ZESZYTY NAUKOWE POLITECHNIKI RZESZOWSKIEJ – ELEKTROTECHNIKA
RZESZOW UNIVERSITY OF TECHNOLOGY JOURNAL OF ELECTRICAL ENGINEERING
39 (2022), s. 93-112

Wiesława MALSKA[1]

SELECTED ASPECTS OF FUNCTIONING OF THE DAY-AHEAD AND INTRA-DAY MARKETS IN THE ELECTRICITY MARKET

The paper presents a statistical analysis of prices and volumes of electricity quoted on the Day-Ahead Market (DAM) and the Intra-Day Market (IDM) of the Polish Power Exchange (POLPX). The analysis was carried out for weighted average hourly prices and volumes of electricity for two selected periods. Data available from the Polish Power Exchange was used. In the face of the energy crisis and the uncertainty caused by war and the limited supply of raw materials used to produce electricity, knowledge of the operation of the DAM and IDM is of significant economic, strategic importance, which is related to the security of electricity supply and its prices. The exchange market in Poland is supervised by the Energy Regulatory Office and the Financial Supervision Commission. During the energy crisis, the role of energy exchanges is increasing, not only in Poland, and knowledge of the functioning of the energy market is also one of the elements of strategic management in the energy sector. The Statistica v.13.3 software was used to analyse the data.

Keywords: Day-Ahead Market, Intra-Day Market, Polish Power Exchange, volume, price

[1] Corresponding author: Wiesława Malska, Rzeszow University of Technology, Faculty of Electrical and Computer Engineering, Department of Power Electronics and Power Engineering, W. Pola 2, e-mail:, ul. W. Pola 2, 35-959 Rzeszów, 17 865 1974, wmalska@prz.edu.pl

1. Introduction

According to the Law "Energy Law" of 10 April 1997, as amended, electricity consumers should be assured of continuity of supply. In Poland, electricity is traded according to the rules of the Polish Power Exchange, with simultaneous supervision and regulation by the Energy Regulatory Office [6]. These institutions work closely together under the supervision of the competent ministry for energy, including electricity. The electricity market is a specific market and depends on many factors. Its proper functioning during the ongoing war conflict and energy crisis is of vital importance for electricity producers (manufacturers) and consumers. Increases in the prices of raw materials used to produce electricity affect its price.

Transactions on the Polish electricity market take place in a number of ways, due to the variability of prices, which is agreed on the basis of multiple contracts. On POLPX, there are annual, seasonal, quarterly, monthly, weekly, daily, hourly, base, peak and off-peak contracts [9].

The electricity market, by its very nature, should fulfil certain conditions to ensure its proper functioning. By providing the opportunity to trade energy to many generators, it allows for a diversity of sources and offers, the multiplicity of traders allows for increased competition, and the transparency of energy price information guarantees transparent transaction conditions. From the operators' point of view, its most important tasks are to obtain energy prices that are a kind of consensus between sellers and buyers, to guarantee energy supplies that meet consumers' requirements and to enable generators to be profitable [7-8].

The nature of the electricity commodity means that the energy market has to operate in real time to meet sudden demand for energy, due to the limited energy storage capacity of the electricity system. This results in high volatility of instantaneous electricity prices and limited predictability. And this also depends on the time of day, the season, the type of day of the week (day off, holiday or weekday).

A model for the operation of the electricity market comprising an active energy market, a technical market and a financial market has been developed in order to fulfil the conditions and tasks. Part of the active energy market is the exchange segment, which is responsible for setting transactional electricity prices and the execution of these transactions [5].

In Poland, electricity trading is carried out within the framework of the Polish Power Exchange, mainly on the Day-Ahead Market and the Intra-Day Market [2-4].

2. Day-Ahead Market

The Day-Ahead Market (DAM) on the Polish Power Exchange is the spot market for electricity in Poland. On 30 June 2000, the first contracts were concluded on the Polish Power Exchange within its framework. Since that time, prices during quotations on the DAM have been the benchmark for all bilateral contracts concluded in Poland, and companies can use it to transact on an ongoing basis and in a secure manner [3].

The main tasks of the DAM are balancing purchase and sale transactions of electricity during quotation hours and organising import and ex-port of electricity to and from Poland [9].

Electricity trading on the Day-Ahead Market takes place the day before the next day on which physical delivery of electricity takes place. This means that energy sellers must make their best estimate of the amount of energy they will be able to supply to the system one day in advance, and then offer the best price for it so that their offer is accepted. Each day is divided into 24 hourly quotations (settlement periods), during which POLPX members can buy and sell electricity. Transactions are carried out by distribution entities on behalf of individual customers, and exchange quotations take place daily. The most important session is the so-called "Fixing I", i.e. the moment when electricity prices are set at particular hours of the day. This takes place daily at 10:30 a.m. In accordance with the Statistical Obligation Act, this data is available on the POLPX.

The price of individual contracts is determined using the „merit order”method. Its purpose is to determine the lowest possible price for the electricity that is needed at any given time. To find this lowest price, all bids from generators are taken and ranked according to price, starting with the lowest and ending with the highest. On the other hand, offers to buy electricity are ranked, also from the lowest to the highest price offered. The final market clearing price for a given trading product in the Day-Ahead Market (e.g. for a specific hour of the next day or block) arises at the point of intersection of the requested quantity and the quantity finally offered. This clearing price („Market Clearing Price”), which is essentially the last bid surcharged, is then paid by all market participants for electricity [8].

The DAM should offer full electricity trade between countries, but in practice this capacity is limited due to the available infrastructure, especially at the interconnections between countries' systems. The development of interconnections is associated with increased bidding opportunities on the DAM, and with it a unification of the energy price and an assumed decrease in the energy price. There are many factors that influence electricity prices. One of them may be the war situation in Ukraine.

3. Intra-Day Market

The Intra-Day Market allows for the day-to-day purchase and sale of electricity in the short term, in contrast to the DAM [2, 9].

Electricity trading on this market usually focuses on time blocks of a quarter or an hour. The most important feature of the DAM is the possibility, introduced in 2011, to trade energy for the quadrant time dimension, as this allows costs to be optimised in the event of difficult-to-predict changes in load and available energy. Energy trading can take place up to 30 minutes in advance.

Reducing the time between the possibility of trading and the execution of a transaction is characteristic of the IDM.

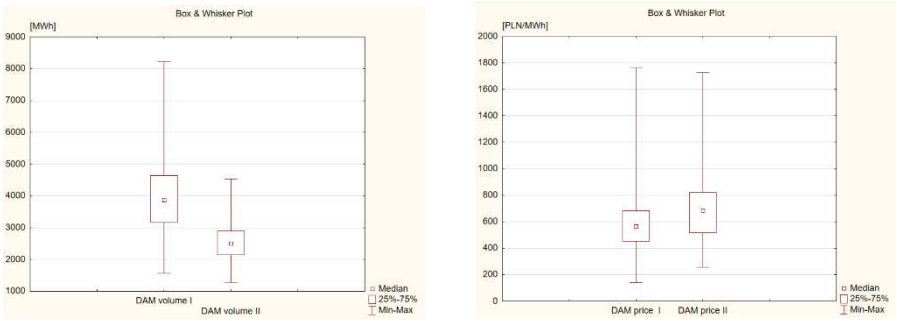
There is a difference between DAM and IDM in determining the price for energy. On the DAM, the last accepted bid decides the final price for energy for all transactions ('merit order'). On the IDM, the pay-as-bid method is used to determine prices for electricity. During trading, a specific price (bid price) is set on an ongoing basis, which is paid for the transaction. This means that there are no fixed prices on the IDM and the cost of the same product can vary depending on the time of the transaction [2, 4]. The data for the IDM as for the DAM are published on the website of the Polish Power Exchange. Trading on the Intra-Day Market is primarily used to minimise shortfalls or surpluses in one's own balancing group by means of short-term, intra-day trading activity in order to meet forecast obligations under the contract with the balancing group and to reduce any balancing costs. However, due to increasingly flexible installations, short-term trading can also be used to produce electricity from installations according to demand in the short term - and thus in the most cost-effective way possible and to ensure system stability.

4. Analysis of changes in weighted average prices and volumes of electricity using the Statistica software

The analysis uses data made available by the Polish Power Exchange concerning weighted average electricity prices and volumes for the Day-Ahead Market (DAM) and the Intra-Day Market (IDM). The data cover the period from 9 February to 11 April 2022 (1st analysed period) and from 13 September to 12 November 2022 (2nd analysed period). The data were analysed by day of the week, type of day (working day/day off) for weighted average electricity prices (rate) and electricity trading volumes (volume) [1, 2-3]. The unit of electricity price is PLN/MWh and the unit of electricity trading volume is MWh.

The data for the period from 9 February to 11 April 2022 are marked with symbol I and the data for the period from 13 September to 12 November 2022 are marked with symbol II. Figure 1 shows a box-and-whisker plot for the volume of electricity for periods I and II (Figure 1a) and a box-and-whisker diagram for the price (rate) of electricity (Figure 1b) over the analysed periods on the DAM. Differences can be seen for the volume - the maximum value for period I is much higher than for period II (Fig. 1. a). The statistics for electricity prices are similar (Fig. 1. b). The exact values of selected statistics are shown in Table 1. Due to the inconsistency of the analyzed data with the Gaussian distribution, the Mann-Whitney U test was used to compare the mean values. For the Mann-Whitney U test, the computer significance level is 0,00 and is lower than 0,05, hence it can be assumed that there is a difference between average electricity prices (Tab. 2d) and volumes (Tab. 2c) for the first and second period.

a) b)



Rys. 1. Wykres ramka-wąsy dla wolumenu energii elektrycznej (a) i cen (kursu) energii elektrycznej (b) dla I i II okresu na RDN

Fig. 1. Box&whisker plot for electricity volume (a) and prices (exchange) of electricity (b) for period I and II on the DAM

Tabela 1. Wartości statystyk dla wolumenu energii elektrycznej (a) i cen (kurs) energii elektrycznej (b) dla I i II okresu na RDN oraz wartości testu U Manna-Whitneya dla wolumenu energii elektrycznej (c) i cen (kurs) energii elektrycznej (d)

Table 1. Descriptive statistics for the volume of electricity (a) and prices (exchange) of electricity (b) for the 1st and 2nd period on the DAM and U Mann-Whitney test values for the volume of electricity (c) and prices (exchange) of electricity (d)

a)

variable	Descriptive Statistics (volumes and prices _of_ electricity.sta)									
	Valid N	Mean	Median	Mode	Frequency of Mode	Minimum	Maximum	Std.Dev.	Skewness	Kurtosis
DAM volume I	1488	3936,5	3873,5	Multiple	2	1563,6	8212,8	1019,2	0,4	-0,1
DAM volume II	1464	2569,9	2506,0	Multiple	5	1286,0	4536,0	591,4	0,6	0,3

b)

variable	Descriptive Statistics (volumes and prices _of _electricity.sta)									
	Valid N	Mean	Median	Mode	Frequency of Mode	Minimum	Maximum	Std.Dev.	Skewness	Kurtosis
DAM price I	1488	584,8	565,7	Multiple	2	140,3	1764,7	196,3	1,4	4,4
DAM price II	1464	697,2	687,5	500	33	2553	17257	224,2	0,9	1,5

c)

variable	Mann-Whitney U Test (w/ continuity correction) (volumes_ and_prices _of _electricity.sta) By variable period Marked tests are significant at p <,05000								
	Rank Sum I	Rank Sum II	U	Z	p-value	Z adjusted	p-value	Valid N I	Valid N II
DAM volume	2970749	1384927	278599,0	35,0	0,0	35,0	0,0	1464	1487

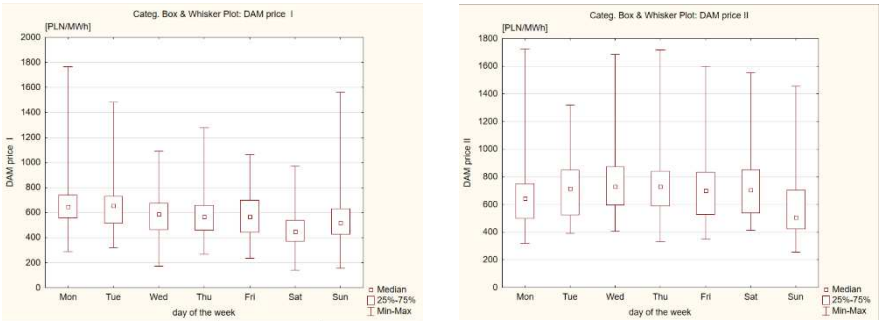
d)

variable	Mann-Whitney U Test (w/ continuity correction) (volumes_ and_prices _of _electricity.sta) By variable period Marked tests are significant at p <,05000								
	Rank Sum I	Rank Sum II	U	Z	p-value	Z adjusted	p-value	Valid N I	Valid N II
DAM price	1810416	2545261	738035,5	-15,1	0,0	-15,1	0,0	1464	1487

A categorised box-and-whisker chart by day of the week for electricity prices (rate) for period I (a) and period II (b) on the DAM is presented in Figure 2. Selected statistics for electricity prices (rate) by day of the week for period I and period II on the DAM are presented in Tab. 2. a) and Tab. 2. b).

Tab. 2. c) and Tab. 2. d) shows the values of the Kruskal-Wallis ANOVA test and the median test for electricity prices. Similarly, for volume, the graphs are presented in Fig. 3 and selected statistics in Tab. 3.

a) b)



Rys. 2. Skategoryzowany wykres ramka-wąsy z podziałem na dni tygodnia dla cen (kurs) energii elektrycznej dla okresu I (a) i okresu II (b) na RDN

Fig. 2. Categorized box&whisker plot broken down by days of the week for electricity prices (exchange) for period I (a) and period II (b) of the DAM

Tabela 2. Wartości statystyk dla cen (kurs) energii elektrycznej z podziałem na dni tygodnia dla I (a) i II (b) okresu na RDN oraz wartości testu ANOVA Kruskala-Wallisa (c) i testu mediany (d)

Table 2. Descriptive statistics for electricity prices (exchange) broken down by weekdays for the 1st (a) and 2nd (b) period on the DAM and values of the Kruskal-Wallis ANOVA test (c) and the median test (d)

a)

Breakdown Table of Descriptive Statistics (volumes and prices _of _electricity.sta) N=1488 (No missing data in dep. var. list)								
day of the week	DAM price I Means	DAM price I N	DAM price I Std.Dev.	DAM price I Minimum	DAM price I Maximum	DAM price I Q25	DAM price I Median	DAM price I Q75
Mon	683,7	216,0	230,7	287,1	1764,7	560,1	647,9	737,7
Tue	663,9	192,0	195,8	321,1	1483,1	516,5	654,5	729,4
Wed	580,3	216,0	154,5	170,8	1092,1	463,4	588,8	673,1
Thu	575,9	216,0	170,4	269,1	1277,4	459,4	569,1	658,8
Fri	578,2	216,0	169,4	234,3	1062,1	441,5	568,0	699,7
Sat	460,1	216,0	140,9	140,3	972,0	373,5	447,4	540,9
Sun	560,8	216,0	214,6	156,9	1562,5	427,6	517,4	631,1
All Grps	584,9	1488,0	196,3	140,3	1764,7	453,9	565,7	681,5

b)

Breakdown Table of Descriptive Statistics (volumes and prices _of _electricity.sta) Smallest N for any variable: 1464								
day of the week	DAM price II Means	DAM price II N	DAM price II Std.Dev.	DAM price II Minimum	DAM price II Maximum	DAM price II Q25	DAM price II Median	DAM price II Q75
Mon	649,7	192,0	204,9	321,0	1725,0	500,0	642,0	751,0
Tue	724,3	192,0	216,1	393,0	1320,0	526,0	714,5	848,5
Wed	758,0	216,0	220,2	405,0	1685,0	597,5	729,5	872,5
Thu	738,4	216,0	224,3	332,0	1716,0	590,0	728,0	840,0
Fri	726,1	216,0	240,9	350,0	1599,0	529,5	700,0	834,5
Sat	711,9	216,0	195,4	414,0	1551,0	540,0	704,5	850,0
Sun	570,1	216,0	207,2	255,0	1456,0	425,0	506,0	704,0
All Grps	697,2	1464,0	224,2	255,0	1725,0	516,0	687,5	822,0

c)

Depend.: DAM price	Kruskal-Wallis ANOVA by Ranks; DAM price (volumes_ and_prices _of _electricity.sta) Independent (grouping) variable: day of the week Kruskal-Wallis test: H (6, N= 2951) =158,2181 p =0,000			
	Code	Valid N	Sum of Ranks	Mean Rank
Mon	1	408	649515,0	1591,9
Tue	2	384	656786,0	1710,4
Wed	3	431	695357,0	1613,4
Thu	4	432	673306,0	1558,6
Fri	5	432	655820,5	1518,1
Sat	6	432	541397,0	1253,2
Sun	7	432	483494,5	1119,2

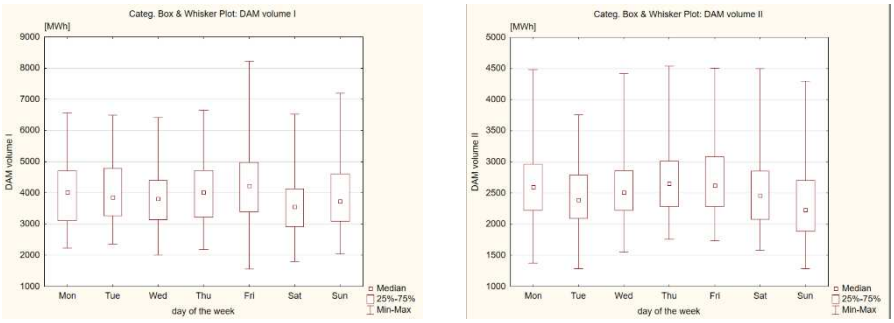
d)

Dependent: DAM price	Median Test, Overall Median = 620,000; DAM price (volumes_ and_prices _of _electricity.sta) Independent (grouping) variable: day of the week Chi-Square = 148,9386 df = 6 p = 0,000							
	Mon	Tue	Wed	Thu	Fri	Sat	Sun	Total
<= Median: observed	168,0	140,0	188,0	201,0	206,0	274,0	301,0	1478,0
expected	204,3	192,3	215,9	216,4	216,4	216,4	216,4	
obs.-exp.	-36,3	-52,3	-27,9	-15,4	-10,4	57,6	84,6	
> Median: observed	240,0	244,0	243,0	231,0	226,0	158,0	131,0	1473,0
expected	203,6	191,7	215,1	215,6	215,6	215,6	215,6	
obs.-exp.	36,3	52,3	27,9	15,4	10,4	-57,6	-84,6	
Total: observed	408,0	384,0	431,0	432,0	432,0	432,0	432,0	2951,0

For the Kruskal-Wallis ANOVA test, the computer significance level is 0,00 and is less than 0,05, hence it can be assumed that electricity prices differ on particular days of the week.

The median test for electricity prices can be interpreted in the same way - the computer significance level is 0,00 and is less than 0,05. Lower weighted average electricity prices per weekday were recorded in period I than in period II. On the other hand, the volume of electricity trading was higher in period I than in period II.

a) b)



Rys. 3. Skategoryzowany wykres ramka-wąsy z podziałem na dni tygodnia dla wolumenu energii elektrycznej dla okresu I (a) i okresu II (b) na RDN

Fig. 3. Categorized box&whisker plot broken down by day of the week for electricity volume for period I (a) and period II (b) on the DAM

Tabela 3. Wartości statystyk dla wolumenu energii elektrycznej z podziałem na dni tygodnia dla I (a) i II okresu na RDN (b) oraz wartości testu ANOVA Kruskala-Wallisa (c) i testu mediany (d)

Table 3. Descriptive statistics for the electricity volume broken down by weekdays for the first (a) and second (b) period on the DAM and values of the Kruskal-Wallis ANOVA test (c) and the median test (d)

a)

Breakdown Table of Descriptive Statistics (volumes and prices _of _electricity.sta) N=1488 (No missing data in dep. var. list)								
day of the week	DAM volume I Means	DAM volume I N	DAM volume I Std.Dev.	DAM volume I Minimum	DAM volume I Maximum	DAM volume I Q25	DAM volume I Median	DAM volume I Q75
Mon	4016,8	216	1032,7	2234,3	6561,6	3105,3	4011,7	4711,4
Tue	4079,1	192	1003,3	2358,0	6499,1	3272,6	3860,7	4777,8
Wed	3861,8	216	865,0	2009,8	6422,4	3140,1	3806,7	4395,4
Thu	3995,1	216	972,8	2178,5	6658,2	3215,9	4012,3	4729,6
Fri	4160,9	216	1167,0	1563,6	8212,8	3390,9	4226,5	4972,1
Sat	3565,8	216	910,6	1797,4	6527,5	2926,1	3553,0	4135,2
Sun	3892,1	216	1055,8	2046,6	7199,6	3092,6	3732,9	4618,2
All Grps	3936,5	1488	1019,3	1563,6	8212,8	3158,9	3873,6	4639,4

b)

Breakdown Table of Descriptive Statistics (volumes and prices _of _electricity.sta) Smallest N for any variable: 1464								
day of the week	DAM volume II Means	DAM volume II N	DAM volume II Std.Dev.	DAM volume II Minimum	DAM volume II Maximum	DAM volume II Q25	DAM volume II Median	DAM volume II Q75
Mon	2656,0	192	593,9	1379	4485	2221,0	2599,0	2963,5
Tue	2445,9	192	5295	1286	3757	2095,5	2390,5	2793,0
Wed	2590,6	216	537,8	1549	4417	2225,5	2511,5	2859,0
Thu	2711,3	216	576,3	1757	4536	2286,0	2656,5	3010,0
Fri	2725,2	216	573,0	1732	4505	2288,5	2619,0	3081,5
Sat	2518,7	216	553,2	1586	4500	2081,5	2465,5	2856,0
Sun	2337,7	216	664,0	1287	4300	1889,0	2227,0	2699,0
All Grps	2569,9	1464	591,5	1286	4536	2153,5	2506,0	2907,0

c)

Depend.: DAM price	Kruskal-Wallis ANOVA by Ranks; DAM price (volumes_ and_prices _of _electricity.sta) Independent (grouping) variable: day of the week Kruskal-Wallis test: H (6, N= 2951) =158,2181 p =0,000			
	Code	Valid N	Sum of Ranks	Mean Rank
Mon	1	408	649515,0	1591,9
Tue	2	384	656786,0	1710,4
Wed	3	431	695357,0	1613,4
Thu	4	432	673306,0	1558,6
Fri	5	432	655820,5	1518,1
Sat	6	432	541397,0	1253,2
Sun	7	432	483494,5	1119,2

d)

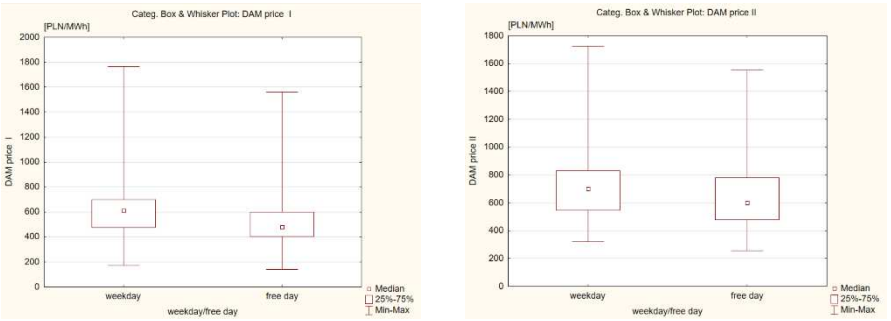
Dependent: DAM price	Median Test, Overall Median = 620,000; DAM price (volumes_ and_prices _of _electricity.sta) Independent (grouping) variable: day of the week Chi-Square = 148,9386 df = 6 p = 0,000							
	Mon	Tue	Wed	Thu	Fri	Sat	Sun	Total
<= Median: observed	168,0	140,0	188,0	201,0	206,0	274,0	301,0	1478,0
expected	204,3	192,3	215,9	216,4	216,4	216,4	216,4	
obs.-exp.	-36,3	-52,3	-27,9	-15,4	-10,4	57,6	84,6	
> Median: observed	240,0	244,0	243,0	231,0	226,0	158,0	131,0	1473,0
expected	203,6	191,7	215,1	215,6	215,6	215,6	215,6	
obs.-exp.	36,3	52,3	27,9	15,4	10,4	-57,6	-84,6	
Total: observed	408,0	384,0	431,0	432,0	432,0	432,0	432,0	2951,0

For the Kruskal-Wallis ANOVA test, the computer significance level is 0,00 and is less than 0,05, hence it can be assumed that the volume of electricity differs from each other on particular days of the week.

Comparing the computer significance level of 0,08, which is higher than 0,05 in the median test for the volume of electricity, it should be assumed that the volumes on individual days do not differ from each other.

A categorised box-and-whisker diagram by type of day of the week (week-day/free day) for electricity prices (rate) for period I (a) and period II (b) on the DAM is presented in Figure 4. Selected statistics for electricity prices (rate) by type of day of the week are presented in Table 4. Similarly, for volume, the graphs are presented in Table 5. and selected statistics in Table 6.

a) b)



Rys. 4. Skategoryzowany wykres ramka-wąsy z podziałem na typ dnia (roboczy/wolny) dla cen (kurs) energii elektrycznej dla okresu I (a) i okresu II (b) na RDN

Fig. 4. Categorized box&whisker plot broken down by day type (weekday/free day) for electricity prices (exchange rate) for period I (a) and period II (b) of the DAM

Tabela 4. Wartości statystyk dla cen (kurs) energii elektrycznej z podziałem na typ dnia (roboczy/wolny) dla I (a) i II (b) okresu na RDN oraz wyniki testu U Manna-Whitneya dla cen (kurs) energii elektrycznej (c)

Table 4. Descriptive statistics for electricity prices (exchange rate) broken down by day type (working/non-working) for the 1st (a) and 2nd (b) period on the DAM and U Mann-Whitney test values for the prices (exchange) of electricity (c)

a)

Breakdown Table of Descriptive Statistics (volumes and prices _of _electricity.sta) N=1488 (No missing data in dep. var. list)								
weekday/free day	DAM price I Means	DAM price I N	DAM price I Std.Dev.	DAM price I Minimum	DAM price I Maximum	DAM price I Q25	DAM price I Median	DAM price I Q75
weekday	615,3	1056	191,5	170,8	1764,7	477,2	611,9	699,2
free day	510,5	432	188,2	140,3	1562,5	405,1	478,0	597,8
All Grps	584,9	1488	196,3	140,3	1764,7	453,9	565,7	681,5

b)

Breakdown Table of Descriptive Statistics (volumes and prices _of _electricity.sta) Smallest N for any variable: 1464								
weekday/free day	DAM price II Means	DAM price II N	DAM price II Std.Dev.	DAM price II Minimum	DAM price II Maximum	DAM price II Q25	DAM price II Median	DAM price II Q75
weekday	720,8	1032	224,6	321	1725	545	700,0	830
free day	640,9	432	213,3	255	1551	479	600,5	779
All Grps	697,2	1464	224,2	255	1725	516	687,5	822

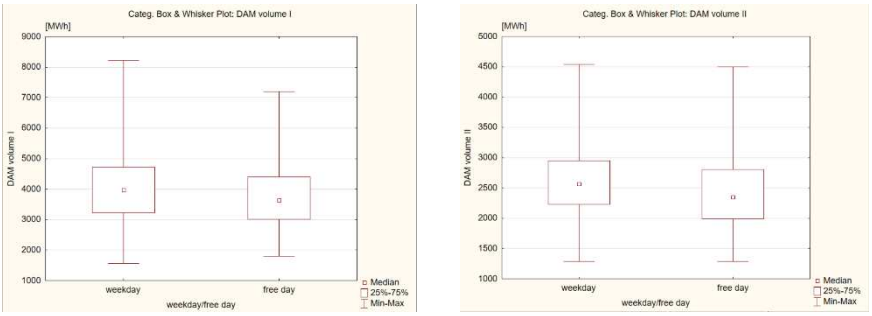
c)

variable	Mann-Whitney U Test (w/ continuity correction) (volumes_ and_prices _of _electricity.sta) By variable weekday/free day Marked tests are significant at p <,05000								
	Rank Sum weekday	Rank Sum free day	U	Z	p-value	Z adjusted	p-value	Valid N weekday	Valid N free day
DAM price	3277963	1077714	661385,5	12,5	0,0	12,5	0,0	2039	912

The computer significance level is 0,00 and is lower than 0,05 in the Mann-Whitney U test, hence it can be claimed that the difference in electricity prices for the type of day (weekday/free day) is significant (Tab. 4. c). According to the electricity demand for period I and period II, the prices and volume for weekdays are higher than for holidays (Fig. 4 and Fig. 5). On public holidays there is less demand for electricity than on weekdays, when offices, institutions and most industrial plants are working.

.

a) b)



Rys. 5. Skategoryzowany wykres ramka-wąsy z podziałem na typ dnia (roboczy/wolny) dla wolumenu energii elektrycznej dla okresu I (a) i okresu II (b) na RDN

Fig. 5. Categorized box&whisker plot broken down by day type (weekday/free day) for electricity volume for period I (a) and period II (b) on the DAM

Tabela 5. Wartości statystyk dla wolumenu energii elektrycznej z podziałem na typ dnia (roboczy/wolny) dla I (a) i II (b) okresu na RDN oraz wyniki testu U Manna-Whitneya dla wolumenu energii elektrycznej (c)

Table 5. Descriptive statistics for the volume of electricity broken down by the type of day (weekday/free day) for the 1st (a) and 2nd (b) period on the DAM and U Mann-Whitney test values for volume of electricity (c)

a)

Breakdown Table of Descriptive Statistics (volumes and prices _of _electricity.sta) N=1488 (No missing data in dep. var. list)								
weekday/ free day	DAM volume I Means	DAM volume I N	DAM volume I Std.Dev.	DAM volume I Minimum	DAM volume I Maximum	DAM volume I Q25	DAM volume I Median	DAM volume I Q75
weekday	4021,4	1056	1016,1	1563,6	8212,8	3223,9	3976,6	4721,8
free day	3728,9	432	998,2	1797,4	7199,6	3019,7	3633,9	4407,2
All Grps	3936,5	1488	1019,3	1563,6	8212,8	3158,9	3873,6	4639,4

b)

Breakdown Table of Descriptive Statistics (volumes and prices _of _electricity.sta) Smallest N for any variable: 1464								
weekday/ free day	DAM volume II Means	DAM volume II N	DAM volume II Std.Dev.	DAM volume II Minimum	DAM volume II Maximum	DAM volume II Q25	DAM volume II Median	DAM volume II Q75
weekday	2629,3	1032	570,4	1286	4536	2229,0	2568,0	2951,0
free day	2428,3	432	617,1	1287	4500	1989,5	2353,5	2806,5
All Grps	2569,9	1464	591,5	1286	4536	2153,5	2506,0	2907,0

c)

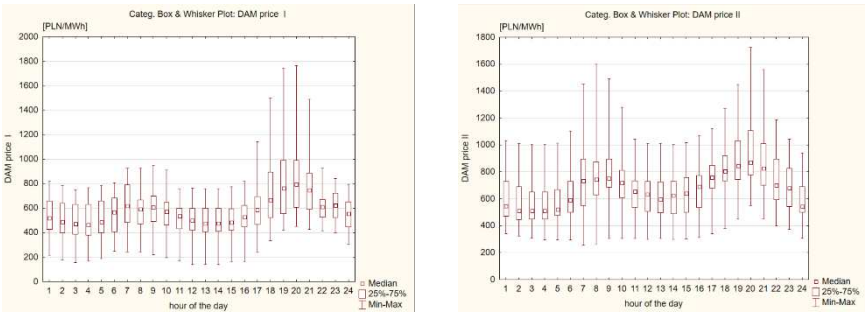
variable	Mann-Whitney U Test (w/ continuity correction) (volumes_ and_prices _of _electricity.sta) By variable weekday/free day Marked tests are significant at p <,05000								
	Rank Sum weekday	Rank Sum free day	U	Z	p-value	Z adjusted	p-value	Valid N weekday	Valid N free day
DAM volume	3180371	1175306	758977,5	7,9	0,0	7,9	0,0	2039	912

The computer significance level is 0,00 and is lower than 0,05 in the Mann-Whitney U test, hence it can be claimed that the difference for volume for the type of day (weekday/free day) is significant (Tab. 5.c).

Fig. 6. and Fig. 7. present categorised box-and-whisker plots by 24-hour period for electricity price (price) and electricity volume for period I (a) and period II (b) on the DAM. It can be seen that the statistics are higher in the so-called evening peak, when a lot of electricity is consumed and when demand is higher than at night. It is easy to see that in period II, the larger values of the statistics are also in the morning hours.

The minimum electricity prices for each hour of the day are higher for the 2nd period analysed. The exact values of the statistics for prices and volume are shown in Tab. 6 and Tab. 7. The differences in the values of the individual statistics are associated with the so-called seasonality component, but other reasons can also affect their final level.

a) b)



Rys. 6. Skategoryzowany wykres ramka-wąsy z podziałem na 24 godziny dla cen (kurs) energii elektrycznej dla okresu I (a) i okresu II (b) na RDN

Fig. 6. Categorized box&whisker plot broken down into 24 hours for electricity prices (exchange rate) for period I (a) and period II (b) on the DAM

Tabela 6. Wartości statystyk dla cen (kurs) energii elektrycznej z podziałem na 24 godziny dla I (a) i II (b) okresu na RDN

Table 6. Descriptive statistics for electricity prices (exchange rate) broken down into 24 hours for the first (a) and second (b) period on the DAM

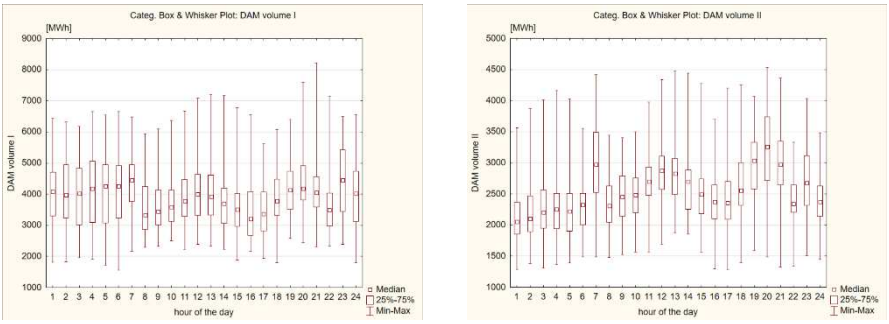
a)

Breakdown Table of Descriptive Statistics (volumes and prices _of _electricity.sta) N=1488 (No missing data in dep. var. list)								
hour of the day	DAM price I Means	DAM price I N	DAM price I Std.Dev.	DAM price I Minimum	DAM price I Maximum	DAM price I Q25	DAM price I Median	DAM price I Q75
1	531,4	62,0	144,5	215,0	824,3	427,9	519,0	660,3
2	499,7	62,0	149,5	176,8	785,2	399,2	486,3	640,1
3	489,4	62,0	153,4	156,9	752,1	389,4	470,1	631,2
4	489,5	62,0	157,2	170,8	767,8	378,8	463,1	632,2
5	508,9	62,0	160,6	189,0	788,2	397,8	486,5	658,6
6	546,5	62,0	156,2	246,2	805,6	407,5	565,2	684,5
7	625,3	62,0	170,8	242,3	925,4	483,2	620,5	790,3
8	586,8	62,0	139,0	242,2	931,5	471,4	592,7	667,4
9	605,2	62,0	148,9	220,3	949,5	489,5	609,1	698,0
10	571,1	62,0	134,3	197,5	911,2	464,1	572,3	646,8
11	525,6	62,0	116,0	171,9	758,4	433,2	535,2	598,8
12	507,3	62,0	117,7	140,7	763,6	421,0	500,3	599,4
13	499,6	62,0	119,0	140,3	759,3	408,9	476,0	598,6
14	499,5	62,0	118,1	140,4	759,3	409,5	477,4	598,2
15	505,7	62,0	117,7	161,2	774,9	418,6	484,0	594,2
16	533,8	62,0	122,4	158,8	819,0	447,6	529,3	621,4
17	600,6	62,0	164,3	245,7	1140,7	467,0	588,5	695,6
18	723,5	62,0	257,0	336,2	1500,8	523,9	668,6	894,7
19	811,3	62,0	302,7	417,7	1742,6	556,0	764,8	989,8
20	838,4	62,0	292,8	452,4	1764,7	605,6	796,4	988,8
21	771,5	62,0	247,5	426,3	1489,3	590,4	747,1	886,5
22	606,1	62,0	120,7	416,3	925,4	528,7	609,7	671,3
23	614,4	62,0	123,9	401,6	843,0	523,4	623,1	721,3
24	546,4	62,0	125,5	309,6	795,3	446,0	554,1	649,8
All Grps	584,9	1488,0	196,3	140,3	1764,7	453,9	565,7	681,5

b)

Breakdown Table of Descriptive Statistics (volumes and prices _of _electricity.sta) N=1464 (No missing data in dep. var. list)								
hour of the day	DAM price II Means	DAM price II N	DAM price II Std.Dev.	DAM price II Minimum	DAM price II Maximum	DAM price II Q25	DAM price II Median	DAM price II Q75
1	601,7	61,0	178,5	341,0	1032,0	470,0	545,0	730,0
2	567,3	61,0	159,0	324,0	1009,0	445,0	511,0	689,0
3	556,1	61,0	151,2	310,0	1001,0	448,0	510,0	651,0
4	560,0	61,0	152,2	295,0	1003,0	450,0	511,0	650,0
5	572,4	61,0	154,0	295,0	1013,0	479,0	520,0	670,0
6	618,8	61,0	178,1	295,0	1104,0	500,0	590,0	730,0
7	755,3	61,0	246,6	255,0	1450,0	550,0	734,0	895,0
8	777,2	61,0	253,6	265,0	1599,0	629,0	745,0	875,0
9	792,3	61,0	245,5	305,0	1491,0	688,0	750,0	896,0
10	734,5	61,0	209,3	306,0	1280,0	608,7	719,0	811,0
11	652,5	61,0	165,7	306,0	1041,0	535,0	655,0	734,0
12	627,3	61,0	165,0	300,0	1011,0	508,0	631,0	730,0
13	613,0	61,0	165,7	305,0	1010,0	495,0	596,0	725,0
14	616,9	61,0	164,7	300,0	1003,0	489,0	625,0	730,0
15	632,7	61,0	167,4	301,0	1017,0	500,0	640,0	758,0
16	682,4	61,0	166,8	314,0	1067,0	535,0	691,0	774,0
17	754,6	61,0	160,4	341,0	1120,0	680,4	758,0	848,0
18	826,8	61,0	177,7	381,0	1269,0	732,0	806,0	919,0
19	900,9	61,0	217,8	451,0	1449,0	743,0	843,0	1031,0
20	971,7	61,0	296,8	549,0	1725,0	777,0	871,0	1107,7
21	890,3	61,0	261,8	453,0	1559,0	701,0	827,0	1011,0
22	732,0	61,0	186,3	399,0	1186,0	595,0	700,0	895,0
23	698,9	61,0	178,9	375,0	1041,0	544,0	678,0	825,7
24	597,8	61,0	151,0	311,0	938,0	500,0	544,0	689,0
All Grps	697,2	1464,0	224,2	255,0	1725,0	516,0	687,5	822,0

a) b)



Rys. 7. Skategoryzowany wykres ramka-wąsy z podziałem na 24 godziny dla wolumenu energii elektrycznej dla okresu I (a) i okresu II (b) na RDN

Fig. 7. Categorized box&whisker plot broken down into 24 hours for electricity volume for period I (a) and period II (b) on the DAM

Tabela 7. Wartości statystyk dla wolumenu energii elektrycznej z podziałem na 24 godziny dla I (a) i II (b)okresu na RDN

Table 7. Descriptive statistics values for the volume of electricity broken down into 24 hours for the first (a) and second (b) period on the DAM

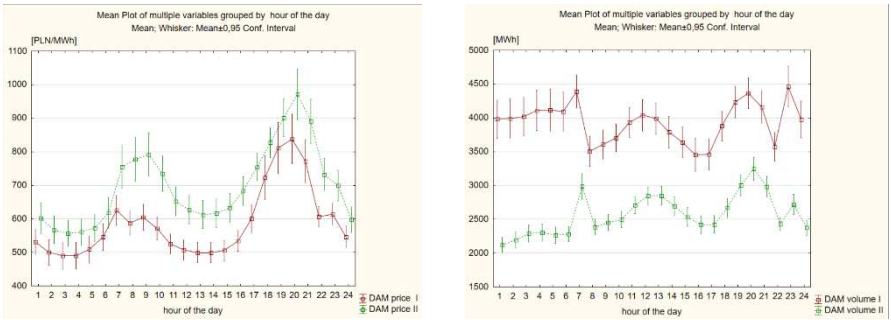
a)

Breakdown Table of Descriptive Statistics (volumes and prices _of _electricity.sta) N=1488 (No missing data in dep. var. list)								
hour of the day	DAM volume I Means	DAM volume I N	DAM volume I Std.Dev.	DAM volume I Minimum	DAM volume I Maximum	DAM volume I Q25	DAM volume I Median	DAM volume I Q75
1	3980,5	62,0	1123,1	1808,2	6439,5	3296,5	4085,7	4709,0
2	3994,8	62,0	1146,3	1839,5	6321,4	3243,1	3965,4	4943,5
3	4017,6	62,0	1129,5	1957,6	6176,4	3018,4	4014,9	4837,7
4	4111,0	62,0	1174,3	1916,7	6646,8	3093,0	4178,2	5055,7
5	4113,6	62,0	1219,7	1699,6	6537,6	3083,9	4253,8	4943,6
6	4093,9	62,0	1121,4	1563,6	6658,2	3241,9	4256,2	4918,5
7	4390,2	62,0	966,4	2167,7	6473,6	3764,0	4455,5	4943,0
8	3504,6	62,0	866,9	2295,3	5936,6	2869,3	3339,6	4235,5
9	3608,2	62,0	828,9	2330,9	6089,1	3021,2	3439,4	4131,1
10	3704,4	62,0	815,0	2498,5	6373,0	3132,3	3581,4	4131,9
11	3933,2	62,0	879,0	2227,8	6667,5	3290,4	3786,8	4469,9
12	4040,4	62,0	904,1	2395,0	7086,7	3320,7	3998,1	4649,1
13	3991,7	62,0	895,9	2328,2	7199,6	3339,9	3918,8	4615,3
14	3788,6	62,0	918,7	2234,3	7157,5	3064,0	3703,5	4200,5
15	3637,4	62,0	911,7	1882,3	6773,5	2957,7	3507,3	4017,0
16	3453,1	62,0	959,3	2168,9	6553,6	2674,3	3206,9	4089,9
17	3458,7	62,0	894,8	1952,0	5621,9	2823,2	3369,8	4070,5
18	3879,6	62,0	859,2	1801,0	6074,0	3323,1	3782,6	4479,9
19	4234,5	62,0	914,0	2589,5	6402,1	3508,9	4124,7	4737,8
20	4368,7	62,0	899,0	2438,9	7596,6	3805,3	4172,5	4907,1
21	4161,3	62,0	942,2	2305,3	8212,8	3591,0	4045,6	4567,1
22	3571,5	62,0	837,7	2326,6	7151,4	2986,1	3490,8	4042,9
23	4464,8	62,0	1175,4	2385,9	6499,5	3452,4	4454,1	5419,6
24	3973,9	62,0	1076,2	1797,4	6561,6	3118,0	4011,5	4733,0
All Grps	3936,5	1488,0	1019,3	1563,6	8212,8	3158,9	3873,6	4639,4

b)

Breakdown Table of Descriptive Statistics (volumes and prices _of _electricity.sta) N=1464 (No missing data in dep. var. list)								
hour of the day	DAM volume II Means	DAM volume II N	DAM volume II Std.Dev.	DAM volume II Minimum	DAM volume II Maximum	DAM volume II Q25	DAM volume II Median	DAM volume II Q75
1	2118,0	61,0	427,7	1287,0	3562,0	1858,0	2053,0	2366,0
2	2196,6	61,0	479,0	1383,0	3874,0	1897,0	2102,0	2467,0
3	2288,6	61,0	495,0	1309,0	4008,0	1954,0	2210,0	2568,0
4	2303,6	61,0	494,7	1365,0	4159,0	1944,0	2253,0	2506,0
5	2266,3	61,0	477,9	1390,0	4025,0	1907,0	2220,0	2508,0
6	2282,9	61,0	431,9	1488,0	3556,0	2004,0	2329,0	2506,0
7	2987,2	61,0	730,7	1490,0	4417,0	2526,0	2972,0	3490,0
8	2386,4	61,0	461,5	1481,0	3442,0	2049,0	2309,0	2629,0
9	2452,7	61,0	467,5	1531,0	3402,0	2140,0	2454,0	2786,0
10	2494,2	61,0	455,6	1568,0	3503,0	2195,0	2484,0	2759,0
11	2708,8	61,0	474,5	1561,0	3983,0	2481,0	2698,0	2929,0
12	2846,0	61,0	498,0	1685,0	4337,0	2572,0	2878,0	3105,0
13	2849,7	61,0	534,6	1877,0	4485,0	2491,0	2828,0	3068,0
14	2694,1	61,0	537,7	1852,0	4438,0	2252,0	2698,0	2882,0
15	2534,0	61,0	531,0	1562,0	4275,0	2181,0	2494,0	2744,0
16	2420,4	61,0	500,1	1300,0	3700,0	2104,0	2372,0	2643,0
17	2425,6	61,0	515,2	1286,0	4200,0	2095,0	2356,0	2704,0
18	2669,3	61,0	561,6	1402,0	4250,0	2319,0	2559,0	3006,0
19	3000,7	61,0	578,3	1589,0	4065,0	2582,0	3038,0	3336,0
20	3246,8	61,0	662,0	1485,0	4536,0	2719,0	3259,0	3738,0
21	2984,0	61,0	591,2	1328,0	4363,0	2648,0	2973,0	3347,0
22	2428,0	61,0	373,4	1339,0	3329,0	2210,0	2339,0	2642,0
23	2720,1	61,0	590,1	1513,0	4036,0	2318,0	2679,0	3118,0
24	2374,5	61,0	448,2	1445,0	3487,0	2144,0	2378,0	2626,0
All Grps	2569,9	1464,0	591,5	1286,0	4536,0	2153,5	2506,0	2907,0

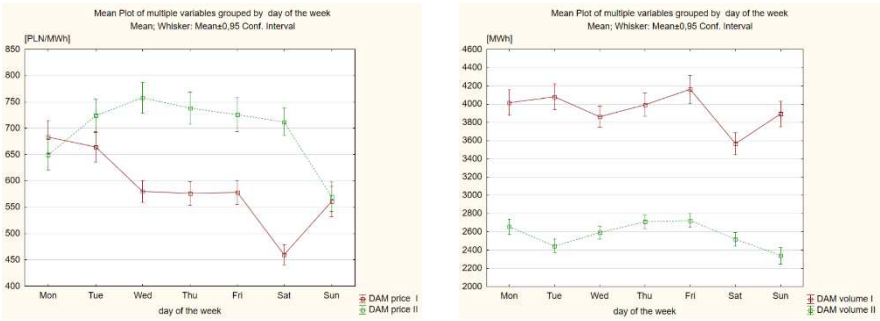
a) b)



Rys. 8. Wykres średnich cen energii elektrycznej wraz 95% przedziałem ufności i średniego wolumenu wraz 95% przedziałem ufności z podziałem na 24 godziny – I (a) i II (b) okresu na RDN

Fig. 8. Diagram of average electricity prices with the 95% confidence interval and average volume with the 95% confidence interval, divided into 24 hours - 1st (a) and 2nd (b) period on the DAM

a) b)



Rys. 9. Wykres średnich cen energii elektrycznej wraz 95% przedziałem ufności i średniego wolumenu wraz 95% przedziałem ufności z podziałem na dzień tygodnia – dla I (a) i II (b) okresu na RDN

Fig. 9. Diagram of average electricity prices with the 95% confidence interval and average volume with the 95% confidence interval, broken down by day of the week - for the first (a) and second (b) period on the DAM,

Tabela 8. Wartości testu ANOVA Kruskala-Wallisa (a-b) i testu mediany (c-d) dla średnich cen energii elektrycznej, wartości testu ANOVA Kruskala-Wallisa (e-f) i testu mediany (g-h) dla średniego wolumenu energii elektrycznej.

Table 8. Values of the Kruskal-Wallis ANOVA test (a-b) and the median test (c-d) of average electricity prices, values of the Kruskal-Wallis ANOVA test (e-f) and the median test (g-h) of average volume

a) b)

De-pend.: DAM price II	Kruskal-Wallis ANOVA by Ranks; DAM price II (volumes and prices _of _electricity.sta) Independent (grouping) variable: day of the week Kruskal-Wallis test: H (6, N= 1464) =128,2956 p =0,000			
	Code	Valid N	Sum of Ranks	Mean Rank
Mon	1	192	121818,5	634,5
Tue	2	192	151147,0	787,2
Wed	3	216	184118,0	852,4
Thu	4	216	177718,0	822,8
Fri	5	216	167384,0	774,9
Sat	6	216	168458,0	779,9
Sun	7	216	101736,5	471,0

De-pend.: DAM price II	Kruskal-Wallis ANOVA by Ranks; DAM price II (volumes and prices _of _electricity.sta) Independent (grouping) variable: day of the week Kruskal-Wallis test: H (6, N= 1464) =128,2956 p =0,000			
	Code	Valid N	Sum of Ranks	Mean Rank
Mon	1	192	121818,5	634,5
Tue	2	192	151147,0	787,2
Wed	3	216	184118,0	852,4
Thu	4	216	177718,0	822,8
Fri	5	216	167384,0	774,9
Sat	6	216	168458,0	779,9
Sun	7	216	101736,5	471,0

c)

Dependent: DAM price I	Median Test, Overall Median = 565,710; DAM price I (volumes and prices _of _electricity.sta) Independent (grouping) variable: day of the week Chi-Square = 145,4838 df = 6 p = 0,000							
	Mon	Tue	Wed	Thu	Fri	Sat	Sun	Total
<= Median: observed	61	63	102	107	107	168	136	744
expected	108	96	108	108	108	108	108	
obs.-exp.	-47	-33	-6	-1	-1	60	28	
> Median: observed	155	129	114	109	109	48	80	744
expected	108	96	108	108	108	108	-108	
obs.-exp.	47	33	6	1	1	-60	-28	
Total: observed	216,	192	216	216	216	216	216	1488

d)

Dependent: DAM price II	Median Test, Overall Median = 687,500; DAM price II (volumes and prices _of _electricity.sta) Independent (grouping) variable: day of the week Chi-Square = 76,74306 df = 6 p = ,0000							
	Mon	Tue	Wed	Thu	Fri	Sat	Sun	Total
<= Median: observed	119	84	83	91	96	103	156	732
expected	96	96	108	108	108	108	108	
obs.-exp.	23	-12	-25	-12	-12	-5	48	
> Median: observed	73	108	133	120	120	113	60	732
expected	96	96	108	108	108	108	108	
obs.-exp.	-23	12	25	12	108	5	-48	
Total: observed	192	192	216	216	216	216	216	1464

e)

Depend.: DAM volume I	Kruskal-Wallis ANOVA by Ranks; DAM volume I (volumes and prices _of _electricity.sta) Independent (grouping) variable: day of the week Kruskal-Wallis test: H (6, N= 1488) =42,92752 p =,0000			
	Code	Valid N	Sum of Ranks	Mean Rank
Mon	1	216	167615,5	776,0
Tue	2	192	152127,5	792,3
Wed	3	216	155197,5	718,5
Thu	4	216	167894,5	777,3
Fri	5	216	181408,5	839,9
Sat	6	216	128729,0	596,0
Sun	7	216	154843,5	716,9

f)

Depend.: DAM volume II	Kruskal-Wallis ANOVA by Ranks; DAM volume II (volumes and prices _of _electricity.sta) Independent (grouping) variable: day of the week Kruskal-Wallis test: H (6, N= 1464) =77,38831 p =,0000			
	Code	Valid N	Sum of Ranks	Mean Rank
Mon	1	192	152651,5	795,1
Tue	2	192	126220,0	657,4
Wed	3	216	161654,0	748,4
Thu	4	216	180108,0	833,8
Fri	5	216	182008,0	842,6
Sat	6	216	149771,0	693,4
Sun	7	216	119967,5	555,4

g)

Dependent: DAM volume I	Median Test, Overall Median = 3873,55; DAM volume I (volumes and prices _of _electricity.sta) Independent (grouping) variable: day of the week Chi-Square = 37,92593 df = 6 p = ,0000							
	Mon	Tue	Wed	Thu	Fri	Sat	Sun	Total
<= Median: observed	97	96	115	93	85	140	118	744
expected	108	96	108	108	108	108	108	
obs.-exp.	-11	0	7	-15	-23	32	10	
> Median: observed	119	96	101	123	131	76	98	744
expected	108	96	108	108	108	108	108	
obs.-exp.	11	0	-7	15	23	-32	-10	
Total: observed	216	192	216	216	216	216	216	1488

h)

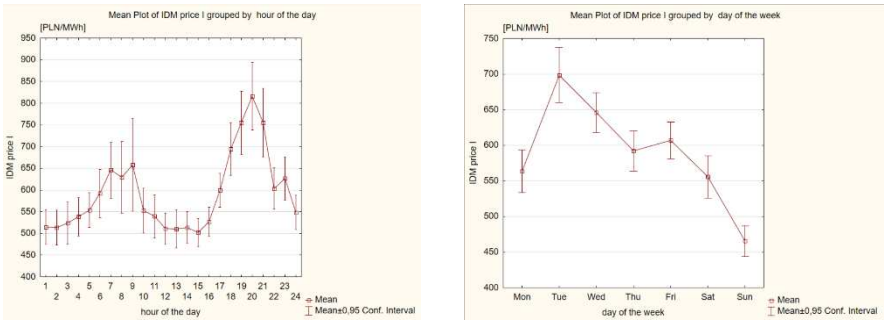
Dependent: DAM volume II	Median Test, Overall Median = 2506,00; DAM volume II (volumes and prices _of _electricity.sta) Independent (grouping) variable: day of the week Chi-Square = 51,37236 df = 6 p = ,0000							
	Mon	Tue	Wed	Thu	Fri	Sat	Sun	Total
<= Median: observed	79	109	107	86	90	117	145	732
expected	96	96	108	108	108	108	108	
obs.-exp.	-17	13	-1	-22	-22	9	37	
> Median: observed	113	83	109	130	130	99	71	732
expected	96	96	107	108	108	108	108	
obs.-exp.	17	-12	1	22	22	18	-36	
Total: observed	192	192	216	216	216	216	216	1464

Interpreting the results of the Kruskal-Wallis ANOVA test for electricity prices (Tab. 8. a) and Tab. 8. b)) in the first and second period, it can be concluded that these prices differ. Similarly, interpreting the results of the median test for electricity prices (Tab. 8. c) and Tab. 8. d) in the first and second period, it can

be concluded that these prices differ. The same results were obtained for the average volume (Tab. 8. e) - 8. h)). Figure 10 shows the graphs of average electricity prices with 95% confidence interval and average volume with 95% confidence interval by 24 hours - Period I and Period II on the DAM. The differences in both electricity prices and volumes by hour of the day are significant. Figure 9 shows the graphs of average electricity prices with a 95% confidence interval and average volume with a 95% confidence interval by day of the week - for Period I and Period II in the DAM. As with the hourly breakdown, in this case the differences are also significant for the 1st and 2nd periods analysed.

Often, in the case of sudden demand for electricity, transactions take place on the so-called Intra-Day Market. Figure 10 presents a graph of average electricity price values with a 95% confidence interval split by 24 hours and a graph of average price values split by day of the week on the IDM for the 1st analysed period. Electricity prices are at a significantly lower level than on the DAM.

a) b)

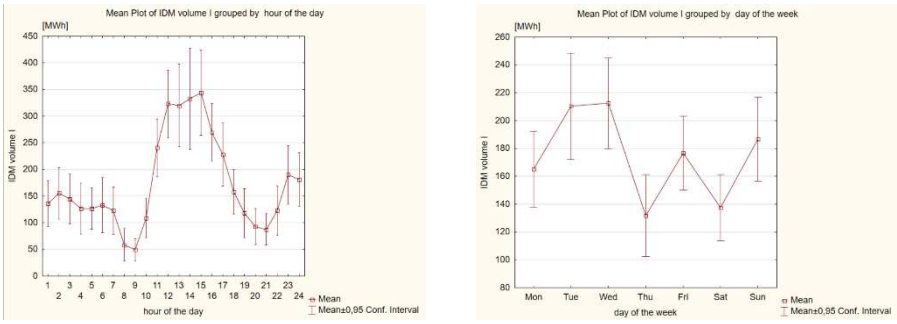


Rys. 10. Wykres średnich wartości cen energii elektrycznej wraz 95% przedziałem ufności z podziałem na 24 godziny (a) i z podziałem na dzień tygodnia (b) na RDB

Fig. 10. Chart of average values of electricity prices with 95% confidence interval, broken down by 24 hours (a) and broken down by day of the week (b) on IDM

Figure 11 presents a chart of the average value of electricity trading volume with a 95% confidence interval with a 24-hour breakdown and a chart of the average value of volume with a weekday breakdown on the IDM for the 1st analysed period. The electricity trading volume on the IDM is also at a much lower level than on the DAM. The IDM has a different specification and is often treated on the POLPX as a supplement to the DAM. The IDM is one of the elements of strategic management in the power industry, which is also important in relation to the global geopolitical situation.

a) b)



Rys. 11. Wykres średniej wartości wolumenu wraz 95% przedziałem ufności z podziałem na 24 godziny (a) i z podziałem na dzień tygodnia (b) na RDB

Fig. 11. Graph of the average volume value with the 95% confidence interval, broken down by 24 hours (a) and broken down by day of the week (b) on IDM

5. Summary

The Polish Power Exchange plays a very important role in the functioning of the electricity market in Poland. The proper fulfilment of tasks imposed on the power system depends to a large extent on transactions on the Day-Ahead Market and Intra-Day Market. The manner of trading on these markets is dictated by the requirements imposed by the system and the specificity of electricity as a resource. The functioning of the Day-Ahead Market allows for balancing transactions of purchase and sale of electricity during quotation hours and organising import and export of electricity to and from Poland. The Intra-Day Market allows for the ongoing purchase and sale of electricity in the short term. Statistical analysis of electricity prices and trading volumes covered the period from 9 February to 11 April 2022 and from 13 September to 12 November 2022. Electricity prices on the DAM and IDM increased during peak hours and decreased during off-peak hours. The exact values of selected statistics and statistical tests are presented in this article. Learning about the mechanisms of the DAM and IDM operation on the Polish Power Exchange may be useful in developing a complex regression model that depends on a number of factors that influence the electricity price and trading volume. The results of simulation studies presented in the article were performed for data available on the Polish Power Exchange.

Such a complex regression model, after detailed verification, can be used in forecasting prices and volumes depending on electricity demand on particular days and particular hours of the day. Summing up, the functioning of the energy market is a complex, constantly changing process, and its proper functioning is desirable both at the level of generation, distribution and users. The entire power system is changing, and thus the electricity market.

Literature

[1] Rabiej M.: Statystyka z programem Statistica, Helion, Gliwice , 2012.
[2] https://tge.pl/energia-elektryczna-rdb, Access: 15.04.2022 i 12.11.2022.
[3] https://tge.pl/energia-elektryczna-rdn, Access: 15.04.2022 i 12.11.2022.
[4] https://www.next-kraftwerke.pl/leksykon/obrot-energia-na-rynku-dnia-nastepnego-day-ahead-trading, Access: 10.11.2022.
[5] Ustawa z dnia 26 października 2000 r. O giełdach towarowych, Dz. U. z 2022 r. poz. 170.
[6] Ustawa z dnia 10 kwietnia 1997 r. Prawo Energetyczne, Dz. U. z 2021 r. Nr. 716.
[7] https://www.ure.gov.pl/pl/urzad/informacje-ogolne/aktualnosci/9286,Rynek-energii-na-rynku-dnia-nastepnego-uruchomiono-mechanizm-Multi-NEMO.html, Access: 30.05.2022.
[8] https://www.cire.pl/artykuly/serwis-informacyjny-cire-24/ Malko J., Weron A., Rynek energii elektrycznej; Mechanizmy funkcjonowania, Politechnika Wrocławska, Access: 30.05.2022.
[9] Niedziółka D.: Funkcjonowanie polskiego rynku energii, Difin, 2018.

WYBRANE APSEKTY FUNKCJONOWANIA RYNKU DNIA NASTĘPNEGO I RYNKU DNIA BIEŻĄCEGO NA RYNKU ENERGII ELEKTRYCZNEJ

S t r e s z c z e n i e

W artykule zaprezentowano analizę statystyczną cen i wolumenu energii elektrycznej notowanych na Rynku Dnia Następnego (RDN) i Rynku Dnia Bieżącego (RDB) Towarowej Giełdy Energii (TGE). Analizę przeprowadzono dla średnioważonych cen godzinowych i wolumenu energii elektrycznej dla dwóch wybranych okresów. Wykorzystano dane dostępne na Towarowej Giełdzie Energii. W obliczu kryzysu energetycznego i niepewności spowodowanej wojną i ograniczoną podażą surowców wykorzystywanych do produkcji energii elektrycznej znajomość funkcjonowania RDN i RDB ma istotne znaczenie ekonomiczne, strategiczne, co wiąże się z bezpieczeństwem dostaw energii elektrycznej oraz jej cenami. Rynek giełdowy w Polsce jest nadzorowany przez Urząd Regulacji Energetyki i Komisję Nadzoru Finansowego. W czasie kryzysu energetycznego zwiększa się rola giełd energii, nie tylko w Polsce, a znajomość funkcjonowania rynku energii jest także jednym z elementów zarządzania strategicznego w energetyce. Do analizy danych wykorzystano program Statistica v.13.3.

Słowa kluczowe: Rynek Dnia Następnego, Rynek Dnia Bieżącego, Towarowa Giełda Energii, wolumen, kurs

DOI: 10.7862/re.2022.7

Submitted/Tekst złożono w redakcji: grudzień 2022 r.
Accepted / Przyjęto do druku: grudzień 2022 r.
Published/Tekst opublikowano: grudzień 2022 r.