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**THE MODERNIZATION OF THE ENERGY SECTOR IN POLAND VS. POLAND'S ENERGY SECURITY****MODERNIZACJA SEKTORA ENERGII W POLSCE A BEZPIECZEŃSTWO ENERGETYCZNE POLSKI**

The paper discusses the essence of Poland's energy security, decisive factors for its attainment and the structure of primary energy sources of the country. It describes the main problem areas in functioning of the energy sector in Poland, as well as the conditions for its modernization. The issues of increasing the natural gas share in the country's structure of primary energy sources and a construction of the first nuclear power plant in Poland have been particularly emphasised. The paper stresses that without modernizing actions it will be impossible for Poland to fulfil international obligations concerning changes in the functioning of the energy sector.

The study, analysing the conditions for increasing the role of natural gas in Poland, points at the necessity to expand the gas infrastructure, to increase a scale of gas production from domestic deposits and to complete liberalization of the energy industry. It also emphasises that a potential delay in the construction of the country's first nuclear power plant may limit competitiveness of the economy.

**Keywords:** modernization, energy market, liberalization, nuclear energy, natural gas

W artykule omówiono istotę bezpieczeństwa energetycznego Polski, czynniki decydujące o jego osiągnięciu oraz strukturę źródeł energii pierwotnej w kraju. Przedstawiono główne problemy funkcjonowania sektora energii w Polsce oraz uwarunkowania jego modernizacji. Szczególny nacisk położono na kwestię zwiększenia udziału gazu ziemnego w krajowej strukturze źródeł energii pierwotnej oraz budowy pierwszej elektrowni atomowej w Polsce. Podkreślono, że bez podjęcia działań modernizacyjnych niemożliwe będzie wypełnienie zobowiązań międzynarodowych Polski dotyczących zmian w sposobie funkcjonowania sektora energii.

Analizując uwarunkowania zwiększenia znaczenia gazu ziemnego w Polsce, wskazano na konieczność rozbudowy infrastruktury gazowniczej, zwiększenia skali wydobycia gazu ziemnego z krajowych złóż oraz na kwestię dokończenia liberalizacji branży. Podkreślono, że dla zwiększenia bezpieczeństwa energetycznego kraju konieczne jest także konsekwentne prowadzenie dalszych działań na rzecz rozwoju alternatywnych technologii energetycznych, co pozwoli na skorzystanie z ewentualnych pojawiających się

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szans dotyczących różnych opcji. Szczególne miejsce w tych działaniach powinna mieć budowa w Polsce pierwszej elektrowni atomowej. Realizacja tej inwestycji pozwoli na pozyskanie taniej i czystej ekologicznie energii elektrycznej. Istotne jest także odnotowywane znaczące poparcie społeczne dla realizacji tej inwestycji. Podkreślono, że ewentualna zwłoka w pracach służących budowie pierwszej elektrowni atomowej w kraju może przyczynić się do ograniczenia konkurencyjności gospodarki.

Ponadto wskazano, że konieczne będą także działania o charakterze edukacyjnym, które uświadomią społeczeństwu skalę wyzwań, jakie stoją przed krajowym sektorem energii, oraz wskażą wpływ upowszechniania konkurencyjnych cenowo źródeł energii na sytuację krajowej gospodarki oraz na utrzymanie i tworzenie miejsc pracy. Działania te przyczynią się do uzyskania poparcia wszystkich uczestników rynku energii dla podejmowania działań na rzecz takiego kształtowania struktury źródeł energii pierwotnej, aby możliwe było uzyskiwanie jak najniższych kosztów wytwarzania energii elektrycznej oraz jednocześnie minimalizowanie konsekwencji ekologicznych prowadzenia gospodarki energetycznej.

**Słowa kluczowe:** modernizacja, rynek energii, liberalizacja, energia atomowa, gaz ziemny

## 1. Introduction

The security of energy supplies is currently one of the key requirements for the functioning of a nation, hence various entities are interested in this issue. Traditionally, a definition of energy security is related mainly to the matter of reliability of energy supplies and having a safe reserve of production capacities. Nowadays, as a result of a transition in the global energy policy concerning liberalization of the energy sector and an increase in the importance of climate protection, energy security needs to involve, among others, a reduction of air pollution, liberalization and integration of the energy market, fulfilment of the country's international obligations in this regard, as well as a reduction of energy prices (Żmijewski, 2007; Johnson & Boersma, 2013). To ensure energy security, it means to take into consideration external and internal conditions for pursuing an energy policy of a country (Żmijewski, 2011; Staško & Kaliski, 2006).

It is particularly challenging for the energy sector in Poland to ensure energy security, as it is facing the need to make its coal-based structure of primary energy sources more flexible, currently being an exception among the remaining EU countries, as well as to complete the liberalization of the energy sector. Without changes in the energy policy, it will be impossible to fulfil the aims of the climate and energy package as well as the third liberalization package. Maintaining the current status is also in contradiction with the public expectations to live in conditions as close to the standard of living in economically developed countries as possible.

One of the key conditions for effective modernization of the energy sector is to design and consistently implement a long-term, at least 25-year plan for a transition in the sector (Rotmans et al., 2001). It requires a consensus of all political powers, the industry and representatives of trade unions regarding the future energy policy of the country. Such an agreement also requires raising awareness of an impact of the country's energy policy on the quality of the natural environment, competitiveness of the economy and the creation of workplaces.

## 2. Natural gas and nuclear energy in the global energy policy

A radical transition in the structure of primary energy sources took place in the world in the past decades. Those changes were connected with a gradual reduction in coal importance in favour of oil and gas. The transition was greatly influenced by the introduction of nuclear energy

and gradual popularization of renewables (Łucki, 2005). It also enhanced the reliability of energy supplies and the protection of the environment (Fig. 1).

The transition led to diversification of the structure of energy sources and to a considerable growth in the importance of fuels, whose utilization reduces emissions of air pollution. As it has been mentioned, it was connected, among others, with a significant increase in the natural gas share. Thanks to its benefits, utilization of natural gas is supported by numerous ecological organizations, societies of individual countries and economic decision makers. The support caused the gas share to reach 23.7% the global structure of primary energy sources in 2011 (BP, 2012). Natural gas, due to its beneficial properties and its well-developed and fast growing market, is considered the fuel of the 21st century (Kaproń & Wasilewski, 2012). A further considerable increase in the fuel's importance is expected in the subsequent years (IEA, 2011).

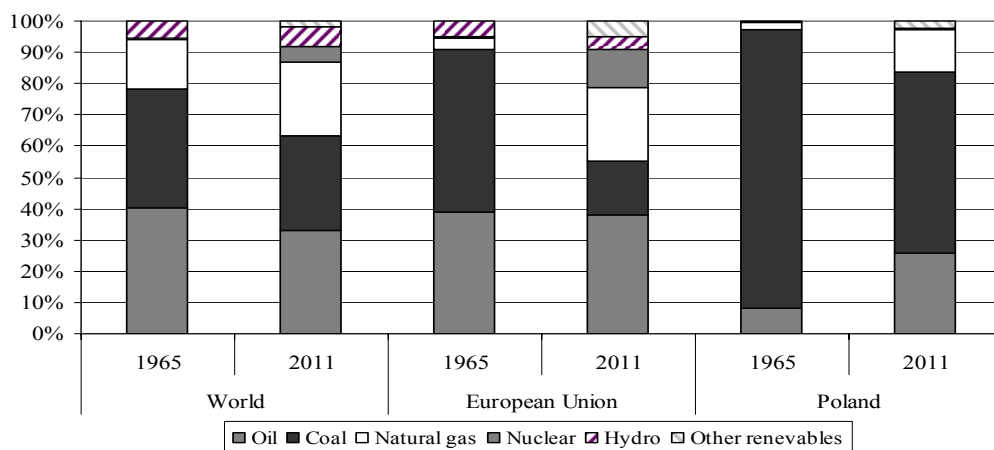


Fig. 1. The structure of primary energy sources in the world and selected EU countries.  
 Source: BP Statistical..., 2012

The development of shale gas has a great impact on the growth of importance of natural gas in the world's structure of primary energy sources. It may be important in this sector to popularize the solutions implemented in the USA and Canada, where the amount of gas acquired from non-conventional deposits increased significantly. In both countries, cuts in production costs and technological progress were the reasons for the production of natural gas to increase. The registered growth shows that it is possible to quickly increase the importance of gas in the energy-mix and to strengthen a given country as a producer on the global gas market.

The development of energy sources fuelled by natural gas in the EU countries will be mainly connected with the development of renewables. Gas power plants are considered to be sources of electrical energy that can work alongside renewables and ensure a possibility for a quick increase of their output in the event of changes in atmospheric conditions hindering or preventing the attainment of energy from wind farms.

Currently, nuclear energy with a 4.9% share in 2011 is a considerable source of primary energy. The share of nuclear energy in the structure of primary energy sources in the EU-27

countries (12.1%) and the OECD countries (8.8%) was much larger than the world's average (BP, 2012). It indicates that economically developed countries benefit from this source of energy, resulting in a competitive level of electricity prices<sup>1</sup>.

The future role of nuclear energy in the EU countries will be subject to, among others, increased awareness of the public concerning the ecological consequences of using conventional fuels, disruptions in energy supplies and increased energy prices, as well as the necessity to protect the climate from the adverse effects of energy production. Apart from those factors, the importance of nuclear energy will also be influenced by the need to meet the requirements of the climate and energy package connected with an obligation to purchase permits for gas emissions. This obligation, by increasing the final cost of electricity obtained from traditional sources, will encourage the EU member states to depart from conventional power industry. This is a chance for nuclear power plants to become more popular in these countries.

The choice of a nuclear option will be determined to a great extent by the assessment from the public and decision makers with regard to the consequences of the Fukushima power plant catastrophe and its actual scale. The results of this assessment will have an influence on the awareness of wide social groups, and on all stakeholders who will be involved in making decisions concerning the future of this particular energy sector.

Before the Fukushima disaster, a global renaissance of nuclear energy was expected. The increasing support (nearly 74%) in the USA, which has the most nuclear power plants (Bisconti, 2008) and the support of politicians of various parties for this kind of energy (EIU, 2011) proved this tendency. After the nuclear disaster in Fukushima, many countries took actions to suppress programmes for the development of nuclear energy, and even shut down the existing reactors. Some of the countries decided to postpone a decision concerning the future of nuclear power industry for a few years, so this decision would not be influenced by current emotions caused by the catastrophe. The opposite approach has been noted in the UK and the USA, which decided not to change the plans for a construction of new nuclear power plants regarding them as safe and competitive energy sources (Malko, 2012; Kaliski & Frączek, 2012).

The increase in imports of primary energy supplies from beyond the EU countries and a related decrease in the countries' energy security may have a great influence on the growth of the importance of nuclear energy. The development of nuclear power industry can considerably minimize the scale of these adverse occurrences.

The construction of new power plants based on nuclear energy and natural gas can also be a key factor influencing the competitiveness of the EU countries' economies considering the initiatives for increasing the role of renewables. Those initiatives, due to a high cost of energy coming from renewables, may lead to a significant decrease in the competitiveness of the EU countries' economies. To counteract such a threat, while deciding on an increase in power production capacities, it is necessary to take into consideration the projected cost of electricity production from various sources, as well as their impact on the environment. Available studies show that taking into consideration costs of emissions of air pollution, nuclear energy is the most price-competitive source of energy. The cost of coal-based energy is marginally lower in comparison with energy from natural gas, however, the ecological consequences of using coal need to be borne in mind. It also needs to be stressed that the price for electricity from renewables is currently several times higher than the price of energy coming from conventional energy supplies (*The Cost...*, 2004; Vattenfall, 2003; IEA, 2009; DECC, 2011).

<sup>1</sup> France, where 41.2% of primary energy was obtained from the nuclear source, registers one of the lowest prices of electricity in the world, for both home and industrial consumers.

### 3. The selected aspects of Poland's energy policy

In Poland, despite the transformation of its political system, which took over 20 years, no significant changes in energy policy have occurred. This is indicated by a marginal liberalization of the energy sector and preservation of the structure of primary energy sources, which is similar to that of the centrally-planned economy period, when the functioning of the sector was subjected to the needs of the economy of the whole Eastern Bloc. Currently, coal is the dominant source of primary energy, with a relatively small share of oil, natural gas and renewables and no nuclear energy. Maintaining such a structure leads to considerable emissions of air pollution, low efficiency of the sector and high prices of energy carriers.

This outdated structure, among others, is a result of the lack of modernizing actions, which have not been undertaken by several governments and other regulatory entities in the past decades, despite a radical transition that had happened in the world's structure of energy sources and the way of functioning of the sector's companies, especially in highly economically developed countries. One of the reasons for the negligence in modernization of the energy sector in Poland is the lack of continuity in implementation of the Polish energy policy, which is due to the fact that none of the plans determining aims of the country's energy policy have been fully carried out in the past years.

However, it needs to be emphasised that some beneficial changes concerning an improvement of the environment's condition and a reduction of air pollution have been performed in the past years (Kudelko, 2005; Urge-Vorsatz, 2006; Uliasz-Bochenczyk & Mokrzycki, 2007). Those changes included, among others, partial privatization of the industry, improvement of the energy efficiency of the companies as a result of initiated restructuring actions, as well as a gradual transition of the energy policy increasing the role of oil, gas and renewables together with popularization of cogeneration (Chalvatzis, 2009; EU, 2012).

Although the changes caused a considerable reduction in greenhouse gases emission, its level is still higher than the average of the EU countries (Table 1).

TABLE 1

The selected data concerning the emission of air pollution in Poland and the other EU countries

	EU-27		Poland	
	1995	2010	1995	2010
CO <sub>2</sub> per Capita – kg CO <sub>2</sub> /cap	9 078	8 105	9 612	8 193
Carbon Intensity – kg CO <sub>2</sub> /toe	2 605	2 381	3 679	3 280
CO <sub>2</sub> GDP Intensity – ton CO <sub>2</sub> /M€'05	499	358	2 280	1 056

Source: EU, 2012.

It means that without a consistent and focused modernization of the energy sector, it will be impossible to fulfil Poland's international obligations, particularly connected with the requirements of the climate and energy package. The need for modernization is shown by the disparities in energy efficiency of domestic economy in comparison with the average of the individual EU countries (Table 2).

TABLE 2

The selected data describing the efficiency of the economies of the EU countries in 2007 (toe)

Specification	PEC	FEC	PEC per capita	PEC/GDP
Poland	90.86	59.4	2.38	0.37
EU-27	1795.94	1242.63	3.57	0.17

PEC – primary energy consumption, FEC – final energy consumption, GDP – gross domestic product

Source: Eurogas, 2010.

Apart from financial penalties for not complying with the requirements of the EU legislation, it could lead to missing a chance to enhance the broadly defined energy security of the country (Table 3). This hazard is a serious challenge, since it could impair the competitiveness of the Polish economy.

TABLE 3

The selected hazards to Poland's energy security and their potential consequences

- neglecting investments in new deposits of coal may cause difficulties in fulfilling energy needs if there are no excess power capacities available, fuelled by alternative electrical energy sources.
- a strong reliance on gas and oil supplies as well as an increase in imports of coal from Russia may lead to sudden disruptions in raw energy supplies (such a risk is mitigated by initiatives for expanding natural gas storage capacities, building connections to gas systems of other countries, and guarantees of supplies included in contracts for oil deliveries to Poland)
- a growing risk of an increase in prices for energy supplies, caused by potential disruptions or reductions in supplies
- sudden adverse changes of an economic condition of the country connected with modifications of prices for energy supplies
- lack of sufficient expenditures on new power production capacities in the energy industry
- lack of adequate reconstruction investments for energy grids, resulting in numerous power failures in winter
- decreasing safety margins of power production capacities in Poland – in the following years the situation in this regard will get worse, as a number of outdated installations will have to be shut down and replaced with new sources
- difficulty in reacting flexibly towards changes in demand for natural gas
- a considerable part of the country lacking in developed gas infrastructure (blank spots) hindering supplies of gas for potential consumers.
- ecological protests of opponents of various expenditures for energy infrastructure, which delay implementation of many investments projects
- growing awareness of the public leading to protests against non-ecological energy sources
- lack of actual liberalization of the energy market in Poland

Apart from the question of meeting the objectives of the climate and energy package, there is a great challenge for the domestic energy sector to satisfy a projected increase in demand for electricity (*Prognoza...*, 2009, *European...*, 2007). According to the government projection (*Prognoza...*, 2009) by 2030 the demand for final energy will have increased by 29.1% and the demand for electrical energy by 44.3% in comparison with the level from 2006 (Table 4). The growth will stem from the society becoming gradually richer, leading to better standards of living.

TABLE 4

The electrical and final energy demand in Poland in 2006 together with a projection

Specification	Implementation	European..., 2007		Proгноza..., 2009	
	2006	2025	2030	2025	2030
Final energy demand (Mtoe)	65.4	82.2	85.5	79.3	84.4
Electrical energy demand (TWh)	150.7	221.1	236.5	194.6	217.4

Source: Own work based on *European..., 2007* and *Proгноza..., 2009*.

It needs to be added that although the registered home consumers' share in the structure of the final energy consumption has been higher than the average of the EU countries in the past decade, there has been a tendency for further increase in the energy consumption among this group. The scale of growth in the final energy consumption among home consumers is higher than the drop in its consumption among industrial and agricultural consumers in Poland, which has led to an increase in the final energy consumption (Fig. 2). In the following years, a crucial factor that is going to influence a growth of the final energy consumption will be the country's expected economic development and the necessity to secure energy supplies for domestic industrial consumers.

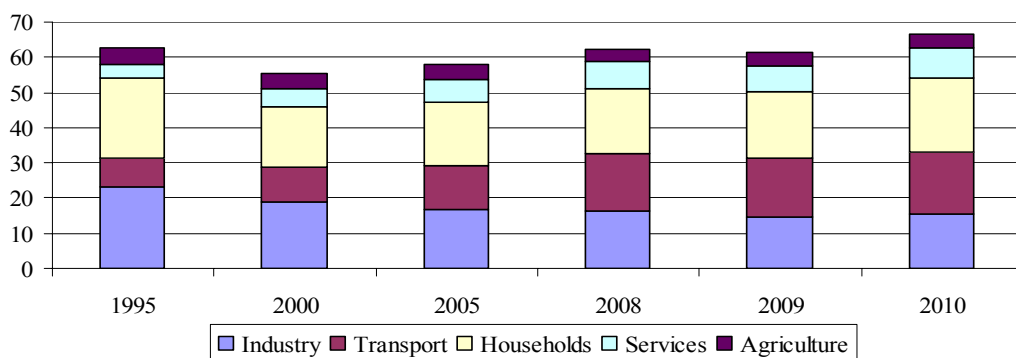


Fig. 2. The structure of the final energy consumption in Poland in 1995-2010

Source: EU, 2012

The current structure of the final energy consumption shows a considerable possibility for home consumers to reduce the consumption of energy. The improvement in energy efficiency will help to fulfil the requirements of the climate and energy package, and to increase the competitiveness of the country's economy by reducing a scale of raw energy supplies consumption. So far, energy-saving projects have been implemented mainly by domestic companies aspiring to improve their competitiveness. Initiatives taken in this regard by government departments help to implement the EU directives for reducing the energy intensity of various groups of consumers.

This tendency to increase the consumption of electricity will be accompanied by accumulation of problems with deteriorating, outdated domestic energy infrastructure. After years of investment neglect in the energy sector in Poland, 37% of power production facilities are 20-30

years old, 43% are over 30 years old and only 8% are 5-10 years old (*Raport...*, 2009). Due to the above mentioned international obligations, a high level of energy infrastructure's wear and tear and an expected increase in the final energy consumption, the country's future energy policy must take into consideration initiatives concerning a simultaneous:

- reconstruction of parts of power production capacities which do not meet the requirements of the climate and energy package and other EU legal acts.
- construction of new power production capacities to satisfy a growing demand for electricity.

Existing projections indicate that by 2020 it will be necessary to build new installations with 6.4 GW power output (about 20% of power capacity installed in the country in 2006), as well as focused modernization of installations with 6.3 GW output (about 19.7% of power capacity) (*Polityka...*, 2009, *EU Energy...*, 2009). According to estimates, expenditures for those investments will amount to about 100 billion euro (Łakoma, 2009). As a consequence of such considerable expenditures, electricity prices are likely to increase. The scale of the necessary investments greatly challenges the domestic energy sector. Simultaneously, the growing awareness of both the public and economic decision makers with regard to the challenges that the energy sector is facing presents a chance for a rapid modernization of the industry. The essence of such modernization should be the development of low-emission and price-competitive energy sources. The application of market mechanisms in shaping the structure of energy sources will facilitate the implementation of modernizing initiatives. The changes will help to adjust the functioning of the country's sector to the EU requirements.

The directions for modernizing actions are included in the *Energy Policy of Poland until 2030*. Their implementation is going to help enhance the country's energy security accompanied by the simultaneous introduction of the principle of sustainable development (*Polityka...*, 2030). According to forecasts, a transition in the structure of energy sources is going to take place in Poland in the following years. However, individual projections show discrepancies in the dynamics and scope of those changes (Table 5).

TABLE 5

The demand for primary energy in Poland in 2006, together with a projection until 2030 (Mtoe)

Specification	Implementation	<i>European...</i> , 2007		<i>Polityka...</i> 2009	
	2006	2025	2030	2025	2030
Coal	56.4	51.9	47.8	45.2	46.4
Oil and oil-based products	24.3	34.9	35.9	29.5	31.1
Natural gas	12.3	21.4	23.3	16.1	17.2
Renewable energy	5	11.8	13.0	13.8	14.4
Other fuels	0.7	0	0	1.4	1.6
Nuclear fuel	0	4.0	8.4	5.0	7.5
Electrical energy export	-0.9	-0.8	-0.9	0.0	0.0
Total	97.8	123.2	127.5	111	118.5

Source: Own work based on *European...*, 2007 and *Polityka...*, 2009.



The projected implementation of changes in the structure of primary energy sources in *Polityka...* (2009), will involve partial modernization of said structure with regard to, among others:

- a possible decrease of hard and brown coal share in the structure of primary energy sources,
- promotion of renewables, connected with the fulfilment of Poland's international obligations regarding this group of energy supplies,
- introduction of nuclear energy after 2020, which should constitute a significant share in the structure of primary energy sources by 2030,
- an increase in the role of gas in the domestic energy sector.

It will be essential for the domestic energy sector to reduce emissions of greenhouse gases and obligatorily purchase emissions permits as a result of the 2003/87/EC directive. It means that the domestic coal power plants must invest in modern technologies for production of electricity and in installations for capturing and storing greenhouse gases (CCS – *Carbon Capture and Storage*). The results of previous studies show that it will be impossible to quickly implement such a technology (*Carbon...*, 2008; Hinc, 2011). It means that the extent of using coal in the domestic energy sector will mainly depend on the pace and scale of construction of such new installations whose operation will not cause air pollution, and on the development of imports of electricity.

Further liberalization of the energy sector connected with the implementation of the third liberalization package will be a necessary requirement for the transition. Popularization of the market mechanisms will facilitate an increase in the role of ecological, price-competitive fuels. Delaying modernization changes to implement the ideas of the climate and energy and the third liberalization packages, may force the country to pay large penalties imposed by the European Commission. This would affect the competitiveness of the domestic energy sector and still it would not free decision makers from their duty to modernize. All of these create a possibility to popularize natural gas and nuclear energy in Poland.

The implementation of the environment-friendly energy policy could be facilitated by taking actions to shape ecological awareness of the public which would entail promotion of clean energy supplies. Low awareness of the public with respect to ecological consequences of the pursued energy policy is one of the critical barriers in a transition in the structure of primary energy sources in Poland.

According to the projection, despite the enormous scale of planned modernization efforts, the domestic energy sector will not completely meet the requirements of the climate and energy package (*Polityka...*, 2009). This means Poland will need to purchase air pollution emissions permits. The cost of those permits – apart from the cost of reconstruction of power production capacities in the sector and the cost of financing these investments – will be one of the most fundamental factors that may cause prices for electricity in Poland to increase (Table 6). A projected doubling of electricity prices for industrial consumers with a similar increase for home customers shows the scale of negligence in modernization of the energy sector in Poland.

TABLE 6

Electricity prices in Poland in 2006 with a projection for 2010-2030 (PLN'07/MWh)

Specification	2006	2010	2015	2020	2025	2030	2030/2006
Industry	233.5	300.9	364.4	474.2	485.4	483.3	207.0%
Households	344.5	422.7	490.9	605.1	615.1	611.5	177.5%

Source: *Prognoza...*, 2009.

#### 4. The position of natural gas in the domestic structure of energy sources

Due to a marginal level of development of the gas market in Poland, a share of this fuel in the structure of primary energy sources is considerably lower than the average of the EU countries (12.5% and 23.5% respectively in 2010) (Eurogas, 2012). The share of natural gas in the structure of primary energy sources in Poland is the lowest among the CEE countries. The main barriers for the development of gas industry in Poland are:

1. Marginally developed gas transmission infrastructure, resulting in no technical possibility to quickly increase gas availability in Poland,
2. Existing political tensions in relations between the governments of Poland and Russia, which make gas supplies to Poland unreliable – it needs to be stressed that the Russian companies are and will continue to be dominant suppliers of gas to Poland,
3. Delays in construction of the first LNG terminal that put the diversification of sources of gas supplies to Poland on hold
4. Difficulty in negotiating a price-competitive offer for LNG supplies, since these supplies are arranged by contract many years in advance,
5. Low pace of legislative works connected with the extraction of natural gas from shale deposits, which causes uncertainty among many investors pursuing exploratory operations,
6. Lobbying activities performed by Russian gas companies aimed at obstructing works beginning the extraction of natural shale gas,
7. A lack of a comprehensive plan to increase the role of gas in Poland – such a plan accepted and implemented in the Netherlands served as a basis for departing from the coal-based structure of energy sources towards the structure based on ecological fuels (Rotmans, 2001).

The market's weak development is also largely due to the market structure heavily dominated (ca. 97 per cent share in natural gas distribution) by PGNiG SA Capital Group (GK PGNiG SA) which explores, mines, stores, trades and distributes the natural gas. Gas transmission is operated by the state company, OSP Gaz-System SA. The monopolistic market structure limits the effectiveness of the domestic gas companies (Frączek & Kaliski, 2009) (Table 7).

TABLE 7

Selected characteristics of gas markets in EU countries

Country	Length of pipeline per employee (in kilometres)	Number of customers per employee	Sales per employee (PJ)
Poland	3.76	198.70	0.02
EU-27	7.78	440.81	0.08

Source: Eurogas, 2010.

Natural gas distribution under GK PGNiG SA is carried out by its 6 distribution companies operating nationwide. Beside them there are independent operators with their own distribution networks, yet their contribution is marginal.

The existing market structure creates a barrier to its development, which results in a very slow replacement of traditional energy carriers by gas – the recorded 38 per cent growth of gas consumption in 2002-2011 is lower than the movement in economically developed EU countries (BP, 2012). GK PGNiG S.A. has a limited response to growing demand for gas, which is why indigenous gas production stabilizes while its consumption increases.

The stabilized output suggests an insufficient efficiency of GK PGNiG SA, which only to a limited extent uses the potential of the domestic deposits, hence the smaller gas production – in comparison with other EU countries – from conventional resources. Despite Poland's size of conventional deposits similar to that of Denmark, Germany or Italy, Poland's R/P ratio (reserves-to-production) is significantly higher which points to the possibility of increasing the country's energy security by means of higher gas production (Siemek et al., 2010).

Gas production from shale deposits can also increase the security of gas supplies for domestic users (Nagy i Siemek, 2010; Siemek i Nagy 2012). According to forecasts of the Polish Geological Institute, shale gas deposits in Poland available to extraction range between 346-768 billion cubic metres (BCM). According to another report of April 2011 prepared for US Energy Information Administration, estimated resources of natural gas from shale gas deposits in Poland reach 5.3 trillion cubic metres (TCM) These figures show that the deposits are many times bigger than the reported conventional gas deposits (ca. 145 BCM).

So far, the few boreholes made do not allow for clear confirmation of predictions concerning the possession of natural gas shale deposits. The success of projects aimed at increasing the production of natural gas from both conventional and shale deposits can affect the national and European natural gas market and bring about changes in the electricity market. For how long these deposits can meet the demand for natural gas in Poland will depend on the dynamics of the developing gas market and the scale of investment in exploration and introduction of these new deposits.

One consequence of a lack of changes in the size of production of natural gas from indigenous sources is a high proportion (about 70%) of imports of natural gas in its consumption. This gas is mainly imported from Russia, as part of the so-called Yamal contract of 1993, and to a lesser extent from Germany and the Czech Republic. Failure to use the potential of natural gas production limits the competitiveness of the national economy due to high natural gas imports to the Polish market. The cost of imported gas is much higher than the cost of gas from domestic resources, which leads to an increase in gas prices for domestic consumers, as the price of gas for domestic customers is a weighted average cost of imported gas and the gas from domestic reserves (*Rozporządzenie. ...*, 2008).

One big quality change for the domestic natural gas market is connected with launching the first LNG terminal, which will allow for imports of natural gas from independent suppliers. The introduction of this technology can help to improve the country's energy security and develop the gas market. This chance is also related to the above-mentioned need to modernize the energy sector (Siemek et al., 2011). The need to reduce emissions of air pollutants creates a great opportunity for the development of the gas industry in Poland. With the rapid increase in the number of cogeneration plants fueled by natural gas, the production of electricity and heat in the country can grow, however, without a significant increase in gas emissions. It is also important that the construction of a natural gas-fueled plant takes much less time than building a coal-fired plant or the construction of nuclear power reactors. In view of the many years of neglect in the construction of new generation capacities, this means a chance for a relatively rapid change in the structure of primary energy sources in Poland.

In order to boost the role of natural gas in Poland, state administrators must apply a range of instruments including:

- a change in the price relationship between coal and other energy carriers, through the use of fiscal instruments to support domestic and clean energy sources,
- corporate governance of PGNiG SA, which can encourage more efficient performance, which is a prerequisite for the development of the gas market in Poland,
- limiting the profitability of PGNiG SA – as part of the corporate governance – which will lead to a drop in gas prices,
- increased pressure of the market regulator (URE) on PGNiG SA and on the Transmission System Operator (GAZ-SYSTEM Sp. z o.o.) with a view to increasing their efficiency and thus lowering gas prices for consumers,
- establishing emission norms and rates for the protection of the environment, thereby encouraging the use of green fuels,
- adopting more favorable depreciation rates for natural gas installations as opposed to coal installations,
- factual liberalization of the natural gas market despite its formal deregulation.

The rate of development of the natural gas market in Poland will be largely dependent on the effectiveness of state institutions who will create conditions for competition in the market and who, in particular, will be involved in implementing the requirements of the third liberalization package. For the release of the national gas market, other suppliers – not only PGNiG SA – will need access to gas. In this regard, Poland may use the experience of those EU countries that have carried out reforms in line with the third energy package. Analysis of the process of liberalization of the gas market in the EU countries shows that this process must, in particular, focus on issues such as (Kaliski et al., 2010; Kaliski et al., 2012):

1. Changes in shaping the gas transmission entry-exit tariffs, which would allow for an adjustment of payments to EU standards.
2. Changes of distribution tariffs.
3. Extending the system network.
4. Increasing the capacity of underground storage facilities.

Changing the system of tariffs and the introduction of a gas release programme, which is being prepared by the market regulator, should facilitate the emergence of new suppliers able to offer gas to domestic customers. With only one potential seller, i.e. PGNiG SA, it is difficult to expect a real liberalization of the gas market in Poland without a regulatory action aimed at freeing the market. The small number of transactions on the Polish gas exchange suggests that too much gas is controlled by PGNiG SA, therefore it needs to be released. Such a move would contribute to better efficiency of PGNiG SA, consequently improving the quality of customer service and the competitiveness of gas in the domestic market of energy (URE, 2013).

To increase the security of supply, in recent years, work has been carried out for the development of gas connections with other countries, which will allow for imports of large quantities of the fuel from other countries than Russia. It is also important to develop the gas pipeline network in the country, which will enable transmission of the fuel during its increased demand and in case of emergencies. Expansion of the gas infrastructure will increase gas availability in the country to many potential domestic and industrial customers. Of great importance for the energy security of the country is also the expansion of natural gas storage facilities. Currently,

such facilities provide storage of only 12% of annual consumption, while in Germany the figure is 23.4% (*Eurogas...*, 2012).

## 5. The prospects for nuclear power

One change option in the sector, whose introduction will not involve progressive reliance on imports of energy, and which at the same time will allow for production of competitively priced energy and reduce air pollution scale is the construction of nuclear power plants in the country. So far the efforts to this end have been futile. The pressure from public protests caused by the fear of repetition of a disaster similar to the Chernobyl disaster of 1986, caused the Parliament in 1990 to suspend the construction of the first nuclear power plant in Żarnowiec. This decision meant losing the opportunity for a qualitative change in the energy policy of the country, it ruled out the possibility of creating an alternative to coal and lignite in the national structure of the dominant sources of primary energy, maintaining high emissions of air pollutants and reduced competitiveness of the national economy due to the renouncement of a source of cheap electricity. It must be added that the national decision-makers were influenced by social expectations, and at the same time did nothing to educate to the public on the advantages of nuclear power and on the importance of the project for the modernization of the national energy sector.

The following years, despite the existing support for nuclear energy, brought no action with a view to building a nuclear power plant or at least creating the scientific and technical base for this project (Hryniewicz, 2001). As a result, Poland does not have its own nuclear power plant, however, it is surrounded by such plants in neighbouring countries. In the immediate vicinity (within 300 km) there are 11 nuclear power plants with 20.7 GW capacity, which corresponds to the total capacity of all Polish power plants (electricity and heat power plants) together (Motowidlak, 2009). Because of the nuclear reactors' proximity, Poland is likely to be affected should a disaster occur.

This delay in the construction of a nuclear power plant signified a lack of willingness to modernize the national energy sector. The decision makers did not take into consideration the future economic needs and the world standard behavior in such situations. They failed to notice:

- the willingness on the part of local governments to build such plants on their territories given the public support for such projects,
- stable production costs in such plants due to multi-sourced supplies of fuel for them,
- already mentioned price competitive and ecological energy,
- high reliability of fuel supplies due to a large number of suppliers of this fuel for energy purposes,
- high safety of nuclear technology due to the use of widely tested procedures safeguarding the installations.

Giving up on the power plant construction in subsequent years also meant not taking the public expectations into account. A survey in 2004 conducted in Poland showed that 42 per cent of the respondents supported the use of nuclear power to meet the demand for energy while 38 per cent reject this solution and a fifth did not have an opinion. At the same time the majority of respondents opted for gradual withdrawal of coal (59% for, 20% against and 21% – no opinion) (Latek, 2005). The public had similar expectations in 2008 when it comes to the reduced use of coal, only 7% of respondents saw it as a preferred source of energy in the future (Bołtrotmiuk,

Burger, 2008). This means that the economy decision makers have no reason to say no to such investments on the grounds of a lack of public support.

The results of a survey on the public support for building a nuclear power plant carried out in 2012 show that this solution is accepted by the public. Increased support for this investment was noted during an awareness campaign informing about the plans for building the first nuclear power plant in Poland (5% increase to the level of 56% supporters) (MG, 2012). According to plans presented in *Polityka....* (2009) the first Polish nuclear power plant will be ready by 2020 and by 2030 energy from nuclear power plants in Poland should provide 6.5% of the national demand for energy. Currently intensive preliminary work is under way. Part of the plan is the Framework timetable for nuclear energy which comprises:

1. Development and acceptance of the Nuclear Power Programme for Poland by the Council of Ministers by 31.12.2010.
2. In 2011-2013 establishing the location of the first nuclear power plant and concluding a construction contract
3. Drawing up a technical project and obtaining all legal permits in the years 2014-2015.
4. Construction of the first nuclear power plant in 2016-2020.

The project of the Nuclear Power Programme for Poland, adopted in August 2010 (MG, 2010) accounts for delays in the Framework. According to the project, the first nuclear power plant will be finished in 2022, which means a 2-year delay in the original plan. In 2011 PGE SA announced a shortlist of potential locations: Żarnowiec and Choczewo in the Pomorskie voivodeship (North) and Gąski in the Zachodniopomorskie (North-West). These sites will be analysed with a view to selecting in 2013 the final location of the first nuclear power plant in Poland.

The construction of a nuclear power plant in Poland will bring a significant qualitative change in the structure of domestic energy sources as it will help reduce air pollution and increase the security of electricity supply. To reduce the risk of significant cost overruns, the construction of the nuclear power plant will be based on proven technology used worldwide. This solution will help meet the completion deadline, and will increase public support for the implementation of this project.

## 6. Summary

The above considerations allow for presenting proposals for the future of modernization in the domestic energy sector. These measures should include continued efforts to increase natural gas production from conventional sources in Poland and consistent efforts to start extracting natural gas from shale deposits. In addition, it is necessary to constantly develop gas infrastructure in order to diversify imports of gas from other countries, and to expand the transmission network in the country. These actions will increase the availability of natural gas in Poland and thereby contribute to increasing the share of natural gas in Poland's energy mix. This will create a solid alternative to fossil fuels, which may result in the reduction of gas emissions. These actions will also contribute to greater gas availability in the country.

In addition to the development of gas infrastructure, it is also vital to continue efforts to develop alternative energy technologies, which will make it possible to take advantage of any different options. Among these activities the construction of the country's nuclear power plant should be given priority. This investment means production of cheaper and cleaner electricity.

It also needs to be emphasized that a significant support for the implementation of this project is being observed.

There will be a need for educational campaigns raising awareness of the scale of the challenges facing the domestic energy sector and indicating the effect that the dissemination of cheaper alternative energy sources will have on the national economy and on keeping and creating jobs. These measures will help to obtain the support of all energy market participants to undertake efforts to shape such a structure of primary energy sources that it will be possible to obtain the lowest cost of electricity production while minimizing the environmental consequences of the adopted energy policy.

Those educational activities will also contribute to a change in the perception of energy security in the country. The current safety assessment based on the possession of significant coal resources does not include the full cost of the fuel and ecological consequences of its combustion, thus disabling the fulfillment of international obligations arising from the climate and energy package.

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