

ANALYSIS OF PRICES FOR ELECTRICITY AT THE POLISH POWER EXCHANGE

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Abstract: The main part presents the analysis of prices for electricity at the Polish power exchange. The structure of production, energy consumption, power generation structure and energy exchange with foreign countries is described and illustrated in the National Power Solution characteristics. The basic specific information about the national system such as installed capacity, achievable capacity, production and consumption of electric power in Poland is provided. Polish Power Exchange is characterized. Furthermore, the existing markets and their nature, forming of turnover and prices mainly on the Day Ahead Market are discussed. The application of the above in terms of management in the power sector and its benefits is outlined. The purpose of this study is to analyse the structure and situation of Polish Power Exchange and to examine functioning of the Day Ahead Market in Poland.

Key words: electrical power system, energy market, power exchange, model

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Introduction

Establishing the energy market, its liberalization, is a consequence of the implementation of Directive 96/92/EC and the Energy Law Act of 1997 (*Prawo energetyczne*, 1997). These activities contributed to the creation of electricity exchanges as well as to the search for effective methods of analysing, modelling and forecasting the volatility of both volume and prices (Mielczarski, 2006 and Niedziółka, 2010). Electricity and the related energy market are characterized with specific features that clearly distinguish it in comparison with other markets. The above includes, among others, the lack of energy storage, limited substitution possibilities and a natural monopoly of system operators. The seasonality of energy consumption is also clear as well as large fluctuations in prices on the exchange (Fijorek, 2010; Grabara and Kot, 2017). According to the scientific literature, the functioning of the Day-Ahead Market is crucial in terms of forecasting energy prices. Moreover, condition of literature in this particular subject is well. There were found and studied several scientific papers and articles where the functioning of the Day-Ahead Market was presented for example work of the Polish-Lithuanian team *Analiza czynnikowa cen dnia następnego na rynku energii elektrycznej w Polsce* (Bobinaite et al., 2012). Another important source is *European day-ahead electricity market clearing model* – paper written by Greek scholars in 2016 (Chatzigiannis et al., 2016.).

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The structure of production, energy consumption, power generation structure and energy exchange with foreign countries have been presented in the NPS characteristics. The characteristics of PPE, the existing markets and their nature have been discussed. From the research which has already been carried out, preliminary results in the form of graphs and tables have been included. Information on researches carried out and a proposal for further research have been presented.

Review of Polish Energy System

The term “National Power System” (NPS) means the cooperation of entities generating power, entities responsible for transmission and distribution together with the systems that control its operations. The Electric Power Market plays a significant and growing role in the operation of NPS. The Power Market caused that the electricity generators may compete with each other and they do so. The companies dealing with transmission and delivery of energy to the end users operate under the natural monopoly conditions. An important and dynamically developing sector of the Power Market is Polish Power Exchange - PPE (Nowak, 2009). At present, NPS consists of four basic sectors. A simplified organizational chart for the energy sector is shown in Figure 1.

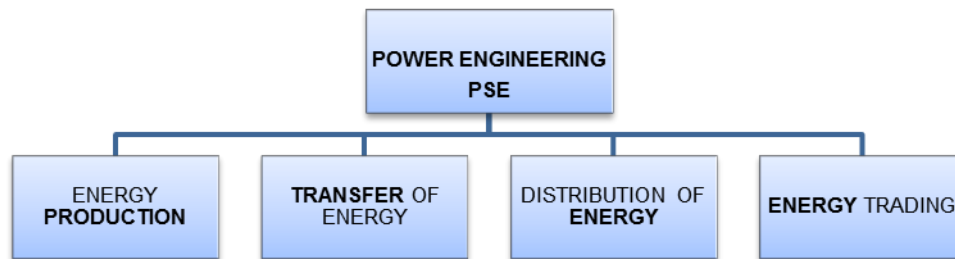


Figure 1. Sectors in NPS

Operational management of technical resources in NPS is provided by dispatching centres in a hierarchical structure:

- National Electricity Supply Board (KDM),
- Regional Electricity Supply Boards (ODM),
- Company’s Electricity Supply Boards (ZDR),
- District Electricity Supply Boards (RDR).

KDM and five ODMs are dispatching services of OSP, and ZDRs and RDRs are services of certain OSD. Responsibilities and scope of their tasks as well as cooperation relations are regulated by the Energy Law Act and specific regulations.

The power installed in the National Power System in subsequent years slightly vary due to the losses resulting mainly from shutdowns of already worn out units and new units put into operations. Table 1 presents the power values in four categories for last four years.

Table 1 Power structure in NPS [MW] (based on ARE S.A. data)

Powers [MW]	Status at the end of the year			
	31 Dec 2013	31 Dec 2014	31 Dec 2015	31 Dec 2016
Power installed	38671	39343	40362	41396
Average annual power obtained on working days in the evening peak	37743	38199	38892	40491
Average available power	26627	26363	26763	28140
Average annual power demand	22155	22301	22529	22832

In 2016, the national power production was 162,626 GWh, total consumption was 166,100 GWh, 14,012 GWh was imported and 12,911 GWh exported. Since 2013, both domestic production and consumption of electricity are at very similar level. Electricity consumption increased by 20% in last 17 years, and the production increased by almost 13% in the same period (*Raport TOE* and *raport.pse.pl*). This imbalance has been stabilized by reducing the losses at various stages, replacing old equipment with new and more energy efficient one as well as by import.

Table 2 Domestic production and consumption of electricity in Poland in 2010-2016 [GWh] (based on PSE data)

Year	National gross power production [GWh]	National power consumption [GWh]	Production dynamics	Consumption dynamics
2005	156,024	144,838	101.7%	100.5%
2006	160,848	149,847	103.1%	103.5%
2007	159,528	154,170	99.2%	102.9%
2008	155,567	154,980	97.5%	100.5%
2009	150,923	148,718	97.0%	96.0%
2010	156,342	154,987	103.6%	104.2%
2011	163,153	157,909	104.4%	101.9%
2012	159,853	157,013	98.0%	99.4%
2013	164,580	160,059	103.0%	101.9%
2014	159,058	161,224	96.6%	100.7%
2015	164,944	164,610	103.7%	102.1%
2016	162,626	166,100	98.6%	100.9%
Average dynamics			100.8%	101.2%

Table 3 and Figure 4 present the level of export and import of power for last 3 years. As it can be noticed, a big jump in import was in 2013. Export of energy in the last three years was rather stable.

Table 3. Import and export of electricity in 2013-2016 [GWh]
(based on PSE data)

Energy [GWh]	Year			
	2013	2014	2015	2016
Import of power	7801	13508	14459	14012
Export of power	12322	11342	14793	12911

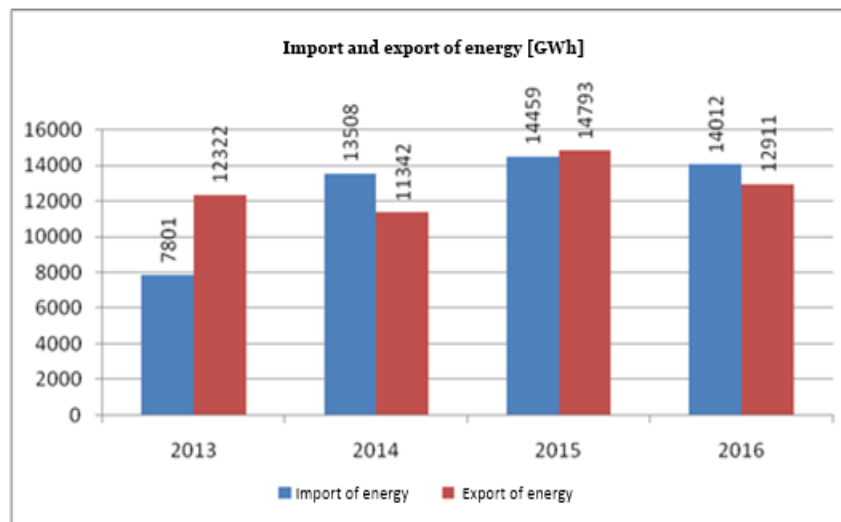


Figure 2 Import and export of electricity [GWh]
(based on PSE data)

PSE S.A. is the operator of the transmission system and also a member of the European Network of Transmission System Operators for Electricity - ENTSO-E). It consists of 41 transmission systems operators from 34 countries. **ENTSO-E** has been operating since December 2008, and since March 3, 2011, it runs its activity under the *Regulation of the European Parliament and of the Council (EC) No 714/2009 of July 13, 2009 on conditions for access to the network for cross-border exchanges in electricity and repealing Regulation (EC) No 1228/2003*.

The cross-border exchange is one of the most significant problems for the developing integrated European market. The Polish Transmission System Operator has been intensively operating in the framework of the exchange between the operators (raport.pse.pl). As part of this exchange, the TSO, takes steps aimed at minimizing harmful energy transmission from Germany to the Czech Republic and Slovakia, for example by purchasing energy on the Polish balancing market.

These activities are aimed at limiting a considerable increase of prices on the balancing market, and thus on the Polish Spot market also. Very important activities include coordination by ENTSO and Agency for Cooperation of Energy Regulators (ACER), work on the assessment of the Polish market as a whole, works that may have an impact on the Polish export and import of electricity as well as concerning the effectiveness of the existing bidding zones in Europe (*tge.pl* and *raport.pse.pl*).

At the turn of 2015 and 2016, the connections between Poland and Lithuania were launched, where the cross-border powers are provided on the same basis as in case of the cable connection with Sweden. Smooth operation of the electricity market in this scope must be secured with instruments that allow to limit the risk associated with the cross-border exchange. One of the factors minimizing this risk is the provision of power not only a day ahead but also in 1-month, 3-month and 1-year periods under the limited PTR rules (Physical Transmission Rights), similar to the model at the Estonia-Latvia border (*tge.pl* and *rynek-energii-elektrycznej.cire.pl*).

National Power System is connected with numerous power systems in neighbouring countries. The summary capacity of this connection is 8 GW, including 6.5 GW with EU member states (*Statystyka elektroenergetyki polskiej*, 2016). Figure 6 shows the evolution of changes in export and import of electricity with trend lines. The growth rate of import is clearly higher by 2013. Since 2014, we can observe that export and import of energy equalized.

The connection of the Polish and Swedish systems with a DC cable provided Poland with full membership in the European Multi Regional Coupling market. The launch of the connection with Lithuania also has an impact on the growth of the exchange. Poland currently has power connections with the Czech Republic, Slovakia, Lithuania, Ukraine, Sweden and Germany. Coupling electricity markets constitutes a complex process that is evolving to bring a uniform integrated European market at a final stage (Market Coupling – MC) (*Raport TOE* and *Rozporządzenie Parlamentu Europejskiego i Rady nr 1227/2011*).

The total capacity of connections of the Polish power system with the EU member states is 2000-3000 MW (depending on the configuration of the system operation) and is limited with transmission capacity within the national system. The current capacity of cross-border connections meets the target set by the European Council which is at least 10% of the cross-border connections transmission capacity in relation to the power installed in the national electricity system. It is assumed that the development of cross-border connections will allow for exchange of the power consumed in the country at the level of 20% up to 2020, and in 2030 - 25% (Wojcieszak, 2017).

Polish Power Exchange PPE and Electricity Market in Poland

PPE, which has been operating for 17 years now, is currently the key element of the Polish commodity market and deals in particular with organization of electricity and natural gas trading. PPE also operates a financial market, creating

a strong link between the energy and financial sector. The Polish electricity market is one of the largest markets of the European Union. The consumption level places our country at the sixth place. In Poland, the electricity market model belongs to the group of decentralized markets. Such market models were implemented with some modifications taking into account local conditions in California (USA), partly in Australia, Scandinavia or the UK (Mielczarski, 2006).

At present, PPE associates 70 entities and their number systematically increases. It contains not only domestic companies but also companies from other EU and EEA member states, i.e. Germany, the Czech Republic, France, Switzerland or the UK (Fijorek *et al.*, 2010). A trend that can be observed on the EU power markets is that the participants join their activity on the electricity and natural gas wholesale market. The primary task of the commodities exchange is to determine an objective price of energy, which later becomes a reference point for other transactions concluded on the energy market. At present, PPE operates the following markets:

- Day Ahead Market – RDN,
- Intraday Market – RDB,
- Commodity Derivatives Market – RTT,
- Gas Market – RTT, RDNg,
- Property Rights Market,
- Financial Instruments Market.

The amendment to the Energy Law (*Prawo energetyczne*, 1997) of 2010 implemented an obligation to sell a certain amount of electricity through the exchange. This solution called “an obligation to trade” has created a new, more transparent model of wholesale trading. Positive experiences related to its implementation caused that the national legislator decided to adopt a similar mechanism to create a competitive natural gas market.

Characteristics of the Markets Operating at the PPE

The domestic electricity market covers several segments (*tge.pl* and *rynek-energii-elektrycznej.cire.pl*). These are: OTC Market – Bilateral Contracts Market, Exchange market – Wholesale Market, Retail Market, Power Derivatives Market RTT, and Financial Market. Due to the subject matter of the study, the author focused mainly on the Exchange Market.

Wholesale Exchange Market

Energy trading at the PPE is carried out mainly at the so-called Day Ahead Market (DAM). DAM trading takes place daily in two sessions: at 8 AM and 10:30 AM. DAM is carried out the day before the day of the actual energy delivery. It consists of 24-hour settlement periods. DAM participants place orders for purchase or sale for individual hours. A supply curve and demand curve are created for each hour. The transaction prices on the exchange are the prices of equilibrium between the orders for sale and purchase of electricity placed independently by the Exchange

Members (*tge.pl*). At the electricity DAM, the hourly contracts are available (trading is carried out independently for each of the 24 hours. Moreover, 3 block contracts are traded at DAM. These are:

- BASE Contract - with delivery of 1 MWh at every hour of the day,
- PEAK Contract - with delivery of 1 MWh of energy at each peak hour 7:00 AM to 10:00 PM,
- Off-peak Contract - with delivery of 1 MWh of energy at each off-peak hour 0:00 AM - 7:00 AM and 10:00 PM - 0:00 AM).

Price volatility at the DAM market is currently presented with 7 price indices referring to a day and time of delivery. The latest index of the electricity market - Tge24, is a reference instrument for the contracts at the market of financial instruments (futures). It is determined based on the exchange transactions concluded on hourly products in the single exchange rate system on I fixing.

A new trading area at PPE is the financial market being a reaction to the Directive of the European Parliament (*Dyrektywa Parlamentu Europejskiego i Rady 2014/65/UE*). The Financial Instruments Market (FIM) on the PPE was implemented in November 2015. The instruments include futures contracts for the Tge24 electricity price index, determined on the market the following day of PPE. The property rights which are an instrument supporting electricity from renewable sources, cogeneration and energy efficiency, constitute a separate category of energy products in the PPE offer. The trading on the market is based on property rights resulting from certificates of origin. There is also trading with property rights resulting from certificates of origin for electricity (PRM). The energy producers in RES in cogeneration and companies obliged to purchase the certificates of origin may trade the property rights to such certificates.

PPE trades also the rights to CO₂ emission (EAM). Trading with these rights is exercised by means of the European Unit Allowance (EUA) in the form of spot transactions.

Turnover at the Polish Power Exchange

Over the last few years, the trade in electricity on all markets operated by PPE increased twice, from little more than 81 TWh in 2010 to almost 187 TWh in 2014. With the annual electricity production at the level of ca. 160 TWh in 2010, 50% of domestic production was traded on PPE. Six years later, the trading oscillated at almost 120% of domestic production (*rynek-energii-elektrycznej.cire.pl* and *raport.pse.pl*). It reflects in a rapid growth of the Polish market liquidity. The growth applied both to the derivatives market as well as the Day Ahead and Intraday Market. The derivative market operated by the biggest European energy exchange, i.e. German EEX, developed at a similar pace. The growth of the spot market in Germany was much smaller, and in the Czech Republic it declined by almost 6%. Since November 2015, the PPE participants may use the financial market FIM. The new products launched in this market are used to cover the risk at the electricity market. The stock market index dedicated to this market was

created - Tge24. This is a reference instrument for the contracts at the financial market (futures). It is believed that the financial market will determine a faster development of the PPE, reducing the distance to the largest exchanges in Europe (*ure.gov.pl*).

In 2015, the trading volume at DAM and IM was at the level of 25.14 TWh, where 25.08 TWh was on DAM and 0.06 TWh on IM. If we compare this to the year 2014, the trading on DAM increased by 6%, and decreased by 26% on IM. Electricity trading at the Spot market increased by 5.5% in comparison to the year 2014. Trading on the Power Derivatives Market RTT in 2015 that constitutes the major part of the total electricity trading on the PPE, was at a similar level as in the previous year. The trading was 161.56 TWh that is 1% more than in the previous year. The total volume of electricity transactions at the Stock Exchange in 2015 including the spot and RTT market was 186.70 TWh, and compared to 2014 when the turnover was 186.80 TWh, it shows a slight decrease.

In 2016, the total volume of transaction concluded on all electricity markets on TGE S.A. amounted to 126.7 TWh, thus it decreased by more than 32% in comparison to 2015. Additionally, the total volume of transactions concerning the sale of electricity with its delivery in 2016 amounted to 179.3 TWh, and it was 107.6% of gross electricity production in 2016. As in 2015, the largest trading volume was obtained on RTT. The trading on this market together with auctions amounted in total to 99 TWh (*tge.pl* and *rynek-energii-elektrycznej.cire.pl*).

The most liquid in 2016 was the annual contract for baseload for 2017 - BASE_Y-17. The trading volume under this contract in 2016 amounted to 43.7 TWh. It is over 44% of the total volume traded on RTT market in terms of electricity. The total volume of electricity transactions carried out on DAM was 27.6 TWh, and it means that there was an increase by almost 10% compared to the previous year. The trading volume on DAM in 2016 amounted to 71.36 GWh.

Conclusion

Implementing DAM trading may minimize the risk connected to pricing and scheduling. Such management strategy in energy sector eases functioning of demand-side because explicit price implication is observed before a given operation. Furthermore, in Europe it is very important to achieve the goals of the "Price Coupling of Regions" project. It is essential in order to establish well balanced and stable European electricity market. Such energy market is expected to increase liquidity and efficiency, moreover to improve social welfare (*epexspot.com*).

Looking at the characteristics of PPE and its results the following conclusions may be drawn. Efficient management of DAM in Poland enables sector stability by giving reliable information for power station. It can also give market signals to demand-side management providers which can improve the participation and offer profits connected to greater system efficiency, lower costs, better risk management, more sustainable solutions, more professional customer service and market power

mitigation. Furthermore, smaller part of generator is prone to price volatility because of the reduced effect of unstable real-time market prices. Since nature of transactions at DAM is more financial and not just a delivery the liquidity increases. Similar effect is achieved because of the arbitration between the day-ahead market and the balancing market. In addition, risk redistribution at the market is possible (Mielczarski, 2000).

Limitations of the study is that it is focused only on the Day Ahead Market whereas there exists different markets (for example intraday market) and some comparison would be appreciated as well as further research related to the methods forecasting electricity prices.

In summary the structure and features of the National Power System are presented as well as the structure of the domestic electricity market. The basic specific information about the national system has been provided whereas dynamics of changes in the consumption and production of electricity over several years has been shown. Information on the international activity of the operator, the scope of exchange with neighbouring countries with specification of the tensions' highs and permissible powers on all trans-border connections has been provided. The Polish Power Exchange has been presented with the chronology of changes. Existing markets and products have been briefly characterized. Forming of turnover and prices mainly on the Day Ahead Market has been discussed. Effects of efficient implementation and management on the Day Ahead Market trading have been outlined.

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ANALIZA CEN ENERGII ELEKTRYCZNEJ NA TOWAROWEJ GIEŁDZIE ENERGII

Streszczenie: Główna część artykułu przedstawia analizę cen energii elektrycznej na towarowej giełdzie energii. Strukturę produkcji, zużycie energii, strukturę wytwarzania energii i wymianę energii z zagranicą opisano i zilustrowano w charakterystyce narodowego rozwiązania energetycznego. Ponadto przedstawiono podstawowe informacje o krajowym systemie, takie jak zainstalowana moc, osiągalna moc, produkcja i zużycie energii elektrycznej w Polsce. Scharakteryzowano Towarową Giełdę Energii. Ponadto w artykule omówiono istniejące rynki i ich charakter, kształtowanie się obrotów i ceny, głównie na Rynku Dnia Następnego. Omówiono zastosowanie wyżej wymienionych w zakresie zarządzania w sektorze energetycznym i jego korzyści. Celem niniejszego opracowania jest analiza struktury i sytuacji Towarowej Giełdy Energii oraz zbadanie funkcjonowania Rynku Dnia Następnego w Polsce.

Słowa kluczowe: system elektroenergetyczny, rynek energii, wymiana energii, model

波兰电力交易所电力价格分析

摘要: 主要部分介绍了波兰电力交易所电力价格的分析。国家电力解决方案的特点描述和说明了与国外的生产结构, 能源消耗, 发电结构和能源交换。提供关于国家系统的基本具体信息, 例如波兰的装机容量, 可实现容量, 电力生产和消费。波兰电力交易所的特点。此外, 还讨论了现有市场及其性质, 主要在日前市场形成营业额和价格。概述了上述在电力行业管理方面的应用及其益处。本研究的目的是分析波兰电力交易所的结构和状况, 并检查波兰日前市场的运作情况。

关键词: 电力系统, 能源市场, 电力交换, 模型