Security of energy supply from the Polish perspective[1]

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[1] The opinions presented in this paper result from the independent research carried out by the author and they do not necessary reflect views of any institution or power industry companies.

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Abstract

There is growing concern about security of energy supply in Poland. The country is dependent on foreign imports for nearly 100% of its oil demand and 65% of gas supplies. Both fuels are imported from Russia, which has recently included political aspects into the export of fuels. Hard coal and lignite deposits are relatively large in Poland and they are able to cover demand for such fuels for the next 80-100 years. However, the policy to reduce CO2 emissions can cause the significant rise of costs of the energy produced from fossil fuels, because the Polish power generating industry uses such fuels for over 90% of its production. Reliability of electricity supply is threatened by the imbalance between fast growing electricity demand, at a rate of 3-4% per year and a lack of incentives to construct new power generating units. It is very likely that after 2010 demand for electricity with necessary regulation reserves will be larger than the domestic production capacity.

The paper discusses various aspects of energy supply security, starting from the definitions of supply security and indicating a need for more precise and uniform meaning of supply security terms, which should be measured using crisp parameters or fuzzy sets methodologies. In the second part the paper presents an overview of the Polish energy industry and the challenges to ensure energy supply security. It indicates that if fuels and energy delivered from the east develop political dimensions attached to them, a common European policy could be an effective measure to improve energy supply security for all member states.

1. What does mean security of supply?

1.1. Supply security concern

There is a growing concern relating to the security of energy supply in Europe. The recently published directive 2005/89/EC [1] deals with the security of supply. Also the problems sketched in Green Paper [2] are discussed in the member states. However, questions such as: what is security of supply, how to define it and how to measure it, still remain unanswered. If any action is to be taken to improve supply security in terms of the investment or political decisions, the public and the decision-makers should be convinced that security will be improved and the degree of improvement can be evaluated. The documents mentioned above not only fail to provide a clear definition of supply security, but also the term *supply security* is used in various meanings across this directive and Green Paper.

There is a strong need for commonly accepted, precise definitions of supply security as well as for methodologies allowing for security evaluation, in terms of crisp numbers, if possible, in order to compare the impact of various actions on supply security.

1.2. Various meaning of supply security

The directive 2005/89/EC defines '*security of electricity supply'* as the ability of an electricity system to supply final customers with electricity, as provided for under this directive. Additionally it introduces '*operational network security'* as the continuous operation of the transmission and, where appropriate, the distribution networks under foreseeable circumstances and indicates the measures aimed at safeguarding security of electricity supply so as to ensure the proper functioning of the internal market for electricity, and to ensure: (a) an adequate level of generation capacity; (b) an adequate balance between supply and demand; and (c) an appropriate level of interconnection between Member States for the development of the European electricity market.

The directive 2005/89/EC uses the term *supply adequacy* when referring to the report[3] which member states should prepare in accordance with the directive 2003/54/EC. The term *reliability* is used twice when mentioning reliability standards[4] and maintaining the reliability of the network[5]. The term *availability* relates to the power generating capacity[6].

Green Paper [2] uses the term ***security*** in various meanings, including network security "*Improved **network security** through increased collaboration and exchange of information between transmission system operators in defining and agreeing common European security and reliability standards*". The mixture of terms "*secure*" and "*availability*" is also used "*Secure availability of energy at affordable prices is crucial*".

The UCTE uses several definitions relating to reliability and security of supply [5], [6], [7]. **Reliability** is a general term encompassing all the metrics of the ability of the system, generally given as numerical indices, to deliver electricity to all points of utilisation within acceptable standards and in the amounts desired. Power system reliability (comprising generation and transmission facilities) can be described by two basic and functional attributes: adequacy and security. **Adequacy** is a measure of the ability of the power system to supply the aggregate electric power and energy requirements of the customers within component ratings and voltage limits, taking into account planned and unplanned outages of system components. Adequacy measures the capability of the power system to supply the required load in all the steady states in which the power system may exist considering standard conditions. The **adequacy reference margin** is 5% or 10% of generating capacity plus the margin against daily peak load. **Security** is a measure of power system ability to withstand sudden disturbances such as electric short circuits or unanticipated losses of system components or

[3] Member States shall ensure that the report referred to in Article 4 of Directive 2003/54/EC covers the **overall adequacy of the electricity system** to supply current and projected demands for electricity, comprising: operational network security; (b) the projected balance of supply and demand for the next five year period; (c) the prospects for security of electricity supply for the period between five and 15 years from the date of the report; and (d) the investment intentions, for the next five or more calendar years, of transmission system operators and those of any other party of which they are aware, as regards the provision of cross-border interconnection capacity.

[4] When promoting electricity from renewable energy sources, it is necessary to ensure the availability of associated back-up capacity, where technically necessary, in order to maintain the **reliability** and security of the network.

[5] When promoting electricity from renewable energy sources, it is necessary to ensure the availability of associated back-up capacity, where technically necessary, in order to maintain the **reliability and security of the network**.

[6] Member States shall take appropriate measures to maintain a balance between the demand for electricity and the **availability of generation capacity**.

load conditions together with operating constraints. Another aspect of security is **system integrity**, which is the ability to maintain interconnected operations. Integrity relates to the preservation of interconnected system operation, or the avoidance of uncontrolled separation, in the presence of specified severe disturbances.

On the other hand, in the US, the FERC [3] defines **reliability** as a term with two parameters "*supply security'* and "*system adequacy*", where *system security* is assumed to be the system's ability to survive disturbances. It seems that a more intuitive term for the system's ability to operate under some disturbances is "*system stability*" or "*system robustness*".

The NEMMCO[7] in Australia [4] employs the term "*system adequacy*" and projects the system adequacy for short-term time horizons (STPASA[8]) and middle-term time horizons (MTPASA[9]). The system adequacy is well defined by the NEMMCO and various levels of probability are used to deal with uncertainties of the electricity demand forecasts. It seems that the system adequacy is an appropriate parameter for defining supply security in more precise manner and it can be used as a staring point in the development of system of metrics to evaluate supply security.

1.3. Conclusions

Despite the importance of supply security there is no a single clear definition used in the European Commission documents. Moreover, the definitions used by the EU publications are not consistent with the approach used in the US, nor with those used by the network operators in Europe, associated in the UCTE.

The directive on supply security imposes some obligations on the member states; therefore such terms as security of supply should be more precise and allow for the construction of tools to simulate improvements of supply security as a function of investment and other measures aimed at supply security. It is especially important if the security of supply is to be improved on a commercial basis with the involvement of power industry companies.

[7] National Electricity Market Management Company
[8] Short Term Projected Assessment of System Adequacy
[9] Middle Term Projected Assessment of System Adequacy

In Poland, the commonly accepted broad definition of supply security is that an adequate level of supply security means the delivery of energy under normal circumstances for reasonable prices. Like other definitions discussed in this paper the Polish definition is also broad and evaluates supply security intuitively and does not measure it in terms of any crisp parameters.

2. Energy and electricity consumption in Poland

The consumption of fuel and energy in Poland results from the structure of industry and housing built before 1990 during the centrally managed economy. Between 1990 and 2006 industry has undergone radical changes. Heavy industries were mostly closed down being replaced by modern production facilities for motor and electronic equipment. Over 60% of the total energy used in Poland comes from solid fuels, namely hard coal and lignite. Natural gas provides 13% of the total energy supply, while oil accounts for about 20% - Fig. 1.

The use of energy per capita in Poland is significantly below the average levels of EU15 or EU25 – Fig. 2. This is mostly caused by lower energy consumption by domestic customers. However, the energy consumption per GDP is relatively high. This results from a continued reliance, despite radical changes, on energy intensive industries as well as from lower labour productivity – Fig. 3.

The fast growth of the economy reaching 6% in 2006 and 2007 drives the demand for energy up. In the case of the total energy consumption, the increase will be moderate and can be limited by improving energy efficiency, especially building insulation, but the demand for electricity will climb at a rate of 3-4% per year, what means the increase of demand for electricity about 35-40% in ten years.

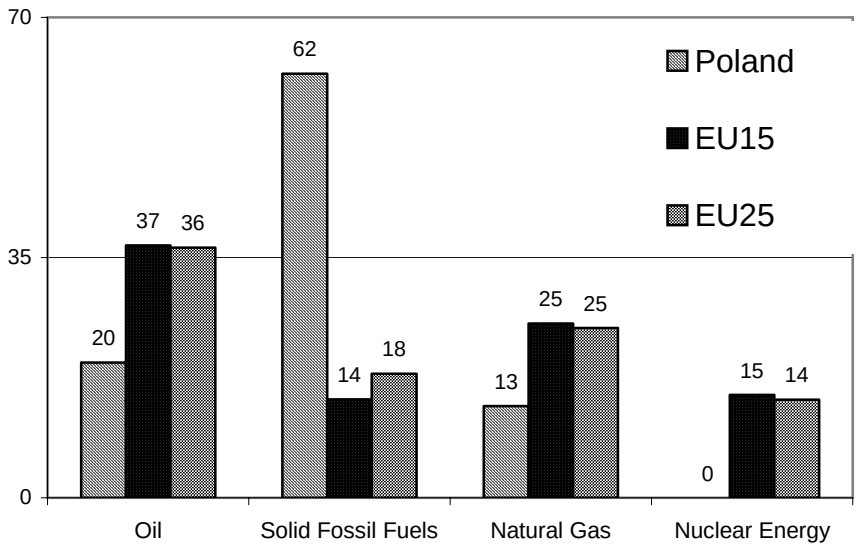

Fig. 1 Energy and fuel consumption structure in percentage of the total use [8]

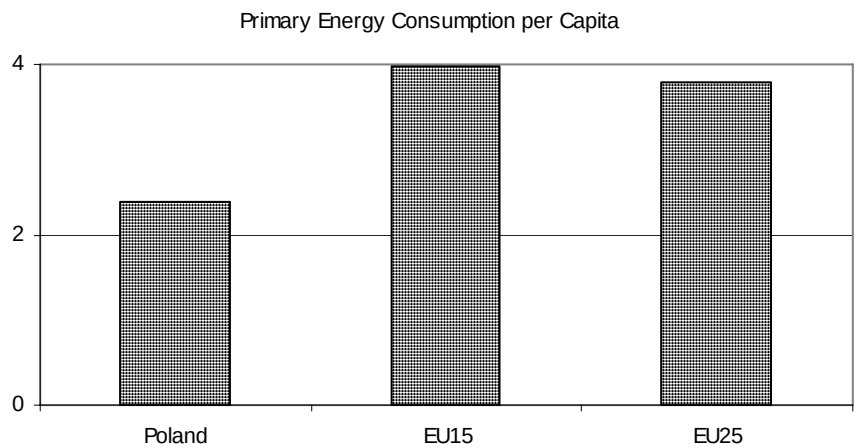

Fig. 2 Primary energy consumption (PEC) per capita. Source: Eurostat.

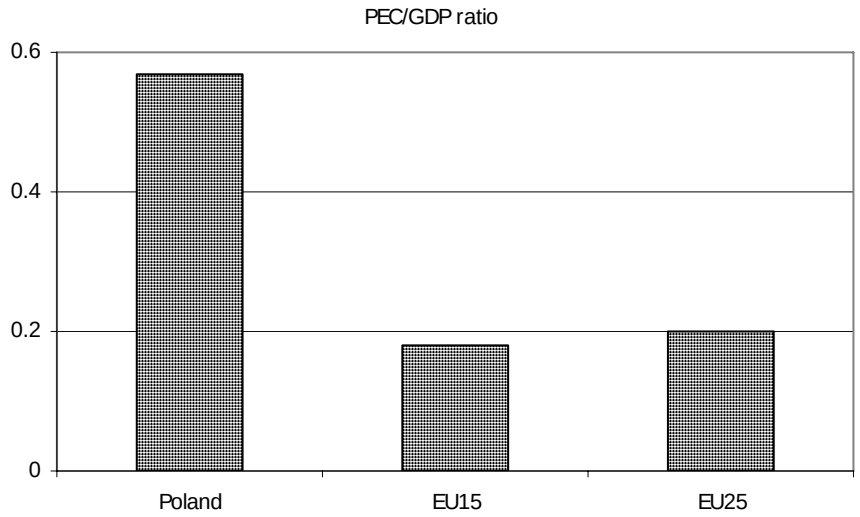

Fig. 3 Primary energy consumption per GDP ratio. Source: Eurostat.

3. Energy sectors' review

3.1. Oil and petrol

The main supply of the oil is the pipeline "Przyjaźń" connecting the east and west borders of Poland [9]. It consists of two main sections. The east section connects Adamowo near Belarus with the depot and the refinery in Plock in the central Poland at a distance of about 100km west-north from Warsaw. The nominal capacity of this pipeline is about 43 million tons of oil per year. The western section connects Plock with the depot situated in Schwedt, Germany. This section's capacity is 27 million tons of oil per year.

The main Polish refinery in Plock is also connected with the handling site in the port of Gdańsk by the oil pipeline with the capacity of 30 million ton per year from Gdansk to Plock and 20 millions from Plock to Gdańsk. A new connection is under discussion. It could connect Brody (the Ukrainian border) with Plock carrying up to 25 million tons of oil per year from the Caspian sea region. However, the construction of this pipeline depends on contracts with the Caspian oil suppliers, which are still being discussed.

Current demand for crude oil reaches 19 million tons per year. The forecasted demand indicates the increase up to 35 million per year in 2025. The domestic production of crude oil is about 0.5 million ton per year and plays insignificant role in balancing demand. The import of oil from the west, including the port in Gdansk, is about 2 million tons. Domestic petrol production is dominated by two main companies: Orlen producing 7 million tons and Lotos with the production of 3 million tons per year. Domestic petrol prices fluctuate with world oil prices.

Poland imports practically all of its crude oil from Russia. The possibility to import oil via Gdańsk reduces dependence on import from Russia. The capacity of the oil pipeline between the port and the main refinery in Płock is about 30 million tons, which is 50% more than the current total annual demand. The increasing demand for oil will drive Poland to seek new suppliers from the Caspian area, but this opportunity can be limited due to the political reasons.

3.2. Gas supply

The total demand for natural gas is over 13 bcm calculated in high-methane equivalent. The main Polish gas company PGNiG produces about 4.3 bcm from domestic resources [10]. The remaining demand has to be covered by gas imports. The main stream of the gas flows via the Jamal gas pipeline under a long term contract until 2022, with the total amount contracted equal to 218 bcm. PGNiG has entered other two small contracts with Germany and Norway amounting for 0.4 and 1 bcm respectively.

As the only about 35% of the gas demand can be covered by the domestic production, Poland is depended on the gas supply from Russia more than most of the European Union countries. Gas supply diversification has become a priority in the Polish energy policy, especially after experiences with the cut in the gas supply by Russia about a year ago due to the dispute between Russia and Belarus. Responding to the supply cut the Polish authorities limited the gas supply to industry, preserving the gas flow to the domestic customers. This has resulted in some claims from industry to cover the losses caused by the decision to stop supply.

The gas supply diversification takes two measures: the construction of a new northern gas pipeline from Norway and the development of an LNG port. The first attempts to obtain gas from Norway were undertaken by the

"Solidarity" government in 1997 – 2001, however the SLD party, which won power in 2001 abandoned plans for diversification. When the PiS party won the presidential and parliamentary elections in 2005, gas supply diversification has again become a priority for the Ministry of Economy.

On 20 June 2007 PGNiG jointed with and acquired 15% interest in the Consortium led by Gassco, which develops the Skanled gas pipeline from Karsto in Norway to Sweden and Denmark. The plans of PGNiG to obtain a gas supply from north are focused on four main activities:

- Ensure a gas supply from the Norwegian continental shelf
- Securing gas transportation from the Norwegian transmission system to Denmark through the Skanled pipeline
- Ensuring the transportation of the gas via the Danish transmission system
- Construction of a Baltic offshore pipeline in cooperation with Energinet.dk

The supply by the pipeline from Norway requires the transportation of 6-7 bcm of gas to make the project economically viable. This amount is not currently possible to be consumed by the Polish industrial and domestic customers so there is a need for finding new gas users. This leads to the plan to construct 2-4 new power generating units using natural gas as fuel in the Dolna Odra power station located near Szczecin in the west-north part of Poland.

The construction of a new gas pipeline under the Baltic, between Russia and Germany, bypassing Poland is causing some political controversy. It is the departure from the previously agreed plan to construct a second pipe along the Jamal pipeline. Because the Baltic pipeline will supply gas directly to Germany and other European countries it will be possible for Russia to reduce the supply of gas to Poland without disturbing the supply to other European countries. This fuels fears that if Poland's gas supply is cut it will not receive support from the rest of the European Union.

The Polish proposals for a common European energy policy are not supported by the main European countries, so it is predicted that Poland will have to withstand the Russian gas policy alone. The construction of the undersea Baltic pipeline is at least three times more expensive than the construction of a second Jamal line, so it is not surprising that the Polish

public recognizes the Baltic pipeline as a politically motivated project. In such circumstances the Polish government seems to be determined to diversify gas supply and it is supported in these activities by the opposition parties and the public.

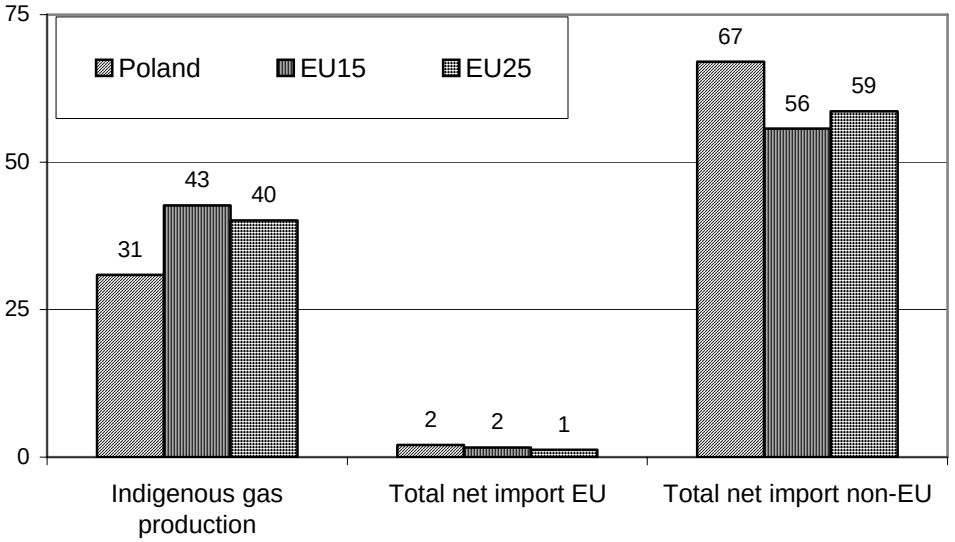

Fig. 4. The gas supply in Poland and EU15 and EU25 from various resources [8]

3.3. Coal

Coal is the main fuel for the power supply industry, as over 94% of electricity in Poland is produced from coal. The total hard coal production reaches 82 million tons per year streaming over 50% of this amount to power stations. Coal export is around 20 million tons, with practically no import. Hard coal deposits are estimated for about 43 billion tons with about 15 billion tons easily exploitable. About 35% of electricity production is obtained using lignite, production of which reaches 60 million tons per year. Lignite deposits are estimated to reach 12 billions tons.

Hard coal and lignite deposits allow Poland to be independent from import and guarantee fuel supply to power stations for at least 80-100 years.

However, the European environmental policy aiming at the reduction of CO2 emission will increase the cost of electricity production from coal. It is also unlikely to have zero emission technologies by 2020, so the Polish power supply industry will generate more and more CO2, if the increasing demand for electricity is to be covered by the domestic electricity production.

3.4. Electricity

Estimating future electricity demand is difficult in transitional economies where heavy industry is being replaced by modern high technologies. The general rule that electricity demand increases in a ratio to the increase of GDP does not always apply to the economy transitional period. Between 1996 and 2002, in some years such as in 1999 the increase of GDP in Poland reached 6% while electricity demand dropped by 0.5%. However, after the year 2002 the trend of increasing electricity demand become stabilised and reached the ratio of 0.5-0.8% of increase in electricity consumption for every 1% of increase in GDP.

To evaluate the growing electricity demand in Poland [11] an analysis of historical electricity consumption in EU15 and four European countries: Greece, Spain, Ireland and Portugal has been carried out for a period of ten years between 1991 – 2001 – Fig. 5. The assumption for this analysis was that the accession of Poland to the European Union would result in similar processes as in other countries that joined the EU before Poland. Based on such historical patterns, the analysis carried out in 2004 indicated an increasing ratio of electricity consumption to GDP (dE/dGDP) from 0.5 in 2004 to 0.7 in 2010 and stabilization of this ratio after 2010.

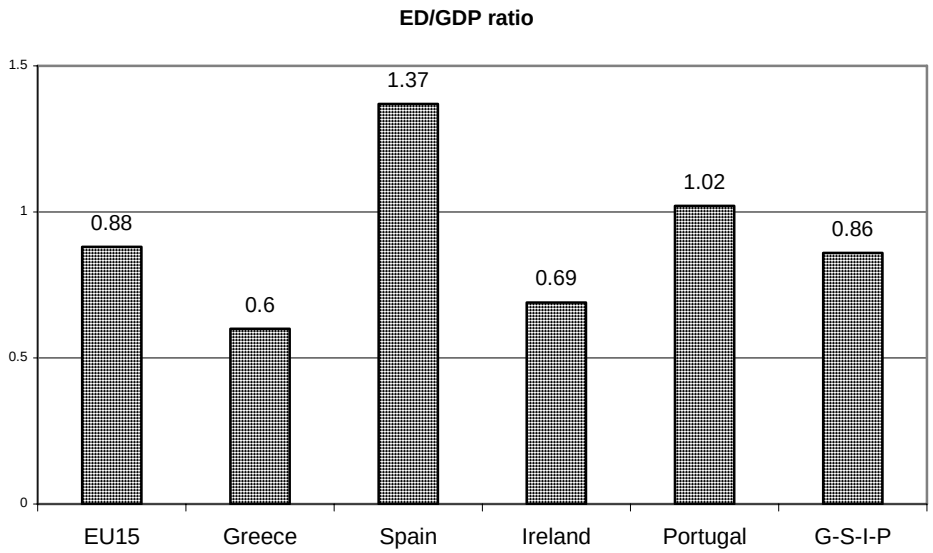

Fig. 5 The ratio of electricity consumption increase (dE) to the increase of GDP (dGDP) [11]

Simulations of electricity demand indicate an increase in electricity consumption of about 30 - 35% to 2015 and about 70 - 80% to 2025 [11]. The growing demand for electrical energy is associated with the aging production facilities. Over 40% of electricity production units are older than 40 years while another 34% of generators have been in exploitation for over 20 years – Fig. 6. This will result in closing down a significant amount of generating capacity in the near future. Moreover, low electricity prices in the market caused by subsidies to power purchasing agreements (long-term contracts) reduce incentives to invest in power generating capacity. Between 2000 and 2010 only three large generating units will be constructed, while simulations indicate that such generating capacity should be commissioned every year.

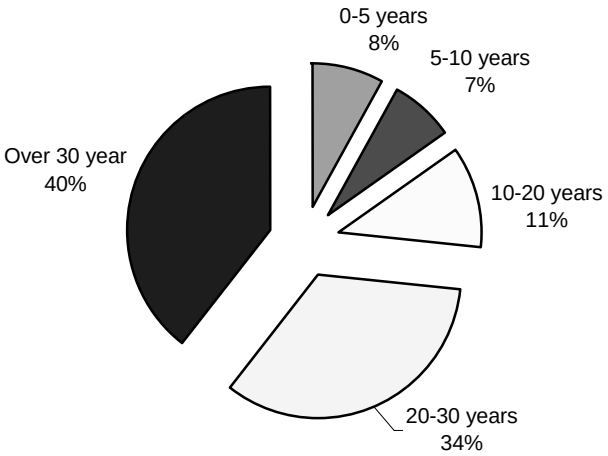

Fig. 6. The age of power generating units in Poland [11]

The increasing demand for electricity with aging power generating equipment and a lack of new investment will lead to a gap between demand and supply. Such a gap will become significant after 2010 – Fig. 7. This imbalance can be partly reduced by import from Ukraine using the existing 750kV line or a new transborder connection with Lithuania, if such a connection will be built and if the old nuclear unit in the Ignalina power station in Lithuania will be replaced by two new generating units producing enough electricity for the Baltic States and allowing for export to Poland.

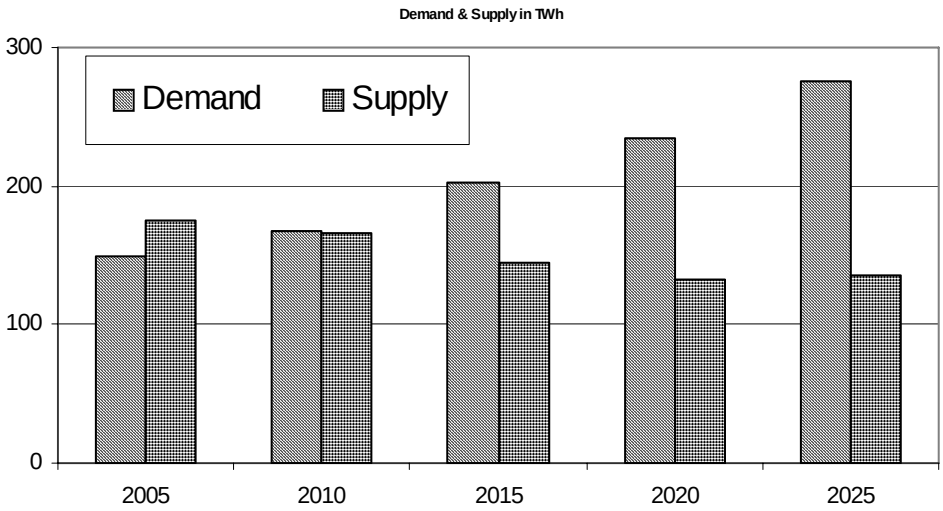

Fig. 7 The forecast of power demand and supply in Poland [11]

The simulations of demand for fuels to produce electricity indicate that coal will remain the main fuel with a limited share of natural gas – Table 1, and with some nuclear power after 2020, if the public will be convinced that such a technology is necessary and the construction of nuclear power stations will be accepted. It is unlikely that the growing use of fossil fuels for electricity production will be changed by the environmental policy of the European Union. There are no other technological options for Poland, so any measure to reduce CO2 emission will result in higher prices, but not in significant changes in generating technologies and the reduction of CO2 emissions.

Table 1. Demand for fuels [MTOE] by the power producing industry [11]

Year	2005	2010	2015	2020	2025
Coal	32.4	37.5	43.6	50.9	53.2
Renewable	1	1.8	2.1	2.5	2.8
Gas	0.7	1.2	1.9	3	4.8
Nuclear	0	0	0	0	5,3
Total	34.1	40.4	47.6	56.3	66.1

4. Conclusions

There is a growing concern relating to energy supply security in Poland. The country is completely dependant on imported oil, while the import of natural gas is about 65% of domestic consumption. Both fuels are imported from Russia, which has recently included political dimensions into the supply of fuels.

A cut in oil supply by pipelines can be compensated for by deliveries to the port of Gdańsk. The relatively large transport capacity of the oil pipeline between Gdańsk and the main oil refinery in Plock in the centre of the country can cover the domestic demand for crude oil and petrol. The import of petrol from Europe can also allow for petrol demand balancing.

Gas import is based on the delivery from Russia by the Jamal gas pipeline. Several years ago a second Jamal pipeline was planned to increase gas

delivery to Poland and other European countries. However, an agreement between Gasprom, E.ON-Ruhrgas and ASF to establish the Northern Europe Gas Pipeline Company, currently Nord Steam AG, and to construct a direct pipeline between Russia and Germany under the Baltic has caused that the second Jamal project is abandoned.

When the pipeline under the Baltic sea is commissioned, Russia can cut gas supply in the Jamal pipeline without disturbing the gas supply to Germany and other European countries. The pipeline under the Baltic sea is not economically justified as the cost of such construction is at least three times more expensive than the second Jamal pipeline. There are also growing concerns relating to environmental aspects of the Baltic pipeline as chemical weapons were dropped into the Baltic sea during the 1st and the 2nd World Wars. The locations of these weapons are unknown, and there is thread that the construction of the gas pipeline may disturb these weapon dumps resulting in environmental catastrophe.

In reaction to the increasingly political aspects of energy supply from Russia, Poland has proposed a common European energy policy which could protect smaller member states from the consequences of the use of energy supply in a political manner. As the proposal was not supported by the most influential member states, Poland has decided to undertake several steps to reduce dependence on gas imported from east. This includes involvement in the exploitation of gas fields in the North Sea and the construction of a gas pipeline from Norway to Poland. The second measure undertaken is the construction of an LNG port.

Hard coal and lignite deposits are relatively large in Poland and they are able to cover demand for fuel for the power generating industry for 80-100 years. However, the policy to reduce CO2 emission can cause that the cost of using coal as fuel will rise significantly. The Polish power generating industry relies on fossil fuels for over 90% of its production. This can be only slightly changed as renewables are not able to cover more than 10-15% of the demand for electricity. Dependence on gas import limits the use of natural gas as fuel for the power generating industry, although several gas power generating units are planned to be constructed. The development of nuclear power generating units is not likely before 2025 as the public remains skeptical of the safety of nuclear power.

Reliability of electricity supply is threaten by the imbalance between fast

growing electricity demand, at a rate of 3-4% per year, and a lack of incentives to construct new power generating units. It is very likely that after 2010 the demand for electricity with necessary regulation reserves will be larger than the domestic production capacity. Temporary measures such as import from Ukraine or the Czech Republic and Germany can postpone the crisis, but the only effective measure to ensure reliable power supply is fast growth of the domestic power production.

Security of delivery of fuels and energy to the economy and the public becomes a large challenge for the Polish administration. The establishment of a common European energy policy, the construction of new gas pipelines to Poland and development of crossborder power line capacity can be found as the necessary measures to improve the security of energy supply.

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