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Economic dimension of Polish energy security

JEL Classification: *Q40; Q41;Q48*

Keywords: *energy security; Poland; energy policy; energy resources*

Abstract
Research background: Stable and reliable access to a variety of energy carriers is undoubtedly a basis for the development of any economy. Therefore, the primary condition for the security of the state and its citizens is to ensure the essential minimum of energy on its territory. We can observe, however, an increasing dependence of the Polish energy sector on external sources.
Purpose of the article: The aim of this paper is to examine and evaluate the economic aspects of the Polish energy security considering the fact of growing de-pendency on foreign supplies of energy carriers.
Methods: In this paper we analyze the Polish energy security using several indicators: fuel/price efficiency ratio, energy intensity of the economy and Herfindahl-Hirschman rate of market concentration. For calculations we use statistical data provided by Energy Market Agency publications, including "Energy Situation in Poland" covering the years of 2000–2015.
Findings & Value added: On the one hand, the Polish energy security depends on its internal conditions and resources — in this context, the available resources of coal and lignite play an extremely positive role because they provide access to a reliable source of energy. On the other hand, Poland is becoming dependent on external commitments that restrict the free use of domestic resources, thus lowering the energy security of the country, speaking in particular of oil and natural gas resources. The analysis carried out in this paper will allow to evaluate the effectiveness of using various energy carriers with respect to their price, market structure and geopolitical conditions.

Introduction

Poland is a country trying to catch up with the level of economic development of its neighboring countries from Western Europe, and as such it also faces serious dilemmas over energy issues. Economic development will increase the demand for energy, which will need to be produced or imported. Poland's energy policy is, however, not autonomous due to its membership in the European Union since 2004. This membership has caused measurable economic and social advances, but it has also obliged Poland to adopt numerous EU regulations, including those of energy issues (Maltby, 2013). The EU aims to reduce the harmful emissions causing environment pollution, to improve the efficiency of energy use and production and to increase the share of renewable energy sources in the overall energy balance. These policies translate into high costs of modernization for Poland's energy production sector as well as into reduction in consumption of solid fuels (Chevalier, 2009, p. 16; Belyi, 2015, p. 9). All this challenges Poland's energy security level especially since the goals of the EU's energy policy do not correspond with the rationale behind Polish energy policy. Turbulent global energy markets also add to this standpoint.

The aim of this paper is thus to analyze Poland's position in the above-sketched energy-related configuration of external and internal factors. This will allow to shed light on the changing level of Polish energy security, as well as on the possibility of pursuing sovereign policy of maximizing energy security while within the European Union. These issues seem to directly contribute to the future development of the country in both economic and ecological dimensions.

Research methodology

The economic analysis of energy security should highlight the effectiveness of using particular energy sources, namely which sources should be used to produce energy, yet taking into consideration the financial capacity of the society and the development level of the whole economy. We should therefore focus on energy price efficiency, so that it finds acceptance among the society, and on energy efficiency, which relates to the issues of fuel and energy demand reduction, which in turn may increase the level of energy security and reduce its negative impact on environment. Additionally, we pay attention to the competitiveness of fuel and energy markets which indirectly affects the price of energy. Our analysis is therefore based on three

indicators, including fuel/price efficiency ratio, energy intensity of the economy and Herfindahl-Hirschman market concentration rate.

The research is based on literature studies as well as on internal and statistical materials of various national institutions of energy sector including: Energy Market Agency, Polish Oil and Gas Industry, Energy Regulatory Authority, Central Statistical Office and the Ministry of Economy. Internet resources (including Eurostat and Central Statistical Office of Poland statistics and other source materials included therein) were also used. Many calculations were carried out using data from the Energy Market Agency published quarterly in newsletters entitled "The Energy Situation in Poland" covering the years of 2000–2015.

Economic indicators of energy security

The fuel/price efficiency ratio expresses the price level of fuel that has to be covered by a society in a given period of time. It therefore shows the structure of real public expenditure on imported fuel and the change in fuel prices over a given period. The value of the indicator is expressed in euro and should be as low as possible. The fuel/price efficiency ratio is expressed by the following formula:

$$ECP = \sum_{j=1}^{m} C_j \cdot Z_{kj}$$

where:
C_j– energy price (imported) [EUR/million t],
Z_{Kj}– national total energy consumption in a given year.

One of the basic synthetic indicators describing an economy of a state is the energy intensity ratio, which refers to the amount of energy consumed for producing the country's GDP. We can differentiate between direct and cumulative energy consumption here. The former relates to the consumption of energy carriers supplied directly to manufacturing processes, whereas the latter covers the total amount of primary energy used in all processes leading to the production of goods and services (Wąsikiewicz-Rusnak, 2005, p. 26; Mikucki, 2005, p. 3).The less energy required to generate the country's GDP, the easier it is to ensure energy security in a given country or economy. It can therefore be presumed that the indicator points to an improvement in energy efficiency if it shows a downward trend, which would mean a lower price or a lower cost of converting energy to GDP. In

turn, high and/or increasing energy intensity will indicate a high price or cost of energy conversion to GDP (*Energy intensity*…, 2008, p. 33). The energy intensity index is expressed as:

$$e = \frac{E}{B}$$

where:
e – energy intensity of the economy,
E – annual energy consumption in the economy,
B – gross domestic product.

Third indicator we are using in this research is the rate of market concentration, which is understood as the 'degree of unequal distribution of the total sum of the measurable element of the variable between units of the surveyed population' (Luszniewicz & Słaby, 2003, p. 59; Mesjasz-Lech 2009, pp. 152–154). According to the strength of concentration, we can distinguish two cases. The first refers to the complete absence of concentration, which means that there is a uniform distribution of the variable among the population in question. The second case concerns the situation in which the distribution is uneven indicating a possibility of market domination and consumer welfare loss.

Microeconomic market research indicates that high concentration of producers most often results in weaker competition. The result of high market concentration on energy markets may translate into high prices of energy products offered, and thus higher profitability of their suppliers, which however creates suboptimal position for consumers of energy. The most commonly used measure of concentration on markets is the Herfindahl-Hirschman index (HHI), which was also employed in this analysis. It is defined as the sum of squared shares in the market including all the firms participating in a particular market. The HHI formula is denoted thus as:

$$HHI = \sum_{i=1}^{n} u_i^2$$

where:
ui– market share of all the producers participating in the market,
i – business / seller index,
n – number of producers / sellers on the market.

Interpretation of the results is as follows: if the value is close to 0, then this will be a highly competitive market structure, and if the value is close to 10000, then the market is a monopolistic formation. The value of the HHI index is influenced by the number of enterprises operating on the energy market and the uneven distribution of market shares. If the number of companies is given, the HHI index will show higher results with rising divergence of market shares (Kamiński, 2009, p. 233)[1].

Data analysis and discussion

Price/fuel efficiency index

The formation of prices at the energy resources markets is of crucial importance for Poland and its energy security level, due to the fact that the country's economy is highly dependent on the imports of crude oil and natural gas. As shown in Figure 1, the largest increase in expenditure on oil and gas purchases occurred between 2004 and 2008 and between 2010 and 2012. Such a sharp price increase occurred due to tense conditions on international fuel and energy markets as well as speculative capital movements seeking the alternative for the crisis-laden real estate markets (Poland 2015, p. 85). The sharp drop in spending on purchasing raw materials that happened in 2009 was caused by prices' decline. Already at the beginning of 2008 the prices began to fall as an effect of the downturn of global economy and this situation persisted through 2009. We can witness another fall in spending since 2012, but this time the reasons of low prices may be attributed to the policy pursued by the Organization of Petroleum Exporting Countries (OPEC), which did not decide to delimit the supply despite the surplus of crude oil on world markets (*Causes…*, 2016).

As shown in Table 1, the expenditure on crude oil purchases decreased by around 34% in 2009 down to 6,3 billion EUR. The main reason for this change was the fact that its price dropped considerably from EUR 459 per tonne in 2008 to EUR 312 per tonne in 2009. The import volume decreased in the same period by 3,3% only to 20,1 mln tons. In the case of natural gas, the drop in prices was more moderate — the cost of purchasing 1000 m^3 of gas fell from 316 EUR in 2008 to 269 EUR in 2009, that makes 15%

[1] In more detail, the result below 750 indicates low market concentration, between 750 and 1800 moderate concentration, between 1800 and 5000 high concentration and above 5000 very high concentration. This classification is in line with the US Department of Justice and the Federal Trade Commission according to which HHI above 1800 is interpreted as a violation of competition rules (Implementation, 2015 p. 15; Kamiński 2009, p. 234).

fall in prices. The decrease in import volume was, in contrast, much higher and reached 11%. In effect, the crisis 2008–2009 and the related price collapse only temporarily halted the long-term trajectory of increased spending on these two energy carriers. In the following years, the expenses rose again, although their pre-crisis level in 2008 was exceeded only in 2011. It is worth noting that between 2010 and 2012 the price of crude oil imported to Poland increased by over 98% and of gas by 37%. The period 2013–2014 brought small decreases in prices that were far from offsetting the recent hikes. As for the price/fuel efficiency ratio it rose sharply by 11,9mln EUR between 2002 and 2014. The fall in prices of 2013–2014 allowed for a slight improvement of the ratio which fell from 15,4 mln EUR by 3,5 mln EUR. In comparison, a similar movement in prices and import volumes in 2009 caused fall in the ratio by 4 mln EUR, although it proved highly unsustainable. The efficiency of Polish fuel imports thus shows eminently adverse tendency and is very sensitive on the developments on international markets.

In 2012 there was a record high level of imports of crude oil and natural gas, amounting to over EUR 19 billion, which was about 20% higher than the year before (see Table 1). A similar situation occurred in 2008, when import spending on the same resources reached almost 13 bln EUR, which is ca. 34% higher than the previous year. Such increases were mainly due to price dynamics rather than to the increase in the volume of imports (see Figure 2).The rise of prices of energy resources in international markets was an effect of unstable political and economic situation of the exporting countries. Markets for energy resources have been lately characterized by high volatility and significant price fluctuations which resulted in an increased uncertainty at the supply side for their importers. As for Poland, the level of price effectiveness is influenced mainly by the formation of prices of crude oil and natural gas, not by the level of demand for the raw materials.

Energy intensity of the economy

The efficiency of energy use of a given economy is an important factor influencing inter alia costs of production, profits of enterprises, and the social cost of living. All these factors are crucial for long-term growth of any economy. Poland is, moreover, obliged to improve its energy efficiency measures respecting international regulations concerning climate and environment protection. The relation of energy consumption to the corresponding volume of production can be shown by the energy intensity index of national economy (Kasman & Duman, 2015, p. 97). Figure 3 shows the

energy consumption data for Poland's GDP expressed in kilograms of oil equivalent (kgoe) per 1000 EUR (base year 2000). Declining primary and final energy intensity of GDP is a result of relatively higher increase of national income compared to the increase in energy consumption (see Table 2). Since 2000 there has been a gradual improvement in the energy intensity of the Polish economy by over 2% per year. The only exception from this trend was 2010, when the energy intensity slightly worsened. In the years 2005–2009 the decrease in energy intensity amounted to almost 4% in the case of primary energy consumption and 3% in the case of final energy consumption. In the years 2010–2014 the corresponding values were 3% and 2%. The greatest improvement in energy intensity took place between 2007 and 2009. It is worth noting that in the 1990s the average energy intensity ratio was 0,698 kgoe/EUR2000 for primary energy consumption and 0,421 kgoe/EUR2000 for final energy consumption (*Poland…*, 2015, p. 21). The reason behind such high values was low energy prices, which did not generate incentive for more efficient use of energy. It was the increase in energy prices accompanied by efforts to respect climate and energy package (like the declared aim of improving energy intensity by 20% until 2020) and the Directive 2006/32/EC on energy end-use efficiency and energy services that had positive combined effect on energy saving contributing to the improved energy intensity index in Poland (Filipović *et al.*, 2015, p. 548).

The Herfindahl-Hirschman index

The improvement of competitiveness of electricity markets is often considered one of basic goals of state's energy policies. It is supposed to translate into cheaper energy access for consumers and manufacturers as well as increased security of energy supply. In the EU this issue is regulated by the Directive 2009/72/EC concerning common rules for the internal market in electricity. The level of competitiveness in this area and market domination can be assessed using the Herfindahl-Hirschman index.

Figure 4 shows the development of the HHI for the electricity sector in Poland. Due to the lack of data from 2000 to 2002, the HHI has been calculated for the 2003–2014 time period. In 2003 the index reached 1189, indicating that the market at that time could be classified as moderately concentrated. HHI based on the actual electrical power capacity was higher by almost 140. The consolidation carried out in 2004 resulted in a significant increase in the HHI based on achievable capacity to over 1700 and even higher for the actual production index to over 2100. The significant impact on the growth of the HHI on the electricity market was the establishment of

the BOT Mining and Power Engineering SA. In addition, the share of the three largest energy producers increased to 62,1% (see table 3). As a result, the Polish energy sector became highly concentrated, according to HHI measure. The year 2005 did not bring any significant changes.

Starting with 2006 significant changes on the electricity market were implemented concerning mainly reorganization of the market[2]. The initial fall in HHI started to rose quickly. The number of producers with a share of more than 5% decreased, whereas the share of the three largest producers after consolidation was almost 60%. With a one-year fall in concentration measure in 2008, the following years showed similar results. In 2009 the HHI measure was close to 2000, indicating high market concentration with respect to the actual power production. This borderline was exceeded slightly in 2011 and 2012.The three largest producers (PGE, Tauron and EDF) hold over half the actual production capacity and were responsible for almost two-thirds of Poland's energy production (*Bulletin*, 2011, p.15). Since 2012 we have been witnessing a downward trend in HHI and the share of three biggest energy producers in the country. In 2015 HHI was the lowest since 2008 indicating moderate concentration of the market. The fall of concentration levels occurred mainly due to the increasing share of energy production from renewable resources (mainly wind farms) (Alper, Oguz 2016, p. 953).

The electricity production market in Poland does not meet the characteristics of a competitive market. Analysis of the concentration index showed that this market remains highly concentrated due to the existence of vertically consolidated capital groups. In this context, it is worth noting that according to the president of Energy Regulatory Office in Poland despite efforts to increase the competitiveness of the electricity market in the country, the consolidation of energy companies, which are state-owned companies, and in particular the creation of four large vertically integrated energy groups, resulted in the use of dominant positions and activities incompatible with competitive markets (*Announcement*, 2008).

Conclusions

Poland's energy security is highly dependent on prices of raw energy resources and the efficiency of energy use in the economy. High dependency on imports of crude oil and natural gas led to a rapid increase in import

[2]According to the government document "Program for Energy" four energy companies were established in 2007 which covered most of Polish territory. Those companies were: Polish Energy Group SA (PGE), Tauron Polish Energy SA, ENERGY SA and ENEA SA.

expenditure on those energy carriers, which culminated in 2008 and 2012. The prices rose not only due to an increase in the global demand, but especially due to the unstable political and economic situation of resource-rich states.

Both these issues remain, however, entirely beyond the Polish sphere of influence. Poland is clearly a price-taker country here. From this point of view, energy policy based on coal is favorable for keeping the high level of energy security. It is worth noting that the perceived level of energy security of a country changes with time *and* with the rotation of political leaders at helm. This suggests that the degree to which resource dependence influences national security concerns among policy makers also evolves with time which translates into various policy agendas and embraced solutions (Hughes & Lipscy 2013, p. 455). Poland's situation is no exception here, but some solutions seem to be quite universal in this regard.

One way to reduce expenditure on imported raw materials is to improve the energy intensity of the economy. The measures taken in this regard must be in line with national security and energy efficiency requirements (Filipović *et al.*, 2015, p. 547). Appropriate steps were taken in this area with the introduction of Energy Efficiency Act in April 2011 (*Ustawa z dnia 15 kwietnia 2011*…), which introduced a system of white certificates. Nevertheless, since 2000 we could have witnessed gradual (2% per year on average) improvement of energy efficiency indicator, which also contributed to rising energy security of the country. The third indicator put under scrutiny here showed that the Polish electricity market does not meet the characteristics of a highly competitive market. HHI pointed to high concentration of energy producers on the supply side which puts consumer welfare at threat, and may contribute to suboptimal energy supply. Despite the efforts of regulators to increase the competitiveness of this market, it has changed only slightly since 2003. The economic dimension of Poland's energy security indicates clearly that more effective steps need to be taken in order to guarantee a higher level of energy supply safety.

The analysis of Poland's energy security has shown that its level is actually quite high, although at present it is possible to observe the process of modernization of the Polish energy industry due to the country's developmental challenges and the EU requirements, which unfortunately causes a gradual reduction of this level of security. Poland must therefore be able to set and achieve energy goals in a timely manner, while strengthening its position in the international network of interests and connections in the energy sector.

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Annex

Table 1. Impact of rising energy prices on import spending in Poland in 2002–2014 (base year 2002)

		2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
crude oil														
volume of imports (thou. tons)		17717	17028	17316	17912	19813	20885	20787	20098	22688	23792	34633	23346	23713
avg yearly price of importing 1 ton (EUR)		178	170	195	292	351	364	459	312	428	574	618	587	524
import expenditure (mln EUR)		3154	2895	3377	5230	6954	7602	9541	6271	9710	12657	15223	13704	12426
change In import expenditure (mln EUR)	altogether	-	259	223	2077	3801	44499	6388	3117	6556	10503	12069	10551	9272
	due to volume change	-	-123	-71	35	373	564	546	424	884	1081	1231	1002	1067
	due to price change	-	-136	294	2042	3428	3885	5841	2693	5672	9422	10838	9549	8205
natural gas														
volume of imports (mln m^3)		7775	8721	9445	9919	10354	9598	10619	9435	10325	11174	11605	11818	11182
avg yearly price of importing 1000 m^3 (EUR)		113	118	112	157	213	213	316	269	276	324	391	341	317
import expenditure (mln EUR)		879	1029	1058	1557	2205	2044	3356	2588	2850	3620	4283	4030	3545
change In import expenditure (mln EUR)	altogether	-	151	179	679	1327	1166	2477	1659	1971	2741	3659	3151	2666
	due to volume change	-	107	189	242	291	206	321	188	288	384	433	457	385
	due to price change	-	44	-9	436	1035	960	2156	1472	1683	2357	3226	2694	2281

Table 1. Continued

		2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
crude oil and natural gas altogether														
import expenditure (mln EUR)		4033	3924	4435	6787	9159	9646	12897	8859	12560	16277	19506	17734	15971
change In import expenditure (mln EUR)	altogether	-	-108	402	2755	5128	5614	8865	4776	8527	13244	15728	13702	11938
	due to volume change	-	-16	117	277	665	770	868	611	1172	1465	1664	1459	1452
	due to price change	-	-93	285	2478	4463	4844	7997	4165	7355	11779	14064	12243	10486

Source: own summary based on: *Poland*… (2010, p. 57); *Poland.*.. (2015, p. 90).

Table 2. Consumption of primary energy and gross domestic product in Poland in 2000–2015

	2000	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**
Domestic use of primary energy (PJ)	3754	3866	3717	3869	3843	3820	4046	4011	4051	3824	4088	4163	3963	3949	3933	3984
GDP (constant prices, bln PLN)	744	779	808	843	924	983	1060	1176	1275	1343	1415	1566	1629	1656	1719	1798

Source: Study based on data: Situation of Energy in Poland; Department of National Accounts, Central Statistical Office. Retrieved from http://www.stat.gov.pl/gus/5840_4403_PLK_HTML.htm (17.01.2012); Verified estimate of gross domestic product for years 2010–2015. Warsaw: GUS. Retrieved form http://stat.gov.pl/obszary-tematyczne/rachunki-narodowe/roczne-rachunki-narodowe/zweryfikowany-szacunek-produktu-krajowego-brutto-za-lata-2010-2015,9,2.html (19.03.2017).

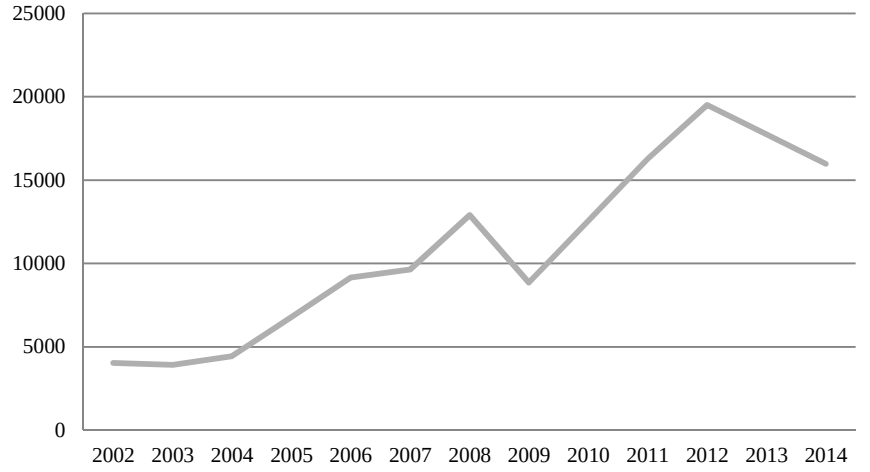
Table 3. Concentration of electricity production in Poland in 2003–2015

		2003^	2004* ^	2005* ^	2006 &	2007 &	2008 &	2009 $	2010 $	2011 $	2012 $	2013 $	2014 $	2015 $
Number of energy producers having >5% share In the market (according to achievable capacity)		9	7	7	6	5	4	5	5	5	5	5	5	5
Share of three biggest energy producers (according to achievable capacity, in %)		49,0	62,1	62,6	52,4	58,0	53,1	59,0	58,1	58,4	56,7	55,4	53,6	52,2
HHI	according to achie-vable capacity	1189,1	1748,6	1779,3	1002,9	1312,7	1363,3	1676,4	1620,4	1677,7	1587,9	1522,3	1441	1366
	according to actualcapacity	1328,1	2138,7	2250,0	1366,6	1710,0	1593,9	1950,0	1834,8	2098,8	2096	1991,7	1823,1	1762,9

Note:
* after establishing BOT Mining and Power Engineering S.A.,
^ for ten most important electricity producers,
&for all entities active in the manufacturing sector, which are subject to statistical obligation,
$ for all entities active in the manufacturing sector, which are subject to statutory obligations, including installed capacity and production of wind and water sources,
** gross electricity production.

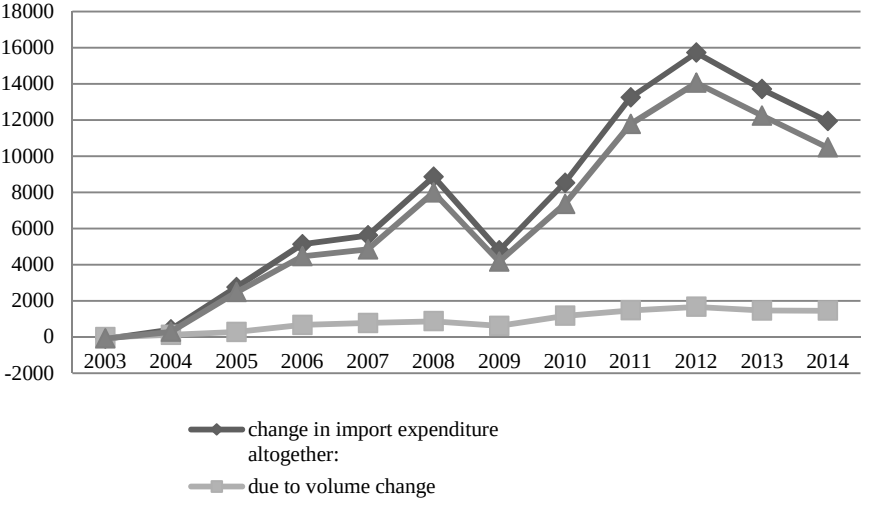
Source: own calculations based on: Bulletin of the Energy Regulatory Office no. 47, 53, 65, 84, 88 and 96.

Figure 1. Price/fuel efficiency ratio in Poland in 2002–2014 (in EUR million)



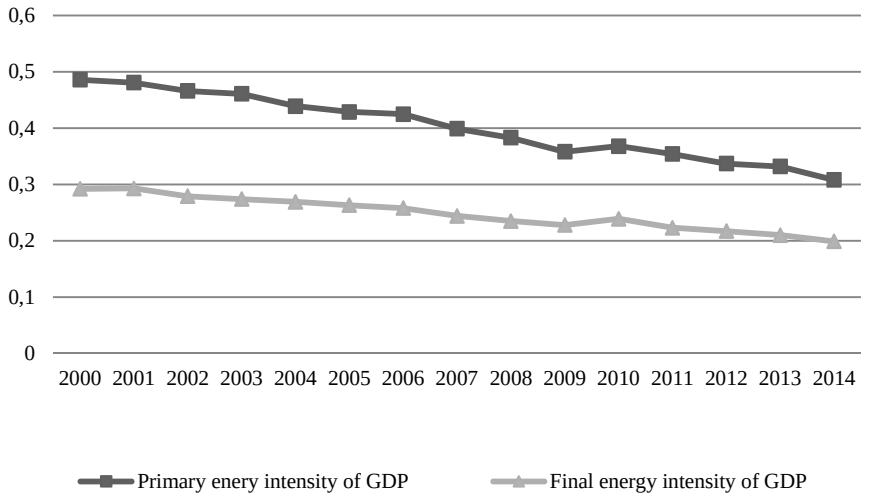
Source: own calculations based on: *Poland…* (2010, p. 57) and *Poland…* (2015, p. 90).

Figure 2. Impact of rising oil and gas prices on import spending in Poland in 2003–2014 (in EUR million, base year 2002)



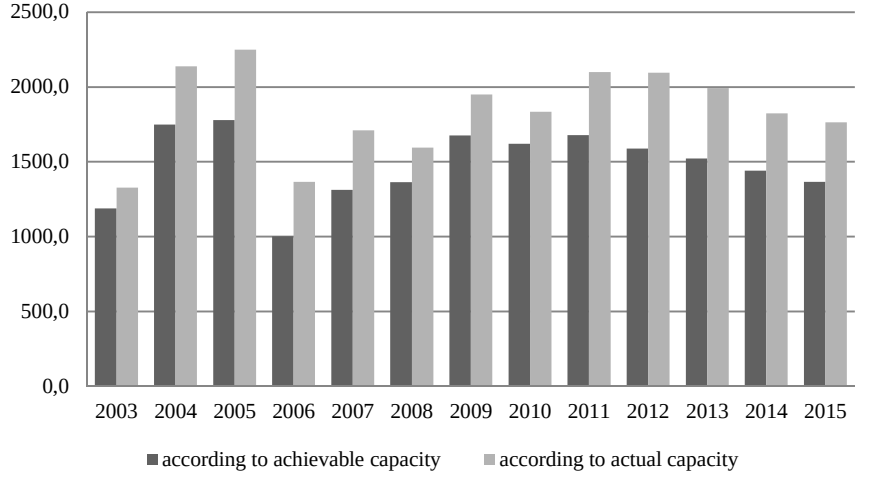
Source: own calculations based on: *Poland…* (2010, p. 57) and *Poland…* (2015, p. 90).

Figure 3. Changes in the energy intensity index of GDP in Poland in 2000–2014 (kgoe / EUR2000)



Source: own calculations based on: *Energy efficiency*… (2011) and *Energy efficiency*… (2016, p. 58-59).

Figure 4. HHI index of the electricity sector in Poland in 2003–2015



Source: own calculations based on the Bulletin of the Energy Regulatory Office no. 47, 53, 65, 84, 88 and 96.