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The DSR Scheme in the Capacity Market of Industrial Enterprises in Poland—Participation Determinants

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Abstract: The purpose of this article is to present the key differences between the Polish Guaranteed DSR (demand-side response) Scheme operating from 2017 to 2020 and the Polish Capacity Market DSR Scheme operating from 2021, and their impacts on the decision to participate in the DSR scheme. The present study attempts to compare the rules of the old and new schemes and their impacts on the participation decision depending on the industry of the potential scheme participant. The study was conducted on a group of 50 randomly selected companies. A structured interview was used to collect information, and a chi-quadrant independence test and a Wilcoxon–Mann–Whitney test were used in the analysis of the collected data. The study was conducted in selected enterprises located in Poland. The results of the study indicate the elements that are similar to the literature on the subject, and key aspects arising from the unique characteristics of the Polish market and the industry of the potential participant. A detailed analysis of the collected data showed that the position of the respondent in the company and the size of the company do not affect the level of knowledge of the DSR market, or the decision concerning cooperation or the manner of reduction. All the respondents have higher opinions about the new Capacity Market DSR Scheme, which confirms the proper direction of the changes in relation to the ending Guaranteed DSR Scheme.

Keywords: DSR; capacity market; DSR guaranteed program; capacity market DSR program

1. Introduction

In recent days, the concept of electric power systems has been discussed in all nations. In the near future, there will be a demand for generating system capacity; a problem in boosting electricity prices; and issues related to carbon emissions and the increasing risks concerning the shortages of power supply [1]. The issues mentioned above create interest among researchers in improving the effectiveness of electricity consumption and the dependability of service within the infrastructure of the present power system [2,3]. For over a decade, there has been heated debate in all EU Member States about ETM (Electricity Target Model)—a European Union integrated energy market [4]. One of the elements of ETM should be an internal capacity remuneration mechanism (hereinafter CRM) taking into account the current situation regarding electricity generation and resource adequacy in each Member State [5]. CRMs have been extensively described in the literature; however, little consensus exists on what constitutes an optimal CRM design and to what extent an optimal CRM can contribute to the well-functioning power market [6]. Despite the development of the European electricity market with a significant excess generation capacity [7], on the one hand, the existing

power plants are getting older. On the other hand, the rise in electricity's necessity and the contributions of renewable energy sources are evidence for the need for reforms and remedies for the market failures of the European electricity markets [8–11]. The problem of specific concern for all European states considers or comprises some type of existing CRM, including the potential inefficiencies that may occur after the selection and execution of a particular CRM within a nation and its possible inaptness with nearby power marketplaces [12]. In order to anticipate any inadequate level of generation and avoid the risk of capacity shortages, Poland has considered the possibility of introducing a market-wide capacity remuneration mechanism [13].

In Poland, the demand for electricity increases every year. According to many market analyses, along with the country's economic development, energy consumption in the coming years will continue to grow. Therefore, it is necessary to manage the existing power resources effectively and to connect new, flexible generation sources to the system.

The Polish national power network produces enough electricity to cover the demands of consumers. However, from time to time, extreme conditions may arise for the functioning of the national power system in which the balance between the demand for electricity and the available options for its generation and transmission is temporarily compromised.

To cope with such situations, based on the auction models of US and UK, the Polish Ministry of Energy started a public consultation considering the feasible execution of a capacity market (CM) in July 2016 in Poland. Currently, the Polish Transmission System Operator (Polskie Sieci Elektroenergetyczne S.A.) has system components, which can be used to ensure continuity of electricity supply. These include intervention work of pumped storage power plants, commissioning of additional power units at power plants, inter-operator assistance and demand side response services (hereinafter DSR). The solutions are an important part of these measures due to the considerable reduction potential and flexibility.

2. Literature Review

DSR is an abbreviation for the term "demand side response"—a service consisting of the temporary reduction of power demand by the final customer at the request of the National Power Network Operator in the event of a power shortage in the National Power System.

Baitch et al. (2007) [14] have done an international review of demand-side programs. The common drivers, challenges and worldwide forms of demand-side integration are disclosed in their study. Baitch et al., in their work, introduced demand-side integration as the fundamental technical problem by including all aspects of demand-side management in the restructured industry environment of the current era. Over a decade, diminishing the energy-only market failures was demonstrated by the capacity markets (CM). Another study by Hong et al. mentioned that if a domestic demand-side response (DSR) is widely adopted, then it can facilitate electricity that is more secure, clean and inexpensive. At the same time that a reliable grid is in the focus of the broader group, it is not apparent that the interests of individuals would be improved by acknowledging the impacts concerning how and when they utilize energy [15]. Without a doubt, a study into the acceptability of demand-side responses (DSR) recommended that there are many concerns people have [16].

The United States have given resources, mitigated investment risks and enhanced the competition [17]. Over many years, capacity markets revolved around a sound market model drawn to build up DSR [18].

Due to the differences in capacity markets, regionally and by country, in literature, it is possible to find the sequence of comprehensive studies treating DSR issue in a multidimensional way. Haoyong et al. (2015) [19] explained the newer integrated planning model of the distribution system of China. This paper has come out with the solution methods to analyze the way of enhancing the economy and dependability of China's distributing system planning by the optimal utilization of distributed generation and resources of DSR. Due to the great technological advancements of most power network transmission systems, the majority of available DSR literature concerns the

development of smart grids [20–22], including an adaptive neuro-fuzzy inference system to predict the relationship among energy intensity and globalization [23].

The study in the United States conducted by Starke et al. (2013) [24] indicated three main groups of electricity consumption: the industrial sector, the commercial sector and residential use. The focus of demand-side load participation is primarily on the industrial sector, where it is found that there is an excess of 12 GW of demand-side load flexibility available in a select list of top industrial facilities. The commercial sector has a load consumption characteristic that is generally more distributed, but facilities with enough flexibility may have the ability to participate. Residential loads have not largely been used since the loads are small, distributed and not automated. Kuzemko et al. (2017) [25] disclosed a governing for demand-side reformations in Germany, which included the high demand response in industrial companies, pumped storage plants and conventional power plants. Though few regulatory modifications have been made, strict rules are followed for primary and secondary balancing capacity, including lowering the minimum bid size and shortening tendering periods. Thus, it leads to a set-back in the participation of industrial demand response.

Though generation units provide most balancing actions in power systems, demand-side actions offer a new way of balancing, making better use of grid investments. The study of De Rijcke et al. (2010) [26] described that balancing the demand and supply by enhancing demand-side response enables the integration of wind power in power systems. From the estimated potential of appliances at home in Belgium, the paper gave the conclusion that the remarkable contributions of a demand-side response can fix the imbalances from wind power. The study of Teng et al. (2015) [27] expressed the need for a major frequency response, and their study also explored the advantages of the frequency response condition from DSR in the upcoming electricity system of Great Britain. The study findings reveal the big changes in frequency response needs determined by wind power. The investigative studies using the highly developed stochastic generation scheduling model propose that the condition of frequency response from DSR significantly decrease the price of system operation, wind limitations and emissions of carbon in the upcoming electricity system of Great Britain characterized by wind power. Active demand-side response (DSR) will provide a significant opportunity to increase the flexibility of the power system in the UK [28]. Goulden et al. (2018) [29], through 21 interviews with experts, have established that the future success of the British DSR depends on market innovations. Goulden et al. have identified two visions of the users, one passive, while the technologies automate on their behalf, and the other integrated to the extent that they are automatic. Research in Australia presents a DSR model that assists electricity end-users to be engaged in mitigating peak demands on the electricity network. The proposed model of the study includes a technological system of programmable Internet transmission, solid-state switches, a router and the appropriate software to manage electricity demand at the premises of users. This programmed software cuts down/shifts the electric loads to the most suitable period following the realized economic method that is drawn to provide increasing economic advantages to the consumers of electricity [30]. The scheme also allows an automatic injection of on-site renewable energy sources as appropriate [31]. The research of smart metering programs in the UK by Fell et al. (2014) [32] indicates that consumer acceptance of domestic electricity demand-side response (DSR) highlights the loss of personal control as a critical concern.

The current structure of the Polish electricity mix results from the large share of coal-based energy. The current EU regulations have prompted the Polish government to reduce CO_2 emissions by increasing the share of energy generated from renewable sources in the electricity mix. The goal of the climate and energy package is to increase the share of renewable energy to 20% in total consumption by 2020 and reduce CO_2 emissions by 20% when compared to 1990 levels. For this reason, in Poland, the capacity market has been created. This solution operates in countries like the United States and Great Britain. The experiences of countries that have introduced such solutions confirm the positive impact, among others, on technology and infrastructure, and the economy of the energy market. Increased social awareness in the management of energy consumption dictated by network demand has a positive effect on the development of DSR. Considering the specific conditions of the Polish power sector, the right choice would be the central power market, since it permits for

logical, competitive involvement of all electricity generation departments and DSR establishments and organizations in the bid sale. Directing the auction in Dutch formula with decreasing bid amounts ensures the systematic conduct of the auction [33].

3. The DSR Market in Poland

This DSR contributes to maintaining stability in the Polish power system for problems with energy balance, in particular at times of peak demand for electricity.

A reduction in the demand can be achieved by:

- Partial or complete switchover to own power generation sources;
- Switching on the back-up power supply (e.g., a power generator) or using energy storage;
- Shifting a part of production to hours outside of the reduction period;
- Temporarily reducing electricity consumption by partially or fully stopping production during the reduction period.

A DSR service participant may be any entity that can shift or reduce its electricity demand, is connected to the power grid and has been positively verified by the operator of the system to which it is connected. Entities that can potentially enlist in the DSR schemes are steel mills, mines, shipyards, large factories and production plants, large stores and shopping centers, office buildings, sports halls and swimming pools, farms using large buildings and equipment for plant cultivation, animal husbandry businesses, greenhouses, piggeries, poultry farms, cement plants, cold stores, gas stations, movie theaters, other cultural and entertainment facilities and other entities [34,35].

Energy consumers can provide the service to the PSE (power grid) [36,37]:

- Directly if they have 1 MW of reduction capacity or more (in the Current Simplified Scheme);
- Directly if they have 10 MW of reduction capacity or more (in the Guaranteed and Current Schemes);
- A smaller electricity consumer may participate in the scheme through an aggregator, i.e., a company that represents the interests of customers through a relationship with the PSE.

In addition to the transmission system operator and the participants of DSR services, there are also entities called aggregators and distribution system operators (hereinafter referred to as DSOs) in the DSR service system. Aggregators are companies that find businesses that can shift or reduce a part of their capacity demand in the framework of the DSR service. By signing contracts with businesses, aggregators:

- Are responsible for submitting a tender following a regular tender procedure;
- Provide them with assistance in obtaining the necessary certificates to provide the DSR service;
- Inform them of any calls for a reduction by the PSE;
- Represent them in contacts with the PSE.

Aggregators in the DSR schemes in place up to and including 2020 are presented in Table 1.

Table 1. Aggregators in the DSR schemes in place up to and including 2020 [38].

No.	Aggregators in the Schemes Until 2020	Aggregators in the Schemes from 2021
1.	ENEA S.A.	Enel X Polska Sp. z o.o.
2.	Enel X Polska Sp. z o.o.	Enspirion Sp. z o.o.
3.	Enspirion Sp. z o.o.	
4.	innogy Polska S.A.	
5.	Lerta Sp. z o.o.	
6.	Power Block Sp. z o.o.	
7.	TAURON Polska Energia S.A.	

DSOs, i.e., distribution system operators, are power companies that distribute electricity and are responsible for network traffic in the distribution system, its operation, maintenance and repair of

the distribution network and the necessary expansion. The five main DSOs that have their distribution networks connected to the TSO's network are:

- Enea Operator Sp. z o.o.;
- ENERGA-OPERATOR S.A.;
- innogy Stoen Operator Sp. z o.o.;
- PGE Dystrybucja S.A.;
- TAURON Dystrybucja S.A.

The DSR schemes in place until 2020:

The first tender procedures under the DSR schemes provided a reduction of up to 200 MW. In order to increase the potential of the customer demand reduction schemes, the PSE decided to re-model the DSR schemes. After the concept of new mechanisms was developed in 2017, the PSE has implemented two schemes:

- The Guaranteed Scheme, which offers a fee for readiness for and implementation of reductions;
- The Current Scheme, which offers a fee for implementation.

These schemes were created with the assumption that they would enable great flexibility in defining product parameters (reduction capacity, block length, time to achieve the reduction) by the implementing entities, allowing their adjustment to the specific characteristics of the energy consumer's equipment. The actions carried out by the PSE brought a significant increase in the available reduction volume. At present, in the Guaranteed Scheme, it is equal to over 600 MW in the summer period (cumulative capacity) and 535 MW in the winter period. In the Current Scheme, the reduction potential is not limited at all and will result from the product proposals submitted by the implementing entities just before the service is needed. A third scheme, the DSR Simplified Current Scheme (DSR SCP) is currently being introduced. The DSR SCP is intended mainly for companies that are medium, small and micro. These companies are interested in obtaining additional revenue from the reduction of power demand, which is subject to restrictions on the supply and consumption of electricity.

The DSR scheme in force after 2021:

The capacity market is rebuilding the existing architecture of the energy market from a single-commodity market to a dual-commodity market [39], where, in addition to the usual buy-sell transactions for the generated electricity, readiness to deliver energy to the grid will also be sold. This mechanism, despite the reservations of some actors, is needed and justified because preventing a situation of electricity shortage is a strategic issue for any economy. A single-commodity market is not able to foster a sufficiently strong investment impulse at the current technology costs. Therefore, one of the reasons for preparing such legislative solutions is to create a support system for the construction of new power generation units and upgrading of existing ones. It should be noted that Poland joined the group of six other countries with an implemented capacity market, i.e., Belgium, France, Germany, Greece and Italy. However, the capacity mechanisms in these countries are different and adapted to their specific internal characteristics. For Germany and Belgium, approval in the form of a "strategic reserve" is the most appropriate solution. This means that dedicated generation capacity will be maintained in these countries, in order to use it only if there is a risk of capacity shortage. Another form has been adopted by mechanisms approved for France and Greece, in which demand management tools, i.e., DSR, considered by the European Commission to be more convenient to use, with better environmental impact, are to play a particularly important role. It is also worth noting that the problems of these countries are mainly related to sudden increases in energy demand in certain weather conditions (in periods of very low or very high temperatures). The last two countries in this group, i.e., Poland and Italy, have been identified by the Commission as countries with "structural" risks to energy supply. This has led to the recognition that in the case of these countries, the best solution is for qualified market players to receive payment for being on

standby for producing, or, as in the case of DSR schemes, for reducing energy consumption upon request.

In accordance with the Energy Regulatory Office President's Information number 22/2018, the Capacity Market Act continues the DSR scheme, while introducing new parts, from 2021. Based on the modifications to the Guaranteed Scheme, it will be in place until the end of 2020. The most important differences are presented in Table 2 [40].

Table 2. Key differences between DSR schemes.

Program Attributes	Guaranteed DSR Scheme		Capacity Market DSR Scheme
Scheme duration	Winter	Summer	Calendar year
	February, March + October, November (working days only)	Second and third quarter of 2020 (working days only)	(working days only) 7:00 AM–10:00 PM
	4:00 PM–8:00 PM	10:00 AM–6:00 PM	1 to 12 h
Scheme duration hours	4-h block	8- or 4-h block	1 test in the fourth quarter of 2020 (1 h) and 1 test at the end of each quarter (1 h) only in the absence of calls for reductions
Reduction time	February 2020 (4 h)	April (8 or 4 h)	up to 12 h (minimum 1 h)
Mandatory tests	7 (+1 test)	7 (+1 test)	1 test in the fourth quarter of 2020 (1 h) and 1 test at the end of each quarter (1 h) only in the absence of calls for reductions
Maximum number of calls for reduction	84 h	+test	* None
Call for reduction	Activation approximately 7:00 PM on the day before the final confirmation up to 1 h before the reduction		8 h before the first hour of the reduction
Remuneration	approximately PLN 80,000–100,000 for readiness with 1 MW per year		approximately PLN 120,000–180,000 for readiness with 1 MW per year **
	Possible additional remuneration of about PLN 10,000 for each reduced MWh		Possible additional remuneration of PLN 1000 for each MWh in the range of 100–110% of the reduction capacity

* Dependent on the aggregator's offer; not available directly at the PSE. ** Dependent on the aggregator's offer; not available directly at the PSE.

An additional important component introduced in the Capacity Market DSR Scheme is the rule by which a call for reduction may be made. In accordance with the Capacity Market Act, calls for reduction (so-called Emergency Periods) may only be announced if the TSO's total planned capacity reserve available within a period not longer than 1 h is less than 9% of the planned demand to be covered by domestic power plants. Regulation (EU) 2019/943 on the internal electricity market provides that non-market re-dispatch of energy generation, storage and DSR may only be applied if:

- No marketable alternative is available;
- All available market resources have been used.

A "non-market measure" means any supply or demand-side measure that constitutes derogation from market rules or commercial arrangements and is intended to mitigate an electricity crisis.

4. Research Methodology

The study was designed to compare the differences in the perception of participation in the Guaranteed DSR Scheme in Poland in 2017–2020 and participation in the Capacity Market DSR Scheme from 2021 among the companies operating in Poland.

To collect and analyze the information, a structured interview was prepared and conducted, which touched upon the most important items for the Polish DSR market. The interview was intended to find answers to the following research questions:

- What are the key motives for the decision to participate in the Guaranteed DSR Scheme?
- What are the key motives for the decision to participate in the Capacity Market DSR Scheme?
- Who on the part of a DSR participant is involved in the decision-making process?
- What is the opinion about the changes introduced in the Capacity Market DSR Scheme compared to the Guaranteed DSR Scheme?

The data for analysis were collected through a structured interview conducted in April 2020. The study was conducted on a group of 50 randomly selected companies that represented the following industries: cars and car parts (13 companies); metal products and machinery (9 companies); agriculture (2 companies); agricultural processing and food production (5 companies); and one company each from the following industries: construction and building materials; furniture manufacturing; electronics; plastics and chemical products; and healthcare and pharmaceutical products; 16 companies represented other industries jointly classified as "other." As of the day of the study, the plants that participated in the study consumed from 0.2 to 31 MW/h of electricity of which the reduction capacity was 30% on average. At the request of the participating companies, their names were not disclosed. In the studied companies, the questions were answered by mid-level and senior managers who were members of working groups that made decisions on participation in the DSR scheme and held positions of lower-level managers (11 out of 50 respondents) or mid-level managers (30 out of 50 respondents). Nine out of 50 respondents were owners/co-owners/directors/deputy directors. The respondents were selected based on a list of members of working groups participating in the decision on participation in the DSR scheme. The survey consisted of 47 questions, divided into areas according to the scope of the study described above, and it was conducted by means of a questionnaire.

The impacts of the various conditions of participation in the schemes on the decision to join a scheme was assessed using a five-level Likert scale, where the different scores had the following meaning: 1—no impact; 2—little impact; 3—neutral impact; 4—large impact; and 5—very large impact.

Taking into account the fact that the decision to join the DSR schemes is influenced by the knowledge of the decision-makers in this area, it has been examined whether this knowledge depends on the size of the company and the position of the decision-maker within the company. This is because small companies have limited resources, which significantly hampers their decision-making process or causes erroneous decisions to lead to much more serious complications than in large companies [41]. Moreover, the ability of companies to grow and innovate depends on the knowledge and vision of their managers [42]. The knowledge and vision are related to the qualifications to perform a specific function in the company. Therefore, a decision was made to examine whether, in the case of decisions to join the DSR scheme, decision-makers have different knowledge depending on the sizes of the companies they represent and the functions they perform, which entail specific technical and managerial skills.

A chi-square independence test was used to demonstrate the relationship between the selected variables. The test verified the impacts of the company size and the position of the respondent on the level of knowledge of the DSR market; and sought the relationship between the size of the company, the reasons for/obstacles to accession and the means of performance of the obligations in the DSR market. The test verified the main hypothesis that the following relationship between the identified characteristics (variables) X and Y is absent in the population:

H0: the characteristics X and Y are independent;
H1: the characteristics X and Y are interdependent,

at the assumed significance level α.

To verify the above hypotheses, the χ^2 statistic was used, the value of which was calculated according to the following formula:

$$\chi^2 = \sum_{i=1}^{r} \sum_{j=1}^{k} \frac{\left(n_{ij} - \hat{n}_{ij}\right)^2}{\hat{n}_{ij}}$$

where: n_{ij} —empirical quantities; $\hat{n}_{ij}$ —theoretical quantities determined using the following formula:

$$\hat{n}_{ij} = \frac{\sum_{j=1}^{k} n_{ij} \cdot \sum_{i=1}^{r} n_{ij}}{n}$$

The Wilcoxon–Mann–Whitney test, on the other hand, was used to indicate how the decision to join each DSR scheme was influenced by the size of the company or the position of the decision-maker. The results of these tests are presented in the next chapter of this paper.

The following statistical hypotheses were therefore adopted:

$H0$: $(x) = G(x)$;
$H1$: $(x) \neq G(x)$;
$F(x)$, $G(x)$—distribution functions of the analyzed population groups.

To verify the above hypotheses, the U statistic was used, the value of which was calculated according to the following formula:

$$U = n_1 n_2 + \frac{n_1(n_1 + 1)}{2} - R_1$$

where the symbols are denoted as follows: n_1—the size of the first sample; n_2—the size of the second sample; R_1—the sum of the ranks assigned to the value of the first sample.

The Wilcoxon–Mann–Whitney test is equivalent to the classic Student's t-test for unrelated samples, and the median is the measure of central tendency for this test.

5. Research Results

The results of the evaluation of the various conditions of participation in the schemes on the decision to join a scheme are presented in Table 3.

Table 3. Evaluation of the DSR schemes.

Guaranteed DSR Scheme	**Number of Responses**				
Likert Scale	**1**	**2**	**3**	**4**	**5**
Scheme duration (2 times a year: winter, summer)	30	3	0	14	3
Scheme hours (8- or 4-h block)	8	9	28	2	3
Reduction time (8 or 4-h block)	4	15	13	13	5
Mandatory tests (8- or 4-h block twice a year)	3	2	25	19	1
Maximum number of calls for reduction (84 h)	6	1	4	29	10
Method of calling for a reduction (activation approximately 7:00 PM on the previous day)	6	1	16	19	8
Fixed remuneration (approximately PLN 80,000–100,000 for readiness from 1 MWh per year)	5	1	9	19	16
Possible additional remuneration of about PLN 10,000 for each actually reduced MWh	17	2	11	14	6
Capacity Market DSR Scheme	**Number of Responses**				
Scheme duration (calendar year)	9	10	2	24	5
Scheme hours (working days only, 7:00 AM–10:00 PM)	0	20	9	12	9
Reduction time (1 to 12 h)	0	19	1	9	21
Mandatory tests (1 h per quarter only in the absence of a commercial call)	1	0	2	28	19
Maximum number of calls for reduction (none—limits to be negotiated in aggregators' offers)	0	1	9	2	38
Reduction call method (activation 8 h before the first hour of the reduction)	0	0	9	6	35
Fixed remuneration (approximately PLN 120,000–180,000 for readiness from 1 MWh per year)	0	8	10	24	8
Possible additional remuneration of PLN 1000 for each MWh in the range of 100–110% of the reduction capacity	1	9	13	6	21

Based on the analysis of the responses, it was demonstrated that in the Guaranteed Scheme, the scheme duration and the possible additional remuneration were indicated by a large number of the respondents as components that did not have any influence on their decisions. The reduction time, on the other hand, was assessed by a large number of the respondents as having little influence on the decision to join the Guaranteed Scheme. The largest number of respondents indicated the hours of the scheme and the obligatory tests as components that had neutral impacts on the decision to participate in the scheme. The largest percentage of the respondents indicated the reduction call method, the maximum number of calls and the fixed remuneration as having massive impacts on the decision to participate. The respondents clearly indicated none of the components of the scheme as having a tremendous impact on their decisions participate in the Guaranteed Scheme.

Concerning the analysis of responses concerning participation in the Capacity Market DSR Scheme, it was revealed that no components of the scheme were assessed by a significant number of the respondents as having no impact. In contrast, a large percentage of the respondents indicated the scheme hours as a component that had a small impact on their decisions. The scheme duration, the mandatory tests and the fixed remuneration were considered by a majority of the respondents as having enormous impacts on their decisions to participate, while the possible additional remuneration, the reduction time, the reduction call method and the maximum number of calls were considered as having huge impacts.

Most of the scheme components were rated higher in the Capacity Market DSR Scheme, where seven out of eight components were at the top of the Likert scale (the answers indicating large and very large impacts), whereby four of them, according to the respondents, had large impacts and three very large impacts on their decisions to participate. Only one component of the scheme was assessed

as having little impact on their decisions. In the Guaranteed DSR Scheme, respondents placed only three of the eight components in the upper part of the Likert scale, and other three components in the lower part of the scale. Two of the components received scores that put them exactly in the middle of the scale (neutral impact). Seven components of the Capacity Market DSR Scheme were rated better than the same components in the Guaranteed DSR Scheme. Only with regard to the fixed remuneration did both schemes receive the same scores. That most probably resulted from the fact that the Guaranteed DSR Scheme provides less income but is settled monthly, while the Capacity Market DSR Scheme provides more income but is settled quarterly. That means that a participant of this scheme can receive more remuneration, but it is only once in every 3 months.

A chi-quadrate independence test was used to demonstrate the relationship between selected variables, as the test was performed on the independence of non-measurable (qualitative) characteristics.

The relationships between the following variables were studied:

1. The level of knowledge of the demand side response (DSR) market concept and the size of the company;
2. The level of knowledge of the demand side response (DSR) market concept and the position held.

Table 4 shows the empirical values of the $\chi 2$ for the relationships as mentioned above.

Table 4. Empirical values of the $\chi 2$ test for the studied relationships (the level of knowledge of the DSR).

Studied Relationship	Empirical Values of the χ^2 Test
The level of knowledge of the demand side response (DSR) market concept and the size of the company	0.937571
The level of knowledge of the demand side response (DSR) market concept and the position held	0.463411

Thus, the tests carried out show that:

- The level of knowledge of the demand side response (DSR) market concept is not influenced by the size of the company, and therefore, the knowledge of the DSR market concept among managers of small, medium and large companies is roughly consistent.
- The level of knowledge of the demand side response (DSR) market concept is also not affected by the position held by the manager: this knowledge is similar for lower and higher-level managers and owners alike.

The chi-square independence test has also checked the relationship between the size of the company and:

- How the implementation of calls for reduction is planned;
- The reasons for joining the demand side response market;
- The main obstacles to joining the demand side response market.

As the survey was a conjunctive cafeteria, the sample population was taken as the number of responses to a given variant of the characteristic and not the number of companies. Therefore, the following null hypothesis was adopted: the number of responses given is distributed proportionally in the table. Therefore, it cannot be concluded whether the examined characteristics are dependent or independent, but only whether the companies in the analyzed groups were willing to provide similar responses. The results of the analysis are shown in Table 5.

Table 5. Empirical values of the χ^2 test for the studied relationships (the size of the company).

Studied Relationship	Empirical Values of the χ^2 Test
Company size and how the implementation of reduction calls is planned	0.722449
Company size the reasons for joining the demand side response market	0.985795
Company size the main obstacles to joining the demand side response market	0.901944

The results of the analysis indicate that in all the cases, the number of responses in the set can be considered to be the same for different categories of companies. Therefore, it can be argued that there is no relationship between the responses given at the level of the companies in the groups. This means that companies in different size groups indicate similar variants of the characteristic. The ways of planning implementation of reduction calls, the reasons for joining the DSR and the main obstacles to joining the DSR market for small, medium-sized and large companies are similar.
The Wilcoxon–Mann–Whitney test examined the relationships between:

1. The company size (a group comprising small and medium-sized companies and a group comprising large companies) and the impacts of the conditions of participation in the Guaranteed DSR Scheme between 2017 and 2020 on the decision to join the scheme in the following areas:
    - Scheme duration (two times a year: winter, summer);
    - Scheme hours (8 or 4-h block);
    - Reduction time (8 or 4-h block);
    - Mandatory tests (8 or 4-h block twice a year);
    - Maximum number of calls for reduction (84 h);
    - Call for reduction (activation approximately 7:00 PM on the previous day);
    - Fixed remuneration (approximately PLN 80,000–100,000 for readiness from 1 MWh per year);
    - Possible additional remuneration of about PLN 10,000 for each reduced MWh;
2. Company size (a group comprising small and medium-sized companies and a group comprising large companies) and the impacts of the conditions of participation in the Capacity Market DSR Scheme from 2021 on the decision to join the scheme in the following areas:
    - Scheme duration (calendar year);
    - Scheme hours (working days only, 7:00 AM–10:00 PM);
    - Reduction time (1 to 12 h);
    - Mandatory tests (1 h per quarter only in the absence of a commercial call);
    - Maximum number of calls for reduction (none—limits to be negotiated in aggregators' offers);
    - Call for reduction (activation 8 h before the first hour of the reduction);
    - Fixed remuneration (approximately PLN 120,000–180,000 for readiness from 1 MWh per year);
    - Possible additional remuneration of PLN 1000 for each MWh in the range of 100–110% of the reduction capacity;
3. The position held (a group of owners and mid-level managers and a group of lower-level managers) and the impacts of the conditions of participation in the Guaranteed DSR Scheme in 2017–2020 on the decision to join the scheme in the following areas:
    - Scheme duration (two times a year: winter, summer);
    - Scheme hours (8 or 4-h block);
    - Reduction time (8 or 4-h block);
    - Mandatory tests (8 or 4-h block twice a year);
    - Maximum number of calls for reduction (84 h);
    - Call for reduction (activation approximately 7:00 PM on the previous day);

- Fixed remuneration (approximately PLN 80,000–100,000 for readiness from 1 MWh per year);
- Possible additional remuneration of about PLN 10,000 for each actually reduced MWh;

4. The position held (a group of owners and mid-level managers and a group of lower-level managers) and the impacts of the conditions of participation in the Capacity Market DSR Scheme from 2021 on the decision to join the scheme in the following areas:
   - Scheme duration (calendar year);
   - Scheme hours (working days only, 7:00 AM–10:00 PM);
   - Reduction time (1 to 12 h);
   - Mandatory tests (1 h per quarter only in the absence of a commercial call);
   - Maximum number of calls for reduction (none—limits to be negotiated in aggregators' offers);
   - Call for reduction (activation 8 h before the first hour of the reduction);
   - Fixed remuneration (approximately PLN 120,000–180,000 for readiness from 1 MWh per year);
   - Possible additional remuneration of PLN 1000 for each MWh in the range of 100–110% of the reduction capacity.

The Wilcoxon–Mann–Whitney test was used to verify the null hypothesis, and it analyzed the samples from the same population or populations with equal medians. The test results are presented in Tables 6 and 7.

Table 6. Results of the Wilcoxon–Mann–Whitney test for companies divided into groups by size.

Studied Relationship	U Statistics Value	*p*-Value
Company size and scheme duration (2 times a year: winter, summer)	14.50000	0.630954
Company size and scheme hours (8- or 4-h block)	0	1
Company size and reduction time (8 or 4-h block)	0	1
Company size and mandatory tests (8- or 4-h block twice a year)	4	0.617075
Company size and maximum number of calls for reduction (84 h)	5.5	0.601508
Company size and call for reduction (activation approximately 7:00 PM on the previous day)	0	1
Company size and fixed remuneration (approximately PLN 80,000–100,000 for readiness from 1 MWh per year)	2	1
Company size and possible additional remuneration of about PLN 10,000 for each actually reduced MWh	5	0.859684
Company size and scheme duration (calendar year)	3.5	0.102471
Company size and scheme hours (working days only, 7:00 AM-10:00 PM)	1.5	0.275234
Company size and reduction time (1 to 12 h)	4.5	0.301700
Company size and mandatory tests (1 h per quarter only in the absence of a commercial call)	14	0.927265
Company size and maximum number of calls for reduction (none—limits to be negotiated in aggregators' offers)	10.5	0.643902
Company size and call for reduction (activation 8 h before the first hour of the reduction)	7	0.723674
Company size and fixed remuneration (approximately PLN 120,000–180,000 for readiness from 1 MWh per year)	9	0.819708
Company size and possible additional remuneration of PLN 1000 for each MWh in the range of 100–110% of the reduction capacity	0	0.105193

The test results allow for the assumption that at the significance level not exceeding 0.1, there are no statistically significant differences between the indications of managers of small and medium-sized and large companies both in terms of the impacts of the conditions of participation in the Guaranteed DSR Scheme in 2017–2020 on the decision to join the scheme in the different areas, and

in terms of the impacts of the conditions of participation in the Capacity Market DSR Scheme from 2021 on the decision to join the scheme in the different areas.

Table 7. Results of the Wilcoxon–Mann–Whitney test for companies divided by the position of the manager.

Studied Relationship	U Statistics Value	*p*-Value
Position of the manager and scheme duration (2 times a year: winter, summer)	6	0.361935
Position of the manager and scheme hours (8- or 4-h block)	0	1
Position of the manager and reduction time (8 or 4-h block)	5	0.470487
Position of the manager and mandatory tests (8- or 4-h block twice a year)	8.5	0.732440
Position of the manager and maximum number of calls for reduction (84 h)	6	0.794003
Position of the manager and call for reduction (activation approximately 7:00 PM on the previous day)	0	1.000000
Position of the manager and fixed remuneration (approximately PLN 80,000–100,000 for readiness from 1 MWh per year)	8	1.000000
Position of the manager and possible additional remuneration of about PLN 10,000 for each actually reduced MWh	9.5	1.000000
Position of the manager and scheme duration (calendar year)	3	0.111348
Position of the manager and scheme hours (working days only, 7:00 AM–10:00 PM)	3	0.155581
Position of the manager and reduction time (1 to 12 h)	3	0.155581
Position of the manager and mandatory tests (1 h per quarter only in the absence of a commercial call)	9.5	0.683092
Position of the manager and maximum number of calls for reduction (none—limits to be negotiated in aggregators' offers)	6	0.695299
Position of the manager and call for reduction (activation 8 h before the first hour of the reduction)	8	0.906186
Position of the manager and fixed remuneration (approximately PLN 120,000–180,000 for readiness from 1 MWh per year)	11	0.918707
Position of the manager and possible additional remuneration of PLN 1000 for each MWh in the range of 100–110% of the reduction capacity	4	0.177911

The test results allow for the assumption that at the significance level not exceeding 0.1, there are no statistically significant differences between the indications of managers who are owners or higher-level managers and lower-level managers, both in terms of the impacts of the conditions of participation in the Guaranteed DSR Scheme in 2017–2020 on the decision to join the scheme in the different areas, and in terms of the impacts of the conditions of participation in the Capacity Market DSR Scheme from 2021 on the decision to join the scheme in the different areas.

6. Conclusions

From the analysis of the results, it is evidenced that the opinions about the Capacity Market DSR Scheme and the changes that will be introduced with the new scheme that will become effective in January 2021 are good, regardless of the industry of the surveyed company. Of the aspects present in the current Guaranteed DSR Scheme, only the scope of the fixed remuneration has received a higher score from the respondents as a component that has a higher impact on the decision to join the scheme. The Capacity Market DSR Scheme has received a higher score in the remaining aspects. From the overall opinions of respondents, the Capacity Market DSR Scheme has received higher scores. It means that the key aspects that determine their participation in the DSR Scheme are the duration and the hours of the scheme. Equally important components that affect the decision to participate in the DSR scheme appear to be the technical elements of the scheme, such as the number and duration of tests, the time of the call for reduction and the limitation on the maximum number of calls for

reduction. At the same time, the results of the study indicate that the decision to participate in the DSR scheme is not influenced by the size of the company, the position of person making the decision or the frequency of remuneration of the scheme participants. This shows that the respondents have a similar perception of the importance of the impacts of different factors on the decision to join the schemes.

The correctness of the direction of changes to be introduced was also confirmed by practice. However, potential participants point out that reduction of the number of tests or their elimination, and an extension of the time from the notification of a call for reduction until the time of the actual reduction would facilitate participation by those who are undecided. Besides, as all potential participants indicated, and as has also been confirmed by the survey, a return to monthly settlements would also have a positive influence on decisions to participate in the DSR scheme.

Managers who consider participation in the scheme should pay attention not only to the rules of the scheme that pertain to direct participation in the program in the case of a contract with the PSE, but should also focus on participation through an aggregator. The conditions offered by an aggregator are much more liberal, and even the basic offers introduce limitations on participation in the scheme, such as a limit on the number of calls per year and the reduction hours per year and/or per day, and are fully negotiable. However, the key element of an aggregator's offer is the fact that there are no contractual penalties in such a contract, and there is a possibility to suspend/terminate cooperation in the DSR scheme at any time.

The analysis of the literature in this paper indicates that so far the authors have focused on improving the efficiency of electricity use and reliability [2,5,12,13,23] and on technical aspects of schemes and possible innovative solutions [25–29] that automate processes which improve stability in the power system.

However, there is no analysis of individual components of the system from the standpoint of a potential DSR scheme participant. As the results of the survey indicate, the changes currently being introduced in the DSR scheme may encourage more participants to join it, which will improve the stability of the power system as effectively as technical solutions—for example, automation of measurement and power source changes [30,31].

The analysis also has some limitations. The first is the number of the surveyed companies: 50 companies represent only a small percentage of all potential users of the DSR system. In addition, the survey has not addressed an important aspect, which is the difference in participation in the scheme through an aggregator and directly with the PSE. For this reason, the study is considered to be a pilot study.

Therefore, future studies should be carried out on a representative group of companies and should cover not only an assessment of the impacts of certain factors on the decision to participate in the scheme but also an indication of the direction of activities leading to an increase in the number of participants and thus to an improvement in Poland's energy security. It is also important to analyze the differences in the assessment of the DSR scheme by companies within individual industries and also the differences between industries in the DSR assessment. Further research should also detail the elements that influence the decision not to participate in the DSR scheme. This will show the direction in which further changes should go in order to expand the group of participants.

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References

1. Rajiani, I.; Pypłacz, P. National culture as modality in managing the carbon economy in southeast Asia. *Pol. J. Manag. Stud.* **2018**, *18*, 296–310.

2. Chuang, A.S. Demand-side Integration for System Reliability. In Proceedings of the 2007 IEEE Lausanne Power Tech, Lausanne, Switzerland, 1–5 July 2007; pp. 1617–1622; doi:10.1109/PCT.2007.4538557.
3. Madzík, P.; Daňková, A.; Piteková, J.; Ferencz, V. Effects of the energy and mining industry on management of national competitiveness. *Acta Montan. Slovaca* **2016**, *21*, 67–75.
4. European Commission 2016—Interim Report of the Sector Inquiry on Capacity Mechanisms. Available online: http://ec.europa.eu/competition/sectors/energy/capacity_mechanism_report_en.pdf (accessed on 2 August 2016).
5. Benalcazar, P; Kamiński, J. Capacity markets and cogeneration facilities: Recommendations for Poland. *Polityka Energetyczna Energy Policy J.* **2016**, *19*, 61–76.
6. Marwan, M.; Ledwich, G.; Ghosh, A. Demand-side response model to avoid spike of electricity price. *J. Process Control* **2014**, *24*, 782–789.
7. Cramton, P.; Ockenfels, A. Economics and Design of Capacity Markets for the Power Sector. *Z Energy* **2012**, *36*, 113–134.
8. Keay, M. *Electricity Markets Are Broken—Can They Be Fixed*? Oxford Institute for Energy Studies: Oxford, UK, 2016.
9. Kasperowicz, R.; Bilan, Y.; Štreimikienė, D. The renewable energy and economic growth nexus in European countries. *Sustain. Dev.* **2020**, in press.
10. Rabe, M.; Streimikiene, D.; Bilan, Y. EU carbon emissions market development and its impact on penetration of renewables in the power sector. *Energies* **2019**, *12*, 2961.
11. REGULATION (EU) 2019/943 on the Internal Market for Electricity. Available online: https://eur-lex.europa.eu/legal-content/PL/TXT/?uri=CELEX%3A32019R0943 (accessed on 1 May 2020).
12. Bhagwat, P.C.; De Vries, L.J.; Hobbs, B.F. Expert survey on capacity markets in the US: Lessons for the EU. *Util. Policy* **2016**, *38*, 11–17.
13. Zamasz, K.; Kamiński, J. Saługa, Capacity Markets in the Polish Power Generation Sector. *Energy Mark. J.* **2014**, *6*, 10–15.
14. Baitch, A. International Perspectives on Demand-side Integration. In Proceedings of the 19th International Conference on Electricity Distribution (CIRED), Vienna, Austria, 21–24 May 2007; pp. 21–24.
15. Liu, H.; Zeng, P.; Guo, J.; Wu, H.; Ge, S. An optimization strategy of controlled electric vehicle charging considering demand side response and regional wind and photovoltaic. *J. Mod. Power Syst. Clean Energy* **2015**, *3*, 232–239.
16. Fell, M.J.; Shipworth, D.; Huebner, G.M.; Elwell, C.A. Public acceptability of domestic demand-side response in Great Britain: The role of automation and direct load control. *Energy Res. Soc. Sci.* **2015**, *9*, 72–84.
17. Spees, K.; Newell, S.; Pfeifenberger, J. Capacity Markets—Lessons Learned from the First Decade. *Econ. Energy Environ. Policy* **2013**, *2*, 1–26.
18. Bowring, J. Capacity Markets in PJM. *Econ. Energy Environ. Policy* **2013**, *2*, 47–64.
19. Chen, H.; Wang, Z.; Yan, H.; Zou, H.; Luo, B. Integrated Planning of Distribution Systems with Distributed Generation and Demand Side Response. *Energy Procedia* **2015**, *75*, 981–986.
20. Haseeb, M.; Kot, S.; Hussain, H.I.; Mihardjo, L.W.; Saluga, W. Modelling the non-linear energy intensity effect based on a quantile-on-quantile approach: The case of textiles manufacturing in Asian countries. *Energies* **2020**, *13*, 2229.
21. Marwan, M.; Kamel, F.; Xiang, W. A Demand-Side Response Smart Grid Scheme to Mitigate Electrical Peak Demands and Access Renewable Energy Sources. In Proceedings of the Solar 2010: The 48th AuSES Annual Conference, Canberra, Australia, 1–3 December 2010.
22. Hongyao, M.; Robu, V.; Li, N.; Parkes, D.C. Incentivizing Reliability in Demand-Side Response. In Proceedings of the 25th International Joint Conference on Artificial Intelligence (IJCAI 2016), New York, NY, USA, 9–15 July 2016; pp. 9–15.
23. Hussain, H.I.; Slusarczyk, B.; Kamarudin, F.; Thaker, H.M.T.; Szczepańska-Woszczyna, K. An investigation of an adaptive neuro-fuzzy inference system to predict the relationship among energy intensity, globalization, and financial development in major ASEAN economies. *Energies* **2020**, *13*, 850.
24. Starke, M.; Letto, D.; Alkadi, N.; George, R.; Johnson, B.; Dowling, K.; Khan, S. Demand-side response from industrial loads. In Proceedings of the 2013 NSTI Nanotechnology Conference and Expo, Washington, DC, USA, 12–16 May 2013; pp. 758–761.

25. Kuzemko, C.; Mitchell, C.; Lockwood, M.; Hoggett, R. Policies, politics and demand side innovations: The untold story of Germany's energy transition. *Energy Res. Soc. Sci.* **2017**, *28*, 58–67.
26. De Rijcke, S.; De Vos, K.; Driesen, J. Balancing Wind Power with Demand-Side Response. In Proceedings of the IEEE Young Researchers Symposium, Leuven, Belgium, 29–30 March 2010.
27. Teng, F.; Aunedi, M.; Pudjianto, D.; Strbac, G. Benefits of demand-side response in providing frequency response service in the future GB power system. *Front. Energy Res.* **2015**, *3*, 36. doi:10.3389/fenrg.2015.00036.
28. Qadrdan, M.; Cheng, M.; Jian, C.; Wu, Z.; Jenkins, N. Benefits of demand-side response in combined gas and electricity networks. *Appl. Energy* **2017**, *192*, 360–369.
29. Goulden, M.; Spence, A.; Wardman, J.; Leygue, C. Differentiating 'the user' in DSR: Developing demand side response in advanced economies. *Energy Policy* **2018**, *122*, 176–185.
30. Marwan, M.; Kamel, F. Demand Side Response to Mitigate Electrical Peak Demand in Eastern and Southern Australia. *Energy Procedia* **2011**, *12*, 133–142.
31. Marwan, M.; Kamel, F. Optimum demand side response of smart grid with renewable energy source and electrical vehicles. In Proceedings of the 2011 IEEE International Electric Vehicle Conference, Brisbane, Australia, 25–28 September 2011.
32. Fell, M.J.; Shipworth, D.; Huebner, G.M.; Elwell, C.A. Exploring perceived control in domestic electricity demand-side response. *Technol. Anal. Strateg. Manag.* **2014**, *26*, 1118–1130.
33. Tucki, K.; Orynycz, O.; Wasiak, A.; Świć, A.; Dybaś, W. Capacity Market Implementation in Poland: Analysis of a Survey on Consequences for the Electricity Market and for Energy Management. *Energies* **2019**, *12*, 839.
34. Decyzja Prezesa Urzędu Regulacji Energetyki z Dnia 30 Marca 2018 r. w Sprawie Zatwierdzenia Regulaminu Rynku Mocy. Available online: https://www.pse.pl/documents/20182/98611984/Decyzja_Prezesa_URE_z_dnia_30.03.2018.pdf (accessed on 3 May 2020). (In Polish)
35. Programy DSR w Polskich Sieciach Energetycznych. Available online: https://dsr.pse.pl/ (accessed on 3 May 2020). (In Polish)
36. Usługi DSR—Odbiorcy Mogą Brać Aktywny Udział w Bilansowaniu KSE. Available online: https://www.pse.pl/uslugi-dsr-informacje-ogolne (accessed on 3 May 2020). (In Polish)
37. IRiESP-Bilansowanie Zmieniona DECyzją Prezesa URE z Dnia 25 Listopada 2016 r.; Znak: DRR.WIR.4320.3.2016.LK. Available online: http://bip.ure.gov.pl/download/3/8449/20161125ZmianaInstrukcjiRuchuiEksploatacjiSieciPrzesylowejPolskichSieciElektroen.pdf (accessed on 3 May 2020). (In Polish)
38. Wyniki Postępowań z Platformy Zakupowej PSE. Available online: https://przetargi.pse.pl/ (accessed on 3 May 2020). (In Polish)
39. Regulamin_Rynku_Mocy. Available online: https://www.pse.pl/documents/20182/98611984/Regulamin_rynku_mocy_zatwierdzony_decyzj%C4%85_URE_z_dnia_30.03.2018.pdf (accessed on 3 May 2020). (In Polish)
40. Informacja Prezesa Urzędu Regulacji Energetyki nr 22/2018. Available online: https://www.ure.gov.pl/pl/urzad/informacje-ogolne/komunikaty-prezesa-ure/7456,Informacja-nr-222018.html (accessed on 3 May 2020). (In Polish)
41. Edvardsson, I.R.; Durst, S. The Benefits of Knowledge Management in Small and Medium-Sized Enterprises. *Procedia Soc. Behav. Sci.* **2013**, *81*, 351–354.
42. Camisón-Haba, S.; Clemente-Almendros, J.A.; Gonzalez-Cruz, T. How technology-based firms become also highly innovative firms? The role of knowledge, technological and managerial capabilities, and entrepreneurs' background. *J. Innov. Knowl.* **2019**, *4*, 162–170.