Moving Poland Beyond Coal: Assessment of Potential and Strategy

Prepared for the

Sierra Club

by

Entri

in cooperation with

The Institute for Sustainable Development, Poland

by[1]

William Chandler (Entri)
Ewaryst Hille (ISD)
Andrzej Kassenberg (ISD)

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Energy Transition Research Institute
Annapolis, Maryland USA 21405
www.etransition.org
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Purpose and Findings

This paper reports on the potential of and possible strategies for a philanthropic effort to hasten the replacement of coal as the primary source of energy (especially for generating electricity and heat) in Poland. This assessment was undertaken on the initiative of the Sierra Club, Inc., with funding by Bloomberg Philanthropies.

We conclude that:

- Current technical and economic conditions increase the likelihood of success for such an effort.
- Private business, European Union leaders, and even the Polish coal industry and labor unions recognize that coal in Poland is increasingly uncompetitive and facing decline.
- Policies of the current ruling party in Poland favor coal for political reasons and neglect coal's negative economic and environmental consequences.[2]

We identified several near-term opportunities for policy interventions that would increase the likelihood of success in moving Poland beyond coal. These include support for:

- Litigation in the European Union courts to block Polish coal subsidies.
- Litigation to block development of new lignite mines.
- Public information efforts by Polish health advocates.
- Promotion of building energy performance standards.
- Creation of a mechanism to finance home energy efficiency improvements.
- Local self-governments in their efforts to promote energy efficiency and develop renewable sources.

We based our findings and conclusions on interviews with more than 30 stakeholders in Poland and on an in-depth review of the scientific and technical literature. We summarize that work below, beginning with a summary of coal supply and demand in Poland.

[2] We do not believe that a statement on this matter by new Polish prime minister Mateusz Morawiecki changes this reality. (See Wojciech Kość, "New Polish prime minister makes air quality a top priority," *Politico*, 12 December 2017.) Though Morawiecki's pledge to make clean air a top priority, we note that his government also indicated it would continue efforts to replace and expand coal mining and use.

Coal Supply and Demand

An Overview of Coal Use in Poland[3]

Coal provides half of Poland's primary energy, with crude oil and natural gas supplying most of the rest. Poland ranks second in Europe (after Germany) in primary coal use, and tenth among all nations (see Table 1).[4]

Table 1: Ranking by Coal Use

Name	Rank	EJ Used
China	1	83
India	2	18
USA	3	16
Japan	4	5
Russia	5	4
S Africa	6	4
S Korea	7	4
Germany	8	3
Indonesia	9	3
Poland	10	2

Note: EJ = Exajoules, or 1 x 10^{18} joules.
For comparison, U.S. total energy use = 100 EJ. All data are for the year 2016.

Source: Rankings by Entri using data from *BP Statistical Review of World Energy 2017*

Poland uses coal for generation of electricity, district heating, and direct combustion in homes, agriculture, and manufacturing. It consumed roughly 138 million tons of coal in

[3] A short digression on what we mean by "coal" in this paper may be in order here to avoid confusion. As suggested above, coal can be described with various names and the energy and carbon content of coal varies with the meaning of those names. Unless otherwise indicated, in this paper we use the term hard coal to include black coal or bituminous coal and we mean coal having an energy content in the range of 20-25 gigajoules (roughly equal to 20-25 million BTU) per tonne. By ton we mean tonne, or 1,000 kilograms, not the "short ton" equal to 2,000 pounds commonly used to indicate a "ton of coal" in the United States. Those terms of course differ from a definition often found in Russian or Chinese literature called the "standard ton of coal equivalent," which is most often defined as about 29 gigajoules per ton and which is not related to the actual energy content of coal produced in those countries. "Steam coal," another term usually used for black coal is defined, at least for European markets, as coal having 6,000 kilocalories per kilogram, which is about 25 gigajoules per ton. The energy content of coal varies, among other things as a function of the amount of dirt and moisture it contains.

[4] British Petroleum, *Statistical Review of World Energy 2017*, BP.com. Conversions from the original data made by converting barrels of oil equivalent to joules at 44 gigajoules per barrel of oil. Rankings from these data done by Entri. Please note that the Russian Federation is included in "Europe" in the original data but we have excluded Russia from our comparison of European nations.

2016 of which about 62 million tons was black—hard, steam, or bituminous—coal, and about 65 million tons of brown coal (also called lignite). In addition, Poland consumed 11 million tons of anthracite coal, mainly in steelmaking. Seventy percent of Polish hard coal is used for heat and power generation, 13 percent in direct use in residences, and 8 percent in industry.[5] (See Figures 1 and 2). Of the 62 million tons of hard coal, half was used for power generation, 20 percent for district heating, and 20 percent in direct combustion in homes and in agriculture.[6] Most of the remaining 10 percent was used in direct consumption by industry, along with a small amount by unspecified users.

Poland exports just under 10 million tons of hard coal and imports about the same amount. These totals can vary, meaning that in some years Poland is a net coal importer and in others a net exporter. As we explain below, however, that situation could change markedly in the future. Still, according to the Polish energy think tank Energy Forum, even if only one new hard coal mine (in the Lublin Basin) is completed, coal import requirements would amount to only about 40 million tons of coal per year in 2050. In scenarios based on more aggressive development of nuclear or renewable energy, the import of hard coal would be not necessary.

Both the quantity of coal produced and the share of coal in total primary energy supply have fallen significantly since 1980 (See Figures 1 and 2).[7] Coal then provided four-fifths of Polish total energy supply. Production of hard coal in particular has declined. Because lignite has more or less half the energy value of hard coal, lignite accounts for only about 12 percent of total Polish energy supply although it provides one-third of power generation compared to about 50 percent for hard coal.

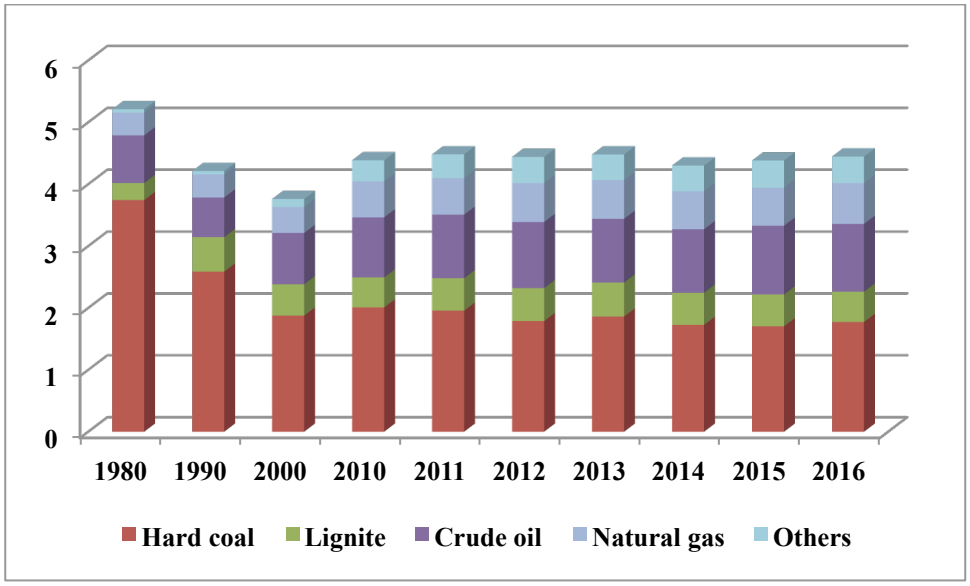
This following section of our report summarizes some of technical issues related to coal use (and provides references for readers interested in greater detail), including:

- The political economy of coal and electric power generation in Poland
- Coal use, including the projections of demand and availability of substitutes
- Coal supply, including resource availability and mining concerns
- Impacts of coal use on carbon emissions, air pollution, and energy security
- Policy discussion in interviews with Poland's energy and environmental experts
- Recommendations for "beyond coal" campaigns and interventions.

[5] IEA, *op. cit*.
[6] More precisely, of the 61.5 million tons of total coal consumption, 30.2 million tons was used in the power system (about 644 petajoules, or 46.6 percent), 12.2 million tons in heating networks (approximately 273 petajoules, or 19.9 percent), and direct consumption of about 17.6 million tons (about 444 PJ, or 32.1%). Out of the total of 17.6 million tons in direct consumption, some 10.4 million tons (about 269 petajoules, or 19.5 percent) is consumed mainly in private households and 1.5 million tons (about 39 petajoules, or 2.8 percent) in agriculture, of which a significant part is for the production of heat in individual appliances.
[7] For an analysis of the role of market liberalization in energy production and use in Poland and elsewhere in Eastern Europe and the Soviet Union, see William Chandler*, Energy and Environment in the Transition Economies* (Boulder: Westview Press, 2000).

Figure 1. Primary energy use in Poland 1980-2016

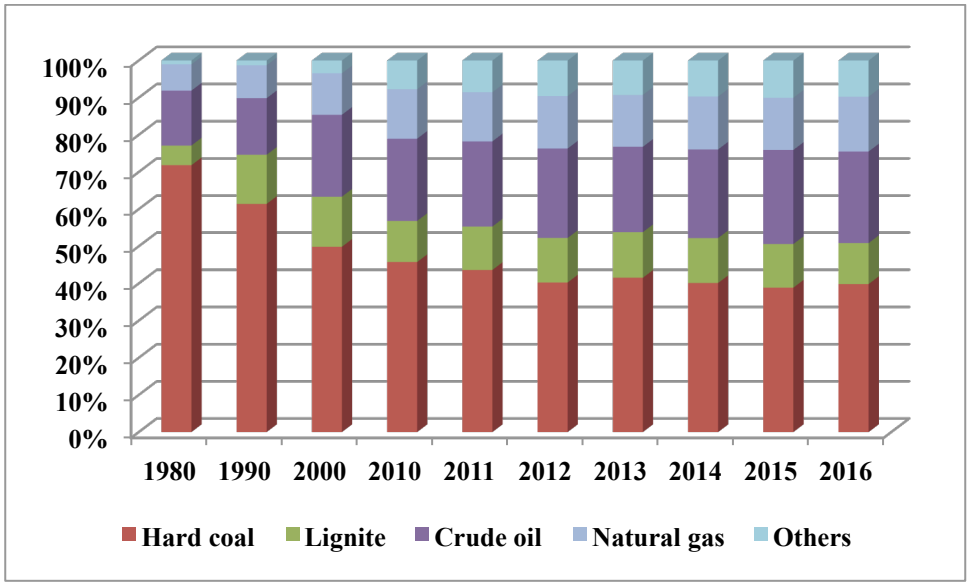
Exajoules



Source: World Energy Council (December 2014), *Energy sector of the world and Poland beginnings, development, present state.* Second edition, updated. Warsaw. *Gospodarka Paliwowo-Energetyczna w latach 2015 i 2016*, GUS 2017.

Figure 2. Structure of primary energy use in Poland

Percent



Source: World Energy Council (December 2014), *Energy sector of the world and Poland beginnings, development, present state.* Second edition, updated. Warsaw. *Gospodarka Paliwowo-Energetyczna w latach 2015 i 2016*, GUS 2017.

The Political Economy of Coal in Poland

Much of the fuel and power supply chain in Poland is concentrated in the hands of a limited group of companies. The four largest groups in this chain are PGE, TAURON, Energa, and Enea which are corporations with state ownership amounting to 58 percent, 30 percent, 52 percent, and 52 percent, respectively. The three largest of these groups, PGE, TAURON, and Enea, in 2016 provided 55 percent of the electricity supplied to the Polish power grid and they controlled more than half of installed power generating capacity.[8]

Hard coal and lignite supply most of the primary energy used in Poland's power and heating stations. The mines that produce that fuel are almost entirely controlled by the Polish government, directly or indirectly as in the case of companies controlled by the state. One exception is the Mining Company Silesia, which is controlled by foreign capital.

Electric power transmission is also controlled by a state-owned company Polskie Sieci Elektroenergetyczne (PSE).

The Polish government recently has been renationalizing assets in the energy sector by purchasing them from foreign-controlled companies. Two prominent examples are transactions related to the withdrawal from the Polish market of Swedish Vattenfall and French EDF.

Electricity trading in Poland has been somewhat liberalized, meaning Polish consumers can choose their power supplier (the so-called "TPA rule"). The number of power providers has been growing, especially among firms that combine other services with electric power delivery. A wholesale market is used to set power prices, but critics, including several of our interviewees, maintain that the market is subject to manipulation by the limited number of actors trading at wholesale. A "capacity market" was proposed by the government to be added to the market for kilowatt-hours before the end of 2017. After that, most of the Polish fleet would be ineligible to participate due to the European Union policy.[9] The "Capacity Market" Bill was approved by the Polish *Sejm* (the lower house of Parliament) and the *Senat* (the upper house) and is at this writing pending Presidential approval.

Indeed, the conservative, state-owned character of the energy economy does reduce the motivation for both environmental protection and economic efficiency—especially in investment decision-making, which is driven by vested interests (management labor seeking to protect their positions) and short-term political concerns. Regulations on protection of the environment mainly arise due to European Union policies and are either delayed or deployed in Poland at the lowest possible level of enforcement. The Polish

[8] Agencja Rynku Energii S.A., *Statystyka Elektroenergetyki Polskiej 2016*, Warsaw, 2017.
[9] "Poland's PGE wants power capacity market in 2017," *Platts*, 26 April 2017.

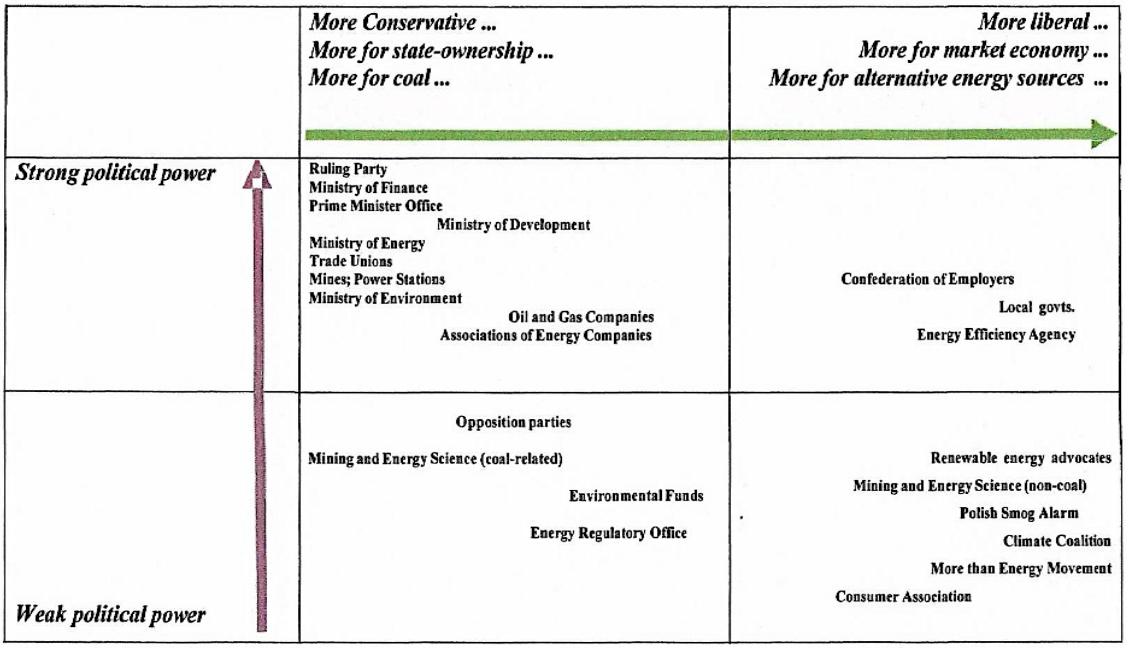
state and its state-owned energy sector see European environmental policy as a threat to the Polish energy sector, and consequently for the Polish economy.

An over-arching concern among conservative (as opposed to European oriented) players is energy security, and energy security more than other concerns drives investment decisions. This narrow focus on security to the exclusion of environmental and economic priorities leads Poland consistently back to decisions to extend and renew the development of coal mines and coal-fired power generating stations. Continuing on this path means in the near-term very large investments must be made in coal-mining and coal-fired power plant life-extension. If the decision is taken to move to coal imports to make up for the impending loss of domestic production, that may extend the use of the coal-fired power plant fleet for a few years, but may actually hasten the replacement of coal with alternatives as it will make less sense to renovate coal-fired power plants just to burn coal from Russia or Russian-controlled territory, or even from far-away Australia.

But the state-owned sector and its political patrons are not the end of the story. There are significant countervailing forces in Poland and these have strong support among various segments of the Polish population. Support for a market-based economy remains a strong influence as memory of the shortages and deprivations of the communist era remain. Support of cleaning up Poland's polluted cities remains a strong force, with Poland-based citizen campaigns such as "Smog Alarm" having an influence on decision-makers, particularly at the local levels but also at the national level. And in many ways, municipal and provincial governments serve as the sources of the strongest efforts in economic efficiency and environmental management. This situation is quite natural because it is the local leaders who must deal on a daily basis with citizens angry that their children are made sick by air pollution, pensioners who cannot afford heat and electricity, and villagers faced with the upheaval of having their homes and villages condemned to make way for new lignite or underground mines.

We have attempted to represent the interplay of political forces across Poland and across the spectra of conservative-to-liberal, state ownership-to-market reform, and coal-to-alternatives. The point of this exercise is to schematically demonstrate forces that support and those that might oppose the continued reliance on coal as the major source of primary energy in Poland (see Figure 3).

Figure 3: A Schematic of Polish Energy and Environmental Politics



Source: Institute for Sustainable Development (Poland)

Electric Power Generation and Use

Generating Capacity and Primary Energy Sources

Total installed power generating capacity in Poland was 41 gigawatts at the end of 2016 composed mainly of hard coal-fired (20 GW), brown coal-fired (9 GW), natural gas-fired (about 1 GW), wind (about 5.8 GW), biomass-fired plants (about 0.3 GW), hydropower (about 1 GW), biogas (over 0.2 GW), and solar (about 0.1 GW).

A combination of hard coal and lignite was used in 2016 to generate four-fifths of Poland's electricity. The total electricity generated that year was approximately 167 TWh. Of that total, hard coal, lignite, wind, and natural gas provided 50 percent, 31 percent, 7 percent, and 4 percent, respectively. The remaining 8 percent was generated mainly by on-site industrial plants, usually with hard coal. Hydroelectricity and oil generated about 1 percent each while solar generated less than 0.1 percent of the national total.[10]

[10] Polish Statistical Yearbook; IEA *op. cit*.

Electric Power Use

Current demand for electricity is dominated by the commercial and industrial sectors at 37 and 35 percent of total, respectively. Private homes consume 25 percent of electricity, while transport uses 3 percent.[11]

Demand for electricity in Poland is expected to increase by 40 TWh by 2030. Electricity demand is driven by GDP growth, increasing wealth, and the substitution of electricity for other energy sources, especially in transport and heating. In official forecasts, prepared by the Polish Ministry of Economy, the factors slowing the increase in demand are the increasing energy efficiency of appliances and industry and a decline in population (see Tables 2, 3, and 4).[12]

Table 2. Intensity of Primary Energy and Electricity in Poland

	2010	**2015**	**2020**	**2025**	**2030**	**2035**	**2040**	**2045**	**2050**
Primary Energy (MJ/ PLN[13])	*3.17*	*2.73*	*2.29*	*1.98*	*1.72*	*1.45*	*1.28*	*1.14*	*1.06*
Electricity (Wh/PLN)	*111*	*97*	*90*	*82*	*79*	*74*	*69*	*64*	*60*

Source: *Wnioski z analiz prognostycznych na potrzeby Polityki energetycznej Polski do 2050 roku*, Ministry of Economy 2015

Table 3. Electricity Demand by Sector (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
Private households	28.6	29.4	32.3	35.1	38.2
Total	119.1	124.4	136.6	147.8	161.4

Source: *Wnioski z analiz prognostycznych na potrzeby Polityki energetycznej, Polski do 2050 roku*, Ministry of Economy 2015.

[11] *Wnioski z analiz prognostycznych na potrzeby Polityki energetycznej Polski do 2050 roku*, Ministry of Economy 2015.

[12] Carbon Dioxide Intensity (reporting standards for 2017, data from 2014)

Description		Calorific value	kg CO_2/GJ	kg CO_2/MWh
Power Stations and CHP	Hard coal [MJ/kg]	21.77	92.3	332.3
Power Stations and CHP	Lignite [MJ/kg]	8.12	110.8	398.8
Industrial CHP plants	Hard coal [MJ/kg]	22.81	94.7	340.9
Other indicators	Natural gas [MJ/m^3]	36.30	56.1	202.0
	Heating oil [MJ/kg	40.40	77.4	278.6
	Firewood [MJ/kg]	15.60	112.0	403.2
	Biogas [MJ/kg]	50.40	54.6	196.6

Source: Polski do 2050 roku, Ministry of Economy 2015

Notes: CHP = Combined heating and power calorific values and carbon dioxide emission factors (EF) in 2014 for reporting under the Emission Allowance Trading Scheme for 2017, KOBiZE 2016.

[13] 1 USD = 3,58 PLN (Polish National Bank 10.12.2017)

Heat Supply and Demand

One-fifth of all hard coal in Poland is consumed to generate heat for district heating systems. These systems distribute hot water mainly to residential apartment buildings for heating and hot water. In 2016, roughly 12 million tons of coal was burned in Poland for district heating. Another 10 million tons was consumed directly by individual households or buildings for heating and hot water.

Half of all Poles live in single-family homes of which almost three-quarters are poorly insulated and under-heated. Some 70 percent of single-family houses are heated by a boiler or a coal furnace, polluting the immediate surroundings with dust and carcinogens.[14]

Primary energy demand for heating is expected to decline. This decline is driven by increasing technical and economic efficiency, changing demographics, as well as a emissions mitigation. The demand for district heating—as opposed to individual heating systems—is in particular expected to decline after some increase (see Table 4). Note, however, that some of this future decline will come at the expense of increasing demand for electricity. This switching from direct coal use to electricity is a function of increasing income.

Table 4. District Heating Projection by Primary Energy Source (PJ)

	2010	2015	2020	2025	2030	2035	2040	2045	2050
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	53
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

Source: *Wnioski z analiz prognostycznych na potrzeby Polityki energetycznej Polski do 2050 roku*, Ministry of Economy 2015

Such forecasts involve considerable uncertainty. Changes in key variables are difficult to predict, including changes in the size, structure, and thermal integrity of buildings. Also difficult to predict is the demand for district heating versus independent stoves and

[14] *Strategia modernizacji budynków: mapa drogowa 2050.*Instytut Ekonomiki Środowiska, Krajowa Agencja Posznowania Energii, Narodowa Agencja Poszanowania Energii, Building Performance Institute Europe przy współpracy PricewaterhouseCoopers. Kraków 2014.

Table 5. Selected Scenarios for Building Energy Use By 2030

Scenario		Base	Low	Medium	High
Energy Savings	TWh/year	14	24	44	75
Coal Savings	Percent	5	***8***	15	***26***
Investment Cost	PLN bn.	21	38	66	122
Savings	PLN bn.	38	59	107	185
Net Consumer Economic Savings	PLN bn.	17	***21***	41	***63***
Net Societal Savings w/o externalities	PLN bn.	159	262	496	828
Net Societal Savings w externalities	PLN bn.	177	291	550	920
Internal Rate of Return	Percent	15.1%	13.4%	13.9%	13.2%
Fast Decarbonization Variant					
Yearly CO_2 savings in 2030	Million Tonnes CO_2/yr	52	54	59	65
2030 saved CO_2 as % of 2010	Percent	47	49	53	59
CO_2 reduction cost	PLN/ Tonne CO_2	-27	-44	-81	-131
Slow Decarbonization Variant					
Yearly CO_2 savings in 2030	Million Tonnes CO_2/yr	9	12	20	32
2030 Saved CO_2 (% of 2010 value)	Percent	8	11	18	28
CO_2 Reduction Cost	PLN/ Tonne CO_2	-272	-351	-454	-516
Net New Jobs	1,000s	18	36	65	119

Note: Values are given for 2030 in 2017 PLN or percent relative to 2017.
Source: *Strategia modernizacji budynków: mapa drogowa 2050.*Instytut Ekonomiki Środowiska, Krajowa Agencja Posznowania Energii, Narodowa Agencja Poszanowania Energii, Building Performance Institute Europe przy współpracy PricewaterhouseCoopers. Kraków 2014.

furnaces. The rate at which modern energy management systems will be adopted adds to the uncertainty. The quality and nature of housing will be shaped in no small part by choices for and investments in transportation modes and their infrastructure. Transportation choices in turn are shaped by affordability (sustainability), public transport investments, and the market penetration of electric vehicles, all of which will proceed at uncertain rates.

However, the most significant factor affecting heat—and therefore coal—demand in buildings is the deployment of energy efficiency. The most important efficiency improvements include the upgrading of the thermal envelopes of buildings, that is reducing heat losses through leaky windows, walls, roofs, and doors.

Some experts project the number of residences heated by in-home direct coal combustion to drop from 3 million buildings today to only about 1 million buildings in 2030.[15] More importantly, they argue (as they did in our private interviews) that a top priority for reducing coal use in Poland is improving the thermal integrity of buildings and replacing existing, very inefficient coal stoves and furnaces with much more efficient ones. The result would be much reduced coal use—even though the furnaces might still use coal.

Comprehensive modernization of building envelopes and heating systems would bring significant benefits in both reduced energy use and greenhouse gas emissions. Even a modest efficiency effort would reduce buildings sector heat demand by 8 percent by 2030 and reduce net out-of-pocket consumer costs by almost US$ 6 billion per year. An ambitious efficiency effort could cut coal use to generate heat for buildings by 26 percent and reduce consumer costs by US$17 billion (see Table 5, above, especially numbers in italics and bold).

Issues In Coal Mining

Overview of Hard Coal and Lignite Mining Problems

Both hard coal and lignite mines are increasingly uncompetitive and resource constrained. Poland faces the prospect of rapid depletion of resources in both types of coal and the necessity of importing large amounts of coal or switching to other energy sources.

Poland has enough recoverable hard coal to last another 30 years at current production levels of 60 million tons per year. Whether it is economically practical to maintain output is very doubtful, however, especially given the unprofitability of and the major investment requirements for continuing the industry.

Some hard coal mines already operate at depths below one kilometer and going deeper will require an ever increasing effort to manage safety risks, including methane buildup, heat problems, and fire. Chronic problems of low labor productivity and marginal or negative profitability makes investment very difficult.

Coal mining experts project declines in underground mining profitability to accelerate by 2020 and suggest the possible disappearance of black coal mining by 2050. In the government's business-as-usual scenarios, black coal imports would need to total from 12 to 23 million tons in 2050.[16]

[15] Own estimate based on National Census and yearly statistics after 2011 by GUS.
[16] Energy Forum, *op. cit.*

The impending decline of production is even more dramatic in lignite mining. Note that almost all Polish brown coal is surface-mined in huge operations and used for power generation in power plants co-located at the mines. There are eight such strip mines in Poland and each of these causes major local environmental damage, in particular changes in land surface, dramatically altering the landscape and dropping the water table so much that it severely impacts agriculture.[17]

Brown coal production has already declined 17 percent over the past three decades.[18] Of the eight large lignite mines in Poland, only two are expected to operate beyond 2040. These two mines, Turów and Szczerców, will have annual production of 20-30 million tons (less than half of total brown coal production in 2016).[19] A major political issue—at least at the local level in the lignite basins in Brody-Gubin in west, Oczkowice and Złoczew in middle of Poland—is whether to develop mammoth new surface mines. Some proposed projects would convert agricultural land to open pit mines and even require the relocation of entire villages.

Future Coal Supply

Despite the fact that Poland has a large hard coal *resource*, coal's availability in *reserves* is severely constrained. We are using these terms in their customary sense of "technically exploitable" asset and "economically exploitable" asset, respectively. These categories are in turn based on geological, technical, economic, social, and environmental conditions. At today's production level of 60-70 million tons per year, Poland has enough economically recoverable hard coal on the same level for the next 30 years – but only if it makes substantial investments in technologies for extraction below a depth of one kilometer or investments for new coal mines and for the technologies to manage the risks of such extraction (that is, methane concentrations, heat problems, and fire). [20] Already, the difficulties of working in Poland's deep underground mines, combined with poor management by state-owned firms, results in low labor productivity and unprofitability in relation to world prices.

The Polish underground coal sector was modestly profitable until 2012. But after netting PLN 3 billion in 2011, it lost PLN 2.2 billion in 2015.[21] Since 2013 there has been a significant decrease in coal sales with the total decrease in revenues from coal sales in the years 2011 to 2015 amounting to PLN 7.2 billion.[22]

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[17] Benedykt Pepliński (2016), *Skutki ekonomiczne dalszej eksploatacji w czynnych odkrywkach węgla brunatnego w zagłębiu konińskim – analiza kosztów dla rolnictwa i przetwórstwa rolno-spożywczego*, Poznań.

[18] http://stat.gov.pl/statystyka-miedzynarodowa/porownania-miedzynarodowe/tablice-o-krajach-wedlug-tematow/przemysl-i-budownictwo/.

[19] Wilczyński, *op. cit.*

[20] Some of the Upper Silesian local communes oppose building new hard coal mines.

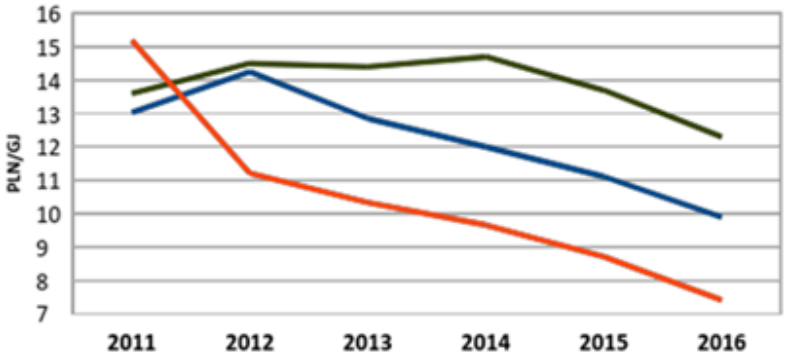
[21] PNL means Polish new zloty. In late 2017, 1 US$ equaled 3.66 PLN. See data in the draft *Program for the Coal Mining Sector in Poland*. Note further that taking into account impairment losses on fixed assets, the loss amounted to PLN 4.5 billion, with loss on coal sales at the level of PLN 2.0 billion.

[22] Ministry of Energy (version 8 from 30.06.2017)*, Hard coal mining sector program* draft.

Polish coal has been more expensive than coal on the European market since 2012 by more than 24 PLN per tonne. In 2016, the cost of extracting one gigajoule of energy in Polish hard coal mines was higher than that of the European market by PLN 4.9. Similarly, the Polish extraction cost exceeded the local Polish price by 2.4 PLN (see Figure 4).[23]

The situation has somewhat improved in 2017 as a result of restructuring and rising world prices. However, in the opinion of many experts, this is a temporary situation. They expect that in any plausible scenario there will be a significant decline in coal mining, perhaps even resulting in its disappearance in by 2050.

Figure 4. Polish Hard Coal Price Vs. Cost and Vs. European Market Price



Legend:
Red line = European market price (ARA cif price)
Blue line = Polish local mine price
Dark green line = Actual cost of Polish hard coal extraction

Source: Michał Wilczyński (2017), *UWAGI do PROGRAMU dla sektora górnictwa węgla kamiennego w Polsce (wersja 8 z 30.06.2017)*. Ministry of Energy[24]

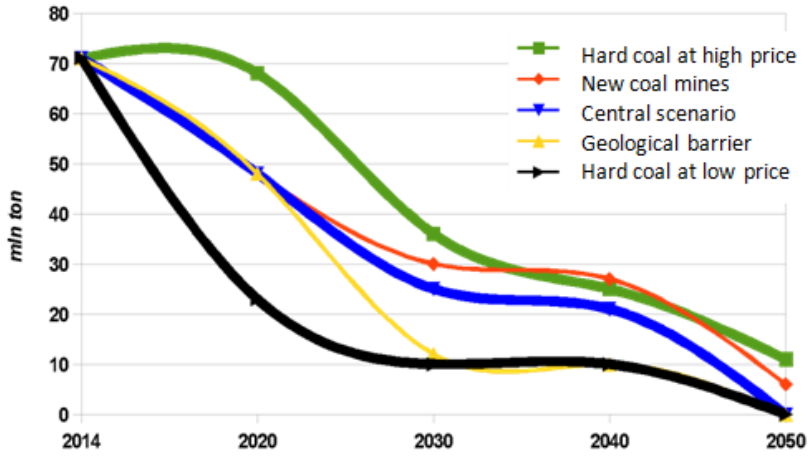
Forecasts suggest that by 2020 restructured state-owned mines will probably extract less coal than they did in 2014—and much less coal in 2050 (see Figure 5). Polish mining in the future would be able to satisfy only a small part of the domestic coal demand forecast coal by the Polish government. Only with the occurrence of exceptionally favorable factors could Poland be self-sufficient in coal, including: efficient coal-mine wage restructuring, high global coal prices, the absence of geological barriers to open new mines, and preferential investment financing by the state or banking sector.

[23] Michał Wilczyński (2017), *UWAGI do PROGRAMU dla sektora górnictwa węgla kamiennego.* For contrast, see "*Program for the hard coal mining sector in Poland"* Ministry of Energy (version 8, 30.06.2017 edition).

[24] M. Wilczyński used the Industrial Development Agency JSC data for the internal market prices, as for ARA - Quandl by BP Database, average PLN/USD exchange course based of National Bank of Poland. For hard coal markets the caloric value was calculated based on the ARA standard Q=25,14 GJ/t. Extraction cost based on the Ministry of Economy data recalculated to the ARA coal standard 25,14 GJ.

But such favorable circumstances are unlikely. Global coal prices are likely to remain soft due to excess of supply over demand on a global scale. Geological barriers are likely to be significant in most Polish coal fields. And the government's ability to finance or direct banks to finance capital-intensive investments in mining raise the possibility that in the not too distant future coal production in Poland could almost disappear. The most probable scenario seems to be one in which restructuring of the sector will face numerous problems with some mines will be able to adapt to new market conditions. New investments in the Lublin Basin will replace part of the depleted deposits in Upper Silesia. In this scenario, Poland will continue to extract hard coal in an economically viable manner, but the volume of this extraction will be continually decreasing.[25]

Figure 5. Scenarios of Future Polish Hard Coal Extraction



Source: Bukowski M., Maśnicki J., Śniegocki A., Trzeciakowski R., *Polski węgiel: Quo vadis? Perspektywy rozwoju górnictwa węgla kamiennego w Polsce*, Warsaw Institute for Economical Studies, Warsaw 2015.

As noted earlier, lignite production in Poland has declined 17 percent over the past three decades.[26] Most of the currently active mines will be depleted before 2040. Only two surface mines will remain: Turów and Szczerców. With only those two mines operating annual lignite production of only 20-30 million ton will be possible—compared with the current production level of 60 million tons. Although it is cheaper to mine lignite than hard coal, lignite mining contributes to severe environmental damage, in particular changes in land surface and reduction in the water table strongly impacts the agriculture sector.[27]

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[25] Bukowski M., Maśnicki J., Śniegocki A., Trzeciakowski R., *Polski węgiel: Quo vadis? Perspektywy rozwoju górnictwa węgla kamiennego w Polsce*, Warsaw Institute for Economical Studies, Warsaw 2015.
[26] http://stat.gov.pl/statystyka-miedzynarodowa/porownania-miedzynarodowe/tablice-o-krajach-wedlug-tematow/przemysl-i-budownictwo/.
[27] Benedykt Pepliński (2016), *Skutki ekonomiczne dalszej eksploatacji w czynnych odkrywkach węgla brunatnego w zagłębiu konińskim – analiza kosztów dla rolnictwa i przetwórstwa rolno-spożywczego*, Poznań.

Health and Other External Costs of Coal

High coal dependence in Poland accounts for much of the pollution that puts 33 Polish cities in the ranks of Europe's 50 most polluted cities. Coal is a major factor in more than 23,000 premature deaths caused by air pollution each year.[28] Some sources place this toll twice as high—at more 48,000 early deaths annually from air pollution. [29] According to the International Energy Agency, air pollution is "one of the largest environmental health risks" Poles face.

The total costs of health impact of the coal in Poland is US$ 3.5-9.0 billion per year. This accounts for one-fifth of the economic health impacts of air pollution in Europe, although Poland makes up less than one-twelfth of the European population (see Table 6).[30]

External Costs, Subsidies

Over the period 1990-2016, direct and hidden subsidies for coal mining and use cost the average Polish citizen PLN 222 per year.[31] Total support for the mining and coal power industry since 1990 has almost reached PLN 230 billion, an average of PLN 8.5 billion per year. For comparison, the support for renewable energy in the period 2005-2016 amounted to PLN 73 per year per person. It should be noted that more than PLN 10 billion was granted to large energy companies as a subsidy for co-burning coal with biomass (Figure 6).

In addition to the subsidies, external costs are an important element of social accounting for coal mining and coal energy production. External costs of combustion of coal in power plants include damage to public health caused by emissions of harmful substances (see Table 7 and Figures 7 and Figure 8). It is estimated that for coal-based energy generation in the period 1990-2016 they amounted to an average of PLN 1.74 billion, which means PLN 1,687 per capita. In total, the subsidies and external costs of coal mining and the coal energy sector cost every resident of Poland over PLN 1,900 per

[28] MVV Consulting and ECOFYS (2008): *Efficiency and Capture Readiness of New Fossil Power Plants in the EU.*
[29] EEA (2011c): *Air pollution impacts from carbon capture and storage (CCS)*. Technical report No. 14. European Environment Agency, Copenhagen, Denmark.
[30] Health and Environment Alliance (May 2013)**.** *NIEPŁACONY RACHUNEK. Jak energetyka węglowa niszczy nasze zdrowie.*
[31] The subsidies include restructuring of the hard coal mining industry (subsidies and debt write-offs to the state plus those resulting from the need to pay social security contributions and environmental fees).; subsidies to social security in mining; the impact of national mining support on coal energy; free allocation of allowances in the Emissions Trading System of the European Union; long-term contracts and stranded costs; capitalization of coal mines by state-owned companies; Power Reserve Compensation Mechanisms, that is the Operational Power Reserve (ORM) and Intervention Cold Reserves (IRZ).

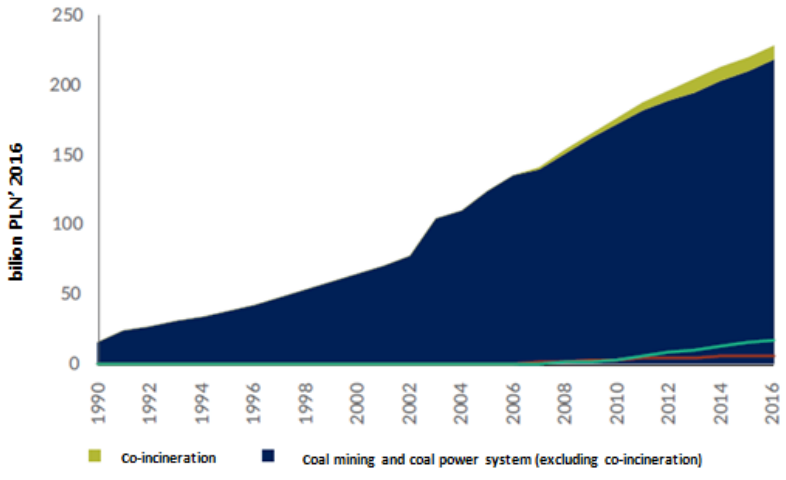
year.[32] Stated otherwise, the mid-range estimate of health cost in Poland last year was roughly US$0.01 per kilowatt-hour.

Table 6. Health Impacts of Coal-Fired Power

Indicator (all costs in million Euros)	European Union	Poland
Premature deaths		
- Number	18,247	3,496
- Value	37,954	
Chronic mortality		
- Years of life	196,218	37,625
- Value	10,596	2034
Chronic bronchitis		
- Cases	8,580	1,644
- Value	1,785	342
Hospitalizations (respiratory/cardiovascular)		
- Cases	5,498	1,071
- Value	13	2.9
Lost work days		
- Number	4,140,942	793,379
- Value	7,030	77
Total costs	15,433-42,811	2,979-8,219

Source: Health and Environment Alliance**.** *Niepłacony Rachunek.* „Jak energetyka węglowa niszczy nasze zdrowie." Maj 2013

Figure 6. Cumulative Support for Hard Coal



Source: Urszula Siedlecka, Aleksander Śniegocki, Zofia Wetmańska (2017), *Ukryty rachunek za węgiel 2017. Wsparcie górnictwa i energetyki węglowej w Polsce – wczoraj, dziś i jutro.* WISE Europa

[32] Urszula Siedlecka, Aleksander Śniegocki, Zofia Wetmańska (2017), *Ukryty rachunek za węgiel 2017. Wsparcie górnictwa i energetyki węglowej w Polsce – wczoraj, dziś i jutro.* WISE Europa.

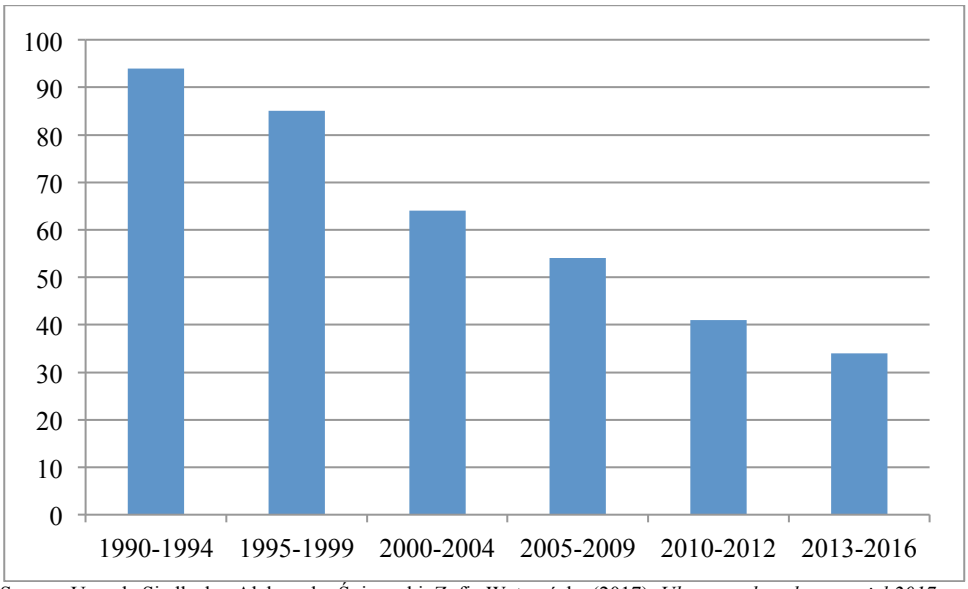
Table 7. Average Annual External Costs of the Polish Coal Power Industry, 1990-2016 (billion PLN, 2016 value)

	1990-1994	1995-1999	2000-2004	2005-2009	2010-2012	2013-2016	1990-2016
Low estimate	47	42	32	27	21	17	32
High estimate	142	128	96	81	61	51	97
Average estimate	94	85	64	54	41	34	65

Source: Urszula Siedlecka, Aleksander Śniegocki, Zofia Wetmańska (2017), *Ukryty rachunek za węgiel 2017. Wsparcie górnictwa i energetyki węglowej w Polsce – wczoraj, dziś i jutro.* WISE Europa.

Figure 7: Annual External Costs of Coal[33]

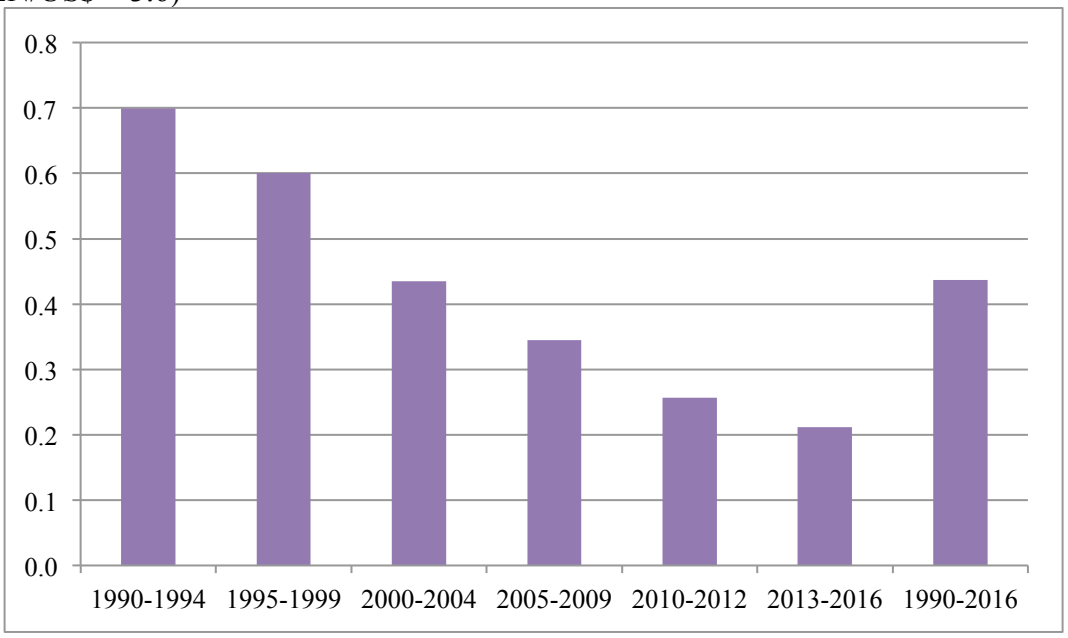
Billion Polish Zloty (PLN) per year



Source: Urszula Siedlecka, Aleksander Śniegocki, Zofia Wetmańska (2017), *Ukryty rachunek za węgiel 2017. Wsparcie górnictwa i energetyki węglowej w Polsce – wczoraj, dziś i jutro.* WISE Europa.

[33] According to the authors of the quoted report, external costs of electrical power emissions have been determined based on data on the actual emission levels of harmful substances (oxides sulfur, nitrogen and particulate matter PM 2.5 and PM 10) and on the basis of unit estimates of external costs of emissions in literature, less for the amount of relevant environmental fees. Calculation of external costs does not take into account the costs of climate change related to greenhouse gas emissions from the energy sector. The amount of external costs indicated in the subject literature differs depending on the method of health and environmental damage assessment. For this reason, in this report the authors present the average value of costs resulting from different estimation methods as well as the lower and upper limits of these estimates.

Figure 8. External Costs per Unit of Power
PLN per kWh electricity production
(PLN/US$ = 3.6)



Source: Urszula Siedlecka, Aleksander Śniegocki, Zofia Wetmańska (2017), *Ukryty rachunek za węgiel 2017. Wsparcie górnictwa i energetyki węglowej w Polsce – wczoraj, dziś i jutro.* WISE Europa.; Main Statistical Office.

Total external costs of power in 2016 exceeded US$.05 per kilowatt-hour.

Electric Power Alternatives to Coal

The Polish coal-fired power plant fleet is quite old. Of the 14,300 megawatts of hard coal-fired plants, all but one plant (at 1,400 megawatts) were built more than 30 years ago (see Table 8).

The lignite-fired fleet is somewhat younger—or has been overhauled in recent years—but faces obsolescence due to depletion of the lignite mines that supply the generating capacity. All lignite plants depend on nearby mines as lignite—which is 50 percent dirt by mass—is too expensive to transport long distances.

Forum Energii[34] recently presented four energy mix scenarios with accompanying analysis of the economic, social, and environmental implications of their implementation (see Figure 9). The report assumed power demand will increase at an annual rate of 1.4

[34] Forum Energii is a think tank using data and analysis to explore a clean, innovative, safe, and efficient energy future for Poland. For background on the organization, see forum-energii.eu/en/about-us.html

Table 8. Polish Coal-Fired Power Plants: Key Characteristics (2016)

Plant	Capacity	Year Built	Annual Production	Annual Coal Use	Annual CO_2
Name	**MW**	**Year**	**GWh/y**	**1000 Tons**	**Mt**
Hard Coal					
Kozienice	2,960	1972-79	13,770	5,945	12.00
Rybnik	1,840	1972-78	7,937	3,450	7.00
Połaniec	1,607	1979-83	9,507	4,130	8.40
Opole	1,492	1993-97	6,830	2,860	5.80
Dolna Odra	1,362	1974-77	4,881	2,120	4.30
Jaworzno 3	1,345	1977-79	4,812	2,090	4.20
Łaziska	1,155	c.1965	3,932	1,710	3.50
Łagisza	700	1960-70	2,365	1,030	2.00
Siersza	546	1958-70	1,734	855	1.70
Ostrołęka B	647	1968-72	2,591	1,125	2.30
Skawina	440	1957-61	1,395	690	1.40
Stalowa Wola	300	1963-66	413	200	0.40
Blachownia	165	1957-60	557	275	0.60
Jaworzno 2	140	1953-62	920	450	0.90
TOTAL	14,699		61,644	26,932	54.5
LIGNITE					
Bełchatów	5,298	1981-88/2011*	32,820	37,510	34,10
Turów	1,498.8	1962/2005*	82,24	9,940	9.10
Pątnów	1,244	1967	4,650	5,620	5.10
Adamów	600	1964-67	2,735	3,540	3.20
Pątnów II	464	2008	2,118	2,440	2.20
Konin	143	1950's	396	540	0.50
TOTAL	9,247.8		50,943	59,592	54.20

Notes: Share of electricity production above power plants in the production of electricity from sources based on fossil fuels is 76%, and in CO_2 emissions is 85%. This is according to the ARE Statistic for 2016 and the indicator from KOBIZE, i.e. 813 kg CO_2/MWh.[35]

* = year renovated.

Calorific value for hard coal = 21.2 GJ/tonne, for lignite 8.1 GJ/tonne. Carbon factor for hard coal = 95.3 kG/GJ CO_2, for lignite = 112.4. Source: Agencja Rynku Energii S.A..*Statystyka elektroenergetyki polskiej 2016.* Warszawa 2017

percent. In 2050, net energy generation will amount to about 220 terawatt hours. These four scenarios were shaped as follows:[36]

- The "Coal Scenario" assumes government funds are provided to construct new hard coal and lignite mines. Carbon dioxide emissions in 2050 would decline only 7 percent compared to the year 2005.

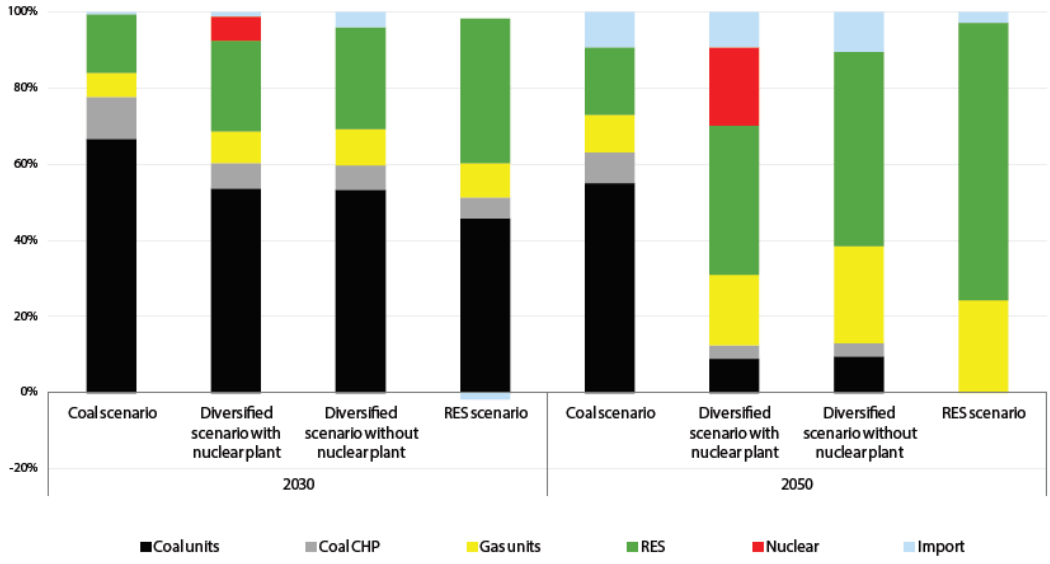
[35] Agencja Rynku Energii S.A..*Statystyka elektroenergetyki polskiej 2016.* Warszawa 2017; Krajowy Ośrodek Bilansowania i Zarządzania Emisjami *Wartości opałowe (WO) i wskaźniki emisji CO2 (WE) w roku 2014 do raportowania w ramach Systemu Handlu Uprawnieniami do Emisji za rok 2017,* 2016.

[36] Forum Energii, *Polish Energy Sector 2050: Four Scenarios*, October 2017.

- The "Diversified Scenario with Nuclear Power" introduces a market-driven mix of energy technologies, including one nuclear power plant replacing a lignite-fired power plant. Carbon dioxide emissions in 2050 would decline 68 percent compared to the year 2005.
- The "Diversified Scenario Without Nuclear Power" replaces energy generation by a nuclear power plant with increased generation from natural gas and renewables. Carbon dioxide emissions in 2050 would decline 65 percent compared to the year 2005.
- The "Renewable Scenario" assumes gradual elimination of carbon-based sources as a result of regulations on carbon dioxide emissions. The share of generation by renewables increases to 73 percent with gas generation helping balance the energy supply. Carbon dioxide emissions in 2050 would decline 84 percent compared to the year 2005.

A key assumption for "Forum Energii's" results is that renewables will be competitive with new coal-fired power plants production within the next few years (see Figure 10). Onshore wind turbines meet that criterion in the shortest period of time.[37] The main conclusion from any analysis of Polish coal and lignite production and power generation is simple: Poland is at a crossroads for its energy future. And it seems that government policy—possibly more than markets or the need to reduce local and global pollution—will determine whether Poland turns back toward reliance on coal or turns forward towards a modern, market-based energy economy.

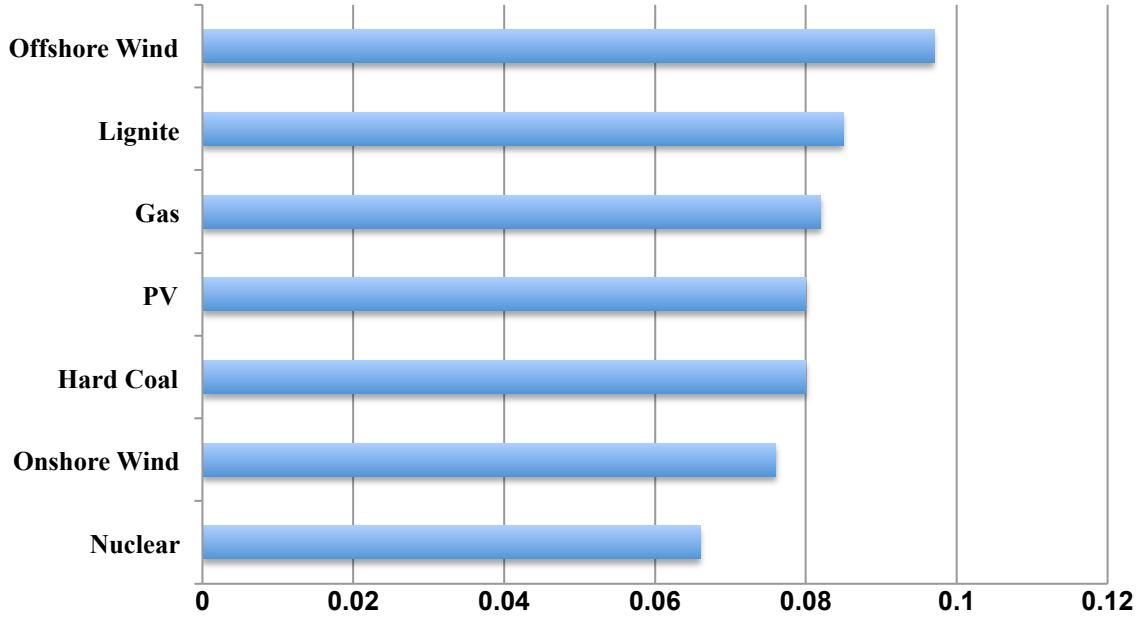
Figure 9: Forum Energy Projections



Source: Forum Energii

[37] Forum Energii, *op. cit.*

Figure 10: Marginal Cost of Power in Poland, 2020
Euro per kWh



Source: Entri integration of two graphics in Forum Energii, *Polish Energy Sector 2050: Four Scenarios*, October 2017.

Policy: Stakeholder Interviews

We (primarily Kassenberg and Hille) conducted more than 30 interviews with academics, politicians, officials of national and local governments, coal industry managers and experts, labor unions, trade and business organizations, health and sociology experts and environmental and consumer non-governmental organizations (see list of interviewees below). The interviews were conducted from August through October 2017, mostly face-to-face. Each interview was conducted under the "Chatham House Rule," which ensures that no comment will be attributed to any individual or organization. Opinions expressed by the interviewees have been incorporated here and have guided our conclusions, but cannot be attributed.

The Nature of the Interviews

Most interviewees were open and forthcoming. Some respondents were reluctant to express opinions on energy strategy because they feel the position of the current government is too weak to ensure that current energy policies will remain in place for the long term. That is, their own opinions may have differed from those of the institutions for which they worked but they were understandably reluctant to articulate those differences in clear statements. Indeed, many respondents stated that the coming year 2018 could be

a turning point in Polish coal policy due to European Union policies scheduled to take effect in Poland next year. Some interviewees expressed surprise that all interests—from environmental advocacy to government to trade unions—were being consulted for our study. While this approach was viewed positively it was thought to be an uncommon one.[38]

Three focal points define the main differences in interviewee opinion: energy security; the resource limits of coal; and the negative consequences of coal. In addition to these three groups, six interviewees placed priority on energy security above all other costs. This group considers renewable and other alternatives to coal plausible only in the long term and only if energy storage becomes feasible. A group of 10 interviewees accepted that coal's future is limited by increasing production costs and geological limits which, coupled with the need to respond to climate change, requires an early response to move away from coal. Another group of 10 interviewees believed that the negative consequences (environmental, health and economic) of continued reliance on carbon-fueled power generation require a shift from coal as quickly as possible. This last group emphasized the worldwide development of energy alternatives and significant improvements in energy efficiency and expressed concern that any delay in moving beyond coal would diminish Poland's chance to introduce innovations that can transform Poland's energy sector and boost its economic competitiveness.

Issues With Coal

Coal supporters are politically active. Several interviewees described a "political trap" that has persisted since the year 2002, when major reforms were instituted for the hard coal mining (but not lignite) industry. The term "trap" is a metaphor for political leaders' fear of losing election support from miners and their families, employees of the large power industry and their families, and employees of companies and institutions operating around these sectors. This political force is strengthened by the strong position of the trade unions. Until now, there has been no countervailing political force strong enough to enable Poland to modernize its power sector and move away from coal.

Political support for coal mining and coal-fired power generation is thought to derive more from weakness of the current government than strength of the coal sector. That is, the ruling party depends—as other parties in fact have done in the past—on support for election on blocs of votes from coal mining areas and does not have sufficient strength elsewhere to stop providing subsidies and policies that favor coal. Because voters in the coal region have a culture shaped by a centuries-long tradition of working in the mines, voters tend to support parties that cater to the interests of the mines. If coal interests turned against them, the current party fears the government would likely fall.[39]

[38] The reader should note that coal-related issues continue to evolve rapidly and not every new issue can be captured in a paper such as this. For example, since an earlier draft of this paper was completed the hard coal mining trade union few days requested in a letter to European Commission that it ease limits on carbon emissions per unit of electricity generated in order to permit more coal production.
[39] The authors think that fear may be exaggerated.

List of Interviewees

	First Name	Last Name	Affiliation	Location	Notes
1.	Tobiasz	Adamczewski	WWF Poland	Warsaw	Coordinator, Energy and Climate NGO Climate Coalition
2.	Maciej	Bando	Energy Regulatory Office	Warsaw	President
3.	Andrzej	Bućko	Lawyer, Expert on Energy Market	Warsaw	Expert, Consumers Federation
4.	Zbigniew	Bochniarz	University of Washington	Warsaw	Economics of Sustainability
5.	Wracław	Czerkawski	Mainers Trade Union in Poland	Katowice	Vice chairman
6.	Leszek	Drogosz	City Hall of Warsaw	Warsaw	Head, Infrastructure Department
7.	Adrian	Furgalski	Group of Economic Advisers TOR	Warsaw	Transport; Co-owner
8.	Lidia	Gawlik	Mineral and Energy Economy Research Institute, Polish Academy of Sciences	Cracow	Professor, Advisory Council to The National Centre for Research and Development
9.	Andrzej	Guła	Polish Smog Alarm	Cracow	Leader
10.	Zbigniew	Karaczun	Natural Science University	Warsaw	Professor, Expert, Polish NGO Climate Coalition
11.	Andrzej	Karasiński	City Hall of Gliwice	Gliwice	Secretary of the City
12.	Leszek	Kąsek	World Bank	Warsaw	Lead Economist, Warsaw Office
13.	Daria	Kulczycka	Polish Confederation of Employers Lewiatan	Warsaw	Industry and Services Director of Climate and Energy
14.	Michał	Kurtyka	Ministry of Energy	Warsaw	Dep. State Secretary
15.	Susan	Legro	Consultant	Prague	Expert, Eastern Europe Energy and Environment
16.	Michał	Krzyżanowski	King's College	London	Professor, Public Health, Epidemiology
17.	Jerzy	Kwieciński	Ministry of Development	Warsaw	Secretary of State
18.	Jaroslav	Marousek	Seven, Czech Center for Energy Efficiency	Prague	Expert on Energy and Carbon Emissions
19.	Szymon	Liszka	Foundation for Energy Efficiency	Katowice	President
20.	Piotr	Naimski	Chancellery of the Prime Minister	Warsaw	Member of Parliament, Law and Justice Party, Plenipotentiary for Strategic Energy Infrastructure
21.	Monika	Rosa	Member of the Parliament	Katowice	Member of Modern Party, Energy Parliamentary Group
22.	Janusz	Ryk	Polish Association of Heat and Power Plants	Warsaw	Heat and Power Plants Executive manager
23.	Janusz	Steinhoff	Chamber of Commerce and Industry in Katowice	Katowice, Warsaw	Chair of Council, Vice Prime Minister Mining Reform (2002)
24.	Marcin	Stoczkiewicz	Client Earth	Warsaw	Head of Warsaw Office
25.	Zbigniew	Szpak	The Polish National Energy Conservation Agency	Warsaw	President
26.	Representative (anonymous)		Economic Society Polish Power Plants	Warsaw	Big power stations association
27.	Wojciech	Szymalski	Institute for Sustainable Development	Warsaw	President
28.	Marian	Turek	Main Mining Institute	Katowice	Professor, Mining and Environmental engineering
29.	Jarosław	Tworóg	National Chamber of Commerce, Elect/Telecom.	Warsaw	Deputy Executive Manager
30.	Michał	Wilczyński	Independent expert,	Warsaw	Formed Chief Geologist
31.	Piotr	Woźniak	Polish Oil and Gas Company	Warsaw	President of the Board
32.	Adrian	Wójcik	Nicolaus Copernicus's University	Toruń	Department of Social and Environmental Psychology

Coal mining is becoming more expensive and less safe. The experts we spoke with acknowledged the problem that existing mines increasingly extract hard coal from greater depths and thinner coal seams and increasingly cause subsidence and other surface damage. These trends translate to higher costs and this, in turn, conflicts with the primacy of work safety in underground mines. Experts noted that global market forces demand labor productivity at a level in excess of 1,500 tonnes of annual output per mine employee—compared to an average in Poland of half that amount. That level of efficiency was not achieved because the mining was managed—some would say poorly managed—to protect labor at the expense of cost-efficiency. The pressure of trade unions to protect jobs prevailed over the necessity to increase the efficiency of mines, and capital was wasted.

The international level of productivity is possible only with advanced methods of applying labor and, in particular, the substitution of capital equipment for labor.

Interviewees called our attention to demographic trends that markedly reduce available labor supply in the Polish underground coal mining sector. Mining experts and representatives from Upper Silesia note that miners actually have mobility in employment because they are technically well educated and experienced in specialties useful in other occupations. Experts further noted that economic opportunities for such employment already exist and are expected to expand in the coal regions. For example, in 2015, the Silesian industrial sector (which includes coal) gained 18,000 jobs against 9,000 lost, while some 3,000 remained vacant.[40] Surprisingly, the interviewees indicated that there exists a shortage of mine workers. That shortage is almost certainly due to the combination of low pay—in the view of the miners—and the high risk of working in underground mines. And, as mentioned, better alternatives exist in the labor market on the surface. This situation makes it difficult for the hard coal industry to attract young people to the mines. It is difficult to overstate the importance of this shortage of mining personnel for the future of the coal industry in Poland. While the shortage could probably be eliminated by increasing wages, the resulting labor cost increase would make underground coal even less competitive than it already is. Some of the interviewees even suggest the need to import coal mining labor from Ukraine and elsewhere.

A different situation may apply to workers in lignite mining and associated power generation because of limited demand for their specialization and limited opportunities for alternative work in those regions.

Coal is heavily subsidized. The Polish coal sector is dominated by state-owned firms, coal-industry experts note that the government's ability to construct new mines depends on its ability to maintain a long-term, steady flow of financial outlays to subsidize coal. This is a position that can be sustained only through state ownership because high costs of investment and higher technical and economic risk make any prospect for commercial

[40] Bartłomiej Derski, *Na węglu świat się nie kończy, zwłaszcza na Śląsku.* Portal Wysokie Napięcie. pl 31.12.2016.

financing very unlikely. Private banks and international financial institutions are withdrawing from the coal sector. Private equity investors may be interested in the construction of coal mines in Poland, but expect certain concessions from the government.

Coal-fired power stations remain competitive only to the extent that government regulations favor them. Those regulations—such as a new policy that essentially bans new wind power development in much of Poland—in turn have limited the market penetration of alternative energy sources including wind and solar power. This new policy restricts wind development in several ways, including limiting the distance that turbines can be built from residential buildings, national parks, nature reserves, and parks protecting certain landscapes.[41] In practice, it means wind farms cannot be closer to any home or park than about 2 kilometers. The combination of high population density and number of parks limits wind farm development. Even in areas where turbines would be permitted, this strict regulation drives up the transaction costs of turbine development through the need for extensive surveys and planning in advance of development. In the opinion of the experts we interviewed, this policy significantly limits the development of wind energy in Poland.

The fact that the government has a vested interest in coal mining and coal-fired power generation through its direct ownership (by the State Treasury) means that current pro-coal policies may long persist and that officials will continue to be opposed to measures that would increase the economic efficiency of the power sector and cut consumer costs, local environmental pollution, and greenhouse gas emissions. Most independent respondents criticized the state's combination of ownership and politically-based regulation and highlighted the perceived bias of professionals in the energy regulatory agency.

Contention about lignite mining is unavoidable. Almost all interviewees agreed that lignite deposits currently in production will be largely exhausted by 2030. Opinions differed, however, on the justification for constructing new open pit (strip) mines to supply on-site lignite power plants. Proposed new lignite mines draw very strong opposition from local governments in the affected areas, environmental organizations, and some industry experts. Still, the Polish central government and the energy companies it owns and controls are pushing ahead with efforts to open new mines near existing lignite operations.[42] Government officials responsible for maintaining Poland's energy

[41] Wind farms will not be able to be built at a smaller distance from residential buildings than 10 times their height with the rotor and blades, i.e. in practice it is 1.5-2 km. The population density in Poland is 123 people/km^2. The same distance would be maintained at the construction of new windmills at the borders, among others national parks, reserves, and landscape parks, totaling more than 2000 sites. Existing windmills which do not meet the distance criterion could not be extended, only their renovation and work necessary for operation should be allowed. The regulation also leads to an increase in fees for the exploitation of windmills. In experts' opinions, this significantly limits the development of wind energy in Poland.

[42] Please note that government ownership is not absolute as private ownership of lignite mining and associated power generation is permitted.

balance—the equilibrium between domestic primary resources for power generation and domestic power demand—insist that building new lignite mines near existing ones is the most reliable way to meet Poland's needs. They also plan to develop lignite mining and mine-mouth power generation in at least one new region. Those experts concede, however, that Poland has obligations to the European Union to limit carbon emissions and that expanding lignite production would require Poland to purchase European expensive emissions allowances. Over the lifetime of the new lignite investments, the price for these allowances could increase from a current level of 7.5 euros per tonne to 30 euros.

Hard coal imports may increase. Interviewees whose livelihood does not derive directly from mining or coal utilization believe that domestic hard coal output will decline and that sustained demand for coal will require a significant increase in coal imports. Some respondents expressed the view that increasing imports would increase interest in the efficiency of coal combustion and electricity use, thus further reducing demand.

Coal fired generating capacity has been over-expanded. Several interviewees expressed concern about and criticism of what they viewed as over-expansion of coal-fired capacity in Poland. This criticism centered on the following points:

The previous government was criticized for developing too many coal-fired plants. Interviewees cited the following developments:

- Roughly 4,000 megawatts of coal-fired capacity are under construction
- Some 15,000 megawatts of existing coal generation is obsolete and will likely be closed, although two-thirds of this total could be reconstructed or kept as backup capacity.
- Coal production could drop below the amount of coal to be required by coal-fired plants even after a number of scheduled plant closings, necessitating a rapid increase in imports of a large quantity of hard coal.
- No new hard coal-fired power plants are planned besides those already under construction.[43]

No consensus on the path to energy security. Most respondents acknowledged that energy security is a fundamental requirement for any Polish energy future, but opinions diverged on how security can be achieved. Representatives of the conventional energy and power sector believe security can be best achieved through expansion of large-scale coal mines, power stations, and the electric grid. Those respondents indicated that they did not perceive external costs to be a significant barrier to coal's future or a priority for national policy.

[43] This statement assumes that the Ostrołęka power station will be completed.

In contrast, many interviewees, particularly those in the private sector, believe security can better be won through diversification of energy and power sources and that in particular the development of distributed energy at the level of cities, industry, small and medium enterprises, and even homes should be the focus of future power development. These experts called attention to a proposal of representatives of the Ministry of Development for the creation of "energy clusters," which is a concept for integrated power production and distribution. Local hybrid energy systems—combinations of renewable plus fossil generation—would be incorporated to ensure some local energy independence.

Health effects are a growing concern. Interviewees expressed concern about human health and safety problems caused by coal production and use. In particular they emphasized the importance of reducing so-called "low-stack emissions," specifically particulates and benzo(*a*)pyrene from small-scale boilers and furnaces with short smokestacks. More than one respondent expressed the opinion that recent research will lead to tighter regulation of particulate concentrations and emissions. The research mentioned indicated that suspended particulates entering the bloodstream accumulate in the body and perhaps have no inherently safe lower limit for concentration in the air. These respondents expect tighter EU regulations of particulates in the early part of the next decade.

They also noted the existence of a strong grass-roots anti-smog campaign organized around health threats, especially for children. Some experts, however, called into question a common response to that campaign, namely the replacement of coal-fired home-heating boilers and furnaces with gas or electricity. Others argue the most cost effective emissions cuts would be to improve the thermal envelopes of homes and replace current coal burners with affordable high-efficiency stoves.

Alternatives to Coal

The most interesting alternatives to coal suggested by respondents include:

- Energy efficiency
- Natural gas-fired generation (as a back-stop technology)
- Large-scale solar and wind power renewable energy including offshore wind
- Distributed energy generation using stable sources such as small hydropower, biomass or biogas, heat pumps, and local natural gas resources (especially if combined with storage)
- Combined heating and power based on a mix of natural gas and coal.
- Imported energy supply, especially imports from nations other than Russia.

Energy security experts prioritize achieving security of natural gas supply. Opportunities for this—which they emphatically insist must not include natural gas from geopolitical rival Russia—include expansion of liquefied natural gas (LNG) port facilities as well as connection to Norwegian sub-sea pipelines across the Baltic. For example, PGNiG (the State Gas and Crude Oil Company) recently signed a five-year contract with

Centrica LNG for LNG gas supplies from the United States for 800 million cubic meters of gas. This contract is the first of its kind and would satisfy 5 percent of yearly Polish gas demand.

Regulations hinder renewables. Independent experts noted the poor position of renewable energy in Poland. This state of affairs they attribute to inconsistent and even hostile regulation. They point to the unilateral termination of contracts with independent wind power producers as a prime example. Such policy moves undermine the credibility of the government as a reliable partner for private investors, especially foreign investors. One interviewee noted that several major, high profile European energy companies have left Poland in recent years for such reasons, for example Vattenfall and EDF.

Large-scale storage capacity is essential. If renewable energy becomes a major source of power generation in Poland, a key issue will be large-scale electricity storage capacity. This requirement, of course, is widely recognized and is the subject of work in many companies and laboratories, albeit not so much in Poland. Use of such technologies will require additional technological breakthroughs. And it will require research funding, which has been deeply cut in Poland over the past few years.[44]

Coal will have a continuing role. Many Polish experts maintain that even in optimistic scenarios of energy sector reform and transformation it will be necessary to maintain and revitalize some number of medium-sized (200-360 megawatts) coal-fired power plants.[45] This is considered less expensive than the construction of large new coal or nuclear power units and would probably be acceptable for the European Commission.

The role of nuclear in the near-term is limited. Some interviewees supported nuclear power as an important energy alternative. Some of these respondents favor small-scale nuclear power unit (50-200 megawatts) as better suited to the architecture of the Polish energy system and as having less "bulky" power and greater flexibility. Interviewees representing non-governmental organizations (NGOs) stated opposition to nuclear. The possibility of nuclear power contributing significantly to the Polish energy mix before 2030 is, however, limited by the lengthy approvals process, the requirement for large capital commitments, and the need for foreign expertise and equipment.

Uncertain role for electric cars. A significant number of respondents mentioned electrification of transportation as important for accelerating changes in the power sector. A Ministry of Energy program forecasts that a million electric cars will be on the road in Poland by 2025. Some observers considered this projection unrealistic, but they embraced the idea of gaining early experience with this technology.

Respondents expressed concern that large-scale electric car market penetration will cause problems in the power system, in particular that of creating peak demand for power in

[44] IEA, *op. cit*.
[45] In Poland today, coal-fired plants of the size of 200-360 megawatts compose 44 percent of total coal-fired generating capacity, or about 18 GW out of 33 GW of coal plants.

concentrated areas. Interviewees suggested that a priority over electric automobiles is development of mass passenger transport, including electric buses, which Poland manufactures. They indicated that electric light-trucks and vans for city use would be characterized by more uniform utilization rates and create more predictable and manageable power demand loads.[46] Interviewees mentioned the positive role electric transport could have in urban environments while noting that as long as coal is the dominant and indeed marginal power source in Poland then electric vehicles will at best not be a tool for countering climate change.

Urban development needs attention. Respondents whose specialization includes knowledge of power systems management asserted that cities will increasingly shape the nature of demand and the character of supply for energy and power in Poland. On the demand side, they mentioned growing interest in upgrading building envelopes along with the deployment of intelligent building controls integrated with local power generation from renewable sources.

Many respondents suggested the need for Poland to develop renewable sources and to acquire advanced, best available technologies for power and heat supply. Some commenters mentioned the need to incorporate municipal waste combustion in the mix, as well as integration of energy supply with water management.

Some interviewees identified the varying condition in central heating systems. While systems in large cities have a good economic prospect, those in small towns are severely constrained by the ability to generate positive cash flows and modernize their systems.

We want to underscore what seems to us a key finding of our interviews: *A showdown is coming in coal subsidies in 2018.* That is because European law allows use of public money to close down mines but that leeway is slated to disappear next year. Many observers believe that subsidies intended for closing mines actually gets transferred within the state-owned companies that operate the mines to pay for on-going mining operations. But the European Union's policy means that subsidies for operating mines—without which almost all of the mines could not operate—is supposed to come to an end.[47] There is concern that the European Union will not have the will to enforce its

[46] For example, the Polish company Ursus can produce electric light-trucks in second half of 2018.

[47] Please note the following excerpt from the "Council Decision" (10 December 2010) on State aid to facilitate the closure of uncompetitive coal mines (2010/787/EU): "In the context of closure of uncompetitive mines, aid to the coal industry may be considered compatible with the proper functioning of the internal market if it complies with the provisions of this Decision. Aid shall cover only costs in connection with coal for the production of electricity, the combined production of heat and electricity, the production of coke and the fuelling of blast furnaces in the steel industry, where such use takes place in the Union ... All aid received by undertakings shall be shown in the profit-and-loss accounts as a separate item of revenue distinct from turnover. The aid granted under this Decision shall be managed in such a way that there is no possibility of it being transferred to other coal production units which are not part of the closure plan or to other economic activities of the same undertaking ... Aid to an undertaking intended specifically to cover the current production losses of coal production units may be considered compatible with the internal market only if it satisfies the many of conditions as for example the operation of the coal production units concerned must form part of a closure plan the deadline of which does not extend beyond

regulations, or that the current Polish government may choose to ignore them. In either case, there would be a crisis of governance for Poland and for the European Union's relation to a key member of the Union.

Non-Russian gas is coming. One new development that attracted the interest of several interviewees is the initiative to build the large gas-fired power plant Dolna Odra close to Szczecin along a new natural gas pipeline bringing gas to Poland from Norway as well as to open a new LNG port facility. The LNG port has been open since December 2015 and the gas pipeline from Norway via Denmark (called the "Baltic Pipeline") is in the process of approval. Many parties in Europe and in Poland have an interest in this approval process. If approved as planned, the pipeline would begin operation in 2022. This is significant because although the largest supplies of natural gas in the world lie to Poland's east—in Russia— and sharp antipathy to Russia and especially for any arrangement that might be perceived as dependence on Russia is, we think it safe to say, unacceptable to most of Polish society. While this point might seem to be disputed by Poland's current import of hard coal from Russia, that practice probably is fundamentally different from gas imports because coal is so easily imported from anywhere in the world but gas resources move by pipeline or through expensive, somewhat risky liquefied natural gas terminals. Hence the Norwegian arrangement is attracting substantial attention.

Summary and Strategies for Moving Beyond Coal

Policy Context

Our technical review confirmed many of the more common views expressed in the interviews.

The majority of interviewees expressed the opinion that moving away from coal as a primary energy source is inevitable. Participants had varying opinions as to the pace of that transition, however. Several facts put these opinions in context, including:

- Most coal mines and coal-fired power plants in Poland are state-owned.
- Subsidies for coal mining in Poland currently averaged $USD 1.35 billion per year over the past several years.[48]
- Demand for coal in Poland already exceeds supply.
- Coal demand in excess of domestic supply is satisfied by importing coal from Russia, Kazakhstan, Australia, and the United States.

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31 December 2018 or the coal production units concerned must be closed definitively in accordance with the closure plan."

[48] Urszula Siedlecka, Aleksander Śniegocki, Zofia Wetmańska (2017), *Ukryty rachunek za węgiel 2017. Wsparcie górnictwa i energetyki węglowej w Polsce – wczoraj, dziś i jutro.* WISE Europa

- At least one-third of existing coal-fired power generating capacity is obsolete and must be closed or replaced. Two-thirds of both boilers and turbines are older than 30 years and contribute to low conversion efficiency and therefore high cost.

Many interviewees expressed the opinion that the future of the coal industry is limited because it has become uncompetitive. We found support for this view, including the following:

- Polish deep-mined hard coal currently costs $95 per ton—more or less, depending on specific product quality.[49] There are minimal barriers to importing coal from Russia, Kazakhstan, Australia, and even the United States at a lower price. The long term world coal price is expected to decline, perhaps to $80 per ton over the next decade.
- The productivity of coal in Poland is 650-700 tons per worker per year. But the minimum productivity to be competitive is close to twice that amount.
- Industry experts have concluded that of 43 operating deep mine coal faces, 15 are so unprofitable that they need to be closed as soon as possible.
- Coal mining has fallen significantly in importance for labor. Only 81,700 persons currently were employed directly in hard coal mining in 2017, though there are many others who work in supporting industries.
- Today there is no shortage of jobs for willing coal workers but that problem is looming. In fact, there is a labor shortage, and foreign workers have been considered for filling vacancies.
- It was noted that in the main coal producing region, Upper Silesia, unemployment is 2 percentage points lower than the national average.[50] However, emigration from the region may account for some of this difference.

We conclude that coal mining capacity is likely to continue to decline for economic reasons.

There are, however, many decisions expected in the coming months or years that could hasten or delay that decline. These include:

- Creation of a power generation capacity market.
- A policy refresh on lignite.
- A new policy on distributed energy.
- A new policy in energy parks, or "energy clusters".
- Continued conflict between private and state-owned energy interests.

[49] Note that this value changes continuously, particularly as a function of calorific value of the coal. See www.gornictwo.wnp.pl/notowania/ceny_wegla/.

[50] The greatest difficulty for employees is in large cities in Upper Silesia. For example, in Katowice unemployment in November 2016 equaled only 2.9 percent, in Tychy 3.4 percent, and in Gliwice 4.3 percent. But in Poland as a whole unemployment was 10.3 percent. Bartłomiej Derski, *Na węglu świat się nie kończy, zwłaszcza na Śląsku.* Portal WysokieNapięcie.pl 31.12.2016.

There does not appear to be a consensus among opponents of lignite mine expansion on the best course to block new investment by the government. [51] Some opponents—and at least one of the authors—accept the argument that legal action and local protest against new lignite mines is a promising course. Others—including at least one of the authors—would argue that a parallel campaign to demonstrate the viability of alternatives is also necessary, and that such an effort should focus on renewables and large-scale storage. The argument is that, in the absence of such a campaign, legal action will be ineffective.

The best leverage to promote clean, distributed energy systems may be to work with the local governments on building performance standards. In this effort, the key will be support for leaders in selected urban municipalities to catalyze and integrate cooperation among private businesses and independent financing institutions. This effort would develop the market of distributed energy services and equipment and could create revolving funds fed by service providers and donors interested in strategic change—for climate mitigation and adaptation, social development, and technology transfer.

The best policy leverage of block extension of coal subsidies is probably legal action outside Poland under the laws of the European Union. But like legal opposition to lignite expansion, the very existence of the subsidies points to a need for better public and private cooperation in planning for long-term energy supply. This planning urgently needs to take into account the real benefits to society of reducing the external costs of the health effects of pollution and the loss of natural assets to coal mining and power generation facilities. It is crucial for environmental activists and opposition leaders to educate the public on the profound benefits to quality of life, employment, and development that the modernization of buildings and energy supply systems can bring about.

Environmental pollution is a serious political issue in Poland, especially coal-related air pollution. Many people attribute the worst problem to low height smoke stacks. This issue is a major headache for local officials. This problem is exacerbated by home heating systems which are inefficient, use low quality coal, and sometime mix in plastic bottles and other household waste. It is vital to remember that more than 70 percent of individual buildings in Poland have very low or no insulation at all.[52]

News reports have made the low-stack emissions problem very sensitive and urgent. One policy suggestion is to support building performance standards at the regional level. This approach could help address the low-stack pollution problem. However, the policy response proposals tend to be very simple and short-term—stop burning low quality coal,

[51] High investment needs lead to the lack of possibility to finance the majority from public funds for budgetary reasons. This implies the need for co-financing from private sources, and these require economic rationality. It is anticipated that public funds will be used to finance investments in a manner that will reduce the risk and lead to economic efficiency and will finance the rest from the commercial sources. But without private means, it would not likely be possible.

[52] *Strategia modernizacji budynków: mapa drogowa 2050.*Instytut Ekonomiki Środowiska, Krajowa Agencja Posznowania Energii, Narodowa Agencja Poszanowania Energii, Building Performance Institute Europe przy współpracy PricewaterhouseCoopers. Kraków 2014.

stop burning waste, and upgrade the boilers. But there is little pressure for thinking about better quality of buildings, for higher-quality fuels. Efforts to simply replace the boiler without insulating the building would be in vain. Quick solutions are the result: replace the boiler, subsidize the use of higher quality coal, but nothing for long term solutions. Good solutions include revolving funds. People trust information offices in municipalities and those can help guide people to high efficiency gas-fired homes. A complimentary policy would provide *a mechanism for government to work through commercial banks or an existing network of local cooperative banks for home efficiency financing.*

Any effective strategy for moving beyond coal in Poland should recognize and accept Polish opposition to Russian gas. Climate is not in the top three policy priorities for most Polish voters. At the same time, such a strategy should recognize that while creating jobs is a top priority in coal regions like Upper Silesia and areas with lignite operations, further investment in *coal-mining-related jobs* is not the most effective approach. Similarly, the strategy should recognize—but not accept—that coal is a state-owned centrally planned monopoly and is sustained by state subsidies.

Many recognized experts on this subject, in our view, believe a beyond-coal campaign should support legal efforts to block coal subsidies through the European Union. This effort is considered both urgent and, with some doubts, winnable. The most important are local governments, especially in regions of coal extraction. Also any partners voting against smog.

Similarly, these thinkers propose to block the extension of coal subsidies in the European courts. Success in this approach is not a foregone conclusion because of the desire of European Union leaders to govern by consensus, but in fact much of Europe probably supports elimination of such subsidies, and it is official European policy.

Likewise, legal efforts to enforce air pollution policies to eliminate low-stack emissions and to oppose new coal-fired power plants (long-term priority) could be a productive activity. This approach would fund legal efforts is to intervene in permitting.

Another key effort would *support legal efforts to block development of new lignite mines This effort is both urgently needed and is probably likely to succeed.* This strategy has a sound legal basis but possibly more productive would be a less confrontational approach based on support for public education on the employment, economic, and health benefits of alternatives to coal. This is based on opinion of our interlocutors. These two direction of activity are needed. Political pressure and almost building from scratch the understand needs for energy transition. In this regard, support for organizing and mobilizing community resources could be placed in the hands of local activists. We are convinced the need is for support for *local* activists—people in the community and even in local government who are trusted by the local population.

We are not convinced that proposed efforts to oppose Russian gas pipeline is a good use of resources for the environmental community. Opposing Russian gas is in all events not

a priority for environmentalists—interests in Poland will take this on without encouragement or support.

We do suggest supporting the efforts of local health activists because they align with the interests of those seeking to move Poland beyond coal, and they are valuable in their own right.

We would also make a priority of supporting market reforms—state-ownership and control was detested under Communism for good reason. Supporting market reform would support the natural forces of price and price response and profit-making which would all discourage use of coal. This could be best supported through private—especially international—business groups.