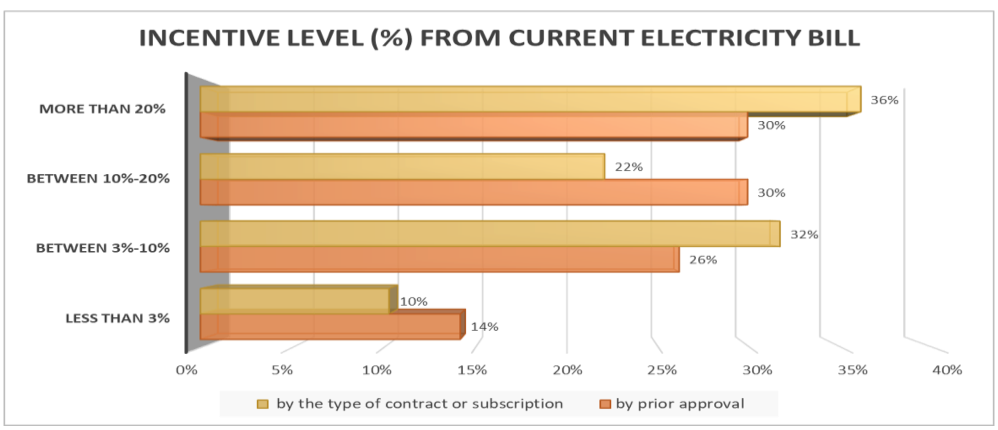

Figure 5. Incentive level (%) for direct control of electric appliances.
Source: Authors' own research.

Analysing with One-Way ANOVA dependent list level of knowledge about aggregators with the factor competencies in the energy sector we obtain the following results in Table 5., Table 6. and Table 7.:

Table 5. One-Way ANOVA Descriptives (95% Confidence Interval for Mean).

My level of knowledge about Aggregators is		N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean Lower Bound	95% Confidence Interval for Mean Upper Bound	Min	Max	Between-Component Variance
0 years		62	2.02	0.859	0.109	1.80	2.23	1	4	
less than 2 years		3	2.33	0.577	0.333	0.90	3.77	2	3	
2-5 years		8	3.38	1.188	0.420	2.38	4.37	2	5	
5-10 years		24	3.29	0.859	0.175	2.93	3.65	1	5	
more than 10 years		40	3.03	1.423	0.225	2.57	3.48	1	5	
Total		137	2.62	1.201	0.103	2.42	2.82	1	5	
Model	Fixed Effects			1.071	0.092	2.44	2.80			
	Random Effects				0.387	1.55	3.69			0.435

Source: Authors' own research.

Table 6. Tests of Homogeneity of Variances.

		Levene Statistic	df1	df2	Sig.
My level of knowledge about Aggregators is	Based on Mean	5.154	4	132	0.001
	Based on Median	5.035	4	132	0.001
	Based on Median and with adjusted df	5.035	4	113.393	0.001
	Based on trimmed mean	5.155	4	132	0.001

Source: Authors' own research.

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Table 7. ANOVA.

My level of knowledge about Aggregators is	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	44.804	4	11.201	9.762	0.000
Within Groups	151.459	132	1.147		
Total	196.263	136			

Source: Authors' own research.

Analysing with One-Way ANOVA dependent list attitude towards the aggregator with the factor level of education we obtain the following results in Table 8., Table 9. and Table 10.:

Table 8. One-Way ANOVA Descriptives (95% Confidence Interval for Mean).

My attitude towards the Aggregator is		N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Min	Max	Between-Component Variance
						Lower Bound	Upper Bound			
High School		46	3.04	0.515	0.076	2.89	3.20	2	4	
Bachelor's Degree		42	3.14	0.472	0.073	3.00	3.29	2	4	
Master's Degree		50	3.32	0.551	0.078	3.16	3.48	2	4	
Total		138	3.17	0.525	0.045	3.09	3.26	2	4	
Model	Fixed Effects			0.516	0.044	3.09	3.26			
	Random Effects				0.083	2.82	3.53			0.015

Source: Authors' own research.

Table 9. Tests of Homogeneity of Variances.

		Levene Statistic	df1	df2	Sig.
My attitude towards the Aggregator is	Based on Mean	4.676	2	135	0.011
	Based on Median	1.727	2	135	0.182
	Based on Median and with adjusted df	1.727	2	132.988	0.182
	Based on trimmed mean	4.967	2	135	0.008

Source: Authors' own research.

Table 10. ANOVA.

My attitude towards the Aggregator is	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	1.890	2	0.945	3.550	0.031
Within Groups	35.936	135	0.266		
Total	37.826	137			

After caring out tests with our data, values of the F-test (9,762 and 3,550) and p-value (0,000 and 0,031) were obtained. Considering the p-value is less than 0,05, we have the evidence of a statistically significant main effect between the independent groups (Scalestatistics, 2022).

Data was processed with Ms Office Professional Plus 2019 and IBM SPSS Statistics Standard GradPack 28 for Windows, Version 28.0.1.1.(14).

5. Conclusions

As mentioned before, part of the interviewed subjects works in the energy sector. Because of this, their knowledge in the researched field is above average and they understand well how the processes work. Their answers are objective. Subjects from different areas of activity that have nothing in common with the energy sector can have wrong assumptions about the matter.

We also have to bear in mind that the questionnaire offers some brief information and explanation about the researched activity in case the subject is not sure about the expression or the process from behind.

The results show that end consumers' level of knowledge on aggregator is high. Regarding their attitude towards the aggregator. the big majority would accept a contract with reservation with an aggregator or they are ready to sign a contract. We can assume that through good information and communication towards consumers on different communication channels, they can be more attracted in the utilization of described services from the moment they will be available. Education and awareness have a huge role in achieving a more rational, optimal and conscious consumption of electricity though demand-side management. The issue has to be raised to the level of importance and acceptance similar to what recycling of other recyclable materials have nowadays. such as paper, plastic, various metals and glass. From our research we can conclude that having contract or subscription to an aggregator, will be attractive to electricity prosumers and consumers, as well will have a greater impact on energy trading and supply business models.

A very positive fact is that they are open to cooperate with an aggregator, furthermore to allow these to control their devices with or without direct approvals. As we have seen, they can be motivated to participate in these programs if aggregators offer some additional services. The most attractive services were information and update about own renewable investments, new solutions and equipment for smart home, and qualitative technical and IT support end consumers

As presented, the role of aggregator is to collect Demand Respond resources of all end consumers. accumulate the load flexibility of residential end consumers and gather small generators as virtual power plant. For usual end consumers beyond these, in order to attract them, it is necessary to offer additional attractive services.

Further to the above mentioned. aggregators have also a main role to communicate that through participation in these programs is supported the rational and optimal consumption of green energy and the decrease of global warming. Through consumer participation in these programs can be reduced electricity generation from fossil polluting fuels.

End consumers should be attracted to these programs in order to reach emissions reduction to zero and to reach total electrification from renewable energy. We must keep in mind that lack of general education, energy poverty, and absence of high-end energy infrastructure, or at least investments and continuous developments, remain a big obstacle against a fast integration of described business models.

Future research will be oriented toward the acceptance and attitude regarding flexible electricity contracts and Demand Response in the Central and South-Eastern Europe region, without the involvement of an aggregator.

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