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Energy and environment policy in Poland: Various aspects in the context of shale gas extraction

Polityka energetyczna i środowiska przyrodniczego w Polsce: Różne aspekty w kontekście wydobycia gazu łupkowego

Abstract: *This article outlines the social approach of meeting the challenges of energy policy in Poland in the context of potential shale gas extraction, focused on social perception and environmental protection policy. While Poland holds promising shale gas resources, the state of current technology indicates that shale gas exploitation is not imminent. However, shale deposits are still considered a potential future resource that could play a central role in diversifying energy sources, developing the economy, and potentially increasing the country's energy security. This paper presents energy opportunities of Poland, a review of Polish society opinion about energy and environment security. This study shows that Polish society sees a connection between energy, environment and policy problems, as well as potential benefits in the context of shale gas, based on research results of various institutions, including the European Commission. The author draws attention to tasks before the economic exploitation of shale gas in order to optimizing socio-economic benefits, and short- and long-term impacts. Since we are a common Europe, a common space for people, we can create an energy policy. It is the way the topic of energy diversification opportunities in Poland and the building of consistent energy and environmental protection policy is still an important issue to discuss in humanistic and economic fields.*

Keywords: *social perception, public opinion, shale gas, energy diversification, energy policy, environment policy, Poland*

Streszczenie: *W niniejszym artykule nakreślono społeczne podejście do wyzwań polityki energetycznej w Polsce w kontekście potencjalnego wydobycia gazu łupkowego, ze szczególnym uwzględnieniem percepcji społecznej i polityki ochrony środowiska. Chociaż Polska posiada obiecujące zasoby gazu łupkowego, stan obecnej technologii wskazuje, że*

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eksploatacja tego surowca nie jest bliska. Jednak złoża łupków są nadal uważane za potencjalny przyszły zasób, który mógłby odegrać kluczową rolę w dywersyfikacji źródeł energii i rozwoju gospodarczym oraz potencjalnym zwiększeniu bezpieczeństwa energetycznego kraju. W artykule przedstawiono możliwości energetyczne Polski, przegląd opinii polskiego społeczeństwa na temat bezpieczeństwa energetycznego i ochrony środowiskowego. Z badania różnych instytucji, w tym Komisji Europejskiej wynika, że społeczeństwo polskie widzi związek między problemami energetycznymi, środowiskowymi i politycznymi, a także potencjalnymi korzyściami w kontekście gazu łupkowego. Autorka zwraca uwagę na zadania stojące przed ekonomiczną eksploatacją gazu łupkowego w celu optymalizacji korzyści społeczno-ekonomicznych oraz oddziaływań krótko i długoterminowych. Jako że jesteśmy wspólną Europą, wspólną przestrzenią dla ludzi, możemy wspólnie kształtować politykę energetyczną i środowiskową. Stąd podjęty w `niniejszym artykule temat pozostaje ważną kwestią do dyskusji.

Słowa *kluczowe: percepcja społeczna, opinia publiczna, gaz łupkowy, dywersyfikacja energii, polityka energetyczna, polityka środowiskowa, Polska*

Introduction

Analysis of the shale gas potential exploitation is still up-to-date and undertaken in many contexts. There are disputes about prospects for shale gas development in Central Europe with the consideration to the local political situation and the environmental risks (Ivanenko, Schlesinger 2012); geopolitical implications of Ukrainian shale gas as well as new perspectives on European energy and security sectors (Little 2012); the socio-economic impact of shale gas extraction in America and potential opportunities for Poland (Albrycht et al. 2012), as well as the implications of findings with regard to the prospects for shale gas development in the EU by 2020–2030 with emphasis placed on the environmental and social aspects of economic extraction of shale gas (Kavalov, Pelletier 2012). There are analyses of factors that reduce hopes of copying the U.S. shale gas revolution in Poland, Ukraine, the Baltic States because of poor exploration results, more restrictive environmental legislation, the obstacles including public acceptance to commercial shale gas production within Europe (Stähr, Madlener 2016). Moreover, a structurally different natural gas infrastructure solution in the stochastic and the deterministic models was presented (Fodstad et al. 2016). In Poland, there is a GDP increase and potential for speeding up economic growth by implementing action

connected with the rise of efficient energy (Kasperowicz 2013). However, failure to produce shale gas domestically would lead to continued high dependency on natural gas imports. That is the reason to simulate possible future patterns of the Eastern European gas supply (Stähr, Madlener 2016), research into possible taxation mechanisms for firms that will be operating in the shale gas industry in Poland (Walentek 2016). The new evaluation method offers insights into the potential reservoir and geo-mechanical properties of shale gas deposits in Poland (Krakowska et al. 2017). Shale gas interacts in mutually reinforcing ways with social, cultural, political, and economic forces (Goldthau, Sovacool 2016). There is a possibility to develop shale gas in a sustainable way (Cooper et al. 2016).

This paper shows the social approaches to potential shale gas extraction, focusing on domestic energy resources and social perception of resources using environmental protection policy, and energy security in Poland. Poland holds promising shale gas resources, which have been widely discussed because of the environment protection, the UE law implementation, and national energy policy. In Polish society, we can observe activity in presenting their opinion about shale gas.

It is widely accepted that the optimal solution for the Polish economy is radical change and departure from the use of coal, as well as its replacement with renewable and nuclear energy as soon as possible. The author decided to look at energy conditions in Poland, including public opinion about shale gas exploitation in the country, recognizing social acceptance of mining activities as a substantial element of energy policy. The study was to analyse the social perception of the use of various energy sources in the country in the context of Poland's economic development and the overall political situation of the region, identified energy resources, and applicable EU directives. The goal was also to indicate specific actions to optimize the potential benefits of shale gas extraction.

An important question in a dynamically developing democratic country is which resources guarantee development and are acceptable to society. Despite the lack of investors' interest in shale gas at the moment in Poland, it is clear that when technological solutions are obtained, the topic of the use of unconventional gas deposits will return to the forefront. What is the rational solution between economic rise, energy resources and environmental and social considerations, on the example of the potential shale gas development in Poland?

The questions that emerged are: What energy condition based on domestic resources are in Poland? What is the Polish perception of shale gas extraction and other energy resources in the country? What are the energy alternatives for Polish policy and the development of the economy? What potential benefits and risk can be from shale gas extraction in this country? Is there a universal model of gains and risk in the context of shale gas extraction?

This article based on some kinds of data: (i) national statistical data (Central Statistical Office of Poland, in Polish: GUS) in the period from 2015 to 2017; (ii) official reports and analyses, e.g. of public opinion evaluation presented by Polish and European institutions; (iii) research articles about energy resources from Poland; (iv)a national and speciality websites, (v) news websites. Most of the background data and information were collected from sources available publicly since 2005. It is a confrontation of different official sources and data and finally a synthesis of political and social perception of energy resources focusing on shale gas potential. Any technological aspects of shale gas exploitation are beyond the scope of this study.

1. Economy of Poland, environment protection and shale gas perspective review

This part of the article presents Polish economic condition and system of environmental protection, including the UE Directives against other countries approaches to shale gas. In Poland, agricultural activities take up 60% of the surface area, forests cover 30% and industrial activities and urban areas the remaining 10% of the country. Agriculture, however, only makes up 4% of the country's GDP, while industry contributes almost a third and services just under two-thirds of its GDP. 32.6% area of the country is subject to various forms of nature conservation (GUS 2020a, *Basic data...*). These comprise national parks; nature reserves, landscape parks and protected landscape areas and others objects of ecological interest, ecological utilities, natural and landscape complexes, and *Natura 2000* (which covers one-fifth of Poland's land area, slightly exceeding the European average) (GUS, 2015). Since 1999 there is formal ecological education in schools (MEN 1999). On the other hand, CO2 emission

in Poland was 7.88 metric tonnes per capita in 2018 (World Bank 2018). In 2004 Poland was admitted as a fully-fledged member of the EU. At the same time, the historically high unemployment rate has been gradually falling (GUS, 2016). Economic growth in Poland is estimated to increase to (3.4% in 2018) (World Bank, 2017), and in 2019 the GDP growth was 4.15% (World Bank 2019).

The new problem is the COVID-19 pandemic, first identified on 30 December 2019, contributed to the aggravation of financial difficulties in Polish households with regard to financing expenditure on energy carriers, and the long downward trend in the level of energy poverty in Poland has reversed (Nagaj, Karpysa 2020). During the COVID-19 pandemic, drastically altered patterns of energy demand around the world are observed, estimating the decrease in CO2 emissions during confinements. Daily global CO2 emissions decreased by –17% by early April 2020 compared with the mean 2019 levels, just under half from changes in surface transport. During the peak, emissions in individual countries decreased by –26% on average. Government actions and economic incentives postcrisis will likely influence the global CO2 emissions path for decades (Quéré et. al 2020). E-commerce has become a substitute source and considered top in this condition, and e-retailers provides goods that usually consumers bought in the superstore traditionally (Bhatti et. al 2020). In Poland, the share of online sales of goods in retail sales increased to 7.3% compared to 6.8% in September 2020 (GUS 2020). It is expected in the future that some companies will adopt this online sales solution as an additional (or completely new) form of business activity.

Poland has adopted a number of international environmental conventions, including the Convention on Biological Diversity, as well as "Ramsar", "Paris", and "Helsinki" conventions; there are nine Man and Biosphere Reserves in Poland.

While these conservation initiatives are welcome, they must be seen in the context of the fact that the development of the Polish economy has caused a continuous increase in energy demand. In 2025–2030, the greatest demand for final energy will register by the following sectors: industry, transport and households. The main media of this demand are oil products, electricity, natural gas, and coal (Ministry of Energy, 2010).

Shale gas resource potential has been recognized in several EU countries (US Energy Information Agency (EIA, 2013). While the EU sets overall goals and targets those countries' respective strategies for energy

development and economic investment opportunities vary, as do their respective political and social situations (Kruger, 2016). Germany, for example, emphasizes renewable energy sources (RES), and France on nuclear energy, while the UK imports natural gas and is seeking new energy sources (Winid, 2016). In some countries, there is inadequate legislative action and a lack of economic opportunities or social acceptance for investigating shale gas extraction. Germany adopted a law prohibiting hydraulic fracturing for the extraction of gas and oil from shale (SHIP, 2014). In Poland, horizontal drilling revealed the complexity of the geological structures and deep position of shale gas. American experiences are insufficient to make a quick operation in Poland.

Poland is not without air pollution. The highest smog in the history of the country was observed in the winter of 2016–2017. The Art. 96 of the Act of the Environmental Protection Law, which is a resolution for reducing emission, resulted in the first anti-smog regional law in the Małopolska region in 2017, then in Silesian, and Mazovian voivodeships.

Areas of Polish shale layers are of clay from the Upper Ordovician and Silurian Baltic Basin and Podlasie – Lublin, of an area of 65 thousand square kilometres. The most promising are part of the northern (Silurian) deposits, as well as the Baltic Sea Basin. With retention deepening in a westerly direction, the thermal maturity of rocks increases. The Fore Carpathian Monocline white clay rocks also partially meet the criteria for extraction.

Shale gas resource estimates by the PIG using Estimated Ultimate Recovery (EUR) indicate that in this strip, from the shelf areas of the land part, the entire shale gas lifespan is approximately from 346 to 768 billion cubic meters and is 5.5 times more than thus-far documented domestic conventional resources. The estimate is based on the layer thickness and the ratio of the Total Organic Carbon (TOC), at least 2 per cent wt. (by weight). The average gas flow test is 11–15 thousand square meters per day from the well, and this is not an economically viable flow. Estimates of oil and gas resources will be adjusted with the incoming data from the areas of exploration (PIG-PIB, 2012a). Oil resources in the same area are estimated within the range of 268 million tonnes, which are more than proven reserves of conventional gas, which are about 26 million tonnes. Poland is even before the stage of economic exploitation, which was initially planned for 2014, although this was an optimistic plan based on the anticipated possibility of using American technology.

Until September 5th, 2016, concessionaires performed reconnaissance on 72 holes (Table 1 and Table 2). Recently, the concentration of concessions has been observed in the regions of Pomorze and Lubelszczyzna.

Table 1. Numbers of wells drilled in 2010–2015

Years	2010	2011	2012	2013	2014	2015
Number of wells	3	12	24	14	15	4
Number of hydraulic fracturings	2	7	8	4	4	0
DFIT	1	0	7	1	0	-

Source: Ministry of the Environment, 2016a.

Table 2. Number of exploratory shale gas wells by type of operation (as of Sep 5, 2016)

	Vertical drilling	Directed drilling into horizontal	Total
Hydraulic fracturing treatments performed	14	14	28
DFIT only (microfracturing)	4	0	4
No hydraulic fracturing	26	4	40
Total	54	18	72

Source: Ministry of Environment 2016.

The latest data from 2017 indicate that no new drillings were made (the number remains at 72) with the existence of 7 licensees (Polish and foreign in total); points to the existence of 26 concessions on land and 3 concessions in the Baltic Sea in Poland at that time. The area covered by the licenses was 15.59 thousand square kilometres (e-petrol.pl dated September 8, 2017). That indicates a change in the shale gas exploration trend and the lack of development in the field of shale gas exploration in Poland. These data are confirmed by other sources (a map published by the Ministry of Environment (2016), NIK report (2016) (Maciejewski 2018) which indicates a change in the trend and no development in the field of shale gas exploration in Poland.

2. Energy resources in environmental context review

Aspects of environmental protection exist for each method of energy generation in Poland.

2.1. Coal

The poor financial condition of the mines is a result of the extraction of ever-deeper coal seams, the bloated structure of management and intermediaries and, additionally, at the present, low coal prices in the world. Despite this, the production of electricity in Poland is 73.6% based on coal it means 48.1% hard coal and 25.5% lignite (Forum Energii 2019). Presently, there are two active coal regions: Upper Silesia and the Lublin region.

The resource of black coal is the foundation of the Polish industry. Mining in 2013 was 76.5 million tonnes, and import 10.8 million tonnes (mainly from Russia, 6.6 million tonnes, 1.6 million tonnes of the Czech Republic, Ukraine 1 million tonnes) (Olkuski, 2011). In 2019 the production of black coal was about 62 million tonnes (and import from Russia, Columbia, Kazakhstan, and others). Lignite mining extraction was 66 million tonnes (in 2013). Polish Energy Policy until 2030 assumes that coal will maintain a significant role in electricity production. The total import and export of coal in Poland are balanced (Olkuski, 2011), and in 2018 the import was 276 thousand tonnes and export 287 thousand tonnes. Black coal is not balanced, and the import was 19,245 thousand tonnes, and in the export was 4,908 thousand tonnes (GUS 2019, Rocznik statystyczny...).

The coal is sufficient to maintain the energy security of the country. Changes in coal energy policy have recently focused on reducing the consumption of raw, crude (unrefined) coal in favour of enriched combustion coal, but the production of this is still too small-scale (Blaschke, 2008). Poland implements the provisions of EU environmental legislation in the energy sector, e.g. 2001/81/EC and 2001/80/EC (Blaschke et al. 2005) and is involved in the EU climate policy whose aim is to achieve a 40% reduction in CO2 emissions by 2030. Research in the field of coal mining indicates the potential to use modern solutions as (i) the processing of the coal in situ (the thermal method of underground coal gasification, production of flue gas and the use of Super Daisy Shaft method) (Palarski 2010); (ii) the method of coal methane drainage before trial operation; (iii)

technology to reduce emissions of sulphur and nitrogen oxides and mercury; and CO2 sequestration (CCS). The priority is now CTW – increasing the efficiency of extraction, processing and combustion, while CCS (CO2 capture and storage) has dropped to second place because of the difficulty of gas storage (Wnukowski 2014). Implementing a 'green' technology that allows coal to achieve the CO2 emissions of natural gas can reduce emissions. At the same time, work is progressing towards reaching: (i) a 2020 target of an up-to-20% decrease in greenhouse gas emissions relative to 1990 levels in Poland; (ii) a 20% share of renewables in the primary energy balance; and (iii) a 20% reduction in total consumption of primary energy (by increasing the efficiency of energy production, the efficiency of receivers, savings, etc.).

The National Plan for Energy and Climate for 2021–2030 (KPEiK) was adopted by the European Affairs Committee at its meeting on December 18, 2019, and it sets the following 2030 climate and energy goals: (i) 7% reduction in greenhouse gas emissions in non-ETS sectors compared to 2005 levels, (ii) 21–23% share of RES in gross final energy consumption (the 23% target will be possible to achieve if Poland is granted additional EU funds, including for a just transition), taking into account:

- 14% share of renewable energy in transport,
- The annual increase in the share of renewable energy sources in heating and cooling by 1.1% annual average,
- An increase in energy efficiency by 23% compared to the PRIMES2007 forecasts,
- A reduction to 56–60% share of coal in electricity production (Ministerstwo Klimatu i Środowiska).

2.2. Nuclear power

European directives indicate nuclear energy as an alternative to coal. Crucial decisions on the use of nuclear power sources were taken in 2009. The National Atomic Energy Agency (PAA) is the central body of the government administration responsible for matters of nuclear safety and radiological protection: "Prawo atomowe" of 2000 and the regulations under that act. Program Polskiej Energetyki Jądrowej 2014–2030 (PPEJ – Polish Nuclear Power Programme) includes the following tasks: issuing permits for construction, commissioning, exploitation and decommissioning of power based on analysis and surveillance safety assessment,

etc. According to PPEJ (Ministry of Economy in 2007 to 2015), the first nuclear unit in Poland was to be launched in 2025 (extended to 2029). There was appointed a team for the implementation of high-temperature reactors (HTR) classified as a new, 4th-generation reactor, and work to explore the potential development of new reactor technologies in Poland. An initial estimate (2015) shows the operation of two nuclear power plants could bring tax revenue of 420 million PLN to the annual state budget for approx. 80 years. This will depend, among others, on the contract value according to the Energy Efficiency Directive 2012/27 / EU (EED). Such information will be known in 2019 (Ministry of Energy, 2017).

But the alternative to coal in Poland could be a source of gas, wind and nuclear (Tyszecki, 2010). However, Polish society has a negative experience of the event in Chernobyl in 1986 and popular opinion on the appropriateness of nuclear power development in Poland.

A Polish-American intergovernmental agreement on cooperation in the development of civil nuclear technology was signed in Tallinn in October 2020. The Nuclear Energy Policy Program (PPEJ) (2020–2033 with a perspective to 2040) was amended and published in the Polish Monitor. The aim of the program is to build and commission nuclear power plants with a total installed capacity of approx. 6 to approx. 9 GW. The implementation of nuclear energy as part of synergy with RES is to be a solution that will enable the rapid achievement of climate neutrality (PAP 2020).

2.3. Renewable energy resources (RES)

The development of the energy sector based on RES is important in achieving the objectives of the EU climate and energy policy and reducing CO2 emissions, as well as the diversification of Poland's energy sources. The concept of RES is well known in Poland, but its location in the temperate zone is not conducive to the wide use of solar energy. Below are the dynamics of growth in the share of RES in obtaining energy. A linear fit was performed to estimate the values of a share of RES in total primary energy generated, in order to fill the gap in the data set in Poland.

The total structure of RES energy production in Poland in 2013 was dominated by solid biofuels (80%), with the remaining sources being liquid fuels (8.2%), wind energy (6.1%), hydropower (2.5%) and solar (2.1%) (GUS 2014). The electricity came from solid biofuels (46.4%), wind energy

(35.2%), hydropower (14.3%), biogas (4%) and municipal waste bioliquids and solar energy (0.061%). Solid biofuels are also a fundamental vehicle in the production of heat from RES (over 97%).

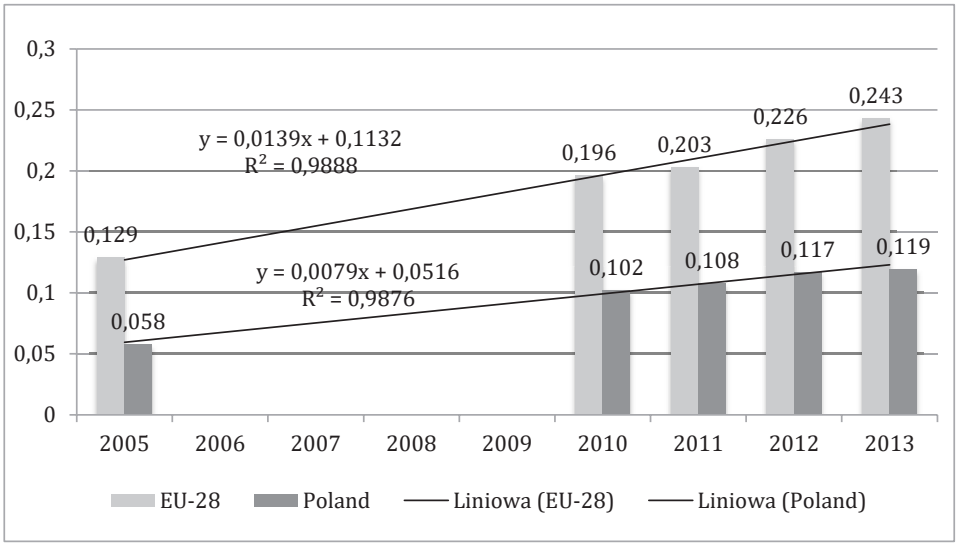

Figure 1. Share of RES in total primary energy in the EU-28 and Poland in 2005, and 2010–2013.

Source: Based on data by 2015a.

The share of RES in the energy mix is gradually rising (Table 3 and 4) Ministry of Energy, 2010. Solid biofuels are still the primary medium in the production of heat from RES (over 97.9%) (GUS, 2015a).

Table 3. Share of RES in Polish energy in 2005–2014, and the 2020 EU target for Poland

	2005	**2010**	**2012**	**2013**	**2014**	**2020**
Gross energy consumption	7.20	9.20	10.90	11.30	11.45	15.00

Source: Based on data by GUS 2015.

Table 4. Share media RES in electricity production and obtaining it in 2014

	Solid biofuels	Wind	Water	Biogas	Solar energy	Bioliquids	Municipal waste	Geothermal energy	Heat pumps
Share in electricity production (%)	46.170	38.680	11.000	4.110	0.035	0.0002	-	-	-
Share of total energy obtained (%)	79.62	8.18	2.33	2.57	0.21	9.23 (liquid biofules)	0.46	0.25	0.15

Source: Based on data by GUS 2015.

In order to implement the Polish Energy Policy focused on increasing the share of RES in final energy consumption to the level of 15.5% in 2020 (19.3% for electricity, 17% for heating and cooling, 10.2% for transport fuels), it is necessary to invest in new generation capacity (Polska Agencja Informacji i Inwestycji Zagranicznych) (PAIZ, 2013).

Polish agriculture provides the raw materials for bioethanol production in the form of corn (domestic maize accounts for 80% of the contribution of raw materials) and other grains. Biodiesel is produced almost entirely from domestically grown rapeseed supplemented by imported rapeseed oil. In 2016 Poland's total production of bioethanol was estimated at 0.2 MMT (there is a significant surplus of current domestic production capacity) and 0.8 MMT of biodiesel. Consumption of biofuels in Poland depends mainly on prices of gasoline and diesel, as well as the policy towards implementing EU regulations. The Renewable Energy Directive (RED) of the EU sets a general target of 20% renewables in all energy used by 2020 and creates a sub-target of 10% renewables in the transport sector. For 2016 the National Indicative Target (NIT) for use of biofuels in transport for Poland was set at 7.1%. The NIT will grow to 7.8% in 2017, to 8.5% in 2018 and to 10% in 2020. As of 2017 the upper limit for first-generation renewable energy is set at 7%, and the remaining part of the target must be met from other sources of biofuel. Fuel suppliers are also required to reduce the greenhouse gas intensity of the EU fuel mix by 6% by 2020 in comparison to 2010 (Global Agricultural Information Network) (GAIN, 2016).

Table 5. Share of RES in energy supplies in Poland (%) in 2010–2020

Sector	Data (%)			
Heating and cooling	12.0	14.0	13.9	17.0
Electricity production	6.2	10.7	12.4	19.4
Transport	5.3	6.0	5.7	10.4
Overall share of RES	9.1	11.3	11.4	15.5

Source: Based on GUS 2015; EU Biofuels Annual. EU-28; IEA, 2010.

According to the EU policy of sustainable development, biofuels produced from waste and non-food products get a bonus. In Poland, bio-components from non-food raw materials (mainly cellulose, lignocellulose and waste residue materials) are promoted. The most common are small electricity or electro-heat biogas plants sourcing from landfill sites, which account for more than half of this type of installation (GAIN, 2016).

The data from 2019 shows that the share of RES in electricity production is 15.4% (ARE), while in 2018 the structure of primary energy production from renewable sources in 2018 RES was as follows: solid biofuels 69.3 %, wind 12.4%, liquid biofuels 10.2%, biogas 3.2%, hydro 1.9%, municipal waste 1.1%, solar energy 0.9%, heat pumps 0.7%, geothermal 0.3 % (GUS 2020, *Energia 2020*).

Poles are also involving in the RES policy in the EU. This can be proved by the diversification of RESstructure of household energy consumption per 1 inhabitant in 2018: natural gas 18.4%, electricity 13%, fuelwood 13.4%, heating oil 0.4%, hard coal 32.3% heat from the network 19.4%, other energy commodities 0.7%, liquefied petroleum gas (LPG) 2.2%. Indirectly, it indicates the growing public awareness of the need to change the energy policy from the use of coal to the use of the RES (GUS 2020b, *Energia 2020*). Various government programs help in the change. The development of RES in 2018–2019 is mainly the result of investments in prosumer installations. At the end of 2019, RES accounted for 9.5 GW (20.1% of installed capacity), of which 1.5 GW (3.5%) were installations photovoltaic. This is the result of several support programs as *My Electricity, Clean Air, Energy Plus, Prosumer, and Agroenergia*. Onshore wind energy accounts for 5.9 GW (12.5%) as of December 31, 2019 (Forum Energii 2020).

According to forecasts, in Poland the installed capacity of photovoltaic installations 2.5 GW in 2020 and may reach 7.8 GW in 2025. (IEO 2020). Furthermore, a 100 hectars solar farm is planned on the site of an opencast lignite mine near Brudzew in Central Poland which will produce 70 MWp of power (Słomiński 2020).

2.4. Natural gas and oil resources

In Poland, apart from coal and wind energy, biofuels (as a source of natural gas) are important in terms of power supply. The statement of the 5th IPCC Report on the possible positive role of natural gas in the fight against global warming and replacing coal as an energy source, sides with the implementation of natural gas production in Poland. Poland has many years of experience in the extraction of conventional natural gas, mainly in the Polish Lowlands (68.6% of the resources) and on the foothills of the Carpathians (30.4%) and in the Carpathians (1%) (where they are mainly deposits with high methane coal) and covers one-third of their needs. Gas consumers are manufacturing (37%), domestic consumers (26%), and the service sector 13% (IEA, 2009). In 2018, the structure of natural gas use in Poland was as follows: 51.5% (industry), 19.9% (households), 14.8% (electricity and heating), 10.4% (services), 3.0 % (transport), 0.3% (others) (Energy transformation in Poland. 2020 edition) (Forum Energia 2020).

Polish conventional natural gas resources amount to 165 billion cubic meters, and annual consumption in 2012 was 15.8 billion cubic meters (Ministry of Economy, 2015). The country produced 4.4 billion cubic meters of gas in 2012, against a demand for 14 billion cubic meters for the year. Imports come mainly from Russia (9 billion cubic meters) and over 2 billion from the EU (Ministry of Economy, 2015). Long-term agreements with Russia mean that imports from this country represent two-thirds of Polish needs, and prices are high (in 2013 they were between $460 and $490 per 1,000 cubic meters of natural gas) and bear no relation to the dynamics of global natural gas prices after the shale gas revolution in the USA. Signing the agreement on the continuation of imports in October 2010 did not improve the economic situation in Poland. Moreover, in 2022, the contract with the Russian state-owned company Gazprom will end).

The forecast of natural gas production in 2021 (evaluated as high-methane gas with a heat of combustion of 39.5 MJ / m3) is 4.0 in billion m3 (PGNiG 2019).

The idea of constructing a gas port in Poland was first presented in 2006 at the meeting of the National Security Council. The first delivery from Qatar was in December 2015. The second, at the beginning of 2016, contained 210,000 cubic meters of liquefied natural gas, equivalent to about 130 million cubic meters of gas in its natural state. The LNG terminal in Świnoujście will be able to receive imports of 5 billion to 7.5 cubic meters of liquefied natural gas (LNG) per year.

The annual growth in demand for natural gas was 2.3% for 2000–2009. This suggests that the demand for gas will increase over the 2009 level by 28% by 2020 and 52% by 2030 (Ministry of Energy, 2010). The daily gas consumption in January 2010 averaged 71.2 mcm/d (IEA, 2011). It is estimated that in the coming years' demand for gas will increase to 16 billion cubic meters per year. The extraction of oil in 2013 in Poland amounted to 1 million tonnes (consumption of 24 million tonnes per year), and the potential to extract oil from shale is attractive. This interest intensified with the advent of the Nord Stream project (in operation since 2012; the dominant share being German–Russian), bypassing Baltic countries, including Poland and affecting Central Europe. Additionally, the armed Russian–Ukrainian conflict has been ongoing since 2014. This is accompanied by a continuation of the economic policies towards the construction of the Nord Stream II, the implementation of which will stop two other natural gas investments in the region: the Jamal II and Amber. With the current political and economic situation in Central Europe, Poland is still seriously considering the use of shale resources.

In 2019, PGNiG received approximately 3.5 billion m3 of LNG from the port of Świnoujście (imports from Qatar, the USA and Norway). This terminal achieved a high level of use, reaching 60–65% in 2018–2019 (Czyżewski 2020).

In the EU, energy issues fall within the exclusive jurisdiction of the Member States, and the decision of whether to take action or not is a decision which belongs to the individual states. However, environmental protection is a matter for the EU. The Committee of Public Health and Food Safety and the Committee of Industry, Research, Science and Energy address issues of unconventional resources. In addition, Poland is subject to, among others, EU Directives: 94/22/EC on the conditions for granting and using authorizations for the prospection, exploration and production of hydrocarbons; 2006/21/EC on the management of waste from extractive industries; the Water Framework Directive (2000/60/EC);

and 2011/92/EU on Environmental Impact Assessment. In 2014 the EC defined what it calls minimum standards' to be applied by member countries in using the method of hydraulic fracturing, and which relate primarily to informing public communities about the chemical composition of the fluid technology and environmental monitoring (EC, 2016).

In Poland, there is no permanent problem with access to drinking water. The average annual precipitation is 600 mm per year. Water resources available for direct operation are about 30 cubic kilometres of surface water and 16 cubic kilometres of groundwater per year. Poland has around 1,600 cubic meters of water per person per year, and the lowest access to water is in the Lodz province, with 1,000 cubic meters per person per year. Water withdrawal for irrigation was 76,766 thousand cubic meters in 2010 (GUS, 2012) and is increasing. In Poland, there are droughts, which sometimes cause long-term water shortages across a region or locally, such as at the turn of 2015–2016. In the Koniecpol commune and other municipalities of Lower Silesia, drought forced investment in deepening wells or building water supplies. The most-affected farms were in the provinces of Kujawsko-Pomorskie, Mazowieckie and Podlaskie. This drought caused agricultural losses of approximately 75%. Record low water levels were recorded for the Vistula River in Warsaw in 2012 and 2015.

The main users of water resources are industry (74.2%), agriculture – including irrigation (10.6%), municipal (for population) (15.2%). According to the assessment of the European Environment Agency (EEA, 2011), Poland belongs to the group of EU countries with a low prevalence Water Exploitation Index, below 20% in 2007, a value that has decreased since the 90s. Hydrological estimates in (Frankowski et al. 2009). Total water consumption for the needs of the national economy and the population was 8,816,039,8 cubic metre in 2019 (GUS 2020a). In this context, vertical fracturing needs about 1,500 to 1,700 cubic meters per frack, and horizontal fracturing uses about 10,000 to 20,000 cubic meters of water per frack. Preliminary estimates of the water abstraction reservoir stimulation process indicated the need for 1,000 to 5,000 cubic meters of water per fracturing, but the first fracturing done in Łebien required nearly 18,000 cubic meters of water (PIG-BIP, 2012b). Geologists point out that, across the whole area, which is rich in shale gas, geological conditions may vary significantly and consequently may need different volumes of water. In Poland, the corporation buys the water for fracturing from a national institution. The first shale gas flowed in July 2013 in the Łebien well (LE-2H)

near Lębork. The pad included 3.74 hectares of land. In 2011 drilling was performed to a depth of 4.1 kilometres and a horizontal length of 1 kilometre, where the fracture was performed. Fracturing consumed 17,322 m^3 of water from the aquifer. The corporation, in accordance with the applicable law, collected the water over a period of several months so that it did not violate groundwater resources. Monitoring before and after fracturing showed no negative changes in the environment. So far several studies have been conducted to evaluate the potential and actual impact on the environment. While modelling potential developments indicates a possible influence of fracturing fluid and a return to the generation of new chemical processes, e.g. corrosion, the tests in surveyed areas showed no effect on the environment or underground water, *inter alia*, as a result of deep shale deposition and sealing layers above them (Krogulec and Sawicka, 2012, 2013). Similar results were obtained by the OOŚ, as well as by reports from various national research centres and institutions (GDOŚ, 2012) and individual regional OOŚ reports for Oleśnica (GEOKrak. 2012) or Łubienia (PIG-BIP, 2012b). They note that, according to current knowledge about potential threats, there is a need to implement safe practices due to the fact that the analysis carried out in Poland applies only to the exploration and reconnaissance stage.

It should take into account the threat of causing earthquakes resulting from injecting hydraulic fluids.

2.5. Policy for shale gas

A distinction is made between general laws relevant to shale gas extraction on the one hand, for example, environmental protection and environmental assessment laws, and legislation dedicated to conventional and unconventional oil and gas extraction, on the other, in particular, the Hydrocarbon Tax Act enacted in January 2015.

Furthermore, the Geology and Mining Law (PGG), has been amended to shorten administrative procedures. It introduces a single, combined concession for the recognition, exploration and exploitation of sources. That preserves the rights previously acquired by investors, with a possible extension of their validity or conversion into a new type of license.

The Ministry of Environment is amending its laws on assessments of environmental impact, transposing EU Directive 2011/92/EU (known as 'Environmental Impact Assessment' – in Polish, OOŚ) onto

the environmental (natural and social) impact assessment of certain public and private projects. There was amended the act on the provision of information about the environment and its protection, public participation in environmental protection and environmental impact assessments, and other acts" (Dz.U. 2015 item 1936 as amended) (ISAP).

The Secretary of State plays an important role in the policy of state resources in relation to the Ministry of Environment, the Chief National Geologist (GGK) and the government plenipotentiary of national resource policy from 2016 creating the Polish Geological Survey with taking into account the State's policy on raw materials, and making amendments to the Act Geological and Mining Law (PGG) and related laws responding to earlier comments in the report of the Supreme Audit Office (NIK, 2013). Now, there is in the construction of a comprehensive policy of geological and raw material policy (Sejm, 2016b). There is no provision for changes in the types of licenses or the Act relating to the special hydrocarbon tax (2014); the execution of the activities referred to in this law PGG (art. 7, paragraph 1 and 2 of the Act of 9 June 2011, the Geological and Mining Law, Dz.U. of 2015, item 196 as amended.) (ISAP) is allowed only if it does not violate its destination properties specified in the zoning plan and in separate regulations, and, in the absence of a local zoning plan, undertaking and pursuing activities specified by the Act is only permissible if this does not violate the use of the property asset in the Study of Conditions and Directions of Spatial Management of the commune and in separate regulations. According to Article 95 paragraph 3 of the Act, within 6 months from the date of approval of the geological investment, deposits of hydrocarbons must compulsorily be entered into the operations of the County Study of Conditions and Directions of Spatial Management (Studium Uwarunkowań i Kierunków Zagospodarowania Przestrzennego Gminy).

In the process of prospecting, exploration and potential extraction of shale gas and oil, the following acts play an important role: (i) the Act on Freedom of Economic Activity; (ii) the Environmental Protection Law (leading to the issuance of licenses for exploration, recognition and extraction); (iii) Geological and Mining – covering activities in the field of exploration and prospecting of minerals, and extraction of minerals from deposits can be made after obtaining a license (Art. 21); in the field of hydrocarbon, concessions granted by the Minister of the environment (Art. 22); (iv) the Water Law, The Act of 18 July 2001, (Journal of Laws of 2005. No. 239, item 2019, with subsequent. D.); (v) The Law of 3 February

1995, for the protection of agricultural and forest land. Other minor acts also apply, such as: (vi) the Law on sharing information about the environment and its protection, public participation in environmental protection and environmental impact assessments; (vii) the Waste Act: The Act of 27 April 2001 (Dz. U. of 2010. No. 185, item 1243, as amended. D.); (viii) the Act on mining waste; and (ix) the Act of 10 July 2008 (Dz. U. 2008, No. 183, item 865) (ISAP).

According to the current law in Poland, there is a prohibition on the implementation of projects in national parks and nature reserves. However, geological and mining work is possible in landscape parks and protected areas of a landscape after establishing no effect in the OOŚ environmental impact assessment, and in Natura 2000 protected areas after establishing in an OOŚ that there will be no significant impact on the objects of protection. Polish law recognises the possibility of environment hazard associated with the exploration and extraction of hydrocarbons involving work being conducted, e.g. in marine areas, underground, or via boreholes to depths of more than 1,000 metres.

Currently, the extraction of natural gas from unconventional shale gas deposits is not a key issue as confirmed by the signed contract for the construction of six nuclear reactors (2020) to launch a nuclear power plant in Poland.

3. Social perception and related aspects of shale gas review

This part of the article shows what is Polish perception of shale gas extraction and other energy resources in the country.

The population density in those areas with proven potential shale gas reserves in Poland is varied. Thus, in rural areas such as the province of Pomerania (Pomorskie) average population density is only 126 persons per square kilometre; and in the Lublin region (Lubelskie) 85 persons per square kilometre. In stark contrast, the density in the urban areas of Trójmiasto, (the three inter-linked cities of Gdansk, Gdynia, and Sopot) varies from 1,762 to 2,179 persons per square kilometre, while Kujawsko-Pomorskie has 116 persons per square kilometre, and Mazowieckie 150 persons per square kilometre. In Warsaw, the population density is over 3,355 persons per square kilometre (GUS, 2015b).

Carrying out exploration and extraction activities in urban areas poses a threat to the quality of life of people living there, including noise and light pollution, temporary increases in traffic in the vicinity of houses, air pollution and general inconvenience to day-to-day activities. In addition, the possibility of shale gas extraction generating earthquakes as a result of injecting fluids is a serious issue, particularly in urban areas with high population density (Ellsworth, 2013).

Although the last 20 years have seen dramatic changes in governance and the rule of law, there are incidences of loopholes being exploited by interested parties, including stakeholders with an interest in furthering a development agenda. Moreover, Poland is not free from corruption, with the Corruption Perceptions Index – Transparency International (CPITI) standing at 62 points in 2016 – a factor which caught the attention of the Supreme Audit Office in Poland – based on analyses from the period 2007–2012 (NIK, 2013). Thus, legal loopholes and corruption are among the factors that increase the risk of proper procedures not being applied at various stages of the shale gas exploration and production process. A related problem is the inability to deal with the overloading of the road infrastructure in Poland during the execution of construction investments. This results in increased risks, such as the risk of an environmental disaster.

A survey and public consultation concerning the extraction of unconventional fossil fuels was conducted in 2013 by the European Commission) (EC, 2016, 2013) in which Poles accounted for 53% of the respondents, according to the Polish Press Agency (PAP). The survey revealed that a third of Poles favour extraction, a third are of the opinion that such activities should only be conducted if there are adequate safeguards for human health and the environment, while the remaining third are opposed to the extraction of unconventional hydrocarbons altogether. A related quantitative research survey, which tested the general opinion of the Poles to the actual and potential use of energy resources in the country, including unconventional gas resources, was carried out over a period of several years and was published in April 2013 by the Public Opinion Research Centre (CBOS). This survey was carried out after the 2011 Fukushima disaster and revealed that 52% of the Polish population opposes the creation of a nuclear power plant in Poland, while 35% support the construction of such a plant. Significantly, in 2009, 50% were in favour of construction. Asked about the potential choice of energy sources, particularly nuclear or shale gas, the number of responses in favour of shale

gas increased between 2011 and 2013 (Pankowski, 2013). The opinion of nuclear energy may be aggravated by the negative experience of Poles after the Chernobyl disaster in 1986.

Eight per cent of the population were in favour of atomic energy or thought it should be the major national energy source. Similar percentages were pro-nuclear as were pro shale gas (23% in 2011 and 24% in 2013), while significantly more opted for more power from shale gas than nuclear, or shale gas only (43% and 47% in the given years) (Pankowski, 2013).

A further survey on a sample of 1,000 Poles aged over 15 showed that 65% of respondents prefer RES, provided that it does not result in increased costs. The preferred sources are shown to be solar energy (38%), wind (22%), coal (17%), gas (12%), nuclear power (6%), and biomass (5%) (RWE, 2014). Despite the existence of certain hazards as a result of the exploitation of shale gas, studies showed that 80% of the populations support exploration and mining on Polish territory. Moreover, more than half of Poles think that any mining would bring more benefits than losses for both the country (51%) and municipalities (county) where work will be conducted (49%). The people are most often interested in information relating to the project's environmental impact and economic aspects of shale gas exploitation (Stasik et al. 2014).

In years 2011 and 2013, the number of people expressing no opinion on shale gas extraction fell, with support rising evenly for groups supporting and opposing the economic activity, which indicates the social interest in the issue and the gradual building of an opinion on shale gas exploitation (CBOS, 2011, 2013).

The respondents did not perceive shale gas and nuclear sources as competing against each other: 24% are in favour of energy production only from shale gas, and 2% only from nuclear power. Twenty-three per cent is for the development of both new branches in Poland, while 43% indicates a focus on shale gas, and 8% focus primarily or exclusively on the production of nuclear energy. Five per cent believe that Poland should not develop either of these branches of power. Studies were carried out on a sample of 1,051 people – a representative random sample of adult Polish citizens in 2011 (CBOS, 2011) and 2013(CBOS, 2013). Most respondents felt that shale gas extraction will increase the energy security of Poland and will protect it from the domination of foreign deliveries, at least in part. This opinion was expressed in the years 2011 and 2013 by 80% and 82%,

respectively, with 3% and 5% opposing the opinion. The group of respondents expressing no opinion fell by 4%, from 17% to 13%.

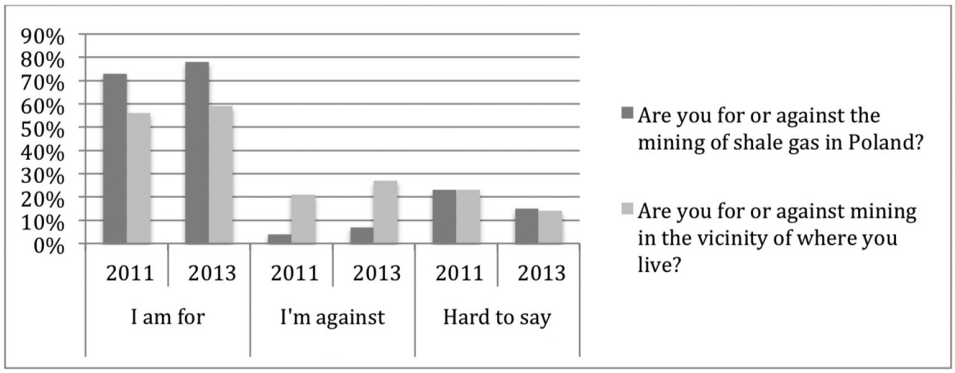

Figure 2. Percentage of the population who are for or against the extraction of shale gas in Poland and in the vicinity of their place of residence, in the survey 2011 and 2013.

Source: Based on the CBOS 2011 and CBOS 2013.

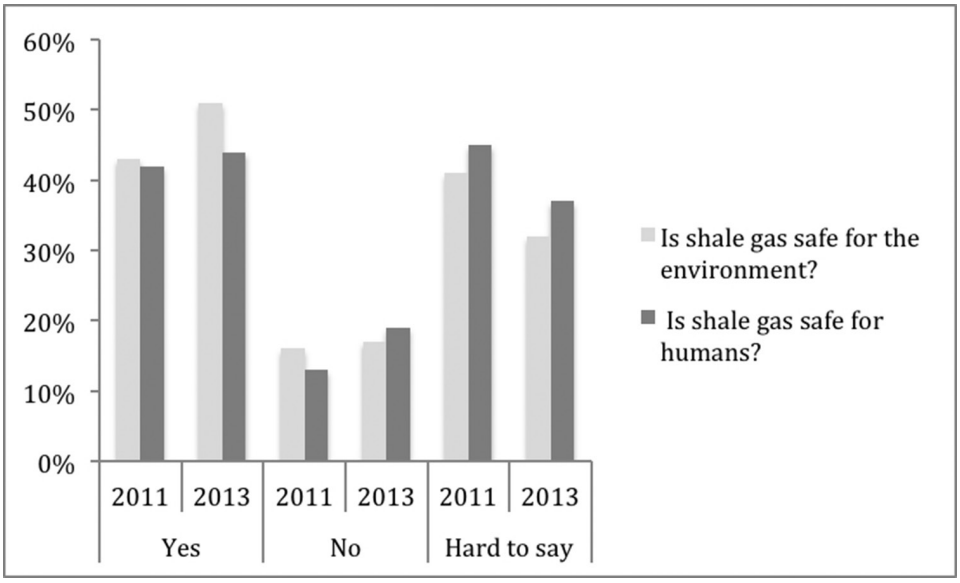

Figure 3. Percentage of the population who are of the opinion that shale gas extraction is safe or dangerous for the environment and the human, in the survey 2011 and 2013

Source: Based on the CBOS 2011 and CBOS 2013.

Computer-Assisted Telephone Interviewing (CATI) was conducted in 2013 among adult residents living in the following four provinces, where shale gas exploration is being conducted or being planned: Pomorskie, Kujawsko-Pomorskie, Warmińsko-Mazurskie voivodeships (for this study referred to as Northern Poland), and Lubelskie. The total research area is home to approximately 4.6 million adults. Among the total population studied, residents of municipalities with drilling exploration represent 10% of the population. The Lubelskie region has 300 municipalities (counties) with drilling concessions but no wells, and 100 municipalities with concessions with wells (total it is 40%); in Northern Poland, there are 450 municipalities with drilling concessions but with no wells and 150 municipalities with concessions with wells (representing 60%). In Northern Poland and Lubelskie, 92% of respondents had heard about shale gas. In Northern Poland, 48% of respondents and 64% in Lubelskie know that their province is covered by concessions for exploration, but on average, only 16% know that a concession has been granted to the county in which they live (in Northern Poland – 14%, in Lubelskie – 20%). Respondents in both areas are similar to the overall Polish population in terms of acceptance of shale gas extraction: 72% are in favour of shale gas extraction, 7% oppose, and the remainder do not have a definite opinion; 58% would stand for the extraction of shale gas in their area if it went ahead (TNS, 2013).

In the context of environmental risks, shale gas is seen in a better light than raw materials such as oil, coal or lignite; 51% of respondents across Poland believe that shale gas is environmentally safe, and 17% that it is dangerous. Across the two regions, the corresponding percentages are respectively 58% and 29%. Most respondents believe that Polish law will ensure environmental protection. Around one-quarter of respondents are sceptical of public institutions and companies' exploration and production. Nearly 23% of respondents had knowledge of which institutions are responsible for the protection of the environment during the exploration and production of shale gas. Knowledge of the potential hazards was declared by less than 40% of respondents, the same in every region. However, residents of Lubelskie expressed more fear of damage related to the water. Half of the respondents from both regions would like to obtain more information on shale gas, most often from local authorities (49%). The vast majority (86%) of the inhabitants of these two regions agreed with the statement that the extraction of shale gas would lead to

the country becoming partly independent from energy supplies, such as natural gas, from abroad (TNS, 2013). Poles are more likely now to participate in meetings about shale gas organized by local governments, and sometimes to resist exploration plans. Awareness of the co-creation of living conditions in communities in Poland has been increasing after decades of communist policy. This is borne out by increased evidence of collective lawsuits against government organizations because of losses in flooded areas during the flood in 2010 in several Polish regions, incidences of so-called 'flickering shadow' caused by wind turbines, and protests by local farmers (Żurawlów near Zamość city) who do not agree to the shale gas exploration by one corporation on a neighbouring parcel. On the other hand, examples from Lubelskie shows interest in the new activity as an opportunity for local development.

4. General model of risk and benefits of shale gas

The question of the new technological solution for the economic shale gas extraction in Poland will arrive remains open. But generally, the balance of economical as well as social benefits and the environmental risk and losses are discussed. The Royal Society and Royal Academy of Engineering concluded in 2012 that the health, safety and environmental risks could be managed effectively in the UK by implementing and enforcing best operational practice. The fact is the water pollution incidents in Wyoming. In response, the US Environmental Protection Agency (EPA) undertook studies on the impacts of fracking on drinking water resources. The 2012 RS/RAE study concluded that fracking taking place hundreds of meters below aquifers, it is unlikely that it will contaminate the aquifers, and this is consistent with the opinion of Polish geological scientists; it found that the more likely cause of possible contamination includes faulty wells, and called for the same stringent controls as apply for offshore wells (Delebarre et al. 2017).

What potential benefits and risk can be from shale gas extraction in this country? Assessment of the potential benefits and losses is complicated in the social context. Benefits can we select by Country economy (the lower price of gas, Greater energy security, Stimulation of development), regional economy (Benefit is higher competitiveness), local economy (New

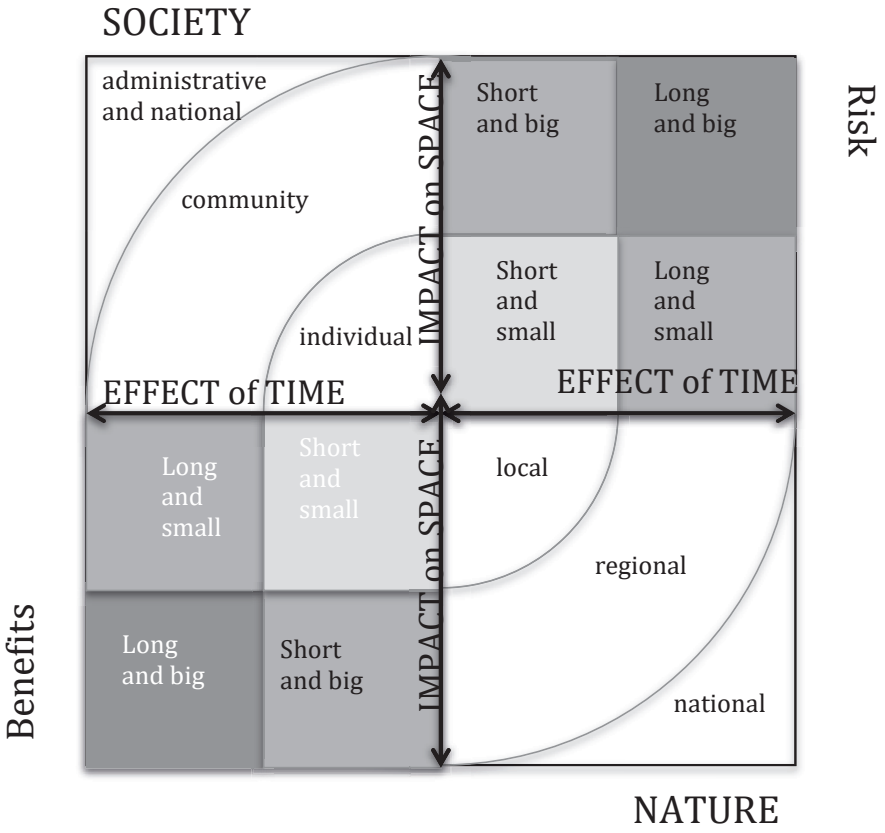

Figure 4. Conceptual model of risks and benefits of shale gas: Temporal and spatial impact on society and nature.

investment, higher employment and lower unemployment, investment of shale gas exploitation companies in local development), Tax braces local communities and small businesses). Potential threats there are soil degradation, forest degradation, the possibility of episodic damage and pollution (air, water pollution, waste), gas emission, periodical emission (light and dust emissions), and periodical load on the existing road network, deterioration of life quality, damage in agriculture and reduced tourism.

The exploitation of gas and oil shale also requires an understanding of the crossing of the spatial and temporal effects: (i) in the spatial context (the presence of protected areas, a large density of population, local spatial

and development plans), (ii) and in terms of time (short- or long-term nuisance to residents, the period of time needed for land reclamation and any long-term changes in nature, as well as the long-term benefits for the local community). The author presents below a conceptual map of the crossing of the spatial and temporal effects as well as benefits and risk as to the universal model. It is a proposal of a theoretical model describing the basic properties of the subject of this study that are the risk and benefits of shale gas operation, in nature and social relationships context. The proposed model is the basis for further scientific discussion as well as investigation.

5. Results and discussion

A review of research has shown that Poles have a different view on shale gas extraction in Poland and the use of nuclear energy than Western European countries.

Looking at energy conditions in Poland, including public opinion about shale gas exploitation in the country, recognizing social acceptance of mining activities is an important element of energy policy in a democratic country. The young Polish market economy has enjoyed rapid growth since its transformation to a market economy because of growth mainly in consumption, investment in construction, and recently the improving tax (especially value-added tax) enforcement. However, the numerous EU directives that have been implemented since 2004 have driven legislative changes, but have slowed down the formation of a stable socio-economic system. Furthermore, political tensions in the region since 2014 have intensified the search for the optimum and secure energy mix needed for the development of the country. The period has seen the gradual withdrawal of Western Europe from developing nuclear energy after the Fukushima disaster in 2011, which resulted in a lack of public acceptance of nuclear energy. Simultaneously natural conditions in Poland are not conducive to wide solar energy and focus yet on coal deposits using. Energy forecasts indicate that energy demand in 2030 will be met in the main by crude oil, natural gas, and coal resources with the particular role of natural gas while adhering to environmental protection regulations and adapting to climate change. The focus on natural gas is consistent with social acceptance for shale gas.

The Poles have demonstrated a strong commitment in expressing their opinion on shale gas during the public consultation by the EC (EC, 2013). Comparison of surveys for the European Commission DG Environment is being agreed with domestic studies.

Polish public opinion is relatively cohesive in accept of potential exploitation of shale gas, and its support for renewable energies, but the wealth of the society does not allow for their widespread use; they are aware of the need to move away from coal as an energy source because of environmental and climate change; the idea of the environment protection is knowledge in Poland because implementation it to school education is from the 90. of XX centre.

This article shows public acceptance of Poles to commercial shale gas production and it is a different point of view than the general view as the obstacles within Europe. Most Poles do not opt for nuclear energy, but incline towards the use of unconventional resources; and they appreciate the importance of domestic energy sources for the security of energy, both the general public and the communities living in the areas of exploration and potential mining.

About half of the public believes that the exploitation of shale gas will be beneficial for the country and local areas; and also aware of the risk to the environment.

This investigation recognized the social perception of the use of various energy sources in Poland in relation to Poland's economic development in the context of the overall political situation of the region, identified energy resources and applicable EU directives. The study shows that awareness of the co-creation of living conditions in communities in Poland has been increasing. Respondents did not perceive shale gas and nuclear sources as competing against each other. But almost a quarter of the society is for the development of both new branches in Poland, while nearly half of society indicates a focus on shale gas, and a few per cent of respondents focus primarily or exclusively on the production of nuclear energy. Most respondents felt that shale gas extraction will increase the energy security of Poland. In the context of environmental risks, shale gas is seen in a better light than raw materials such as oil, coal or lignite. Most respondents believe that Polish law will ensure environmental protection.

It is widely accepted that the optimal solution for the Polish economy is a radical change and a departure from the use of coal as well as the replacement of renewable energy and nuclear energy as soon as possible.

Still, abundant deposits of coal and lignite are the foundation of energy in Poland, and the existing infrastructure means that this raw material continues to make sense in the Polish economy – especially in heating. The mining industry still employs tens of thousands of people in coal mining areas across the country. Lack of nuclear power and relative expensive RES favours existing coal innovated extraction, diversification using gas and LNG import from the new direction of the world, as well as focusing on research of shale gas economic extraction.

Paradoxically, global warming in the temperate zone, where Poland is located, may contribute to a change in approach to energy.

6. Conclusion

The interest of economic shale gas extraction in Poland has multi-levels reasons that are: (i) providing the economic development for the high populated European country, (ii) providing the security of energy policy that need fast diversification, (iii) protection of the environment in the country and larger share of natural gas in the growing economy, (iv) and society accepting for this kind of energy resources using.

An implementation and enforcing of the best operational practice are the universal direction in shale gas using. Therefore the aim for shale gas policy should be to create optimum gains and risk which is a long term and maximum of benefits for the individual, community, regional and national economy as well as reducing the long negative impact of extraction to short time and small losses for space and scale of local, regional and national area and the environment used by the society.

7. Recommendation

Searching for a rational solution for the further guaranteed economic development of Poland, as well as energy and environmental policy accepted by the society, it was found that at the time of economic development, drastic withdrawal from coal exploitation could cause economic weakness, therefore investments in new technologies reducing emissions

from coal mining. During this time, intensive research should be conducted into new solutions for the exploitation of shale gas in Poland. These investments should be parallel to the construction of a new generation nuclear power plant.

Based on this review there is recommended: Diversification using gas and LNG import from the new direction of the world, diversification of energy resources, wider use of wind energy especially on the coast, create attractive projects with an acceptable financial solution for society interested in RES using individual.

The gradual shift from coal mining requires rationalization and investment in new technologies at every stage, while CTW is a priority in improving the efficiency of extraction, processing and combustion, as is the implementation of 'green' coal technology. Technologies for methane obtaining are also being worked out. Other energy sources also require a big investment, as in nuclear reactors (HTR); and the implementation of RES new generation, whose usefulness is not predictable in the long term. In taking into account the implementation of the European legislation and the fulfilment of international agreements to reduce CO2 emissions and protect the natural environment it is possible to use natural conditions for Polish economic growth only by implementing new technologies. On the other hand, the need for the rapid diversification of energy sources in Poland because of the political situation in the region calls for: the use of carbon sources, infrastructure, and existing human resources, with a trend of gently move away from coal mining; the use of unconventional resources; and implementation of RES to a reasonable extent using domestic agriculture for biomass production focusing on second-generation biofuels.

The study also indicated actions to optimize the potential benefits of shale gas extraction. Benefits and risk can be evaluated using short- and long-term impacts and results. Potential long-term benefits in Poland could be local and national: (i) reduction of unemployment in the regions of operation, local and regional development; the social acceptance to extract shale gas is partly linked to development needs (e.g. Lubelskie region), (ii) and national diversification of energy resources and energy security. This has to be done in an environmentally acceptable manner. Poland can witness short-term hazards arising from the exploitation of shale gas: (i) disturbances to the rational use of water in periods of drought, (ii) platforms being located too close to communities and decreased quality of life because

of air, noise and light pollutions (related to the need to refine legal principles), as well as long-term: (i) threats to protected areas, (ii) the possibility of groundwater contamination, (iii) and losses to local agriculture and tourism. A threat can also be posed by the lack in many parts of the country of Local Spatial Development Plans, which are important in residence protection; this lack encourages the possibility of omission of the law.

Assuming exploitation of shale gas will occur in the future, the recommendation is as follows: (i) the environment monitoring of emissions and protection against pollutions, (ii) protecting water in terms of public health and security of water resources, (iii) realizing commitment to reduce emissions in the EU, (iv) avoiding protected areas and large population centres, (v) and reliable remediation after the end of industrial activity by preparing soft and efficient transformation from the mining profession to other professions related to the restructuring of the region and the use of local potential, e.g. history, tourism) and active education of the young generation to adapt to new professions, business and IT.

Using shale gas in Poland would require additionally: (i) verification of Polish law for better protection of social quality life in the local area during extraction; (ii) obligatory local planning in order to adapt to the new social activity because of unconventional resources; (iii) creation of the plan for short and long local development strategy; (iv) wide information system for the local community.

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