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Poland's electricity market. Forecasts of demand for electricity and of electricity prices

Abstract: The subject of this paper is an analysis of the electricity market in Poland. The period of 2008–2015 came under close scrutiny, whereby emphasis was laid on the trends in electricity generation and demand, while taking into account the country's economic development. In addition, the text mentions the forecasted demand for electricity in 2030, and electricity prices. As regards electricity prices, both qualitative and quantitative forecasts have been presented. In the latter case, the results of the author's own forecast have been presented; these were obtained with the aid of selected methods applied for the analysis of the dynamics of economic phenomena (the exponential and linear trend models). In order to make the research problem more specific, the text addresses the following research questions: (1) Is it possible to point out any special characteristics of the structure and operation of the electricity market in Poland? (2) Is it possible to point out a characteristic trend in the changes in demand for electricity in Poland? (3) Is it possible to point out a characteristic trend in the changes in electricity prices in Poland?

Key words: electricity, electricity market, electricity sector, forecasts of the demand for electricity, forecasts of electricity prices

Introduction

The subject of analysis in the present text is a description of the workings of the electricity market in Poland. First and foremost, emphasis will be laid on demonstrating special features of the electricity market. Second, a forecast will be created as regards trends in the demand for electricity as well as trends in changes in electricity prices in Poland. As regards the forecast of the demand for electricity, a qualitative and secondary data-based analysis will be applied, whereas as regards the forecasts of electricity prices, a quantitative method based on an exponential smoothing model and a linear trend model will be applied.

The temporal scope of the description of changes in the electricity market has been limited to 2008–2015. The period witnessed transforma-

tion processes and new directions set for energy policies in the European Union, and by extension in Poland as well. For instance, of great significance was the implementation of the “*Third Energy Package*” (2011) and the “*Climate-Energy Package*” (2009) (cf. Krzykowski, 2013; Kałążna, Rosicki, 2010, pp. 114–164). The former case was one of direct impact on the shape of the electricity market, which comes to be encapsulated in the establishment of the *Agency for Cooperation of Energy Regulators* (ACER) and the *European Network of Transmission System Operators for Electricity* (ENTSO-E), as well as in the implementation of homogeneous market instruments, e.g. network codes and subsequent forms of separation of energy companies (cf. Kotlewski, 2015, pp. 125–172; Grzegorczyk, 2012; Nowacki, 2010). The text also includes forecasts concerned with: (1) a demand for electricity in Poland in 2030, (2) electricity prices in Poland in 2030.

Given the need to elaborate the research problem, the text addresses the following research questions: (1) *Is it possible to point out any special characteristics of the structure and workings of the electricity market in Poland?* (2) *Is it possible to point out a characteristic trend in the changes in demand for electricity in Poland?* (3) *Is it possible to point out a characteristic trend in the changes in electricity prices in Poland?*

Since the market, as a subject of analysis, is a focus of interest for many scientific fields and disciplines, while particular attention should be paid to economic, legal and technical sciences (e.g. Krawiec, 2016; Kotlewski 2015; Paździor, 2013; Kasperowicz, 2012; Pach-Gurgul, 2012; Szablewski, 2012; Lorek, 2007; Pyk, 2007). Each one of the fields and disciplines adduced here will determine a special approach to the issues concerned with the electricity market operation, and so it is impossible to present an exhaustive definition of this kind of market. However, for the purpose of this paper, it must be assumed that “an electricity market is an entirety of processes occurring between end users and producers with a participation of network system operators and a variety of middlemen enabling the most advantageous way of fulfilling end users’ electrical needs at a reasonable profit generated by supplying companies” (PSE, 2016). In this light the market is chiefly viewed as a relation between end users and producers based on intermediary entities – *inter alia*, network operators – whereby a demand for electricity is satisfied in an economically viable manner. Besides, one can treat the market as an institutionally organised “place,” where purchase and sale agreements for the supply of services and products are executed (cf. Motowidlak, 2006; Szczygieł, 2005; Rekowski, 1999, p. 36).

1. Methodology

In the analysis presented in the text, attention is first and foremost given to demonstrating special features of the electricity market against the backdrop of its changes in the period of 2008–2015. Next, the analysis covers a forecast of trends in the demand for electricity as well as trends in the changes of electricity prices in Poland. As regards the forecast of the demand for electricity, a qualitative analysis will be applied, on the basis of secondary data, whereas as regards the forecast of electricity prices, own research results have been presented; these have been obtained by way of selected methods for analysing economic phenomena dynamics.

As for the forecast of electricity prices in Poland, data from 2008–2015 have been used [see Fig. 5]. The data values from that period have been used for extrapolation, that is for making a forecast for 2030. The price values from the period in question concern the prices for the so-called “medium-sized household consumers” and “medium-sized industrial consumers,” in accordance with the division of consumers introduced by Eurostat. It is to be noted that in 2007 the Eurostat changed a methodology for qualifying entities as “small,” “medium-sized,” and “large” electricity consumers (*Electricity price statistics*, 2016). Currently, entities consuming between 2500 and 5000 kWh annually fall under the “medium-sized household consumers” group, whereas entities consuming between 500 and 2000 MWh annually fall under the “medium-sized industrial consumers” group (*Electricity prices by type of user*, 2016; *Energy statistics...*, 2016).

For the analysis of the forecasting of electricity prices for household and industrial consumers, selected methods for analysing the dynamics of economic phenomena were used, that is analytical methods for determining the trend – a linear model, Holt’s method, exponential model and power model (Zeliaś, 2000, pp. 112–163). However, in the presentation of the research results, the use was made of only those models which ensured the lowest value of the standard deviation of the remaining component [see Table 1 and 2]. The result is a presentation of appropriate research results concerned with the linear trends in electricity prices for medium-sized household and industrial consumers in Poland. In the case of the former consumers the exponential model proved appropriate, whereas in the case of the latter ones, the linear model proved appropriate [see Fig. 6 and 7]. The differences in the models ensuring the lowest standard deviation value appeared in comparative forecasts of prices

all over the European Union and Germany. Despite the differences, the text does not feature an analysis of the whole research process; still, the extrapolated values of the electricity prices in the European Union and Germany in 2030 are included.

Table 1

Methods and errors of expired forecasts for trends in electricity prices for medium-sized household consumers

Method	Ex-post errors				
	ME	MSE	RMSE	RMSPE	MAPE
Holt’s model	0.00	0.00	0.01486	10.90%	7.60%
Linear model	–0.01	0.00	0.01312	9.56%	8.34%
Exponential model	0.00	0.00	**0.00768**	5.98%	4.82%
Power model	0.00	0.00	0.00873	6.78%	5.75%

Source: Own work.

Table 2

Methods and errors of expired forecasts for trends in electricity prices for medium-sized industrial consumers

Method	Ex-post errors				
	ME	MSE	RMSE	RMSPE	MAPE
Holt’s model	0.00	0.00	0.00792	9.45%	7.32%
Linear model	0.00	0.00	**0.00545**	6.17%	5.54%
Exponential model	0.00	0.00	0.00549	6.30%	5.24%
Power model	0.00	0.00	0.00563	6.46%	5.27%

Source: Own work.

Exponential smoothing is a simple technique employed for smoothing a time series in a forecast without the need to construct a parametric model (Halicka, Winkowski, 2013, p. 74). The exponential model is linear relative to parameters and the exogenous variable. The assumption that the development of a given phenomenon is to occur according to the exponential function is associated with the assumption that the time series will be changing by geometric progression. In the research the exponential model was reduced to a linear form with the aid of logarithm, which was taken of both sides of the equation.

It must be pointed out that the exponential function often comes in useful as a model of a linear trend in which there is only one exogenous variable, i.e. a temporal variable. The exponential function is used for

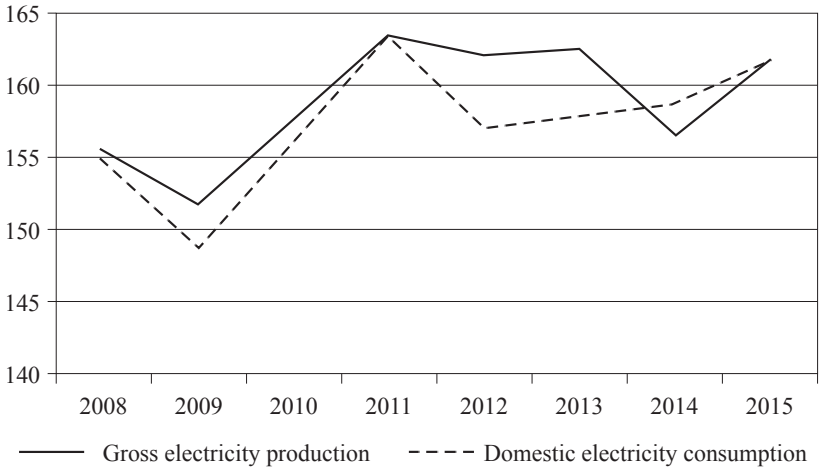
analyses of new product markets (at the stage of popularisation), national income (given a steady increase in a particular quantity), demographic processes, electrical energy production (Zeliaś, 2000, pp. 135–140).

A linear model of a trend is a special form of linear regression, whereby time is the only exogenous variable. To delineate the trend line one must calculate parameters with the aid of the method of least squares (cf. Stanisz, 2007, pp. 21–58; Zeliaś, 2000, pp. 119–125). Applying particular models belonging to a group of classical trend models, one should bear in mind that while making a forecast, it is to be assumed that the linear trend observed thus far will not change (cf. Klóska, Czyżycki, 2009).

2. A description of changes on the electricity market 2008–2015

The period of 2008–2015 witnessed both growths and drops in the domestic production and consumption of electricity in Poland. The changes in the trends on the electricity market were influenced by a number of variables, whereas the main variable was the overall economic situation [see Fig. 1 and 2].

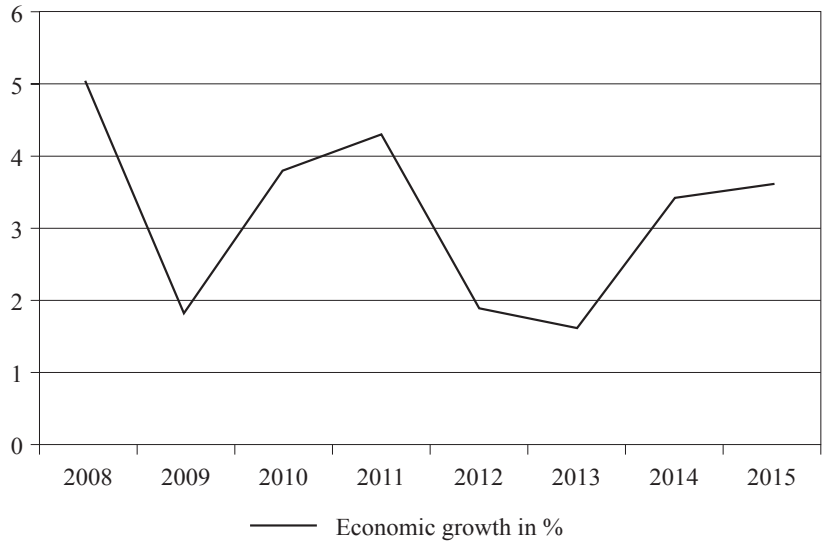
Figure 1. Electricity production and consumption in Poland 2008–2015 (TWh)



Source: own work based on GUS (Central Statistical Office), PSE (National Power Grids) and URE (Energy Regulatory Office) data.

In 2008 changes were made to the rules of the electricity market operation – prices for industrial consumers were liberated, long-term contracts for energy and power purchase were terminated (see Ustawa z dnia 29 czerwca 2007 r., Dz. U. 2007, Nr 130, poz. 905). In 2008 the average annual energy consumption increased by 0.5%, whereas energy production decreased by 2.5%. In the first three quarters of that year the significant dynamics of the increase in the demand for electricity had an effect on the increase in prices. Towards the end of 2008 a slowdown in the economy was to be observed, which resulted in a drop in both the domestic consumption and production of electricity in the following year. The result of the decrease in the demand for energy in the domestic power grid was a drop in prices on spot markets (exchange trading and balancing market). A similar pricing trend did not appear for bilateral contracts, as these had been concluded in the previous year (*Charakterystyka rynku energii elektrycznej 2008*, 2009).

Figure 2. Economic growth in Poland 2008–2015



Source: own work based on GUS, PMR data (www.polishmarket.com).

In 2009 gross electricity generation was at about 151.6 TWh, that is it was more than 2% lower than in the previous year. A similar trend was to be observed in energy consumption, which – compared to the previous

year – dropped by almost 4%. It must also be pointed out that there was a 35% average annual increase in the reserve level of power available to the operator of the transmission system. This was possible thanks to the drop in the demand for energy, but was also related to the declining number of renovations. Hence, like in previous years, Poland was a net electricity exporter, and the excess of export over import increased by 3% (*Charakterystyka rynku energii elektrycznej 2009*, 2010).

The year 2009 brought another series of legal changes affecting Poland’s electricity market. Pursuant to *Act on Excise Duty*, the tax liability was in principle shifted from producers to electricity sellers, who in turn supplied it to end users. In the same year a settlement was made of the state aid extended to entities that were subject to regulations on long-term contract termination. Also, the work on an independent balancing of the distribution system operator was completed.

Unlike the previous year, 2010 saw an increase in both the consumption and production of electricity. Compared to 2009, there was an increase in electricity generation of almost 4%, which was to be associated with a change in the economic growth. Also, greater dynamics in the development of renewable energy sources was to be observed in the energy structure. Apart from the increase in the demand for electricity, one should also point to an increase in the number of renovations, including the so-called emergency renovations, which gave rise to the average annual decline in power available within the transmission system of 24% (*Charakterystyka rynku energii elektrycznej 2010*, 2011).

In 2010 there were more legal changes concerned with, *inter alia*, electricity producers falling under an obligation to sell electricity to the public. Despite the gradual changes in the operation of the market, it was still characterised by little fluidity, which resulted from a substantial share of bilateral contracts and a small amount of exchange trading.

The 2011 economic growth influenced the increase in the demand for electricity of 4.4%. Thus, there is a special cause-effect relationship between the economic dynamics and the demand for electricity, since the GDP increased by 4.3%. The level of the gross domestic electricity generation was at 163.1 TWh, thus being higher for another consecutive year. Also, that period witnessed an excess of electricity generation over the domestic consumption of 5.25 TWh, which was caused by an economic situation related to the foreign trade in electricity (*Charakterystyka rynku energii elektrycznej 2011*, 2012).

A change in the strategy of concluding contracts, which consisted in decreasing the number of bilateral contracts, and in increasing the volume of exchange trading, affected the fluidity and transparency of trading. At the end of 2011 the European Parliament and the European Council Regulation No. 1227/2011 on *Wholesale Energy Market Integrity and Transparency* came into force; it consolidated the information openness and laid down the rules of the energy market monitoring with a view to preventing any possible abuse, including market manipulation (*Charakterystyka rynku energii elektrycznej 2011*, 2012; EU *Regulation* No. 1227/2011).

It should also be noted that the electricity generation structure was not subject to any dramatic change; still, there was a visible and prolonged increase in the share of renewable energy sources in generation. Changes in the increase in the share of two renewable source carriers were of great significance. The year 2011 saw an 18% increase in the commercial generation of electricity based on the co-firing technology, and a 33% increase in the industrial generation based on the biomass-combustion technology. As for biogas there was a 37% decrease in industrial electricity generation (*Charakterystyka rynku energii elektrycznej 2011*, 2012; Rosicki, Rosicki, 2014, pp. 327–349).

The year 2012 saw a small drop in the gross electricity consumption down to 157 TWh. The economic situation was a significant factor affecting the level of electricity generation, which came to be manifested in the decrease in the GDP growth. The result was a 2.84 TWh excess of export over import (*Charakterystyka rynku energii elektrycznej 2012*, 2013).

The previous years saw a predominance of electricity trading occurring among energy companies’ own capital groups. This state of affairs significantly limited the development of a competitive market of electricity. The situation, however, was gradually changing as a result of electricity generating companies being obliged to sell electricity to the public. Similar changes took place in the case of electricity trading companies, though in 2012 bilateral contracts were still predominant in wholesale electricity trading. In spite of the fact that the main forms of wholesale trading were bilateral contracts, there was a slow increase in trading via commodities exchange (Ibidem, 2013).

In 2013 electricity consumption was at 157.9 TWh, which means that there was a slight increase in the consumption compared to the previous year. As for the gross domestic electricity generation, there was also a slight increase in production compared to the previous year. Various

sources indicate that the excess of production over consumption was a result of an upturn in foreign trade in electricity (*Charakterystyka rynku energii elektrycznej 2013*, 2014). In the prospect for 2008–2013 Poland, as a member of the group of the European Union’s largest consumers, was characterised by the highest average annual growth in the volume of consumed electricity, which amounted to 2.64% (*Towarowa Giełda Energii 2014*, 2015, p. 19).

Even though in 2013 there were hardly any particular changes in the structure of electricity generation in Poland, an uptrend in the share of renewable energy sources was observable. Undoubtedly, the upward trend in the installed capacity of wind energy continued, and this type of energy has markedly been on the increase since 2005 (Cf. Gielnik, Rosicki, 2013, pp. 191–205).

The uptrend in the trading volume on the electricity markets realized via commodities exchange (TGE SA) is noteworthy, the greatest part of the trading volume being realised on the commodities futures market (RTT). The rationale behind this market is the possibility of dealing in standard futures for the supply of electricity, the amount of which is identical every hour of the contract execution (cf. *Rynek Terminowy Towarowy*, 2016). In 2013 there was a 36.7% increase in the volume of electricity purchased and sold on the commodities futures market (*Charakterystyka rynku energii elektrycznej 2013*, 2014*; Raport Krajowy Prezesa Urzędu Regulacji Energetyki z 2014*, 2014, pp. 8–9; *Raport o rynku energii elektrycznej i gazu ziemnego w Polsce w 2013 r.*, 2014, pp. 8–10).

The year 2014 saw a slight increase in the gross electricity consumption, whereas the gross domestic electricity production was lower by 3.7% compared with the previous year, and as regards the electricity generating sources based on black coal, a drop in production registered more than 5%. The difference between these two values was smoothed away by import, which in turn resulted in Poland becoming a nett importer of electricity (*Charakterystyka rynku energii elektrycznej 2014*, 2015). Various sources pointed out that the increase in import was caused by lower electricity prices in Poland’s neighbouring countries, from which import was possible, e.g. Sweden (Derski, 2015).

It must be noted that the year 2014 was characterised by an increase in electricity trading on the energy commodities exchange (TGE SA). The trading volume amounted to 186.8 TWh, which means that the exchange trading exceeded 119% of domestic production and 139% of electricity consumption in Poland. The total volume of electricity trading on the

commodities futures market (RTT) amounted to 162.9 TWh, thus increasing by 5.4% compared to the previous year (*Towarowa Giełda Energii 2014*, 2015, p. 11). In the period of 2010–2014 the exchange trading (TGE SA) rose at the average annual rate of as much as 23%. This means that the Polish electricity market began to reach a high level of fluidity, being the most fluid market in Central and Eastern Europe (*Towarowa Giełda Energii 2015*, 2016, p. 40).

In 2015 the gross domestic electricity consumption rose by 1.7% compared to the previous year, and reached the level of 161.4 TWh. Noteworthily, the level of the increase in electricity consumption was more than twice as low as the GDP growth rate [see Fig. 2]. Just like in the case of consumption, electricity generation also registered growth. In 2015 the level of gross domestic electricity generation reached 161.7 TWh, thus being 5.2 TWh higher compared to the previous year (*Charakterystyka rynku energii elektrycznej 2015*, 2016).

The level of the electricity market fluidity was maintained, which is manifested in the total volume of exchange trading in 2015 – 186.7 TWh. As usual, the greatest volume of trading was that of the commodities futures market (RTT), which reached the level of 161.6 TWh. Besides, in November 2015 new exchange instruments were introduced on the exchange, that is the Financial Instruments Market (RIF) was launched (*Charakterystyka rynku energii elektrycznej 2015*, 2016; *Towarowa Giełda Energii 2015*, 2016, p. 36–40). This kind of market is based on the trade in such derivatives as “*futures contracts*,” which make it possible to buy a particular security at an agreed-upon and fixed price in the future. Thanks to the fixedness of the price, it does not change due to a change in a price of a specified security on the market in the future.

While describing the Polish electricity market, one should take into account liberalisation processes, which is to be directly associated with the requirements specified in energy packages launched by the European Union (cf. Krawiec, 2016). It can be assumed that “subjecting electricity to more market-related tendencies” will be more favourable to industrial consumers than household ones (cf. Kaliś, 2011, pp. 106–133). Still, it is noteworthy that successive directives on the construction of the electricity market presuppose a consolidation of household consumers’ position. Despite the above-mentioned processes, it is to be assumed that electricity prices in Poland will continue rising, which will result from, *inter alia*: (1) requirements of low-emission energy generation, (2) the transforma-

tion of the old coal-based technology, and (3) the necessity of developing renewable energy sources.

3. A forecast of the demand for electricity

It must be pointed out that there is a possibility of presenting indicators anticipating electricity consumption, and illustrating a rise or a drop in demand. Analyses by R. Kasperowicz can serve as an exemplification; he researched relationships between economic fluctuations and electricity consumption fluctuations. It was of particular significance for R. Kasperowicz to establish which one of the economic indicators would be better while forecasting future electricity demand. The indicator most frequently used for describing the economic situation is the Gross Domestic Product, which is a measure of economic growth, that is a measure of the “size of economy” (see Kasperowicz, 2012; cf. Alp, 2016, pp. 753–759; Aytaç, Güran, 2011, pp. 101–116).

Besides the Gross Domestic Product there are other alternative indicators to go by when researching the relationship between the economic situation and electricity consumption. A number of values related to the sold production of industry (PSP) may serve as a competitive indicator (Kasperowicz, 2016). According to a definition by the Central Statistical Office, the Sold Production of Industry is “a value expressed in current basic prices, that is ones minus any goods and services taxes (VAT), excise taxes, and plus specific subsidies, that is subsidies earmarked for products (wares and services)” (*Sold Production of Industry*, 2016; Rozporządzenie Rady Ministrów z dnia 9 listopada 2012 r., Dz. U. 2012, poz. 1391). The value of this indicator for the analysis of the economic situation lies in the fact that it offers quick access to data, as well as the fact that the industrial sector is characterised by a significant “sensitivity” to stimuli of the economic fluctuations (Kasperowicz, 2012, pp. 80–87). Still, this does not mean that the Sold Production of Industry is a flawless indicator; its material scope – being limited to one sphere of economy – may be an example of a flaw here.

In the analyses conducted for the years 1995–2010 in Poland, R. Kasperowicz demonstrated that the fluctuations of the Sold Production of Industry indicator remained in a relevant, yet feeble relation to economy-related fluctuations in the consumption of electricity (Ibidem, 2012, p. 88). However, in his in-depth research R. Kasperowicz analysed the

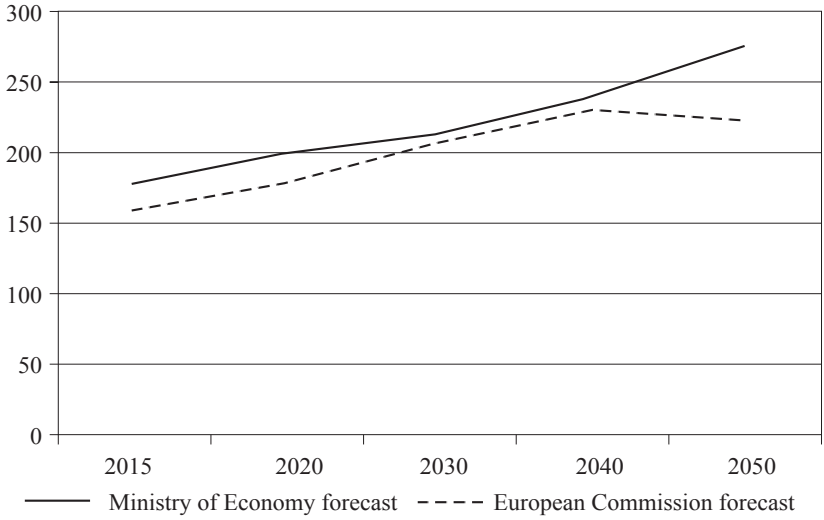
component elements of electricity consumption, reckoning among these the following: (1) electricity consumption by industry, and (2) electricity consumption by households and farms. In the methodology adopted by the author, it was demonstrated that industrial consumption is much stronger connected with the economic fluctuations in industry than electricity consumption by households and farms is. Electricity consumption by industry is therefore an indicator that anticipates economic fluctuations in the whole of industry (by a period of one quarter in research). Furthermore, the above-mentioned relationship is positive, which means that an increase in electricity consumption results in an upswing in the economy. As regards electricity consumption by households and farms, it must be pointed out that it was delayed in relation to cyclical economic fluctuations (by a period of four quarters in research) (Ibidem, 2012, pp. 89–90).

While forecasting the demand for electricity, it is important to note variables anticipating cyclical changes in electricity consumption. An in-depth analysis of these indicators offers a possibility of shaping both the electricity market and a state’s long-term energy policy. In the case of Poland’s energy policy (understood as an instrument of the executive), there is an observable and relatively weak level of forecasting analyses, which are not emphasised as a crucial element even in the *Energy Law* Act, and which as such could be of practical value (Dz. U. 1997, Nr 54 poz. 348, as amended; cf. Rosicki, 2015, pp. 51–62).

The document *“Poland’s Energy Policy Until 2050”* contains a series of forecasts concerned with a demand for, *inter alia*, primary energy, final energy and electricity as supplied via a variety of carriers. It is worth pointing out that forecasts of a demand for electricity, presented on the occasion of “state’s successive energy policies,” differ, which should not come as a surprise, because they are usually long-term forecasts. The nature of such forecasts is more or less concerned with prospective time horizons, which in turn entail considerable forecast errors (cf. Jegorow, 2005, pp. 59–62, 88–94).

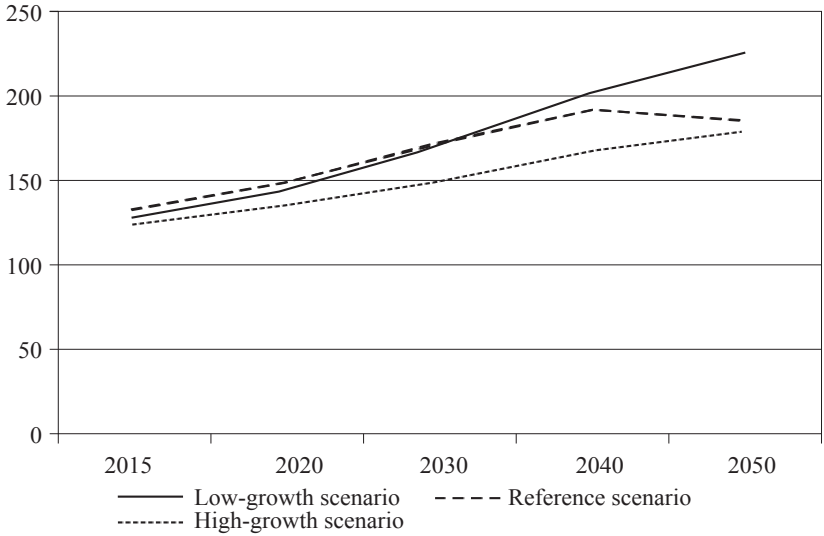
A distinguishing feature of the presented forecasts regarding electricity in Poland is a demonstration of the uptrend in generation and demand for this type of energy. The differences between these forecasts will be chiefly concerned with the kind of carriers that will play a greater or smaller role, as well as the level of demand for electricity or its generation [see Fig. 3 and 4] (cf. *Polityka energetyczna Polski do 2050 r.*, 2015).

Figure 3. Forecasts of electricity generation in Poland in 2015–2050 (TWh)



Source: Own work based on the data from the Ministry of Economy**.**

Figure 4. Forecasts of the final demand for electricity in Poland in 2015–2050 (TWh)



Source: Own work based on the data from the Ministry of Economy.

An increase in the demand for electricity was predicted in the forecasts by the Ministry of Economy, contained in the 2009 document entitled *“Poland’s Energy Policy Until 2030.”* As regards the final demand for electricity it was forecast that the period between 2006 and 2030 would see a 54% increase, whereas in the same period the gross demand for electricity was to rise by 44%. In the first case the assumption was that the level of demand for electricity would amount to 171.6 TWh, whereas in the second case the level was to amount to 217.4 TWh. Analysing and comparing the forecasts of 2009 and 2015 concerned with the final demand for electricity until 2030, it must be pointed out that in the second case the forecasts were revised and reduced by around 10 TWh – the demand for electricity of this kind was estimated at 161.4 TWh (cf. *Polityka energetyczna Polski do 2030 r.*, 2009; *Prognoza zapotrzebowania na paliwa i energię do 2030 r.*, 2009, pp. 14–16).

In 2015 the Ministry of Economy forecast an upswing in the economy in the long term and, by extension, an increase in the final demand for electricity. Such forecasts illustrate the three main scenarios of an increase in the demand for electricity, adopted by the Ministry of Economy – the low-growth scenario, the reference scenario and the high-growth scenario [see Fig. 4]. Within these assumptions it was demonstrated that there might be a rise in the final demand for electricity, depending on the scenario – between 20% and 33% in 2030, and between 44% and 75% in 2050 (cf. *Polityka energetyczna Polski do 2050 r.*, 2015).

4. A forecast of electricity prices

The analyses by the Ministry of Economy demonstrate that between the 1990s and 2013 there was a permanent rise in electricity prices. They rose by 3% for household consumers on the annual average, and by 4% for industrial consumers on the annual average. The electricity price for household consumers dropped in 2013–2014. There was a substantial increase in electricity prices for industrial consumers in 2007–2009, while the following years saw a slight decrease (*Polityka energetyczna Polski do 2050 r.*, 2015, p. 30).

Both the 2009 and 2015 forecasts presupposed a considerable rise in electricity prices. The main premise for the rise in electricity prices in

Poland is a necessity of transforming the energy sector, which is based on burning coal. An important issue is the condition of the energy infrastructure; for instance, nearly 59% of the electricity-generating turbines are more than 30 years old, and around 16% are more than 20 years old. That is why in the first place environmental requirements should be emphasised, that is a development of renewable energy generation, as well as costs of CO_2 emission permits as a determinant of the rising electricity prices in Poland. Furthermore, the transformation of the energy sector should also allow for the costs of the decline of the high level of energy intensity in the Polish economy (cf. *Polityka energetyczna Polski do 2050 r.*, 2015, p. 17; *Prognoza zapotrzebowania na paliwa i energię do 2030 r.*, 2009, pp. 17–18; *Wnioski z analiz prognostycznych na potrzeby Polityki energetycznej Polski do 2050 r.*, 2015).

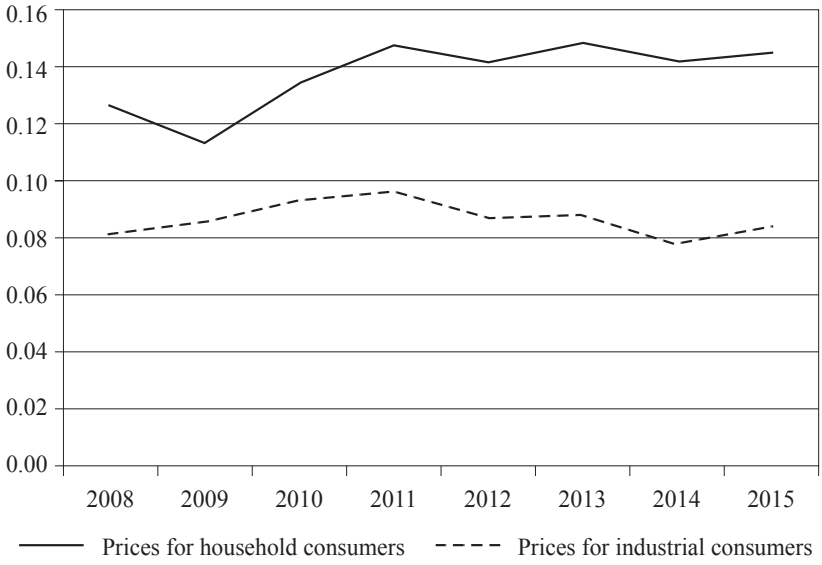
The 2009 forecasts predicted that a more substantial increase in electricity prices would take place around 2020, which would result from the obligation to purchase allowance for the emission of greenhouse gases from electricity production. In the subsequent years electricity prices are to be characterised by relative stability due to, inter alia, a development of the nuclear energy industry (*Prognoza zapotrzebowania na paliwa i energię do 2030 r.*, 2009, p. 17). Still, as of 2015 the adjustment of the failure of the timely development of the nuclear program in Poland, which points to a potential instability of prices, should be taken into account. Despite the projected stability of prices, it must be pointed out that in the case of industrial consumers, electricity prices are to increase by 107% by the year 2030, whereas for household consumers the increase will be of more than 77% (cf. *Rachunki za prąd...*, 2016; Sudak, 2016).

It is noteworthy that the Polish consumer of electricity continues to bear the financial brunt of the old coal-based technology, which is visible in the so-called transition charge which is an item on the electricity bill. This charge was in fact introduced to finance electricity-generating entities, that is in order to co-finance the transformation of the Polish energy sector. For instance, in 2016 the households that consumed more than 1200 kWh per year paid the so-called “transition charge” of about 1 euro. In the changes projected for 2017 the Polish government proposed a more than 100% rise in the charge for this group of household consumers. For other groups of household consumers the charges were to rise by about 90% depending on the consumption level (*Rachunki za prąd...*, 2016).

Of great significance for household consumers will be the action undertaken by energy companies and government officials, who will be trying to shift the costs of the energy sector transformation and of the introduction of the low-emission system onto consumers. It should be assumed that such activities will become intensified around 2020 in connection with the finalization of another stage of the ETS operation in the European Union, even though opinions vary on this point (cf. *Rynek energii...*, 2014, pp. 19–23).

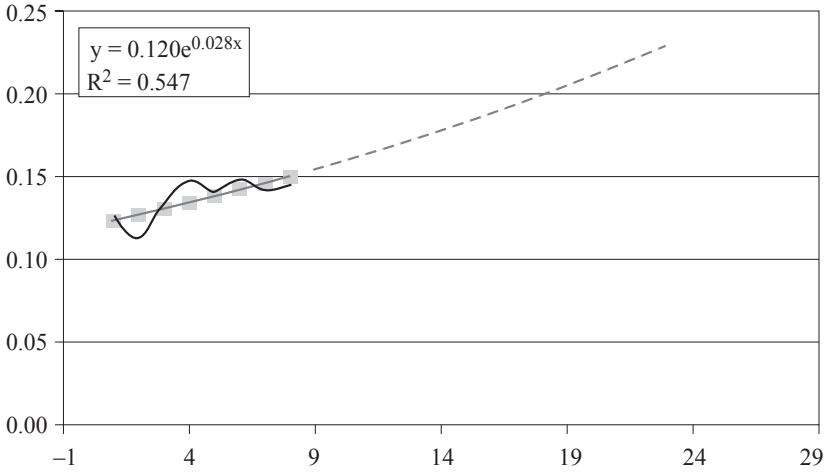
The text undertakes to forecast electricity prices in 2030 on the basis of a selection of methods for analysing the dynamics of economic phenomena. The analysis takes into account the electricity prices for the so-called medium-sized household and industrial consumers in Poland in 2008–2015 [see Fig. 5]. In the case of household consumers, the exponential model proved appropriate, whereas for the industrial consumers it was the linear one [see Fig. 6 and 7]. This results from the fact that in the former case the root mean square error was 0.00768 euro/kWh, whereas in the latter case the root mean square error was 0.00545 euro/kWh.

Figure 5. Electricity prices for medium-sized household and industrial consumers in Poland in 2008–2015 (EUR per kWh)



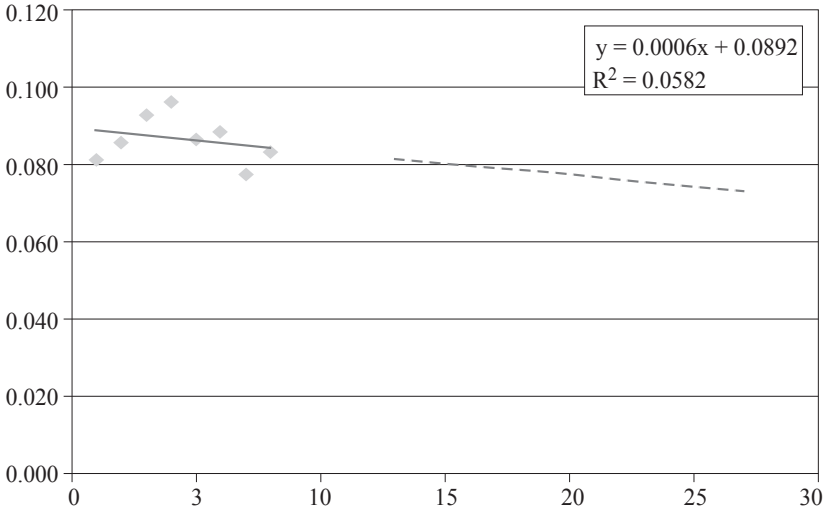
Source: Own work based on Eurostat data.

Figure 6. A diagram of real and compensatory values for the forecast of prices for medium-sized household consumers in Poland in 2030 [exponential model]



Source: Own work.

Figure 7. A diagram of real and compensatory values for the forecast of prices for medium-sized industrial consumers in Poland in 2030 [linear model]



Source: Own work.

On the basis of the adopted methodology, it must be pointed out that compared to 2015 the electricity price for medium-sized household consumers in Poland will rise by 59% by 2030. Taking into consideration the same methodology it can be pointed out that for the same type of consumers all over the European Union, the electricity prices will rise by 90% by 2030 (exponential model), and, for example, in Germany – by 112% (exponential model). At the same time disproportions in electricity prices should be taken into consideration – for Poland the price is expected to be 0.22 euro/kWh, whereas the average price for the whole of the European Union is expected to be 0.4 euro/kWh, and for Germany – 0.65 euro/kWh (cf. *Energy prices and costs report*, SWD/2014/20).

In the case of the forecasts of electricity prices for medium-sized industrial consumers, it must be pointed out that the situation is not as clear as in the case of medium-sized household consumers. Compared to 2015, the electricity price for medium-sized industrial consumers in Poland will decrease by 11% by 2030, whereas in the case of the whole of the European Union, it will increase by 0.7% (power model), and in Germany the prices will decrease by 29% (exponential model). At the same time disproportions in electricity prices should be taken into consideration – for Poland the price is projected to be 0.073 euro/kWh, whereas the mean price in the whole of the European Union is projected to be 0.094 euro/kWh, and for Germany – 0.059 euro/kWh (cf. Ibidem).

Conclusion

The main objective of the present text is to present a synthetic analysis of selected issues concerned with the electricity market in Poland. Within the analysis of the changes in the period of 2008–2015 emphasis was laid on the trends in electricity generation and demand, while taking into account their relationship with the fluctuating level of the gross domestic product. Besides, the main processes taking place in the exchange trading in electricity were pointed to. Next, the demand for electricity up to 2030 was presented, whereby greater attention was drawn to the relationship between the increase in electricity consumption and the level of the gross domestic product and the value of sold production of industry. Another presented forecast was concerned with electricity prices; it included the main determinants of relevance for the drop or rise in prices in the future.

The forecast was supplemented with a presentation of the results obtained with the aid of selected methods for analysing the dynamics of economic phenomena.

Given the need to elaborate the research problem, the text features research questions related to the following conclusions:

(1) ***Is it possible to point out any special characteristics of the structure and workings of the electricity market in Poland?***

The Polish energy market is closely connected with two carriers, that is black coal and lignite coal – the total installed capacity on the National Power Grids for commercial energy generation based on black and lignite coal is 71%. The structure of renewable energy sources is dominated by biomass burning. Poland’s peculiar energy structure determines specific problems for economy. First and foremost, one should point to: (1) the costs of the transformation of the high-emission sector of electricity generation, (2) the costs of the transformation of the old coal-based technology, (3) the costs of the introduction of renewable energy sources. In the future, the aforesaid costs will affect electricity prices, which in turn will give rise to a decline of the competitiveness of the Polish economy. Furthermore, given the median wages of household consumers, a substantial increase in the costs of living is to be expected. A crucial factor that might prevent the rise in electricity prices is market liberalization and consolidation of transmission infrastructure, including cross-border infrastructure, but such changes might also have a negative effect on the Polish energy sector.

(2) ***Is it possible to point out a characteristic trend in the changes in demand for electricity in Poland?***

All the presented forecasts of demand for electricity predict a rise up to 2030. The consequence will be a need to develop the installed capacity in the commercial energy industry and in the renewable energy industry. Also, the rise in consumption will necessitate a development of transmission and distribution infrastructure as well as larger outlays on their renovation, since currently around 16% of the transmission infrastructure is more than 30 years old, and 24% of it is more than 40 years old.

Forecasts of the increase in the demand for electricity are connected with the forecasts of Poland’s economic development. This connection can also be seen in the case of the analysis of the 2008–2015 data, which

have been presented in the text. It must be pointed out that the demand for electricity will continue rising, and its dynamics will depend on the country’s economic situation.

(3) ***Is it possible to point out a characteristic trend in the changes in electricity prices in Poland?***

It should be assumed that electricity prices in Poland will continue rising, which is borne out by both the qualitative and quantitative analysis. The arguments for the rise in electricity prices have already been made in some parts of the conclusion – in general they can be related to the costs of the transformation of the Polish energy sector. The issue concerned with possible action that might be undertaken to avoid that trend is now debatable.

As regards the conclusions drawn from own research into the application of selected methods for analysing the dynamics of economic phenomena, it must be stressed that electricity prices in Poland for medium-sized household consumers will rise by 59% by 2030, whereas electricity prices for industrial consumers will drop by 11% by 2030. The increase in electricity prices will be conditional upon the determinants mentioned in the conclusion; furthermore, there is another factor that will considerably affect the pricing trends, that is both the technical and legal scope of the construction of the homogeneous energy market in the European Union.

It is also worth mentioning that in connection with the conducted analysis it is to be assumed that considerable disproportions in electricity prices will continue in the European Union in 2030 as well. For household consumers in Poland the projected price is to be 0.22 euro/kWh, whereas the average price for the whole of the European Union is to be 0.4 euro/kWh, and for Germany – 0.65 euro/kWh. For medium-sized industrial consumers in Poland, the projected price is to be 0.073 euro/kWh, whereas the average price for the whole of the European Union is to be 0.094 euro/kWh, and for Germany – 0.059 euro/kWh.

The text presents only a selection of issues concerned with: (1) the operation of the electricity market in Poland, (2) forecasts of the demand for electricity, and (3) forecasts of electricity prices. Hence, it must be emphasised that there is a need for further research, which would explore particular topic groups, and address other determinants affecting the presented forecasts of phenomena and/or employ more advanced forecasting methods.

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Rynek energii elektrycznej w Polsce. Prognozy zapotrzebowania na energię elektryczną i prognozy cen energii elektrycznej

Streszczenie

Przedmiotem analizy w tekście jest charakterystyka funkcjonowania rynku energii elektrycznej w Polsce. Bardziej szczegółowej analizie poddano lata 2008–2015; położono w niej nacisk na trendy w produkcji i zapotrzebowaniu na energię elektryczną, przy uwzględnieniu rozwoju gospodarczego kraju. Ponadto w tekście uwzględniono prognozy w zakresie zapotrzebowania na energię elektryczną na 2030 r. i prognozy cen na energię elektryczną. W przypadku prognoz cen na energię elektryczną zaprezentowano zarówno prognozę jakościową, jak i ilościową. W ostatnim przypadku zaprezentowano wyniki z własnej prognozy, które uzyskano za pomocą zastosowanych wybranych metod analizy dynamiki zjawisk ekonomicznych (model wykładniczy i model liniowy trendu). W związku z koniecznością uszczegółowienia problemu badawczego w tekście przedstawiono następujące pytania badawcze: (1) Czy można wykazać specyficzne cechy, które charakteryzowałyby strukturę i funkcjonowanie rynku energii elektrycznej w Polsce? (2) Czy można wskazać charakterystyczny trend w zakresie zmian zapotrzebowania na energię elektryczną w Polsce? (3) Czy można wskazać charakterystyczny trend w zakresie zmian cen energii elektrycznej w Polsce?

Słowa kluczowe: energia elektryczna, rynek energii elektrycznej, sektor energii elektrycznej, prognozy zapotrzebowania na energię elektryczną, prognozy cen energii elektrycznej

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