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Coal transition in Poland

Options for a fair and feasible transition for the Polish coal sector

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Executive Summary

If Poland is to participate in the global effort to minimize the risk of greenhouse effect at the level comparable to other major economies worldwide, it needs to substantially reduce its CO_2 emissions. In the scenario for Poland, which we build on based on several assumptions and using modelling tools, the CO_2 emissions per capita reaches the level of 2.80tCO_2/capita in 2050, which constitutes a 67% reduction comparing to 2010.

Achieving the target is feasible providing a radical reduction of oil and gas consumption. As for the total coal consumption, it would be reduced to a lesser but also substantial extent, namely by 20% between 2015 and 2030 and by 55% between 2015 and 2050. As the modelling exercise showed, the most cost effective way to achieve that is to completely replace coal with alternative energy sources in the power sector by 2050, with the possible exception of existing CHP units. Significant reduction in coal consumption can take place also in the residential sector upon adoption of energy saving technologies and measures.

In the analysed scenario, the drop in coal consumption will contribute to but also follow the phase-down of coal-mining sector in Poland. The reason for this is that most of hard coal consumed in Poland is produced domestically: in 2015 Polish mining sector produced 72.2 mln tonnes of hard coal while Polish economy consumed 71.9 mln tonnes. This contrast with the cases of other major coal consumers in Europe which cover most of its consumption from import.

At the same time, however, existing lignite mines (roughly half of Poland's coal production) are expected to significantly decline in productivity independently of climate policy by the 2030s. This provides a major challenge to the local communities, workers and businesses currently linked to lignite. Poland's coal sector and governments thus has an important window of opportunity to begin preparing for this "lignite transition" that they must use relatively urgently, to prepare for this coming change.

The cut in production of both lignite and hard coal mining raise questions about how to manage the reduction in employment in the coal sector. We estimate that employment in that sector will need to be reduced by 47% during the period 2015-2030 and by at least 77% during the period 2015-2050 (from the current 94 thousands to estimated 63 thousand in 2030 and 27 thousand in 2050).

Coal-mining employs a large share of the workforce in the Slaskie region, although it generates a small share of Polish GDP and plays a minor role in total employment nationwide. The phase-down of the sector implies that employment will need to be considerably reduced in the coming decades. The reduction in employment might happen in two ways: (i) by lay-offs in the mining sector and a shift of workers to other sectors of the economy or (ii) by natural attrition of workers in the mining sector coupled with hiring freeze and directing young generation into other sectors of the economy.

The challenges facing the Polish coal sector, while difficult to accept, also come with opportunities to achieve some important local and national policy objectives, with climate mitigation as a co-benefit. For the affected regions, the need to transition can also be an excuse to more broadly diversify local industry, creating attractive jobs for the next generation. It can also be an opportunity to improve environment and health in the region, to invest in infrastructure and create more attractive local living conditions for the local inhabitants.

Poland has a chance to implement a just transition for regions and workers if it acts now to prepare the transition. A number of policy options are available. Policy makers can use a 'window of opportunity' for relatively harmless employment reduction that results from the natural ageing of the mining workforce. They can further guarantee that assistance measures encourage ex-miners to stay at the labour market; adjust the number of students in mining classes; stimulate labour demand in coal mining areas, especially in manufacturing and construction; promote vocational training to ex-miners ending with formal certification. However, in general, enrolment into retraining and other forms of active labour market policies should be a default option to leavers from the mining sector who fail to find a new job; engage in broad and inclusive consultation to guarantee broad social consensus, including local public administration, NGOs and local organizations, for the reforms to prevent halting due to political reasons.

For the affected regions, a key priority is ensuring sufficient economic activity and infrastructure and soft local attractiveness factors to support employment for the next generation of workers. Some Polish coal-mining regions are already pursuing activities to diversify their industrial fabric. Such activities should be further supported. Poland will be looking to allocate regional development funding from the European Union's next budget to support these activities. Strategic planning and the creation of a multi-level governance structure to coordinate and identify opportunities at the local and regional scale will however be required to ensure efficient governance of this transition.

However, our simulations show that the lay-offs will not be necessary since most of the employment reduction could be achieved through natural attrition and hiring freeze. Natural attrition and the hiring freeze would generate a drop in supply of labour that is very close to the drop in demand for labour in the sector under our ambitious emission reduction scenario. This result is obtained even under the assumption that productivity in the mining sector at fast pace. If the growth of productivity is slower, the necessity of lay-offs will be even lower.

1. Introduction

The issue of Polish coal transition is increasingly on the political agenda. It is closely associated with the European debate on the future energy mix and meeting the global GHG-reduction targets established by the Paris agreement in 2050. But in Poland there is also an internal pressure to speed up coal transition triggered by economic problems of the Polish coal mining, which, despite different forms of public support, struggles to keep its medium- and long-term profitability. Indeed, existing lignite mines, which currently account for just under half of Polish coal production, are expected to be largely exhausted by around 2030. A transition of one sort or another is therefore going to happen in the Polish coal sector – the question is only how it is managed.

Coal employment is still relatively sizeable, especially when analysed from the regional perspective. The collieries are spatially concentrated with most of them being located in Śląskie region. Hence, the region is to carry the largest burden of coal transformation. The previous experience with cutting employment in coal mining shows that employment reduction might lead to intensification of social problems and persistent unemployment among former miners, especially if it is not well anticipated and addressed with public policies.

In this report we discuss a role of coal in Polish economy. We describe the position of coal in Poland's energy mix and changes in coal production in recent history. We also discuss the condition of the coal mining sector and institutional settings affecting the sector. In the following part we present results of simulations projecting Poland's future energy mix under conditions needed to meet 2-degree climate targets. The simulations imply a 70% reduction in production of coal by 2050.

In part 4 we draw a picture of hard coal mining in Poland from the social perspective. We highlight aspects that should be taken into account when proposing socially viable and just coal transition.

2. Coal use in Poland

In this section we present the interlocking factors which makes Poland the second most coal intensive economy in the EU. We point that the abundant reserves of coal and their extensive use, particularly in energy sector, have had their strong impact on CO_2 intensity of the country. We indicate that the role of coal does not reflect the economic profits of this sector, which since the beginning of the transformation in the beginning of 1990s is continuously struggling to become competitive.

2.1. Role of coal in the energy system

2.1.1. Demand for coal

The role of coal in the electricity and heat generation in Poland exceeds by far the role of any other energy source. Coal delivers 81% of the electricity and 86% of heat. In case of electricity production, the two other most important sources are wind (7%) and biomass (6%). As for the heat production, gas and biofuels account for, respectively, 7% and 5 %. The role of oil, hydro and other sources in heat and electricity production is almost negligible (**Figure 1 and 2**).

The use of coal in other sectors is also large. The share of coal in TFC is the largest among other EU member states. In the residential sector coal provides directly a third part of TFC and in the industry sector - the fifth. It has a smaller meaning for the commercial, agriculture and forestry as well as for non-energy use (**Figure 3**).

Since the beginning of the transformation the GDP grew more than twice and at the same time the CO_2 emissions fell by 20%. This decoupling of economic growth and CO_2 emissions was related mainly to restructuring of the economy (growth of services and transport and reduction of industry sector) and of industry in particular.

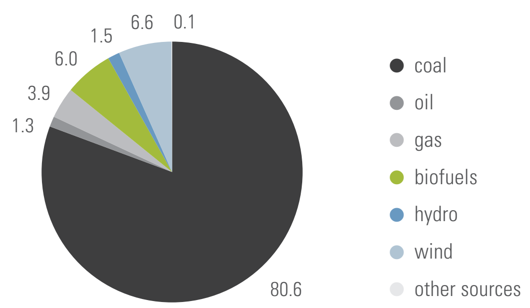
2.1.2. Coal-related GHG emissions

The CO_2 emissions from fuel combustion totalled 282 million tonnes in 2015. The majority of CO_2 emissions (53%) comes from the electricity (around 3/4)[1] and heat sector (1/4). Transport is responsible for 15% of the emissions. Manufacturing sector and construction as well as the residential sector (the latter being the majority of "other sectors") are responsible for around 10% of the total emissions (**Figure 4**).

Poland is the fifth biggest CO_2 emitting EU member state. CO_2 emissions per capita in Poland are at the level of 7.34 (tCO_2/capita) which is somewhat above the EU average (6.28). Instead CO_2 emissions per GDP, which are at the level of 0.51 (kg CO_2/$) are, except the Estonia (0,67), the highest among the EU-member states (the EU average is 0.18).

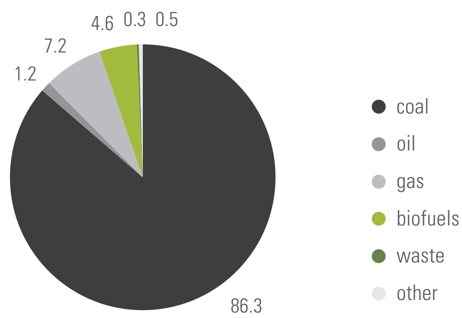
1 Data for the year 2014, in: KOBIZE 2015,

Figure 1. Production of electricity (%), 2015



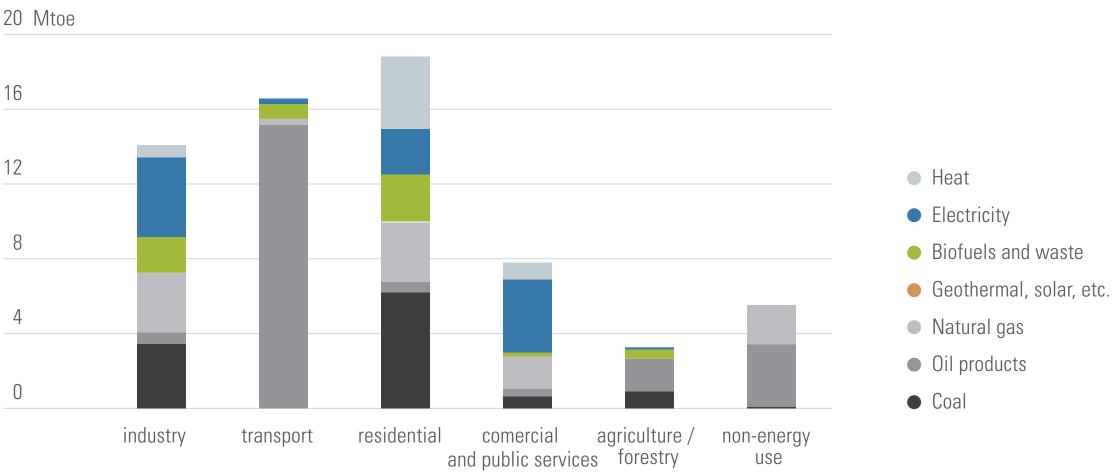
Source: IEA

Figure 2. Production of heat (%), 2015



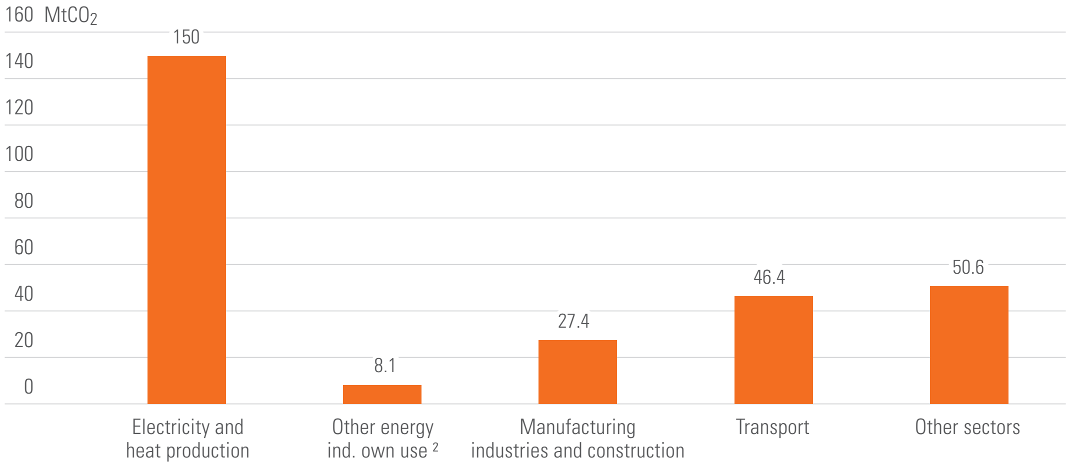
Source: IEA

Figure 3. Total final energy consumption on a net calorific value basis, 2015



Source: IEA.

Figure 4. CO_2 emissions by sector (million tonnes), 2015



Source: IEA, 2017, report retrieved at: https://www.iea.org/publications/freepublications/publication/CO2EmissionsfromFuelCombustionHighlights2017.pdf

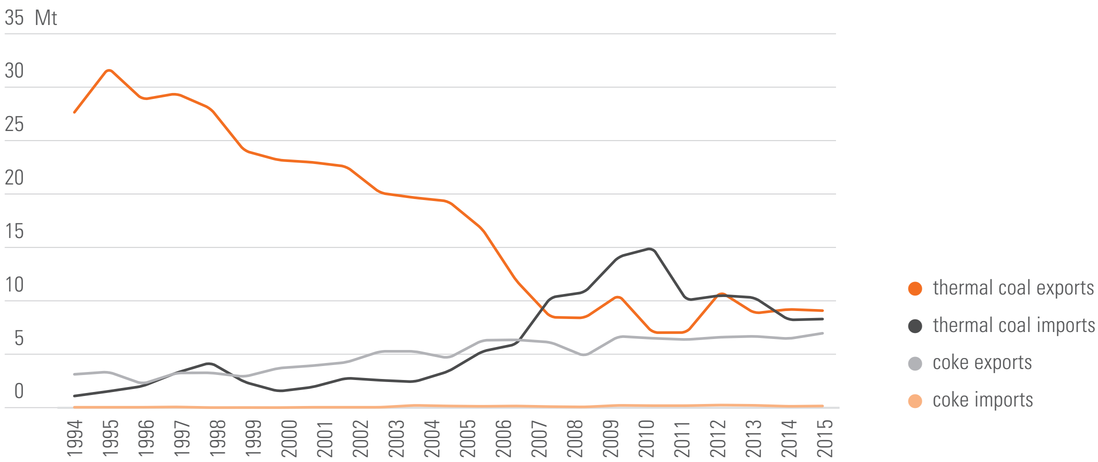
2.2. Role of coal in the economy

Balance of trade in thermal coal was positive with the 5.6 million tonnes of imports and 6.9 of export. Considering the sales price of thermal coal (236 PLN (56,4 EUR) / tonne) and coking coal (368 PLN (88 EUR) /tonne) these values remains insignificant for the GDP. For the coal mining sector however, the increase of the coking coal production became a strategic goal. It is mostly due to its higher profitability and more stable demand (**Figure 5**). Inversely, the import of coking coal was at the level of 2.7 million tonnes and its export at the level of 2.3 million tonnes (**Figure 5**). For physical reasons related to characteristics of lignite and consequently the difficulty of its transport, the import and export of this fuel in Poland remains marginal.

2.2.1. Trends in production and employment in coal mining

After 1989, the coal mining sector turned out to be unprofitable and highly inefficient. Coal production was excessively high whilst the quality of produced coal low and the cost of production high (Czerwińska 2002, Dubiński and Turek 2017). To manage the sector's poor situation, the government decided to close the least profitable mines and reduce employment. In the subsequent years, the sector followed gradual changes aimed

Figure 5. Exports and imports of thermal coal and coke, 1994-2016



Source: Own elaboration based on data from Comtrade.

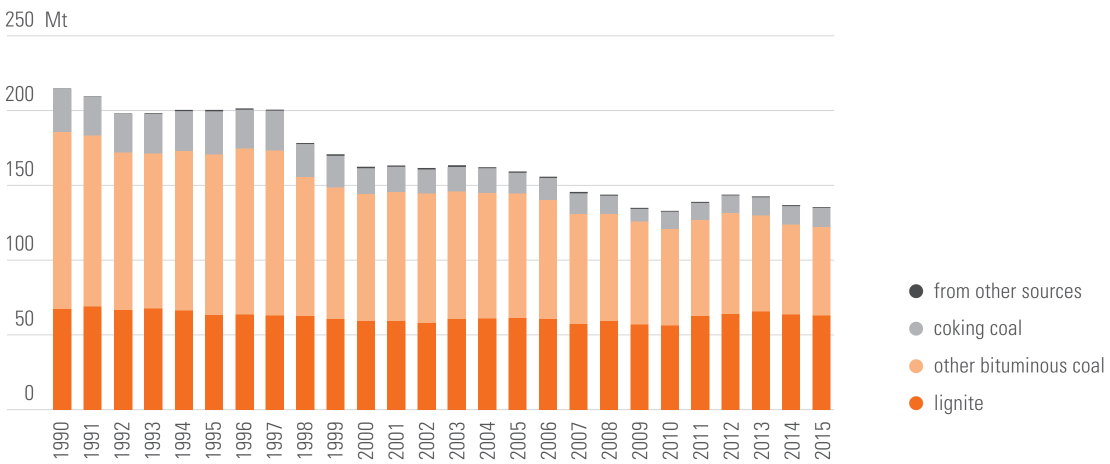
at decreasing its excessive capacities and reducing high costs. Since 1990, the government has adopted several sectoral restructuring strategies. As a result, the number of active hard coal mines fell from 70 in 1990 to 30 in 2014. (**Figure 7**) At the same time yearly production of hard coal decreased by half: from 147.7 million t to 73.3 million tonnes (**Figure 6**).

Production of hard coal was decreasing rapidly since the beginning of the transformation in the early 1990s, primarily in response to decreasing demand from restructured and modernised industry. Another important reason of this trend was internal weakness of the mining sector which shaped by the logic of central planning turned out to be inefficient in new reality of free market rules.

Since 1989 employment in the hard coal sector has decreased by over three quarters. In 1989-2000, employment in the hard coal mining fell by 60%. In the later period the reduction was less significant. Only in recent years employment reduction has accelerated again. In 2015 the government re-established incentives to miners voluntarily leaving the sector which we discuss the instruments in section 4.).[2] By the end of 2015 the em-

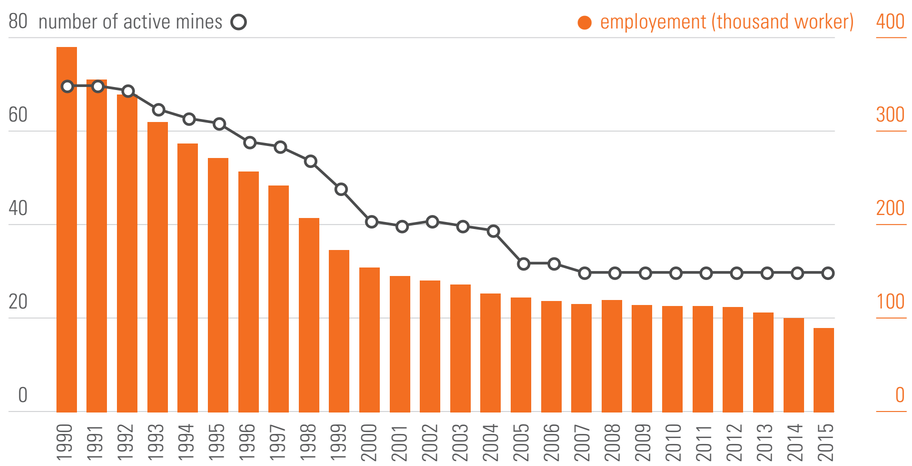
2 In 2016 the most profitable collieries from largest mining company, Kompania Węglowa (KW), were sold to newly-established Polska Grupa Górnicza (PGG). The rest of collieries were transferred to Spółka Restrukturyzacji Kopalń (SRK), which operates collieries intended to shut down. SRK manages also social assistance to miners leaving the sector. KW was liquidated in 2017. The ownership changes aimed at improving the sector's profitability.

Figure 6. Production of coal and lignite, 2015



Source: IEA.

Figure 7. Number of active hard coal mines and hard coal employment in hard coal mining, 1990-2014



Source: data on number of active mines from Kasztelewicz et al., 2015; data on employment from Bednorz 2015 (for 1989-2006), data from the Ministry of Economy and the Ministry of Energy for the rest.

ployment in the hard coal mining reached 90 thousand (**Figure 7**). Today, there are three main types of coal produced in Poland: thermal coal, coking coal (together referred later as hard coal) and lignite[3]. The total volume of hard coal production in Poland in 2015 was 73 million tonnes, of which thermal coal was reaching over 59 million tonnes and coking coal 13 million tonnes. Production of lignite was at the level of 63 million tonnes. Over 2.5 decades the production of lignite remained at the constant level whereas production of hard coal fell two times (**Figure 6**).

Recoverable reserves of coal (both thermal and coking) are estimated for 1.56 billion tonnes and lignite for 1.05 billion tonnes.[4] These estimations however are based - as the governmental *Strategy for the Hard Coal Mining* states - on an outdated resource classification methodology as it focuses on geological aspects and underestimates the economics of reserves exploration.[5] This factor may have been affecting the choice of optimal policies in the past and may still have a negative impact on current policy decisions.

Hard coal mining is restricted to three regions: Śląskie, Lubelskie (one large coal mine) and Małopolskie (one medium-size coal mine). Ślaskie voivodship homes 90% of hard coal mining employment. As for lignite, there are five lignite mines in Poland: Bełchatów (the largest one), Turów, Konin, Adamów and Sieniawa, located in four regions: Łódzkie, Wielkopolskie, Dolnośląskie and Lubuskie. Four of them supply power plants located in their vicinity.

Due to different technology of production, lignite mining is less labour intensive than hard coal mining. Employment in lignite mining fell from 27 thousand in 1991 to less than 10 thousand in 2015. In this period the number of mines was constant, but productivity of the sector tripled from 12 to 37 thousand m^3 per person per year. (Kasztelewicz *et al*. 2015; Ministry of Energy, 2018a).

Importantly, it is commonly believed that lignite mining resources at existing mines will begin to run out significantly by the 2030s (Widera, *et al.,* 2016). These means that without new mining permits – a politically and economically challenging proposal – lignite mining will enter a natural decline during the 2030s, if not beforehad.

Hard coal mining and lignite mining share some similar characteristics. The employment in both sectors is highly masculinised and rather low-skilled (we discuss characteristics of hard coal mining employment in detail in section 4.1). However, due to more spatial dispersion of lignite mining transition in lignite mining is likely to have different implications compared to transition in hard coal mining.

2.2.2. Profitability of the coal mining sector

The Polish hard coal mining sector suffers from significant problems. Although efficiency indicators improved and the average production per worker per day increased from 1.87 t in 1990 to 3.72 t in 2015 (Dubiński and Turek, 2017), the production costs remained relatively high. The low competitiveness of hard coal production has been reflected in falling exports of Polish hard coal and rising imports from other countries (cf. **Figure 2**). Falling coal prices further undermined the financial situation of the sector in recent years.

Despite relatively recent improvements, the sector is again unprofitable. After the period of positive net financial results, up to 3.0 billion PLN in 2011 (720 million EUR), since 2013 the sector has again achieved negative financial results. The largest loss took place in 2015, 4.5 billion PLN in 2015 (1.1 billion EUR). Excess employment and high personnel costs have been the main factors frequently mentioned as obstacles to higher profitability of coal mines (Karbownik and Wodarski 2014). However, the reduction of wages is improbable due to collective wage agreements,[6] hence reduction via extensive margin (number of workers) is virtually the only viable solution.

The other factors behind financial problems of the hard coal sector are: high fixed costs, increased competition due to coal imports, mainly from Russia, which results in unsold production of low quality coal, and high production costs resulting from unfavourable geological characteristics of deposits. In future, the geological conditions could become even more problematic due to depleting of 'easier' deposits and need to start deeper pits (Kasztelewicz *et al,* 2015).

3 Hard coal refers to Polish classifications and it is not be confused with anthracite. In IEA it is referred also as thermal coal or in IEA statistics as other bituminous coal. Other types of coal produced and consumed in Poland on a marginal scale and referred as "from other sources" in IEA statistics are low-grade coal or coal dust

4 These values refer only to the reserves for which concessions have been already granted. The value of total recoverable coal reserves is estimated for 1,56 billion tonnes.

5 E.g. Canadian NI 431-01, or Australian JORC

6 Lower personnel costs are a key factor behind higher profitability of private collieries compared to public controlled ones.

Box 1. Support for coal mining and its contribution to public finances

The situation of coal mining sector is unfavourable despite the state support, mainly in terms of funding pensions for retired miners. Between 2007 and 2015 to expenditures on miners' retirement pension in part which was not covered by the revenues from contributions amounted to 58.4 billion PLN (14.4 billion EUR). However, it is important to keep in mind that this support is likely to be sustained even if the production of coal in Poland is phased-out. Other forms of state support in the 2007-2015 period included 2.4 billion PLN (0.6 billion EUR) on recapitalisation of the sector, 4.8 billion PLN (1.2 billion EUR) on state aid and minor expenses on monitoring of the sector. Coal sectors contributions to public finances in between 2007 and 2015 totalled 64.5 billion PLN (15.9 billion EUR). The largest share, 31.6 billion PLN (7.8 billion EUR) was paid to the state budget and 28.5 billion PLN (7 billion EUR) to Social Insurance Institution and other public entities related to labour [1]. Remaining part was paid to the communes - 2.5 billion PLN (0.6 billion EUR), the national and regional funds for environmental protection and water management (0.9 billion PLN, 0.2 billion EUR) and the National Disabled Persons Rehabilitation Fund (0.9 billion PLN, 0.2 billion EUR).

In 2007-2015 the balance of public support for, and contributions to public finances of the coal mining sector remained slightly negative. Total contributions to the public finances at the level of 64.5 billion PLN (15.9 billion EUR) were surpassed by the state support amounted to 65.7 billion PLN (16.1 billion EUR).

Source: Supreme Audit Office (2017)

Once again, lignite mining resources at existing mines are expected to begin to run out during the 2030s (Widera, *et al.,* 2016). This means that costs are expected to rise as productivity declines.

2.3. Policy aspects of transition

Polish government does not specify its own Nationally Determined Contributions (NDC). The NDC for the entire EU has been declared on behalf of all EU member states by the European Commission[7].

As a relatively large EU country, comprising around 8% of the EU's population, Poland will have a significant impact on the EU's overall CO_2 emissions. However, it is important to note that the EU-wide targets have to be achieved collectively and for several sectors these objectives are based on collective instruments, such as the EU-wide carbon market for power and industry. The modalities of how many of these objectives translate into national policies and projections for individual sectors, such as coal, is therefore difficult to define until member states develop their own plans to translate these EU level goals into national action.[8] The targets as well as the detailed sectoral pathways and contributions for achieving them will only be defined in a new *National Energy and Climate Plan (NECP)* – to be prepared by each EU member state by the end of 2018 and defining national strategies out to 2030. Thus, the precise level of Poland's contributions to the EU's 2030 goals per each sector and the projected impact of the EU's new climate and energy policy framework on the coal sector will not be formulated until then.

Nevertheless, the overall level of Polish climate targets is one of the lowest in the EU. It is established already in the new EU Regulation on binding annual greenhouse gas emission reductions by Member States until 2030, adopted in May 2018 (Regulation (EU) 2018/842). It sets Polish GHG emissions reductions in sectors outside the carbon market (such as residential heating, transport, light industry, and agriculture) at the level of 7% (relative to 2005 levels) against the 40% for Sweden, 39% for Finland and 38% for Germany and 0% for Bulgaria and 2% for Romania.

7 The EU-wide NDC assumes 40% reduction of greenhouse gas emissions by 2030 compared to 1990. The EU long-term goal is to reduce the emissions by 80% by 2050 (relative to 1990).

8 Targets are to be achieved with common but differentiated responsibility among members states which is reflected in current and future goals with deviations depending on given conditions and capacity of Member States.

If current policy trends are continued in Poland, then it is likely that the transition in the power sector proposed by the Polish government in its NECP would not be significant. The primary reason for this is the risk of relatively high social and economic costs associated with the transition away from the consumption of coal. First, the predictions of the energy system optimization model developed in the Department of Strategic Analysis suggest that coal remains the most cost-effective source of energy in Poland. Until the costs of RES installation fall substantially, replacement of coal would likely lead to an increase in electricity prices at least in the short run. Second, since most of coal consumed is supplied by domestic firms, the fuel is often perceived as a warrant of energy security. The increase in the share of intermittent renewables in the electricity mix would likely involve increase in the use of gas in order to balance the system when renewable resources are not available. Finally, large employment in the mining sector may cause a substantial inertia of the transition.

On the other hand, the government expressed its clear intention to contribute to the global mitigation effort in the *National Development Plan* (Ministry of Regional Development, 2017) which defines the most important challenges and growth paths for Polish economy. We expect that in the first place this will be realized in the areas with substantial co-benefits for Polish economy and society. For instance, the *Plan for Development of the Electromobility in Poland* (Ministry of Energy, 2016) designs the strategy for the accelerated deployment of electric vehicles by 2025, which on the one hand increases the fuel efficiency of the transport sector and on the other hand reduces the dependence of the economy on the import of oil. Similarly, the government prepares a programme of support to combating air pollution from the residential sector through retrofitting schemes.

3. Coal transition scenarios

3.1. Quantitative Coal Scenarios

In this section we present projections of coal transition for Polish economy until 2050. We present two alternative scenarios: the baseline scenario and 2-degree scenario. Next, we discuss the current government policies and point at their similarities to our baseline scenario. Finally, we present the obstacles and opportunities in choosing the more ambitious scenario.

3.1.1. Current Baseline scenario

Methodology

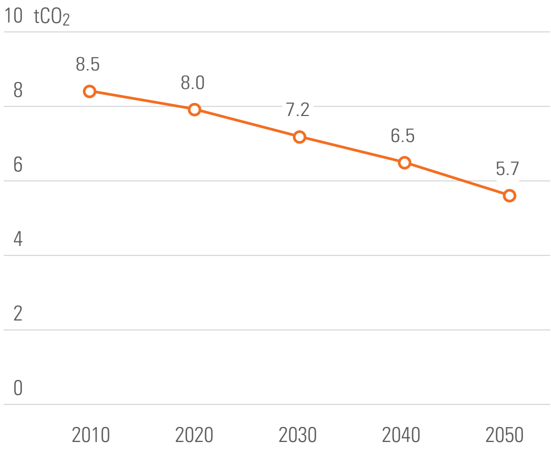
A basic problem with identifying a baseline scenario for Polish coal is the absence of a comprehensive and up-to-date plan with clearly spelled out implications for coal until 2050. In this light, we have decided to construct our own scenarios based on existing objectives in Poland and past governmental scenario development exercises which we discuss in the chapter 3.2. The “baseline scenario” is thus constructed using the business as usual scenario with low ETS prices and no targets for RES prepared in 2015 by Department of Strategic Analyses within the Polish Chancellery of the Prime Minister as well as historic long-term trends. The former source was used to construct the path of coal consumption in the power sector, which is the main source of emissions in Poland. The path of coal consumption in the residential sector is computed using long-term trends in the consumption of coal per unit of GDP. In the case of industry, the projections were made under the assumption that the path of coal consumption converges to the long-term trends in Germany.

An important assumption behind the scenario is a fast growth of energy efficiency until 2030. Improvement in the fuel efficiency of vehicles, retrofitting in the residential sector as well as the modernization of the industry allowed for a spectacular drop in energy consumption in 90s and this trend continued at the fast pace until now. The scenario which we present in this section examines what path of emission and energy consumption we could expect if this trend is continued.

Emissions and Energy

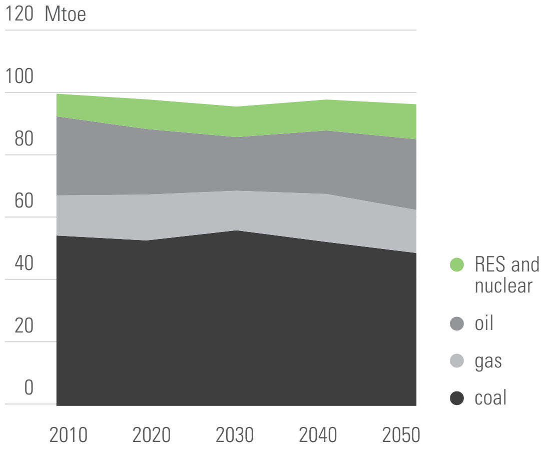
Despite a relatively optimistic increase in energy efficiency, the scenario suggests that the decline in emissions will be modest and delayed relative to the ambitious

Figure 8. CO_2 emissions per capita from fuel combustion



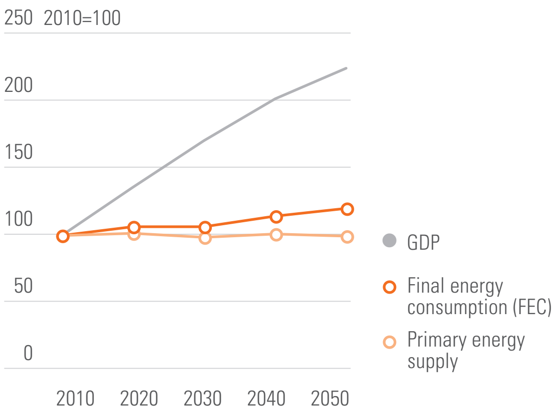
Source: Own calculations.

Figure 10. Total Primary Energy Supply by source



Source: Own calculations.

Figure 9. Final energy consumption and total primary energy supply



Source: Own calculations.

2-degree scenario which we present in the following section. Between 2010 and 2030 the amount of CO_2 emissions per capita will decline from 8.46 t to 7.23t. After 2030 the decline will accelerate to reach 6.54t in 2040 and 5.65t in 2050 (**Figure 8**)

According to the baseline scenario, final energy consumption will continue to increase from the current level of 2.9EJ to 3.1 EJ in 2030 and 3.5 EJ in 2050. The projections show that in 2050 it is going to be approximately 20% higher than in 2010. The growth rate of final energy consumption will be lower than the growth rate of GDP due to the substantial increase in energy efficiency which we have assumed in this scenario (**Figure 9**).

A different picture could be drawn for total primary energy supply. Due to an increase in the efficiency in the power sector we expect that between 2010 and 2050, TPES will stay at approximately constant level. In 2030 TPES will be 1% lower than in 2010. In 2050 TPES will be almost at the same level as in 2010. The decomposition of this path is presented in figure (**Figure 10**).

Coal Consumption

The scenario assumes that the reduction in consumption of coal will be relatively small. The use of coal in 2030 will be at almost the same level as in 2010 reaching 2.519 EJ (comparing to 2.553 in 2010). Only after this date, the decline will speed up. We expect the consumption at the level of 2.369EJ in 2040 and 2.210EJ in 2050.

The power sector

The slow decline in the consumption of coal until 2030 reflects the trends in the use of this fuel in the power sector. The projections suggest that the consumption of coal in power sector will increase by 5% between 2010 and 2030. In the following 20 year the use will be decrease by 11%. The decline will be enabled by two trends: a gradual phase-out of lignite and an increase in the efficiency in the new coal power plants. The electricity generated in the hard coal power plants will in fact increase substantially at the beginning of 2030s. (**Figure 11**).

The total electricity produced from coal will stay roughly constant. However, its share in electricity mix will decline due to an increase in the use of natural gas after 2030 and on-shore wind after 2045 (**Figure 11**). Importantly, this projection for coal use, does not include the possible construction of nuclear power plants. This a much discussed possibility in Poland, although the government have not reached conclusion on this yet.

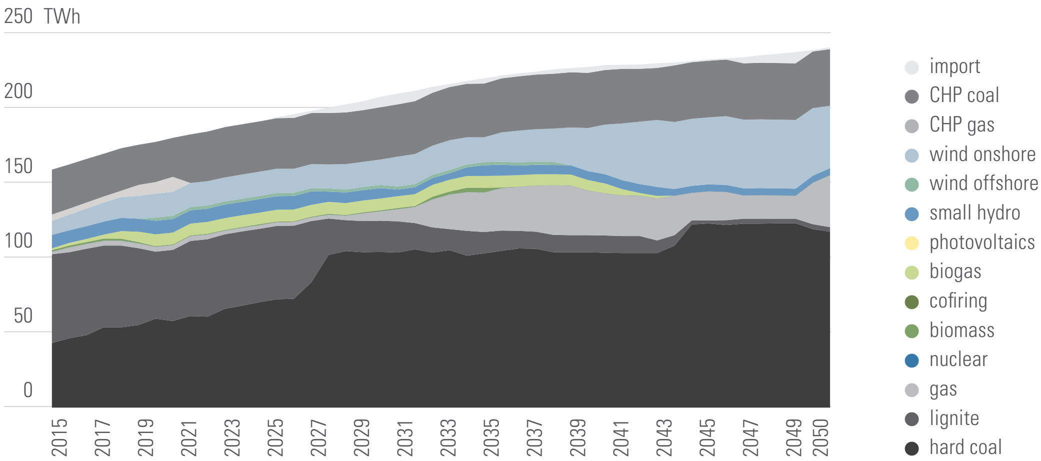
Industry and residential sector

In the case of residential sector, which is responsible for the second largest demand for coal after the power sector (**Figure 13**), the consumption in 2030 is projected to be 21% higher than in 2010. After 2030, the growth of energy efficiency will dominate the growth of GDP and the consumption of coal in the sector will drop.

Such a path of coal consumption requires a substantial energy efficiency improvement in the residential sector. Following historical trends in Germany, we assume that the use of coal per unit of GDP falls at the annual rate of 2% per year[9]. In practice keeping such rate of improvement would require the continuation of retrofitting of houses, continued improvement in the construction technologies for new houses as well as an increase in the efficiency of coal firing.

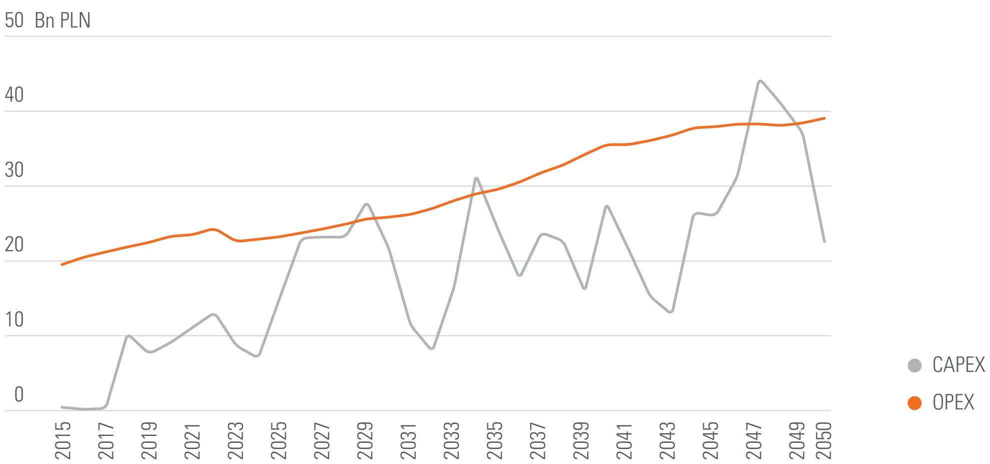
9 In Poland the rate of decline in consumption of coal per unit of GDP in the period 2004-2014 was 4%. In our view maintaining such a pace would be over optimistic. Thus, we decided to make a more conservative assumption that the future decline in Poland will be at the same rate as in Germany in the period 2004-2014.

Figure 11. Generation of electricity by source. The baseline scenario



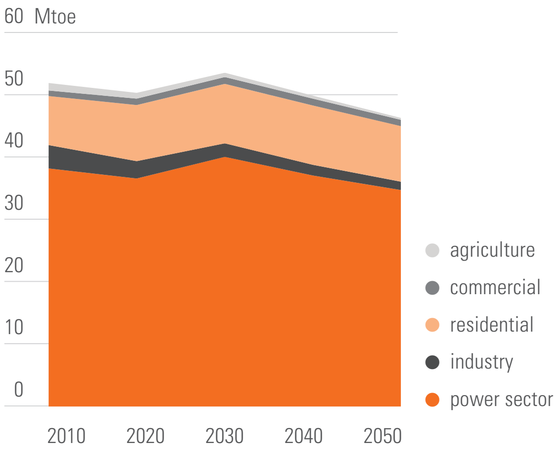
Source: Own calculations based on the baseline scenario of the optimal energy mix model (see section 3.1.1.)

Figure 12. The total costs of operation (OPEX) and investment (CAPEX) required for the power sector in the 2° scenario



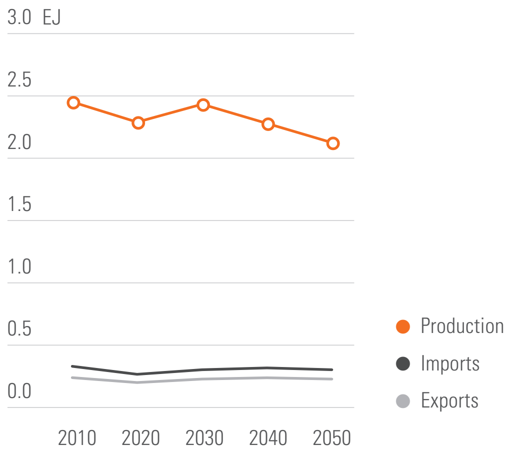
Source: Baseline scenario of the optimal energy mix model (see section 3.1.1.)

Figure 13. Coal consumption by sector (baseline scenario)



Source: Own calculations.

Figure 14. Projected production and trade of coal



Source: Own calculations.

The industry sector is projected to experience a 42% drop in the total consumption of coal between 2010 and 2030 and 64% between 2010 and 2050. The assumption behind this result is a steady progress at the technological frontier allowing for a reduction in the use of energy. Such improvement was evident in the recent history. For instance, in the period 2004-2014 the use of coal in German industry has dropped at the rate of 3% per annum even though the share of industry in GDP in the same period has increased[10].

Coal Production and Employment

Even in the relatively conservative projection of business as usual scenario, the changes in total primary consumption of coal will have significant consequences for the domestic production of the fuel in the second part of the analysed period. Between 2010 and 2030 total production would decrease from 2.462 EJ to 2.444 (a 1% decline). After 2030 it would drop to the level of 2.290 EJ in 2040 (-7% vs 2010) and 2.135 in 2050 (-35% vs 2010). Meanwhile import of coal will decrease insignificantly from 0.335 EJ in 2010 to 0.290 EJ in 2030 and decline to the quantity of 0.307 in 2050 (**Figure 14**).

Under the assumption of the constant growth in productivity in mining (1.4% per annum in years 2008-2015), the trends in the production will be amplified in the trends of employment associated with coal production. Employment in the coal mining, transport and process of coal will fall sharply from the level of 131 thousand in 2010 to 110 thousand in 2030. After 2030 we expect a further reduction: in the 2030s it will be reduced by 12 thousand and in 2040s by further 8 thousand. Nevertheless, even in 2050 it will remain at relatively high level of 81 thousand. The employment in the coal power sector will decrease from 29 thousand in 2010 to 23 thousand in 2030. Afterwards it will drop to 11 thousand in 2050. We discuss the trends and challenges associated with the reduction of employment in the mining sector in section 4.

3.1.2. <2°C-consistent coal transition scenarios and their implications for coal

Methodology

In the 2-degree scenario we assume the Polish economy goes through a deep decarbonisation in accordance with assumptions that were used under the Deep Decarbonisation Pathways Project (DDPP) tp develop global <2°C-compatible energy transition scenarios.[11] In this project, the range of emissions per capita among major economies worldwide was to achieve in 2050 roughly from 1 to 3 tonnes of CO_2 per capita. In our scenario for Poland, the CO_2 emissions per capita reaches in 2050 the level of 2.80 tonnes, which constitute a 67% reduction comparing to 2010. This is achieved with the adoption of the following measures:

10 According to the data in the World Bank database: https://data.worldbank.org/indicator/NV.IND.TOTL.ZS?locations=DE

11 The project was convened under the auspices of the Sustainable Development Solutions Network (SDSN) and the Institute for Sustainable Development and International Relations (IDDRI)

- A decarbonisation of the power sector through the replacement of coal with nuclear and renewables in the energy mix.
- Increase in efficiency of use of gas and coal in industry, residential and commercial sector
- Increase in the efficiency of electricity use in the economy
- Electrification of transport

The pathway of power sector decarbonisation has been computed using the *The Model of an Optimal Energy Mix for Poland by 2060* designed in the Department of Strategic Analysis, which is available for download (Chancellery of the Prime Minister, 2015). We have used the original structure of the model however we have introduced several important changes in the parametrization of the model: first, we have updated the costs of installations of solar PV and we assumed a relatively fast decline of its prices at the rate 8% per annum between 2017 and 2027 and 2% per annum between 2027 and 2050, second we assumed that the amount of gas which could be imported is constrained by 2 billion m3 per year and the total stock of home resource available for use in power sector is 63 billion m3. Third, we assumed that the annual growth of demand for electricity oscillates around the average of 1%. Fourth, we have assumed that bioenergy is emission free. Finally, we have assumed that the cap on emissions in the power sector decreases annually by 3.6 million t of CO_2 by 2030 and 2 million tonnes between 2030 and 2050.

Regarding the use of coal and gas in residential, commercial and industrial sector we assume that the efficiency use of these fuels (use per unit of GDP) follows the path or converges to the paths predicted for Germany in the DDP project[12].

Between 2020 and 2030 the use of oil per unit of GDP decreases at the rate of 4% per rate following the long-run trends. We assume that by 2030 there are not more possibilities to increase fuel efficiency of fuel vehicles. However, the consumption of oil keeps decreasing due to electrification of transport. We assume that this process allows to decrease the oil consumption by 70% between 2030 and 2050. Note that in Poland oil is used only in the transport sector.

High efficiency of electric engines implies that the amount of electricity required for electrification of road transport in Poland is not significant. According to the simulation in Barton *et al.*. (2013), in 2050 the fleet of 24.7 million electric vehicles would require 37TWh. If we assume the target of 500 vehicles per 1000 people and the electrification of the 70% of the fleet, the energy system in Poland would need to reserve 18.2TWh, i.e. 8.7% of electricity production in Poland in 2050.

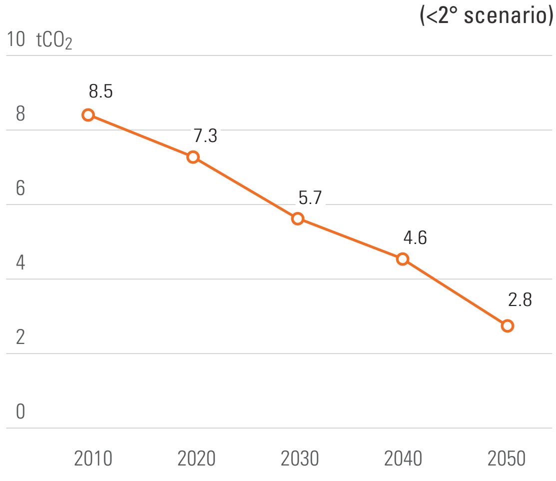
In the projection, the demand for electricity in 2050 excluding the amount of 18.2 TWh reserved for the road transport is 191 TWh. Between 2015 and 2050 the demand should increase at the annual rate of 0.5%. In the same period the expected annual growth of GDP is 2%. For the comparison, in the period between 2000 and 2010, the annual growth of demand for electricity and the annual growth of GDP was 1.4% and 3.6% respectively.

Emissions and Energy

The scenario projects a relatively fast decline of emissions. Between 2010 and 2020 the amount of CO_2 emissions per capita will decline from 8.46 t to 7.33t. After 2020 the decline will accelerate to reach 5.67t in 2030 and 2.80t in 2050 (**Figure 15**).

The projections for the scenario suggest that the final energy consumption will peak in 2020 reaching the value of 2.96, 1% larger than the value in 2010. After 2020 the

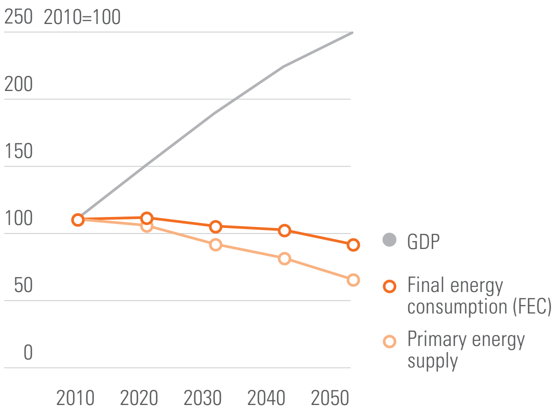
Figure 15. CO_2 emissions per capita from fuel combustion (<2° scenario)



Source: Own calculations.

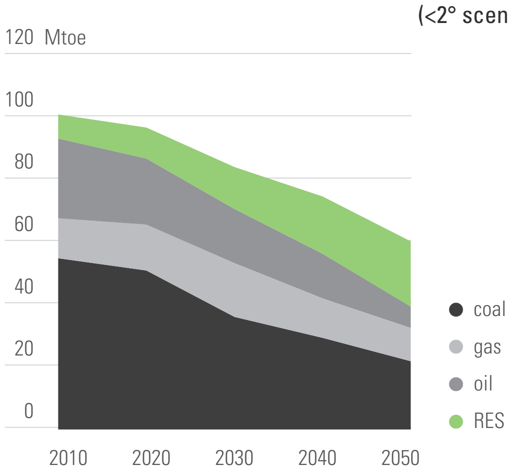
12 Specifically, we assume the following: (i) the reduction in the use of coal per unit of GDP in building takes place at the same rate as reduction of the use of fossil fuels per unit of GDP in buildings in German DDPP scenario, (ii) the reduction in the use of coal per unit of GDP in industry converges to the path of coal use per unit of GDP in industry in German DDPP scenario. (iii) the use of natural gas in the economy (excluding the power sector) per unit of GDP converges to the path predicted for Germany in DDPP scenario.

Figure 16. Final energy consumption and total primary energy supply



Source: Own calculations.

Figure 17. Total Primary Energy Supply the source (<2° scenario)



Source: Own calculations.

energy efficiency increase will offset the effect of growth in income and the demand for final energy will decline: in 2030 it will be at the level of 2.794EJ (5% lower than in 2010) and in 2050 at the level of 2.438EJ (17% lower than in 2010) (**Figure 16**). Notice a substantial difference between the 2-degrees and the above Baseline Scenario: in the latter we expect final energy consumption to increase continuously until 2050.

In the case of total primary energy supply we expect a moderate fall until 2020 (from 4.203EJ to 4.029EJ), which is achieved with an increase in the efficiency of generating electricity. After that date we expect a sharp decline between 2020 and 2040. In 2020s, total primary energy supply will fall by 13% to 3.500EJ. In 2030s we expect a further drop by 11% to the level of 3.107EJ. Over the entire period between 2010 and 2050, total primary energy supply will drop from 4.203EJ in 2010 to 2.508EJ in 2050, i.e. by 40%. The decomposition of this path is presented in **Figure 17**.

Evolution of coal demand

Regarding the consumption of coal, we expect the fast rate of change until 2030. In particular, while in the Baseline scenario the consumption of coal stayed constant in that period, in the 2-degrees scenario, the consumption decreases by 44% (from the level of 2.553EJ in 2010 to 1.432EJ in 2030). In 2030s the drop continues: in the decade the consumption falls by 22%, to the level of 1.115EJ in 2040. In 2050 the consumption of coal in Polish economy is expected to reach the level of 0.759EJ, which is less than one third of the consumption in 2010.

The result above is primarily driven by the path of consumption of bituminous coal. In 2010 the consumption of that type of coal was at the level of 1.735EJ. In 2030 we expect that its consumption will reach the level of 1.168EJ, that is 33% lower than in 2010. After 2030, it will decline to the level of 0.937EJ in 2040 and 0.651EJ in 2050, which is 62% below the level in 2010.

We expect also large changes in the consumption of lignite. The projection suggests that its use will drop from 0.484EJ in 2010 to 0.257EJ in 2020 and 0.062 in 2030. In 2040 we expect that the consumption of lignite will reach the level of 0.02EJ. In 2050 there will be no use of lignite in the 2-degrees scenario.

Power sector

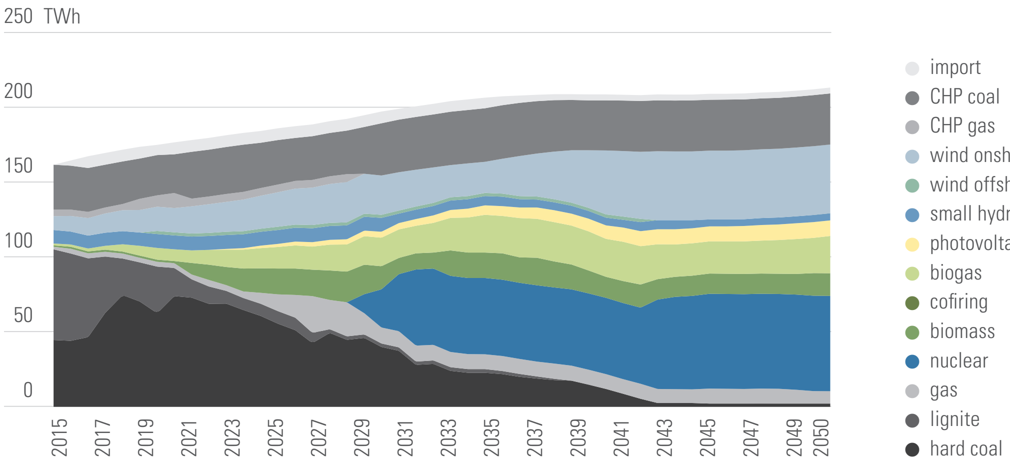
The coal consumption paths are to the large extent determined by the changes in the demand for coal in the power sector. The sector will witness a sharp reduction of the use of bituminous coal from 1.21EJ in 2010 to 0.81EJ in 2030 and then a further reduction to 0.72EJ in 2040 and 0.50EJ in 2050. Regarding the use of lignite, the power sector will reduce its consumption from the level of 0.48EJ in 2010 to 0.06EJ in2030. From 2040 its use in the power sector will be negligible.

As a result of these changes, the share of coal in Polish electricity mix will decline from 87% in 2010 to 41% in 2030 and 18% in 2050. As pictured in **Figure 18**, in the first phase (taking place in 2020s) coal will be replaced by gas, biomass and biogas. In the second phase (taking place in 2030s) it will be replaced by nuclear power plants and in the last phase (after 2040): by an increase in the capacity of onshore wind and solar power. The scenario assumes that between 2040 and 2050 30% coal power plants (2.25GW out of 7.50GW) will have installed CCS technology. If CCS technology is not available by that time, it could be replaced by negative emissions from new forests or further replacement of coal power plants with biomass plants.

The costs of operation (OPEX) and investment (CAPEX) required for the power sector in this scenario are shown in **Figure 19**. The costs do not include the costs of CCS installations. The figure suggests that most of the investment will take place in the period 2025-2030, i.e. during the period of the fastest drop in the use of coal in the power sector.

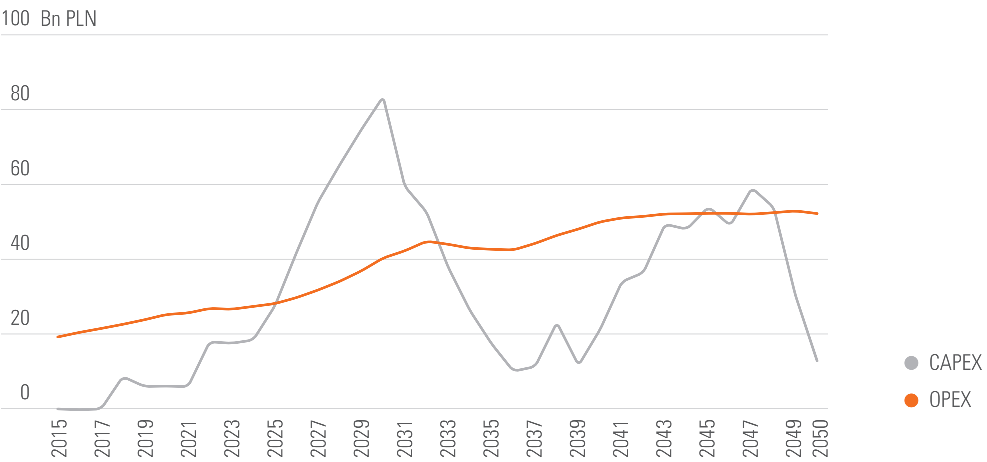
Coal power plants production capacity will drop significantly after 2020. In 2020s the capacity would be reduced by 39% from 28.250GW in 2020 to 17.273GW in 2030. In the following decade, the capacity would be reduced by further 27% reaching the level of 12.675GW in 2040. In 2050 the capacity of coal power plants will be at the level of 7.5GW.

Figure 18. The evolution of electricity mix under the 2° scenario



Source: Two degrees scenario of the optimal energy mix model (see section 3.1.1.)

Figure 19. The total costs of operation (OPEX) and investment (CAPEX) required for the power sector in the 2° scenario



Source: Two degrees scenario of the optimal energy mix model (see section 3.1.1.)

Box 2. Alternative 2 degrees scenario with the use of gas

Box on the alternative 2 degrees scenario with the use of gas

Gas as a transition fuel?

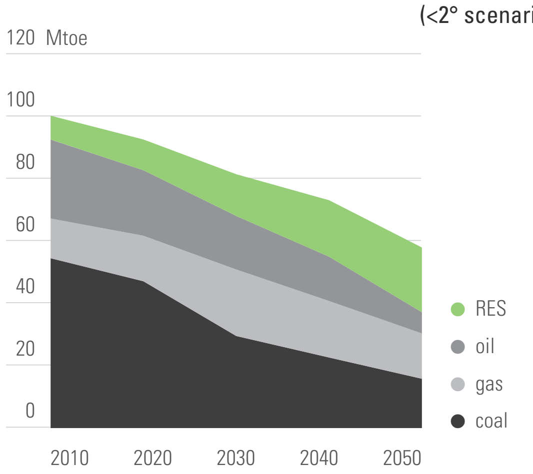
An alternative the evolution of energy mix may be sketched under the scenario which permits larger use of natural gas in the power. The scenario has been constructed using the *Model of an Optimal Energy Mix for Poland by 2060* by imposing the same constraints on the emissions from the power sector as in the 2 degrees scenario but relaxing the constraint on the import of gas. The projections for the electricity mix for this scenario are presented in **Figure 20** and the mix of fuels in the TPES (in the entire economy) is presented in **Figure 21**. The scenario is characterized with lower cost of the energy system than the two degrees scenario with limited use of has presented above, however the difference is not significant. The cumulated costs of investment and operation (including the costs of fuel) for the period 2015-2050 are only 1% lower in the two degrees scenario with gas.

An important disadvantage of the evolution in the scenario with gas is that for the same reduction in emissions, the scenario implies faster decline in coal production and hence employment in mining. Given the expected challenges of the transition, which we highlight in section 4, this may involve higher social cost.

Another obvious disadvantage is the dependency of imported fuel which limit energy security. Replacing the coal by gas as transition fuel have its limits due to political tensions with Russia – the main importer of gas to Poland, which in the past used this fuel as a tool of political pressure. Increase in imports of that fuel from other countries will have its economic limits as Russian gas is competitive in comparison to alternative produces such as US, Qatar or others.

The new investment in gas sector projects aim at increasing the capacity of LNG terminal from 5 to 7.5 billion cubic meters and construction of new routes of gas transport with southern neighbours. In the long run however, this will not suffice to cover the gas increasing demand, which - especially in the 2-degree scenario - fall on the period between 2025 and 2035. It will certainly not allow to replace gas imports from Russia with which Poland will renegotiate its current gas contract in 2022. In view of this process the current government is planning to build new gas pipeline (Baltic pipe) transporting gas from its Norwegian fields. The project would include

Figure 20. Total Primary Energy Supply by source (<2° scenario)



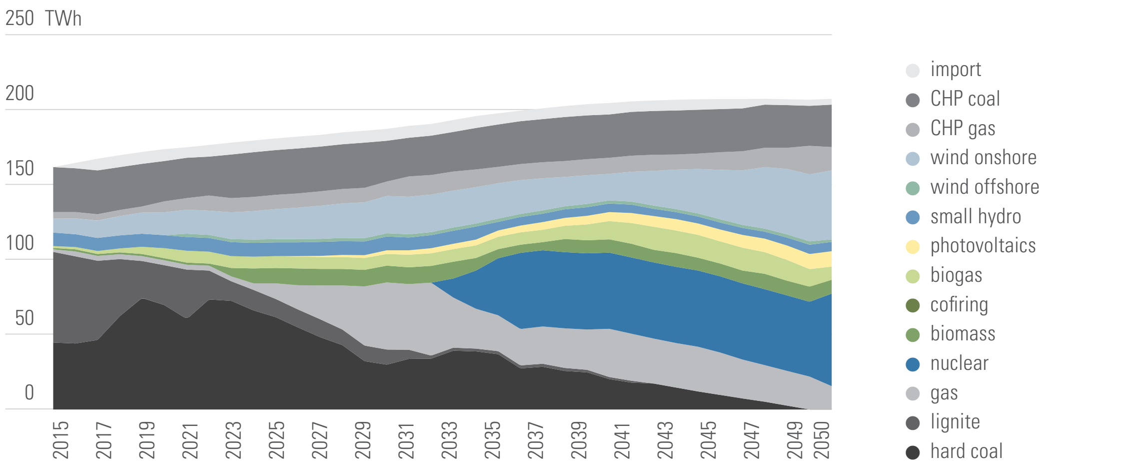
Source: Own calculations.

Denmark (as a recipient and transit country) and Sweden (only as a recipient) both receiving 3 billion cubic meters and Poland as a main recipient of 10 billion cubic meters. Even if price of supply through Baltic Pipe would be higher than of supplies from, the new pipeline would allow to put the upper limit on Russian gas price and in consequence reduce political vulnerability of this commodity in the Polish economy.

In the discussion on the future role of gas a concept of Poland being a gas hub appears. As some experts point out, Poland not only wishes to diversify its gas supply routes but also use it as a tool to play a bigger role as a provider of non-Russian gas in CEE. (Mihm, 2018) From the 2-degrees scenario it appears that the gas is the cheapest option in the period between 2025 -2035. In this period the import of gas would have to double. In that period Poland would not be able to play the role of hub as its domestic demand will be higher than imports through LNG terminal and Baltic pipe.

One should also note that technological progress in the future may bring possibilities to build stable Energy system which does not involve any use of natural gas. One such possibility is the power generation based on large share of intermittent Energy sources (solar and wind) and the use of hydrogen to store energy. Another possibility is the large deployment of offshore wind which is characterized with much larger stability relative to the other intermittent RES.

Figure 21. Evolution of the electricity mix under an alternative 2° scenario (high gas version)



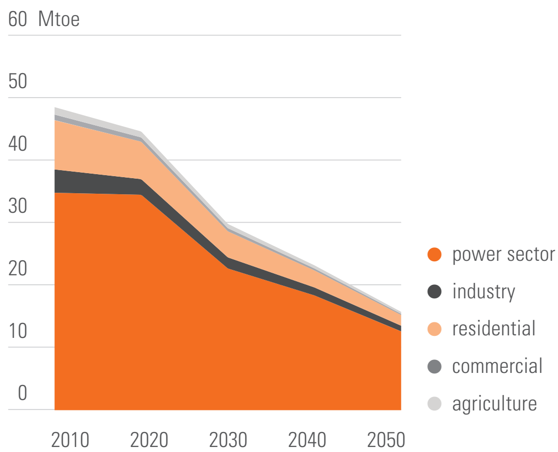
Source: Own calculations.

Residential and Industrial sectors

The residential sector, which currently uses twice as much coal as the industry sector, will witness slightly slower decline in the use of coal. In 2010 the residential sector used 0.368EJ. By 2030 this will be reduced by 24% and reach the level of 0.279EJ. The projections indicate that in 2050, the demand for coal would need to be around the level of 0.080, which is 59% below its level in 2030 and 78% below its level in 2010 (**Figure 20**). The decline in coal consumption could be achieved by a reduction in the demand for heat. The examples of measures enabling such reduction has been discussed in the report of the Deep Decarbonisation Pathways Project (DDPP) on Germany (Hillebrandt *et al.*, 2015) and include increased pace of the retrofitting of existing buildings, the adoption of technologies allowing for passive housing as well as energy saving behavioural changes.

The industry sector reduces its demand for coal from 0.157EJ in 2010 to 0.074EJ in 2030 and, further, to 0.038 in 2050. Within the industry sector, the steel sector alone will report a gradual drop in the use of the fuel. In 2010 its consumption of coal was at the level of 0.035EJ. In 2030 this will be reduced to the level of 0.017EJ. In 2050, the consumption will reach the level of 0.008EJ (**Figure 20**). The reduction could be achieved if Polish industry gradually adopts the energy-saving technologies developed and implemented in German industry under the DDPP scenario.

Figure 22. Coal consumption by sector



Source: Own calculations.

Coal Production and Employment

The decline in the total consumption of coal will have major implications for the domestic production. In 2010, the domestic mining sector supplied 2.462EJ of coal. The projections suggest that by 2030 this amount will be reduced to 1.383EJ in 2040, the production will fall to the level of 1.076. We expect that in the 2-degree scenario, the domestic production in 2050 will be at the level of 0.733, which is less than a half of the production in 2010. The reduction in consumption will affect also import. In the 2-degree scenario we anticipate a gradual reduction from 0.335EJ in 2010 to 0.198 in 2030 and 0.110 in 2050.

The drop in the production and use of coal will be reflected in the fall of demand for labour engaged in mining, transport and process of coal. In particular, the projection suggests that the number of employees in the relevant sectors will drop from 131 thousand in 2010 to 70 thousand in 2030 and 30 thousand in 2050. This implies that in 2050 the number of employees will be 52 thousand less in the two degrees scenario than in the baseline scenario. Similarly, the employment in the coal power sector will drop from 29 thousand in 2010 to 23 thousand in 2030 and 11 thousand in 2050.

3.2. Policy issues and options for implementing <2°C–compatible coal transition in Poland

3.2.1. Current governments' energy policy and implementing baseline scenario

Energy policy of the current government corresponds to the baseline scenario described above. The main goals of that policy are listed in the specific section of the *Strategy for Responsible Development* (SOR). The Strategy is the main, overarching governmental document adopted in 2017, planning the development of Poland until 2020 with an extension to 2030. The energy is regarded as one of the areas impacting the realisation of the main national development goals. Climate policy is regarded as important but external factor to which Poland needs to adapt. The section related to energy does not provide any qualitative scenario, nor it is explicitly based on any

Table 1. SOR priorities with related strategic projects and the state of their accomplishment

1) Improvement of the energy security

a) Capacity market
It was introduced in 2017 and is believed to support the oldest among the existing coal fired power plants but not to incentivise the investments in new power plants.

b) Polish Nuclear Power Program
Its implementation was assessed as delayed, and its content partly outdated. It is believed that with a quick decision of the government it is possible to build the first nuclear power plant after 2030.

c) Gas hub
The concept is being implemented but the main part of the project – new gas corridor from Norway is still in the phase of public consultation therefor its existence is still not sure.

2) Improvement of energy efficiency

a) Intelligent electricity networks
Implemented in various projects by energy companies supported by the government and structural fund. It is defined very broadly therefore it is difficult to assess its results.

3) Development of technology

a) Electromobility
A fast progress in regulatory framework is noted, but with the current coal-based energy mix it is expected to remain of limited impact on the CO_2 emission reduction. It will have positive impact on the reduction of oil import.

b) Geothermal
It is considered of a marginal potential and influence on the energy mix

c) Distributed energy
The project is under slow implementation as the regulatory framework limited its support for RES. According to the indicators 30 energy clusters or energy co-operatives should be created until 2020 and 300 until 2030.

d) Hydro
It is considered of a little influence on the energy mix

e) Innovation in hydrocarbon research and exploration
Early stage of the projects does not allow to clearly assess the possible impact on the future energy mix.

4) Restructuring of the hard coal mining

a) Restructuring of the hard coal mining through the program for the hard coal mining sector in Poland (Ministry of Energy, 2018a) and the program for the Silesia Region (Ministry of Regional Development, 2017)

Both programmes are rooted in the SOR and have been prepared, yet the main problems are not solved. The program for the hard coal mining assumes further public investments in the sector in order to restore its profitability and at the same time openly admits the limited capacity to assess economic value of coal reserves in Poland. The program for the Silesia region is unique in terms of central government involvement at the regional level in Poland. The rationale for the involvement is based on specific problems related to transformation from heavy industry, more specifically coal and metallurgy. It coordinates different initiatives but does not offer any additional financial resources.

modelling exercise. The separate governmental long-term strategy devoted specifically to the energy sector is missing since 2015.

There are four priorities in the section of SOR dedicated to energy: 1) improvement of the energy security; 2) improvement of the energy efficiency; 3) development of technology; 4) restructuring of the hard coal mining. Each of the priorities have its strategic projects of which some were already prepared, and some are still to be designed. The system of monitoring indicators is heterogeneous and does not cover equally all the priorities of the strategy for energy sector. In many aspects it covers the perspective until 2020 and awaits the EU to set the indicators on 2030.

3.2.2. Role of the main fuels in the future energy mix according to the government declarations and their limits

Coal as the main fuel until 2050?

According to the Polish Minister of Energy, the European Commission expects currently from Poland not more than ensuring that the share of coal in the electricity mix will not increase. The Minister foresees a possibility that coal in 2050 will be responsible for a half of electricity production. It means that the increasing electricity demand would be covered by non-coal sources and the investment in coal mining and coal-based energy sector would aim at sustaining the current level of production. (Błoński, 2017)

This is coherent with SOR, which underlined the need for implementation of two interventions reducing the cost of climate policy for the coal-based energy sector. Firstly, it is the capacity market mechanism adopted legally (with the acceptance of the European Commission) in 2018, in order to avoid capacity shortages. The mechanism supports particularly old coal-fired power plants which in the Polish energy system are usually providing the capacity reserves. Another mechanism is R&D investment program "200+" whose implementation starts in 2018. It aims at the modernisation of coal fired units of at least 200 MW, of a total capacity of around 10 GW. It is expected that the program will allow to increase their flexibility in power generation and thus will allow to prolong their availability for another 15-20 years before new energy technologies are going to replace the old power plants.[13]

The priority given to coal is confirmed in the Programme for the Hard Coal Mining until 2030, also recommended by SOR and adopted in the early 2018. The Programme presents three scenarios for the production of hard coal. The reference scenario to produce coal is similar to baseline scenario of this report as the production until 2030 continues at the current level. The production of coal in 2030 according to low and high scenarios differ from the reference scenario by around 20%. In each of the scenario production of coking coal remains constant until

13 With a budget of 200 million PLN it targets around 40 coal fired power plants

Box 3. Current investment plans in new hard coal mines and hard coal power plants

Four new coal-fired power units, which are recently built or are to be finished by 2019 will add almost 4 GW[2] to already existing 19 GW. Additional power unit of 1 GW capacity[3] is considered to be built and according to the Minister of Energy it would be the last facility of that kind. If the construction starts in 2018, the energy generation would start in 2024.

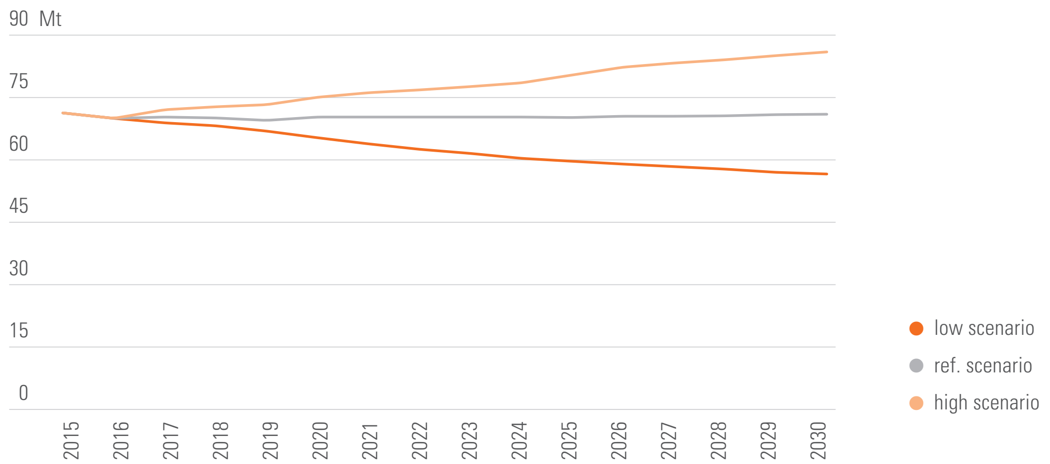
The youngest hard coal mine in Poland was built 25 years ago. The Polish government however, as part of plan for improving the economic performance of the coal mining sector, intends to undertake new investment[4] in re-opening the activity of two coal mines in the Upper Silesia. One aimed at exploration of coking coal and the second for thermal coal. With the necessary investment their production could start in 2030. In a longer perspective the government aims to open new prospective parts of deposits of better quality coal (thus more profitable), particularly of ortho-coking coal and anthracite.

2 One unit in Kozienice (1075 MW) owned by ENEA, two units in Opole (2 x 900 MW) owned by PGE and one unit in Jaworzno III 910 MW owned by Tauron.

3 Construction of a new coal-fired power unit for the Ostrołęka power plant (1000 MW) would be financed by ENERGA

4 To that end, within next 15 years, it will allow for deepening the current wells, building new ones or broadening the existing operating levels.

Figure. 23 Hard coal production (million tonnes)



Source: GWK

Note: figures include coal use for Combined Heat and Power Generation

2030 at the level of 13 million tonnes (Fig 21).

According to the draft programme for lignite mining, similarly to the hard coal sector reserves in currently active deposits are sufficient to explore them in the current volume until 2030. Without opening new deposits, lignite production after 2030 would significantly decrease during the 2030s and residual output would be stopped altogether around 2045. Opening new pits may prolong the period of lignite production beyond 2050. In the “baseline scenario” its production would be at the level of around 35 million tonnes in 2050 and in “development scenario” it would increase to almost 80 million tonnes. (Ministry of Energy, 2018b). However, there is significant debate about whether it will be politically and economically feasible to open new pits, given land-use competition, local community acceptance, regulatory risks for new lignite plant, carbon pricing and the relative costs of alternative energy sources.

It is often indicated that the coal is the only fossil fuel available in Poland which from geological perspective can cover the long term domestic energy demand. Impressive coal reserves which total 21 billion in case of hard coal and 1.4 billion of lignite however can hardly be taken as a point of discussion on the future of coal in Poland. As was mentioned earlier, the underestimated economics of mining is a serious deficiency of the current ground for policy decisions for the energy sector. Low profits from the mining sector for the state budget and at the same time the burdens related to the existence of the sector make it one of the least profitable compared to others.

Nuclear Power

According to the recent declaration of the Minister of Energy the overarching aim is to ensure 4.5-5 GW of nuclear power in the energy system which would cost the investors (presumably - Polish energy, mining and oil companies as well as the Polish Development Fund) 70-75 billion PLN (Krzyczkowski, 2018). The power plants could be built to begin operating by 2030 or shortly thereafter, should the final decisions be taken by the government soon.

The process of implementation of the Nuclear Power Programme is delayed for 10 years. As a report of the Supreme Audit Office (NIK) revealed recently that the delay in implementation of the Nuclear Program from the years 2014-2017 makes the completion of the project possible only after 2030. This delay may bring about additional costs for the budget related only to increased demand for CO_2 emissions permits estimated for 1.5 – 2.6 billion PLN (only in case the program will be ultimately implemented). (The Supreme Audit Office, 2018), Considering current delays and the complication of the similar processes which are observed in other countries the government would need to prepare a back-up strategy including replacement of nuclear with other energy sources.

Offshore wind

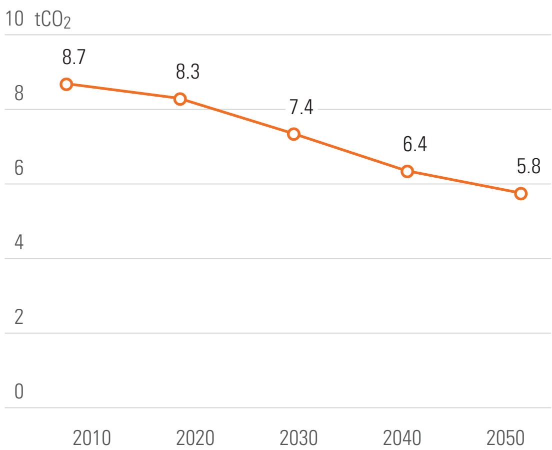
Offshore wind has been recently gaining its proponents among Polish energy companies. Although the Minister of Energy explicitly declared his preference to nuclear power (he regard offshore as a technology of a similar

Box 4. Energy transition scenario by the previous government draft programme - PEP 2050 (2015)

In face of missing quantitative scenarios of the energy policy of the current government, the baseline scenario composed in this report refers to the scenario from the draft of Polish Energy Policy issued in 2015 by the previous government. Despite the fact that it will not be adopted by the current government, it is currently the most comprehensive and relevant document offering the overview of the changes in the sector in view of 2050.

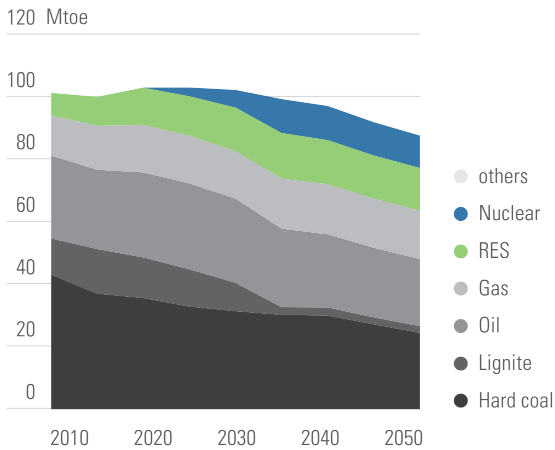
Our baseline scenario and PEP 2050 scenario correspond closely in terms of CO_2 emissions per capita which reaches respectively 5,7 and 5,8 tonnes per capita in 2050 (**Figure 8** and **Figure A**). The primary energy supply remains in both scenario, more or less, at the current level until 2040 and in case of the baseline it remains so even until 2050 (**Figure 10**). In the PEP 2050 scenario it drops after 2040 from the current level by around 10% to 88 Mtoe (**Figure B**). Unlike in the baseline scenario where coal remains at almost the same level until 2050 (**Figure 8**), the role of coal in the PEP 2050 scenario is dropping from 55 to 26 Mtoe (**Figure B**). Instead, the drop of oil and increase of RES in the latter scenario are slower which is the main reason for similar to the baseline scenario level of emissions.

Figure A. CO_2 emissions per capita from fuel combustion



Source: PEP 2050

Figure B. Total primary energy supply by fuel (Mtoe)



Source: PEP 2050

cost but providing less stable supply) it is not excluded that this investment could take place, especially in case of further delay of the Nuclear Program.

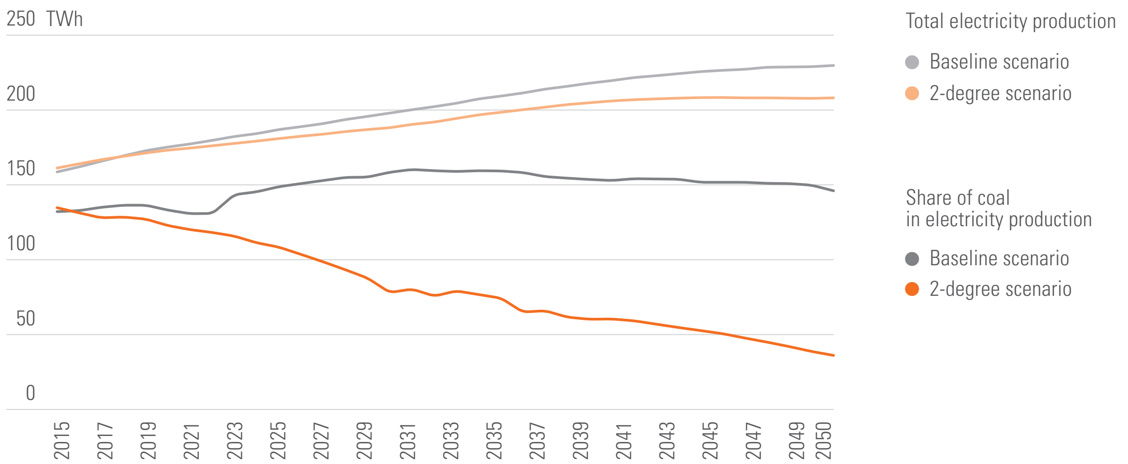
Polish energy companies are interested in offshore projects which could reach almost 5 GW before 2030 (Ciepiela, Chojnacki, 2018). The cost of investment is estimated currently for 12-14 billion PLN per 1 GW (which is lower than official estimations of the Ministry of Energy) and the market potential for the off-shore wind in Poland is between 8 and 10 GW. The first 4 GW could start operation between 2026 and 2030 and another 4 GW before 2035. It is estimated that they would operate 92% of the time during a year and 66% with their full capacity (Stryjecki, 2018).

3.2.3. Moving to 2-degree scenario

Implementing the 2-degree scenario is primarily a political decision which involves certain challenges. At the same time, implementing this scenario creates opportunities such as technological spill-overs, avoiding lock-ins related to coal technologies, avoiding large scale asset stranding, and enabling workers and communities to better prepare for the up-coming transition out of coal.

The role of coal in the electricity production in both scenarios differs substantially. In the baseline scenario the coal is responsible for 64% of electricity production whereas in 2-degree scenario it provides only 17% of the electricity. This is related only in a minor part to the fact of lower total energy demand in the 2-degreee scenario.

Figure 24. Share of coal in total electricity production in the baseline and 2-degree scenarios (TWh)



Source: The optimal energy mix model

The main difference is related to the pace of phase-out of coal in energy and in residential sectors.

Problems with economic efficiency of the coal mining sector, despite the current government policy may grow in a medium and long term. It is related with depletion of easily accessible reserves which leads to two problems - increasing depth of mines and horizontal growth of mines. High costs of new wells lead to increasing length of roadways which increases the time spent on transport and reduces time on coal production. Despite the fact that productivity per miner in longer term has been increasing the number of miners per long-wall has been systematically increasing.

Safeguarding the current coal-based structure of the energy system may also have negative consequences for the Polish energy security. If costs of extraction will increase and if the power sector is not vertically integrated with the mining sector or construction of new coal mines will not take place the power plants might switch to import of coal. This fact contradicts a main priority of Polish energy policy which is energy independence, particularly because coal is imported mainly from Russia which is also the main importer of gas and oil to Poland. The number of economic problems of mines is related also with employment and trade unions (Korski, 2016).

Gas may appear as a natural replacement of coal. From the 2-degrees scenario it appears that the gas competitiveness is the highest in the period between 2025 -2035. Relatively cheap, flexible (in terms of energy production) and less emitting fuel's weakness is its limited availability domestically. In this period the import of gas would have to double which is perfectly doable as currently the energy sector uses only a tiny fraction (around 1 billion m3) of the domestic gas consumption. According to the Ministry of Energy in 2035 Poland will be consuming 18-21 billion m^3 of which majority will be coming from other directions than Russia.

In the 2-degrees scenario the installed capacity in Nuclear power overpasses the current project for 6 GW. It means that the plan would have to be modified or supplemented by another form of reactors. The SOR did open a way for installation of high-temperature gas-cooled reactors (HTGR). According to the analysis of the governmental team of experts, the first installation for the chemical industry of 160 MWth would be possible in 2031. The larger scale for Small Modular Reactors is doubtful at this stage.

4. Labour market aspects of coal transition

Fulfilling the Paris Agreement will create a challenge of significant reduction of coal consumption in Poland in next decades. Additional pressure on coal transition arises from financial problems of collieries. The hard coal mining in Poland exhibits continuously low profitability due to high costs of production, especially personnel costs, and excess production, thus reduction in coal production and coal mining employment is needed to re-establish profitability of the sector. It seems that coal transition is inevitable.

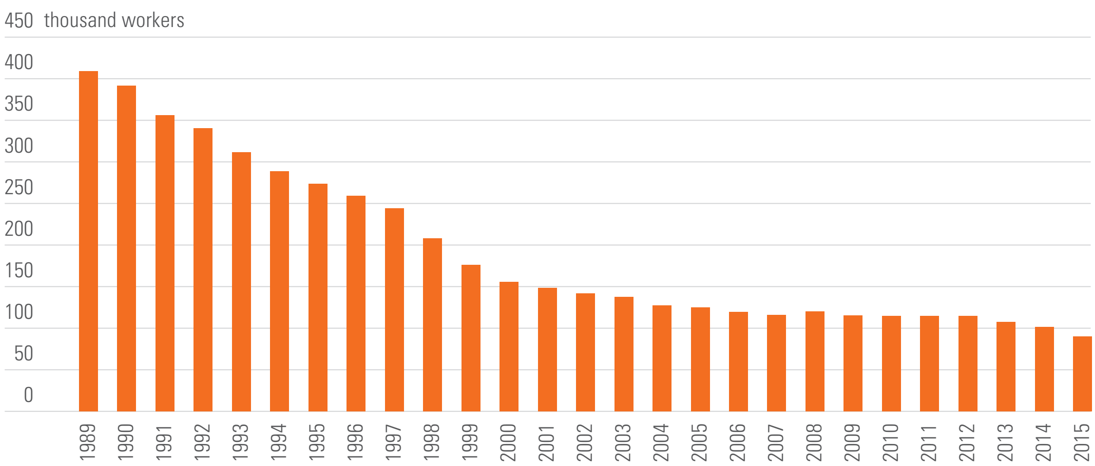
Coal miners are especially vulnerable to adverse impact of the coal transition. Due spatial concentration of hard coal mines the transition can bring about deep shock to local labour markets. On the other hand, the natural outflows from the sector due to employment aging pose an opportunity to reduce hard coal mining employment in a relatively harmless way. To provide socially viable and just coal transition it should be followed by public policy response. In the last section, we build recommendations for such policy response.

4.1. The deteriorating role of coal mining in Poland

After 1989, when Poland moved from a centrally planned to a market economy, the coal mining sector turned out to be unprofitable and highly inefficient. Coal production was excessively high whilst the quality of produced coal low and the cost of production high (Czerwińska 2002, Dubiński and Turek 2017). To manage the sector's poor situation, the government decided to close the least profitable mines and reduce employment. In the subsequent years, the sector followed gradual changes aimed at decreasing its excessive capacities and reducing high costs. Since 1990, the government has adopted several sectoral restructuring strategies. As a result, the number of active hard coal mines fell from 70 in 1990 to 30 in 2014. At the same time yearly production of hard coal decreased by half: from 147.7 million t to 73.3 million.

Although efficiency indicators improved and the average production per worker per day increased from 1.87 t in 1990 to 3.72 t in 2015 (Dubiński and Turek 2017), the production costs remained relatively high. The low competitiveness of hard coal production has been reflected in falling exports of Polish hard coal and rising imports from other countries. Falling coal prices further undermined the financial situation of the sector in recent years. Excess employment and high personnel costs have been the main factors frequently mentioned as obstacles to higher profitability of coal mines (Karbownik and Wodarski 2014). However, the reduction of personnel

Figure 25. Employment in hard coal mining, thousand workers, 1989-2015



Source: Bednorz 2015 (for 1989-2006), data from the Ministry of Economy and the Ministry of Energy for the rest.

Box 4. Unsuccessful coal transition in Wałbrzych region

Due to spatial concentration of hard coal mining, closure of collieries might have strong negative impact on a local labour market, especially when coinciding with other adverse factors. Such unfavourable situation occurred in Wałbrzych region and led to persistently increased unemployment rates and intensified social problems in the subsequent years. Wałbrzych coal region constituted one of three hard coal production regions in Poland.[5] All coal mines in the region were closed in the 1990s, and the last colliery was shut down in 2000. Closure of mines meant loss of 14 thousand jobs in coal mining sector. At the same time Wałbrzych region also experienced shot down of factories in other industries. Moreover, the closure of mines coincided with deterioration of general macroeconomic situation in Poland. With limited employment alternatives, it triggered high and persistent unemployment rate in the region and intensified social problem of exclusion. (Dołzłbasz 2012). Poverty led to occurrence of bootleg pits, i.e. illegal self-made coal pits characterised with high accident risk, of which the first occurred at the end of the 1990s. The bootleg pits were often made by ex-miners who were run out of money from redundancy payments and failed to find new employment (Lorenz 2016).[6]

5 Along with Upper Silesian region and Lublin region.

6 It was estimated that there around 300 workers in bootleg pits around 2004 (see Lorenz 2016).

costs is improbable due to collective wage agreements,[14] hence reduction by number of workers is virtually the only viable solution.

The other factors behind financial problems of the hard coal sector are: high fixed costs, excessive production and increased competition due to coal imports, mainly from Russia, which results in unsold production of low quality coal, and high production costs resulting from unfavourable geological characteristics of deposits, which are to worsen due to depleting of 'easier' deposits and need to start deeper pits (Kasztelewicz *et al.*. 2015). Since 1989 employment in the hard coal sector has decreased by over ¾. Employment was decreasing rapidly in the 1990s, but the changes decelerated later. In 1989-2000, employment in the hard coal mining fell by 60%, from 408 thousand to 155 thousand. In the 2000s the changes in hard coal employment were less significant. In recent years employment reduction has accelerated again. In 2015 the government adopted new restructuring programme for the hard coal mining sector. It re-established incentives to miners voluntarily leaving the sector and introduced ownership changes in the sector.[15] The employment in hard coal mining was 90 thousand people in 2015 (Ministry of Energy 2016). This translates into only 0.57% of total employment in the Polish economy. However, its role in employment in Slaskie voivodship is more pronounced since hard coal mining is strongly geographically concentrated in this region. The majority of active mines are located in Slaskie voivodship. Geographical concentration of mines is reflected in the employment structure. Slaskie voivodship homes 90% of hard coal mining employment. Within Slaskie voivodship, the share of hard coal in total employment is 4.9% (2014), but because of high degree of masculinisation of mining sector, the share of hard coal in male employment equals to 8.0%. The share of mining in region's total value added is 6.8% (2014).

Spatial concentration of hard coal mines in a limited area means that one region is to bear virtually all costs of phasing out from the hard coal mining. It may have

14 Lower personnel costs are a key factor behind higher profitability of private collieries compared to public controlled ones.

15 In 2016 the most profitable collieries from largest mining company, Kompania Węglowa (KW), were sold to newly-established Polska Grupa Górnicza (PGG). The rest of collieries were transferred to Spółka Restrukturyzacji Kopalń (SRK), which operates collieries intended to shut down. SRK manages also social assistance to miners leaving the sector. KW was liquidated in 2017. The ownership changes aimed at improving sector's profitability.

potentially detrimental effect on local labour markets. Moreover, the transition between sectors may face substantial frictions with miners being the most vulnerable to adverse impact of frictions. Their unfavourable situation arises from conjunction of several factors: low education attainments, narrow competences, large pay gap between mining and other sectors.

4.2. Low educational attainment among miners

Low average education levels worsen ex-miners' prospects in finding a new job outside the coal mining. Workers in the coal mining sector are less educated compared to an average in the Polish economy. The education structure in coal mining sector is as it follows: 16% of coal miners have tertiary education, 41% have secondary education, 37% have basic vocational education and 6% have primary education. In total working population the share of workers with tertiary education is over twice the share for the coal mining sector and the share of workers with basic vocational education, which is a type of lower secondary education with vocational training, is 16 pp. lower than in the coal mining sector. Nevertheless, the education structure in the mining sector strongly resembles the construction and manufacturing sectors. As a result of low skill level, the mining leavers are likely to face limited job offers on the broad labour market.

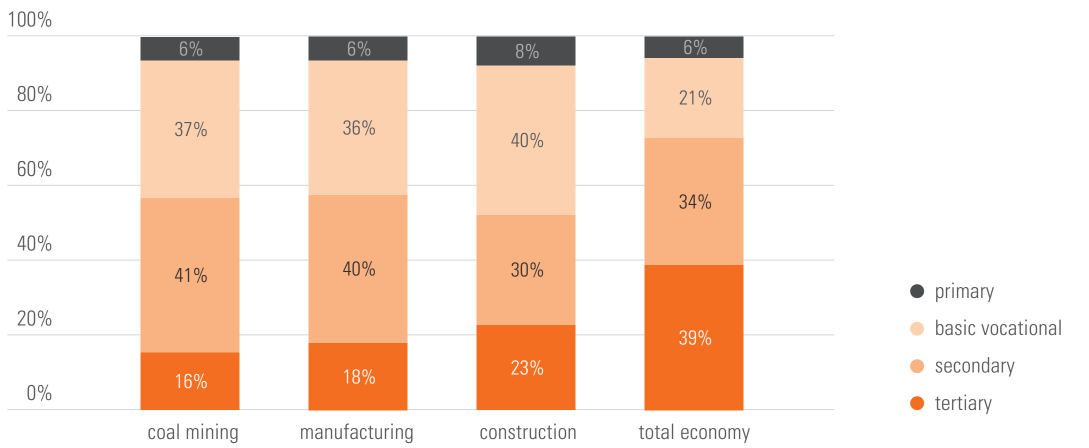
However, miners may find potentially productive employment in the sectors of manufacturing and construction sector. This is because of the relatively low education gap. In fact, the evaluation of the previous financial assistance provided to ex-miners showed that ex-miners often find new employment in occupations of low level of formal education, but usually requiring some specific competences. Individuals who found a job after retraining declared new employment in the following occupations: driver, builder, security worker, tradesman, entrepreneur, car mechanic, welder, plumber, warehouse worker, stoker, policeman, carpenter, locksmith (Turek and Karbownik 2005).

4.3. Wage premia and the lower retirement age in mining

The mining sector remains largely under state control. Most of coal mines are either directly public owned or indirectly state controlled, and private collieries play a negligible role in sector's employment. At the same time, coal mining is the most unionised sector of the Polish economy. In 2015, the unionisation rate of coal mining sector was 72% (Statistics Poland 2015), compared to only 11% of average for the total economy. Imbalance between the number of coal mining trade unions and their members compared to other sectors is likely to affect the imbalance in special measures which coal miners are able to protect.

Despite coal miners are low skilled, the earnings in the coal mining sector are much above the nationwide average. Workers in the hard coal and lignite mining sector experience significant wage premium compared to the

Figure 26. Educational structure of employment in coal mining sector and other sectors, 2014



Source: SES 2014.

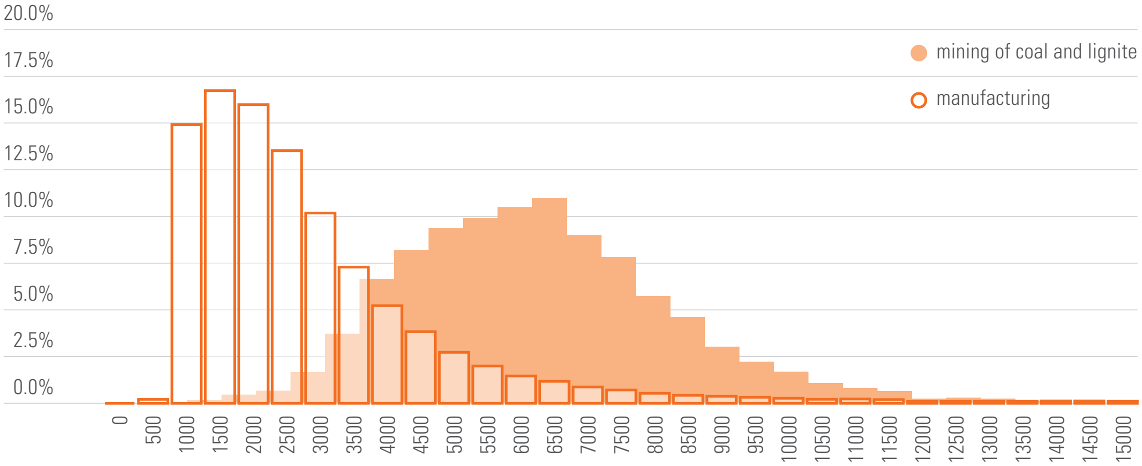
Table 2. Wage premium for working in coal mining vs. manufacturing obtained from wage regression

	Based on October earnings	Based on earnings for full year
Hard coal and lignite	2 412 PLN	3 114 PLN

Notes: Only firms with at least 10 workers employed. Monthly full-time equivalents. The control variables are: gender, age, age squared, specific tenure, specific tenure squared, education level, private/public sector, part time employment, 1-digit occupation group according to ISCO classification, voivodship.

Source: Own calculations based on Polish Structure of Earnings Survey 2014.

Figure 27. Distribution of monthly earnings in the hard coal and lignite sector and the manufacturing sector, 2014



Source: Authors' own elaboration on Structure of Earnings Survey data.

manufacturing sector. The average monthly wage in hard coal and lignite sector was 6559 PLN in 2014, whilst the average wage in manufacturing was 2907 PLN. When we control econometrically for other factors affecting wages such as age, tenure, gender, education etc., the adjusted wage premium between coal mining and manufacturing is between 2412 PLN - 3114 PLN. Large wage differentials make voluntary outflows from the coal mining sector unattractive, unless they are accompanied with financial compensation. Leavers from coal mining sector are likely to have higher wage expectations than other low skilled workers, what might be a factor contributing to prolonged unemployment spells.

In addition, the underground coal miners, which constitute on average 76% of workers in collieries, are covered with early retirement provisions. They can retire at age of 50 if they worked at least 25 years, including 15 years of working underground (which is the most dangerous and conducive form of mining to respiratory illness). This partly reflects compensation for a high risk associated with underground work and its negative impact on health.[16] If the number of years of working underground is 10 instead of 15, the retirement age is 55. The regular retirement age for males is 65, which means that underground miners can retire 15 years earlier than majority of men.[17] Current early retirement regulations were introduced in 2008 with the list of eligible occupations being significantly shortened.[18] Early retirement provisions constitute a strong motivation to stay employed in the mining sector at least to the moment of acquiring eligibility rights. After 15 years of working underground, an ex-miner can work in any other sector without losing the early retirement eligibility right. The early retirement is not obligatory after acquiring the full right.

16 For instance, coal miners at high risk of pneumoconiosis, which is the most common occupational disease among them. Each year there are on average 400 new cases of pneumoconiosis diagnosed among current and former miners (Wyższy Urząd Górniczy, 2017).

17 Although there are no available data on life expectancy for different occupations, it is fair to expect lower life expectancy of miners compared to other workers which is due to high accident risk and occupational disease risk associated with underground work.

18 Contrary to government's initial intent, underground miners secured early retirement after organising massive protests and strikes in 2005.

Table 3. Yearly outflows of workers in mining and manufacturing sector, 2002-2015 average

			Mining	Manufacturing
employment	→	employment(other sector)	1.4%	3.0%
employment	→	unemployment	0.6%	2.9%
employment	→	non-active	5.0%	3.0%
employment	→	employment (same sector)	92.9%	91.1%

Notes: Numbers do not cover people who stopped being observed in the panel. Only data for Slaskie, Malopolskie and Lubelskie voivodships are used.

Source: Own calculations based on Polish LFS data.

4.4. Inactivity among leavers from the mining sector

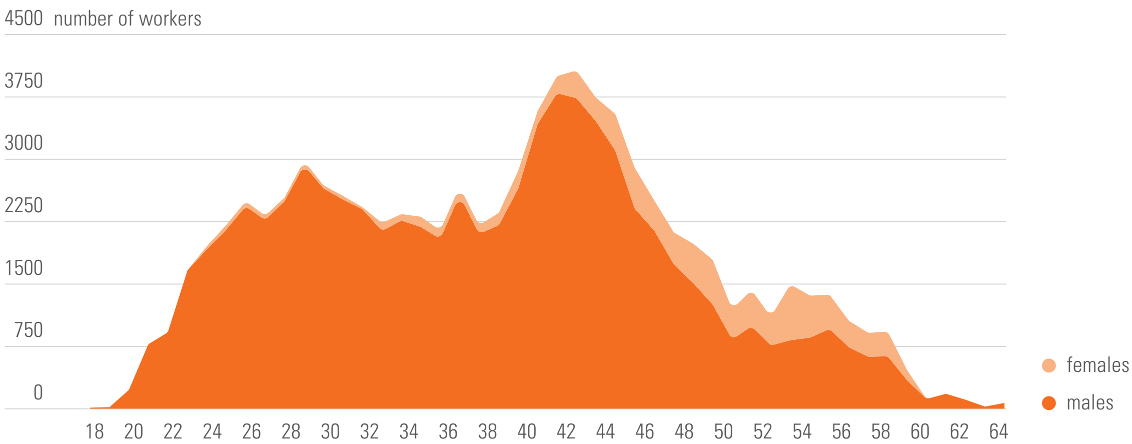
Workers in mining sector experience relatively high work stability. Labour Force Survey data show that if an individual leaves the mining sector, it is usually due to moving to inactivity (7 in 10 individuals leaving the sector).[19] 2 in 10 individuals finds a job in a different sector, whilst 1 in 10 becomes unemployed. It is in a stark contrast with the outflows from the manufacturing, for which each type of outflow (inactivity, unemployment or starting employment in a different sector) corresponds to roughly one-third. Hence, individuals leaving the mining sector are more likely to be in inactivity than in employment or unemployment compared to individuals leaving the manufacturing sector. High incidence of outflows to inactivity is mainly due to early retirement provisions for miners. A similar finding is shown in an official report on condition of the sector. Retirement is the most important reason behind the outflows from the mining sector. In 2013-2014, 17 thousand people left the hard coal mining sector, 80% of whom due to retirement (Ministry of Economy, 2015a).

19 The average for 2002-2015. The outflows are calculated on Labour Force Survey data. Due to lack of detailed data, the outflows are calculated for the whole mining sector in the regions with coal mines.

4.5. Ageing of coal mining employment

Figure 28 depicts detailed age structure of workers in the hard coal mining in 2014. The average age of workers was 39 years (with median age being 40 years). The age distribution reveals that a large share of workers were in the age of 40-45, constituting ¼ of employment in the hard coal mining. In the 2014 they were still below retirement age, but soon they will be eligible to early retirement age, at least some of them who have worked underground for sufficiently long period of time. Forthcoming result of aging process will be intensification of outflows from the hard coal mining (we discuss it

Figure 28. Detailed age structure of employment in hard coal mining, 2014



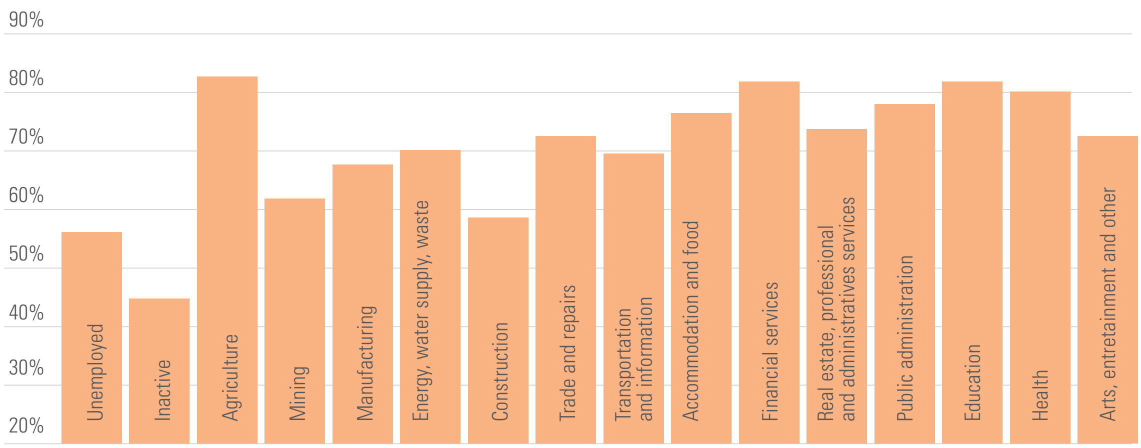
Source: Own elaboration based on Structure of Earnings Survey 2014.

further in the context of policy implications). In fact, it opens a window of opportunity for relatively harmless and significant reduction in employment in hard coal mining in the next decades.

4.6. Traditional roles in miners' families

Household situation is likely to affect miners' decisions on leaving the sector. Miners' households tend to follow one earner pattern more often than other types of workers' households. It is linked to still large popularity of traditional family roles in miners' households (Faliszek 2011). The employment rate of women whose husbands or partners work in the mining sector are below the employment rates of other partnered women. The employment rate of women with husbands or partners working in mining sector equals to 62% (LFS, 2007-2015 average). **Figure 5** shows that miners' households are more dependent on male earnings than other types of households. This finding has two implications. First of all, the miners might be more hesitant to leave the sector voluntarily, secondly, the joblessness among the ex-miners might significantly decrease the standard of living of the households.

Figure 29. Employment rate of partnered/married women according to men's sector, 2007-2016 average



Source: Own elaboration based on data from Polish LFS.

Notes: Only women aged 15-59.

5. Conclusions and further policy implications

Coal transition is an uneasy challenge for coal-dependent Polish economy. Meeting the objectives of the Paris Agreement will require ambitious reduction in coal consumption in next decades. According to the 2-degree scenario discussed in the previous part, the consumption of hard coal will have to fall by 33% by 2030, and by 62% by 2050, compared to the 2010 level. Polish energy sector depends mostly on domestic coal production, hence coal transition would significantly reduce number of jobs in coal mining. Those jobs are very well-remunerated as well as enjoy special retirement provisions and high degree of work stability. Although the coal mining employment plays a minor role in total employment nationwide, it still has a sizeable share in employment in Slaskie region. What is more, coal mining workers are rather low-skilled, and their families are more dependent on their work compared to other workers' households. All these mean that contraction of coal mining sector jobs could translate into a negative shock for a local labour market if not accompanied by proper public policy. Hence it is essential to identify key social aspects of coal transition and propose policies which would mitigate its adverse effects.

Preparing and managing the forthcoming coal transition is in the interests of stakeholders, especially workers and local authorities. Past experience shows, that significant employment reduction in coal mining, especially if it occurs quickly and is spatially concentrated, might bring about persistent hike in unemployment, create difficulties for managing the transition of workers into alternative jobs, raise the risk of creating inactive workers, and a higher risk of social exclusion for the ex-miners and their children. This is an important challenge, but the risks can be, at least, minimised with properly designed public policies. In this section we discuss policy implications for such policies based on findings from previous sections of this chapter.

Although the 2-degree scenario presented implies sizeable fall in demand for hard coal in the following decades, it does not necessarily require massive group layoffs in the hard coal mining sector. Significant employment reduction can be achieved by natural attrition and hiring freeze. The employment reduction that is faster than the natural attrition of workers will require either group layoffs or voluntary quits from the mining sector. However, the Mining Social Package, which assisted cuts in mining employment in 1998-2002, proved that significant employment reduction can be achieved solely via voluntary quits assisted with range of social instruments (see Szpor and Ziółkowska, 2017). Nevertheless, the assistance provided under the Mining Social Package focused extensively on financial measures, turned to be expensive (0.75% of GDP), and little effective in terms of keeping ex-miners at the labour market.

Financial support to miners who quit work in collieries is of course needed to compensate large pay gap between mining and other sectors. Without such compensation miners would be little willing to voluntarily give up employment in the sector. It also cushions a decline in standard of living of miners' households. However, when money is directly given to the ex-miners, there is no guarantee that it will be spent on skill building activities or starting own business. In fact, it was revealed that unconditional financial assistance under the MSP was often spent on consumption.

In the future coal transition, more attention should be paid to conditional financial support provided to ex-miners. The assistance may depend on subsequent labour market status. The ex-miners who stay employed after leaving the mining sector should be given higher financial compensation than ex-miners who fail to find a new job. For instance, the money could be paid in two turns. The first payment would be made just after leaving the mining sector. The second one would be made if an ex-miner found a new job and stayed employed for at least one year.

Conditionality of assistance would require changes in support measures. The two, which are currently in use, are: miners' leaves and redundancy payments. Neither of the two rewards being employed after leaving the mining sector. Ex-miners are given the same money regardless they work or not (the only requirement is that they cannot take up a job in another colliery). With high remuneration, equal to 75% of previous wage in case of

Recommendations for public policy to address labour-related aspects of coal mining transition

- to use a 'window of opportunity' for relatively harmless employment reduction which results from ageing of the mining workforce
- to guarantee that assistance measures encourage ex-miners to stay at the labour market
- to curb a number of students in mining classes
- to stimulate labour demand in coal mining areas, especially in manufacturing and construction
- to promote vocational training to ex-miners ending with formal certification
- enrolment into retraining and other forms of active labour market policies should be a default option to leavers from the mining sector who fail to find a new job
- to increase labour force participation of miners' wives
- to guarantee broad social consensus, including NGOs and local organizations, for the reforms to prevent halting due to political reasons

individuals using miners' leaves, they are likely to give up searching for a new job. This situation is the worst of all: it generates substantial burden for public finance and reduces the labour force at once.

Śląskie region, which homes majority of active coal mines in Poland and is going to carry the greatest burden of coal transition. There is a need of invigorating creation of new jobs in coal mining areas to build region's resilience to adverse effects of coal transition. Due to spatial concentration of hard coal mining, closure of collieries might have a strong negative impact on local labour markets with outcomes such as persistently increased unemployment rates and intensification of social exclusion. To counteract consequences of mine closure the public authorities should consider demand-side measures stimulating number of jobs in affected regions. Establishing (or enlarging already existing) special economic zones, promoting foreign direct investments, giving local authorities means to transform former mining sites are examples of such measures. However previous experience in using them gave rather unsatisfactory results because of time and size discrepancy. It suggests that stimulation of creation of new jobs, when coal transition is already ongoing, might be too late to prevent intensification of social problems. Hence, the government should think in advance how to build resilience of local economies by creating new pathways of development in the region. This process is always long, for instance, it took decades for Ruhr region to develop alternative pathways of development (Campbell and Coenen, 2017). Slaskie is in the mid of this way.

Retaining strong position of manufacturing sector can help in coal transition at regional level. Low education level and narrow specific competences of ex-miners reduce the range of job offers suitable for them. Manufacturing is the sector of similar skill demand as mining sector, and hence it poses a plausible destination of leavers from the coal mining sector. The subregions of Slaskie region which have maintained a strong position of manufacturing sector, especially automotive industry, exhibit apparently better labour market situation than the other. Although the whole region is relatively small in terms of territory, there are large differences in local labour market situation across subregions. To some extent it is the result of limited mobility of workers. Hence, it is recommended that stimulation of creation of new jobs in manufacturing should focus mainly on the mining areas which underperform in terms of labour market situation, to provide that all subregions face similar opportunities to counteract negative effects of coal transition.

Current national-level challenge about improving energy efficiency poses a chance of creation of new jobs in construction sector. Air pollution and energy poverty have recently placed themselves in the centre of public debate in Poland with energy retrofitting of residential buildings as a proposed solution. Besides manufacturing, construction is also plausible destination for the leavers from the coal mining sector. Construction sector and coal mining sector share two similarities: very similar skill structure and high degree of masculinisation. In fact, builders are already a popular occupation among the ex-miners. Implementation of a massive energy retrofitting programme would create up to 100 thousand new jobs country-wide (Lewandowski *et al.*. 2018).

Although manufacturing and construction sectors offer jobs of similar skill level as coal mining, the ex-miners who take up jobs in these sectors (as well as in other sectors) would still require some retraining. Hence, equipping ex-miners with new skills should be an important element of public intervention aiming at mitigation of adverse impact of coal mining employment reduction. The retraining should be preceded by identification of worker's skill shortages and skill advantages. Such individual skill diagnosis would enable to offer tailor-made retraining addressing specific skill shortages on one hand, and further developing strong competences on the other. If it is possible, possessed competences should be verified and formally certified to make them recognised on the broad labour market. Close cooperation between collieries, public employment services and new employers is recommended to smoothen transition to new jobs. Job placements with on-job training might be effective in this context. The authorities could subsidise job placements to make employers more interested in hiring ex-miners.

Ex-miners face weak incentives to acquire new skills on their own and relatively high risk of prolonged unemployment, which can turn into a problem of workers' 'discouragement' and an early labour force exit. Several factors contribute to this: miners' little experience in searching jobs, generous 'golden handshakes' given to individuals leaving the mining sector, and prospects of early retirement. From a societal perspective, it would mean underutilisation of workforce and a welfare loss. Hence, it is important that the authorities take an active role in promoting retraining and other forms of active labour market policies among ex-miners who fail to find a new job immediately after leaving collieries. Enrolment into such measures should be a default option, especially for those who are much before retirement age.

The political aspect of coal mining reduction is also important. Unlike other industrial sectors, the coal mining is heavily unionised as well as remains under state control. These two factors combined makes the government decisions more vulnerable to political context which may not serve to find solutions for economic and social problems. Hence it is important that reforms are agreed not only by social partners, but they also include local governments, and civil society organisations, especially these which are working with local communities.

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COAL TRANSITIONS: RESEARCH AND DIALOGUE ON THE FUTURE OF COAL

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