TRANSrisk
TRANSITION PATHWAYS AND RISK ANALYSIS FOR CLIMATE CHANGE POLICIES

TRANSITIONS PATHWAYS AND RISK ANALYSIS FOR CLIMATE CHANGE MITIGATION AND ADAPTATION STRATEGIES

D3.2 Context of 15 case studies:

Poland: Coal and Renewable Energy Sources

Project Coordinator: SPRU, Science Policy Research Unit, (UoS) University of Sussex

Work Package 3 Leader Organisation: SPRU

Contributing organisation and authors: Institute for Structural Research: Marek Antosiewicz, Jakub Sawulski, Aleksander Szpor and Jan Witajewski-Baltvilks

November 2016

TRANSrisk

Transitions pathways and risk analysis for climate change mitigation and adaptation strategies

GA#: 642260

Funding type: RIA

Deliverable number (relative in WP)	D3.2
Deliverable name:	D3.2 Context of 15 case studies
WP / WP number:	3
Delivery due date:	November 2016
Actual date of submission:	
Dissemination level:	
Lead beneficiary:	SPRU
Responsible scientist/administrator:	Jenny Lieu
Contributor(s):	Institute for Structural Research: Marek Antosiewicz, Jakub Sawulski, Aleksander Szpor and Jan Witajewski-Baltvilks
Estimated effort contributor(s) (PM):	6
Internal reviewer:	ETH Zurich

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1 COUNTRY CASE STUDIES OF THE HUMAN INNOVATION SYSTEM (HIS): THE ENABLING ENVIRONMENT FOR SUSTAINABILITY

The most recent wave of the World Value Survey revealed that Poles declare they care more about the environment than Germans or Swedes. At the same time, most of the respondents in Poland still believe that protecting jobs and economic growth should be the top priority, even if the environment suffers to some extent. The subsequent governments in Poland (including the current government) seem to respect these preferences and, fearing that a low-carbon transition can cause damage to the heavily coal-dependent economy, have traditionally contested all the major steps of the European Commission to adopt more ambitious climate goals. This line has found support from some of the most influential stakeholders in Poland - trade unions and the association of employees.

The stance of Polish stakeholders might appear obsolete, but disregarding their argument would be a dangerous mistake. Constructive dialogue as well as the design of policies that could mitigate the negative effects of low-carbon transition requires understanding their logic. In the Polish case study, we wish to systematise and analyse their arguments using both quantitative and qualitative models (models to be discussed in deliverable D3.3).

At the same time, we wish to study the arguments by those who view the transition towards a low-carbon economy as an opportunity rather than a negative risk for the Polish economy. In particular, we want to explore under what conditions Poland can deploy more low-carbon technologies in the energy sector and what are the potential benefits of such change.

1.1 Research questions for the Polish case study

The overarching research question for the Polish case study is:

How can Poland move towards a more efficient use of energy resources to support sustainable economic growth?

I. What are the risks and opportunities associated with available decarbonisation options (clean coal and renewable energy sources) in the Polish context?
   a. What are the consequences of switching from a coal dominant economy for the labour market, innovativeness, short and long-run economic growth in the time frame: 2050 (study supported with the MEMO model)?
   b. What is the 'optimal mix' of clean energy sources (considering Poland's priorities), what are the costs/options for the integration of these technologies in the energy system (study supported with the Calliope model)?

II. How should the transitions be fostered?
   a. How do current policies shape the future of black and green of electricity generation technologies?
   b. How should these policies be adjusted to foster sustainable economic growth?
   c. What institutional lock-ins could block the transition?
   d. What are the 'optimal policies' when the institutional barriers are taken into account'?

1.2 Introduction to the general context

1.2.1 Policy overview

In the ratification of the Kyoto Protocol, Poland declared that by 2012, it will reduce CO_2 emissions by 6% with respect to the base year 1989. In fact, during the period 1989-2012 Poland cut the emission by 32% (Nowicki, 2010), largely due to the modernisation effect (e.g. shutting down inefficient industries) along the transition to free market economy. The new targets for Poland were agreed at the EU level and comply with the all-EU 20-20-20 target announced by the European Commission. In particular, by 2020 Poland is expected to achieve (Główny Urząd Statystyczny, n.d.):

- 15.5% share of renewable energy
- The total primary energy supply not exceeding 95 Mtoe (Million tonnes of oil equivalent)

Sectors covered with the EU-ETS (emissions trading) system face the common ETS target of 21% lower emissions by 2020 (relative to the 2005 base year). The sectors in Poland which are not part of the ETS are allowed to increase emissions by 14% (Ministerstwo Rozwoju Regionalnego, 2012).

The new EU strategy for years 2020-2030 is currently a subject of consultation between the European Commission and member states. The proposal from summer 2016 assumes that ETS sectors in Poland will be obliged to reduce emissions by 43% in the entire ETS system. To mitigate the potential negative effect on the Polish energy sector, a fraction of the allowances will be distributed for free. Sectors which are not covered by the ETS systems are expected to achieve a 7% cut in emissions (Słojewska, 2016).

The detailed energy development plan is still in preparation. The draft version of the plan has been published by the previous government in summer 2015. Soon after the elections in autumn 2015, the current government announced that it plans to update the document (Derski, 2016). Similarly, in August 2015 the former government presented the draft of the National Plan for the Development of Low-Emission Economy. The new government has not set any agenda for the publication of the plan (idem).

Until the detailed plan is published, the primary source indicating the general directions for the energy and environmental systems are sketched in the Strategy for Responsible Development (Ministerstwo Rozwoju, 2016) presented by the government in summer 2016.

In the chapter dedicated to the environment, the Strategy for Responsible Development puts equal emphasis on global climate changes, air, water and soil pollution, droughts, biodiversity, reduction in level of noise, landscape and minerals, and waste management. Nevertheless, while the plan states the detailed targets for the indicators related to air pollution and recycling, it does not state (or quote) any targets related to GHG reductions. The plan indicates that the national GHG reductions are determined by the EU-level policies. An important part of the plan is a set of programmes aimed at the reduction of emissions originating from buildings and transport, which are not included in the EU-ETS system.

In the chapter dedicated to Energy, the document highlights three key elements of the energy sector reform: modernisation, diversification and allowing for decentralisation of energy sources. In particular, the plan indicates the need for:

- Encouraging investment in conventional energy sources;
- Use of stable Renewable Energy Sources (mention of hydro and biomass);
- Support for cogeneration;
- Adoption of nuclear technologies;
- Support for low-carbon transport;
- Investment in energy-saving technologies (such as retrofitting, development of heating networks);
- Search for hydrocarbons on the territory of Poland; and
- Support of renewable energy sources for local communities.

In the chapter related to industrialisation, the plan mentions Renewable Energy Sources (RES) as prospective technologies which can become one of the elements of the reindustrialisation strategy.

Perhaps most importantly, one shall pay attention to the potential consequences of the general directions of the Polish economy recommended by the plan for climate change and GHG emissions. The two central themes of the plan are the industrialisation and the adoption of advanced technologies. The assumed increase in efficiency should reduce the dependence of the entire economy on conventional energy sources (e.g. adoption of robots will reduce energy use in plants). But the effect on total emissions will depend on the size of the rebound effect.

1.2.2 Natural resources and environmental priorities

Primary energy

As indicated in Table 1 and in **Figure** 1, more than half of the current Total Primary Energy Supply (TPES) originates from coal. The other important fuels are oil (almost a quarter of TPES), natural gas (>14%), biofuels (~9%) and other renewables (~1%). Poland has few hydro power plants (0.2% in TPES) and no nuclear power plants. The government intends to construct a nuclear power plant; however, this is not likely to happen in the 2030 horizon.

The previous governments and the current government have been hesitating to limit the role of coal in Polish energy mix because they consider it a cornerstone of Polish energy security (Ministerstwo Rozwoju, 2016). The other important reasons are the large number of unskilled workers in the mining sector and the experience of low rates of workers' transition between sectors in Poland in 90s (Tyrowicz & van der Velde, 2014).

Table 1: Total primary energy supply (total and indigenous) in Poland in 2014

	Absolute [ktoe]	Share in TPES (%)
coal	49313	52,4
crude oil	21994	23,4
natural gas	13401	14,2
nuclear	0	0,0
hydro	188	0,2
geothermal, solar and other RES	698	0,7
biofuels and waste	8218	8,7
other	215	0,2
total	94027	100,0

Source: International Energy Agency (2016)

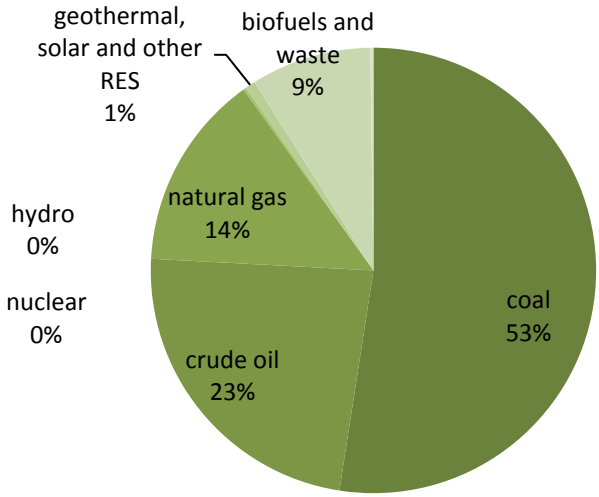


Figure 1: Total Primary Energy Supply in Poland in 2014

Source: Internation Energy Agency (2016)

Almost all oil and 72% of natural gas are imported, mostly from Russia. In the first days of January 2006, after a dispute between Russia and Ukraine, the supply of natural gas to Poland fell unexpectedly by 14% (Stern, 2006). On 6th January 2009 the supply of gas from Russia through Ukraine was completely stopped (although this was compensated by the supply of Gazprom gas through Belarus) (TVPinfo, 2009). The use of the price of natural gas by Russian government as a tool to exert political pressure on Ukrainian and Georgian governments[1] raise the concerns of Polish stakeholders and motivates all subsequent governments to reduce the role of the imported fuels in the Polish energy mix.

The share of renewable energy sources has increased rapidly over the last years, particularly due to increased share of biomass and on-shore wind turbines. However, the growth of the latter will likely decelerate in the coming years due to the introduction of policies limiting the space available for the construction of turbines. In addition, according to industry experts, the best locations for RES installations have been already taken - the characteristics of the locations available for future installations will be less favourable for electricity generation (Interviewee [4], see Table 7: Stakeholder engagement for interviewee details). This will exert a negative force on the productivity of RES in the future.

The government fears that reliance on intermittent renewable energy sources can limit energy security. According to the Minister of Energy, intermittency of RES limits the lifetime of the coal-

[1] Ukraine: see (TVPinfo, 2009), Georgia: see (Financial Times, 2006)

power plants inducing financial losses for the conventional energy sector. Coal-fired power plants could be replaced with gas power plants, which are well suited to balance the intermittency of RES (Elliott, 2016 and Baranes, et al., 2014) but would result in higher reliance on import of energy fuels. In the Strategy for Responsible Development, the government has explicitly stated that the renewable energy source will receive support as long as their intermittency is limited (Ministerstwo Rozwoju, 2016). The prospective role of non-intermittent energy sources, particularly biogas and biofuels has been also noted by interviewee [6] and by the Minister of Energy (Tchórzewski, 2016c).

Electricity

The primary source for electricity generation in Poland is coal (82.7%), as noted in **Table** 2. The second important source is biofuel (6.3%) followed by wind (4.8%). Oil and gas are used to produce less than 5% of total electricity generation.

Table 2: Gross production of electricity from various energy commodities in Poland in 2014

	GWh	%
coal	131551	82.7
oil	1594	1.0
gas	5328	3.3
biofuels	9977	6.3
waste	50	0.0
nuclear	0	0.0
hydro	2734	1.7
solar PV	7	0.0
wind	7676	4.8
other sources	142	0.1
total	159059	100.0

Source: International Energy Agency (2016)

The electricity generation system requires major modernisation. According to the Strategy for Responsible Development, 59% of the generation equipment (turbines) are over 30 years old. 16% of the equipment is over 40 years old. Four large blocks for coal-fired plants (around 900-1000MW each) are currently under construction. Several other projects are in the planning phase[2]. The Ministry of Energy notes that the new power plants are characterised with 47% efficiency (compared to the 30% of efficiency in the old power plants) (Tchórzewski, 2016a). This implies that the replacement of old coal power plants with the new ones reduces the coal consumption and CO_2 emissions by 36%.

In addition, as mentioned in section 1.2.1, the government aims to modernise the energy system by adopting stable RES, construction of nuclear power plants, modernisation of the transmitting system and supporting the cogeneration of electric energy and heat (Ministerstwo Rozwoju, 2016).

Energy-use

The total energy consumption has stabilized since 2002 at the level of around 65 Mtoe and in 2014 it amounted to 65.3 Mtoe as shown in Table 3. Residential sector is responsible for the largest portion of energy consumption (29%), as presented also in Figure 2. 24% is consumed within the transportation sector and 21% is consumed by the industry. The commercial and public services were responsible for ~12% of the total energy consumption.

[2] The complete map and description of the projects can be found on: http://www.rynek-energii-elektrycznej.cire.pl/st,33,335,tr,145,0,0,0,0,0,budowane-i-planowane-elektrownie.html

Table 3: Consumption of energy per sectors in Poland in 2014

	absolute [ktoe]	share [%]
industry	14166	21.7
transport	15639	24.0
residential	18945	29.0
commercial and public services	7795	11.9
agriculture	3401	5.2
other	5324	8.2
total final consumption	65271	100.0

Source: International Energy Agency (2016)

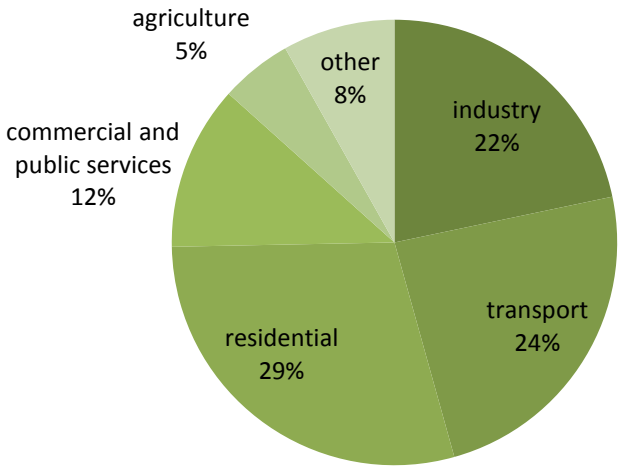


Figure 2: Consumpton of Final Energy by sector in Poland in 2014

Source: International Energy Agency (2016)

Carbon emission per capita and by sector

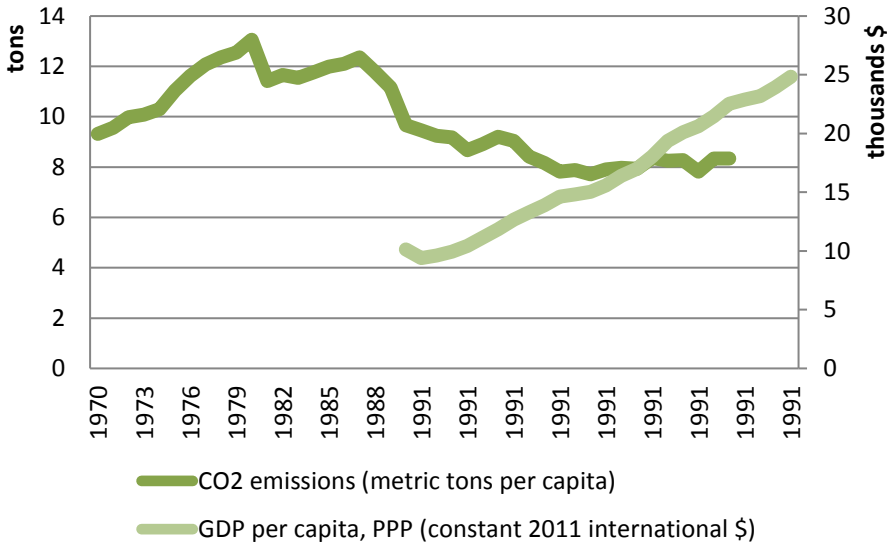


Figure 3: Evolution of CO2 emissions per capita and GDP per capita at constant $ prices after adjusting for purchasing power parity

Source: The World Bank (2016)

The transition of the Polish economy from central planning to a free market economy provides an interesting example of decoupling between GDP and CO_2 emissions (discussed further in section 1.3.1 Overview of Development). The evolution of these two variables is shown in Figure 3. Contrary to the usual positive correlation between GDP and emissions which is typically observed in low and medium income countries, in Poland the growth of GDP was accompanied by a drop in emissions per capita particularly in the first years of the transition period. This effect was largely due to the shutting down of inefficient plants from the communist era.

In 2015, the total emission of CO_2 in Poland was 279Mt. The International Energy Agency (2016) states that in 2014 emissions per capita were 7.25t CO_2 (comparing to e.g. 8.93 tonnes in Germany). The relatively low level of Polish emissions can be explained by a low consumption of energy per capita (2.44 toe comparing to 3.78 toe in Germany).

The largest share of the total emissions originates from the electricity and heat production. The other two large sectors, transport and residential buildings, and commercial and public services, account for 15% and 16% respectively. This is shown in Figure 4.

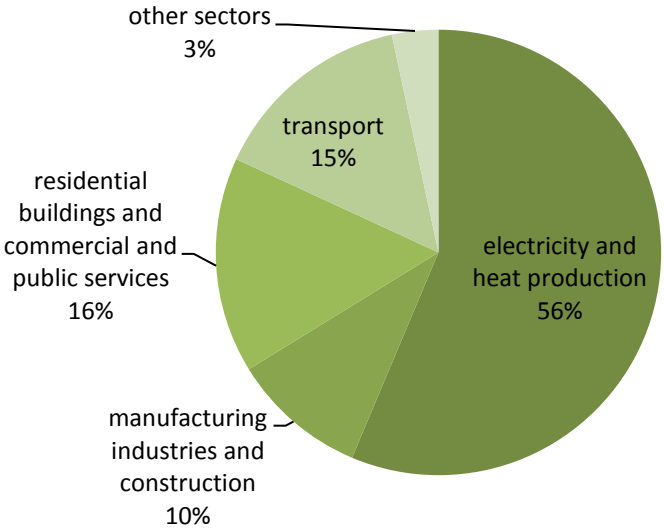


Figure 4: Source of CO2 emissions as % total total fuel combustion in Poland in 2013

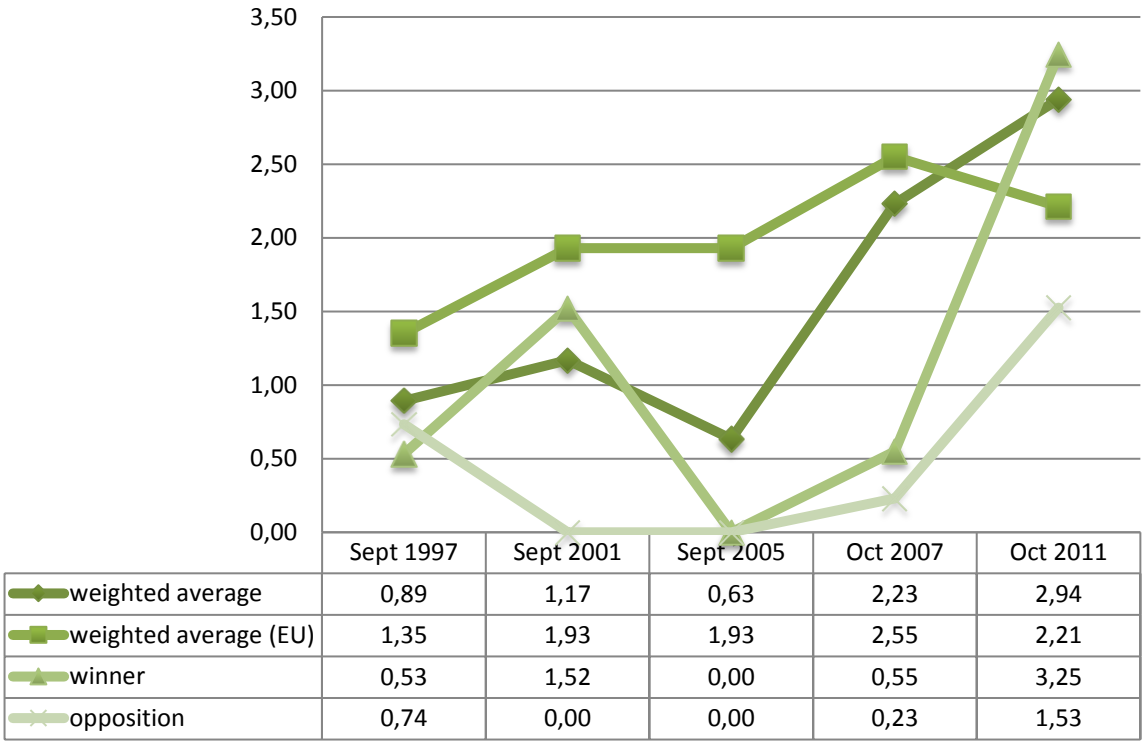
Source: The World Bank (2016)

Environmental priorities

Figure 5 presents the evolution of the salience of environmental issues in political parties' manifestos before general elections in Poland. The figure shows four lines: (i) the salience for the party that won the elections (scored the largest share of votes), (ii) the salience for the party that received the second largest share of votes, (iii) the weighted average of salience for all parties participating in the elections (in which the weighting corresponds to the share of votes scored by each party) and (iv) the weighted average for parties in all EU countries in the 5 year interval around the analysed election date. The salience of the issue for a given party is computed as follows: the party's manifestos (or speeches) are analysed by counting the quasi-sentences referring to some political, economic and social issues. The measure of the salience of environmental issues is the number of positive references to the environment (quasi-sentences) expressed in relation to the total number of references in the document.

The figure indicates that the salience of environmental issues was growing more sharply in Poland than in the entire European Union. In September 2011 the average for parties in Poland was higher than the average for all parties in EU countries in the period 2011-2016[3].

[3] However, one must note that the low level of salience in EU in this period was partly due to accession of Bulgaria and Romania (which in the previous periods did not count into the EU average) and due to economic crisis which hit the Southern European countries more severely than Poland.



	Sept 1997	Sept 2001	Sept 2005	Oct 2007	Oct 2011
weighted average	0,89	1,17	0,63	2,23	2,94
weighted average (EU)	1,35	1,93	1,93	2,55	2,21
winner	0,53	1,52	0,00	0,55	3,25
opposition	0,74	0,00	0,00	0,23	1,53

Figure 5: Salience of environmental issues in political parties' manifestos before general elections

Source: own elaboration based on Volkens, et al. (2015)

A critical view on the EU climate policies is expressed by the Council of Social Dialogue, which is composed of the largest trade unions ("Solidarity" and OPZZ), the largest employers' associations (PRP, "Lewiatan", ZRP and BCC) and representatives of the relevant ministries. In February 2016 the council published its comments (Rada Dialogu Społecznego, 2016) on the propositions of the European Commission on the reform of the EU climate policy. The document states that the intensity of the mitigation effort should vary between countries. Climate protection effort is effective only when all countries will sign the emission reduction commitments. These commitments should reflect the capabilities of each country and should be done voluntarily, in accordance with the spirit of COP21 in Paris. In the opinion of the Council, the proposal by European Council is not in line with this spirit. The council states that in its view:

- The EC proposal has a destructive impact on Polish economy and no significant impact on the global climate policy.
- The proposition will increase energy poverty.

- Some EU propositions such as BAT[4] are introduced too rapidly. Short time for adjustment hazards the stability of the energy system.
- The way the decisions are taken questions the autonomy of individual states.
- The council questions why forest management is not integrated into the proposition by the European Commission, in contrast to the Paris COP21 conclusions.

The opposite stance has been taken by the Coalition for Climate which consists of 22 NGOs. The Coalition issued a harsh criticism (Koalicja Klimatyczna, 2015) of the 'Polish Energy Policy by 2050' (Ministerstwo Gospodarki, 2015) proposed by the previous government led by Civic Platform. The authors accuse the government that its reluctance to limit the role of coal is driven by current political interests. In the document, the coalition emphasises that renewable energy sources can be an opportunity for the Polish economy.

Interviewee [6] stressed that environmental issues often influence international relations. As the role and position of Poland grows in the international arena, the country needs to take more responsibility for global problems, including global warming.

One transition pathway that seems to be well received in the society, is the decentralisation of energy generation (with households generating electricity from RES). This solution has been favoured by one of the leading opposition parties (Nowoczesna.pl). It has been also supported by the minister of Energy (Tchórzewski, 2016b). The growth in number of prosumers has also been advocated by an interviewee [5].

1.2.3 Economic priorities

GDP growth, wages, unemployment and energy poverty

In the last 20 years, Poland grew significantly faster than old members of European Union (EU15). While in 1995 GDP per capita was at the level of $11,100 (33% of the German GDP per capita), in 2015 it was at the level of $24,800 (56% of the German level). This can be primarily explained by growth in productivity. In 1995 the productivity of Polish economy was half of German productivity and in 2013 it was at 80% of the German level. The fast growth can be explained with the technological convergence of Polish economy to the levels of more advanced European countries. As the distance to the most industrialised countries declines, the growth is expected to slow down. The European Commission forecasts that in coming years, the pace of economic growth in Poland will be at the level of 3.5% annually (European Commission, 2016a).

[4] Best Available Techniques, http://eippcb.jrc.ec.europa.eu/reference/

The unemployment rate in the aggregate economy remains at around 7%, which is below the EU average. Unemployment is particularly high (reaching 8.9%) in small towns of below ten thousand inhabitants. It is clearly concentrated in the Eastern voivodeships (regions). The unemployment rate in the Silesia region (the coal mining region) is 5.9%, significantly below the country average (Central Statistical Office of Poland, 2016).

The Polish economy is characterised by a relative low employment rate (the ratio of those who are employed to the working age population) of 68.4%, 2.2 percentage points below EU average. The government aims to increase this rate to 71% by 2020 (European Commission, 2016b).

One of the most important economic problems, recently noted by stakeholders in interviews, is that of energy poverty. On average, Polish households spend 12% of income on energy, gas and other fuels. This is almost two times more than on average in EU. The study by Miazga and Owczarek (2015) finds that the number of people who can be classified as energy poor (based on the low income, high energy spending criterion) is 6.4M, twice as much as the United Kingdom.

Capital vs. labour

Several studies found that since the fall of communism, capital accumulation has not kept pace with the growth in productivity (Jiang, et al., 2001 and (Witajewski-Baltvilks, 2016). As a result, capital is relatively scarce in Poland. While the cost of labour is significantly lower than in other European countries, the cost of capital is significantly higher. This implies that the capital-intensive technological options which are optimal in Western European countries might turn out to be suboptimal in the Polish context[5]. On the other hand, labour-intensive technologies could be a better choice even if they are considered too expensive in Western Europe.

Flow of labour

A transition towards a low-emission economy will require a substantial flow of labour between sectors, particularly away from the mining sector and towards sectors relevant for the clean energy production. Indeed, some of this transition has already taken place. Over the last 25 years the number of operating mines has been reduced by 2/3 and employment has fallen from 400 000 people to 100 000 people.

However, the rise and decline of sectors along the transition is rarely associated with smooth flow of workers from one sector to another. Tyrowicz and van der Velde (2014) found that during the

[5] The suboptimality of frontier technologies for economies with different labour and capital costs than frontier economies is described in Caselli and Coleman II (2006).

economic transition of Central and Eastern European Countries only a small fraction of workers managed to change sector during their life-time career. The change in the composition of sectors which one can see in the data results primarily from the demography: employment in some sectors contracts not because workers change jobs, but because they exit labour force (usually retire). This raises a question whether the transition away from mining sector can be significantly accelerated.

The available evidence suggests that the transition away from mining sector is particularly difficult. The coal miners are relatively low-skilled and they are (traditionally) relatively well paid with the average monthly wage in coal mining at the level 6.9k PLN compared to the average of 3.9k PLN in the entire economy (2014q1) (tvn24, 2015). Despite this wage gap, a large part of society usually sympathises with coal miners, justifying their high wage with the difficult and dangerous working conditions. In a poll carried out in 2015, 68% of respondents declared support for coal miners in their conflict with the government.

Over the last 20 years, the government introduced a number of programmes to incentivise coal miners to leave their work, such as paid two years' transition time to find new job and training. However, the study by Stalewski and Szpak (2000) showed that out of the sample of leavers, only a small fraction found employment in another sector. The majority decided to leave for early retirement. Between 30-40% of those who decided to accept one-time compensation and left work remained unemployed.

The fear of job losses led to a number of coal miners' protests and demonstrations throughout the last 25 years of economic transformation. In August 2003, government's plan for restructuring the mining sector led to protests and riots of tens of thousands of coal miners in Silesia and in Warsaw (Kaczorowski & Gajewski, 2008). In January 2015, 2200 coal miners went on strike and occupied the coal mines following the government's proposal to close the least profitable coal mines (Central Statistical Office of Poland, 2016). The coal mining sector is heavily unionised with trade union coverage reaching 100%.

Mining sector revenue

The statistics of National Bank of Poland (NBP) indicate that the mining sector is one of the least profitable sectors in the economy. Interestingly, according to the World Bank data (2016), in 2014 the rents from coal (0.3% of GDP) were lower than rents from forestry (0.4% of GDP). This is mostly due to the rapidly falling price of coal and the increasing cost of extraction.

The profitability of the mining sector is listed as one of the goals in the Strategy for Responsible Development (Ministerstwo Rozwoju, 2016). The plan notes that this could be achieved with investment to improve the efficiency of the sector and by adjusting to demand. The minister of energy suggests that an important element of this strategy will be vertical integration: merging the coal mining companies with the energy companies (Tchórzewski, 2016a).

1.2.4 Societal priorities: perspective on climate change

Poland is a medium-sized country with a population of thirty-eight million people. One third of the labour force has a tertiary education, which corresponds to the EU average. The enrolment rate into tertiary education in Poland is higher than the average in European Union (The World Bank, 2016).

The attitude of the society towards the environment is reflected in the World Value Survey. The responses of Poles in the 2010-1014 edition of the survey (World Value Survey, 2015) suggest that Poles care about environment more than respondents in Germany or Sweden (see Table 4). However, when the respondents were asked to prioritise between economic growth and job creation, and the environment, most of them prioritised the former (Table 5). This can be explained with the relatively low living standards prevalent still in many areas of Poland.

Table 4: Responses to the question in World Value Survey (2015): 'Looking after the environment is important to this person; to care for nature and save life resources.'

	TOTAL	Germany	Poland	Sweden
Very much like me	17.0%	11.0%	22.0%	23.0%
Like me	32.7%	24.8%	47.5%	34.2%
Somewhat like me	25.5%	29.2%	19.4%	24.1%
A little like me	15.4%	21.5%	6.6%	11.9%
Not like me	6.8%	10.6%	2.4%	4.1%
Not at all like me	1.9%	2.5%	0.3%	2.1%

Table 5: Responses to the question in World Value Survey (2015): 'Protecting environment vs. Economic growth'

	TOTAL	Germany	Poland	Sweden
Protecting the environment should be given priority, even if it causes slower economic growth and some loss of jobs	49.7%	47.7%	37.6%	62.9%
Economic growth and creating jobs should be the top priority, even if the environment suffers to some extent	39.8%	39.1%	51.2%	32.0%
Other answer	6.6%	10.4%	4.7%	1.5%

The fear of job losses, which is apparent in the Polish society, demands a careful examination of the impact of transition pathways on the labour market. The past experience with the economic transformation in Poland, which was not always smooth, raises concerns whether the new transition will not bring new losers, even if on aggregate it can bring economic prosperity.

1.2.5 Politics of energy development priorities

The parliamentary and presidential elections in Poland which both took place in 2015 resulted in a major change of executive and legislative powers. Both are currently in the hands of a social-conservative party, which is sceptical of the human impact on climate change. Although this is not in complete opposition to the previous centre-liberal government, essential aspects of previous energy policy have now been questioned.

1.2.5.1 Urgent or important?

The priorities of the current government lack a complex and long-term framework. Finalisation of the main strategic document "Energy Policy till 2050" (Ministerstwo Gospodarki, 2015), which according to the Polish law should be adopted in 2015, was suspended by the current government and it is not likely that it will be adopted in 2016. The 2030 strategy adopted by the previous government is not valid any longer. The only new document which has a chance to be adopted shortly is the national 2020 strategy (Ministerstwo Rozwoju, 2016) (the document currently is under public consultation) but energy policy is defined in various contexts and in rather broad terms. This strategy sets an overall challenge – to ensure that the Polish economy has sufficient energy supplies at the economically acceptable price and with an increased energy efficiency. It recognises also the requirements of the EU and that energy policy should comply with climate policy and a low-emission transition.

A lack of medium and long term vision is explained by the urgency of current problems. The actual agenda of the government indicates that the main and most urgent priority of the new government is the modernisation of the coal sector which in Poland is essential for its energy system. The modernisation includes development and uptake of new clean coal technologies (e.g. CCS, blue coal, coal gasification) in the production and transformation of coal. The government aims to increase the market outlet for coal - through electrification of transport, development of a district heating sector as well as through increasing exports –to Germany, Czech Republic, Austria and North Africa countries. Shutting down the inefficient coal mines, further redundancies and limitation of labour privileges in the sector are part of a hidden agenda. This agenda has been more or less constant since the economic and political transformation started in 1989. It is based on a combination of different factors related to employment in this sector – relatively high wages

and low skills at the same time, strong unionisation rate, and the dependency of families on the income of one of its members.

The Polish government sustained but postponed the willingness to build first nuclear power plants and developing High Temperature Reactor technologies in collaboration with France, Great Britain and possibly other countries. At this stage, however, considering the difficult situation of that sector and considering the possible problems with financing such a project, further delays are very probable.

The new government is determined to increase the diversification of gas supplies by balancing the share of gas from Russia with gas supplies from other countries. For that reason, it developed plans to build a new pipeline transporting gas from its gas deposits in Norway through Denmark and Baltic sea.

Due to its high dependency on coal, Poland is traditionally in opposition to the ambitious climate goals of the EU. The only attempt to change this position was initiated by the previous Prime Minister Donald Tusk. His “energy community” plan meant to trade a greater independence for Poland (and the EU) from the Russian supplies of gas in exchange for consent to more ambitious climate goals. However, after most of its parts watered down, the interest of both Polish governments in a more consensual approach to EU climate policy never materialised again.

Groups favouring more ambitious climate and environment policies from the Polish government are focused largely around rather weakly positioned NGOs, the Green Party and other organisations. None of the political parties present in the parliament openly oppose the support for the coal mining sector, although one of them (Nowoczesna.pl) is more progressive about the economic viability of such actions.

1.2.6 Conflicts and synergies of priorities

The current government is devoted to developing new, domestic energy technologies in selected areas in order to raise its position in international supply chains. It also strongly believes in developing Polish coal sector through modernisation. The costs of this process are not entirely transparent yet and its economic viability is often questioned by, for instance, environmental organisations. Certainly the Polish government needs to consider the coal and other interlinked trade unions dependent on the coal based economy. The decrease of coal prices, rising price of CO_2 emissions and faster technological progress of alternative energy sources may lead to an exponential downturn of this sector. Thus the investments made to develop it could have a negative impact on the Polish economic growth dynamics in the future.

One of the pathways to lowering emissions of CO_2 declared by the government is electrification of transport. It includes developing electric cars although the current status of research and development in this field does not allow it to be considered as an easily achievable goal.

Another, parallel pathway of lowering the emission of CO_2 proposed by the Polish government, was the absorption of CO_2 by plantation of new forests. The idea was however preliminarily rejected by the European Commission. Without the inclusion of this parameter in the overall calculation of CO_2 emissions per EU member state, Poland may need another pathway to meet its climate goals.

Some of the technologies that are being proposed as substitutes for coal in a future transition will face the problem of acceptance by local communities. This is relevant in particular for nuclear power plants and on-shore wind (currently blocked due to lack of domestic technologies). The local acceptance can however favour a transition from brown coal. Its current operational reserves are limited and there is increasing awareness of the health impact of burning coal in households.

Poland does not possess any evident comparative advantage in renewable sources. Wind, sun and hydro potential are at average level of the EU at most. This was one of the reasons why none of the renewable technologies were developed domestically to the level of allowing for international competition. Weak innovation performance and lack of investment capital (characteristic for transition economies) did not favour development of any technologies, including non-renewable. The lack of clear priorities in domestic energy technology development raises doubts of the capacity to achieve a sufficient pace of transition to a low-carbon economy.

1.3 The Human Innovation Narrative

1.3.1 Overview of the Development of the Polish Energy Sector

Since the economic transformation of 1989, the Polish economy has recorded rapid economic growth which coincided with a significant reduction in CO_2 emissions. The decoupling of income and emissions was made possible due to several factors.

First, the final energy intensity of Poland's economy has decreased significantly. Economic growth which followed the transformation from a centrally planned economy to a free market has been accompanied by a constant level of final energy consumption (Figure 6). This happened due to the replacement of energy-intensive technologies embodied in machines designed in the era of central planning with new energy-efficient ones, often coming with foreign direct investment. Indeed,

the industries which contributed most to the decrease of emission were steel mills and machinery and textiles.

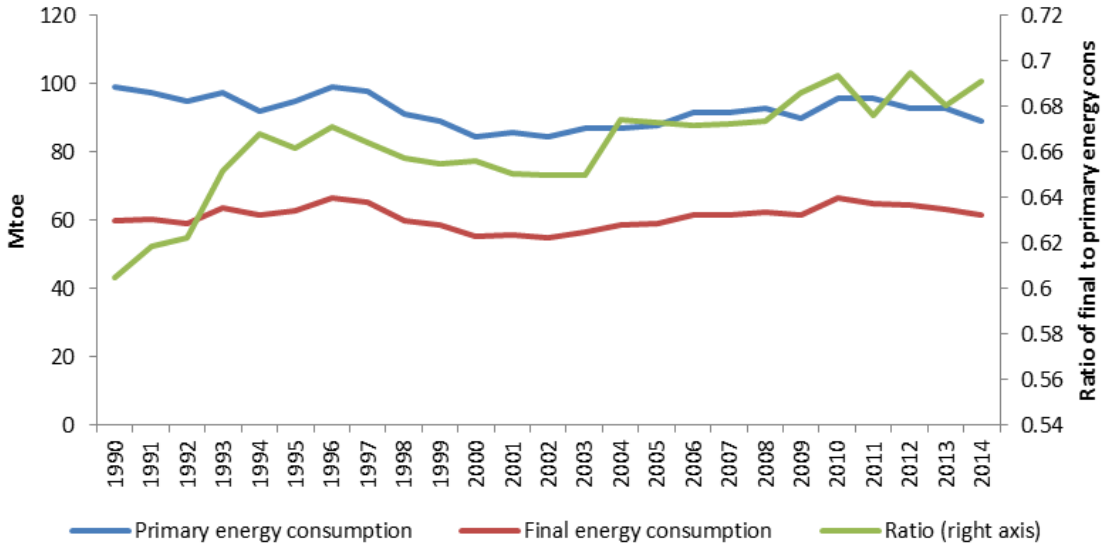


Figure 6: Primary and final energy consumption in millions of tons of oil equivalent in Poland

Source: Own calculations based on Eurostat (2016a) and (2016b)

Second, primary energy consumption decreased by approximately 10%, from 99.1 Mtoe in 1990 to 89.1 Mtoe in 2014, with the largest drop taking place in the last decade of the twentieth century. As final energy consumption remained at a relatively constant level, this resulted in an increase in the ratio of the two from 0.6 to almost 0.7 indicating an improvement in the combustion and transmission of energy.

Overall, these two factors led to a significant decrease in Poland's primary energy intensity economy since 1995. As can be seen from Figures Figure 7 and Figure 8, a large part of energy efficiency improvement occurred in the previous century, with energy intensity decreasing by approximately 30% between 1995 and 2001. With the most advantageous opportunities for generating energy savings being exploited quite quickly, further decreases in energy intensity of the economy have slowed down. As of 2014, the primary energy intensity of Poland is equal to approximately 0.22 kgoe per euro constant price of 2010, and in comparison to the average of the EU28 area it is almost twice as high.

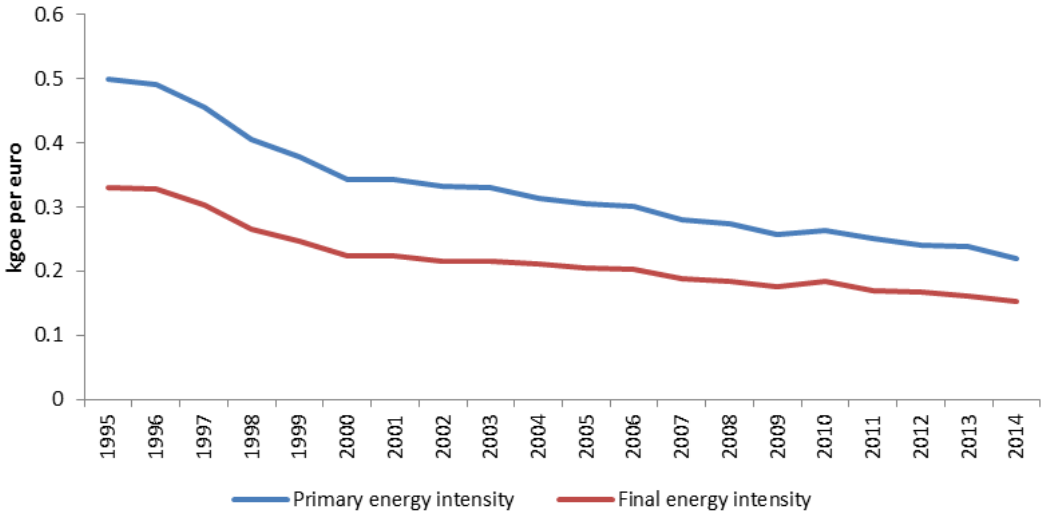


Figure 7: Primary and final energy intensity in Poland in kg of oil equivalent per euro constant prices of 2010

Source: Own calculations based on Eurostat (2016c) (2016a) and (2016b)

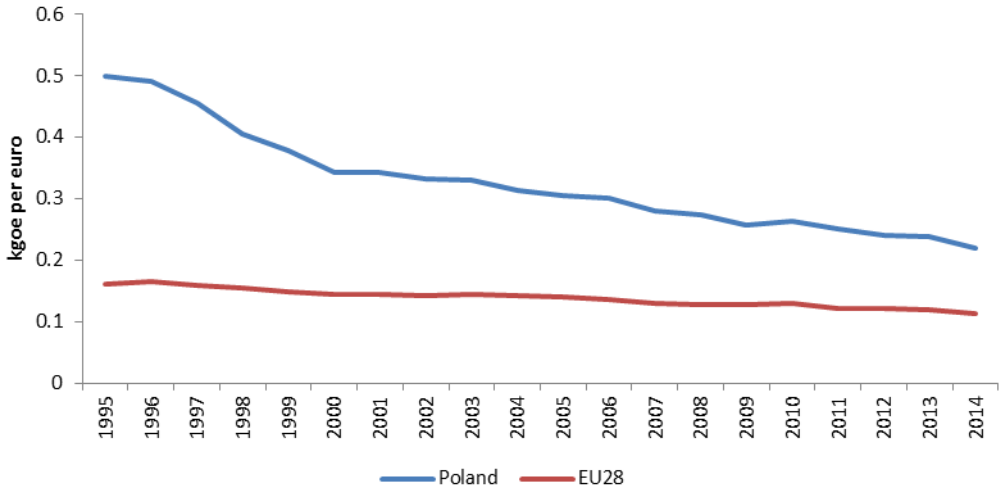


Figure 8: Primary energy intensity in Poland and in EU28 in kg of oil equivalent per euro constant prices of 2010

Source: Own calculations based on ***Eurostat*** *(2016c) (2016a)* ***and*** *(2016b)*

According to the EU Strategy document "Europe 2020"(European Commission, 2010) Poland will contribute to the reduction of greenhouse gas emissions in EU by 20% with respect to the 1990 level. This will be partly achieved by increasing energy efficiency by 20% (measured by primary energy consumption). Improving energy efficiency of Poland is also one of the aims put forward in the Strategy for Responsible Development published in 2016 by the Ministry of Development (Ministerstwo Rozwoju, 2016). The plan assumes that the means through which this will be accomplished include investment in the heating sector, thermal insulation of buildings, increasing fuel efficiency in the transport sector and minimising heat and energy losses during transmission. The Polish energy infrastructure will also require large investment in the coming years. The electrical grid is currently very old and is generating average losses during transmission of 8.2%, (with an average for the EU at 5.7%). The plan assumes also an increase in the efficiency of coal power plants, cogeneration and support for low-emission (electrical) transport.

While policy makers place a lot of hope in the role of energy efficiency improvement in decoupling emissions from growth, they often lack evidence about what economic incentives are required to induce the required improvement and what are the economy-wide consequences of such technological changes for other sectors and for the labour market. In the first research question we will examine this problem at the aggregate level (with the use of a macroeconomic and econometric tools).

Subsequently, we plan to follow a more detailed analysis by narrowing our attention to improvement in energy efficiency in coal-fired power plants and its main competitor –renewable energy sources. We discuss these questions at greater detail in the two subsequent subsections.

1.3.1.1 Improvement in the efficiency of coal-powered power plants

Due to the ageing coal power plant infrastructure and the necessity to meet emission reduction targets, Poland will be forced to replace a large part of its coal energy infrastructure. It is estimated that by the year 2025, Poland will need to invest between 30 and 50 billion zloty in conventional coal energy plants, with an additional 40 billion zloty to be spent on modernising the power grid. These costs will cover the replacement of approximately 7-9 GW of ageing coal power plants as well as the construction of new power supplies in order to meet rising electricity demand.

The Polish Minister of Energy has stated that the Polish energy sector will be based primarily on coal power plants using clean coal technologies. He added that the precise technology is yet to be selected, but the direction is pointing toward the method of gasification of coal. In 2016, Poland will select locations for the first two power plants using the latest clean coal technologies. While the average net energy conversion efficiency of existing coal plants is approximately 36%, those to be built will have efficiency of 45%. This 25% increase also implies a decrease in coal use and carbon dioxide emissions of roughly the same proportion.

For example, Polska Grupa Energetyczna (the energy company) is currently building two coal-fired blocks of 900 MW each in Opole, a city in Southern Poland, which are due to start operations in 2019. They will replace old blocks built in the 60s and 70s, and their net efficiency will be 25% higher than the average existing power plant in Poland and will emit approximately 25% less carbon dioxide per unit of energy. Another example of a new generation power plant which is under construction can be found in Turów, a city in South-Western Poland. This 450MW plant which is due to replace old ones will be powered by lignite with a net efficiency rate of 43.4%. The increased efficiency is achieved by technologies relying on supercritical parameters of steam in the boiler. There is also a steady improvement in the efficiency of heat production in cogeneration and boiler plants, which has risen from 77% in 2004 to 81.5% in 2014.

In our study, we will compare the economic and environmental effects of investment in the clean and efficient coal-firing technologies with the effects of adoption of renewable energy sources in the short and long term. We will pay particular attention to the effect on the labour market in the short run, as well as the effect on the R&D sector, innovativeness and economic growth in the long run.

1.3.1.2 Diffusion of Renewable Energy Sources Technologies

Since the Energy Law Act (1997) came into force in 1997 there has been a widespread public debate about implementing the optimal system of support for renewable energy sources in Poland. The first step was carried out in 1999, when the obligation to purchase electricity and heat from unconventional sources was introduced. In 2005, after becoming a member state of the European Union, Poland amended the Energy Law Act by introducing a system of market regulations to support the production of energy form renewable sources. The system was based on certificates of origin, which were documents proving production of certain amount of electricity from renewable sources. The certificates were the subject of trade between renewables producers and suppliers of energy. The energy suppliers each year had an obligation to obtain an established quota of certificates of origin (representing a certain renewable energy share in total volume of their electricity sales) and present them to the President of the Energy Regulatory Office (ERO) for redemption, or to pay a substitution fee. The intention of public authorities was that the substitution fee (adjusted annually by ERO) should indirectly determine the prices of certificates.

The system of certificates of origin is a quantity-based system, in contrast to feed-in-tariffs or auctions which are price-based. It obliges companies to increase the share of renewables in their energy sources (Abolhosseini and Heshmati 2014). On the one hand it exposes producers to the efficiency of market prices, but on the other hand it offers low revenue certainty for investors (European Commission 2013). In years (2005-2011) the prices of green certificates in Poland was stable – amounting to about 250 PLN/MWh, which was little below the substitution fee. However, since 2012 green certificates market faced an oversupply and prices dropped below 50 PLN/MWh

in 2016. The main reason indicated is too low obligation quotas for years 2010-2012 (they were established in 2006).

The decision to modify the system of support for renewable energy sources in Poland was already made in 2010. In the National Renewable Energy Action Plan (2010), based upon the Directive 2009/28/EC, public authorities were obliged to adopt a separate act dedicated to the promotion of renewable energy sources. In the years 2011-2014, at least six drafts of the Act on Renewable Energy Sources were presented by country legislators. They contained different ideas of renewable energy market support – from just modifying the system of certificates of origin to introducing a completely new system of auctions. That was a time of high uncertainty for all actors in the renewable energy market (investors, producers, prosumers and suppliers). Meanwhile, in 2013, Parliament introduced regulations that gave owners of micro-installations (up to 40 kW) the possibility to sell the surplus of produced energy to the energy grid operator for 80% of the energy market price.

Finally, in February 2015 after four years of legislative work, the Act on Renewable Energy Sources in Poland was adopted. However, shortly after the election held in autumn 2015, the new parliament introduced two amendments to this act. The first amendment, adopted in December 2015, postponed its effective date from 1st January 2016 to 1st July 2016, and the second, adopted in June 2016, changed the emphasis of the support from some renewable sources (especially from wind and PV energy) to other technologies (especially to co-incineration) as well as significantly changed the system of support for micro-installations. Finally, in July 2016, the new system of preferences for renewable energy sources in Poland was introduced. The system is based on auctions announced and conducted by the President of ERO (detailed description in the next section).

A main characteristic of the renewable energy market in Poland in the past few years has been the high level of uncertainty over the system of support and legal framework. Since 2011, when the first draft of the Act on Renewable Energy Sources was presented, stakeholders were faced with rapidly changing concepts of energy market regulations. When the expected Act was finally adopted in February 2015, it took only a few months for the parliamentary majority (elected in autumn 2015) and the new government to introduce amendments, which substantially changed the preferences for RES. Moreover, the Ministry of Energy announced other amendments to the current regulations to be introduced in autumn 2016. The changes intensify stakeholders' concerns about the future of renewable energy investments in Poland. Unfortunately, after years of public debate on the optimal market regulations, there is still no political agreement over the desirable directions for the Polish energy system development.

Despite the high level of uncertainty, the renewable energy market in Poland continues to grow rapidly. The installed capacity of renewable energy sources increased from 1,2 GW in 2005 to 8,2 GW in 2016. The high growth rate was caused mainly by significant investments in wind farms. In 2016 the capacity of wind installations reached almost 5,7 GW, while dating back to 2005 it was close to zero (see Figure 9). As a result, the share of renewable energy in electrical energy sold

in Poland increased from 3,0% in 2005 to 13,3% in 2014 (Urząd Regulacji Energetyki, 2016a). The share of renewable energy in total energy consumption equalled to 11,4% in 2014 (Eurostat, 2016d). That means that Poland still lags behind Western EU countries, but the growth rate of RES installations is promising and gives prospects for reaching the national target of 15,5% renewable energy share in 2020.

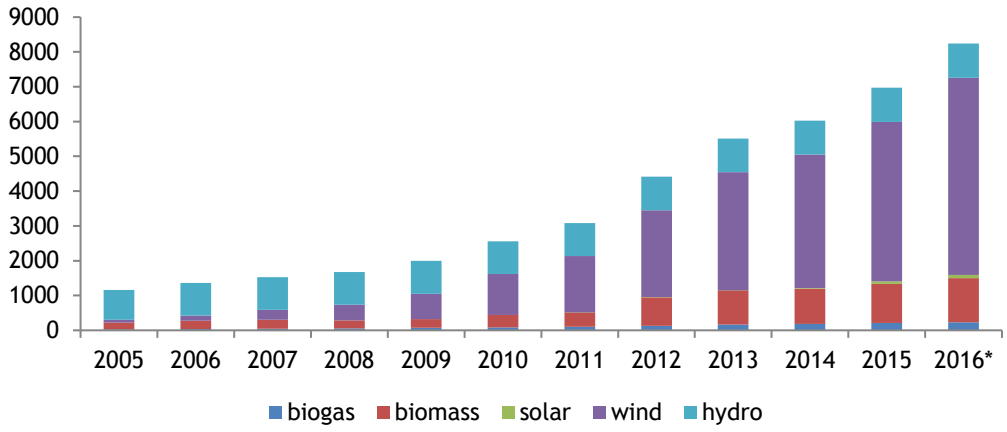


Figure 9: Installed capacity of RES in Poland in MW (2005-2016)

** as of 30.06.2016*

Source: own presentation based on Energy Regulatory Office (2016b)

Whether this high pace of growth of the sector will continue in the future and which particular RES technologies are going to win the largest share depends crucially on the design of the support scheme which is currently debated. In our study, we will discuss the design of optimal support schemes for the renewable energy sources in the context of Polish economy. Furthermore, we will also explore how the growing share of renewable energy sources could affect the functioning of the energy market taking into account their intermittency and, in particular, how is it going to affect the demand for the electricity from coal-fired power plants.

1.3.2 Sector and micro-level analysis: the cradle to grave analysis of technological innovation

TIS value chain of electricity generation

Since the focus of our case study is on the electricity generation sector, which is mainly coal based, we focus on the life cycle analysis of coal. It is important to note that the TIS (technological innovation system) of electricity generation is not entirely linear. The two main components

include on the one hand coal extraction and trade and on the other the development and import of clean coal technologies and construction of power plants.

1. Coal and lignite extraction. Coal is extracted in the south of Poland in the Silesian, Lower Silesian and Lublin Voivodships.
2. Coal import. Poland is currently importing approximately 10 M tons of coal, primarily from Russia. It is used mainly used in power plants in the north of the country.
3. Coal export. Poland is currently exporting approximately 10 M tons of coal. The main importers of Polish coal are Austria, Czech Republic and Germany.
4. Transport of coal. Lignite is used in power plants which are situated next to the open pit mines, whereas coal is transported to domestic plants in the south of the country.
5. End use of coal by households. A significant amount of coal is used directly in households for heating purposes. It is primarily low quality coal and is linked to significant low emission pollution.
6. Development and import of (clean) coal technologies.
7. Decommissioning of coal in power plants.

1.3.3 Policy mixes in the socio-economic system

Subsidies for coal mining sector

Two main streams of public financial support for the coal mining sector in Poland include funds for restructuring the coal mining industry and funds for miners' social security system. The first one covers both: direct financial support for coal companies and remissions of different coal mining sector liabilities (mainly tax and social security contribution liabilities). The cost of these operations in 1990-2012 is estimated to 69 bn PLN (in constant 2010 prices). Two times – in 1990 and 2003 – public authorities introduced broad restructuring programs for coal mining industry, which in both cases amounted to about 2% of GDP. Since Poland joined the EU, the scope of such activities had to be reduced due to EU regulations. Now they amount to about 1 bn PLN annually. The second form of financial support for coal mining sector is a separate pension scheme for miners, which includes early retirement age and multiplying miners' contributions by a factor of 1,5 or 1,8. The cost of these preferences in 1990-2012 is estimated to be 67 bn PLN (in constant 2010 prices). That cost is stable over time – it amounts to about 0,2-0,3% of GDP each year (Bukowski & Śniegocki, 2014).

Renewable energy support

The main element of the system of support for renewable energy sources in Poland introduced in mid- 2016 is the auctions announced and conducted by the President of ERO. The auctions are

organised at least once a year. For each year the Council of Ministers and Minister of Energy establish:

- the amount and value of energy from renewable sources that will be the subject of auctions;
- the maximum prices for 1 MWh (so-called "reference prices"), separately for different kinds of renewable energy source and capacity of installations;
- the period for which the support for renewable energy will be offered (maximally 15 years).

Winners of an auction are those participants whose offers contain the lowest price. They have a warranty of fixed price (indexed by inflation rate) for produced energy for established period of time as well as obligation to produce energy for the declared amount. Failure in meeting this obligation will result in a cash penalty. The main purpose for introducing a new system of support was to provide a stable and predictable revenue stream for investors. That is the key difference between the auction system and system of certificates of origin.

The Act on Renewable Energy Sources introduced 7 categories of installations:

1. with capacity higher than 3504 MWh/MW/year (including co-incineration installations);
2. with capacity higher than 3504 MWh/MW/year and CO_2 emission lower than 100 kg/MWh;
3. using waste in producing energy (not necessarily solely waste);
4. using solely biogas in producing energy;
5. owned by members of energy cluster;
6. owned by members of energy cooperative;
7. other, not mentioned above.

The auctions are conducted separately for each category and separately for installations with a capacity up to 1 MW and installations with capacity above 1 MW. Order of auctions in a particular year is determined by the Council of Ministers. Each auction has defined the maximum amount and value of energy that can be sold.

In an auction system, the determination of the categories, the order of auctions, as well as the amount and value of energy for particular auctions, have crucial effects on how investments in renewables are directed. According to the Act, all types of so-called dedicated co-incineration installations may take part in the auctions. It is sufficient that the energy produced by such an installation has only a 15% share of biomass. Most experts indicate that defined categories give high preference for some energy sources such as water, offshore and multi-fuel installations burning biomass together with coal, while the most common clean energy sources – wind and photovoltaic – can compete in principle only in the last out of seven categories listed above (Ehrehalt (2016) and Wieczerzak-Krusińska (2016)). The authors of the second amendment to the RES Act (adopted in June 2016), which modified the auction categories, indicate that the introduced changes aim at providing more support for the technologies that generate energy in a stable and predictable manner.

The system covers all installations launched after 1st July 2016. Owners of installations which started producing energy before that date may choose whether to stay in system of or to adopt to the auction system. It is worth noting that separate auctions are organised for those producers who launched their installations before 1st July 2016 and decided to join the new system.

System of support for micro-installations

The Act on Renewable Energy Sources introduced also a new system of support for micro-installations. The originally adopted Act (in February 2015) aimed at implementing the most popular system of prosumers support in EU countries – feed-in-tariffs. However, the second amendment, adopted in June 2016, changed the previous intention and established a system of rebates. According to these regulations, prosumers owning installations with capacity lower than 10 kW receive a rebate for each 1 unit of energy surplus introduced into the network. The rebate is equivalent to 0.8 unit of energy. The conversion factor for prosumers owing installations with capacity higher than 10 kW (up to 40 kW) is 1 to 0.7. The validity of this support is established for 15 years.

Wind farm investment regulations

In May 2016 the Polish Parliament also adopted another important act for the renewable energy market – the Wind Farm Investment Act. Its main purpose is to regulate the minimum distance for the location of wind farms from residential estates. The established minimum distance is 10 times the height of the wind farm generator (including rotor and blades), which equals to around 1,5-2,0 km. On the one hand it protects society and environment from negative effects of wind farm investment on noise level, visual amenity, property prices, bird and bat deaths (Moriarty & Honnery, 2016). But on the other hand it significantly hampers the development of the wind energy sector in Poland. A survey, conducted by consulting company Ambiens, covering 1008 wind turbines in Poland showed that 99,2% of projects currently at development stage do not fulfil the new requirements (Kaczerowski, 2016). New regulations are effective from 16th July, but do not cover existing wind turbines and projects with building permission or with submitted application for building permission. The Act is not applicable for micro-installations with capacity lower than 40 kW.

We summarise the key policy instruments in

Table 6. The table lists the key legal acts regulating the functioning of the coal and renewable sectors and determining their future.

Table 6: Polish policy instruments that directly or indirectly impact coal and renewable sectors

Policy themes	Polish National Policy Instruments			
Energy	National Plan for the Development of Low-Emission Economy (under preparation)	The Energy Policy till 2050 (under preparation)	EU-ETS adoption	The 1997 Energy Law
		Renewable Energy Sources Act	Wind Farm Investment Act (minimum distance from residential estates)	
Climate			Programmes by Bank for Environmental Protection	Programmes by National Fund for Environmental Protection
Coal	Coal mining restructuring plan	2007 Act on Functioning of the Coal Mining Sector		
Regional policies	Special economic zones			
Agriculture and land-use	1997 Forest Policy of the State	Bio-components and Biofuels Act		
Air	Environment Protection Law			
Waste/ resource use				
Water				
Biodiversity				

1.3.4 Enabling environment: government institutions

A map of the most important state institutions related to the coal and electricity sectors is presented in Figure 10. We distinguish between several types of institutions. The parliamentary commissions are responsible for analysis and presenting opinions on the most important legal acts. The executive bodies, which are subject to the Prime Minister are responsible for the preparation of strategic plans (mostly, the institutions on the right hand side of the graph) and its execution (the institutions in the central side of the plan). The state-controlled companies, universities and research centres as well as the state-controlled financial institutions can be viewed as instruments assisting the execution of the plan. We highlight the role of the key actors below:

- Department for Strategic Analysis - prepares the horizontal or strategic analysis for the Prime Minister, creates analytical models for policy assessment.
- National Plan for Responsible Development - presents the priorities for economic development and drafts the long-run strategy.
- The National Centre for Emissions Management – responsible for management and administration of the Polish part of the EU ETS, prepares the economic analysis related to the EU-ETS.
- Government Representative for Strategic Energy Infrastructure - represents the Treasury and control companies which are related to the transmission of electricity.
- Energy Regulatory Office - responsible for regulation in energy sector as well as promotion of competition. The President of ERO regulates activities of energy enterprises aiming to balance interests of energy companies and customers.
- Government Representative for Restructuring of Coal Mining – responsible for the preparation and realisation of the conceptual plan for the restructuring the mining sector.
- Polish Mining Group and JSW - the two major mining companies, both controlled by the state
- Polish Power Network - responsible for the transmission, responsible for the security of the electricity sector.
- Major Companies in Energy Intensive Industries - The Treasury is a significant shareholder in a number of major firms in energy-intensive industries. This group includes KGHM (producer of copper and silver) and Grupa Azoty (chemical products).
- Consumer Protection and Competition Authority - analyses structure of markets and ensures competition (preventing excessive integration)
- National Centre for Science and Development - manages and executes strategic research and development program.
- National Fund for Environmental Protection – responsible for financing pro-ecological investments in Poland.
- Bank for Environmental Protection - responsible for financing environmental projects by private firms and households

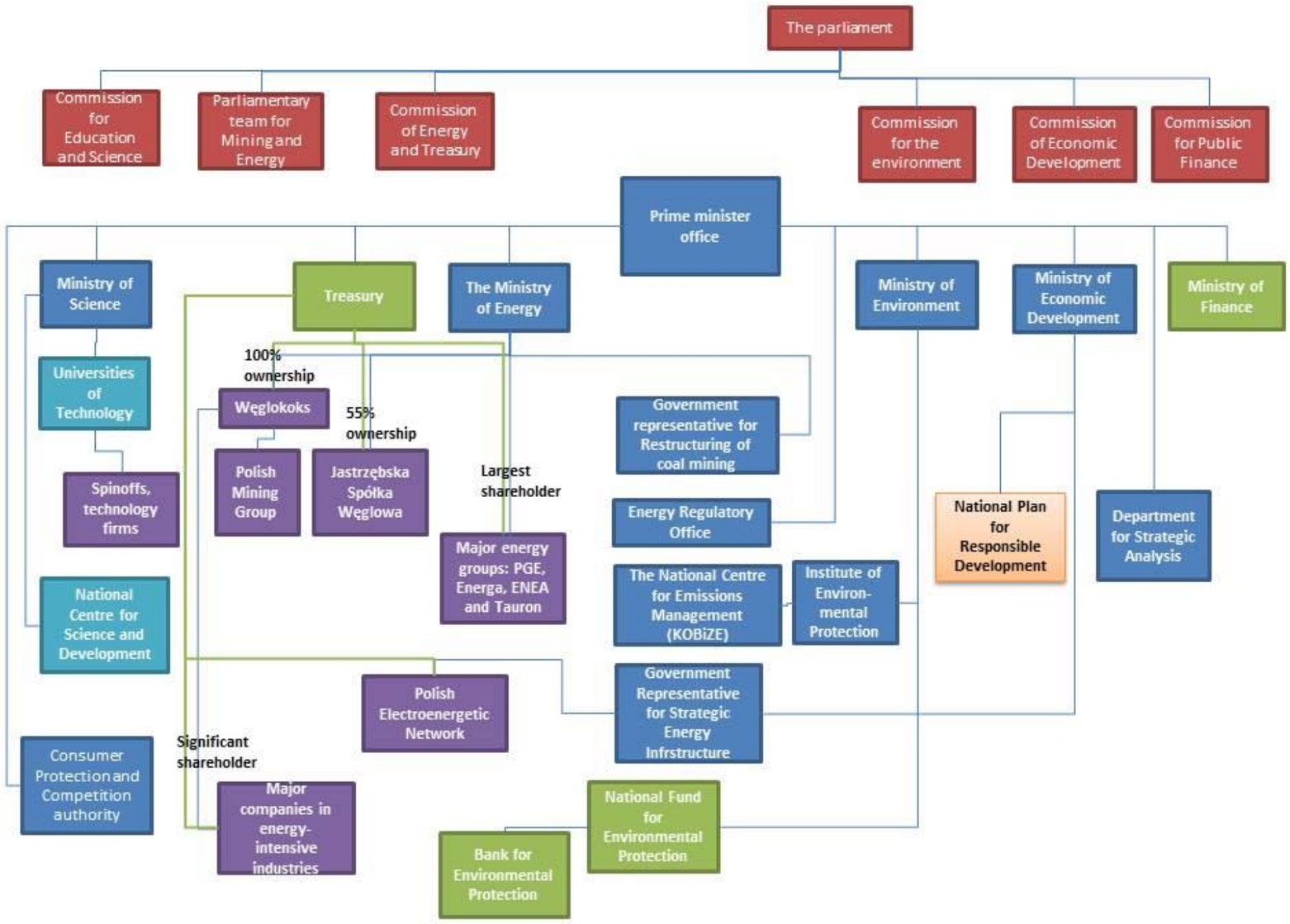


Figure 10: The map of government institutions related to the coal and electricity sector

Source: own compilation

1.4 The Innovation System Map

In Figure 11 we present the human innovation system map for the coal and renewable sectors in Poland. Most of the elements of the map have been already described in the previous sections: the life-cycle analysis has been sketched in the cradle-to-grave analysis in section 1.3.2. and the role of governmental institutions was discussed in the section on enabling environment (section 1.3.4.). To complete this description, we include below a brief presentation of the remaining key elements of the map: local governments, employers' organisations, trade unions and business associations (self-regulatory organisations).

Self-government (administrative divisions) in Poland is based on three levels. The basic level is gminas (2479), the medium level powiats (379), and 16 voivodeships form the largest entities. Gminas perform all tasks of local government not reserved to other units of local government. Powiats are divided into two forms - proper powiat (land county), and city with powiat status (city county). Therefore, the major cities in Poland normally have the status of both gmina and powiat. The local authorities at the level of a gmina and a powiat are elected and chosen in local elections, the administrative authority at the voivodeship level is shared between a governor appointed by the central government, and regionally elected and chosen authorities. There are several organisations consisting of territorial local entities grouped at different levels – Association of Rural Communes of the RP, Stowarzyszenie Gmin Górniczych w Polsce (Association of Mining Communes in Poland), Association of Polish Counties, Związek Miast Polskich (Association of Polish Cities), Union of Polish Metropolises.

There are four main employers' organisations - Business Centre Club, Employers of Poland, the Polish Confederation Lewiatan, the Polish Craft Association and three major labour unions – NSZZ Solidarność, All-Poland Alliance of Labour Unions and Trade Unions Forum. Both employers' and employees' organisations, together with government representatives, form the Council of Social Dialogue. The Council, after its transformation in 2015 has again become an important forum for social dialogue.

Another important group of actors is the self-regulatory organisations among which the National Chamber of Commerce (KIG) is the largest organisation grouping 65 chambers of industry, 59 regional chambers and 32 other organisations. Apart from KIG there are numerous important business, commerce and professional organisation e.g. Polish Electricity Association, Stowarzyszenie Inżynierów i Techników Górnictwa (Association of Mining Engineers and Technicians), Izba Gospodarcza Sprzedawców Polskiego Węgla (Chamber of Commerce Vendors of Polish Coal).

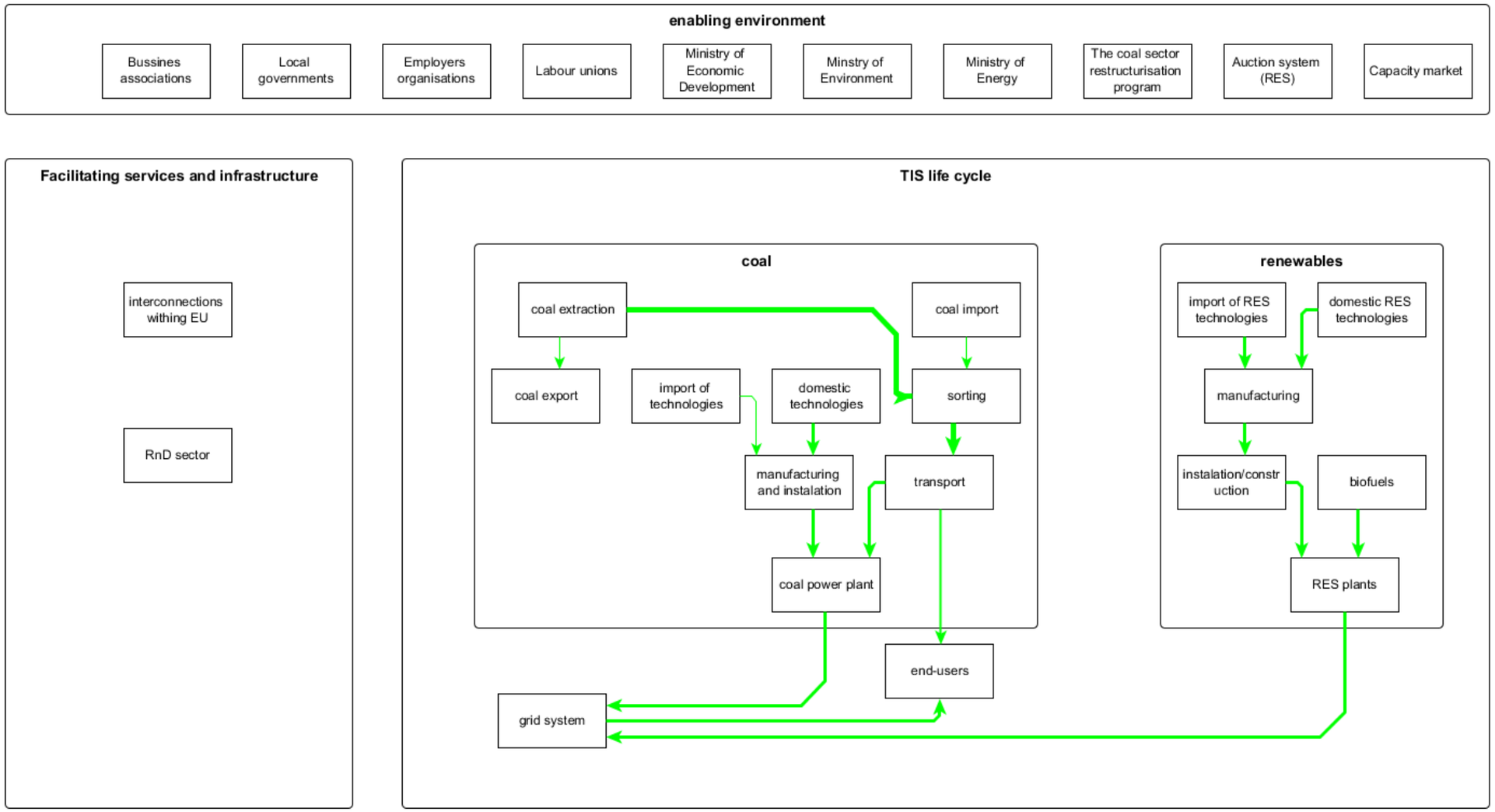


Figure 11: Human innovation system map

1.5 Stakeholder Engagement

Stakeholder Engagement

The Polish case study will be based on at least 15 interviews and a MCDA (multi-criteria decision aid) workshop. Some of the interviewed experts will be selected to participate in the workshop. The participants of the workshop will be composed of the proponents of different transition scenarios and generalists with balanced opinions.

Since February 2016, we have asked 14 stakeholders for interviews. 6 interviews has taken place already, another interview is expected to take place in December, other answers are still awaited (see Table 7). Among the engaged stakeholders, four represent the government, five belong to the private sector (generators and energy firms), two come from NGOs and two are working in the private sector.

Table 7: Stakeholder engagement

Type of stakeholder	Position in the organisation*	Economic sector**	Type of engagement ***	Month and year contacted	Already engaged
1. Academic	Researcher	Environment and energy	Interview	September 2016	Yes
2. Academic	Researcher	Environment	Interview	September 2016	Yes
3. Government	Expert	Environment, Energy	Interview	June 2016	Yes
4. NGO	Expert	Environment	Interview	February 2016	Yes
5. Government	Expert	Environment/International Relations	Interview	February 2016	Yes
6. Consultancy	Expert	Energy	Interview	February 2016	Yes
7. Academic	Researcher	Energy	Interview	November 2016	Yes
8. Business	Expert	Energy	Interview	September	Waiting for response

9. Business	Director	Energy	Interview	November 2016	Waiting for response
10. NGO	Expert	Energy	Interview		Waiting for response
11. Government	Expert	Environment	Interview	November 2016	Agreed to take place in December
12. Government	Expert	Business	Interview	September	Waiting for response
13. Consultancy	Expert	Industry	Interview	November 2016	Waiting for response
14. Consultancy	Expert	Energy, Environment	Interview	September 2016	Waiting for response

* Government (national / subnational), research / consultancy, business, other (specify)
** Energy, Industry, transport, environment, agriculture / forest, financial / trader, other (specify)
*** Full engagement includes Interview, Workshop and Surveys. During October-December 2016, the stakeholders will be approached via survey and/or interview.

References

Abolhosseini, S. & Heshmati, A., 2014. The Main Support Mechanisms to Finance Renewable Energy Development. *IZA DP,* Issue 8182.

Baranes, E., Jacqmin, J. & Poudou, J., 2014. *Renewable and non-renewable intermittent energy sources: friends and foes?,* LAMETA: Universtiy of Montpellier.

Bukowski, M. & Śniegocki, A., 2014. *Ukryty Rachunek Za Węgiel,* Warszawa: Warszawski Instytut Studiów Ekonomicznych.

Caselli, F. & Coleman II, W. J., 2006. The World Technology Frontier. *American Economic Review,* 96(3), pp. 499-522.

Central Statistical Office of Poland, 2016. *Labour force survey in Poland in 1st quarter 2016.* [Online]
Available at: http://stat.gov.pl/obszary-tematyczne/rynek-pracy/pracujacy-bezrobotni-bierni-zawodowo-wg-bael/aktywnosc-ekonomiczna-ludnosci-polski-i-kwartal-2016-roku,4,20.html

Derski, B., 2016. *Minister Energii przedstawił priorytety resortu.* [Online]
Available at: http://wysokienapiecie.pl/prawo-energetyczne/1241-minister-energii-przedstawil-priorytety-resortu
[Accessed 4 November 2016].

Ehrehalt, W., 2016. *Dla kogo nowe koszyki aukcyjne OZE?.* [Online]
Available at: http://energetyka.wnp.pl/dla-kogo-nowe-koszyki-aukcyjne-oze,273134_1_0_0.html
[Accessed 4th November 2016].

Ehrenhalt, W., 2016. *Dla kogo nowe koszyki aukcyjne OZE?.* [Online]
Available at: http://energetyka.wnp.pl/dla-kogo-nowe-koszyki-aukcyjne-oze,273134_1_0_0.html
[Accessed 4 November 2016].

Elliott, D., 2016. A balancing Act for Renewables. *Nature Energy,* Volume 1.

European Commission, 2010. *Europe 2020,* Brussels: European Commission.

European Commission, 2016a. *Country Report Poland 2016.* [Online]
Available at: http://ec.europa.eu/europe2020/pdf/csr2016/cr2016_poland_en.pdf

European Commission, 2016b. *Europe 2020 targets: Employment rate - Poland.* [Online]
Available at: http://ec.europa.eu/europe2020/europe-2020-in-your-country/polska/progress-towards-2020-targets/

Eurostat, 2016a. *Final energy consumption.* [Online]
Available at: http://ec.europa.eu/eurostat/tgm/table.do?tab=table&init=1&language=en&pcode=t2020_34&plugin=1
[Accessed 15th October 2016].

Eurostat, 2016b. *Primary energy consumption.* [Online] Available at: http://ec.europa.eu/eurostat/tgm/table.do?tab=table&init=1&language=en&pcode=tsdcc120&plugin=1
[Accessed 15th October 2016].

Eurostat, 2016c. *GDP and main components (output, expenditure and income).* [Online] Available at: http://ec.europa.eu/eurostat/web/products-datasets/-/namq_10_gdp
[Accessed 15 October 2016].

Eurostat, 2016d. *Share of renewable energy in gross final energy consumption..* [Online] Available at: http://ec.europa.eu/eurostat/tgm/table.do?tab=table&init=1&language=en&pcode=t2020_31&plugin=1
[Accessed 4th November 2016].

Financial Times, 2006. *Gas dispute threatens Belarus, Georgia.* [Online] Available at: https://www.ft.com/content/92fee430-8ae2-11db-8940-0000779e2340
[Accessed October 2016].

Główny Urząd Statystyczny, n.d. *Wskaźniki strategii Europa 2020.* [Online] Available at: http://stat.gov.pl/cps/rde/xbcr/gus/POZ_Wskazniki_Europa2020.pdf

International Energy Agency, 2016. *IEA statistics.* [Online] Available at: http://www.iea.org/statistics/statisticssearch/
[Accessed 1st October 2016].

Jiang, G. ., Doyle, P. & Kuijs, L., 2001. Real Convergence to EU Income Levels; Central Europe From 1990 to the Long Term. *IMF Working Papers,* Volume 01/146.

Kaczerowski, M., 2016. *Ustawa odległościowa vs development.* [Online] Available at: http://www.ambiens.pl/blog/ustawa-odlegloscIowa-vs-dewelopment/
[Accessed 4th November 2016].

Kaczorowski, P. & Gajewski, P., 2008. Gornictwo wegla kamiennego w Polsce w okresie transformacji. *Acta Universitatis Lodziensis,* Volume 219.

Koalicja Klimatyczna, 2015. *Stanowisko Koalicji Klimatycznej w sprawie projektu "Polityki energetycznej Polski do 2050 roku".* [Online] Available at: http://koalicjaklimatyczna.org/lang/pl/page/stanowiska_koalicji/id/7/
[Accessed 1 October 2016].

Krajowy Plan Działania w Zakresie Energii ze Źródeł Odnawialnych (2010) Ministerstwo Gospodarki.

Miazga , A. & Owczarek, D., 2015. *It's cold inside - energy poverty in Poland,* s.l.: Instytut Badan Strukturalnych.

Ministerstwo Gospodarki, 2015. *Polityka Energetyczna Polski do 2050.* [Online] Available at: http://bip.me.gov.pl/node/24670 [Accessed 1 October 2016].

Ministerstwo Rozwoju Regionalnego, 2012. *Strategia Rozwoju Kraju do 2020.* [Online] Available at: https://www.mr.gov.pl/media/3336/Strategia_Rozwoju_Kraju_2020.pdf

Ministerstwo Rozwoju, 2016. *Strategy for Sustainable Development,* Warszawa: Ministerstwo Rozwoju.

Moriarty, P. & Honnery, D., 2016. Can renewable energy power the future?. *Energy Policy,* Volume 93, pp. 3-7.

Nowicki, M., 2010. *Zaobowiązania Polski Dotyczące ochrony klimaty.* [Online] Available at: http://www.ine-isd.org.pl/theme/UploadFiles/File/konferencje/Prof_Maciej_Nowicki.pdf

Rada Dialogu Społecznego, 2016. *Uchwała Nr 5.* [Online] Available at: http://www.dialog.gov.pl/gfx/mpips/userfiles/n.krasuska/Posiedzenie%20RDS%20-%2018.02.2016/Uchwala%20nr%205%20-%20strona%20spoleczna_2.pdf [Accessed 1st October 2016].

Słojewska, A., 2016. *Polska będzie musiała drastycznie obniżyć emisję dwutlenku węgla poza przemysłem.* [Online] Available at: http://www.rp.pl/Energianews/307209878-Polska-bedzie-musiala-drastycznie-obnizyc-emisje-dwutlenku-wegla-poza-przemyslem.html#ap-1 [Accessed 4 November 2016].

Stalewski, T. & Szpak, A., 2000. Likwidowanie kopalni wegla w malym miescie gorniczym. *Studia Regionalne i Lokalne,* Volume 4.

Stern, J., 2006. *The Russian-Ukrainian gas crisis of January 2006,* University of Oxford: The Oxford Institute for Energy Studies.

Tchórzewski, K., 2016a. *Gazeta Prawna* [Interview] (4 January 2016a).

Tchórzewski, K., 2016b. *Rzeczpospolita* [Interview] (26 January 2016b).

Tchórzewski, K., 2016c. *wnp.pl* [Interview] (13 February 2016c).

The World Bank, 2016. *World Development Indicators.* [Online] Available at: http://databank.worldbank.org/data/ [Accessed 1st October 2016].

tvn24, 2015. *Sondaż dla "Faktów TVN i TVN24: "Nie" likwidacji kopalń, poparcie dla górników.* [Online] Available at: http://www.tvn24.pl/wiadomosci-z-kraju,3/sondaz-o-gornictwie-rozmowy-rzadu-z-gornikami-nie-dla-zamkniecia-kopaln,505658.html [Accessed 4 November 2016].

TVPinfo, 2009. *Polska bez rosyjskiego gazu z Ukrainy*. [Online] Available at: http://www.tvp.info/328809/biznes/polska-bez-rosyjskiego-gazu-z-ukrainy/ [Accessed 4 November 2016].

Tyrowicz , J. & van der Velde, L., 2014. Can We Really Explain Worker Flows in Transition Economies?. *Working Papers*, Volume 28.

Urząd Regulacji Energetyki, 2016a. *Udział energii elektrycznej z OZE w krajowej sprzedaży energii elektrycznej odbiorcom końcowym w latach 2005-2015*. [Online] Available at: https://www.ure.gov.pl/pl/rynki-energii/energia-elektryczna/odnawialne-zrodla-ener/potencjal-krajowy-oze/5754,Udzial-energii-elektrycznej-z-OZE-w-krajowej-sprzedazy-energii-elektrycznej-odbi.html
[Accessed 4th November 2016].

Urząd Regulacji Energetyki, 2016b. *Moz zainstalowana*. [Online] Available at: https://www.ure.gov.pl/pl/rynki-energii/energia-elektryczna/odnawialne-zrodla-ener/potencjal-krajowy-oze/5753,Moc-zainstalowana-MW.html
[Accessed 4th November 2016].

Ustawa z dnia 10 kwietnia 1997r. - Prawo Energetyczne (1997) Sejm.

Volkens, A. et al., 2015. *The Manifesto Data Collection. Manifesto Project (MRG /CMP/MARPOR)*, Berlin: Wissenschaftszentrum Berlin für Sozialforschung.

Wieczerzak-Krusińska, A., 2016. *Dużo biomasy, mało wiatru i słońca*. [Online] Available at: http://www.rp.pl/Energianews/304039892-Duzo-biomasy-malo-wiatru-i-slonca.html#ap-1
[Accessed 4 November 2016].

Wieczerzak-Krusińska, A., 2016. *Rzeczpospolita*. [Online] Available at: http://www.rp.pl/Energianews/304039892-Duzo-biomasy-malo-wiatru-i-slonca.html#ap-1
[Accessed 4th November 2016].

Witajewski-Baltvilks, 2016. Catching-up in Poland, Czech Republic and Hungary. *Bank and Credit*.

Witajewski-Baltvilks, J., 2016. Catching up in Czech Republic, Hungary and Poland. *Bank and Credit, National Bank of Poland,* 49(4), pp. 319-340.

World Value Survey, 2015. *World Value Survey wave 6 (2010-2014)*, s.l.: World Values Survey Association.