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SECURITY OF ENERGY SUPPLY AND GAS DIVERSIFICATION IN POLAND

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Security of energy supply and gas diversification in Poland*

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Abstract

Poland entered the twenty-first century with an unsustainable energy/electricity mix, strongly over-dependent on coal. This situation seems to be changing very slowly, while there are multiple factors that make it imperative for the issue to be urgently addressed. On the one hand, this paper aims to assess the security of the stationary fuel supply by applying the conventional three-dimensional approach, encompassing availability, affordability and sustainability. On the other, we plan to use our own scheme to analyse gas diversification (*Weiner*, 2017: 6), i.e. a fuel which, alongside coal, is a very sensitive issue linked to the security of the Polish electric power fuel supply. We demonstrate that the three-dimensional approach is also appropriate for addressing the issue of supply security in the case of a country with a securitized energy agenda based on fears of problems with the availability and affordability of Russian gas supplies. It also highlights Poland's concern over foreign technological reliance regarding renewables production. We show how the energy perspective, the institutional context, as well as perceptions regarding threat, dependence and Russia influence choices made from among different security of supply dimensions. We find that though the role of coal will surely decrease, there is great uncertainty about Poland's energy policy and security of supply because of deficiencies in infrastructure and the unknown future role of the particular fuels in the energy/electricity mix, also expected to include nuclear. We can observe that every energy policy step possible is being taken to maintain the role of coal, and Poland moves toward sustainability only as much and as soon as it is required by its EU membership. Not only does the coal industry capture Poland's energy policy, but also geopolitical considerations cement reliance on coal, providing low energy import dependence. Regarding gas, we find that since the January 2009 Russian–Ukrainian gas crisis, Poland has taken action to diversify its gas supplies, and it has finally achieved results, but there is still a lot of uncertainty surrounding Russian gas imports.

JEL: L71, L95, O13, P28, Q4

Keywords: Poland, Russia, Central and Eastern Europe, energy security, security of supply, gas diversification, coal, gas, nuclear energy, renewables

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1. Introduction

This paper is the second in a series assessing gas[1] diversification and the security of the supply of stationary fuels in selected Central and East European (CEE) EU member states (Hungary, Poland, Lithuania and Bulgaria). With in-depth case studies, this series underlines these countries' different conditions, various priorities, and thus differing energy policies, despite their common concerns, primarily linked to being dependent on Russia for energy supplies (*Weiner*, 2016). These differences have broad policy-oriented implications. For instance, due to the cross-border implications of energy policy decisions, one cannot ignore the energy policies of other countries. Conflicting energy policies can lead to conflicts and become barriers to regional cooperation, while such is essential to enhance supply security and has been strongly encouraged by the EU. Since the 2009 Russian–Ukrainian gas crisis, not only the EU member states but also the EU itself have been focusing strongly on supply security and establishing such cooperation networks. With events in Ukraine in 2014, Russia came to represent a real threat for many Europeans, and thus the EU found an external enemy against whom to unite (*Overland*, 2017: 126). The EU's February 2015 Energy Union Framework Strategy called for moving away from fossil fuels and a centralized, supply-side approach relying on old technologies and outdated business models, as well as away from a fragmented system of uncoordinated national policies and energy-isolated areas (*Vinois*, 2017: 43). The Energy Union Framework Strategy stated that it would consider reframing the energy relations with Russia (*Yafimava*, 2015: 15). Since then, the European Commission has published several packages of measures to ensure the Energy Union is achieved, and has also published regular reports on the progress of the Energy Union (*European Commission*, n.d.-b). However, without a complex assessment of the particular CEE countries, one will not understand the reasons behind energy policy decisions and security of supply and diversification achievements or be able to influence these processes.

The first country assessment referred to Hungary (*Weiner*, 2017). In the first part of our research, we defined several energy policy-related concepts, and then focused on security of supply and diversification in order to find the appropriate methodology for

[1] If otherwise not indicated, gas refers to natural gas.

assessing the selected CEE countries. As a result, on the one hand, we took a conventional approach to assessing the security of stationary fuel supply, and, on the other, we used our own scheme in order to understand gas diversification. The presented methodology allows cross-country comparisons, and makes it possible to arrive at some generalizations. Thus, using the same methodology, this paper looks at our second country, Poland.

This paper is structured as follows. *Section 2* discusses the methodology. It deals with two notions, security of supply and diversification. Regarding security of supply, it questions whether the chosen methodology can be applied without modifications to a country which has a securitized energy agenda. Here, geopolitical considerations and the notion of the “energy/gas weapon” are addressed in detail. *Section 3* presents and discusses the empirical results through the lens of two case studies. After providing a snapshot of Polish electricity market trends, *Section 3.1* assesses the security of supply of coal, renewables and nuclear power in Poland. *Section 3.2* starts with a look at the role of gas and Russian gas in Europe (*Section 3.2.1*), while *Section 3.2.2* centres on Poland’s gas diversification options and achievements. Finally, conclusions are drawn in *Section 4*.

2. Theoretical framework

In order to assess energy policy decisions and achievements, comprehensive definitions of several energy policy-related concepts should be provided. For a net energy importer, the most important among these are security of supply and diversification. Security of supply is one aspect of energy security, while the other is security of demand, which net energy exporters aim to increase.

Security of supply has no uniform definition. There are different ways of approaching the term (*Table 1*). One can limit one’s understanding of the issue purely to traditional survival-based definitions, but special care should be shown when attempting to move the term security from a military context and apply it to non-military issues, particularly to energy (*Buzan et al.*, 1998).[2] Another approach is applicable if security of supply is considered as a concept that has different dimensions. The simplest and oldest definitions are two-dimensional, referring to availability and price. These two dimensions can also be called the physical and the economic dimensions (*Cherp et al.*, 2012: 330) or physical and price security (*Wicks*, 2009: 8). However, over time, many multidimensional definitions have emerged, reflecting the different interests and energy-related challenges in various time periods, but many dimensions can overlap in one way or another. Aside from the aforementioned, other possible definitions have also been proposed. For example, according to *Cherp and Jewell* (2011), security of supply has three perspectives – sovereignty, robustness and resilience.

Table 1. A compilation of different definitions of security of supply

1. Traditionalists' survival-based definitions
– *Buzan et al.* (1998)
2. Dimensional classifications
– two-dimensional definitions: availability and price (cost)
– *Manners* (1964), *IEA* (1985), *UNDP* (2000), *Yergin* (2006, 2011)
– three- and multidimensional definitions
– *Elkind* (2010): availability, reliability, affordability and environmental sustainability
– *APERC* (2007): four 'A's: availability, accessibility, affordability and acceptability
– *Sovacool and Mukherjee* (2011): availability, affordability, technology development, sustainability and regulation
– *Alhajji* (2007): economic, environmental, social, foreign policy, technical and security dimensions
– *Wicks* (2009): physical, price and geopolitical security
– *Hippel et al.* (2011): environment, technology, demand-side management, social-cultural factors and international relations or military risks
3. Other definitions
– *Cherp and Jewell* (2011): three perspectives: sovereignty, robustness and resilience
– *Stirling* (2007): system properties consisting of stability, durability, resilience and robustness

Source: Weiner (2017: 4).

In our paper (*Weiner*, 2017), we argued that the conventional three-dimensional approach, encompassing availability, affordability and sustainability, was appropriate to consider security of supply. Here, the main focus is on primary energy fuels – coal, natural gas, renewables and nuclear fuel[3] – in relation to electricity as a secondary energy source,[4] but the three-dimensional approach is also applied, in part, to electricity

[2] Cited by *Yafimava* (2012: 12).
[3] Oil is not discussed here as it is principally a transportation fuel.
[4] Heat is only partially covered here. However, regarding gas diversification, the whole domestic gas consumption is taken into consideration.

(i.e. in relation to specific primary energy).[5] As mentioned, the great advantage of this simple method is that it allows cross-country comparison. However, Poland's approach to energy policy is securitized. For one who looks at energy as a private good with strong public goods characteristics, energy is a matter of low politics. Nevertheless, for many states, such as Poland, energy policy is also a matter of high politics. Hence, some of its public goods characteristics are of a strategic nature (a strategic good) (*Anderson et al.*, 2017b: 4). Poland's attitude is no novelty. What is new is how the EU's approach has changed. Due to the return of geopolitics in the 2000s and the 2010s, the EU has begun to implement policy answers aimed at making its regulatory state approach fit the current situation, in which other players are more mercantilist and consider energy both as a strategic good and a potential foreign policy tool. The European Commission responded to the Russian geopolitical challenge by treating Russia's state-controlled gas giant Gazprom as a dominant market player and deploying its full regulatory toolbox, as well as by applying a more direct and interventionist use of the EU's economic power (*Anderson et al.*, 2017a: 14).

Geopolitical considerations are also related to the notion of the "energy/gas weapon/diplomacy",[6] which has been widely debated in literature. There are two main questions linked to the energy weapon. One aspect to consider is the precise meaning of the term, and the other is whether Russia really uses such methods. According to *Smith Stegen* (2011: 6506–6506), "energy weapon" refers to a situation in which resources are converted into real political power through the manipulation of supply and prices and then used to yield foreign policy gains (to influence policies, coerce political concessions or punish customers). *Smith Stegen* (2011: 6506) claims that four stages or conditions are necessary for the successful implementation of an energy weapon: (1) the state must consolidate the country's energy resources; (2) the state must acquire control over transit routes; (3) the state must use the energy resources in an attempt to further its own political objectives; and (4) the dependent government must acquiesce to the

[5] Thus, exports, imports, electricity transmission infrastructure, and so on, are not in the forefront of the issues we consider.
[6] This is related to one of *Cherp and Jewell*'s (2011) three perspectives, i.e. *sovereignty*, even though this is a different approach. *Cherp and Jewell* suggest the following three perspectives on security of supply: the *robustness* of energy systems (sufficiency of resources, reliability of infrastructure and stable and affordable prices), their *sovereignty* (protection from potential threats from external agents, such as unfriendly political powers and overly powerful market agents) and their *resilience* (the ability to withstand diverse disruptions) (see *Table 1*).

threats, price hikes or cut-offs. *Smith Stegen* (2011: 6506) finds that Russia was more often unsuccessful than successful in implementing its energy weapon. *Yafimava* (2015: 3) defines the "gas weapon" as a reduction or cut-off of supplies in order to force compliance with political and strategic aims, and finds no evidence of Russia having used it in European countries, but acknowledges its application in Ukraine in the 1990s. *Grigas* (2012: 33) clarifies this by stating that except for the 1993 incident with Estonia, an unsuccessful one-day gas cut aimed at changing Estonia's citizenship policies, Russia has never engaged in a direct gas war in non-CIS Europe.[7] *Smith Stegen* (2011: 6509) also mentions the Baltic States as examples in non-CIS Europe – Estonia is again cited. Nonetheless, the supporters of the political argument can point to Putin's February 2003 speech at the tenth anniversary of the founding of Gazprom, during which he stated that Gazprom was a powerful political and economic lever of influence over the rest of the world (*Kupchinsky*, 2004).

Researchers with the Oxford Institute for Energy Studies have consistently and convincingly argued that Gazprom's commercial interests prevail over political considerations. *Pirani* (2012: 14) states that Russia's activities on export markets were directed mainly at strengthening Gazprom's commercial position, and this was very rarely trumped by political considerations. *Stern* (2015: 11) uses the concept of political pricing for Gazprom's decisions, supported or ordered by the Russian government, to tie gas prices to decisions on gas infrastructure or investments, or to other non-gas bilateral issues between Russia and the given country. *Stern* (2015: 11) argues that the European Commission's Directorate-General for Competition (DG COMP) confirmed the first allegation in relation to Bulgaria and Poland (see in *Section 3.2.2* below). As to the second allegation, we find that the practice of package deals can also be maintained by the consumer nation. For example, the Hungarian government (2010–) has tended to combine very different issues (the long-term gas supply contract, the Paks II project, the Budapest subway, and so on) into a single deal (*Menedzsment Fórum*, 2010; *24.hu*, 2010; *Grib and Lukyanov*, 2010). Even so, *Stern* (2015: 11) questions allegations over Gazprom's political gas pricing in non-CIS Europe, claiming that Russia aims at extracting maximum revenues (referring to the practice of discriminating monopoly

[7] The 12 non-Baltic former Soviet Republics still tend to be referred to as the CIS (Commonwealth of Independent States) countries, though, currently, it is a regional organisation consisting of only ten post-Soviet republics (Georgia and Ukraine are not members of the CIS).

pricing) rather than political concessions. However, *Stern* (2015: 11) mentions a recent exception, which occurred between the summer of 2014 and March 2015, when Gazprom intentionally failed to meet daily gas volumes as requested by many European buyers. This was supposedly at the request of the Russian president with the commercial intentions of curtailing reverse flow gas to Ukraine from Europe and thus forcing Ukraine to buy more Russian gas. It might also have been a means of providing support for falling European hub prices. *Yafimava* (2015: 3) also advocates the commercial argument, since "much of Gazprom's behaviour towards all European countries could be explained by its desire to extract maximum revenues rather than political concessions".

The problem is that once a sector is securitized, this legitimizes extraordinary steps to solve a policy problem and prevents that sector from becoming subject to regular political or academic debates (*Boersma and Goldthau*, 2017: 111). The Polish energy landscape is determined by two main factors. The first is Poland's need to reduce external dependence, while the second is to preserve the role of coal. The latter is also partly related to the first factor, in addition to other domestic economic, social and political aspects. Besides coal, the most sensitive issue regarding the Polish supply security is that of gas.[8] In contrast to coal, Poland is heavily dependent on gas imports. Poland's focus on self-sufficiency and independence from foreign influence is not a reaction limited to Russia alone, but also includes Germany (*Heinrich et al.*, 2017: 6). Dependence on Russia is linked mainly to gas and oil imports,[9] while in the case of Germany this dependence is seen as related to the country's renewable technologies. *Heinrich et al.* (2016: 2) argue that renewables are viewed by many as not only potentially risky for security of supply because they are considered expensive, unreliable and volatile, but they can also perpetuate Poland's energy dependence on foreign countries. There is concern that Germany is interested in spreading its transition by promoting its own industries and in further enhancing its technological dominance. Naturally, Poland considers Russia and its gas as the main threat to Poland's security of supply. Nonetheless, the trans-Baltic Sea Nord Stream gas pipeline brought together Germany and Russia within the framework of a project that poses a threat to Poland. It

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[8] The importance of the gas sector is also underlined by the Polish Policy for the Natural Gas Industry, adopted in March 2007, though this is a short and quite unsophisticated document (*Ministry of Economy*, 2007).

[9] Russian coal imports are not regarded as a threat (see below in section dealing with coal).

should be emphasized that Poland has palpable historical grievances towards both countries. For this reason, Poland is particularly sensitive to any such arrangements between its two neighbours. Historical relations with Russia have a decisive role in Polish energy policies. In the EU, Poland is considered to be part of the group of Russian sceptics, wishing to see the EU use mercantilist tools within the Energy Union to strengthen its position vis-á-vis Russia (*Nosko and Mišík*, 2017).

Politicians and industry players in Europe approach gas security differently. *Stern* highlights that "when politicians and media commentators speak about gas security problems, they only talk about Russia and nothing else", while gas industry people speak about "the decline of production in the Netherlands, the UK and, further in the future, Norway" (*Simon*, 2018). Poland is sticking to the "dependence on Russian imports equals gas insecurity" formula, which would be in line with the 1970s definition of supply security. The Baltic states approach gas security similarly, while other CEE countries are less politically motivated (*Jonathan Stern*, email communication, 7, 9 February 2018).

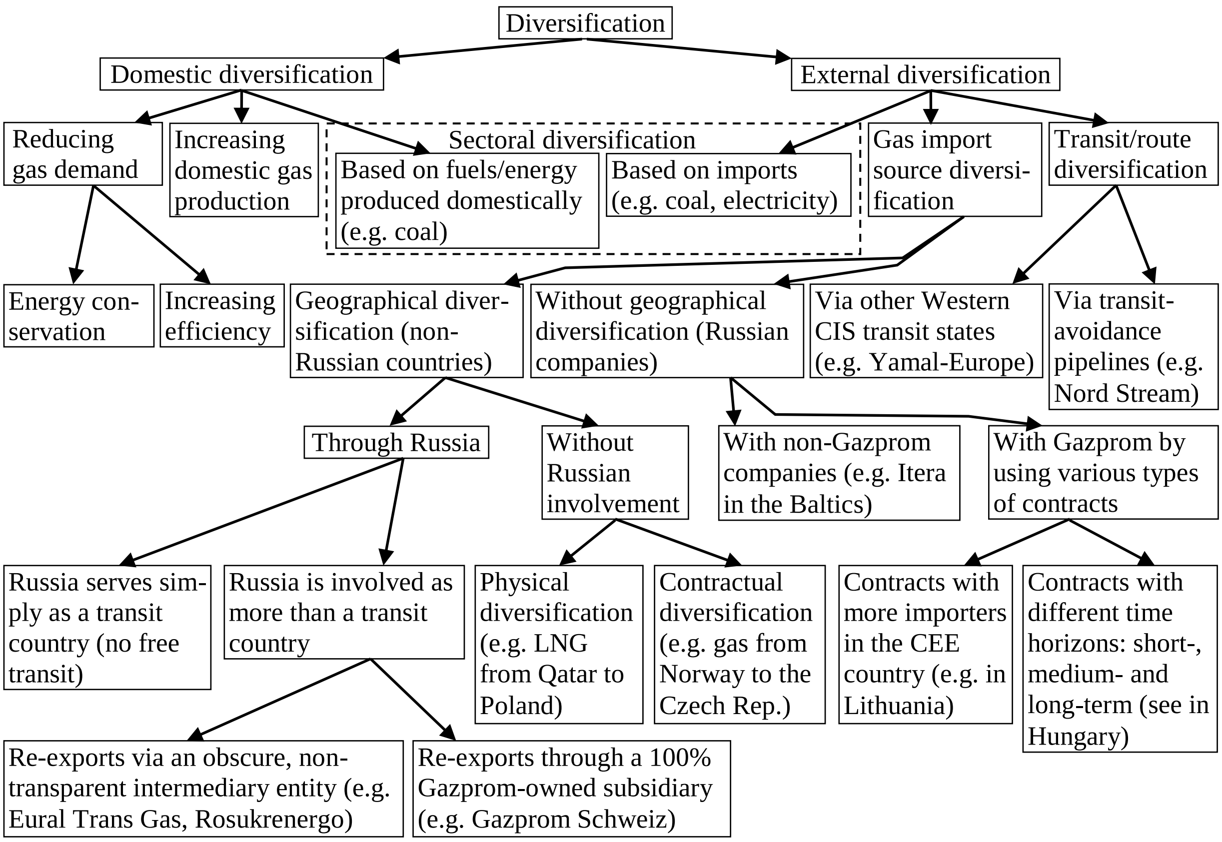
Energy independence can basically be interpreted in two ways. According to the hard definition, energy or gas independence refers to independence from energy or gas imports (i.e. self-sufficiency) (*Weiner*, 2016), while the soft definition suggests that the aim is to have import source diversity, in order to reduce reliance on unstable and unfriendly nations (*Branko*, 2012; *Stelzer*, 2009). Seemingly, Poland understands independence in a very strict sense, but, as *Bazilian et al.* (2013) conclude, this aim can promote suboptimal policy choices. However, full independence is extremely difficult to achieve.

Since the aim to reduce external dependence as much as possible is related to the fact that the energy policy agenda is securitized in Poland, a politically-motivated approach should also be included in the dimensional assessment of security of supply. Existing literature provides three options of coping with this problem: (1) these political considerations should represent another distinct (fourth) dimension of security of supply – in addition to availability, affordability and sustainability; or (2) these aspects could be included under the dimension of availability; or (3) an attempt should be made not to mix security of supply with geopolitical arguments, thus to treat geopolitical threats as outside the scope of security of supply. As presented in *Table 1*, there are several examples of the treatment of a politically-motivated approach as a distinct dimension of security of supply, such as *Alhajii's* (2007) six dimensions (economic, environmental, social, *foreign policy*, technical and security), *Wicks'* (2009: 8) three-dimensional approach (physical, price and *geopolitical* security), *Hippel et al.*'s (2011) comprehensive concept of supply security (environment, technology, demand-side management, social-cultural factors and *international relations or military risks*) and, for instance, the US President's All-of-the-Above Energy Strategy (energy supply availability, reliability, affordability and *geopolitical considerations*) (*EOP*, 2014: 20). Conversely, *APERC's* (2007) four 'A's of security of supply include geopolitical aspects under the dimension of *accessibility*. However, *Hughes* (2012: 229) claims that the omission of accessibility could be justified, since accessibility can be considered as part of availability: if access to an energy flow is problematic, this is reflected in its availability. In contrast, regarding gas, *Dickel et al.* (2014) distinguish gas security from among the various geopolitical threats to national security when discussing European dependence on Russian gas, and suggest that countries with strong geopolitical fears need to either terminate or not renew their long-term contracts with Gazprom. However, they warn this would require taking many additional measures, including investments in liquefied natural gas (LNG) import terminals, pipeline connections, alternative energy sources, energy conservation and efficiency. *Yafimava* (2015) also differentiates between commercial and geopolitical points of view when analysing European dependence on Russian gas.

In opposition to the above-discussed three options of coping with the analysed issues, we claim that the politically-motivated approach is not a separate dimension, or part of a dimension, or outside of the three dimensions, but rather an influencing factor. We argue that decisions on security of supply and diversification are the consequences of choices made from among different security of supply dimensions. These choices should be made on the basis of such influencing factors as the following: (1) the energy perspective (the energy market supply/demand and price conditions); (2) the institutional context (the role of the EU); (3) the government's approach towards dependence and its perceptions and expectations of threat, as well as its relations with Russia. Naturally, all these factors are dynamic and change over time. The politically-motivated approach equals our third category. As *Palonkorpi* (n.d.) claims, perceptions are important when evaluating dependence. In the case of Poland, these perceptions have a major influence on choices made from among different security of supply dimensions.

Finally, besides security of supply, another important concept is diversification, which is a means of enhancing security of supply. We have developed a scheme of different CEE diversification options for Russian gas imports (*Figure 1*). Basically, diversification can be domestic or external. Possible domestic diversification options include reduced gas consumption, increased internal gas production and sectoral diversification on the basis of fuels or energy produced domestically. External diversification comprises gas import source diversification, transit or route diversification, and sectoral diversification based on imported fuels or energy. The aforementioned diversification options can be further broken down.

Figure 1. Central and East European gas diversification scheme



Source: Weiner (2017: 6), partly based on *Balmaceda* (2008, 2013) and *Stern* (2002).

When evaluating stationary fuel supply and gas diversification, we review energy policies and related national and EU documents, as well as statements made by governments and other stakeholders on security of supply (threats). We also analyse stated aspirations and progress made towards enhancing stationary fuel supply and gas diversification over the past ten years, and investigate the reasons behind the results.

3. Case studies

3.1. Case study 1: security of supply in Poland

Since 1990, final electricity consumption and total gross electricity production in Poland has followed an upward trend with some slumps, while net heat production has shown a declining trajectory also with some fluctuation (*Eurostat*, 2018c, 2018d). In 2016, electricity production reached 166.6 TWh, while domestic consumption totalled 168.6 TWh. Poland used to be a net electricity exporter, but, for the first time in 2014, and then in 2016 (but not in 2015), it imported more electricity than it exported.[10] Net imports were 2 TWh (*Table 2*) (*Eurostat*, 2018c).[11]

Table 2. Poland's electricity balance, 2004–2016 (GWh)

	2004	2005	2006	2007	2008	2009	2010
Imports	5 312	5 002	4 789	7 761	9 034	7 403	6 310
Exports	14 605	16 188	15 775	13 109	9 703	9 594	7 664
Net imports	-9 293	-11 186	-10 986	-5 348	-669	-2 191	-1 354
Total gross production	154 159	156 936	161 742	159 348	155 305	151 720	157 657
Total net production*	140 789	143 615	147 685	145 393	141 498	137 908	143 457
Available for final consumption	104 193	105 005	110 634	114 092	117 189	112 305	118 690
Final consumption	104 193	105 005	110 634	114 092	117 189	112 305	118 690
Total consumption**	144 866	145 750	150 756	154 000	154 636	149 529	156 303
Net imports/total consumption (%)***	-6.4	-7.7	-7.3	-3.5	-0.4	-1.5	-0.9

(continued on next page)

[10] In 2016, Poland's electricity import partners were as follows: Germany – 8 754 GWh, Sweden – 2 764 GWh, Lithuania – 1 034 GWh, Ukraine – 957 GWh, the Czech Republic – 505 GWh, and Slovakia – 3 GWh. On the other hand, exports came from the following countries: the Czech Republic – 7 193 GWh, Slovakia – 4 187 GWh, Lithuania – 440 GWh, Sweden – 176 GWh, and Germany – 15 GWh (*Ministry of Energy*, 2017b: 37).

[11] We use our own calculations based on Eurostat data. The Polish Energy Regulatory Office (URE) claims 162.6 TWh for electricity production and 164.6 TWh for domestic consumption (*URE*, 2017: 11).

Table (continued)

	2011	2012	2013	2014	2015	2016
Imports	6 780	9 803	7 801	13 508	14 459	14 017
Exports	12 022	12 643	12 322	11 342	14 793	12 018
Net imports	-5 242	-2 840	-4 521	2 166	-334	1 999
Total gross production	163 548	162 139	164 580	159 059	164 944	166 635
Total net production*	148 913	147 649	150 079	145 214	150 695	152 003
Available for final consumption	121 492	122 169	123 557	125 347	127 819	132 839
Final consumption	121 492	122 169	123 557	125 347	127 819	132 839
Total consumption**	158 306	159 299	160 059	161 225	164 610	168 634
Net imports/total consumption (%)***	-3.3	-1.8	-2.8	1.3	-0.2	1.2

* Total net production = total gross production – own consumption of power plants.
** Total consumption = net imports + total gross production.
*** Negative numbers indicate that Poland was a net exporter during the indicated years.
Source: Eurostat (2018c).

***Box 1.* The list of Poland's energy policies since 1990**

Since the change of regime, Poland has had five energy policies. The first one was accepted in 1990 (for the period up to 2010), followed by the second one in 1995 (also to 2010). The third energy policy was approved in 2000 (to 2020). This was evaluated and amended in 2002. In 2005, the fourth energy policy (to 2025) was approved. The final, fifth one (to 2030) was approved in 2009. Currently, a new energy policy, the sixth one (to 2050) is being prepared. The first version of the draft energy policy was published in August 2014, while the last version dates to August 2015.[12] However, in October 2015, the opposition Law and Justice (PiS) party won the parliamentary elections in Poland, removing the ruling Civic Platform (PO) from power. The document was subsequently withdrawn and is being revised by the Ministry of Energy (*IEA*, 2017a: 24). There will probably be significant changes in the new energy policy that would otherwise have already been published (*Ernest Wyciszkiewicz*, email communication, 6 June 2018). As long as the new energy policy for the period up to 2050 is an ongoing project, the 2009 Polish Energy Policy until 2030 and the 2014 Strategy for Energy Security and Environment remain the two key strategic documents outlining Poland's policy for the energy sector.[13]

Electricity consumption continues to rise in Poland. The Polish Energy Policy until 2030[14] predicted net electricity production (*Table A5 in the Appendix*), final electricity demand (*Tables A1 and A4 in the Appendix*), and final demand for network heat (*Table A1 in the Appendix*) to grow by 37, 55 and 50 per cent from 2006 to 2030, respectively (*Ministry of Economy*, 2009b: 11, 15). The draft Energy Policy until 2050 consists of several documents. One of them includes a variety of forecasts prepared by the Polish

[12] The main forecasts for the Energy Policy until 2030 (*Tables A1–A6*) and the draft Energy Policy until 2050 (*Tables A7–A16*) are presented in the *Appendix*.
[13] The 2014 Strategy for Energy Security and Environment identifies key reforms and necessary steps for cleaner energy and for safeguarding security of supply up to 2020 (*Ministry of Economy/Ministry of Environment*, 2014; *IEA*, 2017a: 24). In this paper, we focus on the Energy Policy until 2030 and the draft Energy Policy until 2050.
[14] A list of Polish energy policies is presented in *Box 1*.

National Energy Conservation Agency S.A. (Krajowa Agencja Poszanowania Energii S.A., KAPE), the Polish Energy Market Agency S.A. (Agencja Rynku Energii S.A., ARE) and the European Commission (*Ministry of Economy*, 2015c). Although the new draft Energy Policy is based on or follows none of these documents, the Ministry of Energy considers the forecasts made by the Polish National Energy Conservation Agency to be the most reliable (*the Polish Ministry of Energy*, email communication, 22 June 2018).[15]

At end-2016, the installed electricity capacity in Poland amounted to 41.4 GW. The power sector has seen a substantial lack of investment (*Berkenkamp et al.*, 2016: 1). Almost 59 per cent of the turbines are over 30 years old. Another ca. 16 per cent are more than 20 but less than 30 years old, while only the remaining 25 per cent are younger. The situation of the boilers in Poland is even more alarming (*Wierzbowski et al.*, 2017: 51; *Ministry of Economy*, 2015b: 16). Therefore, since the estimated lifespan of such coal blocks is between 40 and 45 years, 6.4 GW of capacity will be lost by 2020, and the construction of new conventional generation with a capacity of at least 10-12 GW will be required by 2030 for the renewal of existing assets (*Ministry of Economy*, 2015b: 16). *Wierzbowski et al.* (2017: 51) claim that by 2050, almost half of Poland's installed capacity must be replaced. About 5 GW of power capacity must be commissioned by 2020, a further 5 GW by 2030 and 9 GW by 2040.

In this situation, it is predicted that issues with power shortages will begin to occur. In August 2015, the heat wave, lack of wind (needed for wind farms) and lack of rain (needed to cool coal-fired power plants) forced Poland to cut the electricity supply to industries, while electricity exports were also limited (*Reuters*, 2015). It was impossible to start up the cold reserve (*Wierzbowski et al.*, 2017: 54).

Another problem is related to the weak domestic electricity grid and interconnections, as well as the phenomenon of uncontrolled/unscheduled loop flows from Germany to Poland. The transmission network is old and the grid's density is not even (*Wierzbowski et al.*, 2017: 55). During the August 2015 crisis, the Polish state-owned grid operator PSE claimed that the loop flow phenomenon had blocked imports from neighbouring countries (*Schlandt*, 2015).

[15] The above forecasts are presented in the *Appendix* – for electricity production in *Tables A9, A13 and A16*, for heat production in *Table A10*, for electricity demand in *Tables A11 and A14*, and for heat demand in *Table A12.*

The Polish state maintains major shares in the four biggest energy companies, three of them – PGE Polska Grupa Energetyczna S.A., Enea S.A. and Energa S.A. – are majority state-owned, while Tauron Polska Energia S.A. has minority state ownership. These four dominate the electricity market (*Jankowska and Ancygier*, 2017: 187). In Poland, energy policy has been used to strengthen the dominance of state-owned energy groups to the detriment of individuals and local communities (*Szulecki et al.*, 2015: 16).

At the time of the change of regime, Poland was almost completely a coal land (*Szulecki*, 2017: 7). More than two and a half decades later, at end-2016, hard coal still accounted for 46 per cent of installed electricity generation capacity, while lignite provided a further 23 per cent (*Table 3*) (*Szulc*, 2017). In 2016, solid fuels were responsible for 78.2 per cent of electricity generation, while 14.0 per cent of electricity generation was from renewables. The share of natural gas stood at only 4.7 per cent in 2016, compared to 0.9 per cent in 2001 and 0.1 per cent in the early 1990s (*Table 4*) (*Eurostat*, 2018c). Similarly, in 2016, solid fuels provided more than 80 per cent of derived heat production.[16] Natural gas had only about 7 per cent, while less than 5 per cent of the generation of heat was from renewables (*Table 5*) (*Eurostat*, 2018d). To place this data in a wider context, in 2016, solid fuels had a 49.1 per cent share in gross inland consumption, and an 18.1 per cent share in final energy consumption (*Table 6*) (*Eurostat*, 2018a). However, this heavy reliance on domestic coal is reflected in low energy (import) dependence. In 2015, with a 29.3 per cent energy dependency ratio, Poland was the fourth least dependent on energy imports behind Estonia (7.4%), Denmark (13.1%) and Romania (17.1%), while the EU stood at 54.1 per cent (*Eurostat*, 2017).

[16] The structure of space heating in residential buildings is as follows (2015 data): district heating – 41 per cent, solid fuel dual-purpose boilers – 23 per cent, solid fuel single-purpose boilers – 14 per cent, solid fuel stoves in rooms – 6 per cent, solid fuel fireplaces – 4 per cent, natural gas dual-purpose boilers – 7 per cent, natural gas single-purpose boilers – 2 per cent, fixed and portable electric radiators and electric underfloor heating – 2 per cent, other techniques – 1 per cent. The different types of warm water production in residential buildings include the following: district heating – 30 per cent, electric boiler or heater – 22 per cent, bathroom gas heater – 18 per cent, natural gas dual-purpose boiler – 8 per cent, solid fuel dual-purpose boiler or water heater – 18 per cent, other techniques – 1 per cent, no running warm water – 3 per cent (*Ministry of Energy*, 2017a).

Table 3. The share of different power plants in installed electricity generation capacity and electricity generation in Poland, 2016 (%)

	Installed capacity (end-2016)	Electricity generation (2016)
Coal-fired utility power plants	46	50
Lignite-fired utility power plants	23	32
Gas-fired utility power plants	4	4
Wind and other renewables	15	7
Industrial plants	6	6
Hydro utility power plants	6	1
Total	*100*	*100*

Source: Szulc (2017).

Table 4. Gross electricity production in Poland, by fuel, 2004–2016 (%)

	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Solid fuels	91.5	90.4	90.9	90.4	89.4	87.9	86.6	85.5	83.0	83.7	81.4	79.1	78.2
Gases	3.2	4.2	3.8	3.9	4.1	4.1	4.2	4.7	5.0	4.4	4.6	5.4	6.3
Natural gas	2.1	3.3	2.8	2.8	3.0	3.2	3.0	3.6	3.9	3.2	3.3	3.9	4.7
Derived gases	1.2	0.9	1.0	1.1	1.1	1.0	1.2	1.1	1.1	1.2	1.3	1.5	1.6
Petroleum products	1.9	1.8	1.8	1.8	1.8	1.8	1.8	1.5	1.3	1.1	1.0	1.3	1.4
Renewables	3.1	3.5	3.3	3.8	4.6	6.1	7.3	8.3	10.7	10.7	12.8	14.1	14.0
Biomass and renewable waste	3.1	3.5	3.3	3.8	4.6	6.1	7.3	8.3	10.7	10.7	12.8	14.1	14.0
Hydro	2.4	2.4	1.9	1.8	1.8	2.0	2.2	1.7	1.5	1.8	1.7	1.5	1.6
Wind	0.1	0.1	0.2	0.3	0.5	0.7	1.1	2.0	2.9	3.6	4.8	6.6	7.6
Solar PV									0.0	0.0	0.0	0.0	0.1
Renewable municipal waste													0.0
Solid biofuels excluding charcoal	0.6	0.9	1.1	1.5	2.2	3.2	3.7	4.4	5.9	4.8	5.8	5.5	4.1
Biogas	0.1	0.1	0.1	0.1	0.2	0.2	0.3	0.3	0.3	0.4	0.5	0.5	0.6
Other liquid biofuels						0.0	0.0	0.0		0.0		0.0	0.0
Others	0.2	0.2	0.2	0.2	0.1	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.2
Non-renewable waste	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1
Heat from chemical sources	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.1	0.1	0.1	0.0
Other sources	0.1	0.2	0.2	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*

Solid fuels: hard coal, lignite and derivatives.
Derived gases: coke oven gas, blast furnace gas and other recovered gases.
Non-renewable waste: industrial and municipal waste.
Note: Empty cells show zero values.
Source: Own calculations based on *Eurostat* (2018c).

Table 5. Derived heat production in Poland, by fuel, 2004–2016 (%)

	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Solid fuels	89.3	89.1	88.7	89.0	87.0	86.2	85.4	83.8	82.2	84.3	84.0	81.3	82.4
Gases	7.7	7.8	8.3	7.5	9.0	8.5	9.2	10.0	9.9	8.8	9.0	12.2	10.9
Natural gas	6.2	6.2	5.7	5.6	6.1	6.2	6.2	6.5	6.7	6.0	6.0	7.2	7.2
Derived gases	1.5	1.6	2.6	1.9	2.9	2.3	3.0	3.5	3.1	2.8	3.1	5.0	3.7
Petroleum products	2.0	2.0	2.0	1.9	2.0	1.9	2.0	1.3	1.4	1.1	1.2	1.2	1.2
Renewables	0.7	0.8	0.8	1.2	1.6	3.2	3.2	4.5	6.2	5.3	5.2	4.6	4.8
Biomass and renewable waste	0.7	0.8	0.8	1.2	1.6	3.2	3.2	4.5	6.2	5.3	5.2	4.6	4.8
Solid biofuels	0.6	0.7	0.8	1.2	1.6	3.2	3.1	4.5	6.1	5.2	5.0	4.4	4.6
Biogas	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.2	0.2
Renewable municipal waste											0.0	0.0	0.0
Liquid biofuels						0.0	0.0	0.0				0.0	
Heat pumps						0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Others	0.3	0.3	0.3	0.4	0.4	0.2	0.3	0.5	0.4	0.5	0.6	0.7	0.7
Non-renewable waste	0.0	0.1	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.3	0.5
Heat from chemical sources	0.2	0.2	0.2	0.2	0.2	0.1	0.2	0.3	0.2	0.3	0.4	0.4	0.2
Other sources	0.1	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0
Total	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*

Solid fuels: hard coal, lignite and derivatives.
Derived gases: coke oven gas, blast furnace gas and gas works gas.
Non-renewable waste: industrial and municipal waste.
Note: Empty cells show zero values.
Source: Own calculations based on *Eurostat* (2018d).

Table 6. The share of different energy sources in Poland's energy balance, 2016

		Total	Solid fuels	Oil	Gas	Renewables	Wastes (non-ren.)	Derived heat	Electricity
Gross inland consumption	ktoe	99 930	49 079	26 535	14 633	8 769	742		172
	%	100.0	49.1	26.6	14.6	8.8	0.7		0.2
Final energy consumption	ktoe	66 652	12 069	21 627	9 688	5 540	637	5 669	11 422
	%	100.0	18.1	32.4	14.5	8.3	1.0	8.5	17.1

Source: Eurostat (2018a) and own calculations.

Table A5 in the Appendix presents forecasts from the Polish Energy Policy until 2030 for net electricity production in Poland by fuel as follows:

– The role of hard coal will fall from 58.3 per cent in 2006 to 32.4 per cent in 2025, but will again increase to 35.6 per cent by 2030.

– The share of lignite will decline from 33.8 per cent in 2006 to 21.0 per cent in 2030.

– In contrast, the share of natural gas will rise from 3.1 per cent in 2006 to a still very low 6.6 per cent in 2030.

– Also, the role of renewables will grow from 2.6 per cent in 2006 to 20.2 per cent by 2025, but is expected to decrease to 18.8 per cent by 2030.

– Finally, nuclear will enter the electricity generation mix and reach 15.7 per cent by 2030.

The August 2015 Energy Policy presented three scenarios for Poland's energy mix: the sustainable or balanced scenario and two alternative scenarios (a nuclear scenario and a gas + renewables scenario). According to the sustainable scenario, coal will continue to be dominant in the energy balance, but with a decreasing share, while the share of other individual fuels/energy will be even and amount to around 15-20 per cent per fuel type, including an approximately 12 per cent share of nuclear energy through the construction of two nuclear power plants with a total capacity of 6 GW.

In contrast, the nuclear scenario is characterized by a 45-60 per cent share of nuclear energy in the energy balance, while other fuels/energy will provide roughly equal shares: hard coal and lignite – 10-15 per cent, crude oil – 10-15 per cent, natural gas – 10-15 per cent, and renewables – approximately 15 per cent.

The gas + renewables scenario is based on the assumption of large-scale domestic gas production from unconventional reservoirs, as well as the development of technologies for renewable energy production and energy storage. This scenario results from the fact that when the draft energy policy was written in 2014, there were still significant hopes for shale gas (*Ernest Wyciszkiewicz*, email communication, 6 June 2018). The scenario assumes that the share of natural gas and renewables in the energy balance will reach about 50-55 per cent, with hard coal and lignite – approximately 30 per cent, and crude oil – 15-20 per cent. The Energy Policy states that the "gas scenario"[17] anticipates the share of renewables to be at a minimum of 20 per cent and of nuclear at approximately 12 per cent.[18] Under the gas + renewables scenario, the use of natural gas in the power industry would increase from around 3.5 per cent in 2013 to 20-30 per cent in 2050. The draft energy policy argues that gas and renewables complement each other nicely

[17] This sentence in the Policy is confusing, because it uses the wording "gas scenario" and not "gas + renewables scenario".
[18] In the first version of the draft Energy Policy, the gas + renewables scenario assumed the use of renewables to amount to at least 20 per cent and nuclear sources to reach a level of approximately 10 per cent (*Ministry of Economy*, 2014c: 39).

and gas would allow for flexible balancing.[19] A significant increase in the use of gas in road transport is also expected (*Ministry of Economy*, 2015b: 40–46). This scenario, however, would require the further development of gas transportation infrastructure and storage. According to the draft Energy Policy, this would also signify searching for new gas suppliers as gas consumption would drastically increase (*Wierzbowski et al.*, 2017: 67–68).

Coal. The coal industry has long established itself as a strategic element of the Polish industry and economy, leading to a path-dependency in energy policy that continuously reinforces the status quo aiming to maintain a conventional system based on fossil fuels, centralized production facilities and non-flexible consumption patterns (*Jankowska and Ancygier*, 2017: 186–187).

It is necessary to make a differentiation between hard coal and lignite.[20] Poland is the tenth largest hard coal producer in the world and the largest in Europe. The restructuring of hard coal mining in Poland started in 1990, but it has not been completed so far (*Kamola-Cieślik*, 2017). Meanwhile, hard coal production decreased from 151.3 million tonnes (mt) in 1990 to 66.5 mt in 2016. In the same period, the number of employees dropped from 416 thousand to about 85 thousand (*PSG*, 2017e), though hard coal mining is still indirectly responsible for an additional 300 thousand jobs (*Adamczewski*, 2015). In 2016, hard coal consumption amounted to 74.2 mt (*PSG*, 2017f), while 8.3 mt of hard coal was imported, and exports stood at 9.1 mt. Importing hard coal to Poland is a relatively new phenomenon. For many years, Poland imported only those types of coal that it was not possible to obtain in the country (especially low phosphorus coking coal). It was only at the beginning of the 2000s that Poland started to import thermal (steam) coal. In 2008, for the first time, Poland imported more hard coal than it exported. Between 2008 and 2016, exports were higher than imports only in 2013, 2015 and 2016 (*PSG*, 2017b). The largest import partner is Russia (*Energetyka24*, 2017; *Herold et al.*, 2017: 1). Thus, increasing coal imports could lead to higher Russian coal dependence, but this could be perceived differently than gas, since Russian coal imports can be replaced in their entirety in the event of a conflict (*Baca-Pogorzelska*,

[19] As *Stern* (2017) notes, new coal stations are also able to provide backup electricity for renewables.
[20] For a detailed coal and coal product balance, see *Table 7*.

2018). Nonetheless, recently concern has been voiced over Poland's increasing amount of (Russian) coal imports, and the Polish government plans to introduce import limits, despite the lack of sufficient domestic production. The aim of limiting imports is also included in the Programme for the hard coal mining sector in Poland, adopted in January 2018. In addition, illegal anthracite coal imports coming indirectly from Donbas have become an issue of concern (*TVN24 BiS*, 2018; *Łazarczyk*, 2018; *Miłosława Stępień*, email communication, 14 August 2018).

Table 7. Poland's coal and coal product balance, 2016 (ktoe)

	Solid fuels	Anthracite	Coking coal	Other bituminous coal	Lignite/ brown coal	Patent fuels	Coke oven coke	Coal tar	BKB
Primary production	52 092		9 337	31 076	11 679				
From other sources (recovered products)	216			216					
Imports	5 044	178	1 541	3 161	56	10	84	2	13
Stock changes	2 648	-10	143	2 471	13		31		
Exports	10 921	12	1 700	4 071	41	2	4 745	347	2
Gross inland cons.	49 079	156	9 321	32 852	11 706	8	-4 630	-345	11

BKB – brown coal briquettes. Ktoe – thousand tonnes of oil equivalent.
Source: Eurostat (2018a).

Some domestic economic, social and political aspects of hard coal mining influencing the situation include the 85 thousand jobs, the strong unions and high state ownership level (*Schwartzkopff and Schulz*, 2017: 2, 5; *Wierzbowski et al.*, 2017: 5–7). Among this sector's major problems, we should count the high costs of mining, high social costs, low labour productivity, geological factors and issues with the quality of the product as compared to imported hard coal (*Kamola-Cieślik*, 2017: 254). Hard coal industry relies heavily on subsidies. Low international coal prices compared to domestic production costs have resulted in financial problems for hard coal mining. However, since mid-2016, coal prices have been growing, though with high fluctuations. These increases follow a significant decline between 2011 and 2015 (*Trading Economics*, 2018). Also, as compared to gas, coal was cheap until 2016, but this is no longer true if it is bought in the international market (*Jonathan Stern*, email communication, 7 February 2018) (*Table 8*) (also, see *Section 3.2.1*). Under these circumstances, Poland's Law and Justice government pledged to save and defend the coal industry, as well as modernising existing coal power plants and building new plants that would increase coal lock-in

(*Wood et al.*, 2017: 3; *Wierzbowski et al.*, 2017: 6.). In contrast, in 2017, a fundamental change was seen in the government's rhetoric when the Minister of Energy at the time said that a particular project would be the last coal investment (*Ciepiela*, 2017; *Reuters*, 2017a). Nonetheless, presented as part of the draft Energy Policy until 2050, the 2013 forecasts of the Polish National Energy Conservation Agency suggest that despite some decrease in the share of hard coal in heat production (*Table A10 in the Appendix*), its role will remain extremely high, while its declining share in electricity generation will also continue to be untenably high (*Table A9 in the Appendix*).

Table 8. Selected natural gas, coal and spot crude prices, 2004–2017

	LNG	Natural gas			Coal	Crude oil
	Japan (cif)	Average German import price (cif)	UK (Heren NBP Index)	US (Henry Hub)	Northwest Europe marker price	Brent spot prices
	USD per million Btu				USD per tonne	USD per barrel
2004	5.18	4.30	4.46	5.85	72.08	38.27
2005	6.05	5.83	7.38	8.79	60.54	54.52
2006	7.14	7.87	7.87	6.76	64.11	65.14
2007	7.73	7.99	6.01	6.95	88.79	72.39
2008	12.55	11.60	10.79	8.85	147.67	97.26
2009	9.06	8.53	4.85	3.89	70.66	61.67
2010	10.91	8.03	6.56	4.39	92.50	79.50
2011	14.73	10.49	9.04	4.01	121.52	111.26
2012	16.75	10.93	9.46	2.76	92.50	111.67
2013	16.17	10.73	10.64	3.71	81.69	108.66
2014	16.33	9.11	8.25	4.35	75.38	98.95
2015	10.31	6.72	6.53	2.60	56.64	52.39
2016	6.94	4.93	4.69	2.46	60.09	43.73
2017	8.10	5.62	5.80	2.96	84.51	54.19

Btu – British thermal units. Cif – cost + insurance + freight (average prices).
Source: BP (2019).

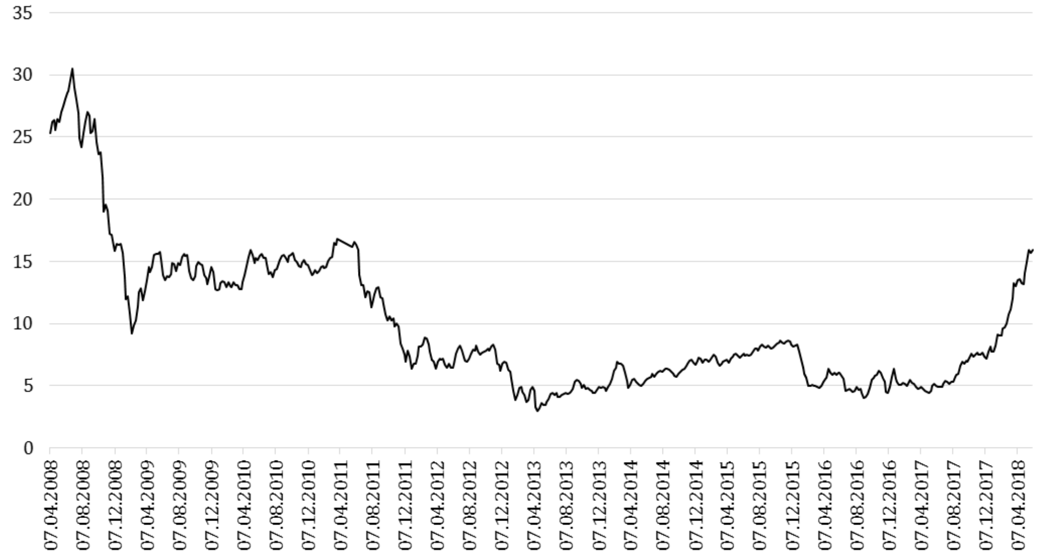
As for lignite, Poland is the fourth producer worldwide and the second in the EU. Compared to hard coal, lignite production has remained relatively stable with certain fluctuations. Notwithstanding, it decreased from 69.2 mt in 1991 to 60.2 mt in 2016 (*Szczepiński*, 2016; *Kasztelewicz*, 2018).[21] Compared to 27 thousand in 1991, only ca. 10 thousand people are now employed in lignite mining (*Schwartzkopff and Schulz*, 2017: 5). Yet, reportedly, the sector indirectly employs 100 thousand people (*Adamczewski*, 2015). Regarding the availability dimension, one should also highlight that in contrast to

[21] Lignite has a much lower heating value than hard coal.

hard coal, lignite has minimal foreign trade (mainly limited to the Czech Republic, see *PSG*, 2017a), and lignite mining has more private ownership than in the hard coal sector. Almost all Polish lignite production is utilized for electricity generation by the five so-called mine-mouth power plants, located close to the operating opencasts (*Widera et al.*, 2006: 154). Individual consumers have a very minor role. They primarily use lignite in heating. According to the January 2017 statement of the Polish Geological Institute, a sharp decline in lignite mining may occur already post-2022, unless lignite production from new deposits is added (*PSG*, 2017d). The president of the Polish Mining Chamber of Commerce and Industry argued in early 2018 that without exploiting further deposits, Poland would simply run out of lignite by 2030 (*PSG*, 2018). According to the Polish National Energy Conservation Agency, the role of lignite in electricity generation and heat production will drastically decrease in the first half of the 2030s and the first half of the 2040s, respectively (*Tables A9 and A10 in the Appendix*) (*Ministry of Economy*, 2015c: 6). The affordability dimension is associated with the facts that lignite is cheaper than domestically sourced hard coal (*Buchsbaum*, 2018), and the cost of producing electricity from lignite is much lower than that of hard coal (*Szczepiński*, 2016; *Szulc*, 2017). However, regarding sustainability, lignite's carbon dioxide emissions are higher. Sustainability issues linked to lignite mining include social conflicts when buying agricultural land from farmers for lignite opencasts (also associated with the resettlement of part of the rural population living in the area) and environmental impacts (noise and dust; changes in the geological and hydrogeological conditions in the area; and the creation of external dumps to store overburden) (*Widera et al.*, 2006: 156). *Honoré* (2018b) claims that many coal plants (19 GW) do not comply with the standards of the EU's 2010 Industrial Emissions Directive and while Poland has an exemption under the current EU Emissions Trading System (EU ETS) (Phase 3, 2013–2020), it has no derogations for Phase 4 of the ETS (2021–2030).[22]

[22] *Figure 2* shows carbon prices on the EU ETS.

Figure 2. European Union Emissions Trading System carbon market price day-by-day, 2008–2018 (EUR)



Source: Sandbag Climate Campaign (2018).

Poland was the fifth largest EU emitter of greenhouse gas (GHG) in 2015. GHG emissions in Poland decreased by 37 per cent between 1990 and 2002, but after 2002 emissions grew by 3 per cent by 2015 (*Herold et al.*, 2017). So far, Poland has failed to comply to air quality standards. In some places, especially in the south, air quality can periodically be worse than in Beijing and New Delhi, the world's most polluted cities (*Reuters*, 2018c). In 2018, the European Commission took Poland to court over its slow response in addressing poor air quality caused by extensive coal and rubbish burning in homes (*Koester and Barteczko*, 2018).

Renewables. As has been shown, from among the three dimensions, sustainability is clearly the most neglected in Poland.[23] Because of energy independency targets and the aim of preserving coal-based electricity, Poland is a hard-line climate policy opponent. A global survey conducted in 2014 found 22 per cent of Poles, the highest rate among the countries surveyed, believed that climate change was not at all or probably not a threat to humanity (*Global Challenges Foundation*, 2014). It seems that Poland would not have promoted renewables if there had been no pressure from the EU. There has also been no strong bottom-up movement promoting the development of renewables (*Szulecki et al.*,

[23] Select thoughts on energy transition in presented in *Box 2*.

2015: 12–13, 15). Close links between the government and state-owned energy enterprises have hindered the development of renewables and strongly limited market access for small and medium-sized renewable energy companies (*Jankowska and Ancygier*, 2017: 183, 187).

***Box 2.* Select thoughts on energy transition**

It is important to question whether the Polish government is aware of the dynamics of the energy transition process and whether it is capable of addressing the multiple complex problems it faces which require the application of completely new solutions.

The electricity power generating system is Europe's single biggest carbon dioxide emitting sector (*European Climate Foundation*, n.d.). The decarbonisation of the power sector means reducing its carbon intensity (*LSE*, 2014). Reduced carbon dioxide emissions per unit of electricity generated can be achieved in many ways. Most obviously, it can be done by switching to nuclear or renewables. However, burning natural gas instead of coal can also decarbonise to a high degree. In addition, to some extent, energy efficiency measures in power generation can help decarbonise without shifting to another energy carrier. If only the reduction of carbon dioxide emissions is the goal, then energy conservation in itself without efficiency improvements, supporting the use or loss of less electricity, can also be a tool. Another option is decarbonised natural gas (see *Box 4*). There are also several alternatives that can help decarbonise the heating (and cooling) sector. This can be done by (1) upgrading boilers, (2) developing micro combined heat and power (micro-CHP or mCHP) and fuel cell technology, or (3) switching to other forms of heating, including increasing the share of renewables. The latter can mean replacing fossil fuels with renewables (bio-energy, solar thermal, geothermal and heat pumps), installing hybrid heating systems (e.g. a gas-condensing boiler with an electric heat pump), repurposing the gas network for renewable gases (see *Box 4*), and the electrification of the heating sector (heat pumps) (*Honoré*, 2018a: 39–44). And, again, energy conservation in itself, without reducing heat intensity (e.g. installing better home insulation), can also cut carbon dioxide emissions in this sector. *Stern* (2017: 6) states that in the heating sector, non-hydrogen based solutions for decarbonising heat, such as electric heat pumps and district heating based on non-gas alternatives, are in the forefront of policy for many governments. *Dickel* (2018: 1) claims that it is essential to make the distinction between a carbon-free energy sector (which can include decarbonised fossil fuels) and a sustainable energy sector (which will have to be all renewable).

There is a debate about whether the ongoing transition from the old model with baseload power provided by large, inflexible power plants towards a modern, flexible electricity system based on renewables can actually be executed. It requires a completely new approach. The main focus is on the availability and affordability of electricity from renewables.

Due to the intermittency and variability of renewables, it is still widely believed that renewables, other than large hydro power plants, can only supplement the established electricity system and it is considered that there is an inherent upper limit on the share of renewables (*Hinrichs-Rahlwes*, 2013: 90). Among power plants based on non-renewable energy resources – such as fossil fuel power plants and nuclear power stations –, nuclear and coal-fired power plants typically provide baseload power, while natural gas is a much more flexible power, and can be an on-demand power source (*Gonzalez-Salazar et al.*, 2018). Renewables are also different in terms of dispatchability. Wind power and solar photovoltaic (PV) power are non-dispatchable. The main argument used to justify nuclear energy is that it is, along with hydropower, the only low-carbon power source that can supply reliable baseload electricity on a large scale. In contrast, the advocates of the new model argue that energy generation with a dominant share of renewables that are flexible according to demand is feasible and supported by both practical experience and computer simulations (*Diesendorf*, 2016). *Diesendorf* (2016) discusses the four main conditions that make this possible. Firstly, the fluctuations in wind and solar PV can be balanced by flexible, dispatchable renewables, such as by hydropower with dams, open cycle gas turbines (OCGTs) fuelled by green gas (see *Box 4*) and concentrated solar thermal power (CSP) with thermal energy storage (TES). Secondly, one should rely on diverse renewables (i.e. multiple technologies and spreading out wind and solar PV farms geographically). Thirdly, new transmission lines may be needed to achieve this wide geographic distribution of renewables. Fourthly, smart demand management can shave the peaks in electricity demand and manage periods of low electricity supply. Smart meters and switches are controlled by both electricity suppliers and consumers, and programmed by consumers to switch off when demand on the grid is high and/or supply is low. *Stern* (2017: 6) warns that progress in relation to demand-side management would not only further reduce the problem of renewable intermittency, but also foster the need for backup from gas (or other fossil fuel) generation.

As to the affordability dimension, data collected by the International Renewable Energy Agency (IRENA) shows that the levelised cost of electricity (LCOE) for bioenergy-for-power, hydropower, geothermal and onshore wind projects commissioned in 2017 was at the lower end of the LCOE range for fossil fuel options (*IRENA*, 2018: 16). *Lazard* (2017) states that "in some scenarios the full-lifecycle costs of building and operating renewables-based projects have dropped below the operating costs alone of conventional generation technologies such as coal or nuclear". Meanwhile, attitudes towards nuclear energy have changed after Japan's 2011 Fukushima nuclear accident. The nuclear industry seems to be in trouble, primarily in the West, reflected in the French Areva's virtual bankruptcy and the US Westinghouse's bankruptcy proceedings. However, at the same time, Russian Rosatom has improved its performance (*Minin–Vlček*, 2018: 98).

Another question centres on the future role of natural gas, the cleanest fossil fuel, which is discussed in *Section 3.2*.

Nonetheless, there was a period during which an increase in the role of renewables occurred in Poland. The share of energy from renewables in gross final energy consumption was less than 7 per cent in the mid-2000s. Ten years later, in 2015, it reached close to 12 per cent; however, in 2016, its share decreased slightly (*Table 9*).

Table 9. Share of energy from renewable sources and targets for 2020 in Poland, 2004–2016 (%)

	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2020 target
Share of energy from RES in GFEC	6.9	6.9	6.9	6.9	7.7	8.7	9.3	10.3	10.9	11.4	11.5	11.7	11.3	15*/ 15.85**
Share of electricity from RES in GOC	2.2	2.7	3.0	3.5	4.4	5.8	6.6	8.2	10.7	10.7	12.4	13.4	13.4	19.13**
Share of RES in heating and cooling	10.2	10.2	10.2	10.5	10.9	11.5	11.7	13.1	13.4	14.1	14.0	14.5	14.7	17.05**
Share of RES in transport	1.4	1.6	1.7	1.6	4.0	5.3	6.6	6.8	6.5	6.6	6.2	5.6	3.9	10*/ 10.14**

RES – renewables. GFEC – gross final energy consumption. GOC – gross electricity consumption.
* Target set by the 2009 Renewable Energy Directive of the European Parliament and Council.
** Target set by the 2010 National Renewable Energy Action Plan of Poland.
Source: Eurostat (2018e), *Ministry of Energy* (2010).

***Box 3.* EU targets for renewables, energy efficiency and GHG emissions cuts**

Climate change moved to the forefront of the EU's agenda at the beginning of the 1990s (*Solorio and Bocquillon*, 2017: 24). The first EU target for renewables was set in the mid-1990s. The European Commission's 1996 Green Paper sought views on setting an indicative (not legally binding) objective of 12 per cent for the contribution of renewables to the EU's gross inland energy consumption by 2010. The 1997 White Paper established this average indicative target for the EU, and member states were obliged to decide on their own specific objectives and develop their own national strategies to achieve them (*Hinrichs-Rahlwes*, 2017: xi; *European Commission*, 1996, 1997). The so-called Campaign for [Renewable Energy] Take-Off started in 1999, aiming at accelerating the development of the renewables strategy in its early stages by the year 2003 (*European Commission*, 1999). The 2001 Renewables Electricity Directive set a 22.1 per cent indicative target for the share of electricity produced from renewables in the EU's electricity consumption by 2010, while the annex included national indicative targets (*European Parliament and Council*, 2001). To promote the improvement of the energy performance of buildings within the EU, the first Energy Performance of Buildings Directive was adopted in 2002, followed by the new directive in 2010 (*European Parliament and Council*, 2002, 2010). Another milestone was the 2003 Biofuels Directive that contained "reference values" of a 2 per cent market share for biofuels in transport in 2005 and a 5.75 per cent share in 2010 (*European Parliament and Council*, 2003). The March 2007 European Council Conclusions with its 20-20-20 targets made the EU a frontrunner and a role model for sustainable energy policies (*Hinrichs-Rahlwes*, 2017: xi). These binding 2020 targets included (1) a 20 per cent cut in GHG emissions compared with 1990, (2) a 20 per cent share of renewables in the total energy consumption underpinned by differentiated binding national targets for each member state, (3) a 20 per cent increase in energy efficiency and (4) a minimum share of at least 10 per cent of transport fuels from renewables. These targets were enacted in legislation in the 2009 Renewable Energy Directive, which entered into force in 2010 (*European Parliament and Council*, 2009a; *European Commission*, n.d.-a, 2010). The directive for the first time comprised all three sectors – electricity, heating and cooling, and transport (*Hinrichs-Rahlwes*, 2017: xiii). The Energy Efficiency Directive was adopted in 2012. The EU's long-term goal is to achieve GHG emission reductions of at least 80-95 per cent by 2050 compared to 1990 levels. This was called for by the October 2009 European Council Conclusions and was also repeated by the Energy Roadmap 2050 in 2011 (*Council of the European Union*, 2009; *European Commission*, 2011). Nevertheless, the October 2014 European Council Conclusions on the 2030 Climate and Energy Framework renounced its position as a leader in global renewables development. Member states closely linked to the incumbent fossil and nuclear energy system asked for ambitions to be lowered, no 2030 targets at all, or for only a GHG reduction target. Finally, the European Council endorsed a binding EU target of an at least 40 per cent domestic reduction in GHG emissions by 2030 compared to 1990, and a binding EU target of at least 27 per cent for the share of renewables consumed in the EU in 2030. Also, an indicative target at the EU level of at least 27 per cent was set for improving energy efficiency in 2030 compared to projections of future energy consumption based on the current criteria. Thus, the EU resigned from introducing binding national targets after 2020. Meaningful reforms of the EU ETS were also postponed (*Hinrichs-Rahlwes*, 2017: xi; *European Council*, 2014a, 2014b). Finally, in May 2018, the Regulation on binding annual national emission reductions from 2021 to 2030 (the Effort Sharing Regulation) was adopted (*Council of the European Union*, 2018). In June 2018, the Parliament and the Council agreed that renewables should account for at least 32 per cent of the EU's gross final consumption in 2030 (with an upwards revision clause by 2023), and that at least 14 per cent of fuel for transport purposes must come from renewables by 2030 (*European Parliament*, 2018b, 2018d). Also, in June 2018, a binding energy efficiency target for the EU for 2030 of 32.5 per cent, with a clause for an upwards revision by 2023 was reached between negotiators from the Commission, the European Parliament and the Council (*European Commission*, n.d.-e, 2018c).

In 2001, the Polish parliament adopted the Development Strategy for the Renewable Energy Sector and the Ministry of Economy developed an ordinance that set the minimum green electricity fraction at 7.5 per cent in the total electricity sales for 2010 (*Figorski–Gula*, 2009: 418; *Jankowska and Ancygier*, 2017: 188). This was part of the Polish Accession Treaty (*Frost & Sullivan and PAIiIZ*, 2008). To support renewables development, the system of "Green Certificates" was introduced in 2005 by amending the 1997 Energy Law. A separate renewable energy law (the Renewables Act) was adopted only in February 2015. The National Renewable Energy Action Plan was adopted in 2010, but only six months later than required by the 2009 Renewable Energy Directive (*Jankowska and Ancygier*, 2017: 188–190). The Renewable Energy Directive specified a target of 15 per cent for the share of energy from renewables in gross final energy consumption to be achieved by 2020 (*European Parliament and Council*, 2009; *Eurostat*, 2016). This is higher than Poland initially (11%) and eventually (13%) proposed. In contrast, Poland was successfully against binding renewables targets for 2030 during the meeting of the October 2014 European Council. The National Renewable Energy Action Plan includes the 2020 target of 15.85 per cent, and not 15 per cent. The 2009 Energy Policy believed that the 2020 target is feasible on condition of the accelerated development of all types of renewables, in particular wind energy, but it did not believe a 20 per cent share was possible by 2030 (*Table A2 in the Appendix*) (*Ministry of Economy*, 2009b: 13). Poland's 2010 National Renewable Energy Action Plan would achieve its 2020 EU goal through the development of wind energy, biomass co-firing and the building of one additional large hydropower plant, suggesting further reliance on huge conventional power companies (*Jankowska and Ancygier*, 2017: 190–192). According to the Polish Institute for Renewable Energy (IEO), the development of renewables between 2006 and 2015 was based on relatively cheap bank financing and a growing share of corporate financing, but these sources of funding have begun to shrink, and unpaid loans to finance renewables projects, mainly wind, have already reached PLN 11 billion. Banks complain about the lack of a broader perspective (for a 25-year framework) in state policy, the legal instability, as well as the various *ad hoc* and not always well-thought-out regulations (*IEO*, 2018).

In Poland, GHG emissions dropped by 20 per cent in just over two years between 1988 and 1990. This rapid drop was followed by a slower 20 per cent decline from 1990 to 2014. Carbon dioxide is the largest GHG, contributing 82 per cent of Poland's total emissions in 2014 (*IEA*, 2017a: 24). The 2015 draft National Programme for the Development of a Low-Emission Economy aims for a 44 per cent carbon dioxide emissions reduction by 2050 compared to the 2010 level (*Ministry of Economy*, 2015a). Regarding binding national targets by the EU for the period 2021–2030 for sectors not covered by the EU ETS, Poland was against its 7 per cent cut in GHG emissions by 2030 as compared to 2005, despite allocation of the fourth smallest goal among EU member states (see the Effort Sharing Regulation in *Box 3*) (*European Commission*, 2016, n.d.-c, n.d.-d; *European Parliament and Council*, 2016, 2018; *European Parliament*, 2018a, 2018c).

In the 2000s and 2010s, a fundamental restructuring of the role of different renewables occurred in renewable electricity generation. Before 2007, hydropower ranked first. From 2007 to 2014, solid biofuels (biomass) played the most significant role. In 2015, wind power came in first, after becoming the second largest renewable power source in 2011. The role of solar energy is still almost invisible (*Table 10*).

Table 10. The share of renewable sources in renewable electricity generation in Poland, 2004–2016 (%)

	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Hydro	65.2	55.6	48.6	41.8	33.6	26.4	22.7	18.3	13.9	13.8	11.9	10.7	10.5
Wind	3.7	5.3	7.2	9.9	12.7	13.4	16.4	22.7	26.6	35.8	38.0	44.0	53.6
Solar	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.6
Solid biofuels	28.4	36.3	40.7	44.6	49.9	56.5	57.0	55.5	56.2	46.3	46.0	41.0	30.8
All other renewables	2.7	2.9	3.6	3.7	3.8	3.7	3.9	3.5	3.3	4.0	4.1	4.1	4.6
Total	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*

Notes: Hydro is normalised and excludes pumping. Wind is normalised. Solar includes solar photovoltaics and solar thermal generation. The other renewables include electricity generation from gaseous and liquid biofuels, renewable municipal waste, geothermal, and tide, wave and ocean. Grey cells indicate the renewable source with the highest share.
Source: Eurostat (2018b).

The availability dimension of *hydropower* relates to Poland's scarce water resources, due to its geographical position (low rainfall and high evaporation rates). Thus, the potential for hydropower production in Poland is low, and it has been utilised to a limited extent. It does not exceed 12 per cent of the hydropower technical potential (*Majewski*, 2013: 52–53). Hydropower had long been a major contributor to renewables simply because other renewables were performing badly. Over 75 per cent of the potential is in the Vistula catchment area. The Vistula River itself represents half of the

Polish potential. Oder with its tributaries contributes to the total with a further 20 per cent (*Steller*, 2012: 1).[24] According to *Majewski* (2013: 45, 53), all Polish strategic development documents refer to the need to increase the retention storage capacity for the water reservoirs, which would result in substantial opportunities for electricity generation. Obstacles include the overly restrictive environmental law and lack of political will. The sustainability dimension focuses on land use and wildlife impacts. In addition, calculations suggest the life-cycle emissions of hydropower plants can be relatively high (*Union of Concerned Scientists*, n.d.-a).

Biomass co-firing had long been profitable due to the old Green Certificate system. Biomass imports were also given a boost, which increased Poland's dependency (*Szulecki et al.*, 2015: 15–16; *Wierzbowski et al.*, 2017: 58). This affected the availability dimension of supply security. Regarding the sustainability dimension, replacing coal with biomass theoretically results in reduced carbon emissions, since, by law, burning wood is "carbon neutral" as the emitted pollution is reabsorbed by newly planted trees. In fact, GHG emissions from energy generated using biomass are generally lower than those from fossil fuels, but not always.[25] Similarly, biogas represents a carbon-neutral fuel source, since carbon emitted by its combustion is equal to the amount of carbon that was absorbed from the atmosphere during plant growth. Regarding this issue, in June 2018, the European Academies' Science Advisory Council (EASAC) published a commentary to highlight that "the concept of all bioenergy being carbon-neutral is too simplistic and does not offer any general context-independent justification to increase forest utilisation". EASAC claims that the so-called payback period (the time needed for forests to reabsorb the carbon dioxide emitted during biomass combustion) ranges from decades to hundreds of years (*EASAC*, 2018). The distance for biomass transportation and imports to the energy plants also largely contribute to global warming potential and other environmental impacts (*Bowyer*, 2012). Further, co-firing decreases the efficiency and lifetime of boilers that were principally designed for coal use (*Wierzbowski et al.*, 2017: 57–58).

[24] There are also some pumped-storage power plants in Poland.
[25] According to the UK Environment Agency, using short rotation coppice chips to generate electricity can produce 35 to 85 per cent less emissions per unit of delivered energy than a combined cycle gas turbine power station, while using straw cans, in some cases, produces over 35 per cent more (*Bates et al.*, 2009).

The Green Certificate mechanism did not set different prices for different renewable technologies (*Jankowska and Ancygier*, 2017: 189). It treated all energy sources the same and did not take into consideration their environmental impact and development potential (*Szulecki et al.*, 2015: 13). *Szulecki et al.* (2015: 14) claim that (old large) hydropower plants and (inefficient) coal-fired power plants burning biomass belonged to the main beneficiaries of the Green Certificate support mechanism. Onshore wind, and thus foreign investors, also benefitted (*Szulecki et al.*, 2015: 15). The 2015 Renewables Act introduced a new auction system starting from 2016 (the first auction took place on 30 December 2016), though it maintained the Green Certificate system for the existing renewable installations with restrictions.

When evaluating the availability dimension of the Polish *onshore wind* sector, we concentrate on Poland's wind potential and equipment/technology imports. Poland's wind conditions are relatively ideal for wind energy development, though they vary regionally and are thus uneven. The northern and central regions are distinctly the most favourable (*Hajto et al.*, 2017). Poland's installed wind power capacity increased from only 18 MW at end-2001 to 6.36 GW at end-2016 and 6.40 GW at end-2017 (*Statista*, 2018), with this last figure showing a halt in the growing trend. Due to the spectacular rise observed until 2016, Poland has the seventh largest wind power capacity in the EU. However, taking effect in mid-2016, a new Act on investments in wind power plants, the Wind Farm Investment Act (also called the Distance Act) introduced restrictions in its development due mainly to citizens' complaints about noise from wind farms (*Reuters*, 2016), which is also part of the sustainability dimension. Instead, the Law and Justice government stated its preference for geothermal energy or biomass. Nonetheless, geothermal has not yet been developed to any significant extent. There were speculations that the new situation could give an advantage to coal-fired power (*Kowalski*, 2016). As growth in renewables had been driven by wind energy over the previous few years, it became questionable how Poland would achieve the target of 15 per cent renewable energy in gross final energy consumption without growth in wind generation. Certainly, a new wave of biomass co-firing or biogas usage could help reach the target (*Easton*, 2016). However, in the summer of 2018, the 2015 Renewables Act and the 2016 Wind Farm Investment Act were, to some extent, relaxed to encourage onshore and offshore wind development (*ICIS*, 2018; *Renewables Now*, 2018; *Richard*, 2018).

End-2015 data suggest that the majority of onshore wind farm projects are owned by so-called independent power producers (IPPs). Approximately 19 per cent of installed capacity is in the hands of state-owned companies. At end-2015, the Danish manufacturer Vestas enjoyed the leading position (38%) among manufacturers with the highest installed capacity in Poland, followed by the Spanish Gamesa (now Siemens Gamesa) (14%) and the American GE (13%) in second and third place, respectively (*PSEW*, 2016). Used wind turbines have been imported from Germany and Denmark (*Friends Against Wind*, 2016). In its annual report, the Polish Wind Energy Association (PSEW) complained in 2017 that the provisions of the Wind Farm Investment Act would prevent the modernization of existing wind farms failing to meet the minimum distance requirement, i.e. in 99 per cent of cases. If there is no possibility of installing new technical wind turbine elements, this will encourage importing used wind turbine components (*PSEW*, 2017: 47).

Poland has no *offshore wind* energy (*Offshore Wind Journal*, 2017), but the outlook is hopeful for the period after 2020. According to *McKinsey & Company* (2016), Poland has the potential to become a leader in the development of offshore wind power for which the Baltic Sea offers favourable conditions. It believes that building 6 GW of capacity by 2030 is feasible. In contrast, the Polish Foundation for Sustainable Energy (FNEZ) stated in early 2018 that Poland could have 4 GW of installed offshore wind capacity in the Baltic Sea by end-2030 and 8 GW by end-2035 (*Offshore Wind*, 2018). WindEurope, formerly the European Wind Energy Association (EWEA), has three scenarios leading up to 2030 – a central scenario with 3.2 GW, a low scenario with 2.2 GW, and a high scenario with 6 GW (*WindEurope*, 2018b: 26). In April 2018, the president of the Polish state-owned grid operator PSE confirmed their support for offshore wind when he claimed that 4 GW of offshore wind could be installed (i.e. PSE is capable of connecting such capacity to its power grid) by 2026/2027 with up to 8 GW in the longer term (*O'Brian*, 2018; *Petrova*, 2018). To put these numbers into perspective, Europe had a total installed offshore wind capacity of 15.8 GW at end-2017, of which the UK represented 43 per cent (6.8 GW) (*WindEurope*, 2018b: 18). Offshore wind projects would benefit from the release of a draft plan for spatial development in Polish waters

(*Renewables Now*, 2018). The availability dimension of offshore wind energy supply security also includes the issue of reliance on foreign technology/equipment. However, recent years have brought about significant changes in this respect. Poland has become a strong player in the supply chain with major investments in the manufacturing of turbine foundations and the cranes and jack-up vessels used in installation and maintenance. The Polish wind industry provides 12 thousand jobs. The president of the Polish Wind Energy Association (PWEA) claimed in April 2018 that Polish companies could deliver up to 50 per cent of the components required to build offshore wind farms (*WindEurope*, 2018a).

Solar photovoltaic energy was almost non-existent before 2014, but it has grown considerably since 2015. More than 29 thousand solar systems with a cumulative capacity of 281.4 MW were installed in Poland by end-2017, the majority of which are micro-installations not exceeding 40 kW. Out of the 29 thousand solar systems, 589 systems with a total capacity of 107.7 MW were licensed by the Polish Energy Regulatory Office (*Pietruszko*, 2018). As in the case of wind energy, the availability dimension of solar energy supply security consists of both the amount of solar radiation and technology imports. Poland has about 1,600 sunshine hours per year, and the average solar irradiation on horizontal surfaces is approximately 1,080 kWh/m^2 (*Renewable Market Watch*, 2016). Thus, Poland has solar exposure conditions similar to those of Germany, a world leader in terms of PV capacity (*Majewski and Szymanek*, 2012: 21). As seen, the availability dimension is also affected by the dependence on technology imports. Most recent data show that 60 per cent of PV modules come from Polish producers, while the rest is imported. In 2016, China had the largest share in imports (36.3%), followed by Germany (24.8%). The share of the US fell significantly in favour of Germany. For the first time, at some point in 2016, the average wholesale prices of German PV modules were lower than the Chinese ones. Polish exports consisted of both modules produced by Polish producers (OEM modules), but also modules that Polish companies imported and then exported. The Netherlands (OEM exports), Belarus and Ukraine were the main export directions (*IEO*, 2017: 6, 20). As to sustainability, the environmental impacts of solar power include land use in the case of large utility-scale

PV and CSP projects, CSP water use for cooling purposes[26] and hazardous materials resulting from the PV cell manufacturing process (*Union of Concerned Scientists*, n.d.-b).[27]

As already discussed, non-fossil-fuel power technologies also induce life-cycle GHG emissions. However, according to *Pehl et al.* (2017), life-cycle emissions from solar, wind and nuclear power are many times lower than from coal or gas with carbon capture and storage or sequestration (CCS, see *Box 4*). Though highly uncertain and variable, life-cycle emissions from hydropower and bioenergy are substantial, and comparable in scale to those generated by fossil fuel carbon capture and storage plants (higher than from gas CCS, but lower than from coal CCS) (*Evans*, 2017). Sustainability questions also arise in the case of intermittent energy that is dependent on backup power or energy storage. In the old model, backup power is derived from the combustion of fossil fuels, typically natural gas, which cause GHG emissions. However, energy storage also increases emissions.

In summary, Poland has chosen to increase the share of renewables in the power system at the lowest possible cost. Almost all of the money has gone to either big energy companies or large foreign investors. Until recently, job creation from renewables has largely been a missed opportunity (*Szulecki et al.*, 2015: 15), though, as described above, changes have recently occurred. *Jankowska and Ancygier* (2017: 199) find that renewable policies have been designed in ways that do not affect the role of the conventional power industry or which at least try to minimize these changes.

Nuclear energy. Poland has no nuclear capacity, although plans for the development of this sector have been in place for decades. In 1982, construction began near the village of Żarnowiec, close to Gdańsk, but it was halted in 1990 during the democratic transition due to widespread public opposition. One and a half decades later, the 2005 Energy Policy until 2025 confirmed the intention to have the first nuclear power plant in operation by 2021 or 2022 (*Latek*, 2005; *Ministry of Economy*, 2009a: 54). More or less

[26] Compared to GHG emissions, far less attention is paid to the water footprint. Water is used (1) as a source that is converted to steam to turn turbines (a working fluid); (2) for flue gas desulfurization in coal facilities; (3) for cooling; and (4) for cleaning. Water is also used for growing energy crops for biopower facilities. For the water consumption of different types of power plants, see *Macknick et al.* (2012).
[27] There are no CSP projects in Poland.

in the same period, in 2006, Lithuania invited Poland to join its project of building a new nuclear power plant in Lithuania, despite Latvia and Estonia being opposed to Poland's involvement. Later, the Baltic states agreed to discuss cooperation with Poland, and in 2007, it was announced that Poland would indeed participate (*World Nuclear Association*, 2017). However, this regional project was stalled (*The Baltic Course*, 2016). Meanwhile, in January 2009, a resolution was adopted to develop the Polish Nuclear Energy Programme, followed in November 2009 by the adoption of the Polish Energy Policy until 2030, which supported the addition of nuclear power to the national energy mix (*Gawlikowska-Fyk and Nowak*, 2014: 16; *Ministry of Economy*, 2009a). The energy policy assumed the first nuclear block would be constructed by 2020. By 2030, three nuclear blocks with a total net capacity of 4.5 GW (gross capacity of 4.8 GW) would be in operation (*Ministry of Economy*, 2009b: 15). In January 2009, the Polish government designated the state-owned PGE Polska Grupa Energetyczna S.A., Poland's largest power producer, as responsible for the set-up and implementation of the nuclear programme. Therefore, first, in December 2009, PGE Energia Jądrowa (PGE EJ) S.A. was established, and then, in 2010, PGE EJ 1 Sp. z o.o., as a special-purpose vehicle, was founded with 51 per cent equity from PGE EJ S.A. and 49 per cent from PGE S.A. (*PGE*, 2011; *World Nuclear Association*, 2018). After years of negotiations, it was only in 2014 that PGE S.A. concluded a shareholders' agreement with Enea, KGHM Polska Miedź, Tauron Polska Energia (as mentioned earlier, the first is a majority state-owned Polish company, while the other two are minority state-owned) for the sale of 10 per cent interest in PGE EJ 1 to each new party (*PGE*, 2014). Also, in 2014, the Polish Nuclear Energy Programme was approved. It aimed to build two nuclear power plants with a capacity of approximately 3 GW each. The first unit of the first nuclear power plant was expected to be online by 2025, while the other units by 2035 (*Ministry of Economy*, 2014b). The draft Polish Energy Policy until 2050 in essence simply repeats these deadlines. The first unit with a capacity of 1.5 GW should be commissioned in 2024, while the combined capacity of 6 GW should be reached sometime between 2030 and 2035. As described, all three scenarios of the draft Energy Policy until 2050 are partly constructed around nuclear energy: the sustainable scenario – around 12 per cent, the nuclear scenario – 45-60 per cent, and the gas + renewables scenario – approximately 12 per cent. A 45-60 per cent share, however, would require huge nuclear capacity, much more than 6 GW. Nevertheless, so far no decision has been taken on whether to build the first nuclear plant. In addition, it has not been decided how the project will be funded (*Wood et al.*, 2017: 5). In April 2017, Poland's energy minister stated that the first 1.2-GW nuclear power station could be built by around 2030 (*Reuters*, 2017b, 2017c). In September 2017, the same minister noted that they wanted to build three units in five-year intervals, with the first one by 2029 (*Reuters*, 2017a). In March 2017, the Polish daily Rzeczpospolita reported that the European Commission proposed Poland should include nuclear power in its mix, targeting 3.3 GW by 2035 and eventually 8.2 GW by 2050.[28] In February 2018, PGE said it was ready to cooperate with more partners – not long after state-run Polish oil refiner PKN Orlen stated that it was examining the nuclear project (*Reuters*, 2018b). In May 2018, PGE decided to abandon its role and to instead focus investments on offshore wind energy. At the same time, media reported sources as saying PKN Orlen might take on PGE's role as the party responsible for the execution of investment in Poland's first nuclear power plant (*Barteczko and Goraj*, 2018). However, in May 2018, Poland's energy minister confirmed that the three minor investors would not take part in the project, adding that there was no decision that PGE would withdraw from the project and that he wanted PGE to maintain its leading role (*Poland in English*, 2018; *PolskieRadio.pl*, 2018).

Wood et al. (2017: 4) claimed that Poland was considering using the construction of nuclear power plants as one of its arguments in negotiations with the European Commission over capacity market emission performance standards. In March 2017, the Polish energy minister believed that adding nuclear power to the energy mix along with the development of renewables would improve Poland's bargaining position in talks with the European Commission and allow for the longer use of coal-fired power plants (*Warsaw Voice*, 2017).

In the case of nuclear energy, the geopolitical influencing factor is linked to technological reliance. These considerations exclude the use of Russian technology at a time when Rosatom has improved its performance (see above) (*Minin–Vlček*, 2018). In November 2015, it was reported that five players – the American Westinghouse, the Japanese GE Hitachi, the Canadian SNC-Lavalin Nuclear, the French Areva and EDF, and the South Korean KEPCO – had expressed interest in participating in a tender for the

[28] According to this source, wind farms should reach 18.8 GW, while the share of coal should gradually decline as lignite is eliminated from the energy mix (*Warsaw Voice*, 2017).

construction of Poland's nuclear power plant (*World Nuclear Association*, 2018). The availability dimension of nuclear energy supply security points to the availability of nuclear fuel in sufficient quantities at the site of the nuclear power plant and the possibility of diversifying nuclear fuel for the selected type of reactors. These issues, however, cannot be evaluated at such an early stage in the planning process. The affordability dimension requires finding a financing model, producing a positive return on investment, and not being classified by the European Commission as illegal state aid (*Gawlikowska-Fyk and Nowak*, 2014: 30). The sustainability dimension is supported by the very small amount of emissions to the atmosphere, while problems are centred on safety and nuclear waste management. Persistent safety concerns have intensified since the Fukushima disaster, though nuclear energy is safer than generally believed (*Breakthrough Institute*, 2013). *Heinrich et al.* (2016: 3) find that nuclear energy is presented in the Polish media as an answer to Poland's energy dependence problems. According to *Heinrich et al.*, from the security point of view, the referent object is the nuclear project itself, and the two key threats or challenges are low societal acceptance of nuclear energy and mounting investment costs. Therefore, the Polish government launched a substantial media campaign. Recent opinion polls indicate that Poles support the construction of a nuclear power plant (*World Nuclear News*, 2017). On the other hand, regarding an energy policy to "be primarily conducted in Poland in the near future", a 2013 poll shows that 70 per cent of Polish people want an energy policy supporting the development of renewables, compared to only 18 per cent for coal and 16 per cent for nuclear energy (*Greenpeace*, 2013).

3.2. Case study 2: Poland's gas diversification

3.2.1. The role of (Russian) gas in Europe

The future of gas is being disputed in Europe. It is questioned whether (1) natural gas can have a future as a bridge or transition fuel displacing or, more precisely, substituting coal until renewables enter the sector on a massive scale, first complementing renewables, and then becoming a sunset fuel (*van Foreest*, 2011); or whether (2) it can be a destination fuel, i.e. a significant part of a low-carbon energy balance; or if (3) it is a fuel with no future; or if (4) it can be part of the carbon-free energy future as decarbonised natural gas in the form of hydrogen by natural gas steam reforming (see the last in *Box 4*).

***Box 4*. Natural gas decarbonisation**

The decarbonisation of natural gas can principally take two forms. Firstly, it seems the most frequently discussed method is the post-combustion decarbonisation of natural gas through CCS, during which carbon dioxide is separated from the flue gas and then stored in geological formations (reservoirs), though this technology is still at an early stage (*van Foreest*, 2011: 15). Secondly, the pre-combustion decarbonisation of natural gas through natural gas reforming (steam methane reforming or SMR) to acquire hydrogen is another possible path and a solution allowing for the further use of the existing resource base and related infrastructure (*Dickel*, 2018: 2–3). SMR is the cheapest and most often used way to produce hydrogen (*HydrogenTrade.com*, n.d.). Although the combustion of hydrogen with oxygen produces water as its only product, carbon monoxide and then (in a subsequent step) carbon dioxide are also generated during the SMR process. These substances should also be captured and stored in geological formations, which is the most difficult problem linked to natural gas conversion to hydrogen (*Stern*, 2017: 6). Among others, hydrogen can also be produced by the electrolysis of water by using electricity from renewable sources (power-to-gas). Further, hydrogen can be created by coal and biomass gasification, biological production, liquid reforming and other processes (*HydrogenTrade.com*, n.d.; *Gleason*, 2013: 149; *DOE*, n.d.). According to *IGU* (2009: 26), about half of the global hydrogen production is from natural gas, 30 per cent is from oil, and most of the rest is from coal. Water electrolysis, contrary to widespread belief, accounts for only 4 per cent. IGU believes that manufacturing hydrogen from natural gas remains the best option until at least 2030. As seen, in the case of post-combustion decarbonisation of natural gas through CCS and pre-combustion decarbonisation of natural gas through SMR and CCS, natural gas is still used as feedstock. *Stern* (2017: 24) argues that only CCS with hydrogen distribution provides a solution for large-scale natural gas decarbonisation. According to *IGU* (2009: 25), it may be possible to transport in excess of 30 per cent hydrogen in existing high-pressure transmission networks, but because of the age and thus the state of many domestic appliances, the maximum allowed percentage may turn out to be 10 per cent or less.

Besides pre-combustion and post-combustion CCS, there is a third primary carbon dioxide capture system, called oxy-fuel combustion. In the oxygen-combustion process, air is replaced by oxygen to combust the fossil fuel (*Li*, 2016: 14–15). CCS to power stations, especially in the heating sector, has made limited progress (*Stern*, 2017: 13). According to the *Global CCS Institute* (2017: 28), there were 17 large-scale CCS projects in operation around the world at end-2017: nine in the US, three in Canada, two in Norway, and one in Brazil, Saudi Arabia and the United Arab Emirates each. Only two projects are related to power generation. Both are with a coal-fired power plant. One is with Unit 3 of the Boundary Dam in Estevan in Canada, while the other is with Unit 8 of Petra Nova in Thompsons, Texas. The industrial structure of the remaining CCS projects is the following: natural gas processing – eight, hydrogen production and fertiliser production – two-two, chemical production, iron and steel production and synthetic natural gas – one for each. As indicated, in Europe, there are only two large-scale projects in operation. In Norway, two gas fields, the Sleipner and the Snøhvit, produce natural gas with higher carbon dioxide content. It is stripped, collected and stored in geological formations deep underground (called industrial separation) (*Global CCS Institute*, n.d.).

Under certain conditions, a natural gas grid can also be used in the case of gases of biological origin. In this paper, we distinguish these from natural gas decarbonisation, because here the feedstock is not natural gas. These renewable gases can be produced by either anaerobic digestion (biogas) or gasification (bio syngas). Biogas (as a raw gas) can be purified to biomethane, while bio syngas can either be methanised to achieve a bio-substitute or bio-synthetic natural gas (bio-SNG) or it can be reformed into bio-hydrogen. Biomethane can also be used as a gaseous biofuel (biomethane vehicle fuel), for which it must be compressed (also called compressed biogas/biomethane – CBG, or bio-compressed natural gas – bio-CNG) (*IGU*, 2012: 8–9, 14–15). EBA (European Biogas Association) data suggest that there were at least 17 376 biogas plants in Europe at end-2015 (*Biogas barometer*, 2017: 5). Biogas can also be combusted to produce heat and/or power locally (*IGU*, 2009: 29). According to the think tank France Biométhane and Sia Partners consultancy, which monitors nine European countries, the sector had some 480 plants injecting biomethane into Europe's natural gas grids at end-2016 (*Biogas barometer*, 2017: 6). The production of biomethane in Europe is only about 2 bcma (*Honoré*, 2018a: 43), and biogas growth is slowing due to policy revisions in Germany and Italy (*Stern*, 2017: 11).

European gas demand has failed and will continue to fail to meet previous gas industry expectations. Based on temperature-corrected data, the period of gas demand expansion ended in the mid-2000s, followed by a three-year long plateau and then a period of decline until 2015 (*Stern*, 2017: 1). Since then, however, some growth has been observed. Although *Henderson and Sharples* (2018: 2, 8) indicate the surprisingly rosy image of rising gas demand owing to the accelerating shift away from coal in the power sector, the phase-out of nuclear plants and delays in new nuclear plants, *Stern* (2017: 3–4) highlights fundamental problems, including (1) the lack of traction of gas advocacy messages promoting gas in relation to its environmental advantages; (2) the issue with the price competitiveness of gas between 2011 and 2014 with lasting damage to the commercial image of gas in many countries (*Table 8*); (3) a coal and renewables paradigm in the power generation sector led by the gas price competitiveness problem; (4) low carbon prices (*Figure 2*); (5) cost reduction and technological advancement in the field of renewables and electricity storage; and (6) political controversy surrounding the import of Russian gas.

Deák (2017) highlights that Russia has played a significant role in natural gas not being incorporated into the EU's decarbonisation policies, due to the negative image associated with gas as a result of the January 2009 Russian–Ukrainian gas crisis and Russia's actions in Ukraine in 2014. Thus, in contrast to the original concept of gas as a bridge or transition fuel, it has not become part of the sustainable fuel pool, rather occupying a back-up position as the second best option if the primary policy targets fail.

Nonetheless, from a Russian perspective, the European era of growing gas exports has not yet ended, but there is a major shift from demand growth to import increase expectations in Europe (*Deák*, 2017). After mixed but limited results between 2009 and 2015, including very low levels of exports in 2009, 2010 and 2012, Gazprom unexpectedly delivered record volumes of gas to Europe in 2016 and 2017 due to (1) lack of competition from other suppliers because of delays in new LNG start-ups, higher LNG demand in Asia and problems with other pipeline gas suppliers (including Algeria); (2) higher coal prices mainly owing to increasing Chinese coal imports; (3) the decline in European indigenous production as a consequence of older, more mature fields in the North Sea and serious problems at the Groningen field in the Netherlands; (4) the rebound in European gas demand driven by the European economic recovery, cold winter temperatures and increased coal-to-gas switching (following the higher coal prices and significant rise in the carbon price in Europe); and (5) the change in Gazprom's pricing strategy in response to demands from customers and pressure from the European Commission through the Third Energy Package and the DG COMP investigation (*Henderson and Sharples*, 2018).

Russia's share has increased in the European gas market and could approach 40 per cent in the foreseeable future (*Henderson and Sharples*, 2018: 1). While the political perspective is that Russian gas's market dominance is the most important security problem for European gas markets, the gas perspective points to (1) the decline in European conventional gas production; (2) the failure to diversify pipeline gas supplies and uncertainty about the duration of the ongoing LNG supply surplus; and (3) the rising gas prices in Europe in the case of any restriction of Russian gas supplies (*Stern*, 2017: 9–10). According to *Henderson and Sharples* (2018: 26), irrespective of political risks, the forecasted increase in Russia's share raises the question of over-dependence and presents a security of supply issue for European policy-makers in purely commercial terms.

Russia has the lowest cost of delivery for substantial volumes of pipeline gas into Europe (*Stern*, 2017: 10). Besides Russian gas, global LNG constitutes the only significant source of potential extra supply. However, the affordability dimension of security of supply contributes to the increasing share of Russian gas in the European energy mix, with the possible exceptions of Poland and Lithuania (*Henderson and*

Sharples, 2018: 26). The prospects for alternative pipeline imports are relatively poor due to problems with North African supplies and the limited prospects from the Caspian region. In contrast, European LNG imports are likely to grow substantially and the global oversupply of LNG could last until at least 2020 and potentially up to 2025 (*Stern*, 2017: 10–12). According to *Henderson and Sharples* (2018: 26), the long-anticipated surge in new LNG is likely to arrive by 2019, as US and Australian projects come online and ramp up, and the oversupply could last from 2019 into the early 2020s. *Deák* (2017) argues that the emergence of LNG underpins Europe's relaxed approach to the issue of gas markets due to the huge regasification capacity in Europe (although unevenly distributed among the various countries). LNG is an instrument that could be used to reshape the EU gas markets because (1) it is a constraint for Gazprom's leverage on European prices, and (2) it provides a flexible and only moderately more expensive alternative (*Deák*, 2017).

In contrast to West European EU member states, Central and East European countries do not enjoy a sufficient degree of gas supply diversification, and thus have high vulnerability and low resilience, but it should be noted that the conditions and opportunities differ significantly across the various CEE countries. The EU has finally recognised that these deficiencies should be addressed as a matter of priority not only at a national but also at the EU level, irrespective of whether one subscribes to a commercial or geopolitical point of view (*Yafimava*, 2015: 6). Therefore, recently, the EU has actively supported infrastructure development to cope with supply disruption events, though perhaps many of these projects are not commercially viable (*Stern*, 2017: 12).

3.2.2. Diversifying Polish gas supplies

Poland is the seventh biggest gas consumer in the EU, with 16.0 bcm consumed in 2016. Gas production amounted to 4.2 bcm, while imports reached 13.9 bcm. Gas exports from Poland increased to 839.3 million cubic metres (mmcm) in 2016 (*Table 11*) (*Ministry of Energy*, 2017c: 29).

Table 11. Poland's gas balance, 2004–2016 (TJ)

	2004	2005	2006	2007	2008	2009	2010
Primary production	164 428	162 630	162 463	163 147	154 487	153 980	154 617
Imports	341 520	358 692	374 162	346 884	383 350	341 507	373 125

Exports	1 578	1 500	1 570	1 509	1 323	1 399	1 577
Stock changes	-6 955	-7 588	-8 291	14 602	-10 406	10 939	9 943
Gross inland consumption	497 538	512 337	526 870	523 228	526 204	505 129	536 211

(continued on next page)

Table (continued)

	2011	2012	2013	2014	2015	2016
Primary production	161 186	163 570	160 067	156 014	154 196	148 745
Imports	404 586	420 496	429 951	406 506	418 358	510 167
Exports	989	107	3 224	2 592	1 901	29 965
Stock changes	-27 348	-11 192	-11 702	1 289	6 111	-16 276
Gross inland consumption	537 527	572 834	575 158	561 256	576 769	612 671

Source: Eurostat (2018f).

Although gas still has a small share in Poland’s electricity and energy mixes, forecasts show this will increase. The Energy Policy until 2030 assumes that gas consumption will grow by 40 per cent from 14.5 bcm in 2006 to 20.2 bcm in 2030 (*Table A3 in the Appendix*). In contrast, the 2013 forecasts of the Polish National Energy Conservation Agency, presented as part of the draft Energy Policy until 2050, show a smaller increase for the period up to 2050 (*Table A7 in the Appendix*). *Honoré* (2018b) highlights that the role of renewables has increased much faster than that of gas in recent years. *Honoré* believes that it is unlikely that natural gas will profit in the 2020s. Regarding sustainability, the replacement of coal power plants with gas reduces carbon dioxide emissions, but leakages cause methane emissions that are typically not taken into account (*Brook et al.*, 2014; *Horn*, 2017).

However, in Poland, there is room for reducing gas demand either through increasing efficiency or without increasing efficiency (energy conservation). Yet the significance of these ways of introducing domestic diversification tends to be underestimated. Despite attempting to achieve the same outcome, energy efficiency and energy conservation are two different things. Energy efficiency refers to using technologies that require less energy to perform the same function (e.g. using LED light bulbs, home insulation). In contrast, energy conservation means changing behaviours in order to use less energy (e.g. turning the lights off when leaving the room) (*EIA*, 2018).

So far, four National Energy Efficiency Action Plans have been prepared in Poland (2007, 2011, 2014 and 2017). The fourth one was adopted in early 2018 (*Ministry of Economy*, 2014a; *Ministry of Energy*, 2018). The 2017 National Energy Efficiency Action Plan claims that according to the forecasts of the Polish Ministry of Energy – which are, in fact, the 2013 forecasts of the Polish National Energy Conservation Agency included in the draft Energy Policy until 2050 and presented in *Table A7 in the Appendix* – the Polish primary energy demand will remain stable at around 102-103 million tonnes of oil equivalent (mtoe) per year until 2020, and then it is expected to decrease by about 15 per cent by 2050 (*Ministry of Energy*, 2017a). At the same time, Poland's indicative national energy efficiency target for its primary energy demand in 2020, pursuant to the 2012 Energy Efficiency Directive aimed at helping the EU reach its 20 per cent energy efficiency target by 2020, amounts to 96.4 mtoe. This would require achieving economic development without increasing primary energy consumption (or with decreasing primary energy demand). In contrast, final energy consumption is well below 70 mtoe, while the national indicative target for 2020 is 71.6 mtoe, which leaves room for increases until 2020 (*Table A8 in the Appendix*) (*IEA*, 2017a: 24).

Between 2005 and 2015, an increase was witnessed in the share of transport (from 22 per cent to 28 per cent) and services (from 12 per cent to 13 per cent) in final energy consumption, and a drop in the share of industry (from 26 per cent to 24 per cent), households (35 per cent to 31 per cent) and agriculture (from 8 per cent to 5 per cent). Households remained the largest consumer despite a drop in its share (*Ministry of Energy*, 2017a: 6).

In 2015, Poland's energy intensity was 16 per cent higher than Germany's and the IEA European average,[29] but 6 per cent lower than that of the Slovak Republic and 23 per cent lower than that of the Czech Republic (*IEA*, 2017a: 24). The Energy Policy until 2030 predicted a significant reduction in primary energy consumption per unit of GDP from around 89.4 tonne of oil equivalent (toe)/PLN million at 2007 prices in 2006 to approximately 33.0 toe/PLN million at 2007 prices in 2030. Consumption of electricity per GDP was expected to decline from 137.7 MWh/PLN million at 2007 prices in 2006 to 60.6 MWh/PLN million at 2007 prices in 2030. To put these numbers into context, the Energy Policy until 2030 declares that the energy efficiency of the Polish economy will only reach the 2005 EU15 average at the very end of the forecasted period (*Table 12*) (*Ministry of Economy*, 2009b: 17). Forecasts prepared by the Polish National Energy Conservation Agency and presented as part of the Polish Energy Policy until 2050 indicate that the energy intensity of the Polish economy will decrease by about two-thirds over the period 2010–2050 (*Table 13*).

[29] IEA Europe refers to the European member countries of the International Energy Agency (IEA).

Table 12. Forecasts of the Polish Energy Policy until 2030 for energy and electricity intensity in Poland, 2006–2030

	2006	2010	2015	2020	2025	2030
Energy intensity (toe/PLN million at 2007 prices)	89.4	73.1	56.7	46.6	38.6	33.0
Electricity intensity (MWh/PLN million at 2007 prices)	137.7	110.4	90.4	77.8	67.8	60.6

* Energy and electricity consumption per GDP, respectively.
Source: Ministry of Economy (2009b: 18).

Table 13. Forecasts of the Polish National Energy Conservation Agency (2013) for energy and electricity intensity in Poland, 2010–2050

	2010	2015	2020	2025	2030	2035	2040	2045	2050
Energy intensity of the economy – primary energy (toe/PLN million at 2010 prices)	72	62	52	45	39	33	29	26	24
Energy intensity of the economy – final energy (toe/PLN million at 2010 prices)	47	41	36	32	28	24	20	18	17
Electricity intensity of the economy (MWh/PLN million at 2010 prices**)	111	97	90	82	79	74	69	64	60

* Energy and electricity consumption per GDP, respectively.
** Originally, GWh/PLN million is given as the unit of measurement, but our calculations and the figures in *Table 13* suggest that the appropriate unit of measurement is MWh/PLN million
Source: Ministry of Economy (2015c: 9).

In order to implement the 2012 EU Energy Efficiency Directive, Poland decided to adopt a 1.5 per cent annual saving of energy by energy distributors or retail energy sales companies from 2014 to 2020 (i.e. a total of 10.5 per cent) (*Ministry of Economy*, 2014a). In May 2016, the Polish Parliament adopted a new Energy Efficiency Act, which replaced the 2011 Energy Efficiency Act. As of 2013, the 2011 Energy Efficiency Act introduced a system of energy efficiency certificates, so-called White Certificates, imposed on companies selling electricity, natural gas or heat to end-users in Poland. This scheme is the key energy efficiency support mechanism in Poland (*Ministry of Energy*, 2017a). However, there are many other ways of improving energy efficiency. *Wierzbowski et al.* (2017: 60) mention the anticipated efficiency increase due to new highly efficient power generating units replacing older assets. It is also possible to reduce electricity grid losses, as current grid losses are above the EU average. In addition, improvements can be made to heat production and distribution. Combined heat and power (CHP) generation should gradually replace heating boiler technology. District heating modernization or replacement and the better insulation of homes would also contribute to energy efficiency through the limitation of heat losses. Regarding this last aspect, up to 70 per cent of stand-alone houses in Poland (around 3.6 million) are insufficiently insulated (*Ministry of Energy*, 2017a). Finally, the popularity of low-energy buildings and household appliances should also be increased (*Wierzbowski et al.*, 2017: 60).

The diversification scheme (*Figure 1*) indicates that a further option lies in sectoral diversification, either domestic or external. Similarly to the category of "reducing gas demand" (either through energy efficiency or energy conservation), sectoral diversification also aims at reducing gas demand but in a different way. Nonetheless, because of the low share of natural gas in the energy/electricity mix, sectoral diversification has little relevance in the case of Poland. However, increasing electricity imports would be an option as a form of external sectoral diversification.

In the early 2010s, many believed that increasing domestic gas production, another means of domestic diversification, would be a real opportunity for Poland. In Central and Eastern Europe, only Romania has a substantial gas production, but it is also not negligible in Poland. Gas production is relatively stable, amounting to around 4 billion cubic metres per annum (bcma). It accounts for around a quarter of the Polish balance of gas supply (domestic production + imports), if gas exports and changes in gas inventories (gas storages) are not taken into account (*Ministry of Energy*, 2017c: 29).

Shale gas was regarded as a genuine prospect in Poland, but the hype of the early 2010s has proved to be an illusion. At that time, the government expected to start commercial production of shale gas in late 2014 or early 2015. In its Golden Rules Case or best-case scenario, the *IEA* (2012) predicted unconventional gas production in the EU would be led by Poland, starting in the mid-2010s. Poland wanted the state-controlled PGNiG company to double its gas production with both conventional and unconventional gas by 2019 (*Reuters*, 2012). In September 2011, Polish Prime Minister Donald Tusk believed Poland would basically be able to switch to using its own gas sources by 2035 (*Vzglyad*, 2011). However, so far all efforts have failed. Everything started with lower resource assessments than expected (*Figure 3*). This was followed by low exploratory activity. By June 2017, concession holders had drilled only 72 exploratory wells (*PSG*, 2017c). Foreign companies have faced difficult geological and regulatory challenges in Poland, leading them to pull out of the market. Also, lower oil prices have discouraged investment in unconventional gas reserves. Furthermore, in 2010, *Gény* suggested that Polish projects would not be cost competitive with imports over the following decade. However, there is hope in Poland that in the long-term perspective unconventional gas could play a crucial role (*Wierzbowski et al.*, 2017: 60). With shale gas, Poland aimed to eliminate dependence on Gazprom. Climate incentives (i.e. the need to replace coal) were not considered.

Figure 3. Shale gas resource assessments in Poland by different institutions

EIA (April 2011)	>	*EIA* (June 2013)	>	Polish Geological Institute (*PSG*, March 2012)	>	USGS (*Gautier et al.*, July 2012)

Source: Weiner (2016: 25).

Poland is still highly dependent on Russian gas supplies. In 2016, 74.3 per cent (10.3 bcm) of the total gas imports (13.9 bcm) came from Russia. Supplies from Germany and the Czech Republic represented 18.2 per cent (2.5 bcm) and 0.04 per cent (4.9 mmcm), respectively. Due to the start of commercial LNG deliveries in 2016, the share of gas from Qatar and Norway was 6.9 per cent (963.6 mmcm) and 0.6 per cent (78.4 mmcm), accordingly (*Ministry of Energy*, 2017c: 29).

Poland was the first country to receive Soviet gas in the mid-1940s. After the change of regime, in the 1990s, Russian gas supplies were initially arranged according to the Yamburg and Orenburg agreements. These were replaced by the 1996 Yamal contract up to 2020 to supply Russian gas, which was related to the 1993 intergovernmental agreement and 1995 protocol to build the Polish section of the Yamal-Europe transit gas pipeline running from Russia to Germany across Belarus and Poland. The Yamal-Europe pipeline was commissioned in 1999 (see below). However, due to formerly overestimated gas demand in Poland, the Yamal contract was modified in 2003. It was extended until 2022, while annual import volumes were reduced. In contrast, Poland significantly increased its gas imports from Russia in 2009, after the early 2009 removal of the controversial Russian–Ukrainian intermediary company Rosukrenergo (also, see below). That year, Poland was the only country to increase its imports from Gazprom Export, Gazprom's export arm, and at that significantly so.[30] In 2010, Poland was Gazprom Export's fourth largest customer outside the former Soviet Union, ahead of France. While other countries worried about the excess gas volumes contracted, Poland was trying to adjust its negative gas balance in 2009–2010. After a short-term contract

[30] Switzerland took roughly the same amount as in 2008 (*Weiner*, 2013).

in 2009, it was only in October 2010 that an annex to the Yamal contract was signed, allowing for an increase in gas purchases. With this step, Gazprom's role in Poland's gas supplies increased. However, the contract was never actually renewed or extended until 2037.

High gas prices compared to other Gazprom buyers have been the subject of continuous disputes. In 2011, Poland's PGNiG turned to arbitration, while in 2012, PGNiG secured a deal with Gazprom. Again, in 2015, PGNiG filed a lawsuit against Gazprom over gas prices. Poland was one of the Central and East European EU member states in which the European Commission investigated Gazprom's anti-competitive practices. It is broadly known that following inspections at the premises of concerned gas companies in these selected states in 2011, DG COMP opened formal proceedings against Gazprom in 2012 and, finally, issued a Statement of Objections in 2015. All of DG COMP's three main findings (preliminary view) referred to Poland. Firstly, DG COMP found that Gazprom imposed territorial restrictions (export bans, destination clauses and other measures) preventing gas exports. Secondly, these restrictions could have resulted in higher gas prices and allowed Gazprom to pursue an unfair pricing policy. Thirdly, Gazprom might have been leveraging its dominant market position by making gas supplies conditional on obtaining unrelated commitments concerning gas transport infrastructure. In Poland, gas supplies were made dependent on the acceptance of Gazprom reinforcing its control over the Yamal-Europe pipeline (*Stern and Yafimava*, 2017: 2–3). In February 2017, Gazprom proposed commitments to address the European Commission's competition concerns, and in March 2017, the European Commission invited comments from all interested parties on these proposals. Finally, in May 2018, the European Commission adopted a decision imposing a set of binding obligations on Gazprom (*European Commission*, 2018a). Firstly, Gazprom must remove restrictions on customers to re-sell gas cross-border. Secondly, Gazprom has to facilitate gas flows to and from isolated markets by swaps, flexibility, as well as fixed and transparent service fees. Thirdly, Gazprom has to ensure competitive gas prices, reflecting competitive West European price benchmarks. Fourthly, regarding the Yamal-Europe pipeline, the European Commission found that the situation could not be changed through such an antitrust procedure, as gas relations between Russia and Poland are determined by intergovernmental agreements. A May 2015 decision by the

Polish Energy Regulatory Office did not confirm allegations that Gazprom would have foreclosed the Polish gas market with regard to the Yamal-Europe pipeline, since its owner, Europolgaz, co-owned by Gazprom, was unable to delay or block investment on the pipeline (investment enabling reverse flows from Germany was also implemented) (*European Commission*, 2018b).

PGNiG has decided not to extend the Yamal contract with Gazprom when it expires in 2022. Poland is to replace Russian gas mainly with that of Norway via a yet-to-be built pipeline and with LNG via the new LNG terminal.

Geographical gas import source diversification implies both contractual relations for sale and purchase and the construction of the appropriate infrastructure. In Poland, a minimum level of diversification is required by legislation. In 2000, the maximum share of imported gas from one country of origin relative to the total volume of imported gas was set for each year until 2020: 88 per cent in 2001–2002, 78 per cent in 2003–2004, 72 per cent in 2005–2009, 70 per cent in 2010–2014, 59 per cent in 2015–2018 and 49 per cent in 2019–2020 (*Regulation of the Council of Ministers*, 2000). The Regulation applied to all wholesalers buying gas from abroad. However, these requirements raised doubts as to their compliance with EU law. In 2017, a new regulation was published to specify the maximum percentage share of gas imported from one country. Accordingly, it cannot exceed 70 per cent in 2017–2022 and 33 per cent in 2023–2026. The regulation contains a formula for calculating this share, and makes it possible for there to be exemptions from the obligation (e.g. for the LNG terminal in Świnoujście, see below). It is notable that intra-EU purchases and supplies originating from the states of the European Free Trade Association (EFTA) and Switzerland are not defined as imports (*Kancelaria.LEX.pl*, 2017). Until recently, Poland has mostly just talked about diversifying away from Russian gas supplies. Instead of costly investments in infrastructure and contractual relations, Poland has tended to emphasize solidarity as a means of concealing its own responsibility, while – as *Bartuška* (2008: 57) has aptly formulated – there can be no supply security without a willingness to pay for it.

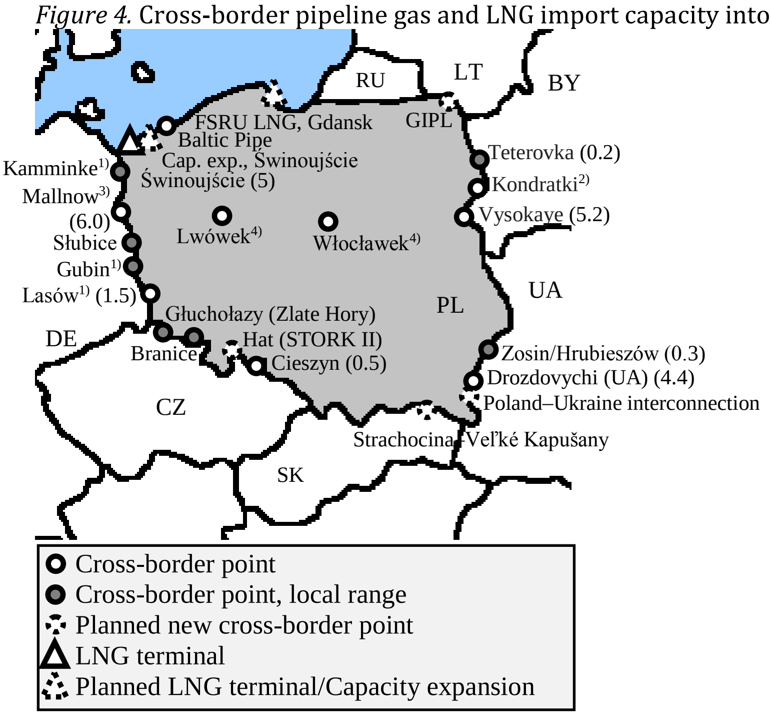
Poland requires not only new cross-border infrastructure but also significant enhancement of its domestic pipeline network. Finally, in the 2010s, notable steps have been made to achieve diversification. Since 2016, Poland has been able to import non-Russian gas not only by pipeline but also as LNG. Via pipeline, Poland can buy gas from the east, west and south, but capacities are very limited at the southern and western borders. Some of the cross-border pipelines aim only to meet local needs and gas is not introduced into the transmission grid. Poland can physically receive gas through the following channels:

(1) from the east through Belarus (through two entry points from the Gazprom Transgaz Belarus network and two exit points from the Yamal-Europe gas pipeline) and from/through Ukraine (through two entry points);

(2) from the west from/through Germany (through four entry points); and

(3) from the south from/through the Czech Republic (through three entry points) (*Figure 4*).

Figure 4. Cross-border pipeline gas and LNG import capacity into Poland



1) Effective April 2016, the existing cross-border connections at Lasów, Gubin and Kamminke were replaced with a single point called GCP Gaz-System/Ontras (its capacity is 1.6 bcma).
2) The Yamal-Europe gas pipeline cross-border entry point.
3) The Yamal-Europe gas pipeline cross-border exit point and virtual entry point.
4) Yamal-Europe gas pipeline exit points (located) in Poland.
Note: According to my collected data, all the border crossings are indicated on the map (including pipelines of local significance; either for transmission or distribution). In parentheses, 2017 import capacity is indicated in bcma where data are available (*URE*, 2018: 147–148).
Source: Own compilation.
Blank map: http://www.youreuropemap.com/.

Until the January 2009 Russian–Ukrainian gas crisis, only one interconnection worth mentioning had been built to receive gas from the non-east direction. This German–Polish interconnection with an entry point at Lasów has been used to import gas from Germany and Norway. Recently, Poland's import possibilities from the non-east directions have been increased due to (1) a new interconnector with the Czech Republic (called STORK); (2) virtual reverse flow services on the Yamal-Europe gas pipeline; (3) capacity expansion at Lasów, and (4) the first LNG terminal in Świnoujście. Without taking into account the virtual reverse flow service, more than 6 bcma of capacity has been added. These three (No. 1, 3 and 4) provide a total of 7 bcma of cross-border entry capacity into Poland (*Table 14*), compared to the 16 bcma for consumption.

Table 14. New cross-border pipeline gas and LNG import capacity in Poland since the January 2009 Russian–Ukrainian gas crisis

	Capacity (bcma)	Year of putting into operational
Pipeline gas		
Czech–Polish interconnection (STORK)	0.5	2011
Virtual reverse flow service on the Yamal-Europe gas pipeline	6.0	2011–2016
Capacity expansion of the German–Polish interconnection at Lasów	1.5 (from 0.9)	2012
LNG		
LNG terminal in Świnoujście	5 (3.7 mtpa)	2016*

Mtpa – million tonnes per annum. 1 mt of LNG = 1.36 bcm of natural gas.
* Commercial operation.
Source: Own compilation.

Further pipeline plans or projects include the Baltic Pipe, an interconnection between Denmark and Poland for transporting Norwegian gas; new Poland–Ukraine and Poland–Czech (STORK II) interconnections; and the first Poland–Slovakia and Poland–Lithuania (GIPL) interconnections. The main geographical source diversification project aiming to end Russian gas imports by 2022 is the Northern Gate project that includes the Baltic Pipe and the LNG terminal. While the LNG plan has finally been realised, the Baltic Pipe is still a long-running plan going back to 2001 without a final investment decision despite strong Polish commitments. In addition to diversifying away from Russian gas, there are two other main reasons for this project. Firstly, it is related to Poland's presence on the Norwegian Continental Shelf. Secondly, the pipeline might serve regional cooperation, as Poland may perhaps become a gateway for gas supplies to the south and east (*Gawlikowska-Fyk and Godzimirski*, 2017: 5). Future LNG plans/projects include not only the extension of the regasification capacity of the existing plant from 5 bcma to 7.5 bcma and the construction of a second quay (enabling trans-shipment, bunkering and developing inland waterway navigation), but also a Floating Storage and Regasification Unit (FSRU) in the Gdansk Bay (*Table 15*). Only with the launch of the Baltic Pipe (planned to have a 10 bcma capacity), Poland would be able to import 17 bcma of non-Russian gas. This would be supplemented by (some of) the above-mentioned projects. However, so far, none of the projects have entered construction phase. As of end-May 2018, among these seven plans/projects, two, the Poland–Slovakia and the Poland–Lithuania interconnections have final investment decisions (*Kuś*, 2018).[31]

Table 15. Plans/projects to increase cross-border pipeline gas and LNG import capacity in Poland

	Entry capacity (bcma)	Exit capacity (bcma)	Status	Year of expected commis-sioning
Pipeline gas				
Poland–Ukraine interconnection	5	5	Market screening ongoing until 8 June 2018	2022
Polish–Czech interconnection II (STORK II)	6.5	5	Pre-investment phase	…
Poland–Slovakia interconnection	5.7	4.7	CA signed in Apr. 2018 (FID)	2021
Poland–Lithuania interconnection (GIPL)	1.7	2.4	CA signed in May 2018 (FID)	2021
Baltic Pipe (Denmark–Poland interconnection)	10	3	Design phase	2022
LNG				
Extension of the regasification capacity of LNG terminal in Świnoujście	7.5 (5.6 mtpa)		Preparatory works finalised	2022
FSRU LNG in the Gdansk Bay	4.1–8.1			2021

CA – connection agreement. FID – final investment decision.
Source: Own compilation based on *Bielecki* (2017), *Gaz-System* (2017, 2018, n.d.), *Gaz-System and Energinet* (2017), *Kus* (2018), *Reuters* (2018a).

The 10 bcma of capacity of the Baltic Pipe and a similar contract with Norway would mean excess capacity and surplus supplies to Poland, which Poland intends to transmit to neighbouring countries, such as Slovakia, the Czech Republic and possibly Ukraine (*Radio Poland*, 2018a, 2018b).

Regarding non-Russian gas supplies, Poland has been supplied by Germany and the Czech Republic since the 1990s, taking only a very small amount of gas for their own

[31] Concerning non-Russian imports, people tend to talk only about import capacity, while a domestic pipeline network also needs to be prepared for non-eastern imports.

local needs. The 1990s saw a stream of diversification announcements about bringing pipeline gas from Netherlands, Norway and Denmark. But despite negotiations and even at times signed contracts, only a small contract was concluded with Norway on the supply of a mere 0.5 bcma of gas for the period between 2000 and 2006 (*Stern*, 2005: 116; *Statoil.ru*, 1999). Russian gas was cheaper than Norwegian (*ICIS Heren*, 2006). In the early 2000s, Poland was unable to go ahead with a large Norwegian contract due to problems with accommodating large amounts of gas. The Norwegians wanted to export 9-10 bcma of gas to ensure that the pipeline was profitable, while Poland intended to import only 5 bcma (*Warsaw Business Journal*, 2001). Poland did not succeed in finding other buyers for the remaining quantities (*ICIS Heren*, 2006).[32]

A certain type of diversification was achieved from the east by introducing gas imports from Ukraine's Naftohaz and from Central Asia through intermediary companies. Naftohaz was selling a very small quantity of gas to satisfy local needs under a long-term gas supply contract, signed in 2004 for the period until 2020, but Ukraine permanently suspended deliveries in 2010. Intermediary companies first included Eural Trans Gas, which was registered and operated in Hungary as an offshore business entity, and then the Swiss-based Russian–Ukrainian Rosukrenergo, which functioned until end-2008. Contrary to the listed intermediaries, Gazprom's Gazprom Schweiz, which re-exports Central Asian gas to Central and Eastern Europe, is not present in Poland.

As noted, Poland began receiving commercial LNG deliveries in June 2016. Poland has one long-term and one mid-term LNG supply contract and it also buys gas on the spot market. A long-term contract with Qatar's Qatargas was signed in 2009 for the supply of 1 mtpa of LNG for 20 years to be delivered as of 2014. The contract was amended in 2014 and 2015 to divert LNG supplies destined for Poland to other clients in 2015 and the first half of 2016 because of delays in the LNG facility's operation start-up time. However, in 2017, an agreement was reached to double volumes to 2 mtpa. A mid-term LNG supply contract was signed with the UK-based Centrica to receive nine LNG shipments which were to be sourced from the US Sabine Pass LNG Terminal between 2018 and 2022. In addition, in June 2018, two long-term agreements (but still not final contracts) were signed, each for the purchase of 2 mtpa of LNG from the US over 20

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[32] Import diversification is reflected as German (since 1993) and Czech imports (since 2012) in the IEA and Eurostat statistics.

years.[33] Yet, as emphasized, availability is only one dimension of security of supply. There are serious questions about the price or affordability dimension of LNG supplies. "PGNiG agreed a contract with Qatar for one of the highest prices seen in any gas contract anywhere in the world" (*Jonathan Stern*, email communication, 14 January 2013). A 2009 source stated that LNG supplies from Qatar might be 30-50 per cent more expensive than Russian gas (*GOwarsaw.eu*, 2009), while another source from 2013, with precise numbers, suggested more than 50 per cent higher prices (*Reuters*, 2013). However, low(er) oil prices experienced since the mid-2010s have contributed to a decrease in Qatari LNG prices. In 2015, a Polish expert even went as far as saying that Qatari LNG could be competitive when comparing with Russian gas import prices (*Denková*, 2015).

The final type of diversification is transit or route diversification. Poland would have had the possibility of diversifying its transit options through the Nord Stream gas pipeline but it did not ask for that opportunity. The German government invited Poland to the Nord Stream project, but Warsaw refused. Wingas – then a Russian–German joint venture, now a wholly owned subsidiary of Gazprom – also offered to link the Polish gas grid to the OPAL gas pipeline, a European onshore connecting pipeline of Nord Stream, but Poland did not accept (*Cameron*, 2007: 3). Poland has shown strong opposition to Nord Stream. Instead of building this pipeline, Poland unsuccessfully campaigned in favour of either Yamal-Europe 2 or Amber. Yamal-Europe 2 would not have been a parallel pipeline to Yamal-Europe 1, but would have run from the Belarusian border via Poland to Slovakia, while Amber was a proposed pipeline crossing EU countries, from Russia through Latvia, Lithuania and Poland to Germany.[34] However, Russia's goal was to circumvent (unreliable) transit states (only secondary consideration was given to the creation of additional capacity). Above all, Poland attacked Nord Stream on the grounds of its environmental consequences (a potential ecological disaster) (*BruxInfo*, 2008). Former Polish Defence Minister Radek Sikorski and others complained that Germany

[33] One is with the US Port Arthur LNG scheduled to start flowing in 2023 from an LNG facility being developed in Jefferson County, Texas, and the other – with the US Venture Global LNG to be supplied from LNG facilities which will be located in the Gulf of Mexico in Louisiana, and which are expected to be completed in 2022 and 2023, respectively (*PGNiG*, 2018a, 2018b; *Reuters*, 2018d).

[34] Previously, another plan was called Amber, a joint plan involving Poland's PGNiG, Denmark's DONG (now Ørsted) and Lithuania's Lietuvos Dujos (later merged into Lithuania's Energijos Skirstymo Operatorius), which would have delivered gas to Lithuania through Poland. However, other plans also exist that have been referred to as Amber.

had not consulted with Poland before the decision was made on the pipeline, and considered the project to be President Putin's most outrageous attempt to divide the EU leading to economic and geopolitical disaster. They regarded Nord Stream as economically absurd, referring to the costs of constructing and financing the pipeline, future tariffs and Gazprom's growing dominance (*Cameron*, 2007: 2). They feared that with the construction of Nord Stream, Gazprom would turn off the gas tap to Poland without violating West European (German) interests. Fears were also expressed not only because of Poland losing its bargaining power and becoming more vulnerable to blackmailing, but also due to a potential transit revenue drop.[35] While Gazprom's growing dominance could be a problem, and Nord Stream 2 could bring further negative consequences, the above accusations have so far not been confirmed.

Gas transit via Ukraine will continue to be necessary in sizeable volumes until Nord Stream 2 and Turkish Stream are launched. However, thanks to Nord Stream 2 and its European onshore connecting pipeline EUGAL, gas transit via the Ukrainian–Slovakian cross-border point is expected to fall considerably, while gas transit via Poland through the Yamal-Europe pipeline is likely to continue. On the other hand, the launch of Turkish steam's first line will result in a substantial decline in gas transit via the Ukrainian–Romanian cross-border point due to the diversion of gas destined for Turkey and the Black Sea away from Ukraine, Romania and Bulgaria. Nonetheless, even though Ukraine will perform a smaller role, it will not be completely eliminated and it will remain an important player. The major issue is the commercial viability of maintaining a large gas transmission system with multiple exit points for the delivery of relatively small annual volumes (*Sharples*, 2018). Currently, the majority of the spare capacity comes via Ukraine, and, as *Henderson and Sharples* (2018: 26) argue, the EU wants to protect the Ukrainian transit route not only for commercial but also for political reasons.

[35] In January 2008, Russian Foreign Minister Sergei Lavrov tried to assure Poland that Russia would not reduce transit through Poland (*Rosukrenergo*, 2008).

4. Summary and conclusions

This paper started with the question of whether the three-dimensional approach is appropriate for addressing Polish supply security due to Poland's securitized energy landscape. We find that it can do so without requiring modifications. We also find that besides the energy perspective, the institutional context given by the EU and the geopolitical factor play very important roles among our so-called influencing factors. Due to the geopolitical factor, Poland has fears of (1) problems with the availability and affordability of Russian gas supplies and (2) foreign (German) technological reliance regarding renewables production, while (3) Russia could not be assigned a role in the case of nuclear energy. However, the overemphasised role of the geopolitical factor may lead to suboptimal energy policy decisions. In the past, energy market factors proved to be stronger, primarily due to prioritizing the affordability dimension, but recently, signs of a shift have started to appear.

Poland's power sector consists of a fleet of very old facilities with a structure that is not suitable for the twenty-first century in terms of sustainability. There is great uncertainty about Poland's energy policy and security of supply because of infrastructure deficiencies and the unknown future role of the particular fuels in the energy/electricity mix. One thing is sure that everything revolves around coal. It seems as if every possible energy policy step is taken to maintain the role of coal for as long as possible. It is as if Poland moves toward sustainability only as much and as soon as it is required by its EU membership (the role of the institutional influencing factor). Although it would be easy to suggest that the coal industry captures Poland's energy policy, the fact is that the geopolitical considerations also cement reliance on coal (in agreement with *Heinrich et al.*, 2016: 1–2; *Schwartzkopff and Schulz*, 2017: 9–10), providing low energy import dependence. Nevertheless, the role of coal will surely decrease. The question is to what extent and which energy/fuels will substitute it. Forecasts used for the draft Polish Energy Policy until 2050 indicate that the expected role of hard coal by 2050 stands in complete opposition to environmental sustainability and EU objectives, whereas the role of lignite seems to decrease dramatically as of the 2030s.

Although in a 2050 perspective, nuclear energy is to take over the biggest part of this niche, no ultimate decision has been made to implement a nuclear project in Poland. For a country in which no nuclear power plants have ever operated and experience and knowledge are quite limited, no quick decision should be expected, especially at a time when European energy sector trends are against nuclear energy. In this respect, affordability considerations, as well as the issue of conformity and compliance with EU rules should be addressed. However, currently, even the most basic questions related to nuclear energy remain open and completely unanswered.

After nuclear energy, renewables are expected to be the second to substitute coal in the Polish energy balance, whereas Poland is sceptical about renewables, and so far renewables have not affected the role of conventional fuels. Legislative uncertainty also holds back renewable energy development. The 2016 legislation has blocked onshore wind projects, which are both a highly political topic and the main driver of total renewable production. This caused a serious setback to Poland achieving the EU renewables target. However, the 2018 amendments to the relevant Acts may encourage both onshore and offshore investors. Offshore wind may enter the Polish electricity mix soon and will perhaps be a driver, backed by the domestic industry. Solar power is a late arrival on the Polish power landscape that might show significant growth in coming years, from which domestic PV modules production could also profit. Biomass, a contradictory renewable energy source, continues to expand, and provides an easy way to increase the role of renewables, while hydropower is not expected to significantly grow.

Finally, natural gas could also witness a relatively substantial increase in Poland. However, the issue of gas is very sensitive in Poland, despite the small share of gas in the energy/electricity/heat mix. This sensitivity is derived from Russia's dominant role in gas imports, the still insufficient level of geographical diversification, and perceptions of Russia as a security risk. As proved, perceptions are very important when evaluating dependence. These geopolitical considerations have a crucial (but not necessarily decisive) role in determining the Polish energy policy. Since the January 2009 Russian–Ukrainian gas crisis, Poland has taken action to diversify its gas supplies, and after many years of only speaking about diversification and solidarity, it has finally achieved results. Geopolitical aspects would lead Poland towards not prolonging its long-term gas supply contract with Russia. This decision comes in spite of the facts that (1) Russian gas is and will remain very important to Europe, (2) the role of gas is expected to increase in Poland, and (3) the institutional context given by the EU (the Third Energy Package, the antitrust procedure, and other measures now related to the Energy Union) increase security of supply through both the availability and affordability dimensions. The question is whether the termination of Russian gas supplies will actually happen, and whether this would really serve security of supply, as diversification alone does not inevitably lead to achieving this goal. The answer to the first question primarily depends on the Baltic Pipe project and the supply contract to import Norwegian gas. Despite Poland's confidence and determination, there is no certainty that the project and the supply contract will go ahead as planned. Poland will suffer loss of face if the Law and Justice government should finally arrive at a deal with Russia. Should the Baltic Pipe project and Norwegian gas imports fail, it is questionable whether Poland will still want to and be able to build a portfolio of non-Russian pipeline gas and LNG purchases without a Russian contract. However, the end of Russian long-term contract gas does not mean the definite end of Russian gas purchases. Answering the second question also requires the actual prioritisation of different dimensions of security of supply, taking into account various influencing factors (e.g. potential higher gas prices backed by a solid availability dimension versus the suspected high risk related to the availability and affordability of Russian gas supplies). This points to a complexity of preferences and choices, as well as to the constant uncertainty surrounding outcomes, which the long-awaited new Polish energy policy should also address.

Appendix

Table A1. Forecasts of the Polish Energy Policy until 2030 for final energy demand in Poland, by energy carriers, 2006–2030 (mtoe)

	2006	2010	2015	2020	2025	2030
Coal	12.3	10.9	10.1	10.3	10.4	10.5
Oil products	21.9	22.4	23.1	24.3	26.3	27.9
Natural gas	10.0	9.5	10.3	11.1	12.2	12.9
Renewables	4.2	4.6	5.0	5.9	6.2	6.7
Electricity	9.5	9.0	9.9	11.2	13.1	14.8
Network heat	7.0	7.4	8.2	9.1	10.0	10.5
Other fuels	0.6	0.5	0.6	0.8	1.0	1.2
Total	*65.5*	*64.4*	*67.3*	*72.7*	*79.3*	*84.4*

Source: Ministry of Economy (2009b: 12).

Table A2. Forecasts of the Polish Energy Policy until 2030 for gross final energy demand from renewables in Poland, by types of energy, 2006–2030 (ktoe)

	2006	2010	2015	2020	2025	2030
Electricity	370.6	715.0	1 516.1	2 686.6	3 256.3	3 396.3
Solid biomass	159.2	298.5	503.2	892.3	953.0	994.9
Biogas	13.8	31.4	140.7	344.5	555.6	592.6
Wind	22.0	174.0	631.9	1 178.4	1 470.0	1 530.0
Hydro	175.6	211.0	240.3	271.4	276.7	276.7
Photovoltaics	0.0	0.0	0.0	0.1	1.1	2.1
Heat	4 312.7	4 481.7	5 046.3	6 255.9	7 048.7	7 618.4
Solid biomass	4 249.8	4 315.1	4 595.7	5 405.9	5 870.8	6 333.2
Biogas	27.1	72.2	256.5	503.1	750.0	800.0
Geothermal	32.2	80.1	147.5	221.5	298.5	348.1
Solar	3.6	14.2	46.7	125.4	129.4	137.1
Transport biofuels	96.9	549.0	884.1	1 444.1	1 632.6	1 881.9
Carbohydrate-starch bioethanol	61.1	150.7	247.6	425.2	443.0	490.1
Rapeseed biodiesel	35.8	398.3	636.5	696.8	645.9	643.5
Second generation bioethanol	0.0	0.0	0.0	210.0	240.0	250.0
Second generation biodiesel	0.0	0.0	0.0	112.1	213.0	250.0
Biohydrogen	0.0	0.0	0.0	0.0	90.8	248.3
Total gross final energy from renewables	4 780	5 746	7 447	10 387	11 938	12 897
Gross final energy	*61 815*	*61 316*	*63 979*	*69 203*	*75 480*	*80 551*
% share of renewables	7.7	9.4	11.6	15.0	15.8	16.0

Source: Ministry of Economy (2009b: 12).

Table A3. Forecasts of the Polish Energy Policy until 2030 for primary energy demand in Poland, by fuel, 2006–2030 (mtoe and natural units)

		2006	2010	2015	2020	2025	2030
Lignite*	mtoe	12.6	11.22	12.16	9.39	11.21	9.72
	mt	59.4	52.8	57.2	44.2	52.7	45.7
Hard coal**	mtoe	43.8	37.9	35.3	34.6	34.0	36.7
	mt	76.5	66.1	61.7	60.4	59.3	64.0
Oil and oil products	mtoe	24.3	25.1	26.1	27.4	29.5	31.1
	mt	24.3	25.1	26.1	27.4	29.5	31.1
Natural gas***	mtoe	12.3	12.0	13.0	14.5	16.1	17.2
	bcm	14.5	14.1	15.4	17.1	19.0	20.2
Renewables	mtoe	5.0	6.3	8.4	12.2	13.8	14.7
Others	mtoe	0.7	0.7	0.9	1.1	1.4	1.6
Nuclear fuel	mtoe	0.0	0	0	2.5	5.0	7.5
Electricity exports	mtoe	-0.9	0.0	0.0	0.0	0.0	0.0
Total primary energy	*mtoe*	*97.8*	*93.2*	*95.8*	*101.7*	*111.0*	*118.5*

* Calorific value of lignite: 8.9 MJ/kg.
** Calorific value of hard coal: 24 MJ/kg.
*** Calorific value of natural gas: 35.5 MJ/m^3.
Source: Ministry of Economy (2009b: 14).

Table A4. Forecasts of the Polish Energy Policy until 2030 for electricity demand in Poland, 2006–2030 (TWh)

	2006	2010	2015	2020	2025	2030
Final energy	111.0	104.6	115.2	130.8	152.7	171.6
Energy sector	11.6	11.3	11.6	12.1	12.7	13.3
Transmission and distribution losses	14.1	12.9	13.2	13.2	15.0	16.8
Net demand	136.6	128.7	140.0	156.1	180.4	201.7
Own use	14.1	12.3	12.8	13.2	14.2	15.7
Gross demand	*150.7*	*141.0*	*152.8*	*169.3*	*194.6*	*217.4*

Source: Ministry of Economy (2009b: 14).

Table A5. Forecasts of the Polish Energy Policy until 2030 for net electricity production in Poland, by fuel, 2006–2030 (TWh)

	2006	2010	2015	2020	2025	2030
Hard coal	86.1	68.2	62.9	62.7	58.4	71.8
Lignite	49.9	44.7	51.1	40.0	48.4	42.3
Natural gas	4.6	4.4	5.0	8.4	11.4	13.4
Oil products	1.6	1.9	2.5	2.8	2.9	3.0
Nuclear fuel	0.00	0.00	0.00	10.5	21.1	31.6
Renewables	3.9	8.0	17.0	30.1	36.5	38.0
Pumped hydro	0.97	1.00	1.00	1.00	1.00	1.00
Waste	0.6	0.6	0.6	0.6	0.7	0.7
Total	*147.7*	*128.7*	*140.1*	*156.1*	*180.3*	*201.8*
Share of energy from renewables (%)	2.7	6.2	12.2	19.3	20.2	18.8

Source: Ministry of Economy (2009b: 15).

Table A6. Forecasts of the Polish Energy Policy until 2030 for fuel consumption for power generation (including for co-generation) in Poland, 2006–2030 (ktoe)

	2006	2010	2015	2020	2025	2030
Hard coal	25 084	20 665	18 897	17 722	16 327	18 331
Lignite	12 517	11 091	12 036	9 266	11 095	9 615
Natural gas	961	970	1 094	1 623	2 114	2 473
Oil products	533	591	732	791	806	837
Nuclear power	0	0	0	2 515	5 030	7 546
Renewables	703	1 461	2 912	5 128	5 995	6 212
Hydro	174	209	239	270	275	275
Wind	22	174	632	1 178	1 470	1 530
Biomass	458	943	1 566	2 693	2 749	2 805
Biogas	48	135	475	986	1 500	1 600
Solar	0	0	0	0	1	2
Waste	144	154	162	168	185	201
Total fuel consumption	*39 942*	*34 933*	*35 832*	*37 213*	*41 552*	*45 215*

Source: Ministry of Economy (2009b: 16).

Table A7. Forecasts of the Polish National Energy Conservation Agency (2013) for primary energy demand in Poland, by fuel, 2010–2050

	2010	2015	2020	2025	2030	2035	2040	2045	2050
Mtoe									
Hard coal	43.0	36.9	35.5	32.8	31.3	30.1	29.9	27.1	24.4
Lignite	11.6	14.3	13.0	11.9	9.1	2.5	2.6	2.2	2.1
Crude oil	26.5	25.4	27.2	27.5	26.9	25.1	23.4	22.3	21.5
Natural gas	12.8	14.1	15.2	15.3	15.2	16.1	16.1	15.8	15.5
Renewables	7.3	9.2	12.0	12.6	14.0	14.6	14.1	13.8	13.7
Nuclear energy	0.0	0.0	0.0	2.8	5.6	10.8	10.9	10.6	10.3
Others	0.6	0.3	0.4	0.4	0.4	0.4	0.4	0.4	0.4
Total	*101.8*	*100.2*	*103.2*	*103.3*	*102.5*	*99.5*	*97.3*	*92.2*	*87.9*
%									
Hard coal	42.2	36.8	34.4	31.8	30.5	30.3	30.7	29.4	27.8
Lignite	11.4	14.3	12.6	11.5	8.9	2.5	2.7	2.4	2.4
Crude oil	26.0	25.3	26.4	26.6	26.2	25.2	24.0	24.2	24.5
Natural gas	12.6	14.1	14.7	14.8	14.8	16.2	16.5	17.1	17.6
Renewables	7.2	9.2	11.6	12.2	13.7	14.7	14.5	15.0	15.6
Nuclear energy	0.0	0.0	0.0	2.7	5.5	10.9	11.2	11.5	11.7
Others	0.6	0.3	0.4	0.4	0.4	0.4	0.4	0.4	0.5
Total	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*

Source: Ministry of Economy (2015c: 5).

Table A8. Forecasts of the Polish National Energy Conservation Agency (2013) for final energy demand in Poland, by sectors, 2010–2050 (mtoe)

	2010	2015	2020	2025	2030	2035	2040	2045	2050
Agriculture	3.8	3.2	2.8	2.4	2.3	2.1	2.0	1.9	1.7
Industry and construction	15.4	15.2	16.8	17.8	18.9	20.0	20.9	21.0	20.2
Transport	17.6	18.9	20.9	21.4	21.0	19.5	17.9	16.6	16.0
Services	8.5	8.6	8.7	8.2	8.1	7.9	7.5	7.5	7.2
Households	21.1	21.4	22.4	22.5	22.0	21.0	19.9	18.7	17.6
Total	*66.5*	*67.2*	*71.6*	*72.3*	*72.3*	*70.4*	*68.2*	*65.7*	*62.7*

Source: Ministry of Economy (2015c: 6).

Table A9. Forecasts of the Polish National Energy Conservation Agency (2013) for electricity production in Poland, by fuel, 2010–2050

	2010	2015	2020	2025	2030	2035	2040	2045	2050
TWh									
Hard coal	87.9	72.5	76.9	75.9	79.0	84.4	88.8	82.3	74.5
Lignite	48.6	58.4	53.8	49.6	38.1	11.1	11.3	10.7	10.3
Natural gas	6.8	5.8	11.8	11.9	13.0	18.4	17.5	23.3	20.4
Renewables	11.6	20.6	34.0	36.9	51.9	61.1	65.1	67.5	73.2
Nuclear energy	0.0	0.0	0.0	11.8	23.3	45.1	45.4	44.2	43.2
Others	2.6	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4
Total	*157.7*	*158.8*	*177.9*	*187.5*	*206.8*	*221.4*	*229.7*	*229.5*	*222.9*
%									
Hard coal	55.7	45.7	43.2	40.5	38.2	38.1	38.7	35.9	33.4
Lignite	30.8	36.8	30.2	26.5	18.4	5.0	4.9	4.7	4.6
Natural gas	4.3	3.7	6.6	6.3	6.3	8.3	7.6	10.2	9.2
Renewables	7.4	13.0	19.1	19.7	25.1	27.6	28.3	29.4	32.8
Nuclear energy	0.0	0.0	0.0	6.3	11.3	20.4	19.8	19.3	19.4
Others	1.6	0.9	0.8	0.7	0.7	0.6	0.6	0.6	0.6
Total	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*

Source: Ministry of Economy (2015c: 6).

Table A10. Forecasts of the Polish National Energy Conservation Agency (2013) for net heat production in Poland, by fuel, 2010–2050

	2010	2015	2020	2025	2030	2035	2040	2045	2050
PJ									
Hard coal	280.6	274.5	278.1	278.0	270.1	258.4	245.1	237.5	221.4
Lignite	6.4	7.0	7.7	7.9	7.9	7.8	7.5	0.1	0.1
Oil products	6.7	6.1	6.0	5.9	5.7	5.6	5.5	5.4	5.3
Natural gas	31.6	32.7	51.3	52.2	52.1	50.9	49.2	46.9	44.3
Renewables	12.4	28.3	24.8	26.6	27.7	28.3	28.5	28.1	27.1
Others	7.1	9.1	10.1	10.6	11.1	11.6	12.1	12.1	11.5
Total	*344.8*	*357.8*	*378.0*	*381.3*	*374.7*	*362.7*	*347.9*	*330.0*	*309.8*
%									
Hard coal	81.4	76.7	73.6	72.9	72.1	71.2	70.5	72.0	71.5
Lignite	1.9	2.0	2.0	2.1	2.1	2.2	2.2	0.0	0.0
Oil products	1.9	1.7	1.6	1.5	1.5	1.5	1.6	1.6	1.7
Natural gas	9.2	9.1	13.6	13.7	13.9	14.0	14.1	14.2	14.3
Renewables	3.6	7.9	6.6	7.0	7.4	7.8	8.2	8.5	8.7
Others	2.1	2.5	2.7	2.8	3.0	3.2	3.5	3.7	3.7
Total	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*

Source: Ministry of Economy (2015c: 6).

Table A11. Forecasts of the Polish Energy Market Agency (2013) for electricity demand in Poland, by economic sectors, 2010–2030 (TWh)

	2010	2015	2020	2025	2030
Industry and construction	41.8	43.8	46.5	49.3	53.5
Transport	3.3	3.4	3.6	3.8	4.1
Agriculture	1.6	1.6	1.7	1.8	1.9
Trade and services	43.7	46.2	52.5	57.9	63.8
Households	28.6	29.4	32.3	35.1	38.2
Total	*119.1*	*124.4*	*136.6*	*147.8*	*161.4*

Source: Ministry of Economy (2015c: 11).

Table A12. Forecasts of the Polish Energy Market Agency (2013) for network heat demand in Poland, by economic sectors, 2010–2030 (PJ)

	2010	2015	2020	2025	2030
Industry and construction	58.9	61.7	64.6	67.5	72.0
Agriculture	1.1	1.0	1.1	1.1	1.1
Trade and services	36.7	33.0	36.6	39.7	42.7
Households	195.0	176.1	174.1	171.2	168.8
Total	*291.6*	*271.9*	*276.4*	*279.5*	*284.6*

Source: Ministry of Economy (2015c: 11).

Table A13. Forecasts of the Polish Energy Market Agency (2013) for net electricity production in Poland, by fuel, 2010–2030 (TWh)

	2010	2015	2020	2025	2030
Lignite	45.4	48.5	48.3	48.3	43.6
Hard coal	81.2	68.7	72.8	68.2	66.8
Natural gas	4.7	10.7	14.5	13.7	17.1
Heating oil	2.7	2.3	2.3	2.2	2.1
Nuclear fuel	0	0.0	0.0	11.2	22.3
Biomass	4.6	7.3	7.4	7.5	6.5
Biogas	0.4	1.1	2.0	2.4	2.8
Bio-oil	0	0.0	0.0	0.0	0.0
Hydropower	2.9	2.3	2.4	2.4	2.5
Wind	1.7	6.9	11.1	16.0	21.7
Solar	0	0.06	0.35	0.99	1.91
Others	0.26	0.23	0.18	0.12	0.10
Total	*143.8*	*147.9*	*161.2*	*173.0*	*187.5*

Source: Ministry of Economy (2015c: 12).

Table A14. Forecasts of the Polish Energy Market Agency (2013) for final electricity demand in Poland, various scenarios, 2015–2050 (TWh)

	2015	2020	2030	2040	2050
Low scenario	124	135	149	167	179
Reference scenario	127	140	162	186	204
High scenario	128	144	171	202	225

Source: Ministry of Economy, (2015c: 13).

Table A15. Forecasts of the European Commission (2013, reference scenario) for primary energy production in Poland, by fuel, 2015–2050 (mtoe)

	2015	2020	2025	2030	2035	2040	2045	2050
Had coal and lignite	56.1	56.2	53.5	43.0	39.7	37.3	37.4	36.8
Oil and oil products	28.2	28.5	28.0	27.8	27.5	27.0	27.1	26.9
Natural gas	15.1	15.4	17.8	19.0	20.0	20.5	21.1	21.9
Nuclear energy	0.0	0.0	3.0	11.2	14.1	17.0	17.0	17.0
Renewables	10.3	13.5	14.8	16.7	18.0	18.7	19.6	20.0
Total	*109.7*	*113.7*	*117.1*	*117.7*	*119.2*	*120.5*	*122.2*	*122.5*

Source: Ministry of Economy (2015c: 16).

Table A16. Forecasts of the European Commission (2013, reference scenario) for electricity production in Poland, by fuel, 2015–2050 (TWh)

	2015	2020	2025	2030	2035	2040	2045	2050
Had coal and lignite	155	165	156	118	109	108	122	135
Renewables	17	27	32	36	43	43	46	49
Nuclear energy	0	0	13	48	61	74	74	74
Natural gas	5	7	9	11	12	14	18	17
Total	*177*	*199*	*210*	*213*	*225*	*239*	*260*	*275*

Source: Ministry of Economy (2015c: 16).

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