ARCHIWUM ENERGETYKI tom **XLII**(2012), nr 1, 109–122

Maciej Kaliski∗
Stanisław Nagy∗
Jakub Siemek∗
Andrzej Sikora†
Adam Szurlej‡[1]

∗ AGH University of Science and Technology
Faculty of Drilling, Oil and Gas
Kraków
† Energy Studies Institute
Joint Stock Company
‡ AGH University of Science and Technology
Faculty of Energy and Fuels
Kraków

# Unconventional natural gas — USA, the European Union, Poland

The global gas market is currently undergoing considerable changes. The most promising places in Europe, as far as the natural gas search and output potential from unconventional resources is concerned, are Austria, Hungary, Poland, Germany and Sweden, among others. Taking into consideration the status of supplies of this type, which is still quite uncertain, and the possibilities of their output in Europe, the European Union (EU), in its prognoses, still does not consider them in the total assessment of demand and supply of natural gas for the EU. The conservatism of Europe is fully justified because practically nobody in Europe possesses "know-how" (lack of equipment or human resources which could be soon referred to defined operations.) What is absolutely necessary is verification of assumptions of the Polish energy policy (PEP2030). The possibility to prepare and, possibly, implement the principles of common energy policy of the EU must be considered.

## 1 Introduction

The last several years, in particular the period 2009–2012, was a time when the technological revolution of gas search and output from unconventional resources, especially the shale natural gas, changed the American economy and opened

[1]Coresponding author. E-mail: szua@agh.edu.pl

completely new possibilities for the energy sector of the United States (US). This is the time when natural gas reaches its historically lowest prices stimulating the economic growth, when unemployment declines and new workplaces are created. It is the first time for many years when gas prices stabilize, as well as the level of national output which enables a considerable limitation of gas import needs in liquefied natural gas (LIVC) LNG form and the USA become a net exporter of this energy material. In the USA natural gas becomes a natural substitute of hard coal and a possibility of much more extensive use of renewable energy sources for generation of electric current. As it is stated in the IHS Cambridge Energy Research Associates (CERA) report [4] of December 2011, this economic activity considerably affects the economy of the USA, for instance:

- Employment: only in 2010 in the USA the industry connected with shale gas led to creation of at least 6 million new workplaces. CERA estimates that by 2035 it is going to be a total of 1.6 million workplaces in the American economy [4].
- Revenues: IHS Global Insight [4] expects that the yearly revenue of the America's budget, resulting from taxation of personal revenues and those of enterprises will rise from USD 18.6 billion in 2010 to USD 28.6 billion in 2015 and to USD 57.3 billion in 2035. Moreover, so-called royalty payments for the country will rise from USD 161 million in 2010 to USD 239 million in 2015 and they will exceed USD 580 million in 2035.

The global, in particular European (i.e. the European Union) gas market is currently undergoing considerable changes. Only at the beginning of 2008 most of the analytics expected a systematic, continuous increase in gas consumption and continuance of trends which shaped within 20–30 previous years (e.g. average increase in consumption of LNG in the world in the amount of 7.4% per year in the years 1965–2007 [3]. However, the economic slowdown that started in 2008 with the financial crisis and considerable increase in own gas production of the US significantly changed the gas market. As a result, there was natural gas 'excess' on the market – i.e. possibilities of its delivery by the manufacturers are much higher than the 'appetite' of consumers. This is particularly visible in the case of LNG market, where the excess of assets in the entire value chain, starting from liquefying plants, through liquid gas carriers to regasification terminals, led to freezing (or even abandonment) of practically all new investment projects, with a simultaneous decrease of production powers, ships used to transport LNG and receiving terminals [5,6].

Breaking the continuance of economic processes leads to considerable limitation of the possibilities of using research instruments created in the past. Analyses

and prognoses connected with gas production and consumption performed before 2008 are useless in the current situation. The prognoses that were made after 2008 are based on too short time series, and they describe moreover, the global economy being 'in shock', attempting to regain its balance in the new reality. Therefore, they are naturally inexact and it is very risky to draw far-reaching conclusion based on them. These economic phenomena were, at the same time, overlapped by technological revolution in natural gas output from unconventional resources in North America. Due to great demand, developed transfer structure and similarity of geological structures to the US, the market of the EU seems to be a very promising for gas search and output from these sources. Thanks to unconventional gas sources, proved reserves of this resource rose in the USA from the amount of 5 trillion $m^3$ in 2000 to the level of approximately 6.95 trillion $m^3$ in the end of 2008 only to rise by 77% in 2011[2] and reach the level of 12.3 trillion $m^3$, although in the same period, the total output volume in the US amounted even to 4.3 trillion $m^3$. The estimated level of the output gas reserves from unconventional resources in Europe is assessed[3] for between 2.8 to 11.3 billion $m^3$. Assuming that the proved reserves may constitute approximately 30% of the entire supplies, the potential of own production in Europe (excluding Norway and countries of the FSU[4]) may, theoretically, increase by 30–120%, giving an additional yearly amount of 60–200 billion $m^3$ gas from own, European sources. The most promising places in Europe, as far as the gas search and output potential from unconventional resources is concerned, are Austria, Hungary, Poland, Germany and Sweden among others. Taking into consideration the status of supplies of this type, which is still quite uncertain, and the possibilities of their output in Europe, the EU, in its prognoses still does not consider them in the total assessment of demand and supply of natural gas. The subject of prognoses for EU market has been discussed in [7].

Since 2009 attempts have been made to assess the amount of natural gas in Polish unconventional supplies. Due to the insufficient amount of information, different methodologies applied and statistical calculations made based on data concerning North-American supplies, these estimates are vastly different. As-

[2]This is, most of all, caused by the development of shale gas output in Louisiana, Arkansas, Texas, Oklahoma and Pennsylvania [15].

[3]All proved gas reserves in Europe (excluding Norway and countries of the FSU) amounted, at the end of 2010, to approximately 2.7 trillion $m^3$. Source: *BP Statistical Review of World Energy, June 2011.*

[4]FSU - Former Soviet Union – 1. Armenia; 2. Azerbaijan; 3. Belarus; 4. Estonia; 5. Georgia; 6. Kazakhstan; 7. Kyrgyzstan; 8. Latvia; 9. Lithuania; 10. Moldova; 11. Russia; 12. Tajikistan; 13. Turkmenistan; 14. Ukraine; 15. Uzbekistan

sessments made by respected international institutions concerning the amount of shale gas supplies possible to mine reach from 1.37 trillion $m^3$ (Wood Mackenzie, August 2009) [15,16], through 1.87 trillion $m^3$ (EUCERS, May 2011) [9], 2.83 trillion $m^3$ (Advanced Resources International, December 2009), to 5.3 trillion $m^3$ (EIA, April 2011) [3,5,6]. The latest description of EU supplies can be found in [10]; compare also [11]. In March 2012, the first assessment of these supplies – only for the Baltic and Lublin–Podlasie Basin – was made by Polish Geological Institute (*Państwowy Instytut Geologiczny* – PIG). In the published report [14], total supplies of natural gas from shale formations, possible to mine, for Polish land and shelf (sea) part of the Baltic and Lublin-Podlasie basin were assessed for the maximum of: 1.92 trillion $m^3$. PIG also assessed that, most probably, these supplies also fall into the range 346–768 billion $m^3$ (2.5 to 5.5 times more than the documented supplies of conventional gas). Analogous amounts for shale oil (the same area) amount to the maximum of 535 million tons and, most probably, in the range: 215–268 billion tons (8.5 to 10.5 times more than the documented supplies from conventional gas.

Comparing the amounts gained by PIG and international institutions, several essential facts must be stressed:

- The estimates of PIG were made only for the Baltic and Lublin-Podlasie basin, not for the entire area of Poland (together with the supplies of Przedgórze Sudeckie), as it was made by international institutions.
- PIG for the first time indicated relatively large (when compared to the entire country) amounts of oil in shale.
- The PIG report has been made based on archive data, obtained from diagnostic holes made between 1950 and 1990. This data was was well-known to all companies which decided to search for gas in Polish shale formations.

The PIG assessments may change (and they probably will) having taken into consideration the data obtained from exploratory boreholes made after 1990 (in particular after 2010) during performance of exploratory and mining works for shale hydrocarbons[5]. Compare [1,2]!

[5] As far as the assessment of the PIG report is concerned, it should be taken into account that opinions concerning it – even among Polish experts – are divided. For instance, the information of Polish Press Agency (*PAP*) of 2nd April 2012 may be quoted here:

*As professor Stanisław Nagy, the head of the Gas Engineering Department in AGH, said, what is the most important problem is the methodology US Geological Survey (USGS), assumed by the Institute, which leads to - in his opinion - considerable underrating of these supplies due to lack of production wells in Poland. Nagy states that, due to the fact that there is no data concerning*

## 2 A review of market environment in natural gas search and output from unconventional supplies, with particular taking into consideration of so-called shale gas

Currently in Poland, in accordance with information of the Ministry of the Environment as on May 1, 2012, 19 entities were granted 110 concessions for searching for shale gas. The map of concessions is presented in Fig. 1. The following companies (some of them operate through their subsidiaries) have the concessions for searching for shale gas:

- PGNiG SA – 15,
- PETROLINVEST S.A. – 13,
- Marathon Oil Poland Sp. z o.o. – 11,
- 3Legs Resources Plc (Lane Energy) – 9,
- Orlen Upstream Sp. z o.o. – 7,
- LOTOS Petrobaltic Sp. z o.o. – 7,
- BNK Petroleum – 6,
- ExxonMobil Exploration and Production Poland Sp. z o.o. – 6,
- San Leon Energy – 6,

*shale gas output in Poland, "it would be more favourable to estimate only the geological gas supplies, based on classic methodology, so-called PRMS, too, approved by numerous international associations and institutions, such as, among others: Society Petroleum Engineers, American Association of Petroleum Geologists or World Petroleum Council, commonly applied in all gas and oil companies. The expert explained that the classic method is applied, among others, to examine the volume of the gas-saturated supply, saturation with formation water (ground water accompanying a supply), rock porosity, also the amount of free gas in fissures and pores is assessed. Obviously, such examinations are more difficult, as they are more time-consuming and require detailed data, also from the process of test mining" – he said. The head of Polish Geological Institute (PIG) Jerzy Nawrocki explained that the American (USGS)geological service is "the authority on this field and it estimates the supplies not only for the United States, but, upon the request from the US government, it make reports for the entire world, with the use of the same methodology". In his opinion, the so-called classic method of estimation of geological supplies does not take mining possibilities into account, and this is what is the main interest of everyone in the case of unconventional supplies. "We decided that it is better to speak about resources technically possible to mine than promise great geological supplies" – he said. "In my opinion, our approach is more realistic. The report concerns techniques applied today. If there are new ones and if there is more data from other boreholes, we are going to update our studies" – he explained.*

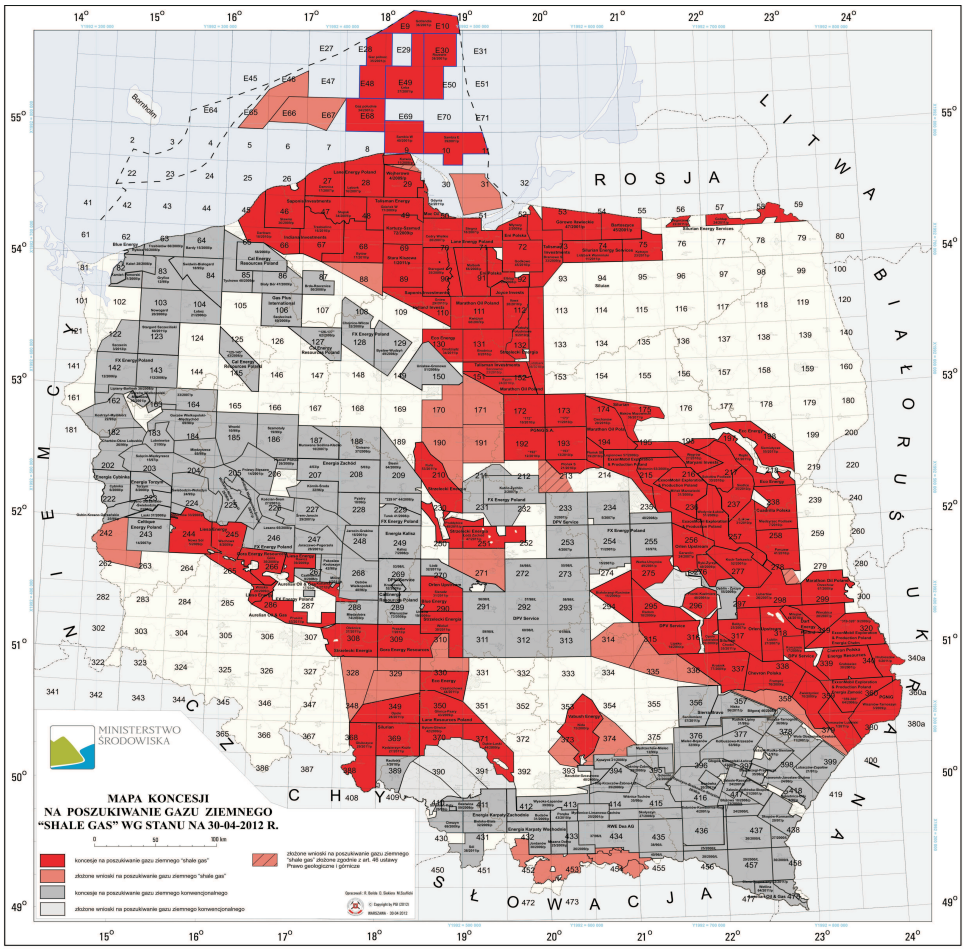


Figure 1. Map of concessions for searching for shale gas, state as on May 1, 2012 [19].

- Strzelecki Energia Sp. z o.o. – 6,
- Emfesz (DPV Service Sp. z o.o.) – 5,
- Chevron Corporation – 4,
- Eni Polska Sp. z o.o. – 3,
- Realm Energy International Co. – 3,
- Talisman Energy Polska – 3,
- Cuadrilla Polska Sp. z o.o. – 2,

- Aurelian Oli & Gas Poland Sp. z o.o. – 2,
- Dart Energy Poland Sp. z o.o. – 1,
- Mac Oil (Poland) Sp. z o.o. – 1.

Currently, on the aforementioned concessions, only exploratory works are performed, gas output has not started yet. Only on two concessions, their owners (PGNiG and San Leon) informed about discovery of shale gas. Research performed by ExxonMobile in two boreholes ended in a fiasco and the company, in its report, stated that 'the two test boreholes made at the end of 2011 with the aim of searching for shale gas in Poland, turned out to be disappointing. The amount of gas found in the first boreholes of ExxonMobil in Poland was insufficient to start regular, commercial output of the raw material[6].

As far as the total amount of concessions for search and recognizing of hydrocarbons is concerned (oil and natural gas in conventional and unconventional supplies – including shale gas), their amount reaches 257 (including 96 concessions of PGNiG). At the same time, the amount of concessions for output of hydrocarbons, granted by the Ministry of the Environment, amounts to 233[7]. From the aforementioned number of 233 output concessions, 225 belong to PGNiG, 4 to Lotos Petrobaltic, 2 to San Leon Energy and one each to FX Energy and DPV Service. In natural gas output, similarly to the remaining areas of gas operations, in Poland, (apart from gas transfer) PGNiG plays a dominant role. The national output reaches 4–4.5 billion $m^3$ per year and this amount is rising. Other companies dealing with gas output play minor roles (with the output amounting to 100–150 million $m^3$ per year, they have a total of 2–3% share in the national output).

As far as total documented supplies of natural (conventional) gas are concerned, depending on the source, they are assessed in the range from 100 to a little more than 150 billion $m^3$ in terms of methane-rich gas. Approximately 2/3 of Polish gas supplies is located in Niż Polski (Polish Lowlans) (mainly high-nitrogen gas), 30% in Przedgórze Karpackie (Carpathian Foreland) (methane-rich gas), not quite 1% in Karpaty (the Carpathian Mountains) and approximately 3% on the shelf of the Baltic Sea [14]. The exploratory and mining operations, when it comes to conventional gas in Poland, are mainly concentrated in Wielkopolska (Greater Poland) and in Podkarpacie (Sub-Carpathian region). The supplies of shale gas are supposed to be much larger, yet it must be noticed that in this case

[6]David Rosenthal, vice-head for investment relations in Exxon.

[7][18] Ministry of the Environment, *Juxtaposition of concessions for searching, recognizing and output of oil and natural gas supplies in Poland – February 1, 2012;* www.mos.gov.pl

the estimates of their size are much more diversified [3]. At the same time, it should be added that specification of this data may take place only as a result of beginning of shale gas supplies mining on an industrial scale.

National gas output constitutes only approximately 1/3 of the natural gas consumption on the Polish market; this consumption amounts to, approximately, 14 billion $m^3$/year[8]. Approximately 97% from this amount is supplied by PGNiG, in particular from import. As far as import is concerned, a dominant supplier is Gazprom (approx. 10 billion $m^3$ per year). About 3% of gas is sold on the Polish market by companies not being subsidiaries of PGNiG (GEN Gaz Energia, EWE Polska, KRI and CP Energia, among others). The expected freeing of prices on the gas market (probably from 2013 for all recipients, except for households) should change this situation, however, the scale of these changes depends on the model of the target gas market which is supposed to be implemented in Poland and which still is neither prepared, nor defined. In paper [8] consequences of the possible influence of output increase from unconventional supplies on the Polish economy have been discussed more specifically; compare also [6,7].

Currently – unfortunately still in Poland – all kinds of operation on the gas market – transfer, distribution, storing and turnover in gas fuel – are subject to the tariffication obligation. Analogically to the energy market, the function of a regulatory authority is fulfilled by Energy Regulatory Office (*Urząd Regulacji Energetyki* – URE), also gas tariffs (referring to transfer and distribution) are formed based on the same principles. In accordance with the energy law in Poland, there is one operator of the transfer system (TSO) (OSP – *operator gazociągów przesyłowych*) – Gaz-System S.A. This company is also an owner of most of transfer gas pipelines. What constitutes the only exception is the transit Yamal pipeline, the owner of which is EuroPolGaz S.A. (but URE designated Gaz-System as the operator).

The main import accesses to the transfer system are located on the eastern border in Wysokoje and Drozdowicze (with flow capacity 650 thousand $m^3$/h and 625 thousand $m^3$/h, respectively – approx. 5 billion $m^3$/year each). Apart from the above, gas is imported through Lasów, through so-called virtual reverse on the Yamal gas pipeline in Mallnow and an access point in Cieszyn, put to use last year (Moravia gas pipeline), but with much smaller flow capacity (after its development – in particular in the Czech part – a total of 1.5–2 billion $m^3$ per year).

[8]In accordance with Polish standards, all values concerning gas volume are specified in normal cubic metres. A cubic metre of gas fuel in normal conditions ($m^3$) — a unit of measure that indicates the amount of dry gas fuel contained in the volume of 1 $m^3$ in the pressure of 101325 kPa and temperature 0 °C.


Figure 2. Map of transfer system of GAZ-SYSTEM S.A. (source: Gaz-System).

The current investments of Gaz-System in the development of the transfer system aim at introduction of possibilities of reversing the traditional directions of gas transfer, mostly – considering the function of the LNG terminal in Świnoujście which is the most important from the investments currently performed in the gas sector in Poland. The first in Poland (and, for the time being, the only one) terminal for gas regasification is being construed in Świnoujście, more precisely – in Warszów – a right-bank district of Świnoujście. The estimated, specified by the investor, investment expenditures only for the construction of the terminal, amount to approximately EUR 500–600 million. The construction of the LNG terminal will allow to increase the diversification of natural gas supply. In the first stage of operations, the terminal will allow to receive 5 billion $m^3$ of natural gas per year. In the next stage, depending on the increase of gas demand, it will be possible to increase the regasification possibilities to 7.5 billion $m^3$/year. Installations to unload LNG will be adjusted to service of Q-flex ships (maximum capacity – 216000 $m^3$, draught – 12.5 m, length – 315 m). The works on the construction of the terminal started in September 2010 and, in accordance with the applied schedule, the date of putting it to use is 30th June 2014.

The main function of the aforementioned Yamal gas pipeline (transit gas pipeline system) is transfer of Russian gas to the German market. Its flow capacity reaches 33 billion $m^3$/year. On the territory of Poland, two gas reception points to the transit network have been constructed on the route of the gas pipeline: in Włocławek (maximum technical flow capacity 350 thousand $m^3$/h, which gives over 3 billion $m^3$/year) and in Lwówek (maximum technical flow capacity 270 thousand $m^3$/h, which gives over 2.3 billion $m^3$/year). At the same time, the access points are Kondratki and Mallnow (only the virtual reverse enabling import to Poland[9]).

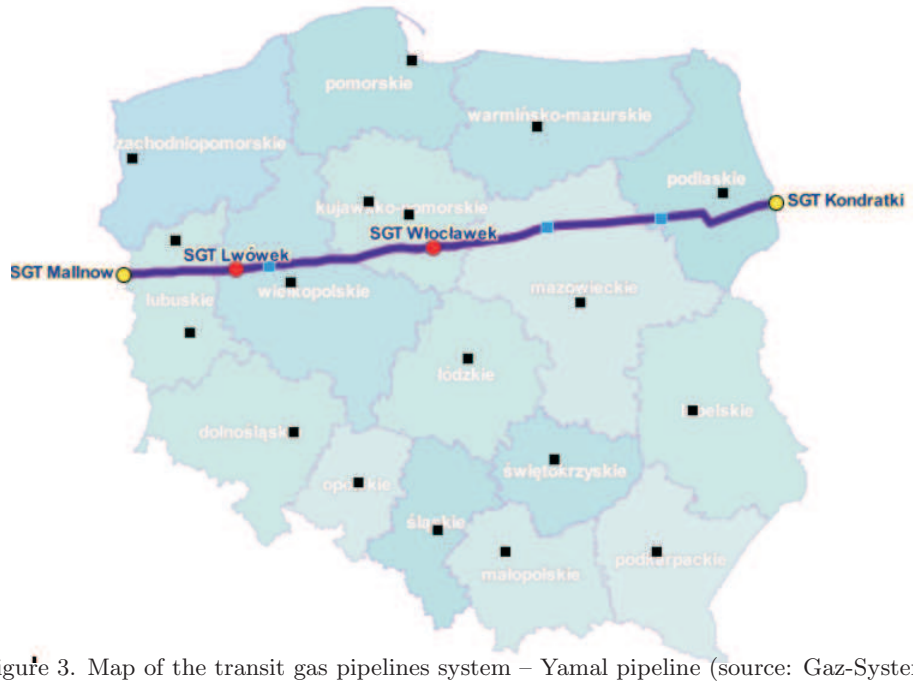


Figure 3. Map of the transit gas pipelines system – Yamal pipeline (source: Gaz-System).

The entity which plays a dominant role in natural gas distribution is PGNiG Group. Its six distribution companies cover the area of the entire country and serve approx. 98% gas consumers. On the areas excluded from PGNiG distribution networks, independent distribution companies operate, from among the only ones which are essential are the aforementioned GEN Gaz Energia, EWE Polska, KRI and CP Energia.

[9]Technical transit capability in the Mallnow virtual reverse is equal to the sum of technical transit capability of reception points to the Polish system.

## 3 The developing gas market based on output from unconventional resources?

Whereas a global increase in natural gas demand from the chemical industry in Poland should not be expected – the positive scenario is a return to the consumption level from the years 2006–2008, the need of change or diversification of suppliers of this raw material to nitrogen plants is more and more often mentioned by management boards of these companies, annoyed by the fact that the main supplier – PGNiG treats their enterprises more as balancing elements, cutting off or limiting the supplies in the case of shortage of the raw material in the network than as key customers. This policy of the gas potentate on the Polish market, which is quite short-sighted, is a great opportunity for new entities developing gas output from unconventional resources, to gain perfect (balanced, stable reception profile) customers. Reaching such 'dissatisfied' customers who are, at the same time, determined by the will of change, is possible based on direct contracts between the supplier and the customer, therefore acquiring them by new entities on the gas market seems to be relatively easier. The gas market in Poland, however, will not reflect the situation in the entire EU.

In May 2010 EUROGAS (the European Union of the Natural Gas Industry) published its prognosis titled *Long Term Outlook for Gas Demand and Supply 2007-2030* [19] which, to a great extent, corresponded with the PRIMES baseline model of 2007. Since the document became outdated rather quickly, in October 2011 EUROGAS, replying to the needs of the market, so to speak, prepared another document, which, this time was not of a forecast nature, *Eurogas roadmap 2050*. The authors wanted to describe what a European energy mix could look like in 2050, with the assumed 80% reduction (in relation to the year 1990) of the greenhouse gases emission in the EU, just as it was proposed by the European Commission in a document titled *Roadmap for moving to a low-carbon economy in 2050*.

The aim of *Eurogas roadmap 2050* was to present paths leading to the intended reduction goal which was supposed to constitute the basis for the European debate in December 2011, concerning *Energy roadmap 2050*. The document was created after the crisis in 2009, but still before the fundamental change concerning shutdown of nuclear power plants in Germany after the Fukushima tragedy. Nevertheless, *Eurogas Roadmap 2050* stressed the considerable potential of technologies connected with natural gas – in all sectors – for reaching the reduction goal. The document, in the 2030 perspective shows the advantage given by natural gas in the sector of electric energy and heat and in minimizing $CO_2$ emission.

An additional benefit of this raw material is the flexibility of adjustment of the gas sector to the development of renewable energy sources. Roadmap notices the necessity of implementation of technologies connected with $CO_2$ capture and storage (CCS technologies) for the years 2030–50 without the analysis of the influence of potential of gas from unconventional resources. As it is stated by the authors of the document, this will practically lead to stabilization of consumption of natural gas in the energy sector at the level of 191 billion $m^3$ in 2050 (with 162 billion $m^3$ in 2010). Furthermore, they are of the opinion that energy consumption in the sector of households and in the sector of services will decline to 86 billion $m^3$ as a result of implementation of the energy effectiveness package. Moreover we can see a considerable increase in consumption of natural gas in transport in the years 2030–50.

It should be stressed here that one can notice lack of an econometric mar-

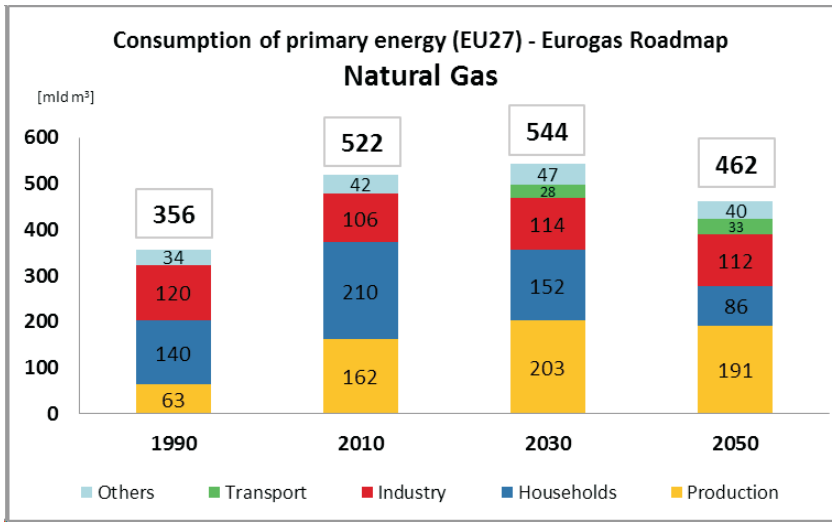


Figure 4. Natural gas consumption in the European Union according to *Eurogas Roadmap 2050* (source: own study based on *Roadmap for moving to a low-carbon economy in 2050).*

ket model (in particular in the case of natural gas market) at the EU level. This is curious, as demands are made from different areas (also from suppliers and importers of natural gas) concerning the necessity to prepare such a model at European level, since the applied PRIMES model does not provide satisfying prognostic results, nor does it perform well in shorter verification periods. Furthermore a modern model for the Polish market is absolutely necessary, in particular when facing the expected shale gas mining. The most important are

the analysis and estimation of the influence of the output development and, subsequently, consumption of gas from unconventional resources (in particular shale gas) on the economic and social problems in Poland, taken as a whole, taking into consideration the issues of ecologic nature and energy safety of the country. The results of the study could also constitute an appropriate basis for creation of standard legal, organization, economic, political, ecologic and social solutions, which will enable appropriate and socially acceptable integration of the area of exploration and output of gas from unconventional resources with legal, economic and social frameworks binding in our country.

## 4 Conclusions

To conclude, we wish to stress, that in spite of more than three-year period of warming up the atmosphere and creation of 'shale euphoria' in Poland, other EU countries are very sceptic or even reluctant when it comes to this topic. It is not very possible to speak about a 'revolution' on the gas market, the way it is happening in the USA or about economic revolution in this sector. The conservatism of Europe is fully justified, not only because the degree of recognizing and development of possible supplies is at much lower level than in the USA, or because practically nobody in Europe possesses 'know-how', but also an appropriate amount of equipment or human resources which could be soon referred to operations of this kind. What is absolutely necessary is verification of assumptions of the Polish energy policy (PEP2030). The possibility to prepare and, possibly, implement the principles of common energy policy of the European Union, must be considered.

*Received in June 2012*

## References

[1] Ministry of Economy 2009: *Projection of demand for fuels and energy until 2030*. Appendix 2 to 'Energy Policy of Poland until 2030'. www.mg.gov.pl (in Polish).

[2] Ministry of Economy 2011: *Update of projection of demand for fuels and energy until 2030*. www.mg.gov.pl (in Polish).

[3] EIA, World Shale Gas Resources: *An Initial Assessment of 14 Regions Outside the United States*, April 2011.

[4] HIS Global Insight CERA: *The Economic and Employment Contributions of Shale Gas in the United States*. http://anga.us/media/235626/shale-gas-economic-impact-dec-2011.pdf

[5] Kaliski M., Krupa M., Sikora A.: *The potential of the Polish power [energy] market as a possible direction of monetization of the Polish unconventional natural gas resources*. Department of Economics and Business at the Cracow University of Economics, ISBN 978-83-62511-25-9, 792-806 (in Polish).

[6] Kaliski M., Krupa M., Sikora A.: *Possible impact of the unconventional natural gas reserves and economic crisis for the current forecasts and LNG market development in Europe*. R. Borowiecki, J. Czekaj, eds.). Toruń 2011, ISBN 978-83-7285-612-8 (in Polish).

[7] Kaliski M., Krupa M., Sikora A.: *Projeciotion and / or scenarios, including quantification area of forecasting, time and costs* . Arch. Min. Sci. **57**(2012), 2, 423–439 (in Polish).

[8] Janusz P., Kaliski M., Rychlicki S., Siemek J., Sikora S., Szurlej A.: *Impact of shale gas on the natural gas market in Poland*. Rynek Energii **5**, 118-124 (in Polish).

[9] Kuhn M., Umbach F.: *A game changer with implication for the EU's energy security*. EUCERS Strategic Perspectives of Unconventional Gas, May 2011.

[10] Nagy S., Siemek J.: *Natural gas production from shale rock in Europe: state of the technology – the risks and opportunities.*. Arch. Min. Sci. **56**(2011), 4, 727–760 (in Polish).

[11] Nawrocki J.: *Balance of Natural Gas Resources in Poland*. January 2010.

[12] Kuuskraa V.A., Stevens S.H.: *Worldwide gas shales and unconventional gas: A status report*. Advanced Resources International, December 2009.

[13] Ministry of Economy: *Polish energy policy until 2030*. www.mg.gov.pl, 2009 (in Polish).

[14] Polish Geological Institute: *Assessment of extractable resources of natural gas and oil in shale formations*. First Report. Warsaw 2012 (in Polish).

[15] Radler M.: *Worldwide oil production steady in 2011; Reported reserves grow*. OGJ, December 5, 2011.

[16] Wood Mackenzie: *Unconventional gas service analysis: Poland/Silurian Shales*. August 2009.

[17] Wood Mackenzie: *Unconventional gas for Europe – A game changer or incremental supply?*. April 2011.

[18] EUROGAS: *Roadmap for moving to a low-carbon economy in 2050*. www.eurogas.org.

[19] Ministery of the Environment: www.mos.gov.pl/kategoria/260_mapy (in Polish).

**Niekonwencjonalny gaz ziemny – Stany Zjednoczone, Unia Europejska, Polska**

S t r e s z c z e n i e

Światowy rynek gazu przechodzi obecnie istotne zmiany. Najbardziej obiecujące miejsca w Europie, do poszukiwań i wydobycia gazu ziemnego z niekonwencjonalnych zasobów to, między innymi: Austria, Węgry, Polska, Niemcy i Szwecja. Biorąc pod uwagę możliwości ich wydobycia w Europie (choć ciągle jest ona dość niepewna) Unia Europejska (UE), w swoich prognozach, nadal nie uznaje ich w ogólnej ocenie popytu i podaży gazu ziemnego. Konserwatywne podejście w Europie do zasobów gazu z łupków ciągle jest jeszcze w pełni uzasadnione, ponieważ praktycznie nikt w Europie nie posiada '*know-how*' (brak jest sprzętu lub zasobów ludzkich, które mogłyby być wkrótce wykorzystane do tych działań). To co jest absolutnie konieczne na obecnym etapie to weryfikacja założeń polityki energetycznej Polski (PEP2030 ). Możliwość przygotowania i ewentualnie wprowadzenia zasad wspólnej polityki energetycznej Unii Europejskiej, muszą być uwzględnione.