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Climate for Poland
Poland for Climate

1988 – 2018 – 2050

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Keywords: GHG, transformation, emission, greenhouse gases, carbon dioxide, climate protection, energy sector, mining, carbon leakage, electromobility, EU ETS, non-ETS, agriculture, transport, building sector, industry.

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Abbreviations

AAU	Assigned Amount Unit
AC	Adaptation Committee
ACEA	European Automobile Manufacturers Association
AEA	Annual Emission Allocation
AF	Adaptation Fund
APA	Ad Hoc Working Group on the Paris Agreement
ARE	Agencja Rynku Energii (Energy Market Agency)
BEV	battery electric vehicles (battery electric vehicles)
CAK	Centrum Analiz Klimatycznych (Centre for Climate Policy Analysis)
CAKE	Centrum Analiz Klimatyczno-Energetycznych (Centre for Climate and Energy Analyses)
CCU	Carbon Capture and Utilization
CCS	Carbon Capture and Storage
CDM EB	Clean Development Mechanism Executive Board
CL	Carbon Leakage
CMP	Conference of the Parties serving as the Meeting of Parties to the Kyoto Protocol
CNG	Compressed Natural Gas
COP	Conference of the Parties
CP1, CP2	Commitment Period 1 and 2
EC WIM	The Executive Committee of the Warsaw International Mechanism for Loss and Damage
CO_2eq	CO_2 equivalent
EMP	Electromobility Poland S.A.
ERU	Emission Reduction Unit
ESD	Effort Sharing Decision
ESR	Effort Sharing Regulation
EV	electric vehicle
EU ETS	European Union Emissions Trading Scheme
GIS	Green Investment Scheme
GHG	greenhouse gases
GCF	Green Climate Fund
HFC	hydrofluorocarbons
IOŚ-PIB	Instytut Ochrony Środowiska – Państwowy Instytut Badawczy (The Institute for Environmental Protection - National Research Institute)
IPCC	Intergovernmental Panel on Climate Change
JI	Join Implementation
JISC	Joint Implementation Supervisory Committee
JRC	Joint Research Centre
KOBiZE	Krajowy Ośrodek Bilansowania i Zarządzania Emisjami (The National Centre for Emissions Management)

KPEiK	Krajowy plan na rzecz energii i klimatu (National Energy and Climate Plan)
LNG	Liquefied Natural Gas
LULUCF	Land Use, Land-Use Change and Forestry
MSR	Market Stability Reserve
NCBR	Narodowe Centrum Badań i Rozwoju (National Centre for Research and Development)
NDC	Nationally Determined Contribution
NFOŚiGW	Narodowy Fundusz Ochrony Środowiska i Gospodarki Wodnej (National Fund for Environmental Protection and Water Management)
non-ETS	sectors not covered by the EU ETS
NPRGN	Narodowy Program Rozwoju Gospodarki Niskoemisyjnej (National Scheme for the Development of Low-Carbon Economy)
NRA	Japanese Nuclear Regulation Authority
NSI	Narodowa Strategia Integracji (National Integration Strategy)
OECD	Organisation for Economic Cooperation and Development
UN	The United Nations
RES	energy from renewable sources
PEV	plug-in electric vehicles with 2 supply types
PFC	perfluorocarbons
KP	Kyoto Protocol
GDP	gross domestic product
PA	Paris Agreement
PPP	Purchasing Power Parity
REDD+	reducing emissions from deforestation and forest degradation
SBI	Subsidiary Body for Implementation
SBSTA	Subsidiary Body for Scientific and Technological Advice
RDP	Responsible Development Plan
TEN-T	Trans-European Transport Network
VAT	Value Added Tax
EU	European Union
UNFCCC	United Nations Framework Convention on Climate Change
USD	American Dollar

Introduction - Prologue

United Nations Framework Convention on Climate Change (UNFCCC) was adopted in New York on 9 May 1992 and submitted to the countries for conclusion during the "Environment and Development" Conference in Rio de Janeiro in June of the same year (hereinafter referred to as the Convention, Climate Convention or UNFCCC)1. It came into force on 21 May 1994.

The basic objective of the Convention is to stabilize the greenhouse gas emission at a level, which would mitigate the negative impact of human activities on climate changes. The Climate Convention assumes international cooperation for tackling climate changes, especially limiting the emission of greenhouse gases responsible for the phenomenon of global warming.

The Convention was agreed and signed in June of 1992 and constituted a formal beginning of international cooperation for counteracting climate changes and also contributed to the development of further agreements in this field. The Convention obliges the countries to cooperate in the field of reducing greenhouse gas emissions, adapting to climate changes, scientific research and systematic climate monitoring, disseminating the technologies, practices and processes reducing anthropogenic emissions of greenhouse gases, reporting greenhouse gas emissions and financially aiding developing countries in this regard. The Convention was ratified by 196 countries. The first agreement, which supplemented and specified the provisions of the Convention is the Kyoto Protocol, passed in December 1997.

Poland, by signing the Kyoto Protocol on 15 July 1998, committed to reduce greenhouse gas emissions by 6% in the years 2008-2012, compared to the level of emissions in 1988. Poland exceeded this objective, because domestic GHG emission reductions in the years 2008-2012 were estimated at a level of ca. 30% compared to the baseline year.

In May 2004, Poland became a Member State of the European Union. Since then, together with other Member States and the European Commission, Poland has been co-shaping the climate energy policy of the EU and has been involved in negotiations conducted by the Member States within the Climate Convention. In 2011, Poland, taking the presidency of the EU Council was, i.a., responsible for developing a joint EU position. It also applied to climate negotiations and the COP18 in Doha taking place during the Polish presidency of the EU, which involved adopting, i.a., an Amendment to the Kyoto Protocol, the so-called Doha Amendment.

In December 2015, during the COP in Paris, the so-called Paris Agreement was adopted, which constitutes the next step in the climate policy after the Kyoto Protocol, engaging all parties to the Convention in climate protection activities. The agreement was signed by Prime Minister Beata Szydło on 22 April 2016 in New York. Next, on 6 October 2016, President Andrzej Duda concluded a law ratifying the agreement and the letters (instruments) of ratification were submitted by Poland on 7 October 2016. On 28 September 2018, Poland submitted an instrument of ratification regarding an amendment to the Doha Amendment at the General Secretariat of the United Nations in New York.

Poland may take pride in many years of active involvement in climate negotiations at the UN forum. Polish representatives were involved in both the development of the Convention itself, as well as in its implementation, since its entry into force, which took place in 1994.

COP24 in Katowice will be the third Conference of the Parties organized in Poland. So far, Poland has already acted as a host of the Conference of the Parties to the UNFCCC: COP14 was held in Poznań in 2008, while COP19 took place in Warsaw in 2013. It should be noted that in 1999, during COP5 in Bonn, the position of the President was held by Jan Szyszko, acting as the Representative of the Government for the Climate Convention. This means that the current Secretary of State in the Ministry of Environment and the Representative for the Presidency of COP24, Michał Kurtyka, will act as a COP President as the fourth Pole in history. This function, on behalf of Poland, was previously held by, in chronological order: prof. Jan Szyszko - COP5 President (in the years 1999-2000), prof. Maciej Nowicki - COP14/CMP4 President (in the years 2008-2009) and Marcin Korolec - COP19/CMP9 President (in the years 2013-2014).

[1] OJ 1996 No. 53, item 238

Achievements of COPs hosted by Poland

The result of the 14th Conference of the Parties to the Climate Convention (COP14) held in Poznań in 2008 was, among others:

- launching of the Adaptation Fund, which was established in order to ensure the financing for projects and adaptation schemes in developing countries, exposed to the negative effects of climate changes;
- adopting the Poznań Strategic Programme on Technology, aimed at assisting in a rapid and effective transfer of climate-friendly technologies; and
- starting the GreenEvo programme: Green Technology Accelerator, developed in order to promote Polish environmental technologies and support the development of companies in the field of environmental protection.

The achievements of the Conference of the Parties to the Climate Convention (COP19), which took place in Warsaw in 2013 include:

- creating of the Warsaw International Mechanism for Loss and Damage aimed at financing the adaptation activities, as well as operations associated with the effects of rapid climate change phenomena in developing countries. The Warsaw Mechanism is a particular achievement of the Warsaw Summit since the most exposed countries had lobbied in favour of its establishment since the very conclusion of the Convention, hence, more than 20 years;
- the Warsaw Framework for REDD+ were defined - a system designed to protect tropical forests. The REDD+ mechanism refers to the issue of deforestation and forest degradation;
- solid foundations had been laid for a new climate agreement, which was to be agreed in Paris in 2015;
- thanks to the démarches during the Polish presidency, it was possible to mobilize the countries - parties to declare a total of USD 100mn in donations to the Adaptation Fund;
- a decision was made with regard to financing the Green Climate Fund - among others, it was agreed that the developed countries would annually allocate a minimum of USD 10mn for tackling climate changes in the developing countries, in order to further mobilise funds from private sources.

Poles within the Climate Convention authorities

Polish representatives have been present in the bodies of the institutions and authorities functioning within the Climate Convention for many years. Apart from the aforementioned highest positions of the Presidents of the Conferences of the Parties, since the 1990s' Poles have often been the members of the COP Bureau. Over the years, Poles have acted as the presidents of subsidiary bodies to the Convention, the SBSTAs (Subsidiary Bodies for Scientific and Technological Advice) and twice as presidents in the SBI (Subsidiary Body for Implementation). Poles are also present in such UNFCCC bodies as: the GCF (Green Climate Fund), the APA (Ad Hoc Working Group on the Paris Agreement), the EC WIM (Executive Committee of the Warsaw International Mechanism for Loss and Damage), the CDM EB (Clean Development Mechanism Executive Board), the JISC (Joint Implementation Supervisory Committee), the AC (Adaptation Committee) and the AF (Adaptation Fund) or the UNFCCC Roster of Experts.

Economic transformation in Poland

in the light of greenhouse gas emissions

Pre-transformation Poland

1989 is deemed the conventional beginning of the political and economic changes, when Poland left the centrally controlled economic system and started to follow the path of transformation towards market economy. However, before the system and economic structure changed, one of the first effects of such a breakthrough was the initial decrease in production. The year 1990 – assumed as the baseline year in the Kyoto Protocol – was the first year in Poland after the essential transitions, which was clearly exhibited by the imbalance of economic stability[2]. It was in 1990, when the transitional collapse of the Polish economy happened. This is why the volume of greenhouse gas emissions in 1990 did correspond neither to the normal emissions level, which result from the developmental demand of our country, nor the actual economic potential of Poland. Therefore, this year, as a baseline year, was not conclusive for the Polish economy. It was taken into account during Kyoto Protocol negotiations and consequently, the reference level for estimating emission reductions under this agreement was set for the year 1988.

Pre-transformation Poland, as a country with an area of ca. 312km^2 is different from the country we see today. In 1988, the total population amounted to 37.9mn, population density was 121 inhabitants/km^2, and the natural growth rate was - 5.7‰. The population in the cities accounted for 61.2% of the total Polish population. There were 860 cities in Poland, while 20 of those were inhabited by more than 200 thousand citizens. The capital of Poland - Warsaw - had a population of 1.7mn, and just like today, it was the biggest city in the country.

In 1988 Poland had a centrally controlled economy, and at the same time was experiencing a socio- political conflict. One of the adverse effects of such a state was a high inflation level (62.2%) and, additionally, the so-called hidden inflation caused, i.a., by the regulation of food products. On the other hand, unemployment was minimal (below 1%). At the time, Poland significantly diverged from the wealth level of other European countries, for example, with an almost three-fold difference in the GDP and the purchasing power parity per capita. Families allocated a major part of their expenditure to food and fixed housing fees, which accounted for more than 45% to almost 64% of the total household expenditure.

GDP energy-consumption in 1988 was 23.6 kJ/USD'94 ppp. The basic factors responsible for such a value of this index were, i.a., low economic efficiency in the past, low share of carriers, i.e., oil and natural gas in the primary energy structure; low share of highly-productive carriers, i.e., electricity and liquid and gas fuels in the final energy structure, and the low consumption of electricity per capita.

The energy consumption share in 1988 amounted to 42% for industry, 1.5% for the builidng sector, 2% for agriculture, 5% for transport and 1% for the household sector, with the remaining part assigned to all other sector together. Energy consumption per capita in 1988 was 14.04 GJ. The energy demand and supply balance in Poland was largely based on fossil fuels - coal accounted for 76.5%, oil for 14.3% and gas for 7.8%. The share of renewable energy sources in the domestic primary energy consumption structure was below 1%.

Industry was the largest contributor in the GDP structure – its share in 1988 reached an estimated level of 49%. Processing of primary raw materials - energy and material-consuming - was the main distinguished of the industry of that period. In the same year, the construction sector was responsible for 12% of the GDP, just like agriculture (the total agricultural production remained stable since 1983). Polish debt in 1988 amounted to USD 30bn.

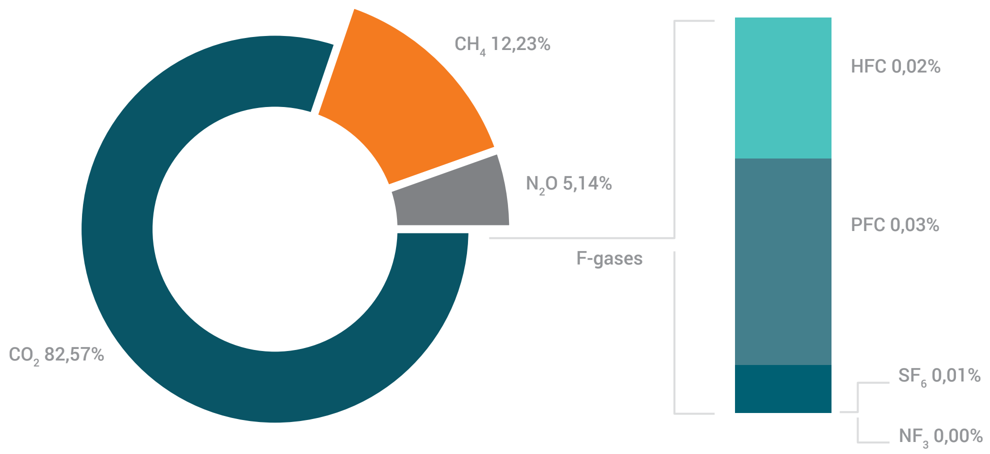
In 1988 there were almost 8.7mn ha of forest in Poland, which accounted for 28% of the country's area (27.7% forest coverage).

Capital expenditure on environmental protection in 1988 amounted to approx. 0.8% of the distributed national income, including ca. 22bn zloty (pre-denomination) for atmospheric air protection. Unfortunately, it did not translate into the desired effects and in many regions, the pollution standards were significantly exceeded.

[2] A detailed explanation of adopting 1988 as the baseline year for Poland is included in the 1st governmental Report for the Conference of the Parties to the convention (1994)

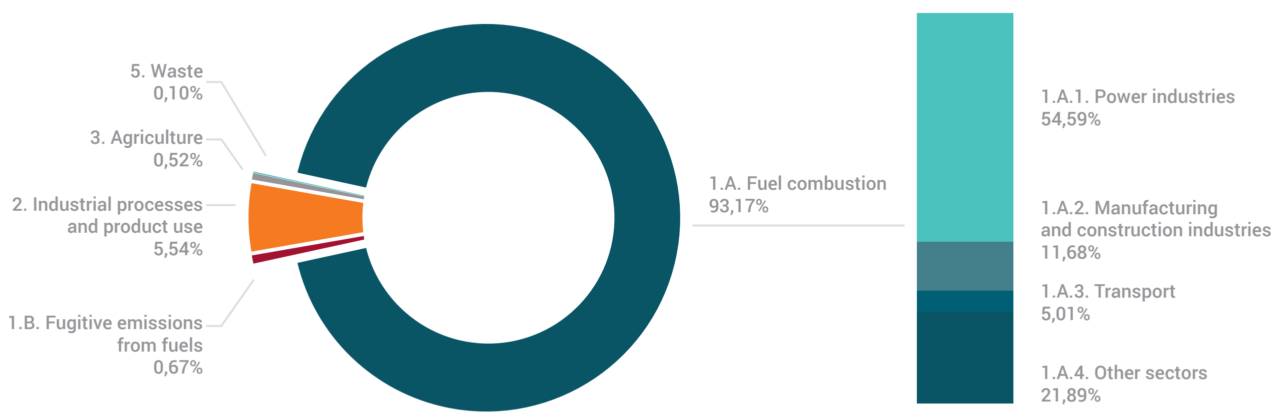
Regardless of the effects of a centrally controlled economy, Poland with its economic indicators, was included in Annex I to the United Nations framework convention of the on climate change. Ratification of the Convention resulted in the same obligations imposed on Poland, as in the case of other countries referred to in this Annex. The most important was to return, by the end of this decade, to the previous level of anthropogenic emission of carbon dioxide and other greenhouse gases not covered by the Montreal Protocol (art. 4 par. 2 cl. (a) of the convention). For this group of countries, it meant a return to the emission level of 1990, whereas for Poland, it meant a stabilization of the emissions in 2000 at a level from 1988. The reasons for Poland adopting an assumption regarding the change of the baseline year from 1990 to 1988 were described above.

Fig. 1. Share of individual GHGs in the total domestic emissions 1988 (w/o LULUCF)



Source: KOBiZE own study

Fig. 2. Carbon dioxide emissions (exc. LULUCF) in 1988, by category



Source: KOBiZE own study

Greenhouse gases emission in Poland during transformation

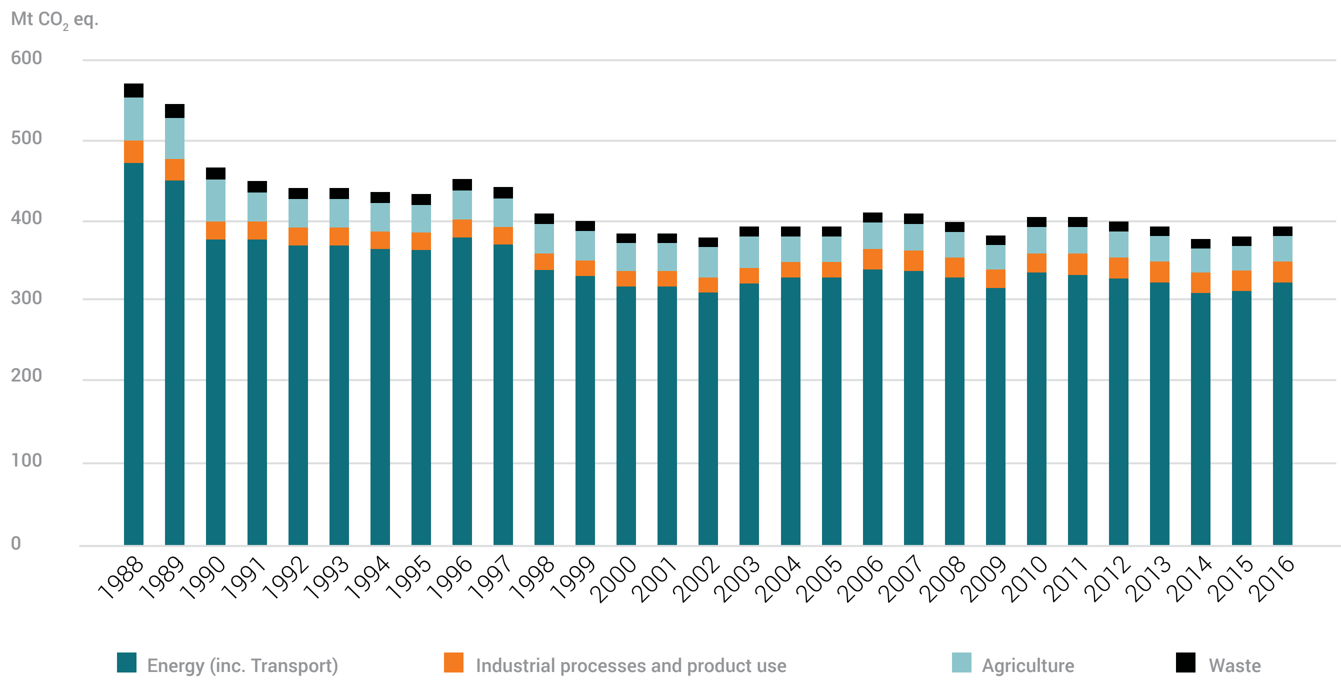
Over the last nearly 30 years, Poland has come a long way from an economy based on central planning, with an inefficient industry and agriculture and a poorly developed service sector, to a market economy, joining the ranks of developed countries. One of the challenges still ahead of Poland is to reconcile economic growth (avoiding the average income trap, in particular) with attention to the environment, including the reduction of greenhouse gas emissions. Nonetheless, transformations and the associated, at least in its initial period, decrease in the production led to a halt in the economic growth in Poland between 1989 and 1991 and a large decline in the GDP. It was possible to make up for this decline only in 1993. Therefore, this was a significant socio-economic cost, and the GDP loss caused by the economic transformation had to be made up for in the years to come.

During the post-1989 transformation period, Poland witnessed a significant progress, one of the largest in Europe, in the field of effectively utilizing energy and improving the quality of the environment. The largest contributors were the power and industry sectors, which recorded improved trade indices, as well as witnessed beneficial structural changes. Most of the changes and improvements resulted from the restructuring of the economy and modernization of industrial plants, which led to, among others, improving energy efficiency. Reduced hard and brown coal consumption in favour of petroleum fuels has been recorded for many years, while the RES energy share in the final gross energy consumption has been steadily rising, and in 2016 exceeded 11%. All these activities resulted in Poland, with a large surplus, meeting its reduction target specified in the Kyoto Protocol, namely, reducing emissions by 6% in the years 2008-2012, compared to the emissions in the baseline year.

Despite such a difficult transformation period, the efforts Poland made were very fruitful, which is highlighted by the fact that on 24 September 2018 Poland joined a group of 25 most developed economies in the world, which includes, among others, Germany, Japan or the United States. No other country managed to do so within the last decade. Poland became the pioneer and economic leader in Central and Eastern Europe.

Another important aspect from the country's perspective, not only political, but also economic and environmental, was the Polish accession to the European Union. Opening the door for the EU enabled to take the chances provided by EU's internal market and the free movement of goods, people, capital and services. From the point of view of the environment, it

Fig. 3. Greenhouse gas emissions in the period 1988-2016



Source: KOBiZE own study

was extremely important to adapt Polish legislation and the imposed duties to the requirements of EU's environmental policy. On one hand, some of the actions at EU level were very strict from the Polish perspective and it was possible to negotiate the introduction of temporary deviations, also in the field of emission, e.g. low emission derogations, derogations within the climate and energy package. On the other hand, the fact that European integration also opened new sources for financing the investments aimed at improving the state of the environment in Poland was very positive.

From the very beginning of the transformation, a model in which the income from fees and penalties for introducing pollution into the environment fund the NFOŚiGW and provincial funds has been functioning in Poland. Since its establishment in 1989, the National Fund has contributed to improving the quality of the environment, also in the scope of the climate. Since 2004, which was the year Poland joined the EU, the Fund has been an important institution providing support for the beneficiaries in the scope of own contribution necessary to acquire EU funding. The Infrastructure and Environment Programme as well as the LIFE Programme are widely used in this field. Moreover, the structure of the Fund provides an opportunity to have a genuine impact at the regional and local levels.

The total domestic GHG emission in 2016 amounted to 395,82mn tons excluding the emission and absorption of category 4 greenhouse gases. Land use, land-use change and forestry (LULUCF). Compared to the baseline year, the volume of emissions in 2016 decreased by 30.6% (tab.1).

Table 1. Domestic greenhouse gas emissions in the baseline year and in 2016

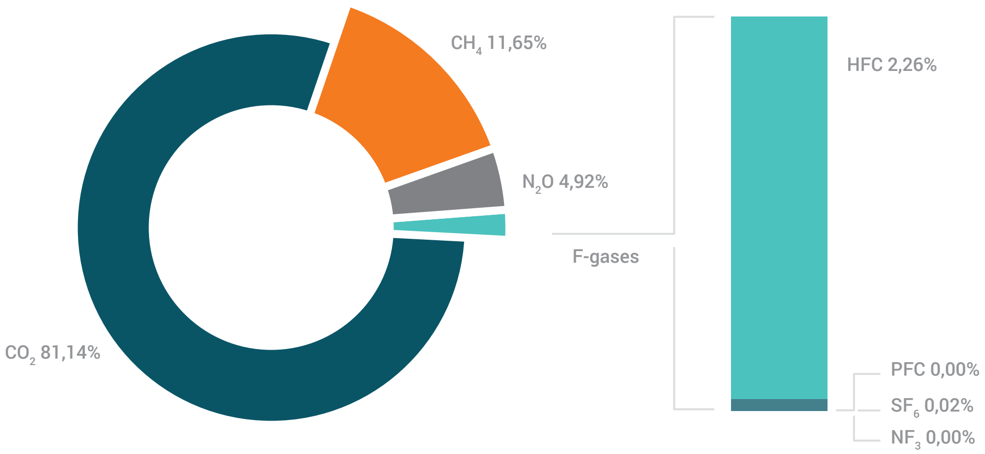
Greenhouse gas	Emissions in CO_2eq [kt]		(2016- baseline) /baseline [%]
	Baseline year	2016	
CO_2 - with LULUCF	454 509,07	291 962,85	-35,76
CO_2 - w/o LULUCF	470 650,56	321 182,01	-31,76
CH_4 - with LULUCF	69 765,46	46 154,18	-33,84
CH_4 - w/o LULUCF	69 721,30	46 109,36	-33,87
N_2O - with LULUCF	29 492,29	291 962,85	-29,79
N_2O - w/o LULUCF	29 322,00	321 182,01	-33,55
HFC	134,69	46 154,18	6 550,21
PFC	171,97	46 109,36	-92,70
Miks HFC i PFC	NA,NO	NA,NO	NA,NO
SF_6	29,12	78,38	169,13
NF_3	NA,NO	NA,NO	NA,NO
Total - with LULUCF	554 102,60	367 871,72	-33,61
Total - w/o LULUCF	570 029,64	395 823,53	-30,56

The baseline year is understood in table 1. and the entire report as: 1988 for CO_2, CH_4 and N_2O, 1995 for HFCs, PFCs and SF_6 , and 2000 for NF_3.

Source: KOBiZE own study

Carbon dioxide (81,1%) has a dominant role in the domestic emissions, with the share of methane and nitrous oxide significantly lower, at a level of: 11,6% and 4,9%, respectively. Fluorinated industrial gases (so-called F-gases) have a minor share in the domestic GHG emissions (a total of ca. 2,3%), while NF_3 emissions were not recorded in Poland. The share of individual gases, not taking into account the category 4 emissions and absorption are depicted in figure 4.

Fig. 4. Share of individual GHGs in the total domestic emissions 2016 (w/o LULUCF)



Source: KOBiZE own study

Table 2 shows greenhouse gas emissions expressed in CO_2eq for the baseline year and 2016, and their changes divided into main source categories. All source categories recorded a decrease in the emission compared to the baseline year, while increased coal absorption is visible in sector 4. The biggest decline in GHG emissions was recorded in the following categories: 1. Energy and 3. Agriculture (31% and 37%, respectively). In the Energy sector this was caused by the heavy industry

Table 2. Domestic emissions of greenhouse gases by category, baseline year and 2016

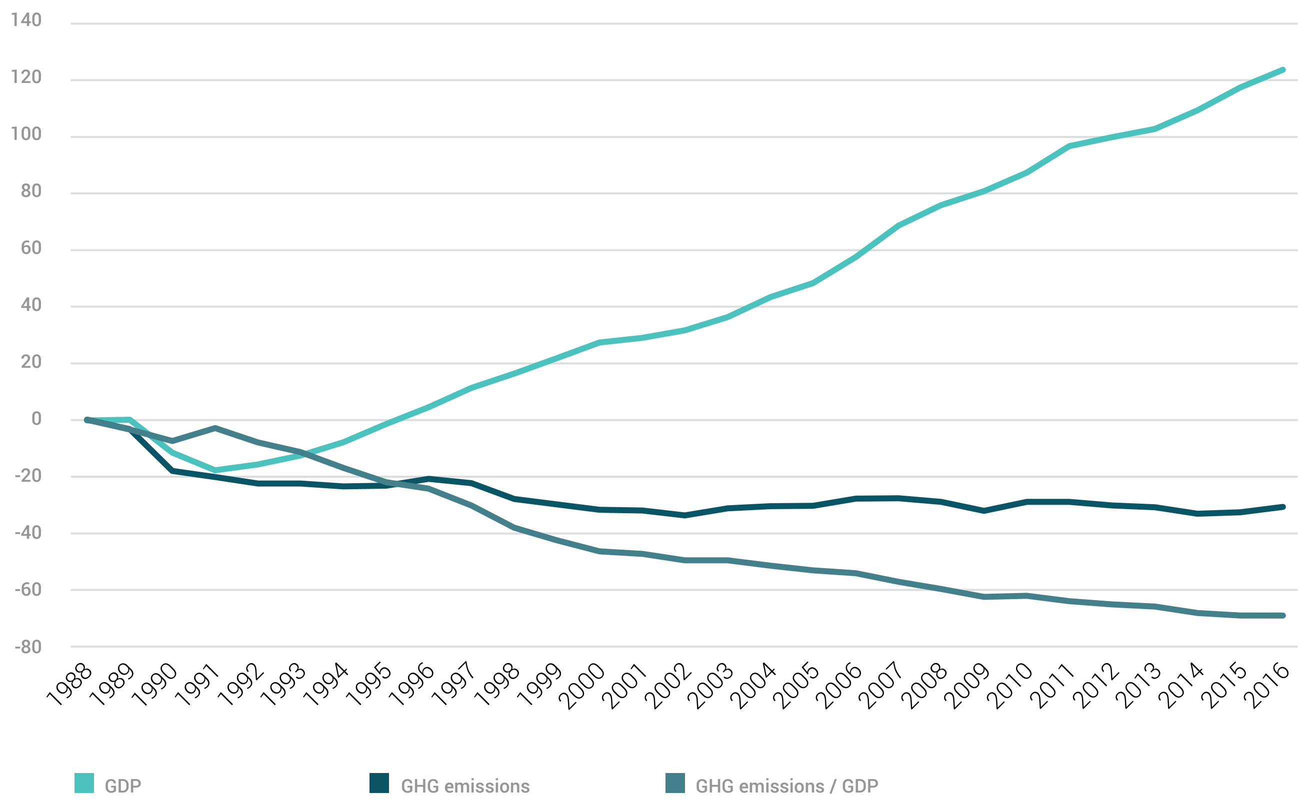
	Total [mt CO_2 eq.]		(2016- baseline)/ baseline [%]
	Baseline year	2016	
TOTAL (with LULUCF)	554 102,60	367 871,72	-33,61
TOTAL (w/o LULUCF)	570 029,64	395 823,53	-30,56
1. Energy	474 732,14	326 536,84	-31,22
2. Industrial processes and product use	31 386,74	28 666,35	-8,67
3. Agriculture	47 835,68	30 062,89	-37,15
4. Land use, land use change and forestry	-15 927,04	-27 951,80	75,50
5. Waste	16 075,08	10 557,45	-34,32

Source: KOBiZE own study

transformation process in Poland, decline in the coal extraction and consumption, as well as implemented actions for a more effective utilization of energy. Whereas such a significant emission reduction in agriculture was caused by post-1989 structural and economic changes, including a reduction in livestock and crop production (e.g. cattle population decreased in the years 1988-2016 from over 10mn to less than 6mn, and sheep population from over 4mn to approx. 240 thousand). (tab.2).

A wide package of structural, legislative and economic changes ultimately results in a simultaneous economic growth and emission decrease. In the period from 1988 to 2016, Poland recorded an almost two-fold decrease in the GDP and a 30% decrease of GHG emissions. The phenomenon of the separation of the two processes, which from a historic perspective could follow a similar course was called decoupling. It is particularly visible when referencing greenhouse gas emissions and energy consumption to the GDP, where the changes have already exceeded -60%.

Fig. 5. Decoupling of emissions from economic growth - changes in the GDP and greenhouse gas emissions compared to 1988

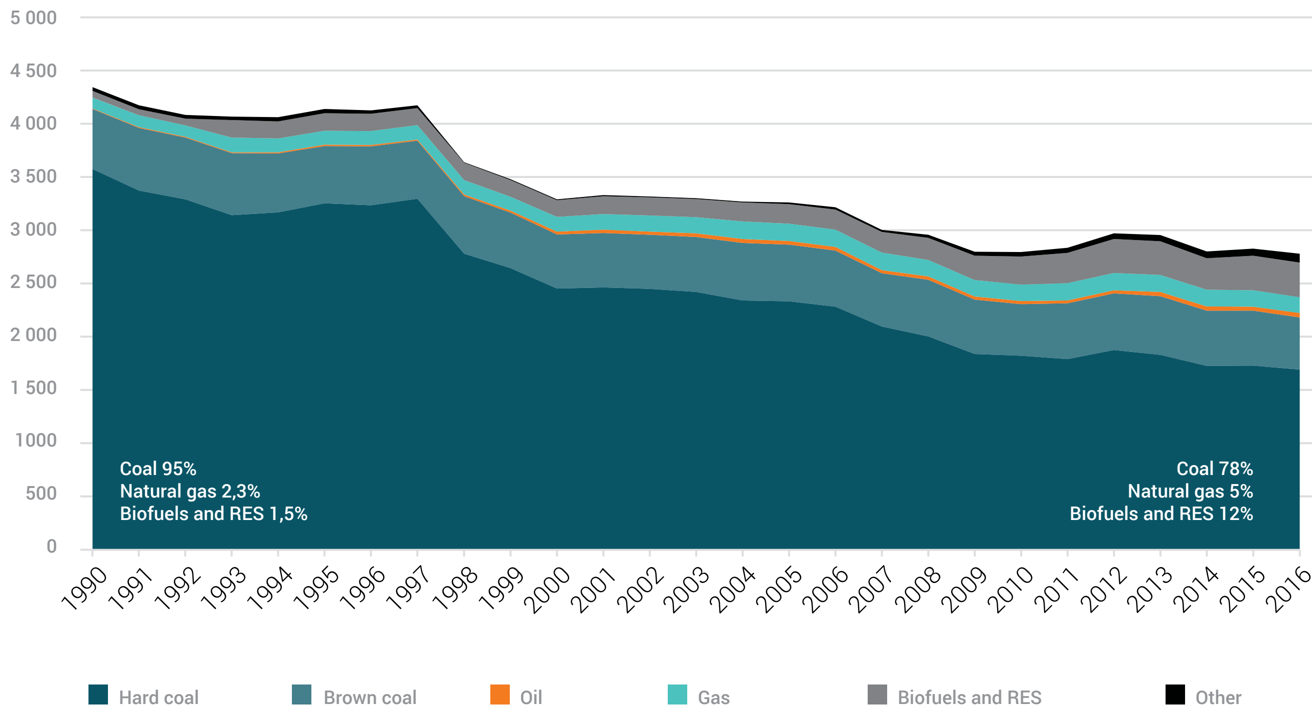


Source: own study based on: World Bank, KOBiZE

Changes in the energy sector

After 1989, Polish energy policy significantly focused on transforming the energy sector, which involved adapting the industry to the requirements associated with the reform of the entire Polish economy, eliminating many years of negligence, especially in the field of manufacturing efficiency and environmental protection. The energy sector dominated by State property, strictly centralized and managed through a command-and-quota system had to be adapted to a new, free-market economy focused on creating competitive condition within the industry and to the environmental protection requirements in the field of commitments adopted by Poland. The restructuring of the Polish energy sector was to mainly involve dividing the activities into three sub-sectors: distribution, trading and generation, and was supposed to be based on demonopolization, with privatization being the next step. The privatization process was possibly only after a deep decentralization and the implementation of market mechanisms[3]. However, at the beginning of the 21st century it turned out that the restructuring and privatization strategies for the power sector, which had been under implementation since the mid-1990s, had failed to result in the actual competition and improved efficiency. The main reasons for this included, i.a., the lack of a systemic solution to the problem of long-term contracts and the absence of unanimity and consistency in implementing the schemes, as well as the failure to accomplish the privatization objectives and the sector consolidation plans. New objectives of the energy policy were to be accomplished through the construction of a competitive energy market, creation strong entities capable of competing with foreign companies and the establishment of clear legislative regulations. The process of "vertical consolidation as a more effective solution, providing a possibility of a better use of the economy of scale and synergy at a specific degree of concentration" was launched[4]. As a result, four energy capital groups were created, and a Transmission System Operator and Distribution System Operators as independent legal entities were separated. A restructuring plan for long-term contracts was developed. The changes observed within the Polish energy sector over the last dozen or so years satisfy the basic principles of the energy

Fig. 6. Primary energy acquisition structure in Poland, 1990-2016 [PJ]



Source: own study by KOBiZE based on EUROSTAT

[3] Demonopolizacja i prywatyzacja elektroenergetyki [Demonopolization and privatization of the power sector], document by the Economic Committee to the Council of Ministers, Warsaw 1996.

[4] Program dla elektroenergetyki [Power sector strategy], The Ministry of Economy, Warsaw, 27 March 2006

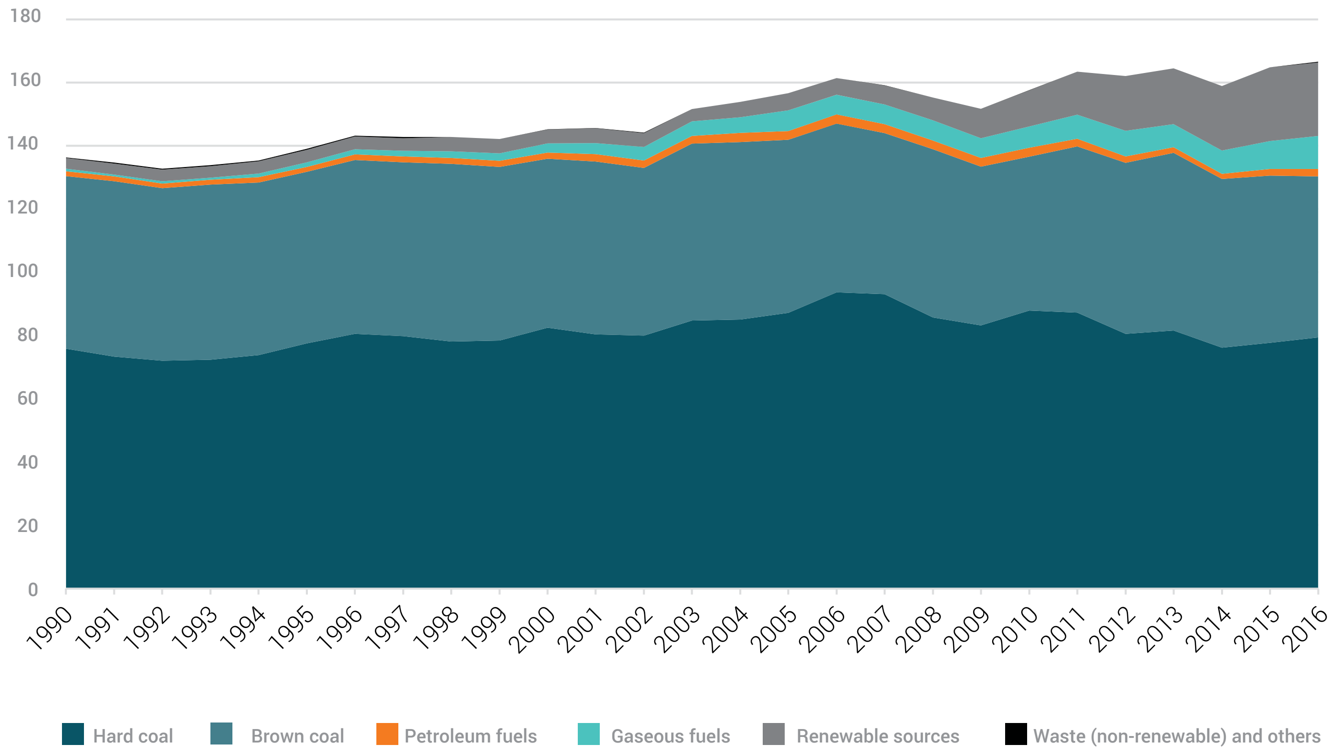
market liberalization process. These are: commercialization, privatization, separation of activities, access for third parties, competition and the supervision of an independent regulator. Gradual liberalization of the Polish energy market significantly impacts the development of the industry. In free-market conditions, due to the optimization of functional costs, with the costs associated with the new, increasingly stringent environmental regulations being their significant components, the energy generation technology is gradually changing.

The structure of primary energy acquisition for the entire economy has changed in Poland over the last thirty years. The primary energy acquisition level decreased from 4 344 PJ in 1990 to 2 781 PJ in 2016. The share of coal in the primary energy acquisition structure declined from more than 95% in 1990 to 78% in 2016, while the acquisition of brown coal is constantly at a similar level. At the same time, the importance of biofuels and renewable energy sources increased: from approx. 1.5% in 1990 to 12% in 2016.

The factor having a decisive impact on decreased acquisition of primary energy was a decline in hard coal mining. This is associated, among other, with decreased demand and a significant decline in the export of this fuel.

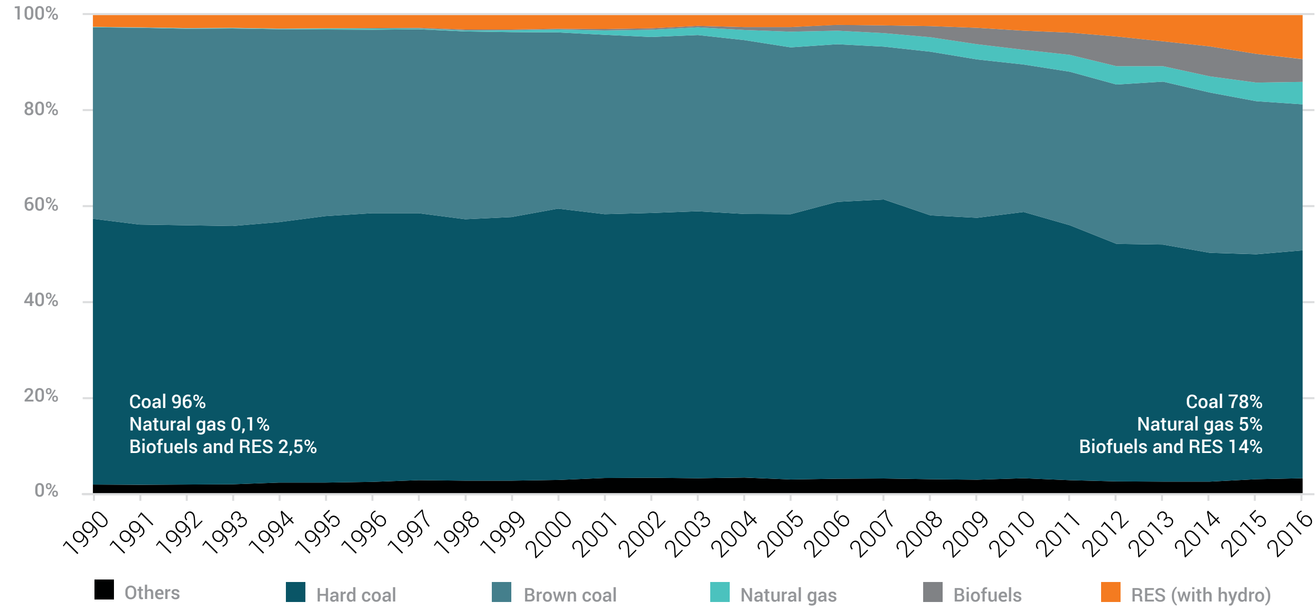
Electricity generation increased from a level of 136 TWh in 1990 to 166 TWh in 2016. Coal is the dominating raw material in the electricity generation structure. Coal-fired electricity generation has been at a similar level between 130 and 140 TWh since 1990, however, the share of coal in production fell from 96% in 1990 to 78% in 2016. Production of electricity from renewable energy sources and biofuels jumped from 2.5% in 1990 to 14% in 2016.

Fig. 7. Electricity generation in Poland, 1990-2016 [TWh]



Source: own study by KOBiZE based on EUROSTAT

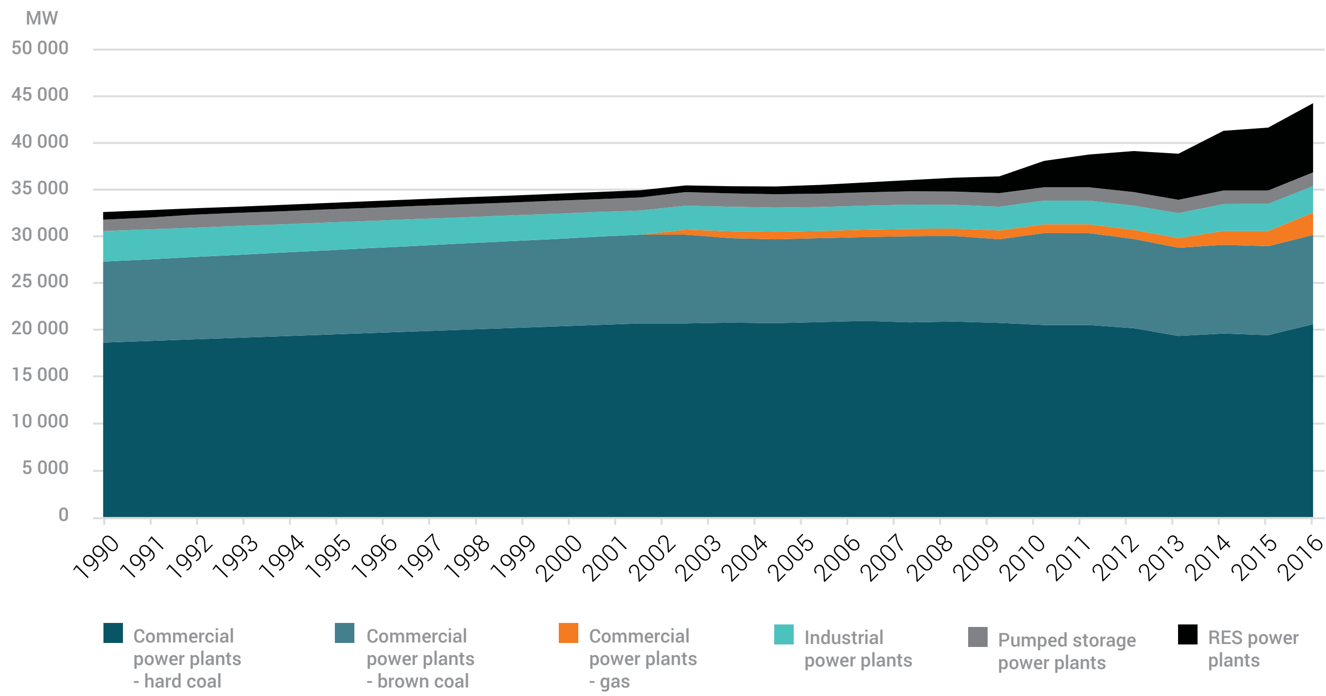
Fig. 8. Electricity generation structure in Poland, 1990-2016



Source: own study by KOBiZE based on EUROSTAT

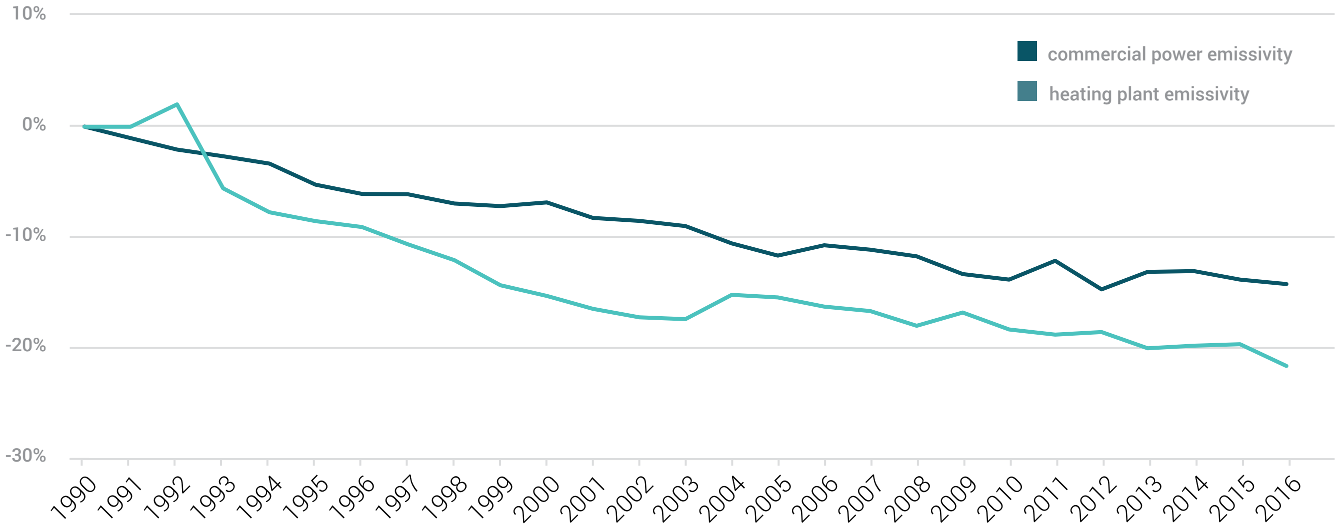
The installed capacity in the system in the years between 1990 and 2017 increased by over 11 GW, i.e., by more than 35%, whereas, starting from 2006, these increases mainly involved renewable energy. At the end of 2017, the total installed RES capacity was equal to 7256 MW. An increase in the installed gas-fired energy capacity is also visible.

Fig. 9. Installed capacity in KSE (National Grid System), 1990-2017



Source: own study by KOBiZE based on PSE and Eurostat

Fig. 10. Changes in the emissivity [CO_2] of the electricity and heat generation sector compared to 1990

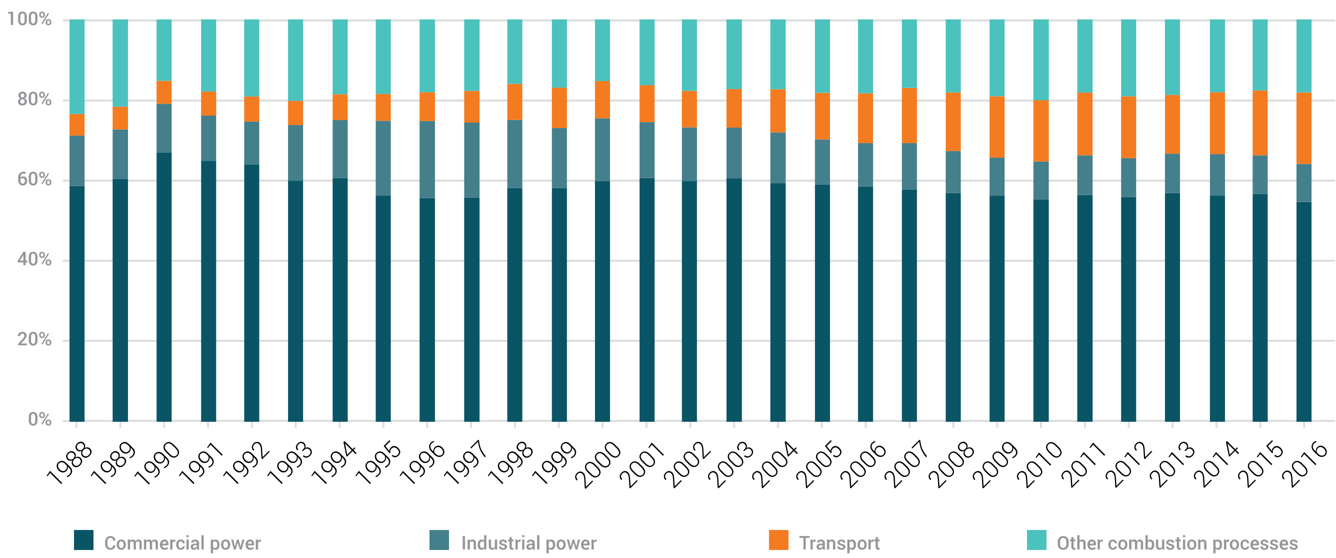


Source: KOBiZE own study

The effects of the energy sector restructuring since 1990 are manifested by the gradually decreasing emissivity of this sector.

By dividing the fuel combustion sector into smaller industries, Fig. 11. shows that since 1988, invariably, over 50% of CO_2 emission has come from commercial power plants. The second most emissive industry is a collection of all kinds of small industrial services, fuel combustion in agriculture and the communal-housing sector (households). In this case, the average share of carbon dioxide emissions did not exceed 20% of the general balance. The last two industries, namely transport and industrial energy, take over from 17% (beginning of the industrial transformation) to over 30% of the general emission (2016). The share of these two sectors has risen almost twofold throughout the years in question. The distribution inside the sectors is quite interesting, i.e., industrial energy limited emissions by 25% compared to 1988, and the emissions in transport has more than doubled compared to the same year.

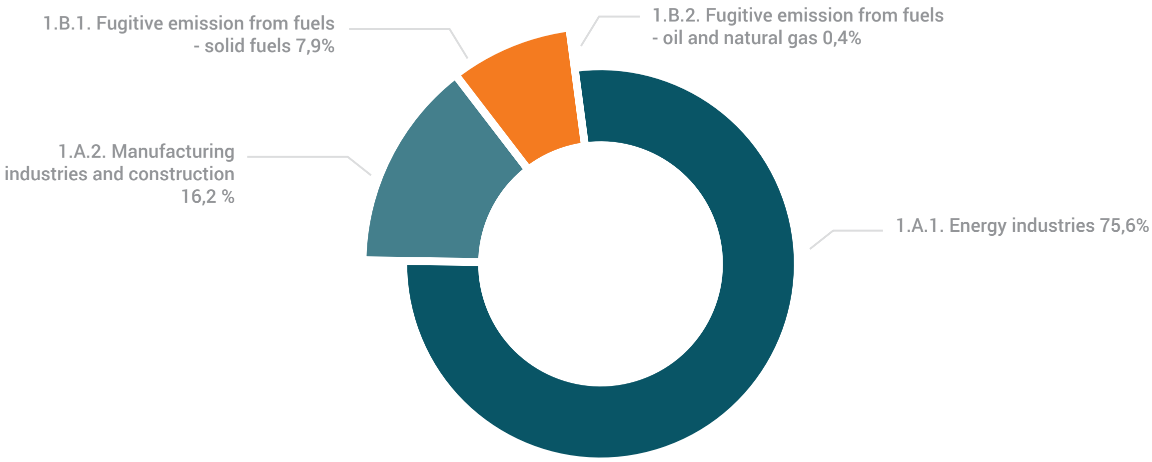
Fig. 11. Sectoral share in the fuel combustion emission balance, 1988-2016



Source: own study by KOBiZE based on EUROSTAT

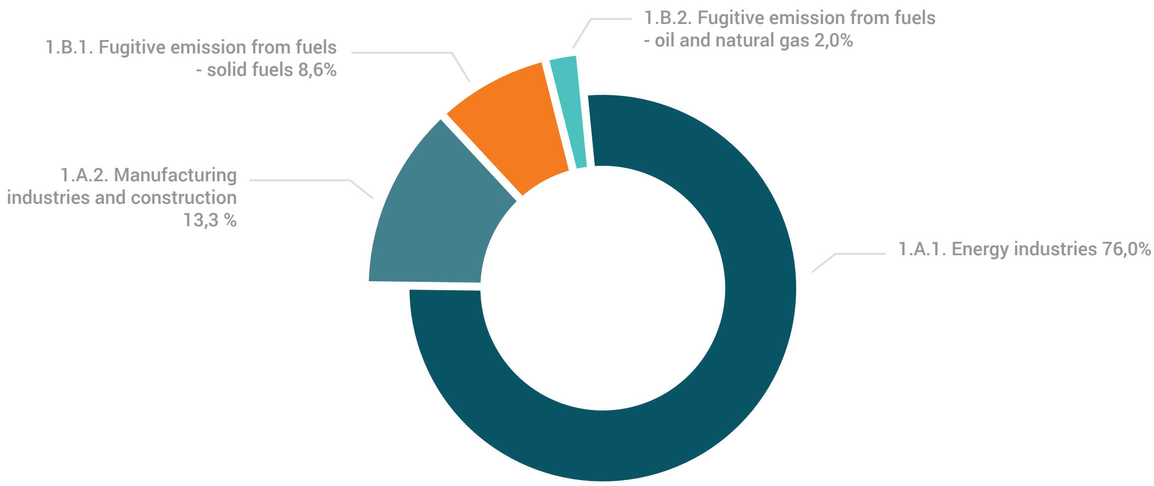
The dominant share in the emissions associated with the energy sector, both in 1988 and 2016 was recorded by the energy generating industries, and their subcategory 1.A.1.a. Electricity and heat generation. (47-60%). Changes in this subcategory had the greatest impact on the emission trend in category 1. Energy. A decline in the emissions stems mainly from a decrease in the fuel consumption in this sector and a fall in the share of hard and brown coal in the fuel structure (in subcategories 1.A.1 and 1.A.2, the total decline in fuel consumption between the baseline year and 2016 amounted to almost 32%, and the fuel consumption share decreased from ca. 90% to ca. 70%).

Fig. 12. Share of sub-sectors in the emissions of the IPCC 1 sector. Energy in 1988. Including all greenhouse gases recalculated to CO_2eq without emissions from transport (1.A.3) and buildings (1.A.4)



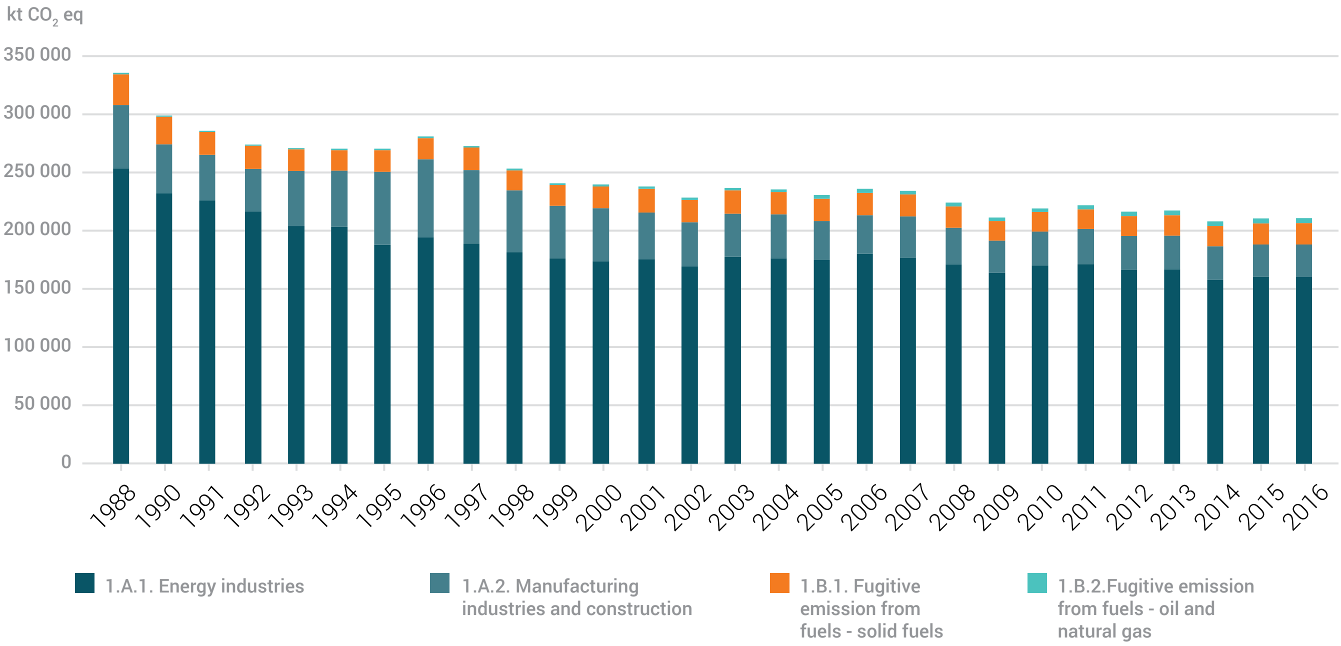
Source: KOBiZE own study

Fig.13. Share of sub-sectors in the emissions of the IPCC 1 sector. Energy in 2016. Including all greenhouse gases recalculated to CO_2eq without emissions from transport (1.A.3) and buildings (1.A.4)



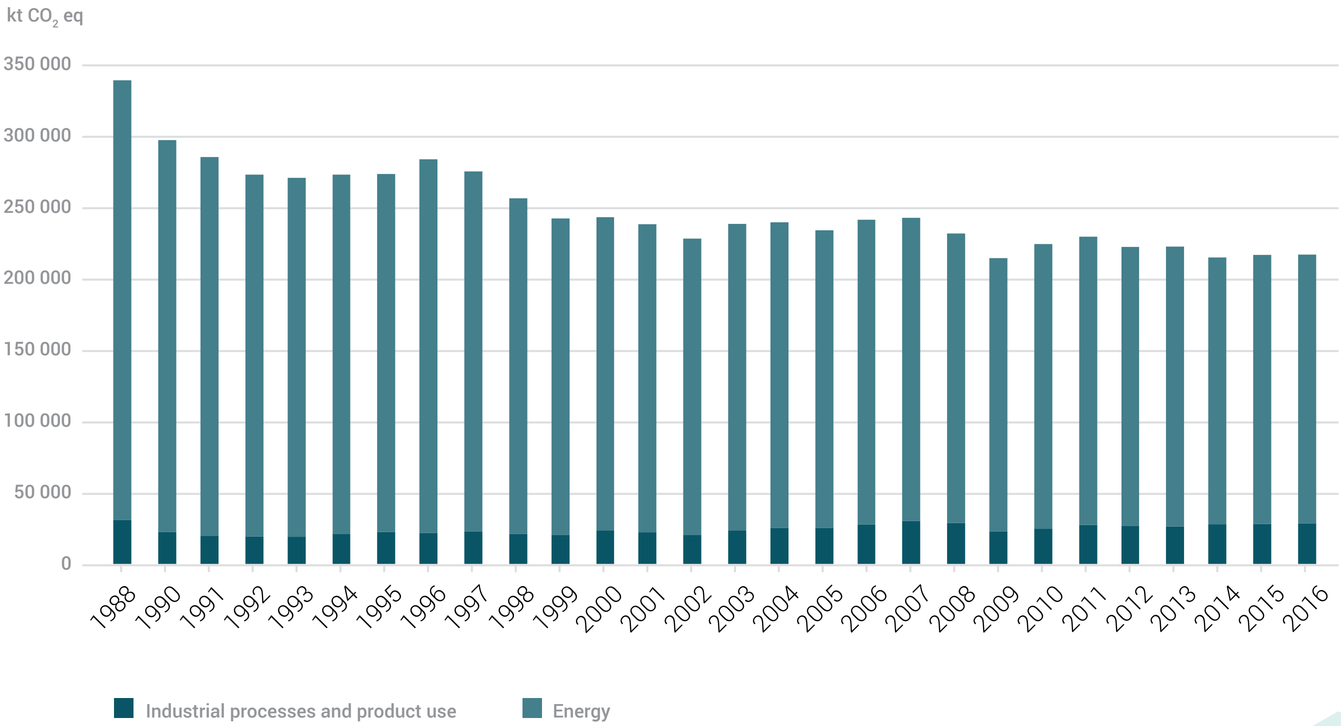
Source: KOBiZE own study

Fig. 14. Emission trend for the IPCC 1 sector. Energy in the years 1988-2016 divided into sub- sectors. Including all greenhouse gases recalculated to CO_2eq without emissions from transport (1.A.3) and buildings (1.A.4)



Source: KOBiZE own study

Fig. 15. Emission trend for the IPCC 1 sector. Energy and IPCC 2. Industrial processes and product use in the years 1988-2016 Including all greenhouse gases recalculated to CO_2eq without emissions from transport (1.A.3) and buildings (1.A.4)



Source: KOBiZE own study

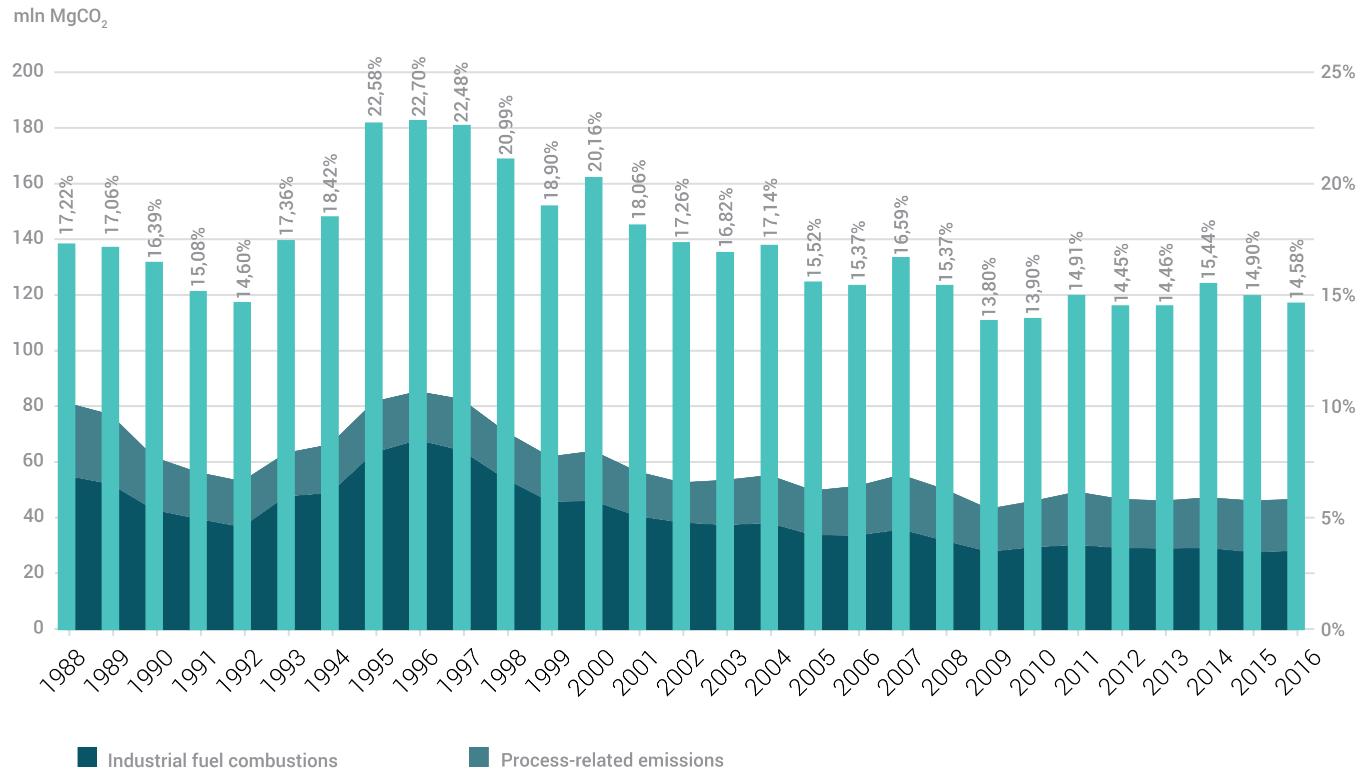
Changes within the industry

In the period before 1989, Poland was dominated by a market of State-owned companies, with most of them classified as heavy industry, and a centrally controlled structure. The distinguishing feature of these enterprises was their low-efficiency and an energy- and material-consuming industry. Political and economic changes at the turn of the 1980s and 1990s forced a turn in the manufacturing technology towards more innovative systems. Above all, the solution decreasing the energy- consumption of production gained importance. The objective of the transitions was also to decrease the industrial production costs through the application of modern technologies and limiting the importance of heavy industry. Additional activities aiming for a uniform distribution of the industry throughout the territory of Poland and enabling the development of small and medium-sized companies formed a part of the tasks determined by the transformation. The privatization of manufacturing plants and opening the Polish market for foreign investors included the implemented market-oriented solutions.

The industrial sector was the main beneficiary of the economic transition. Access to modern technologies resulted in the plants becoming competitive to non-Polish companies. Savings in the raw material economy were introduced, product manufacturing and processing mechanisms improved. Companies began to switch to gas technologies. Generally speaking, numerous factors contributed to reduced industrial emissions. Ultimately, the achieved result was very favourable from the perspective of emission reductions - a relative decrease in carbon dioxide emission in the industrial sector reached over 40% of the value from 1988 (see Fig. 16.). A significant improvement was recorded in the field of fuel combustion, where the emission was limited by 48%. Due to the limitations in the emission reduction possibilities within the process transitions, the progress was not so rapid, however, the achieved relative 28% can be deemed a good result.

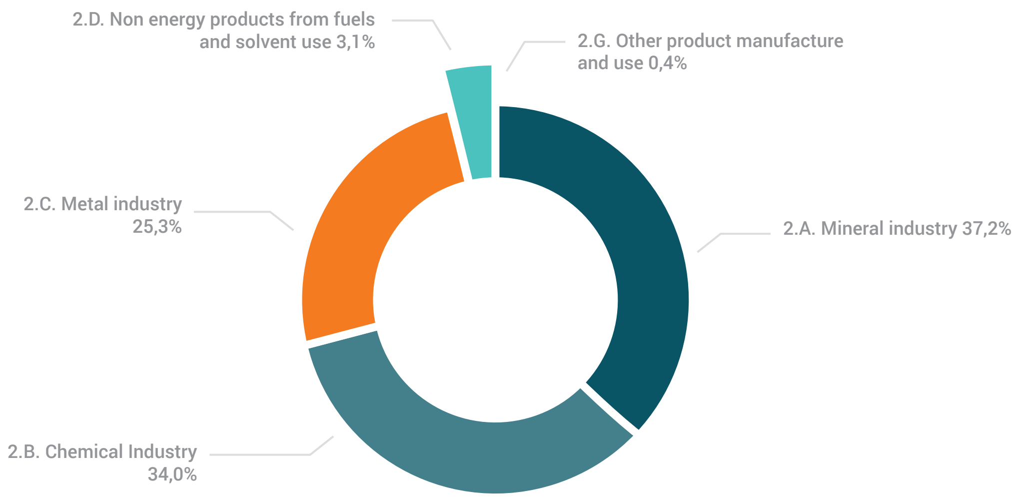
The share of emissions associated with the metallurgical and chemical industries decreased in favour of fluorinated gases used mainly in refrigeration.

Fig. 16. The share of industrial emissions in the general carbon dioxide emission balance in Poland, 1988-2016



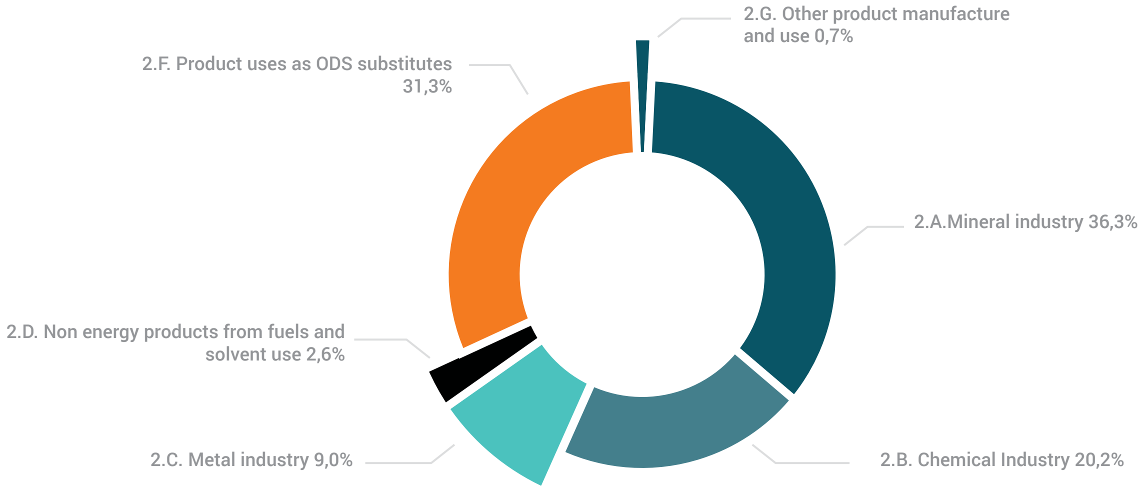
Source: KOBiZE own study wg EUROSTAT

Fig. 17. Share of sub-sectors in the emissions of the IPCC 2 sector. Industrial processes and product use in 1988. Including all greenhouse gases recalculated to CO_2eq



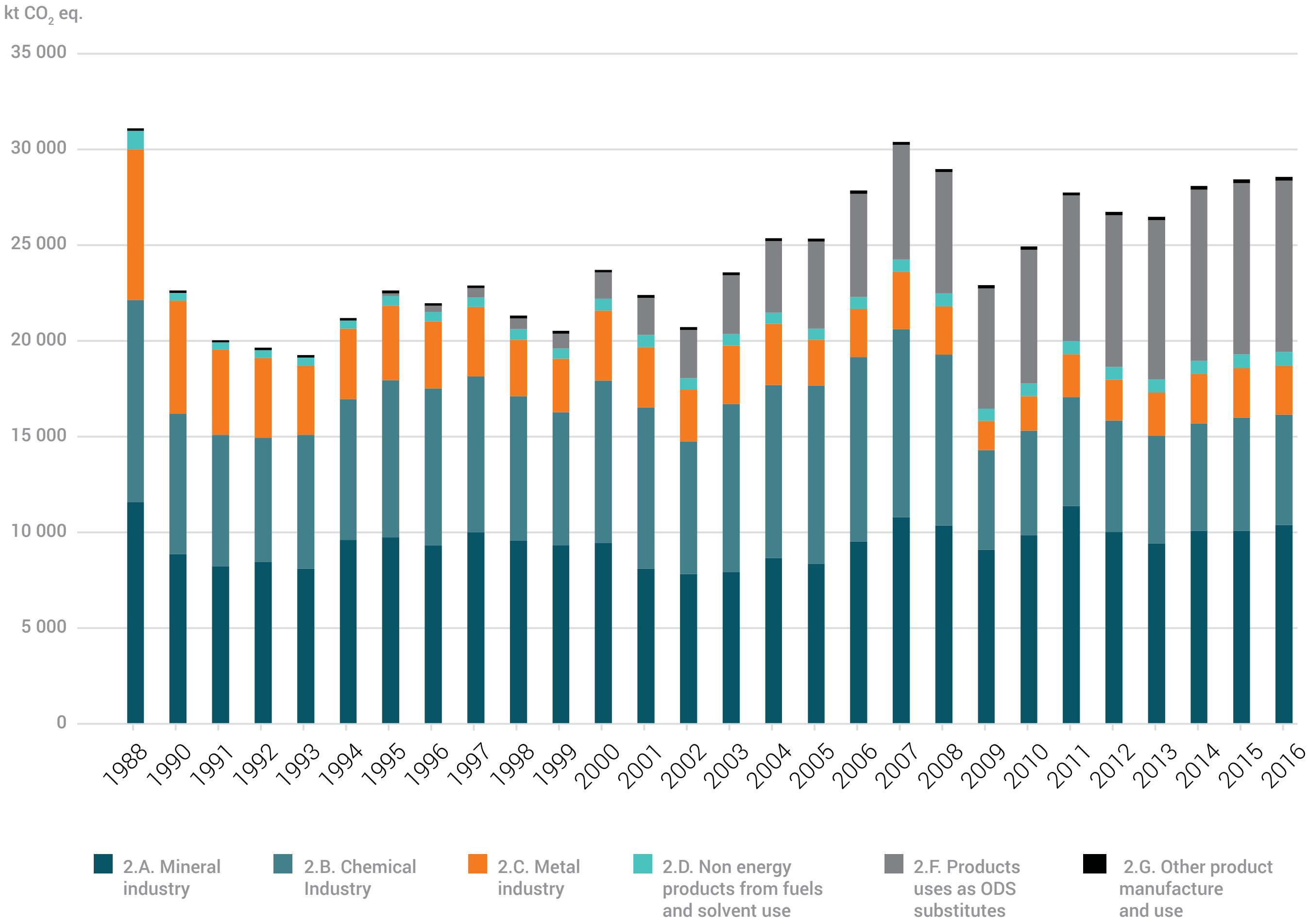
Source: KOBiZE own study

Fig. 18. Share of sub-sectors in the emissions of the IPCC 2 sector. Industrial processes and product use in 2016. Including all greenhouse gases recalculated to CO_2eq



Source: KOBiZE own study

Fig. 19. Emission trend for the IPCC 2 sector. Industrial processes and product use in the years 1988-2016 divided into sub-sectors. Including all greenhouse gases recalculated to CO_2eq



Source: KOBiZE own study

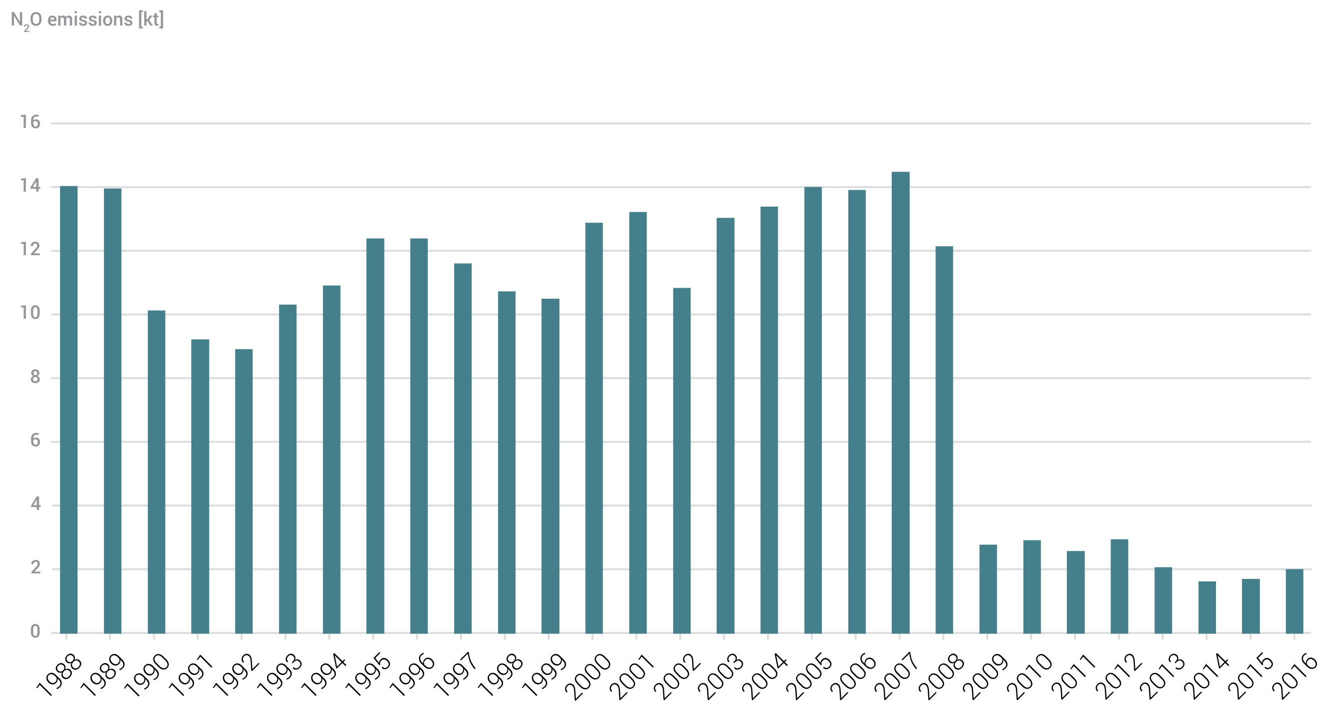
When analysing the emission change trend for 1988-2016 in the sector of industrial processes and product use, we can see they declined by more than 8%. In this case, we can notice clear emission fluctuations, resulting mainly from the economic situation on the domestic and international markets, which can be seen in clinker production, accounting for approx. 20-30% of the emissions in this sector. However, it should be noted that the decline in the emission in the analysed sector are also influenced by specific reduction measures. A good example is the introduction N_2O catalytic converters in the chemical industry, in the nitric acid production process, which, i.a., was the case in Poland as a result of the execution of joint implementation (JI) (more on this matter in chapter 3.2). In this subcategory (2.B.2), the decrease in the emissions compared to 1988 was over 85%, following a decline in the N_2O emission index for this process.

It should be noted that a significant increase of the share of HFC, PFC and SF_6 fluorinated gas emissions has been recorded in the recent period. Emissions of these gases, particularly PFC, have been associated with the production of primary aluminium since the beginning of the reported series (1988), however, they began gaining importance when gases from the HFC group had been introduced to the domestic market in 1995. Gases from the HFC group gradually began to play a dominant role in the stock of f-gases, which was caused by the development of the refrigeration market, as well as using HFC substance to replace other substances ousted from the market of refrigeration equipment under the Montreal Convention. SF_6 emissions are marginal compared to other HFCs and PFCs - their only source in Poland is magnesium casting and electrical equipment.

Example: Changes in the emission of nitrous oxide in Poland, in the years 1988-2016

A dramatic example of the modernization of the Polish chemical industry, i.a., as a result of JI project execution, was the use of nitrous oxide decomposition catalysts in ammonia oxidation reactors of nitric acid production systems, which contributed to reducing N_2O emission by over 80% at the brink of 2008 and 2009.

Fig. 20. Changes in the emission of nitrous oxide from nitric acid production in Poland, 1988-2016

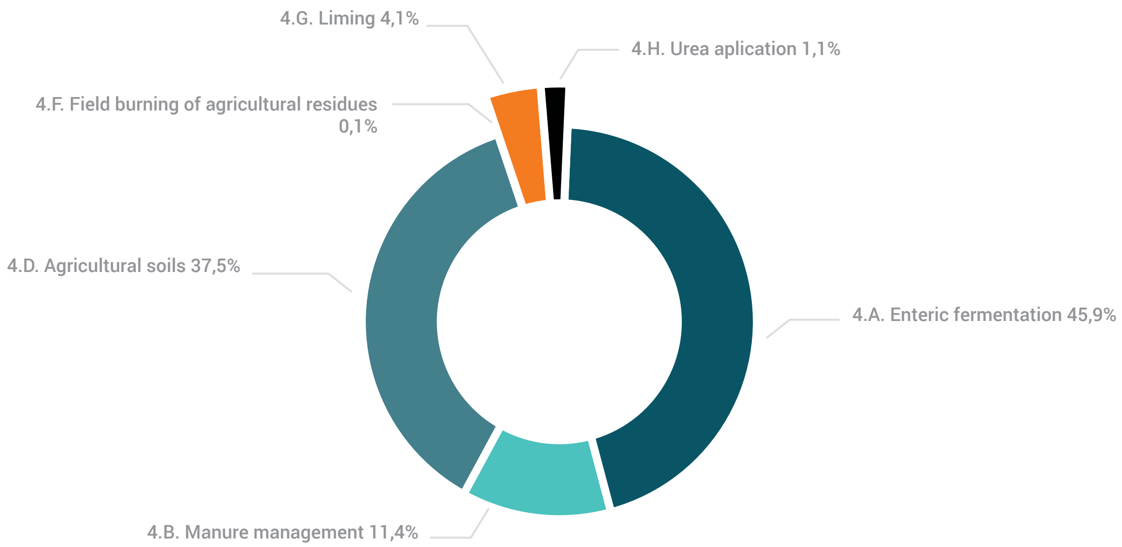


Source: KOBiZE own study

Agriculture

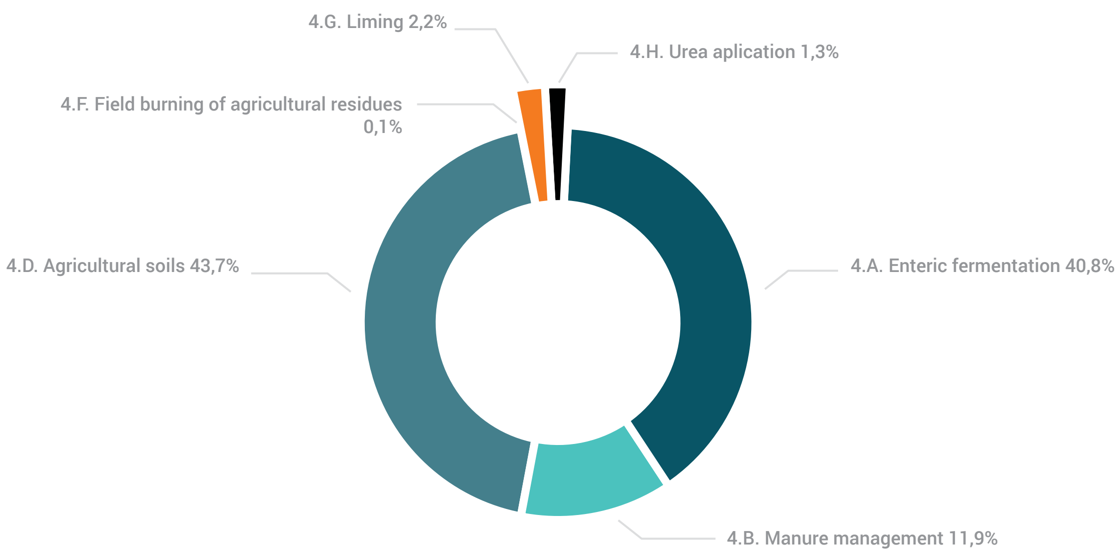
Two main sources of greenhouse gas emissions in the agricultural sector include the enteric fermentation of livestock (CH_4) and agricultural soils (N_2O) accounting for more than 80% of the greenhouse gas emissions, while the share of these sources changed between 1988 and 2016: the number for enteric fermentation is decreasing, while the share of soil emissions is increasing. The remaining a dozen or so percent covers: natural fertilizers (CH_4 and N_2O), liming and the use of urea fertilizers (CO_2) burning crop residues (CH_4 and N_2O).

Fig. 21. Share of sub-sectors in the emissions of the IPCC 3 sector. Agriculture in 1988. Including all greenhouse gases recalculated to CO_2eq



Source: KOBiZE own study

Fig. 22. Share of sub-sectors in the emissions of the IPCC 3 sector. Agriculture in 2016. Including all greenhouse gases recalculated to CO_2eq

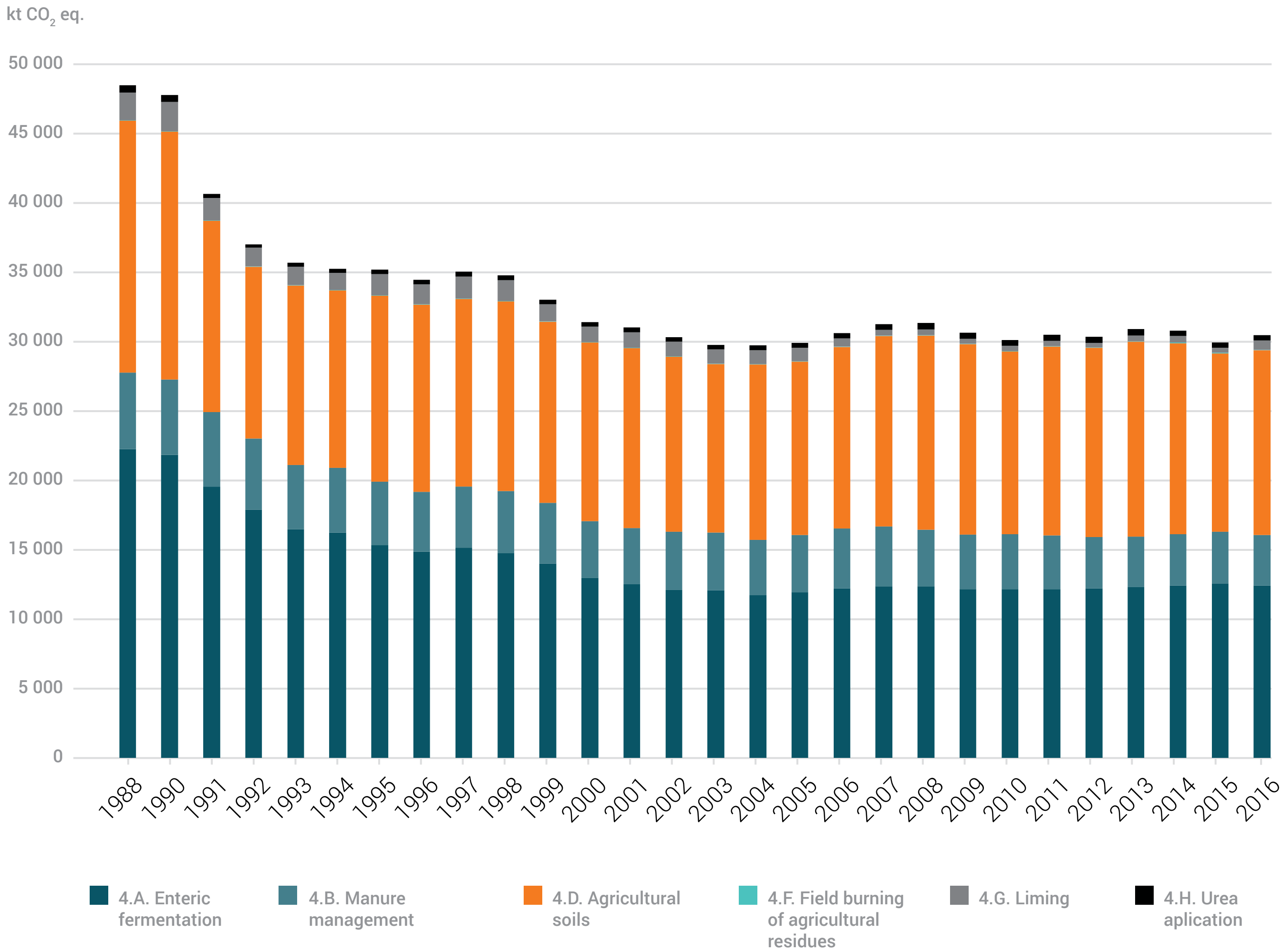


Source: KOBiZE own study

The total emission of greenhouse gases in agriculture was 30.1 Mt CO_2eq in 2016 and was lower by 37% than in 1988. The greatest changes in the emissions occurred after 1989, during the socioeconomic transformation ongoing in Poland. At this time, the profitability of agricultural production significantly changed - as of 1989, the prices for agricultural products, as well as for production measures (such as mineral fertilizers or tractors) were marketized, and State subsidies for agricultural production abandoned. The emission decrease after 1989 was mainly impacted by a significant reduction in the livestock number, when the cattle population dropped by almost a half - from over 10 million in 1988 to 5.7 million in 2002. Since 2002, so just before the Polish accession to the European Union (in 2004), the population of dairy cows has stabilized, along with the fixing of milk quotas, which normalized the dairy market. During the same period, the population of sheep fell by approx. 94% (from 4mn in 1988 to 0.27mn in 2012). Additional reasons for the decreasing agricultural output in the 90s of the last century was limiting the Polish export to eastern markets, deterioration of the ratio between the price of agricultural products and price of production measures, as well as increased competitiveness of the food imported from Western Europe.

The worsening of macroeconomic conditions for agricultural production in the early 1990s, during the economic restructuring, resulted in the changes of the farmstead structure after 1989. State Collective Farms (PGR) were becoming ineffective in the new market conditions and began to fall. The changes also affected private farms, which had to adapt to the new market conditions. On the other hand, private and cooperative farms specializing in large-scale animal husbandry were gradually developing. However, still approx. 54% of Polish farmsteads have an area of less than 5 ha. Since 2004, that is, the Polish accession to the EU, the Common Agricultural Policy, above all aimed at improving the agricultural productivity through the introduction of technical progress and the stabilization of the agricultural market has been of crucial significance for the development of Polish agricultural and rural areas.

Fig. 23. Emission trend for the IPCC 3 sector. Agriculture in 1988-2016, divided into sub-sectors Including all greenhouse gases recalculated to CO_2eq

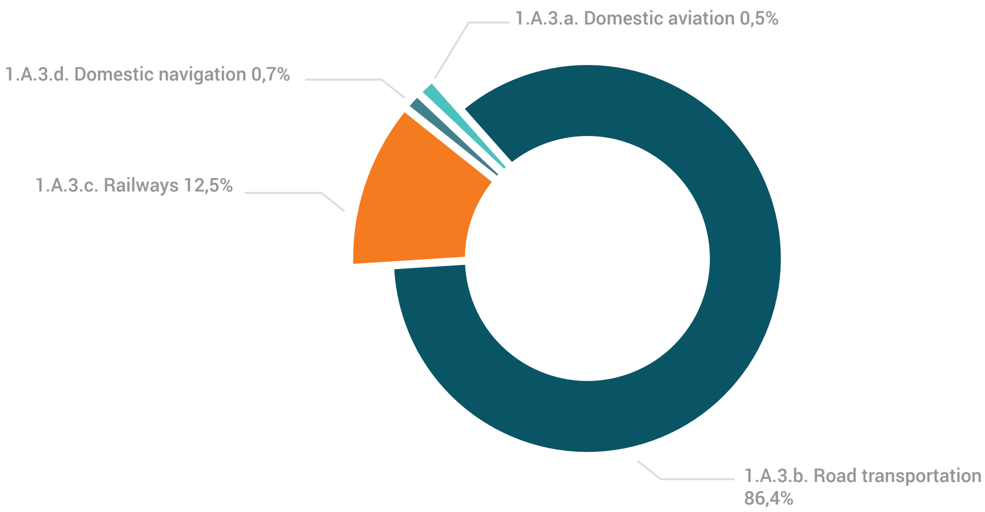


Source: KOBiZE own study

Transport

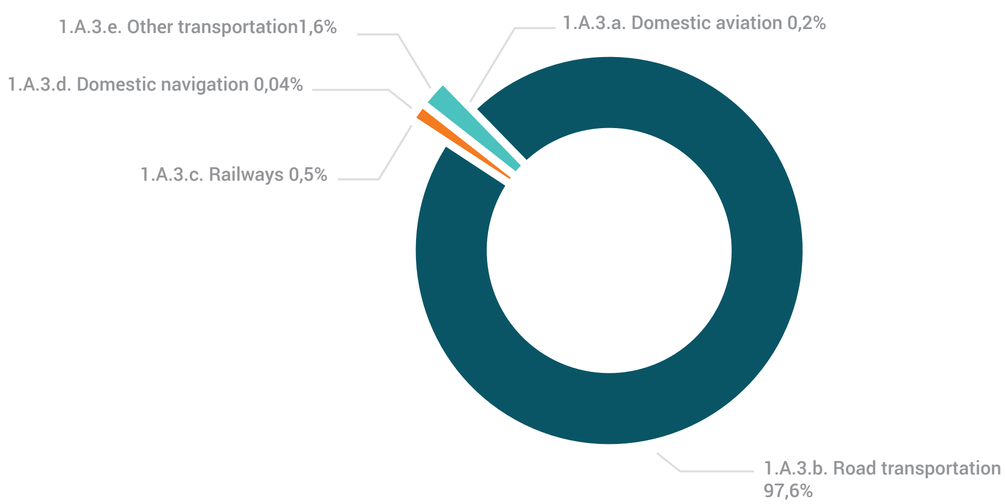
In the years 1988-2016, the greenhouse gas emissions in Polish transport increased by 120%, along with the dynamically rising number of vehicles and fuel consumption. At the same time, the share of this sector in the total greenhouse gas emissions increased from 4% in 1988 to over 13% in 2016. In the case of means of transport, the road transport emissions are largely dominant, with its share increasing from 86% in 1988 to almost 98% in 2016. (fig. 24a and b).

Fig. 24a. Share of sub-sectors in the emissions of the IPCC 1.A.3 sector. Transport in 1988. Including all greenhouse gases recalculated to CO_2eq



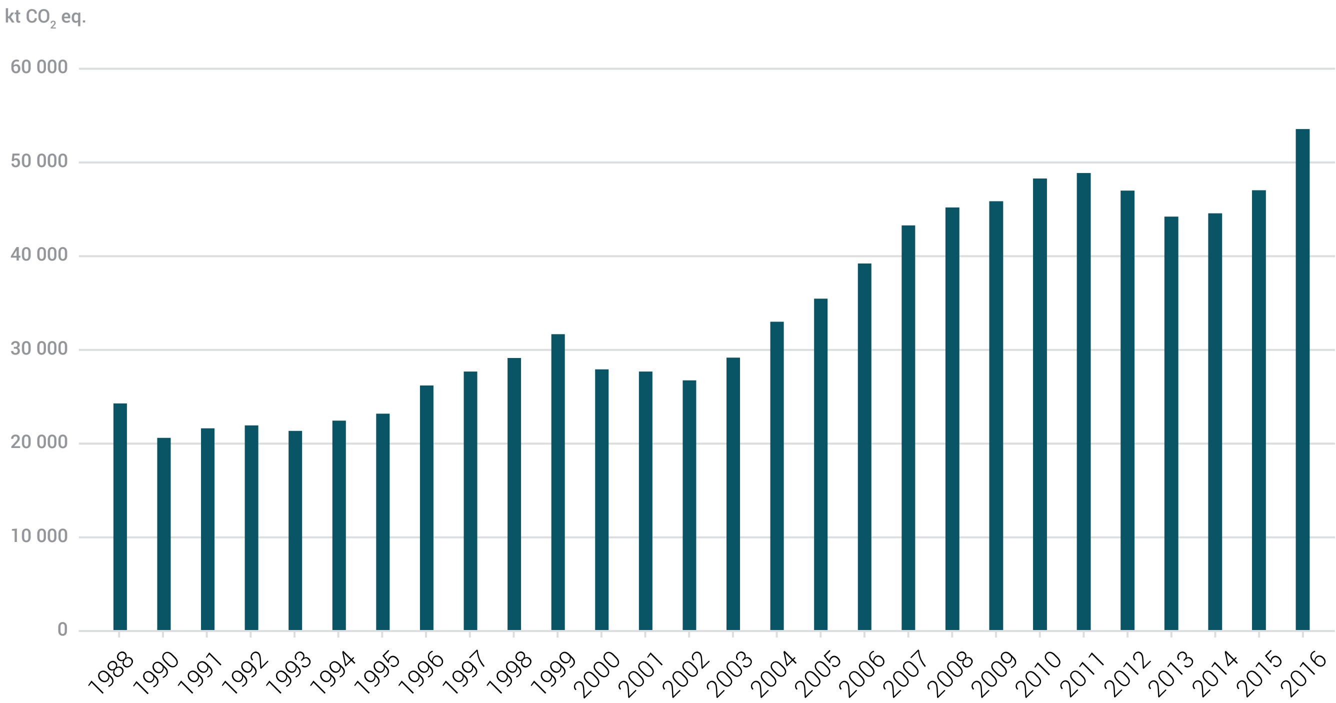
Source: KOBiZE own study

Fig. 24b. Share of sub-sectors in the emissions of the IPCC 1.A.3 sector. Transport in 2016. Including all greenhouse gases recalculated to CO_2eq



Source: KOBiZE own study

Fig. 25. Emission trend for the IPCC 1.A.3 sector. Transport in the years 1988-2016. Including all greenhouse gases recalculated to CO_2eq

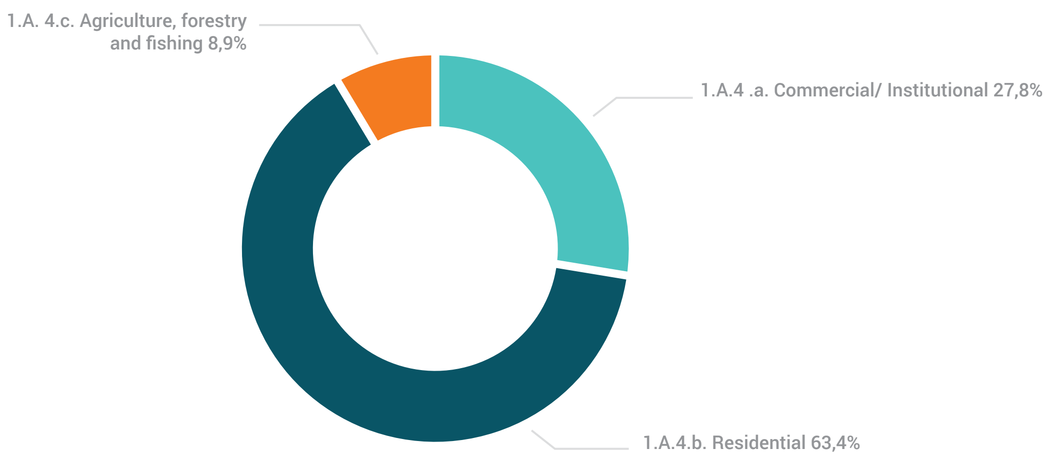


Source: KOBiZE own study

Building sector

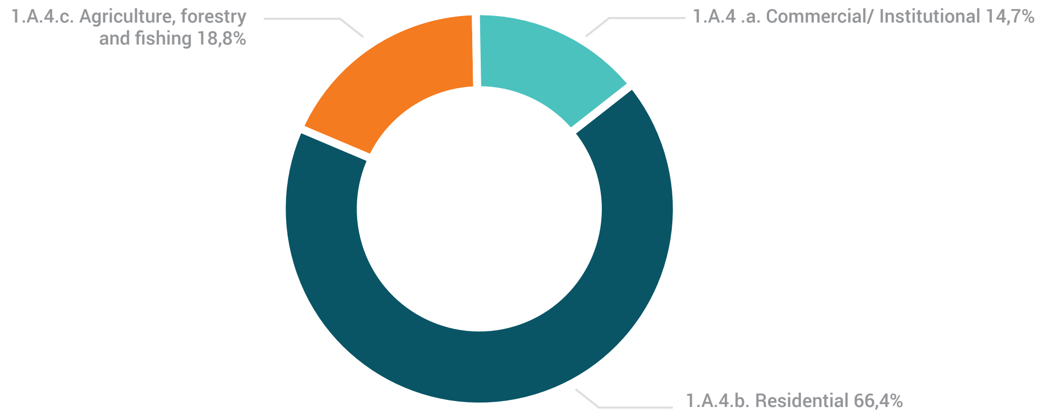
Greenhouse gas emissions associated with fuel combustion for the needs of service buildings and institutions, residential buildings and buildings used in agriculture, fishing and hunting were included in the source category 1.A.4..

Fig. 26a. Share of sub-sectors in the emissions of the IPCC 1.A.4 sector. Other (covering service buildings and institutions, residential buildings and buildings used in agriculture, fishing and hunting) and in 1988. Including all greenhouse gases recalculated to CO_2eq



Source: KOBiZE own study

Fig.26b. Share of sub-sectors in the emissions of the IPCC 1.A.4 sector. Other (covering service buildings and institutions, residential buildings and buildings used in agriculture, fishing and hunting) in 2016. Including all greenhouse gases recalculated to CO_2eq



Source: KOBiZE own study

Households (category 1.A.4.b) have the prevalent share in the greenhouse gas emissions in this category, amounting to 60-68%, depending on the year. The decline in the share of service buildings and institutions in favour of an increased share of fuel combustion for agricultural purposes between 1988 and 2016 is also visible.

Given the trend, the total GHG emissions between 1988 and 2016 decreased by over 46%. The main reason for this decline was the total reduction of fuel consumption compared to 1988 (by approx. 29%) and a change in the fuel structure – decreased fuel consumption from 67% in 1988 to 40% in 2016 and increased utilization of natural gas from 10% in 1988 to 27% in 2016.

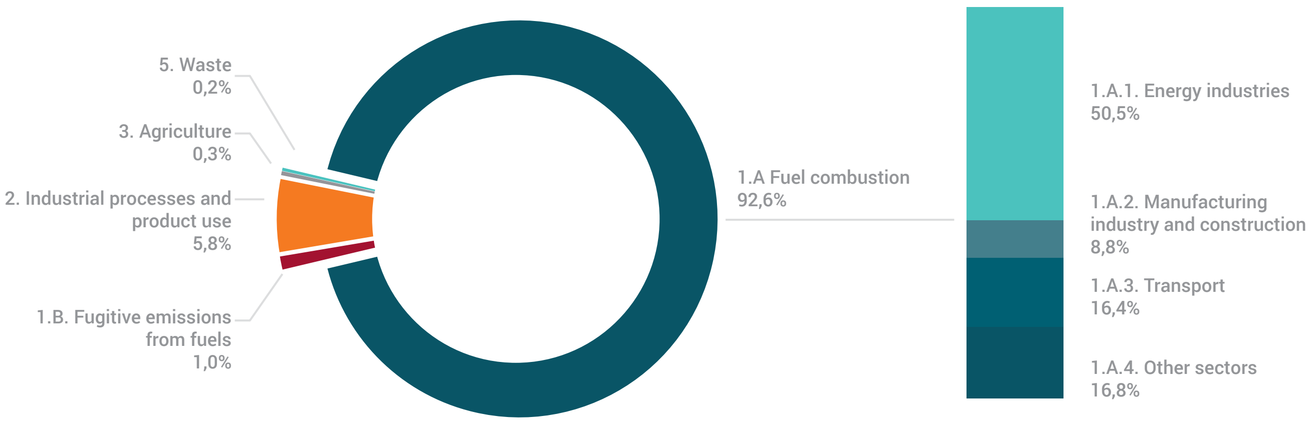
Fig. 27. Emission trend for the IPCC 1.A.4 sector. Other (covering service buildings and institutions, residential buildings and buildings used in agriculture, fishing and hunting) in 1988-2016. Including all greenhouse gases recalculated to CO_2eq

Source: KOBiZE own study wg EUROSTAT

Greenhouse gas emission structure in Poland in 2016

CO_2 emissions (w/o LULUCF)in 2016 were estimated at approx. 321,18 Mt CO_2eq. This is 31,8% less compared to the baseline year (1988). CO_2 emissions (w/o LULUCF) accounted for 81,14% of the total GHG emissions in Poland in 2016 (fig. 4). The main source of CO_2 emission is the Fuel Combustion subcategory (1.A). The share of this category accounted for 92,6% of the total CO_2 emissions in 2016. The shares of major subcategories within category 1.A were as follows: Power generation industries – 50,5%, Manufacturing and construction industry – 8,8%, Transport – 16,4% and Other Sectors – 16,8%. The share of the Industrial processes and product use category in the total CO_2 emissions in 2016 was 5,8%. The main emission sources in this category are Mineral products (particularly Cement production). The structure of emission sources in shown in fig. 28. CO_2 absorption in category 4 for 2016 was estimated at approx. 29,2 Mt CO_2eq (approx. 9,1% of the total CO_2 emissions).

Fig. 28. Carbon dioxide emissions (w/o LULUCF) in 2016, by category

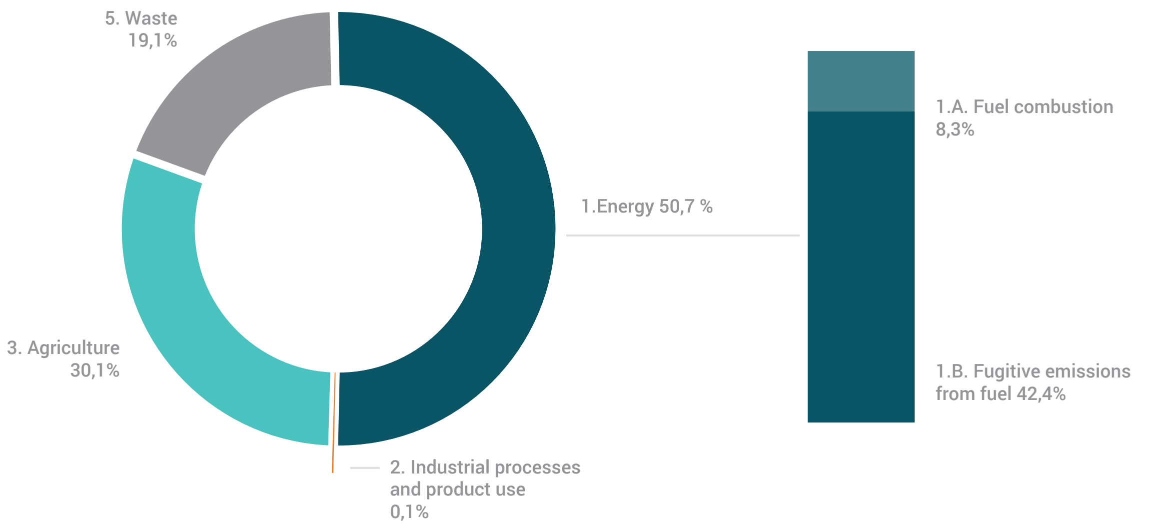


Source: KOBiZE own study

Methane emissions

Methane emissions (w/o LULUCF) in 2016 amounted to 1 844.37 kt, i.e. 46.11 Mt CO_2eq. Emissions in 2016 compared to the baseline year were lower by 33.9%. The share of methane in the total domestic GHG emissions in 2016 was 11.6% (fig. 4). Three of the main methane emission sources belong to the category: Fugitive emissions from fuels, Agriculture and Waste. Their shares in the domestic methane emissions in 2016 were 42.4%, 30.1% and 19.1%, respectively. The emissions in the first of the aforementioned categories included emission from underground mines (approx. 36.9% of the total CH_4 emissions) and emission from extraction, processing and distribution of oil and gas (a total of approx. 5.5% of emissions). Emission in the Enteric fermentation category (3.A) was the dominant source in the Agriculture category, with a share of approx. 26.,6% in methane emissions in 2016. Emission from Landfills amounted to ca. 17.6% of the domestic methane emissions, while Wastewater management emission accounted for 1.1% of the domestic emissions (fig. 29).

Fig. 29. Methane emissions (w/o LULUCF) in 2016, by category



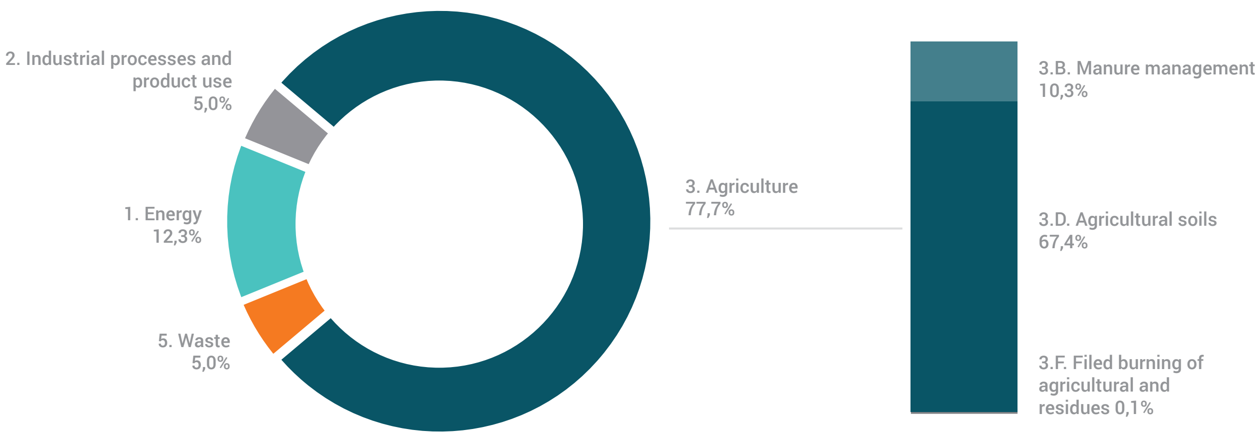
Source: KOBiZE own study

Nitrous oxide emissions

Nitrous oxide emissions (w/o LULUCF) in 2016 was 65.38 kt, i.e., approx. 19.48 Mt CO_2eq. N_2O emissions in were 33.6% lower than in the baseline year (1988). The share of N_2O emissions accounted for 4.9% of the total GHG emissions in 2016 (fig. 4).

The main nitrous oxide emission source in Poland is sector 3. Agriculture, while the shares in the total N_2O emissions in 2016 are as follows: Agricultural soils –67.4%, Livestock manure – 10.3%, Chemical industry – 4.3% (in sector 2. Industrial processes and product use) and Fuel combustion – 12.3% (in sector 1. Energy) (fig. 30).

Fig. 30. Nitrous oxide emissions (w/o LULUCF) in 2016, by category

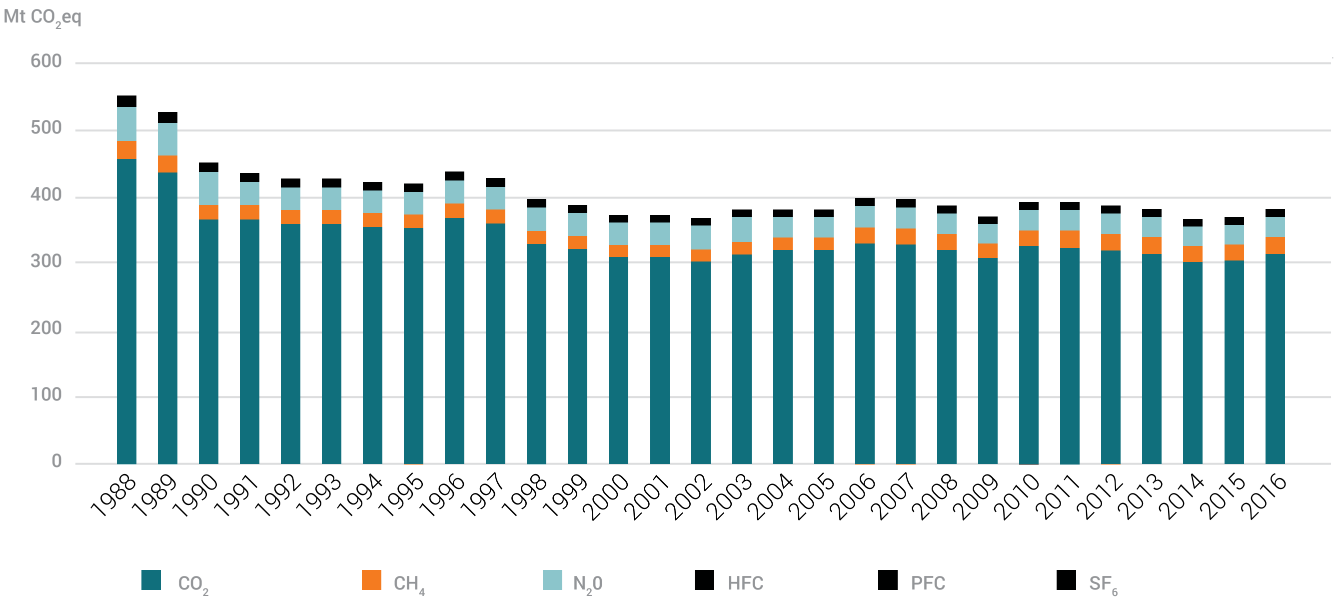


Source: KOBiZE own study

Fluorinated gas emissions

The emissions of fluorinated industrial gases (HFCs, PFCs and SF_6) in 2016 amounted to a total of 9.05 Mt CO_2eq, which constituted 2.3% of the total GHG emissions in 2016 (fig. 4). Industrial gas emissions was 2594.7% higher compared to the baseline year (1995). Such a significant increase in this group of gases is caused by an escalation in the emissions associated with the operation of cooling and A/C equipment. The shares of HFCs, PFCs and SF_6 emissions in the total emissions in2016 were: 2.26%, 0.003% and 0.020%, respectively. NF_3 emissions were not recorded.

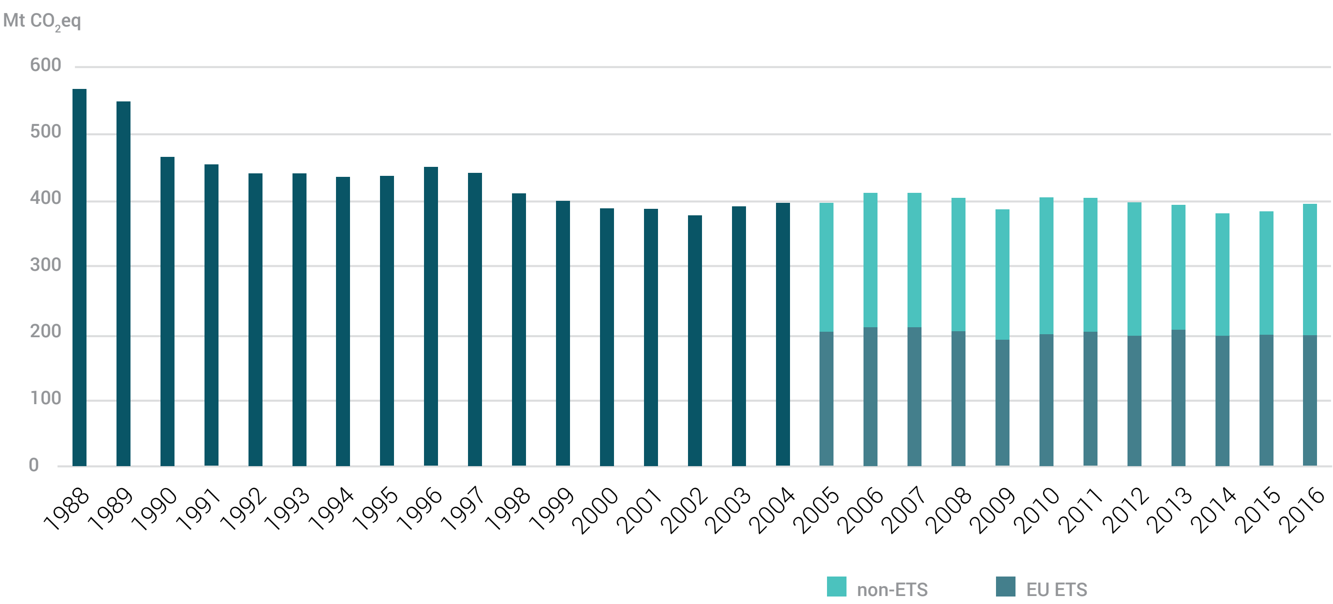
Fig. 31. Greenhouse gas emissions in the period 1988-2016, by gases



Source: KOBiZE own study

Since 2005, Poland has been participating the EU system of emission allowance trading, developed on the basis of, among others, Kyoto Protocol flexibility mechanisms supporting the efforts to reduce emissions. The share of emissions from systems operating within the EU ETS, in the total domestic emissions in Poland for the period 2005–2016 (fig. 32.) was 51% on average, although it should be noted that since 2013, the EU ETS scope has expanded onto new types of activities (e.g. nitric acid production) and greenhouse gases (nitrous oxide).

Fig.32. Domestic emissions of greenhouse gases w/o LULUCF in the period 1988-2016



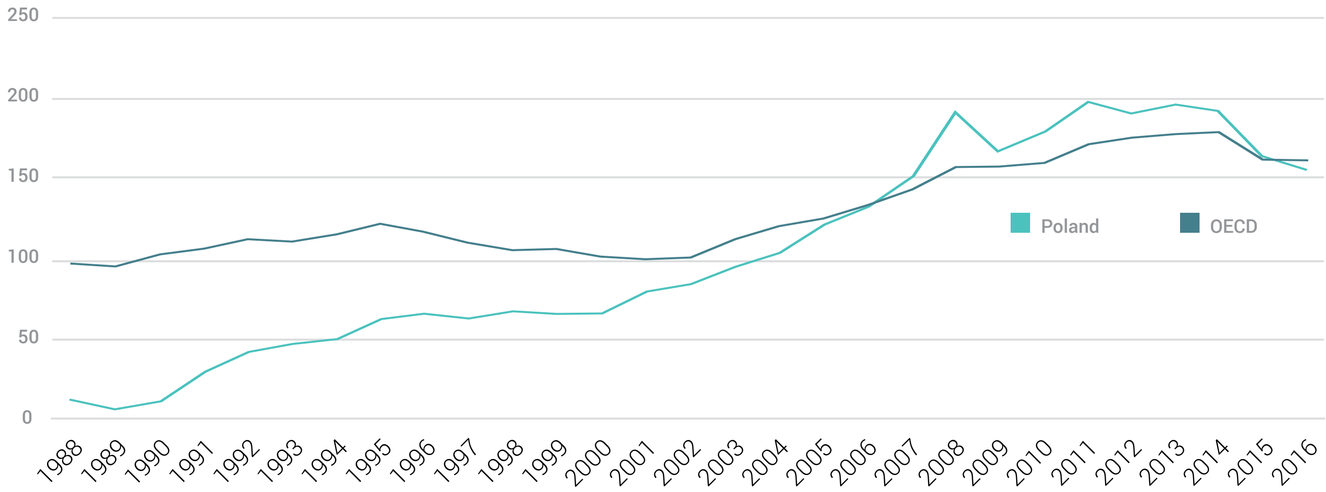
Source: KOBiZE own study

Transformation cost for the economy and the society

Increasing electricity prices

The dynamic increase of electricity prices for households as well as the industry in the years 1989- 1992 was associated in Poland with the economic transformation and the implementation of market mechanisms. Despite a significant economic growth, the prices stabilized in the period of 1992-2000. Next, up until 2008 we could witness a very strong growth of electricity prices in the country, largely relating to the next period of accelerated economic growth and growing fuel prices. The price for households in 2005-2006 approached an OECD average and in 2007-2015 it even exceeded that value. The industry was affected with relatively smaller price increases and the prices exceeded the OECD average only in 2008-2011.

Fig. 33a. The evolution of electricity prices for households – Poland and OECD average [USD/MWh - nominal prices]



Source: KOBiZE own study based on IEA data "Energy prices and taxes"

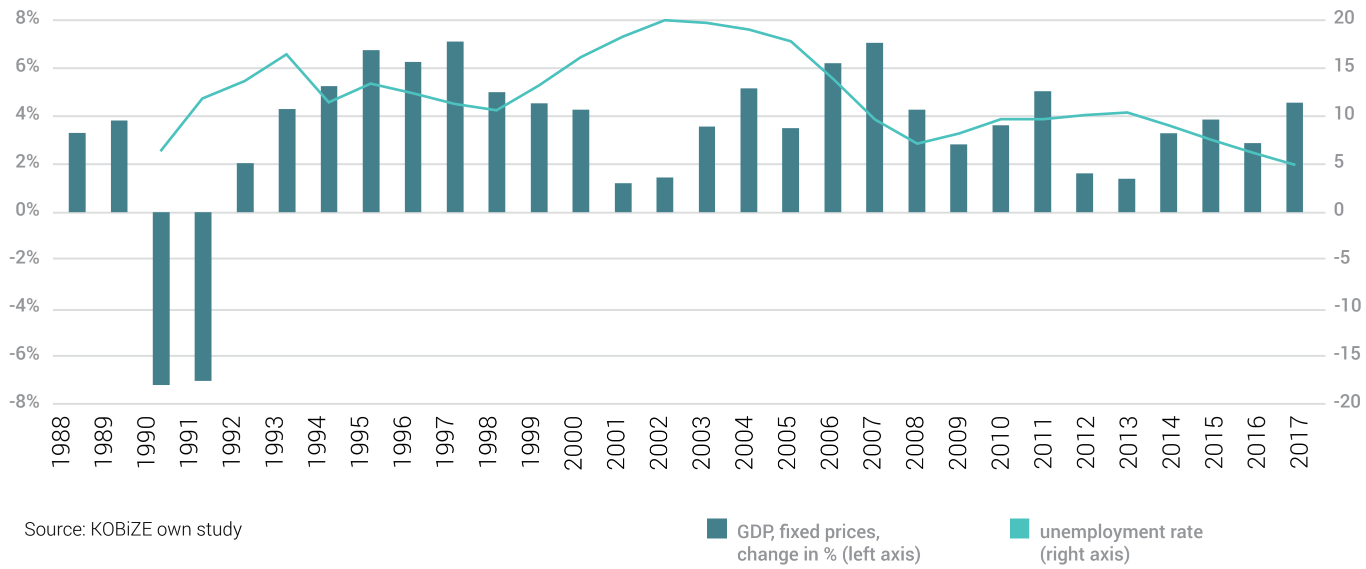
Fig. 33b. The evolution of electricity prices for the industry – Poland and OECD average [USD/MWh – nominal prices]

Source: KOBiZE own study based on IEA data "Energy prices and taxes"

Unemployment

Economic changes resulted in decreased employment, mainly in the energy-consuming sectors, contributing to a rise in the unemployment. In the first years after the economic transformation, i.e., during the period from 1990 to 1993, unemployment in Poland was growing even in the years with growing GDP, i.e., 1992-1993. Therefore, a decline in the production due to the transformation, constituted a heavy burden for the society. This was associated, among others, with the need to retrain for some professionally active people, in order to adapt to the new economic conditions.

Fig. 34. Change of the GDP growth rate and unemployment rate, %



Source: KOBiZE own study

Polish integration with the EU

The Polish accession into the structures of the European Union on 1 May 2004 was preceded by a 5- year (1997-2003) integration period, which was aimed at working out the conditions of accession to the EU, which would guarantee the fastest possible, and at the same time the most beneficial from the Polish point of view course of the integration. The integration was based on a belief that it was a process that would be advantageous for both parties. The integration process was implemented as per the assumptions of the National Integration Plan (NSI) adopted by a resolution of the Sejm (lower chamber of the Polish parliament) of 14 March 1996.

One of the essential integration elements, as pointed out by the NSI, was the field of "Environment". Introducing legal solution from the EU through adapting the domestic legislation to the legal acquis communautaire resulted in the need to incur significant expenditure, particularly in the field of environmental protection. This is why, it was necessary to develop a compromise between a rapid implementation of these solutions and an appropriate distribution of costs over time that could be accepted by the society. Objectives associated with environmental protection at the central level could be accomplished through the introduction of economic instruments, which would, in a market- oriented economy, stimulate efforts aimed at improving or protecting the environment. They included, apart from the fees and penalties applicable in Poland also preferential loans for pro- ecological investments, product taxes, fuel taxes, ecological deposits, tax abatements, etc. Issues associated with the activity of certain sectors of the economy required particular attention during the integration process, in the context of environmental protection standards, because adapting the industry to the ecological standards meant the need to, among others:

- limit the production in the plants most strenuous for the environment or modernize them and replace obsolete technologies with new standards, focusing on rationalizing the use of water resources, raw materials and energy, as well as environmental protection;
- increase the efficiency and improve the competitiveness of the industry;
- equip existing plants with devices protecting the environment, which could result in increased manufacturing costs;
- including the role of emergency services in environmental protection, under the obligation to perform environmental rescue services and restore the land to its original state;
- decentralize the decision-making in terms of environmental protection and include local communities in the decision-

making process, especially in regard to localization decisions associated with environmental impact assessment.

Implementing ecological standards arising from EU legislation in a short-term perspective was associated with high adaptation costs. This is why the rapid adaptation process could impact the competitiveness of Polish companies. The government developed a path to achieve EU standards, which would enable minimizing the costs in the event of a complete integration of EU legislation.

The Position of 24 October 2001 (CONF-PL-95/01) worked out jointly with the European Union closed the negotiations in the field of "Environment", thanks to the transposition of EU regulations into the national law and the Parliament of the Republic of Poland adopting a package of environmental laws in 2001, particularly:

- act of 27 April 2001 Environmental protection law (EPL),
- act of 27 April 2001 on waste,
- act of 11 May 2011 on packages and packaging waste,
- act of 11 May 2001 on the obligations of entrepreneurs in the field of managing certain waste, the product fee and deposit fee,
- act of 7 June 2001 on introducing the act - Environmental protection law, act on waste and amending certain acts,
- act of 18 July 2001 - Water law.

In order to mitigate the adverse effects of integration in the area "Environment", it was necessary to work out derogation (deviation) principles. These derogations were formalized in the Treaty of Accession of the Czech Republic, Estonia, Cyprus, Latvia, Lithuania, Hungary, Malta, Poland, Slovenia and Slovakia (O J UE L 236 of 23/9/2003, p.17). The Treaty, in Annex XIII cl. 13 introduces "Environmental" derogations, with none of them directly relating to greenhouse gases, however, they impacted sectors, which were sources of GHG emissions, the energy industry in particular. In the course of the negotiations, Poland achieved a transitional period for certain facilities, including the existing municipal heating plants with a capacity from 50 to 300 MWt until 2010. The objective of a full adaptation to the ecological standards in the scope of SO2 andNOx was accomplished by 2010.

The issue of reducing, limiting or avoiding GHG emissions was not a subject of the negotiations, among others, due to the fact that EU activities in the field of climate protection were formalized only at the end of 2003, therefore, already after completing the formal accession negotiations.

At the end of the 20th century, the Member States started an intensified debate on the human responsibility for climate changes, which was indicated in the European Climate Change Programme, adopted in June of 2001. In this document, the European Union (EU) confirmed its important role in satisfying the obligation arising from the United Nations Framework Convention on Climate Change, as well as ratified the Kyoto Protocol on 31 May 2002. Poland, not a member of the EU at the time, ratified this protocol on 13 December 2002. The Green Book, which recommended the formation of a greenhouse gas emission allowance trading system was developed, in order to fulfil the obligations imposed by the Convention and the Protocol. Using an economic tool as an emissions trading scheme (EU ETS) in order to reduce GHG emissions was introduced by way of directive 2003/87/EC of the European Parliament and the Council of 13 October 2003, establishing an emissions trading scheme within the Community and amending the directive of the Council 96/61/EC.

Summary of the transformation period

An evaluation of the previous Polish achievement in the field of climate policy must take into account the context of structural, political and economic transformation, as well as the associated challenges, social costs and the burden of the pre-1989 centrally planned economy. The years after the breakthrough of 1989 mainly involved a thorough reconstruction of the economy and creating conditions for economic growth and development, which could enable improving the prosperity level.

In the light of such important and demanding challenges, it would be fully justifiable to shift additional effort in the area of the environmental and climate policy to a later period (which would be a similar path that the highly-developed countries followed). This was not the case. From the very beginning of the transformation, Poland valued the importance of the quality of the environment and the significance of risk associated with global warming. Already 1991 saw the development and adoption of a state ecological policy based on the assumptions of sustainable development, at the time one of the most advanced and ahead of the adoption of The Fifth Community Environment Action Programme in 1992, which promoted the same principles. The information about the quality of the environment and taking urgent actions aimed at removing the threats, despite numerous other economic and social challenges, since the very beginning have been one of the priorities of the country's policy. Poland showed similar involvement in the international aspect, including the participation in the development and the quick ratification of the United Nations Framework Convention on Climate Change and the later Kyoto Protocol.

As a result, it was possible to achieve high environmental improvement, greenhouse gas emission reduction and economic energy-consumption reduction indicators during the period of political and economic transformation in Poland, largely contributed by the energy and industry sectors. What is important, these achievements were accomplished along with an effective reconstruction of the economy, improvement of social indices and an impressive effort to adapt the country to EU requirements, prior to the accession in 2004. Among the many indices, it is worth to recall that in the period from 1988 to 2016, Polish GDP almost doubled, and simultaneously, greenhouse gas emissions decreased by more than 30% - in other words, GDP emissivity decreased by over 60%.

In assessing the aforementioned achievement from a time perspective, it can be concluded that Poland, by stepping up to the challenge of including the environmental and climate policy in the nation reconstruction programme saw not only the associated social and economic costs, but also - perhaps a unique - opportunity to achieve improvement in this field. The indices of today regarding the quality of the environment and the impact on global warming prove that this chance was taken.

Functioning and experience

of the implementation of the EU emissions trading scheme (EU ETS) in Poland

The economic mechanism of emissions trading implemented by the directive 2003/87/EC of the European Parliament and the Council of 13 October 2003 establishing a scheme for greenhouse gas emission allowance trading within the Community and amending Council Directive 96/61/EC[5] has been operating within the European Union since 1 January 2005. The objective of the emission allowance trading system is to limit greenhouse gas emissions in a profitable and economically- efficient manner. The basis for the functioning of the European Union Emissions Trading Scheme (EU ETS) was based on the "cap and trade" principle, which involves defining an emission allowance pool and enabling market trading. The Directive 2003/87/EC was implemented in the Polish legislation by the act of 22 December 2004 on trading allowance for greenhouse gas and other substance emissions to the atmosphere[6], which was the first legal regulation stipulating the functioning of an atmospheric emissions trading scheme in Poland. The directive was amended several times, among other, in order to add further greenhouse gases and additional activities, as well as to change the principles of allocation emission allowances, which resulted in the need to amend the domestic legislation in this regard. The first big change of domestic legislation in the field governing emissions trading was a result of adopting the act of 28 April 2011 on the greenhouse gas emissions trading scheme[7], which waived the act of 2004. Until the end of 2012, the allowances were allocated individually by each Member State, bearing the mind the guidelines of the European Commission regarding the allocation principles. Adopting the directive of the European Parliament and the Council 2009/29/EC of 23 April 2009 amending the directive 2003/87/EC so as to improve and extend the greenhouse gas emission allowance trading scheme of the Community introduced a modification of the functioning of the system, among others, through determining an emissions allowance pool for the entire EU and not individual Member States, and thus, introduced uniform principles of allocating emission allowance between systems. This act introduced new principles regarding the allowances, their distribution and sales, namely:

- allowances for electricity generation are not granted,
- the basic allocation principle is the sales of emission allowances at an auction,
- allocation is based on benchmarks defined for products.

[5] OJ EC L 275 of 25/10/2003

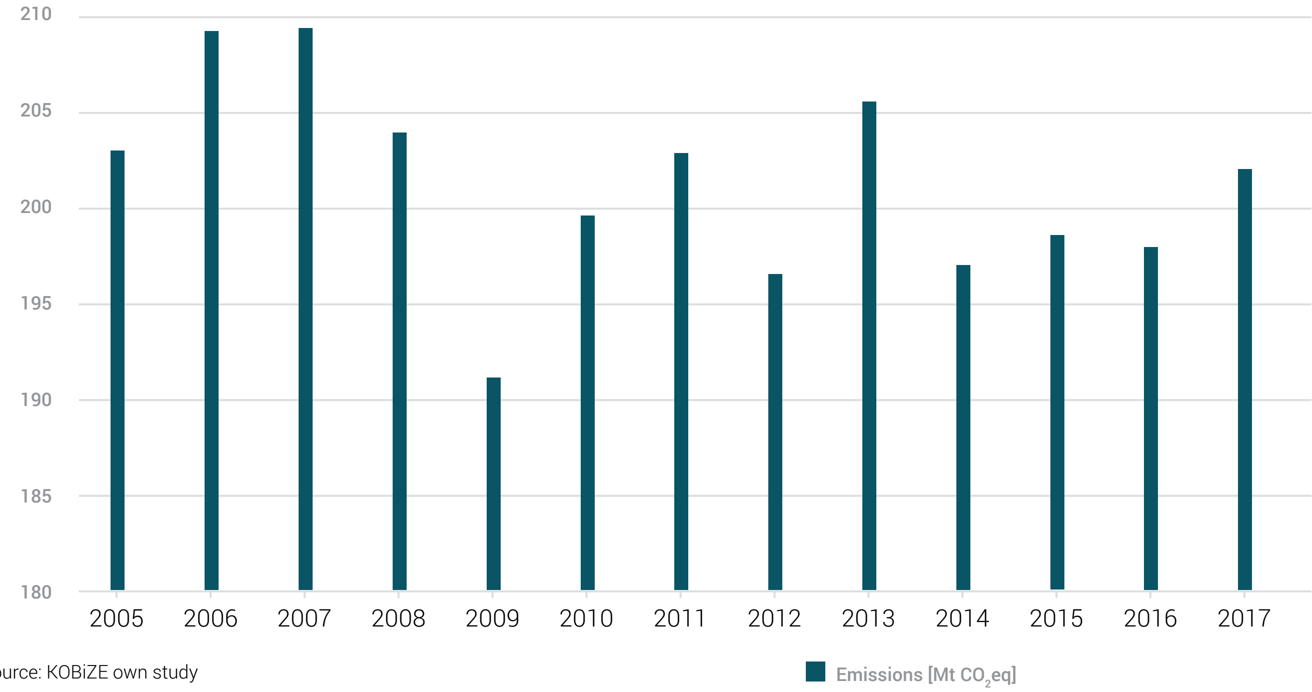
[6] OJ 2004, No. 281, item 2784, as amended

[7] cons. text of 2013, item 1238

The EU ETS system covers greenhouse gas emissions, including carbon dioxide from systems in particular (fig. 35). Perfluorocarbon and nitrous oxide emissions is included in the system only for the activities within the system specified in the directive, with the emission of pollutants of this kind obligatorily covered by the system since 2013. The Member States are allowed to include other greenhouse gases into the system optionally, after meeting prerequisites defined in the provisions of art. 24 of the amended directive. NO2 emissions from systems within the EU ETS are shown in fig. 36.

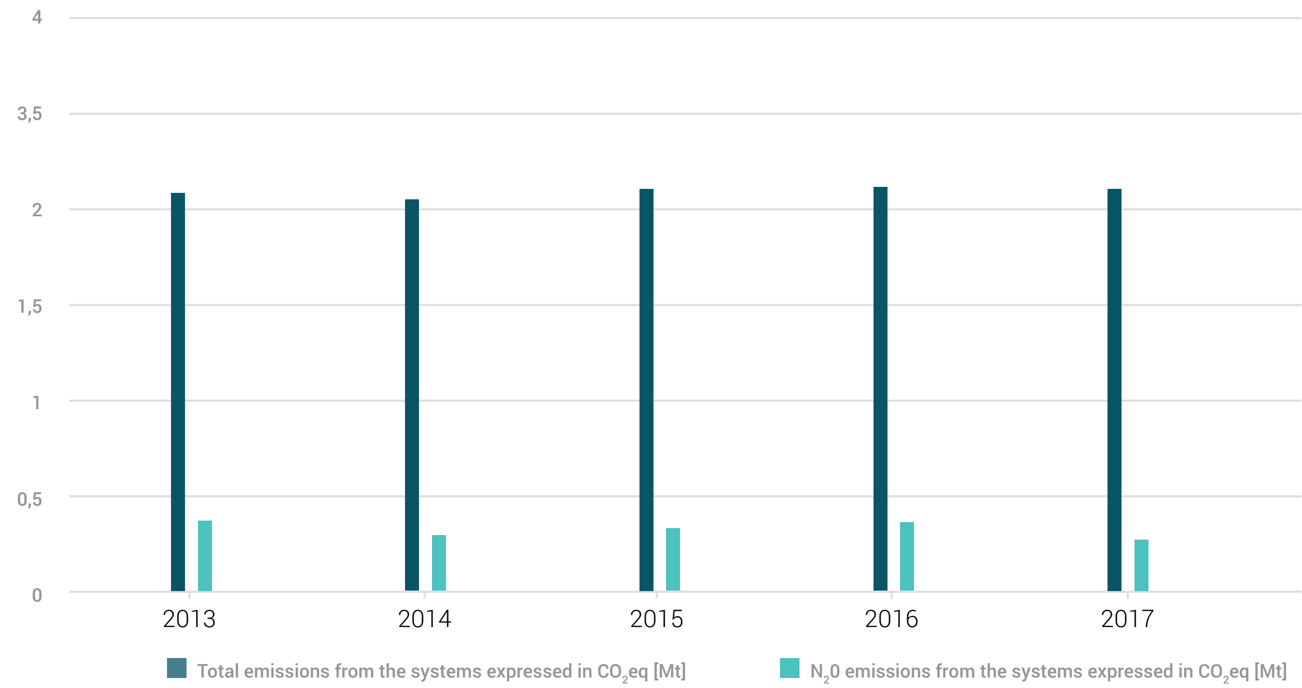
Besides the emissions, a second important elements of the EU ETS system are the entities (systems) therein, as well as the activities and processes they conduct. It is the type of the activities conducted within the system, which determined them being covered by the EU ETS. The types of systems covered by the system were subject to modifications during the functioning of this mechanism. Originally, the system covered 9 types of activities conducted within a system, among others: power systems, refineries, coke ovens, ferrous metal production and processing or the mineral industry, including cement production, glass production or the production of ceramic products and the paper industry. The first change in the scope of actions carried out in regard to systems covered by the system involved a unanimous understanding of the term fuel combustion system. The definition of a fuel combustion system was understood differently in various Member States. The biggest modification in the field of the types of systems covered by the EU ETS was introduced in 2013 and involved including new types of activities within a system. The change primarily applied to the chemical sector. The aforementioned changes were introduced into the domestic legislation by way of the act of 12 June 2015 on the greenhouse gas emissions trading scheme (cons. text. Dz.U. 2018, item 1201). The largest group of systems covered by the EU ETS system are fuel combustion systems with a total rated thermal capacity exceeding 20 MW. The number of systems broken down into activity types is shown in fig. 37.

Fig. 35. Carbon dioxide emissions from installations covered by the EU ETS in the years 2005- 2017, expressed in Mt CO_2eq



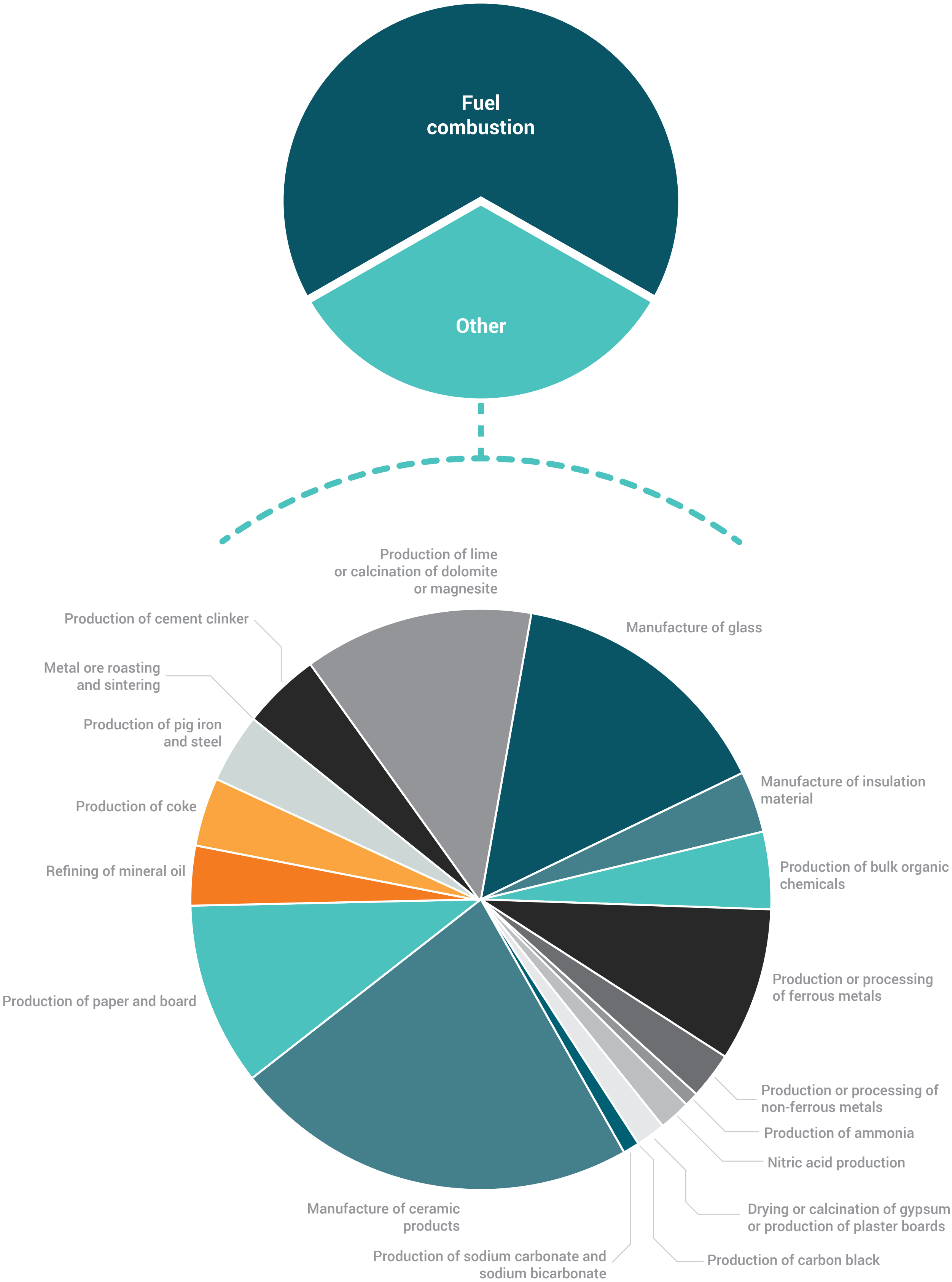
Source: KOBiZE own study

Fig. 36. Installations reporting nitrous oxide emissions, covered by EU ETS since, expressed in Mt CO_2eq



Source: KOBiZE own study

Fig. 37. The share of EU ETS systems, broken down into types of activities

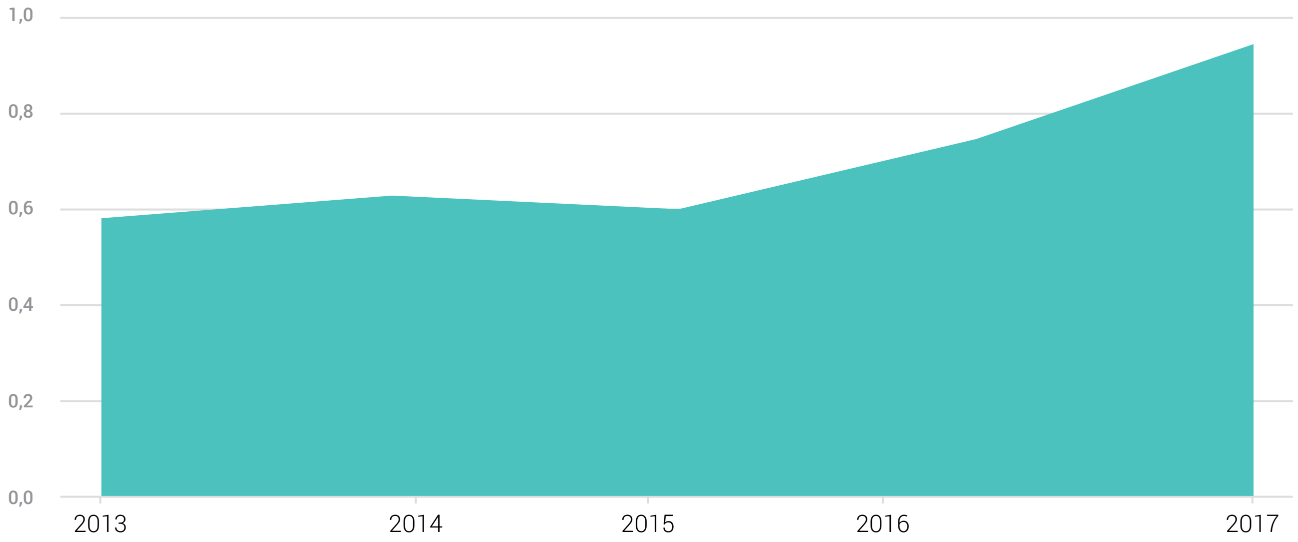


Source: KOBiZE own study

The emissions trading system also covers the aviation sector, under the Directive of the European Parliament and the Council 2008/101/EC of 19 November 2008 amending the directive 2003/87/EC in order to include the aviation activity in the EU greenhouse gas emissions trading scheme[8]. As legitimate participants of the systems, aircraft operators were included in 2012, whereas already in 2010, these operators were obliged to monitor the emissions and so-called tonne-kilometres, in order to determine the allowances for 2012 and the period of 2013-2020. Emissions in 2012 amounted to 641 424 Mg CO_2.

Formally, for the period of 2013-2020, approx. 40 operators are assigned to Poland as a so-called administering State, whereas the actual number of aircraft operators qualified for the EU ETS in Poland (after taking into account the exemptions permitted in the directive) in the years 2013-2017, never exceeded 10 in any of the aforementioned years, and the yearly average emissions volume reported by the entities within the EU ETS was approx. 700k tonnes of CO_2 (fig. 38).

Fig. 38. Emissions associated with aviation activity reported within the EU ETS in the years 2013-2017, expressed in Mt CO_2



Source: KOBiZE own study

[8] OJ EU L 8 of 13/1/2009, pp. 3-21

Project mechanisms and financing

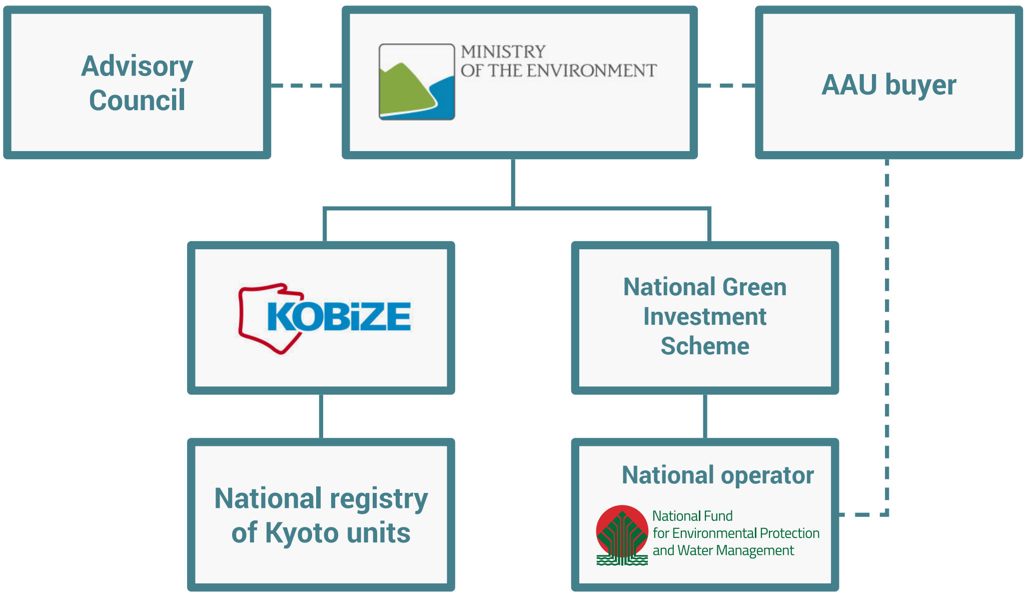
GHG emission reductions in Poland - based on the Green Investment Scheme and the joint implementation mechanism.

Green Investment Schemein Poland

The green investment scheme, functioning under the Kyoto Protocol is a form of converting funds from the sales of AAUs[9] into supporting the investments in activities conducive to climate protection. Utilizing the funds for such specific targets is defined as "marking", which is ensuring the allocation of funds acquired from selling surplus emission units to the execution of specifically determined objectives associated with environmental protection in the country of the unit seller.

The functioning of the GIS system in Poland was enabled by the act of 17 July 2009 on the system for managing the emissions of greenhouse gases and other substances (cons. text OJ 2018, item 1271), which along with creating the GIS system, introduces legal provisions in the scope of effective managements of funds derived from the sales of AAUs. The act stipulates, which schemes and projects can be subsidised from these funds. For the proper functioning of the GIS system, the act sets out institutional framework, entrusting the function of a national operator of the green investment system to the National Fund for Environmental Protection and Water Management (NFOŚiGW). Pursuant to the act, the funds derived from the sales of AAUs are sent to a separate bank account called the climate account, managed by the NFOŚiGW. The act stipulates such tasks of the national operator as, i.a., organizing the acquisition of applications for project subsidies and their assessment, and then monitoring, which is supervising the implementation and execution of schemes and projects, and the evaluation of their environmental impacts. The act governs the rules for the acquisition and selection of funding applications, as well as monitoring the implementation of subsidised programmes and projects, reported by the NFOŚiGW to the Minister of the Environment.

Fig. 39. Institutions involved in the functioning of the GIS system in Poland



Source: KOBiZE own study based on NFOŚiGW presentation "Polish experience – sectoral priorities and actual implementation of GIS", 2018.

[9] AAU means an Assigned Amount Unit, which is a permission to emit 1t of CO_2.

Poland, having a large surplus of AAUs at its disposal in the years 2008-2012, concluded 11 AAU sales contracts until September 2015. The buyers of Polish units became: European Bank for Reconstruction and Development on behalf of the Kingdom of Spain and the government of Ireland, a Japanese governmental Organization for the Development of New Energies and Industrial Technologies and private Japanese entities, the International Bank for Reconstruction and Development acting as a trustee of the Spanish Carbon Fund and the Carbon Fund for Europe, the government of the Kingdom of Spain and the government of the Republic of Italy.

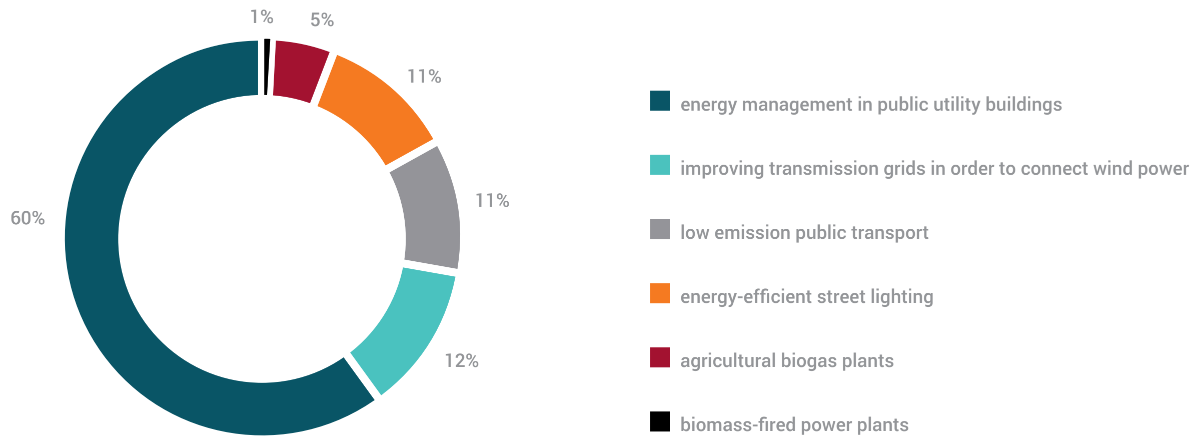
The funds from the aforementioned buyers of AAUs were transferred in 2009-2018[10] to the climate account in the total sum of PLN 796.5mn. They are used to finance tasks associated with supporting ventures executed within the framework of programmes and projects covered by the national green investment scheme. The funds accumulated on the climate account were allocated to finance tasks in the scope of:

- energy efficiency in the building sector (thermo-modernization),
- renewable energy sources (agricultural biogas plants, biomass CHPs and heating plants, connections to wind power generation sources)
- energy-efficient street lighting,
- low carbon and carbon free urban transport.

In total, in the years 2011-2017, 419 financing contracts for a total amount of PLN 818mn and 240 repayable financing contracts from other NFOŚiGW funds for a total amount of PLN 530mn were concluded to support the execution of the ventures within the framework of 7 priority schemes of the NFOŚiGW. The total costs of the implemented projects amounted to PLN 2.5bn, and the share of subsidies from the funds accumulated on the climate account and from other NFOŚiGW funds accounted for 55% of the total cost.

The structure of the allocation of funds for the projects executed within the green investment scheme is shown in fig. 40. The most frequently funded were the activities in the scope of energy efficiency, mainly thermo-modernization of approx. 1823 public utility buildings, with 60% of the total funds allocated. Other GIS priority programmes are: improving industrial grids in order to connect wind power, with allocated 12% of the funds, carbon free public transport - 11%, energy-efficient street lighting - 11%, agricultural biogas plants - 5% and electricity generation through biomass combustions - 1%.

Fig. 40. Priority schemes implemented within GIS



Source: KOBiZE study based on NFOŚiGW presentation "Polish experience – sectoral priorities and actual implementation of GIS", 2018.

[10] NFOŚIGW, wrzesień 2018 r.

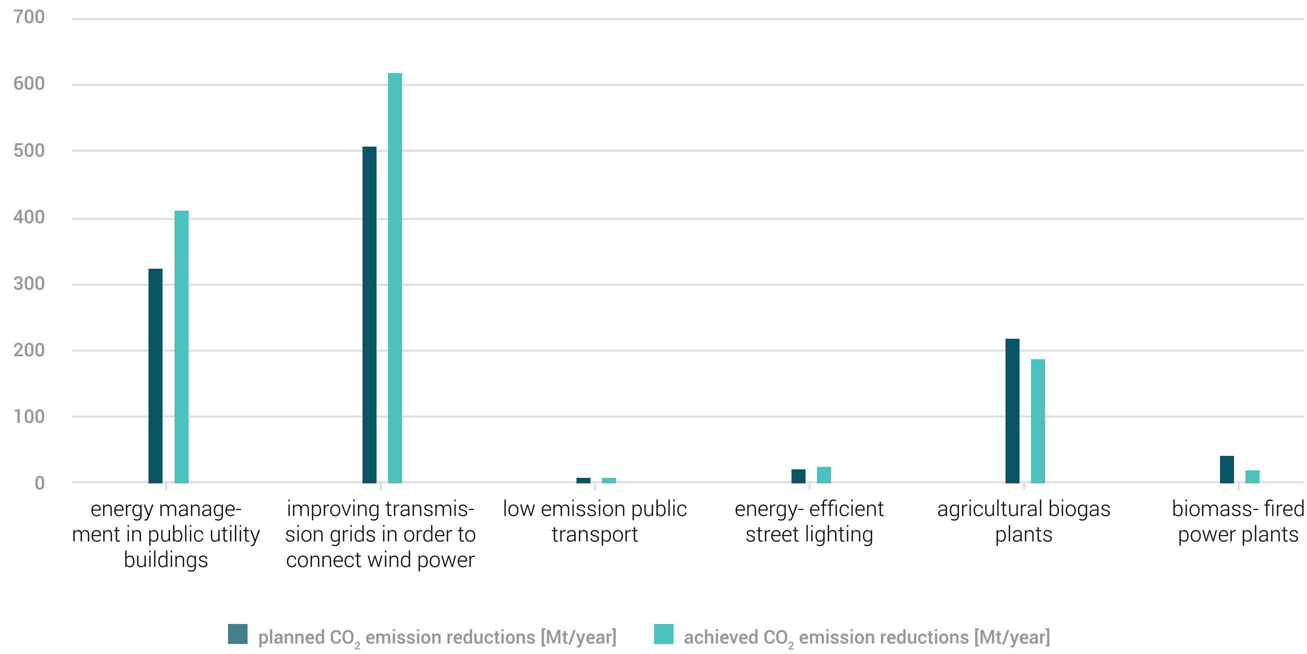
The expected ecological effect of the implementation of the tasks within GIS programmes, in the form of CO_2 emissions, is estimated at approx. 1 Mt CO_2 per year[11].

Although the entire society benefited from the implementation of GIS programs and projects, their direct beneficiaries (around 400) gained the most. They included, i.a.:

- private and State companies,
- public institutions,
- local government units,
- universities,
- cultural facilities,
- scientific-research institutes,
- public and non-public health facilities,
- churches and other religious communities.

Fig. 41 shows a comparison between the expected and achieved environmental effects in the form of curbing CO_2 emissions. The greatest reductions were generated by 9 large projects associated with streamlining transmission networks, in order to connect wind energy (almost 0.65Mt CO_2/year). Whereas the runners-up are the projects associated with energy management in public utility buildings, as many as 489, resulting in a reduction of more than 0.42Mt CO_2/year. The total volume of achieved emissions reduction exceeded the assumptions and amounted to approximately 1.24Mt CO_2/year.[12]

Fig. 41. Comparison of the expected and achieved environmental results



Source: KOBiZE study based on NFOŚiGW materials

The main advantages of the GIS system for unit buyers were such its characteristics like guaranteed greening, namely, intended allocation of acquired funds solely to financing carefully selected activities associated with environmental protection, responsible implementation of these tasks as per the national legal regulations enabling the functioning of the GIS in Poland, as well as a credible monitoring and reporting system concerning the implemented programmes and projects, coordinated and supervised by the NFGOiŚW. It should be noted that the funds from selling AAUs were, as per their purpose, accumulated on the climate account and thus, did not constitute the income of the State Treasury, and their spending was not subject to any kind of inspection. Assigning NFGOiŚW as the national operator of the green investment scheme enabled institutional securing and substantive functioning of the GIS system in Poland.

Polish experience in negotiating AAU sales contracts, the development of the system and the execution of GIS projects may prove invaluable when creating the architecture of domestic emissions reduction projects within the non-ETS field.

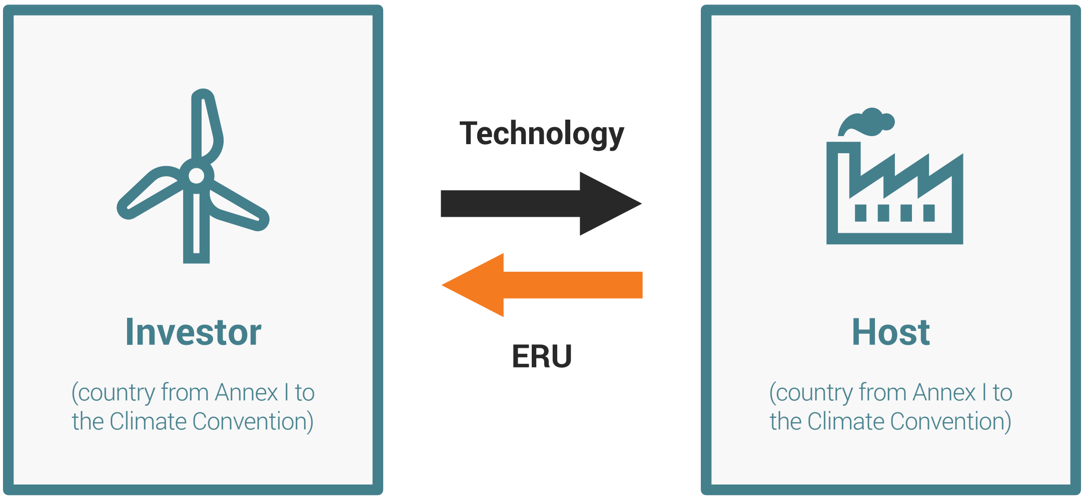
[11] Data from the NFOŚiGW presentation from 6NC "Polish experience – sectoral priorities and actual implementation of GIS"

[12] ibidem

JI mechanism in Poland 2008-2012

The joint implementation-JI mechanism is an instrument established by the Kyoto Protocol, pursuant to its art. 6. The idea of the JI mechanism involves fulfilling the reduction commitments by the countries referred to in Annex I to the Climate Convention, through creating the opportunities to credit the reductions achieved as a result of investing in another country referred to in Annex I to the Climate Convention. The Investor-country decreases its emission reduction costs (compared to the costs, which would have to be incurred when implementing domestic investments) and increases its emissions limit. Whereas the Host-country (project host) gains eco-friendly, modern technologies. In practice, functioning of the JI mechanism means implementing joint projects and decreasing greenhouse gas emissions. The implementation of a JI project results in a reduction of the emissions, which after verification are converted into emission reduction units (ERUs), so that they could be transferred from the Host-country to the Investor-country. The resulting ERUs can help in the settlement of international emission commitments in a cost-effective manner.

Fig. 42. The principle of operation of a joint implementation (JI) mechanism



Source: KOBiZE own study.

The JI mechanism had been actively functioning in Poland in the year 2008-2012. During this period, in consequence to the implementation of 37 JI projects, the total reduction of emissions achieved in Poland amounted to 21MtCO_2eq. 99% of the accomplished emission reductions were verified positively, with the number of emission reduction units transferred to foreign partners, the investors, amounted to EUR 20mn. It should be noted that out of the 16 EU Member States with implemented JI projects, it was Poland, which generated the highest ERU number, accounting for 23.4%[13] of all EU- originating ERUs.

JI projects implemented in Poland differed in terms of expected emission reduction volume, the method for achieving the reduction, type of reduced gas, as well as the sector of economy where they were executed. Based on these criteria, it was possible to distinguish several types of projects, associated with:

- industrial processes (4 projects),
- coal mine demethanization (8 projects),
- replacing energy generation using mining methane combustions (3 projects),
- replacing building materials with hydraulic binders (1 projects),
- boiler modernization (1 project),
- energy efficiency (1 project),
- the use of renewable energy sources (19 projects).

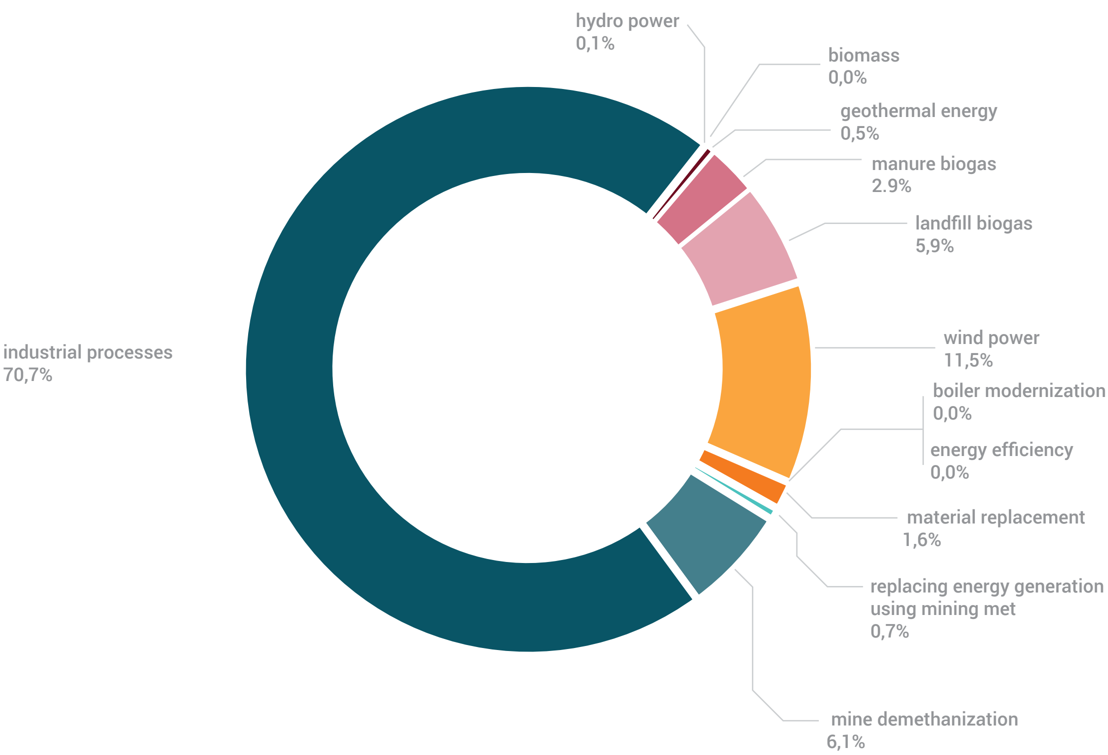
[13] Own calculation based on: http://www.cdmpipeline.org/ji-projects.htm

The aforementioned JI project types covered the reductions of the following greenhouse gases: carbon dioxide (CO_2) – 20 projects, methane (CH_4) – 13 projects and nitrous oxide (N_2O) – 4 projects. The share of individual greenhouse gases in the total expected emission reduction volume due to JI projects varied, which resulted mainly from the properties of these gases, differing in terms of the so-called global warming potential value[14]. As a result, the share of nitrous oxide in the total expected reductions amounted to 67%, methane - 17% and carbon dioxide - 16%.

The type of project regarding the reductions of a specific greenhouse gas was strictly associated with a particular economy sector, which the project concerned. In projects associated with power and heat engineering, carbon dioxide emission reductions were achieved thanks to the use of RES, in such systems as wind farms, hydro plants and heating plants using geothermal energy and biomass. Projects associated with CO_2 reduction were the most numerous, while their share in the total expected greenhouse gas emission reduction volume due to JI projects was the lowest. Methane emissions were reduced in landfills through degassing systems, in biogas plants using pig farm fertilizer and in mining methane acquisition and disposal systems. Whereas nitrous oxide emissions were reduced in nitrogen plants.

The JI mechanism in Poland was of vital importance for the Polish chemical sector, associated with nitrogen fertilizer production. Four large nitrogen plants in Puławy, Włocławek, Kędzierzyn-Koźle and Tarnów, aided by foreign partners, implemented four JI projects aimed at reducing N_2O emissions. Thanks to the use of nitrous acid decomposition catalysts in ammonia oxidation reactors for nitric acid production systems in these plants, it was possible to modernize the nitric acid production through significant reduction of N_2O emissions. This way, the entire Polish chemical sector of nitrogen fertilizers was covered by the JI mechanism. This resulted in environmental and economic benefits and enabled to stay ahead of the requirement to adapt to more stringent legal regulations applicable from 2012, when N_2O emissions were included in the EU ETS system. Thanks to JI projects, Polish companies from the chemical industry reduced current emissions and modernized themselves, being able to correctly operate within the EU ETS system, without incurring additional costs.

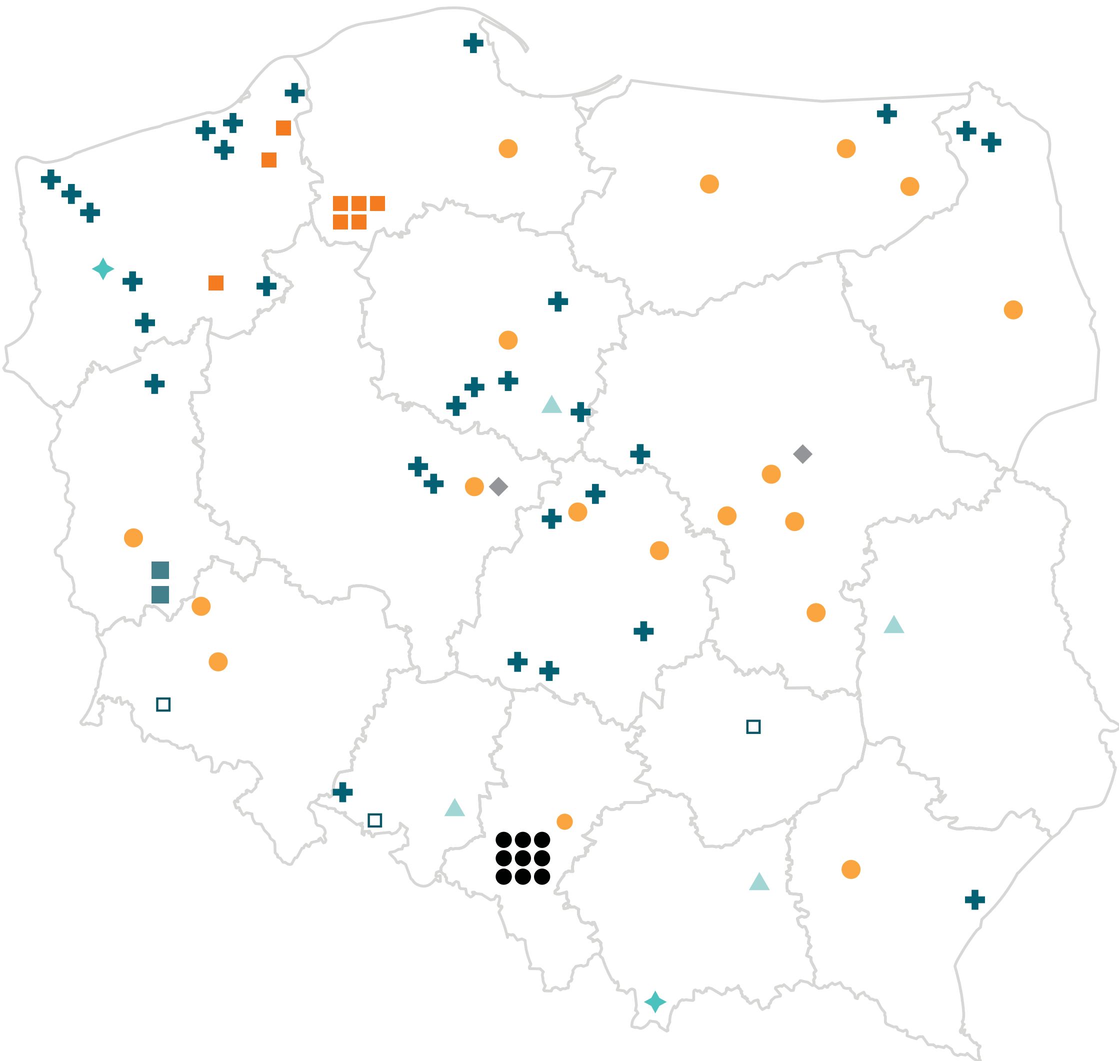
Fig. 43. The structure of achieved emission reduction volumes, depending on the type of JI projects, 2008-2012 [%]



Source: KOBiZE own study

[14] In the period of 2008-2012, in order to calculate the volume of greenhouse gas emissions, the following values of the warming potential were used, expressed in the form of carbon dioxide equivalent: 1 – for carbon dioxide (CO_2), 21 – for methane (CH_4) and 310 – for nitrous oxide (N_2O).

Fig. 44. Spatial arrangement of facilities covered by JI projects in Poland



Sign	Objects/ activity	Number of facilities	Number of projects
▲	nitric acid plant/ N_2O abatement	4	4
●	landfill/ gas utilisation	18	4
■	biogas utilisation	8	1
✚	wind farms	30	10
✦	geothermal plants	2	2
□	boilers (biomass boiler and boiler modernization)	3	2
■	small hydro-power plants	2	2
●	coal mine/ methane utilisation	9	11
◆	hydraulic binder manufacturing plants	2	1

Source: KOBiZE own study

Political and legal conditions

Objectives and obligations of Poland and the EU for 2020

Poland has been a party to the UN Framework Convention on Climate Change since 2004 and the Kyoto Protocol since 2002, therefore, has been participating in the activities aimed at limiting climate changes attempted by the international community. In the first period of commitments resulting from Poland ratifying the Kyoto Protocol, Poland attempted to decrease greenhouse gas emissions in 2008-2012 by 6% compared to the emissions in the baseline year. In the second commitment period defined in the Doha amendment, i.e., in the years 2013-2020, Poland has not been aiming to achieve an individual reduction objective, because the European Union, its Member States and Iceland concluded an agreement on meeting a common target. The common reduction target was expressed as a commitment to achieve annual average emissions at a level of 80% of the total emissions by all countries in the baseline years.

Within the UNFCCC, the European Union has also made a commitment to reduce greenhouse gas emissions by 20% until 2020, compared to 1990.

The European Union has been pursuing its objective through a EU policy and domestic policies of the Member States, while EU emissions are divided into two main sectors: emissions covered by the EU emissions trading scheme (so-called EU ETS sector) and other emissions (so-called non-ETS sector). EU legislation imposes emissions limits on the Member States (including Poland) only in the non-ETS sectors (which includes emissions from agriculture, transport, waste, fugitive emissions and emissions from small industrial-power facilities). Whereas in the EU ETS sector (which covers large industrial and power facilities), the EU Member States do not have any commitments regarding emission reductions - because emissions are limited at the EU level, and not by individual countries.

Table 3. International and EU commitments of Poland until 2020.

Specification	International commitments (UNFCCC)			International commitments (UNFCCC)	
	Kyoto Protocol		Convention	Climate and energy package	
				EU ETS	ESD
Commitment period and target year	First commitment period (2008–2012) – CP1	Second commitment period (2013–2020) – CP2	2020	2013–2020	2013–2020
Emission reduction target	-6%	-20%	-20%	Total emission reduction in the EU by 21% compared to 2005 r.	Increase in the emissions by 14%, compared to 2005, as per the annual emission limits
Baseline year	1988 fla CO_2, CH_4, N_2O 1995 for HFCs, PFCs, SF_6	1988 for CO_2, CH_4, N_2O 1995 for HFCs, PFCs, SF_6, 2000 for NF_3	1990	1990 for total emissions; 2005 for RES and energy efficiency and for EU ETS and ESD emissions	
Included gases	CO_2, CH_4, N_2O, HFCs, PFCs, SF_6	CO_2, CH_4, N_2O, HFCs, PFCs, SF_6, NF_3	CO_2, CH_4, N_2O, HFCs, PFCs, SF_6	CO_2, CH_4, N_2O, HFCs, PFCs, SF_6	

Source: KOBiZE own study

Climate and energy package 3x20

On 23 January 2008, the European Commission presented a package of documents, mainly legislative, defined as the so-called climate and energy package. These documents are aimed at meeting the assumptions adopted by the European Council in 2007 associated with tackling climate change, stipulating that by 2020, the European Union will:

- reduce greenhouse gas emissions by 20% (with an option of a 30% reduction, provided relevant international agreements in this respect are concluded) compared to the level of emissions from1990;
- increase the share of renewable energy in final energy consumption to 20%;
- increase energy efficiency to 20%, compared to the predictions for 2020;
- increase the share of biofuels in the general consumption of transport fuels at least to 10%.

In December of 2008, after almost a year of work, an agreement was reached between the European Parliament and the EU Council - and the climate and energy package passed, with the publication of individual elements in the EU Official Journal on 5 June 2009.

The two crucial elements of the adopted package, relating to greenhouse gas emissions are:

- Directive of the European Parliament and of the Council 2009/29/EC of 23 April 2009 amending Directive 2003/87/EC so as to improve and extend the greenhouse gas emission allowance trading scheme of the Community (so-called EU ETS directive), and
- Decision of the European Parliament and of the Council No. 406/2009/EC of 23 April 2009 on the efforts of Member States to reduce their greenhouse gas emissions to meet the Community's greenhouse gas emission reduction commitments by 2020 (so-called non-ETS decision).

EU ETS

Due to the fact that the EU greenhouse gas emissions trading systems (EU ETS) covers approx. 10 thousand facilities in the energy sector and other industry branches, which are responsible for more than half of CO_2 emissions and 40% of all greenhouse gas emissions, it is the main tool to curb emissions in the EU. In this regard, it is assumed that during the third implementation period of the EU ETS, in the years 2013-2020, greenhouse gas emissions should be limited by 21% compared to the emission levels from 2005. This fact, regardless of the allowance allocation method, determines the average number of allowance available to business entity within this system.

Generally, the basic method for allowance allocation is an auction system. However, this obligation is introduced gradually (as a result of negotiations, 90% of the allowances in industrial sectors will be granted free-of-charge), according to various paths and based on varying criteria, depending on the sector of the economy. Essentially, the EU ETS directive divides sectors within the EU ETS system into three groups: exposed to carbon leakage, electricity producers and other industry branches, including heat generation, which are not exposed to carbon leakage.

The system of free allowance allocations is based on emission indicators (benchmarks), determined for individual sectors by way of a decision of the European Commission (2011/278/UE). Moreover, by way of a decision of the European Commission of 2009 (2010/2/EU) and 2014 (2014/746/UE), the list of sectors exposed to carbon leakage was determined.

The issue of carbon leakage is associated with a risk of relocating production outside of the EU, due to excessive burden for the manufacturers covered by the EU ETS system in the form of emission allowance purchasing costs. These sectors are entitled to a maximum of 100% free allowances. Industrial sectors not exposed to carbon leakage can, in turn, based on determined indicators, since 2013 receive a maximum of 80% free allowances, with the number decreased annually, aiming to reach a maximum level of 30% in 2020. However, it should be noted that the application of emission factors additionally lowers the allocation of free allowances.

Furthermore, the possibility of applying derogation for the energy sector in new EU Member States was introduced, i.e., derogations from the 100% requirements to purchase allowances at auctions. The energy sector can receive some allowances for free, provided it meets the conditions set out in the directive.

Allowance allocation principles applicable in the III EU ETS settlement period give rise to the need to purchase, depending on the sector, a rather large part of the allowances. The missing allowance can be purchased at auctions, secondary market, purchase Kyoto units or use the saved allowances purchased in the years 2008-2012.

Non-ETS

The term non-ETS means the part of domestic greenhouse gas emissions, which are not subject to the EU ETS system, which applies to large facilities emitting GHGs. Non-ETS emissions include the following sectors: transport, agriculture, waste, non-ETS industrial emissions and the municipal-housing sector with buildings, small sources, households, services, etc.

The volume of GHG emissions classified as non- ETS is in Poland roughly similar to the EU ETS emissions (accounts for approx. 50% of domestic emissions).

The need to reduce emissions is non-ETS sectors stems from the EU adopting the climate and energy package by 2020. In contrast to EU ETS, which applies directly to the volume of emissions from individual installations, the non-ETS emission volume is determined at the level of EU Member States. The volume of emissions granted to Poland for the period of 2013-2020 is +14% compared to 2005, therefore, it assumes a possibility of increased non-ETS emissions in Poland by 2020, compared to the baseline level, which is the 2005 emissions level for this field. In the scale of the entire EU, the objective for non-ETS is -10% by 2020. In the light of the fact that non-ETS covers domestic emissions, reporting and the settlement of annual emission volumes within the non-ETS sectors is the duty of the government.

Annual Emission Allocation units (AEA), which are allocated to Member States based on their reduction targets are used to settle domestic emissions. 1 AEA = 1CO_2eq.

To a limited extent, it is also allowed to use CER/ERUs (up to 3% of greenhouse gas emissions in 2005), so-called offset, by utilizing international units coming from emission reducing projects, i.e., JI and CDM projects implemented as per the Kyoto Protocol.

The issue of non-ETS emissions is governed by the provisions of the so-called non-ETS decision (Effort Sharing Decision - ESD), namely, decision 2009/406/EC of 23 April 2009 on the efforts of the Member States aimed at reducing greenhouse gas emissions to meet the Community's greenhouse gas emission reduction commitments by 2020.

The non-ETS decision is associated with other, particularising legal acts, such as the decision of the Commission, which set domestic emission limits[15] in non-ETS sectors for all Member States, for the individual years of the 2013-2020 period, namely, AEA units allocated to each country, which they can use to settle their emissions in this area. Moreover, based on the reported domestic emission volumes, the Commission issues decisions determining the non-ETS emission volumes in Member States, in the year a report covers. The volume of these emissions in a given year will have to be balanced by the annual emissions allocation (covered by the AEAs allocated to a country) and - depending on the needs - by relevant actions specified in the ESD, such as, the so-called flexibility mechanism and the use of CER/ERUs. The non-ETS is governed in the domestic legislation by the act of 17 July 2009 on the system for managing the emissions of greenhouse gases and other substances (cons. text OJ 2018, item 1271), which introduces legal regulations in the scope of non-ETS.

According to the available data, Poland is on the right path to satisfy its reduction commitments for 2013-2020 - with a surplus, estimated at approx 65 Mt CO_2.[16]

Energy efficiency policy and efforts to improve it

Energy efficiency policy of the EU

The current commitments of EU Member States in the field of increasing energy efficiency result from the package of legislative documents publish in January 2008, the so-called climate and energy package, according to which the Member States are obliged in this field to, i.a.:

- increase energy efficiency in 2020 by 20%, compared to the forecasts for 2020,
- increase the consumption of RES energy in the EU up to 20% by 2020, fixed at 15% for Poland.

The objectives associated with energy efficiency result mainly from the provisions of the directive of the European Parliament and the Council 2012/27/UE of 25 October 2012 on energy efficiency. The directive stipulates that each Member State shall set an indicative domestic energy efficiency target, based on its consumption of primary or final energy, primary or final energy savings or energy intensity. The target values should be also expressed in the categories of absolute primary and final energy consumption level in 2020. The directive also imposes the obligation to establish a system committing to energy efficiency on each Member State. This system should ensure the energy distributors or retailers, and companies which are active within a given Member State, to achieve the total objective in the field of final energy savings by 31 December 2020. This objective is at least equivalent with all the energy distributors or all retailers achieving new savings each year from 1 January 2014 until 31 December 2020, in the amount of 1.5% of the annual sales of energy to end consumers, averaged over the last 3- year period prior to 1 January 2013. The sales volume of energy consumed in transport can be partially or fully excluded from this calculation.

[15] One decision specifies he annual emission allocation(decision of the Commission no. 2013/162/EU of 26 March 2013), a second one corrects them (decision of the Commission no. 2013/634/EU of 31 October 2013 on the adjustments to Member States' annual emission allocations for the period from 2013-2020), whereas the third (decision of the Commission no. 2017/1471/EU of 10 August 2017 amending decision 2013/162/EU in order to revise the annual emission allocations for Member States for the period from 2017 to 2020), amending the first decision in the scope of defining the annual emission allocations for 2017-2020.

[16] *Trends and projections in Europe 2018. Tracking progress towards Europe's climate and energy targets.* Annex 1. Progress towards greenhouse gas emission targets: data and methodology. Table A1.5. Cumulative gaps between historical and projected Effort Sharing Decision (ESD) emissions and annual ESD targets, 2013-2020., str. 40. EEA, 26 October 2018.

Energy efficiency policy in Poland

The most important document defining the energy efficiency policy in Poland include:

- Polish Energy Policy until 2030,
- National Action Plans (KPD) regarding energy efficiency (1, 2, 3, 4 KPD for the years 2007, 2012, 2014, 2017, respectively), the development of which is imposed by the directives 2006/32/EC and 2012/27/EU.

The Third Action Plan (3. KPD) adopted in 2014 on energy efficiency summarized the achieved energy efficiency improvement targets, presented the objectives for 2020 and updated the actions and measures taken, as well as planned in order to accomplish the goals. In 2011, an act on energy efficiency was passed (Dz.U. 2011 No. 94, item 551), which was aimed at developing the mechanisms stimulating the improvement of energy efficiency. Above all, this act introduced an obligation to achieve a relevant number of energy efficiency certificates, so-called white certificates, by power companies selling electricity, heat or natural gas to end consumers connected to the grid in Poland. The aforementioned act was replaced by a new act on energy efficiency of 20 May 2016 (Dz. U. 2016 item 831), aimed at the further improvement of energy efficiency of the Polish economy and ensuring the accomplishment of the domestic target. The act introduced a regulation, pursuant to which a unit from the public sector may implement and fund projects, based on a contract for the improvement of energy efficiency. All Polish public authorities have the obligation to purchase energy-efficient products and services. They must purchase or rent energy-efficient buildings and fulfil the recommendations on energy-efficiency in modernized and reconstructed buildings, belonging to the State Treasury. The act enabled maintaining the system of energy efficiency certificates (so-called white certificates), which has been functioning since 2013. One of the provisions of the new act requires all large companies to conduct energy audits.

Domestic objectives in terms of energy savings

Setting the domestic energy efficiency target for 2020 is the implementation of art. 3 par. 1 of the directive 2012/27/EU. Table 4 shows the energy efficiency target for Poland, set pursuant to the directive 2012/27/EU. This target, understood as limiting the consumption of primary energy in the years 2010-2020 by 13.6 Mtoe17, which in the conditions of economic growth also means improving the energy efficiency of the economy. The objective, expressed in the categories of absolute level of primary and final energy consumption in 2020, was set based on the data developed through analyses and forecasts for the needs of a governmental document titled "Polityka energetyczna Polski do 2030 roku [Polish energy policy until 2030]".

Table 4. Energy efficiency targets for 2020 – pursuant to directive 2012/27/UE

Energy efficiency target	Absolute energy consumption in 2020	
Limiting the consumption of primary energy in the years 2010- 2020 [Mtoe]	Final energy consumption in absolute values [Mtoe]	Primary energy consumption in absolute values [Mtoe]
13,6	71,6	96,41[18]

Source: Efektywność wykorzystania energii w latach 2005-2015 [Energy consumption efficiency in the years 2005-2015], GUS, Warsaw 2017

The aforementioned analyses indicate that limiting the consumption of primary energy will result from a series of already implemented projects, as well as conducting actions aimed for improving energy efficiency, stipulated in the domestic energy policy.

[17] Toe - tonne of oil equivalent

[18] According to the reference values for Poland contained within a forecast developed for the European Commission (PRIMES - Baseline 2007), primary energy consumption is forecast at a level of 110 Mtoe in 2020, therefore, taking into account the energy consumption reduction by 13.6 Mtoe, we get: 110 Mtoe – 13.6 Mtoe = 96.4 Mtoe

Improving energy efficiency in the industrial sector

The system imposing energy efficiency was introduced by way of an act of 15 April 2011 on energy efficiency. The energy efficiency certificates, so-called white certificates, play a crucial role in this system. The white certificate system focuses on industrial sectors. The act requires power companies selling energy to end consumers with a duty to acquire energy efficiency certificates, so-called white certificates, and to submit them to the President of the Energy Regulatory Office (URE) for redemption. Projects, for which they may be granted, include:

- increasing energy savings of end consumers,
- increasing energy savings through managing house loads, understood as a set of auxiliary facilities or systems supporting the electricity or heat generation process,
- reducing the losses of electricity, heat or natural gas in the course of transmission or distribution.

The new act on energy efficiency of 2016 abolished the requirement to conduct a tender, which results in the URE President selecting projects to improve energy efficiency, for which energy efficiency certificates may be granted. The new act introduces changes in the manner of settling savings based on final energy, and not primary energy, as previously. The legislative changes also enable entities covered by the EU ETS system, and were previously excluded from the tender, to participate in the white certificate system. It was estimated, that the value of final energy in the EU ETS area, saved in the years 2016-2020 as a result of the implemented project may amount to 2.645 Mtoe.

Measures for the improvement of energy efficiency in the housing sector

Supporting investments in the field of energy efficiency of buildings is based on the act of 21 November 2008 on assisting thermomodernizations and renovations. The funds from the Thermomodernization and Renovation Fund, supplied from the State budget, were used to finance the Programme for supporting thermomodernization projects and tasks associated with the thermomodernization of renovation projects, implemented in old, multi-family residential buildings. This programme has been functioning in its current form since 2009. The resources from the Thermomodernization and Renovation Fund were allocated to refinancing parts of the costs of thermomodernization and renovation projects aimed at improving the technical condition of existing housing stock, while simultaneously decreasing the heat demand. Table 5 shows energy savings until 2015[19] with a forecast by 2020[20], within the operation of the Thermomodernization and Renovation Fund.

Table 5. Energy savings within the Thermomodernization and Renovation Fund

Year	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Achieved energy savings [GWh]	3 765	4 283	4 801	5 321	5 584	6 246	6 863	7 379	7 895	8 411	8 928	9 444

Source: Efektywność wykorzystania energii w latach 2005-2015 [Energy consumption efficiency in the years 2005-2015], GUS, Warsaw 2017

Summary of the energy efficiency policy in the EU and Poland until 2020

The period of 2005-2016 in Poland21 saw a consistent improvement of energy efficiency. Primary energy consumption was decreasing during that period by an average of 3% per year, and the final energy consumption by over 2% annually. The fastest rate of energy efficiency improvement was recorded in the industry sector. A slowdown of the energy efficiency improvement was recorded in 2016. The GDP primary and final energy consumption decreased in 2016, compared to 2006, by 28% and 24%, respectively.

The share of the transport and services sector in the final energy consumption increased in 2006-2016, while the share of the industry, households and agriculture decreased. The share of transport jumped from 23 to 29% due to the increasing importance of road freight and passenger transport. In the field of transport in 2016, more than 94% of the energy was used in road transport, below 4% in aviation, less than 2% in railway, and minimum values used by inland and coastal navigation.

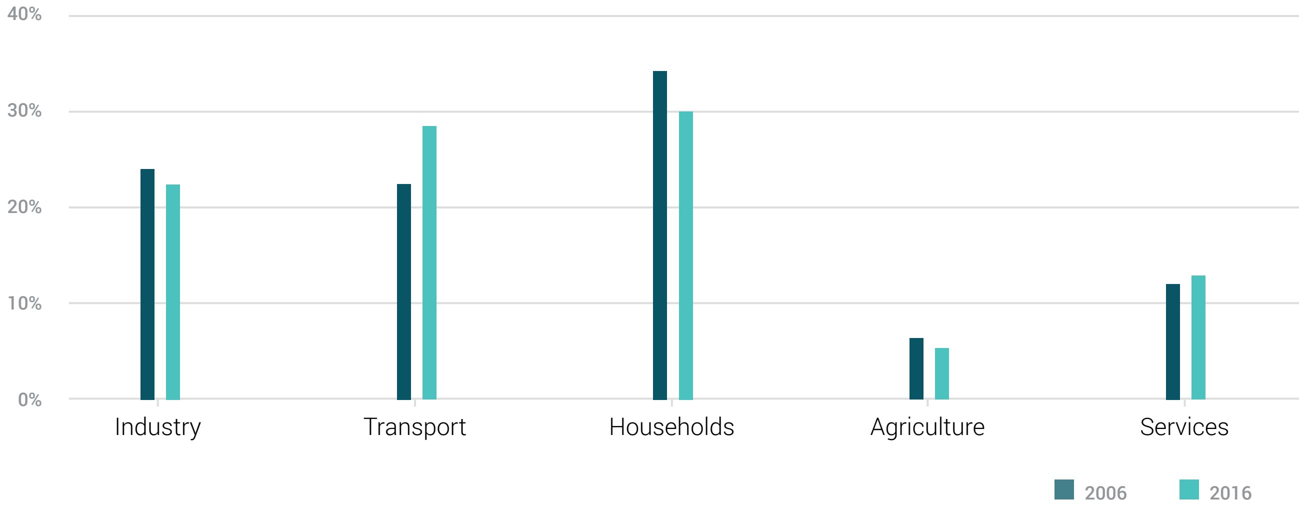
[19] W latach 2013-2015 oszczędności energii obliczono na podstawie ilości przyznanych premii termomodernizacyjnych

[20] W latach 2016-2020 założono roczny przyrost energii finalnej na poziomie 516 GWh, co jest średnią z lat 2009- 2015

[21] Efektywność wykorzystania energii w latach 2006-2016, GUS, 15.06.2018 r.

The fuel consumption in road transport over the years 2006-2016, increased by 42% (annual growth rate of 3.5%), with a simultaneous, clear decrease of energy consumption in railway transport. Overall, the average annual fuel consumption growth rate in the field of transport (without air transport) amounted to 3.1% for the years 2007-2016. It was shown in fig. 45.

Fig. 45. The structure of final energy consumption in Poland, by sector, 2006-2016



Source: Efektywność wykorzystania energii w latach 2006-2016 [Energy efficiency in the years 2006- 2016], GUS, 15/6/2018

Despite a decrease from 35 to 30%, the largest consumers of electricity were the households. In 2016, the share of households accounted for 30% of the final energy consumption. The most frequently used carrier was carbon fuel, although its share fell from 35% in 2006 to 33% in 2016. Next in line were: heat (its share was 20% in 2016), natural gas (18%), electricity (13%), other carriers (14%) and liquid fuels (3%).

The most important direction of energy consumption was heating the rooms, with its share amounting to 66.4% in 2016. Heating water consumed 15.8% of energy, lighting and electrical appliances 9.7% and cooking meals 8.0%. This is shown in table 6.

Table 6. Household energy consumption structure, by directions of use [%]

Specification	2002	2009	2012	2015	2016
Total	100,0	100,0	100,0	100,0	100,0
Heating rooms	71,3	70,2	68,8	65,5	66,4
Heating water	15,0	14,4	14,8	16,2	15,8
Cooking meals	7,1	8,2	8,3	8,5	8,0
Lighting	2,3	1,8	1,5	9,8*	9,7*
Electrical appliances	4,3	5,4	6,6		

* łącznie oświetlenie i urządzenia elektryczne

Source: Efektywność wykorzystania energii w latach 2006-2016 [Energy efficiency in the years 2006- 2016], GUS, 15/6/2018

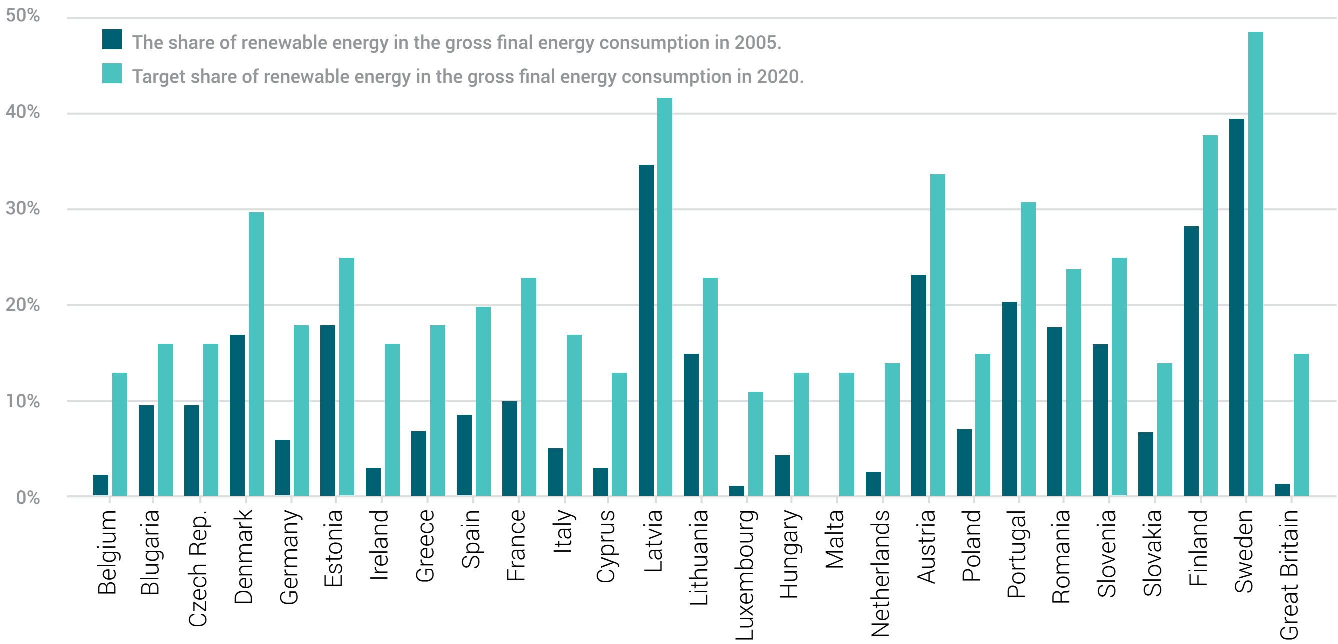
Energy from renewable sources
Energy from renewable sources is a type of energy derived from natural, repeating environmental processes, acquired from renewable energy sources (energy from water, wind, solar radiation, geothermal energy, waves, sea currents and tides) and energy generated from solid biofuels, biogas and liquid biofuels, as well as energy of the environment (natural environment) used by heat pumps. Renewable energy sources are an alternative for traditional, primary, non-renewable energy carriers (fossil fuels). Their resources are replenished through natural processes, which practically allows to treat them as inexhaustible. Furthermore, acquiring energy from these sources is, compared to other, traditional sources (fossil), more eco-friendly. The use of RES significantly decreases the adverse impact of the energy sector on the natural environment, especially through limiting the emissions of harmful substances, greenhouse gases in particular. The extent of renewable energy utilization in EU Member States is governed by relevant EU documents and normative acts. The basic document is the Directive of the European Parliament and of the Council 2009/28/EC of 23 April 2009 on the promotion of the use of energy from renewable sources, amending and subsequently repealing directives 2001/77/EC and 2003/30/EC (OJ L 140, 5.6.2009, p. 16). U. L 140 of 5/6/2009). This directive stipulates a series of tasks for EU Member States, in particular:

- joint framework for the promotion of energy from renewable sources,
- mandatory overall national targets in relation to the overall share of renewable energy in the
- gross final consumption of energy and in relation to the share of renewable energy in transport,
- principles regarding:
  - statistic transfers of certain amounts of RES energy between Member States,
  - joint projects between the Member States and third countries,
  - guarantee of origin,
  - administrative procedures,
  - information and trainings,
  - access of energy from renewable sources to a power grid;
- sustainable development criteria for biofuels and bioliquids.

The general domestic targets in the field of consuming energy from renewable sources in the final energy gross consumption stipulated in the directive for individual EU Member States are shown in fig. 46.

Directive of the European Parliament and of the Council (EU) 2015/1513 of 9 September 2015 amending the Directive of the European Parliament and of the Council 2009/28/EC of 23 April 2009 on the promotion of the use of energy from renewable sources was published on 15 September 2015 in the Official Journal of the European Union. The aforementioned amendment applied to the algorithms for calculating the share of energy from renewable sources in transport, in the event of using biofuels, which satisfy the criteria of sustainable development and electricity generated from renewable sources.

Fig. 46. General domestic targets in the field of consuming energy from renewable sources in the final energy gross consumption in 2020



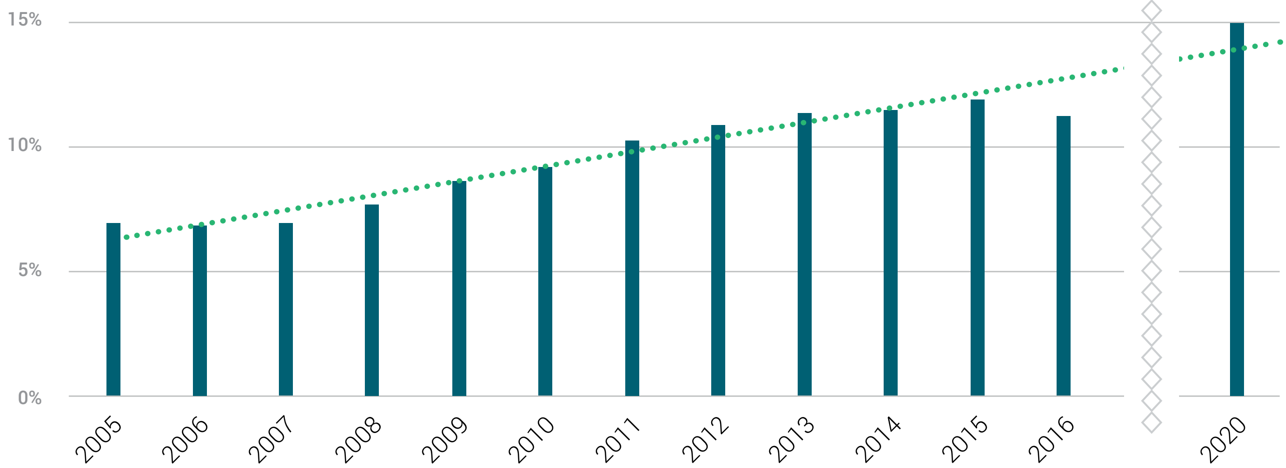
Source: Energia ze źródeł odnawialnych w 2016 r. [Energy from renewable sources in 2016], GUS, Warsaw 2017

Pursuant to directive 2009/28/EC, Member States are obliged to ensure a certain share of energy from renewable sources in the gross final energy consumption in 2020. The mandatory overall national targets make up the assumed 20% share of renewable energy in the gross final energy consumption within the Community.

Share of energy from renewable sources in the gross final energy consumption – calculated as a product of the value of gross final consumption of energy from renewable sources and the value of the gross final consumption of energy from all sources, expressed as a percentage (%).

For Poland, this goal was set at a level of 15%. Furthermore, each Member State should ensure that, by 2020, the share of energy from renewable sources in all types of transport is at least 10% of the final energy consumption in transport.

Fig. 47. The share of energy from renewable sources in the gross final energy consumption in transport in the years 2005-2016 [%]

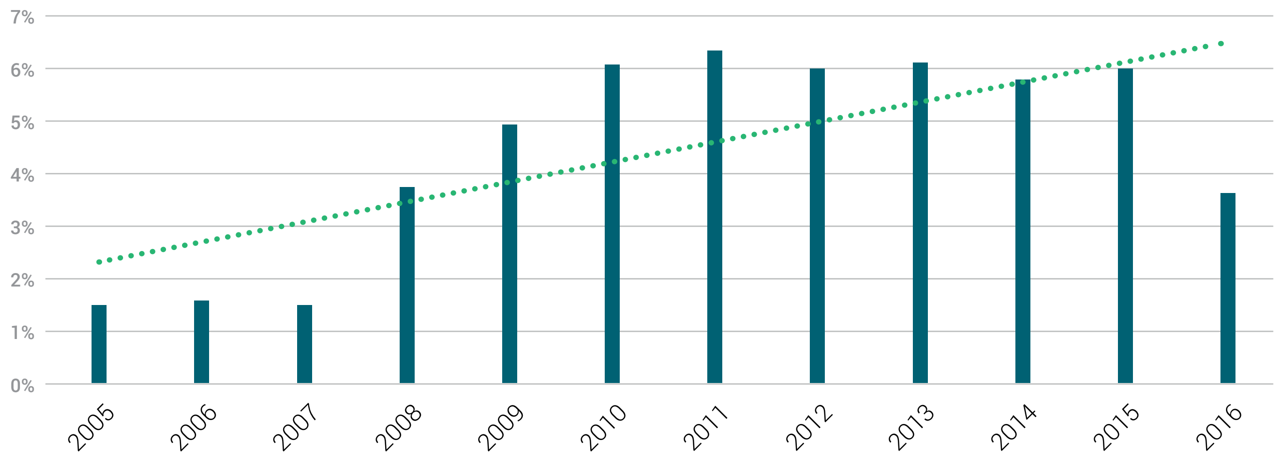


Source: Energia ze źródeł odnawialnych w 2016 r. [Energy from renewable sources in 2016], GUS, Warsaw 2017

The share index of energy from renewable sources in the gross final energy consumption in 2016 was 11.30% (fig. 47) and increased by 4.39% compared to 2005. The average annual growth rate for the share of energy from renewable sources in the gross final energy consumption in 2005-2016 was 4.6%.

The value of the share of RES energy in the gross final energy consumption in transport fluctuated. In 2016 it amounted to 3.93% (fig. 48) and increased by 2.31% compared to 2005. The average annual growth rate for this index in 2005-2016 was 8.4%.

Fig. 48. The share of energy from renewable sources in the gross final energy consumption in transport in the years 2005-2016 [%]



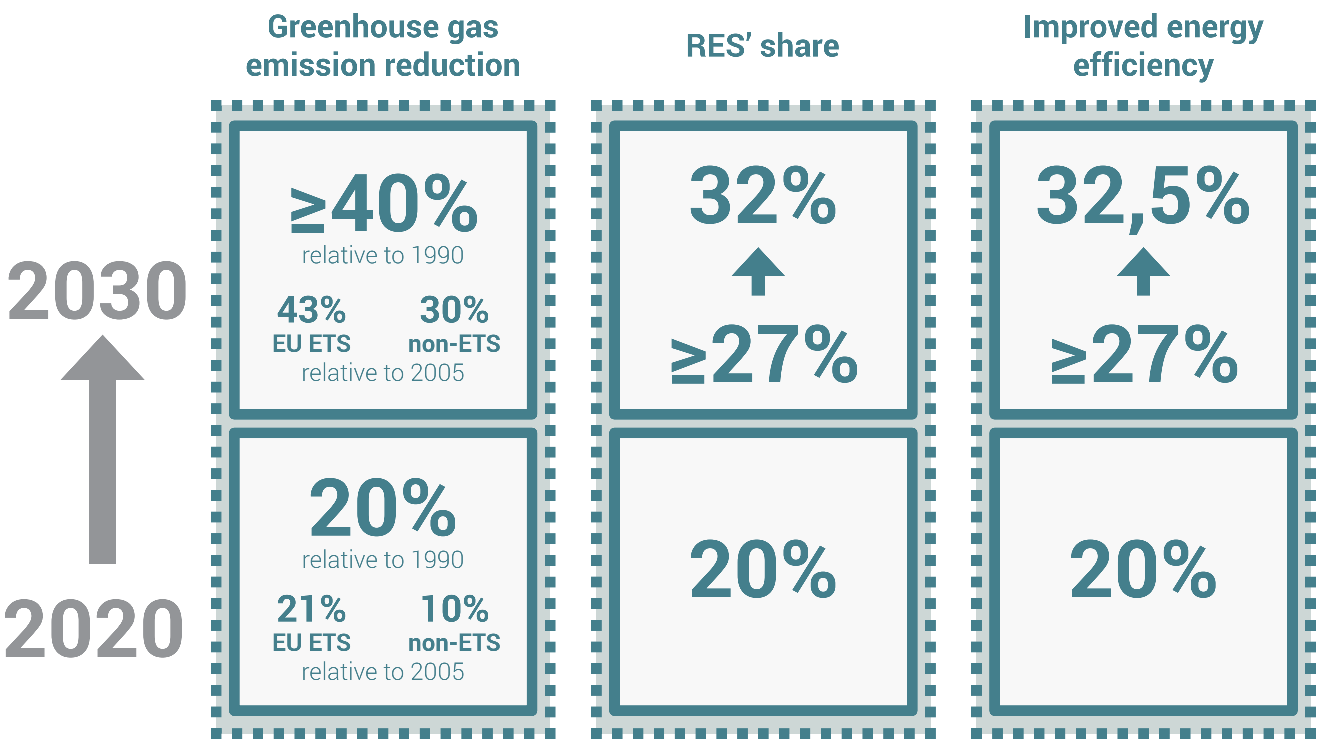
Source: Energia ze źródeł odnawialnych w 2016 r. Energy from renewable sources in 2016], GUS, Warsaw 2017

Targets and commitments of Poland, EU and the world for 2030

During the Conference of the Parties to the Climate Convention in 2015 in Paris (COP21), 195 countries of the world agreed on the activities associated with climate change (Paris Agreement - PA). Art. 2 of the PA defines the global reduction target - stopping the growth of average global temperature at significantly below 2 C and making efforts to limit the temperature growth to 1.5 C compared to the pre-industrial era levels. All EU countries, including Poland, ratified the PA. The agreement does not impose a method for the signatories to use in order to achieve their target - it leaves the decision at the discretion of the countries, which are to declare their reductions themselves (NDCs – nationally determined contributions).

Already in 2014, the European Union agreed its reduction targets for 2030 - the overall and divided into EU ETS and non-ETS sectors. The European Union also adopted ambitious objectives in the field of RES and energy efficiency, which were raised even more in 2018[22]. The explanatory memorandum emphasizes that meeting such defined targets will result in the economy of the European Union, including its power system, becoming more competitive, with a simultaneously increasing level of energy security and the efficiency of tackling climate change. The aforementioned targets for the climate policy apply to the entire European Union, while the level of detail and the role of Member States and the sectors of the economy in reaching them area being currently defined in various manners. Comparison of EU commitments for 2030 with the objectives for 2020 is shown in fig. 49.

Fig. 49. EU commitments by 2030 compared to the 2020 target



Source: KOBiZE own study

EU ETS

EU Member States - similarly to the years 2012-2020 - do not have individual reduction targets for emissions within the emissions trading scheme by 2030, because the EU ETS target is settled only at EU level.

The adopted climate policy assumes that approximately a half of the general reduction effort is to be made by the emission allowance trading system (EU ETS), which remains the basic EU instrument in this field. It is assumed that the reduction of EU ETS greenhouse gas emissions by 2030 will reach 43% compared to the emission level from 2005. It should be note that the conclusions from the summit included a direct reference to the reformed emissions trading scheme, which is a clear sign of support for the implementation of market stability reserve (MSR). It is anticipated that this will help reduce the impact of other activities in the climate protection policy on the emission allowance prices.

It was also decided that, in order to protect the international competitive position of European enterprises, the EU ETS system will still allow allocating free allowances in the sectors exposed to the risk of carbon leakage. However, it should

[22] RES target – from 27% to 32%, energy efficiency target from 27% to 32.5%. Source: http://europa.eu/rapid/press-release_IP-18-4229_en.htm

be noted that the principles of allocating free allowances will be verified, with particular attention to the elimination of the impact of other factors - besides the climate policy - on this mechanism, which weaken the competitive position (e.g. increase of labour costs).

For the first time, the decisions made by the leaders of EU Member States in regard to the climate policy indicated a need to take into account both direct, as well as indirect emission costs (e.g. impact on energy prices). Previously, the issue of compensating for indirect effects was left to the discretion of the Member States. In consequence, already the very conclusions from the summit contain a decision regarding financial support for poorer countries, to be implemented mainly through two mechanisms.

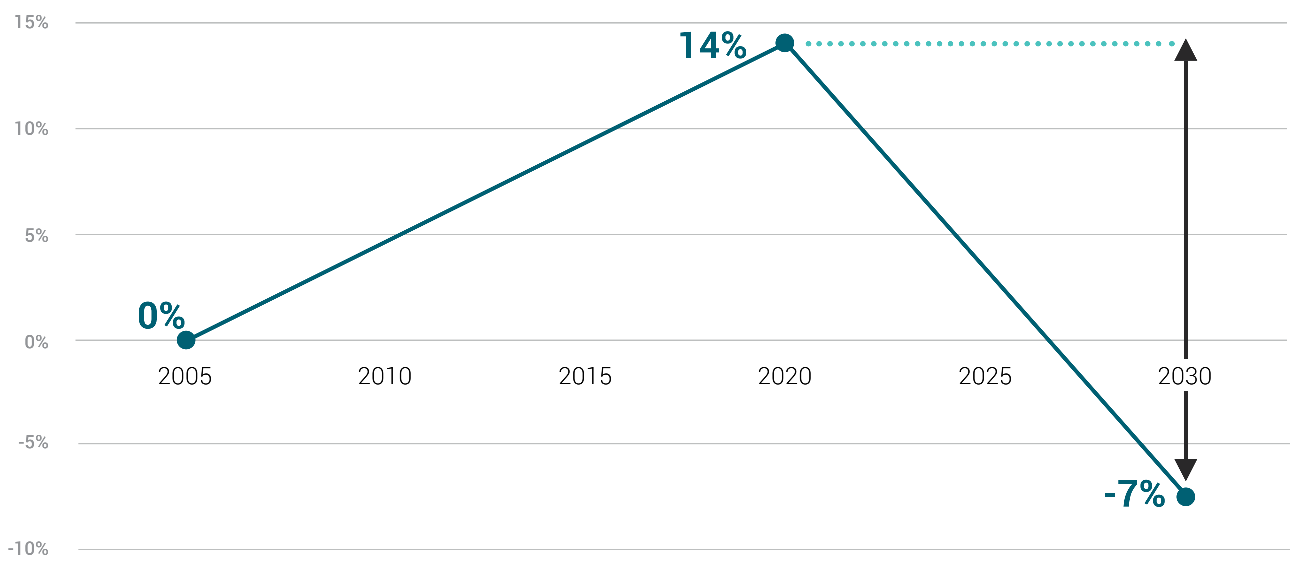
In the case of the Member States, where the GDP per capita is at a level of approximately 60% of the EU average, it is suggested to create a special fund, which could support necessary additional investments in the energy sector. The Fund would generate cash inflow from the sales of allowances, from a specially formed reserve covering 2% of the total pool of EU ETS allowances. The distribution of the money from the Fund among entitled Member States would be equally based on two criteria: 50% would be allocated based on the historical level of emissions and 50% based on the GDP index. The selection criteria for the projects are to be developed by 2024, and the qualification procedure itself is to be participated by the European Investment Bank.

The second form of support for poorer Member States are the additional emission allowances coming from separating a 10% pool assigned to auctions. It means that apart from the allowance from the 90% auction pool allocated as per the criteria of historical emissions, the Member States with a GDP per capita is lower than 90% of the EU average would receive additional units from this 10% pool. Furthermore, special support for the power generation sector was allowed, which involved the allocation of up to 40% of free allowances in countries with a GDP per capita below 60% of the EU average (40% of the amount received from the 90% pool). Aid resulting from the aforementioned mechanisms will be carefully monitored, so that it could be transpicuously used to modernize the energy sector and not as a form of just simple support for fossil fuel-fired systems.

Non-ETS

The reduction target for 2030 in the non-ETS sector was "divided" into EU Member States. The value for Poland is -7% compared to the emissions in this sector for 2005. It is a very ambitious objective, given the fact that in the period of 2013-202, Poland is entitled to increase non-ETS emissions by 14% compared to 2005 (see fig. 50). Non-ETS emissions are mainly related to transport, fuel combustion in the municipal sector (e.g. household furnaces) and agriculture (soil fertilization, animal droppings)[23]. Transport emissions are growing, and it is anticipated that they will continue to grow, as a result of economic development and increasing passenger transport and cargo freight. The mitigation effect in this regard is expected as a result of the Plan Rozwoju Elektromobilności w Polsce "Energia do przyszłości" [Development Plan for Electromobility in Poland "Energy to the future"][24]. Emissions in the municipal sector will be decreased, i.a., as a result of the governmental "Clean air" scheme, which will impact not only smog reduction but also greenhouse gas emissions.

Fig. 50. Comparison of targets stipulated by the ESD and ESR



Source: Own study

[23] Also waste and minor power-industrial facilities, not covered by the EU ETS.
[24] https://www.gov.pl/web/energia/elektromobilnosc-w-polsce

Possible development scenarios until 2050,

according to available reports and studies – comparative analysis

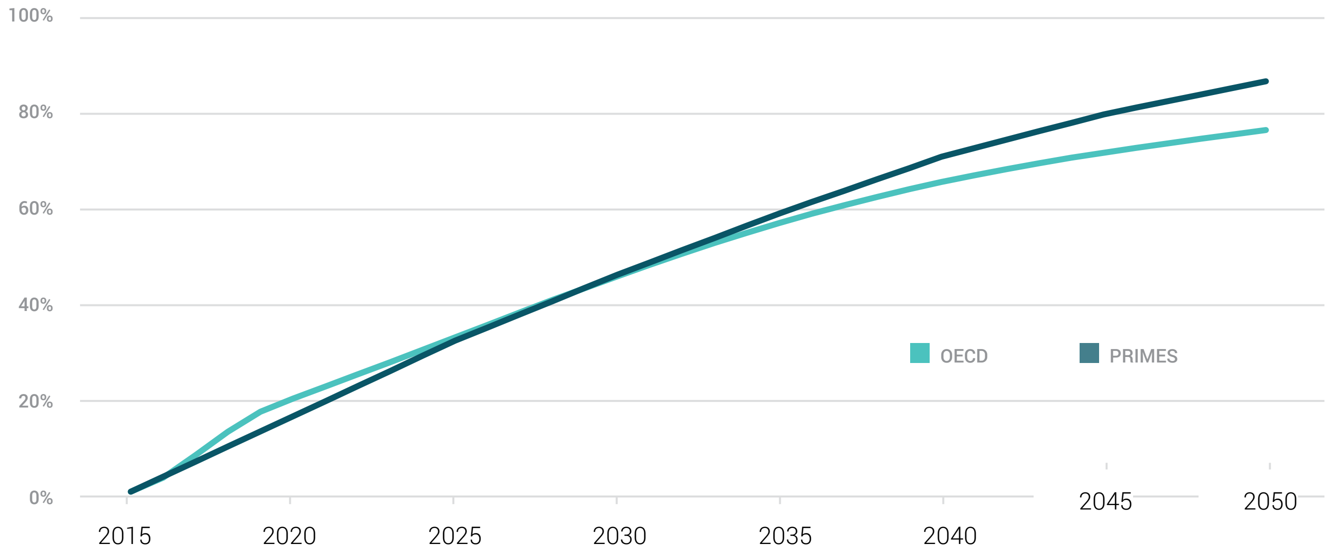
Forecasting the global and national development until 2050 in dynamically changing conditions is a tough challenge, burdened with a considerable degree of uncertainty. At the same time, the specific of climate change and the resulting policy requires long-term planning, which comes with adopting certain forecast-related assumption.

European Union institutions involved in preparing analyses for the purposes of developing energy and climate policies and evaluating the effects of suggested solutions often rely on scenarios developed with the use of a set of analytic tools, where the major role is played by the PRIMES energy sector partial equilibrium model. This set of tools helps forecasting not only the so-called energy mix of individual Member States or the associated CO_2 emissions, but also various macroeconomic indicators, such as, e.g. GDP[25].

According to the latest available scenario, it is anticipated that the Polish GDP will grow by 87% between 2015 and 2050, reaching a level of EUR 793bn (fixed prices in 2013). The scenario also forecasts a decrease of the domestic population during the same period by 10%, to 34.77mn, improvement of energy generation emissivity by 54%, which in turn, is to lead to a 45% carbon dioxide emission reduction per capita and a 50% reduction in national emissions.

The anticipated directions of the changes for selected indicators contained in the PRIMES scenario are in line with other forecasts, however, one can notice certain difference in their values forecast for 2040. In the case of GDP, the long-term forecast published by OECD predicts that in the same period, Polish economy will record a real growth of over 76%, which means 10 percentage points less than adopted in the PRIMES scenario. It should be noted that this forecast was developed taking into account both domestic factors, as well as the situation in the global economy, using model analyses and expert opinions. Fig. 51 shows the projected growth paths according to the aforementioned studies.

Fig. 51. GDP real growth forecast for Poland, according to PRIMES and OECD (2015-2050)

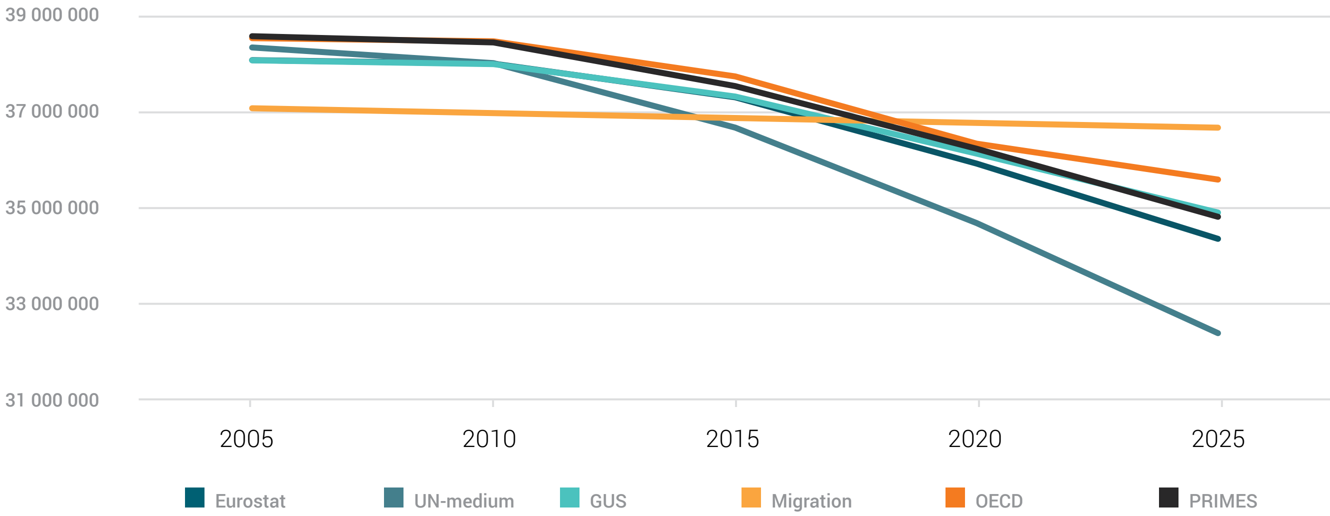


Source: own study based on: OECD (2018), Real GDP long-term forecast and PRIMES Reference scenario (REF2015).

[25] Apart from the PRIMES model, the development of the analyses involved using the global CGE GEM-E3 model, the PROMETHEUS global model for the power sector partial equilibrium, the TREMOVE model for the transport sector partial equilibrium, the CAPRI and GOLBIOM models for the partial equilibrium of the agricultural sector and the GAINS model for forecasting the emissions of other greenhouse gases than CO_2.

In the case of demographic forecasts, the discrepancies are even larger. As per the UN predictions, the population of Poland in 2050 will be approx. 32.4mn, while according to OECD, it will amount to 35.5mn. The predictions by GUS (Central Statistical Office), Eurostat and the PRIMES scenario fit somewhere between these values. All demographic forecasts for Poland anticipate a decrease in the population during the next several decades. The degree of the decline depends on the adopted method, including the degree of inclusion of migration streams of Poles and foreigners, uncertainty estimation and the very criterion for defining the population. In this context, attention should be paid to results of a study based on an econometric analysis of migration streams, according to which the Polish population in 2050 will be 36.6mn, hence, much more than anticipated by most sources[26]. Fig. 52 shows a comparison of selected demographic forecasts.

Fig. 52. Demographic forecasts for Poland until 2050



Source: own study based on forecast developed by: Eurostat, ONZ (UN-medium scenario), GUS-Central Statistical Office, PRIMES, OECD and taking into account migration streams (M. Anacka, A. Janicka "PrognozaludnościdlaPolskinapodstawieekonometrycznejprognozystrumienimigracyjnych"- Population forecast for Poland, based on the econometric forecast of migration streams").

Based on and using reference scenarios, various option of the energy and climate policy are analysed, both those with an advanced degree of implementation, as well as the variants suggested by different authors and scientific-research centres. The PRIMES reference scenario (Ref201%) anticipates that in the period from 2015 to 2050, carbon dioxide emissions in Poland will fall from 312mn tonnes to 155mn tonnes, i.e., by 50% (also compared to 2005, when the level of CO_2 emissions amounted to 308mn tonnes). In the light of the constant growth of the EU and global level of ambitions in terms of the climate-energy policy, the anticipated emission reduction may prove to be insufficient.

The available studies analysing the Polish reduction potential and the effects of implementing climate- energy policy variants are based on various assumptions, cover different time perspectives and adopt various reference scenarios. As a consequence, diverse results are made available and should be interpreted individually, with their comparison requiring attention and adopting a series of provisions. Nonetheless, generally, these studies give a certain idea regarding the scale of the possible activities and their economic effects.

Selected results from the following studies devoted to analysing the Polish greenhouse gas emission reduction potential and their economic effects are presented below:

- *Sharing the burden of the EU climate and energy policy 2030: an economic impact assessment for the EU Member States (Centre for Climate Policy Analysis, Warsaw 2015).*
- Transformacja w kierunku gospodarki niskoemisyjnej w Polsce [Transformation towards a low- carboneconomy in Poland] (World Bank, Warsaw 2011).
- 2050.pl. Podróż do niskoemisyjnej przyszłości [Journey to a low-carbonfuture] (collective elaboration edited by Maciej Bukowski, IBS-InRE, Warsaw 2013).
- Symulacje makroekonomiczne efektów realizacji Narodowego Programu Rozwoju Gospodarki Niskoemisyjnej do 2050 r. [Macroeconomic simulations of the effects of implementing the NationalLow-Carbon Economy Development Plan] (M. Bukowski, A. Śniegocki, WISE, Warsaw 2014).

[26] M. Anacka, A. Janicka: Prognoza ludności dla Polski na podstawie ekonometrycznej prognozy strumieni migracyjnych [Population forecast for Poland based on the econometric forecast of migration streams]. Wiadomościstatystyczne, Vol. 8(687) 2018, pp. 5-27.

- Ocena wpływu ustanowienia celów redukcji emisji wg dokumentu KE "Roadmap 2050" na sektor energetyczny, rozwój gospodarczy, przemysł i gospodarstwa domowe w Polsce do roku 2050 [Assessment of the impact of establishing emission reduction targets according to the "Roadmap 2050" EC document on the energy sector, economic development, the industry and household in Poland by 2050] (EnergSys, Warsaw 2012)

The Centre for Climate Policy Analysis (CAK), which is a joint project of the ministries involved in implementing the climate policy and the World Bank, located in the National Centre for Emissions Management, conducted a series of analyses regarding the effects of solutions within the EU climate policy[27]. The aforementioned report analyses the macroeconomic effects of the EU climate policy project for 2021-2030, presented by the European Commission in 2014. The targeted greenhouse gas emission reduction by 40% in the European Union by 2030 (compared to the 1990 level), also confirmed in the conclusions of the European Council of 2014 is associated not only with increased costs of the climate policy, but also their uneven distribution among Member States. The analysis results relate to the baseline scenario, which is identical to the contemporary PRIMES reference scenario (Ref2013), which takes into account the already implemented climate and energy package for 2020 (3x20), whereas the simulations were conducted using the PLACE global general equilibrium model, developed within CAK. Achieving the EU reduction target for 2030 by Poland translates to a difference of 12% between the continuation scenario and the new policy. In the most probable scenario (Central+), this will decrease the forecast GDP growth in Poland by 1.8%, with the EU average of 0.7%, which places Poland among the countries incurring the highest costs of the EU climate policy. This analysis does not include forecasts of the effects for 2050.

In 2015, a project of the National Scheme for the Development of Low-Carbon Economy (NPRGN) was developed, which aimed to identify a long-term path and methods for decreasing greenhouse gas emissions, while ensuring sustainable development of the country. Such development would be possible due to increasing innovation and implementing new technologies (RES), decreasing energy intensity, while creating new jobs and, in consequence, improving the competitiveness of the Polish economy. Implementing the actions anticipated by NPRGN would enable decreasing greenhouse gas emission to approx. 250 Mt CO_2.e, i.e., by 44% compared to the level from 1990 (by 37% in relation to the scenario without implementing the activities provided for in the Scheme). A 27% reduction of emissions in the power generation sectors, a 25% reduction in the building sector and a 17% reduction in the field of transport would contribute to achieving this effect (central scenario, values compared to the baseline scenario). At the same time, macroeconomic simulations show that this target could be achieved at a 2.5-fold growth of the GDP during the same period[28]. The simulation utilized a multi-sectoral macroeconomic general equilibrium model of the DSGE type, which is referred to also in a further section concerning the World Bank analysis.

The report „2050.pl – journey to a low-carbon economy" is, in turn, an attempt to analyse Polish options of reaching a low-carbon economy by 2050, made by the Institute of Structural Research and the Institute for Ecodevelopment[29]. It suggests an economy modernization scenario, which apart from improving the quality of public institutes, focuses on innovation and the effective utilization of human capital and natural resources. The authors argue that changes within the indicated areas will translate to stable conditions for the development of low-carbon technologies, improvement of energy efficiency and a significant decline of the external running costs of the economy. Implementing a number of the actions suggested and described in the Report would not only lead to a 44% decrease of greenhouse gas emissions in 2050 (compared to the level in 1990) but also to a GDP higher by 1.2% (compared to the reference scenario) and improved employment rate.

The World Bank report used a dynamic stochastic general equilibrium (DSGE) model named: „macroeconomic mitigation options" (MEMO). The study was developed by the employees of a World Bank office in Warsaw, with the participation of the Institute of Structural Research and McKinsey & Company Poland. This report, among others, compares the projected results of changes in the GDP, unemployment rate, greenhouse gas emissions and energy intensity in Poland and other EU Member States. However, it should be stressed that other EU countries were included in the model as one aggregated region, which impacted modelling results. The MEMO model divided the economy into 11 sectors and attempted to quite realistically reflect the division of the sectors into those belonging to EU ETS and the ones in the non-ETS area. The macroeconomic effects of the climate policy are much more significant in the EU ETS sectors, where a decrease of added value may reach a level of 9% in 2030, while at only 0.6% in the non-ETS sector. As mentioned in the report, fiscal effects of introducing the climate policy are directly associated with the method of its funding. Depending on the manner of model "closure", costs for the economy expressed in % of the GDP vary from 1.5 to 3% in 2020 and from a 0.6% loss to a 0.6% gain in 2030.

[27] The Centre for Climate Policy Analysis (CAK), operating within KOBiZE in the years 2013-2016, was the predecessor of the current Centre for Climate and Energy Analyses (CAKE), which continues and expands the policy analysing options.

[28] M. Bukowski, A. Śniegocki: Symulacje makroekonomiczne efektów realizacji Narodowego Programu Rozwoju Gospodarki Niskoemisyjnej do 2050 roku. Raport. [Macroeconomic simulations of the effects of implementing the National Scheme for the Development of Low-Carbon Economy until 2050] WISE 2014 (report commissioned by the Ministry of Economy).

[29] 2050.pl – podróż do niskoemisyjnej przyszłości [2050.pl - journey to a low-carbon future.] Coll. Study., Ed. M. Bukowski. IBS/InRE, Warsaw 2013.

The report developed by Energsys, titled "Ocena wpływu ustanowienia celów redukcji emisji wg dokumentu KE "Roadmap 2050" na sektor energetyczny, rozwój gospodarczy, przemysł i gospodarstwa domowe w Polsce do roku 2050[Evaluation of the effects of establishing emission reduction targets according to the "Roadmap 2050" document by the EC on the energy sector, economic development, the industry and households in Poland by 2050]" evaluates the effects of implementing the low-carbon economy roadmap for Poland (KOM(2011)112). A set of modelling tools, together with the CGE-PL model was used in the course of the studies. The utilization of this model only for Poland, when analysing this type of solution throughout the entire UE and due to the structure and functioning of the EU ETS system, significantly impacted the obtained results. The authors of the Energsys report developed three major scenarios. The first one was based on the assumption of continuing the current energy-climate policy, the second one assumed implementing a roadmap for low-carbon economy, and the third one is a comparative (reference) scenario, which the absence of any kinds of greenhouse gas emissions. EUA emission allowance prices are an exogenous variable in the model, therefore, they are not a result of modelling. Various EUA prices were assumed, depending on the scenario. A rather controversial assumption was for the scenario to adopt decarbonization, the same price in the case of EU ETS and non-ETS sectors, where in fact, there is no obligation to settle CO_2 emissions via emission allowances. The price for 2050 was assumed at a level of EUR 136.1 per allowance. In the Energsys report, the extent of emissions covered by the requirement of purchasing allowance at auctions was imprecisely defined since the currently applicable regulations assume numerous possibilities for the allocation of emission allowances in a free manner, and these solutions are to be functioning until at least 2030, and even much longer in the case of sector exposed to carbon leakage. Therefore, the assumption in the model that business entities emitting greenhouse gases will have to purchase most necessary EUAs starting in 2020 is out of date.

Figure 53 shows a summary of necessary or possible greenhouse gas reduction in Poland for various periods of the a/m studies. The figure is just a list of the results obtained under various assumptions, therefore comparing them with each other is subject to certain restrictions. First of all, pay attention to the reference year for the reduction value and the time horizon of its accomplishment.

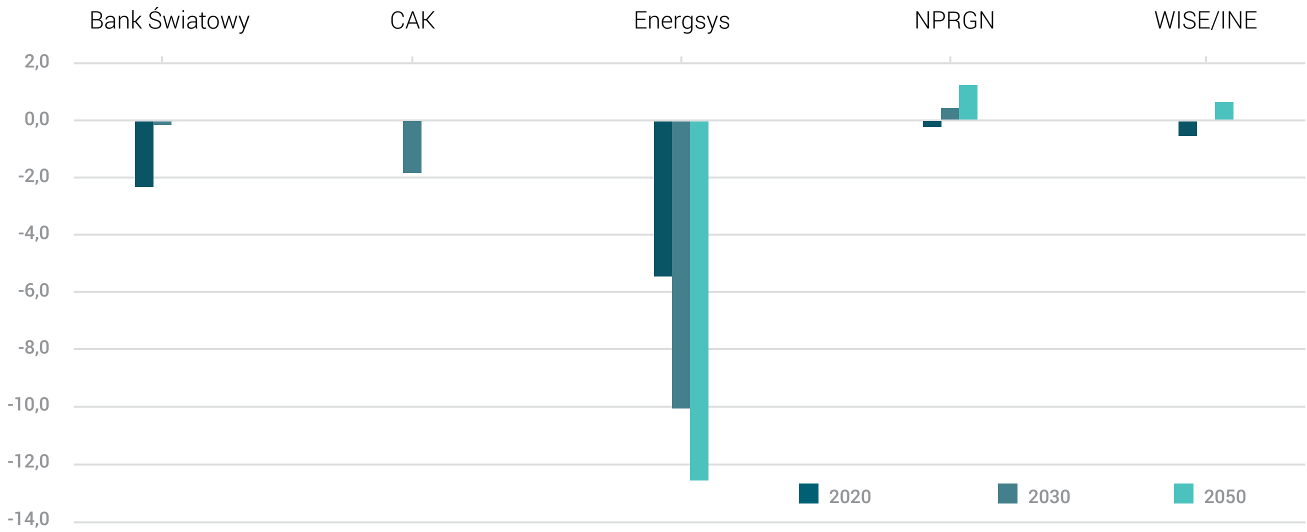
Fig. 53. Possible or expected greenhouse gas emission reductions in Poland according to selected studies (dates in parentheses indicate the reference year for the reductions) [%]

Source: own study based on reports referred to in the text.

Even if we assumed that it was allowed to compare the results, for which the reference year is common or similar, the differences are significant. The PRIMES scenarios assume a reduction of only 19% in 2030 (compared to 1990), whereas the CAK analysis anticipates a reduction in the emissions by 12%, while Energsys by even 26% (compared to 2007 and 2005, respectively). On the other hand, the WISE/InRE study and the NPRGN impact analysis indicate a reduction in 2030, compared to the level from 1990, by 29% and 21%, respectively. The forecast for 2050 in the aforementioned analyses predicts an emission reduction from 42 to 55%, whereas this value is to be achieved compared to the level in 2005, as well as in reference to 1990.

Even greater differences appear in the case of forecasting the economic effects of implementing the climate-energy policy and meeting reduction targets. Figure 54 shows these effects expressed as GDP changes in relation to the growth forecast in the reference scenario.

Fig. 54. Impact of greenhouse gas emission reductions on GDP change in Poland, according to selected studies [%]



Source: own study based on reports referred to in the text.

As in the case of comparing CO_2 emissions, the list of results from the analysed reports on GDP is mainly illustrative. The costs of implementing a solution package aimed at curbing CO_2 emissions differ significantly from study to study, from a GDP lower by approx. 12% in 2050 compared to the reference scenario in the most pessimistic variant of the Energsys analysis, to an almost 1% GDP growth in 2050 according to NPRGN. The main difficulties associated with the possibility to compare the results of selected analysis arise from, among others:

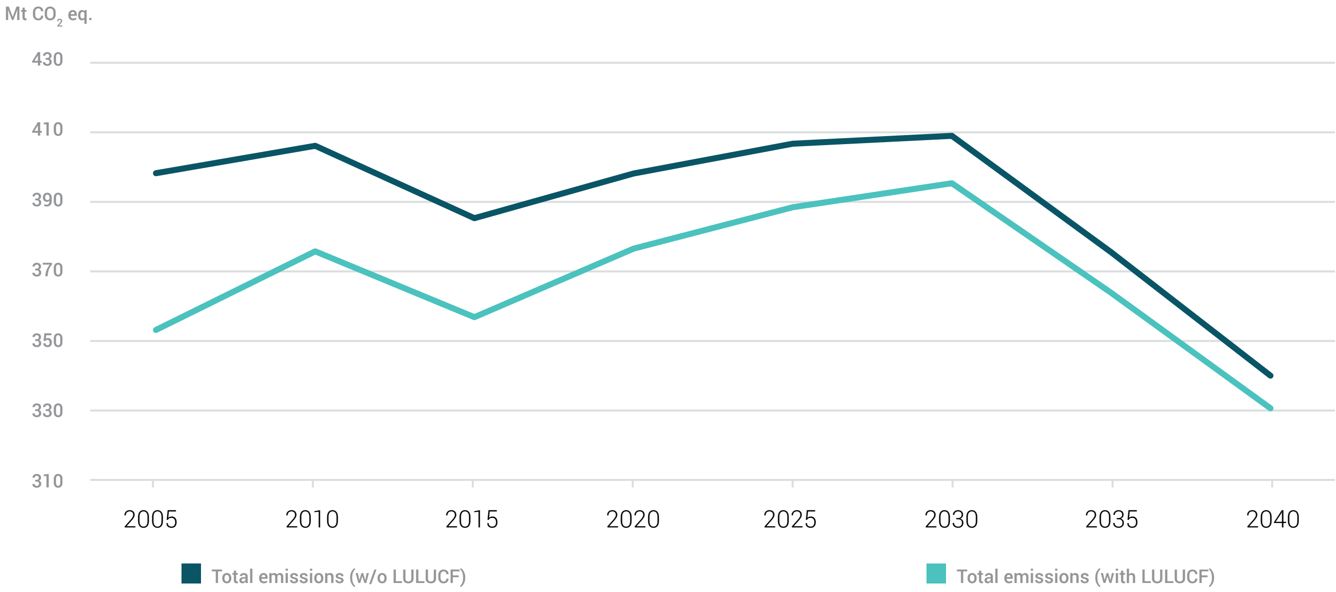
- different scenarios for the development of the Polish economy,
- introducing various policies/measures aimed at limiting greenhouse gas emissions,
- different modelling of the EU ETS allowance market,
- adopting various baseline years,
- adopting various emission allowance prices,
- the possible impact of the foreign environment on the economy,

A scenario covering the forecast in the variant of "implemented policies" was developed for the purposes of the "Integrated National Energy and Climate Plan for the years 2021-2030". It takes into account the already implemented activities and policies or those, in relation to which a political decision was already made. The scenario was developed by the consortium of the Agencja Rynku Energii S.A. (Energy Market Agency) and ATMOTERM S.A. in December 2007.[30] A second scenario is currently under development, and it includes further reduction activities.

In the forecasts developed under the discussed scenarios until 2040, the main factors impacting the level of future energy demand are: economic growth described by a number of macroeconomic indices (GDP and added values in individual sectors of domestic economy), demographic processes, expected changes in the lifestyle of the society, technological progress and processes improving energy efficiency. Greenhouse gas emission projections until 2040 were developed based on the forecasts of activities in the Energy sector prepared by ARE S.A. for the needs of KPEiK and for other sectors, based on "SiódmyraportrządowydlaKonferencjistronRamowejKonwencjiNarodówZjednoczonych w sprawie zmian klimatu [Seventh governmental report for the Conference of the Parties to the United Nations Framework Convention on Climate Change]", developed by the National Centre for Emissions Management (KOBiZE), IOŚ-PIB. The forecasts take into account the implementation of actual policies and regulations in the scope of: improving energy efficiency, increasing the safety of fuel and energy supplies, diversification of the fuel structure in the energy sector, developing the consumption of energy from renewable sources, developing competitive fuel and energy markets, limiting the impact of the energy sector on the environment. The discussed scenario anticipates an increase of the total greenhouse emissions in 2030 by 3% compared to 2005. After that period, the emissions will begin to decrease to a level of ca. 340 Mt in 2040 (fig. 55). It means a reduction by ca. 17% during the period of 2005-2040.

[30] Agencja Rynku Energii, Atmoterm, "Analizy i prognozy na potrzeby opracowania Krajowego planu na rzecz energii i klimatu na lata 2021-2030" [Analyses and forecasts for the purposes of developing a National Energy and Climate Plan for the years 2021- 2030]", Warsaw, December 2017

Fig. 55. The volume of greenhouse gas emissions in Poland for the period 2005-2040, including and excluding the LULUCF sector, according to a study by ARE-ATMOTERM

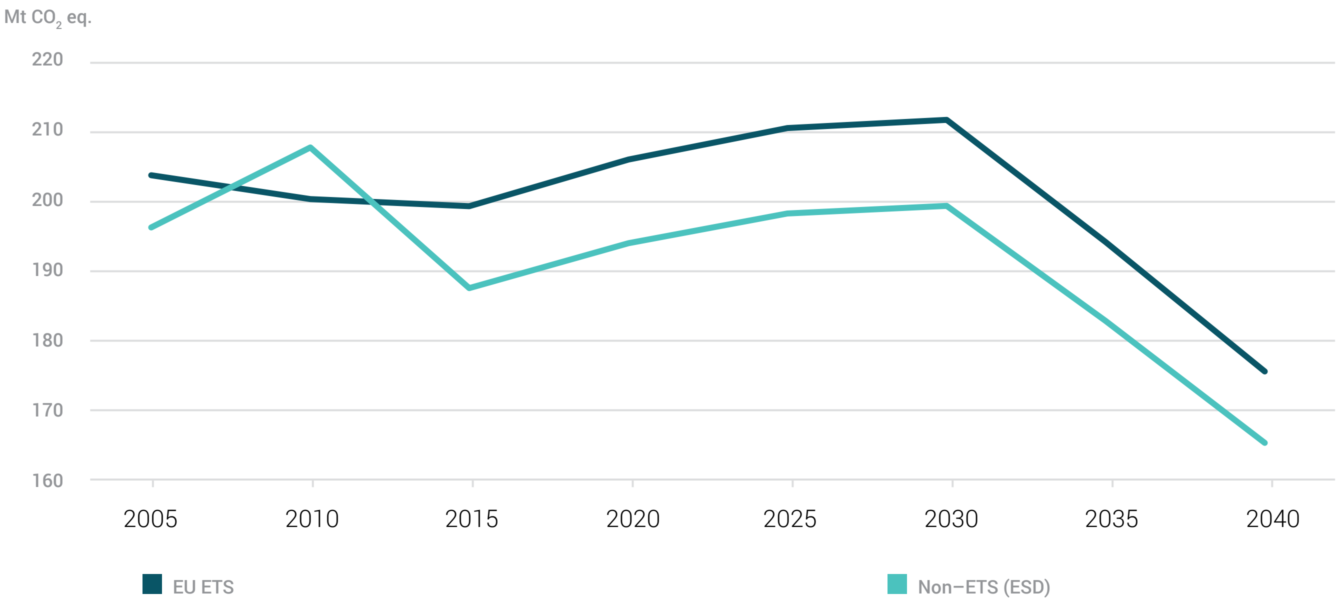


Source: own study based on ARE-ATMOTERM report.

It is anticipated that the largest share in the emissions in 2040 will still belong to the energy sector, including fuel combustion, although the emissions in this sector will gradually decrease. A slight upward trend is anticipated in the sector of industrial processes and product use. Greenhouse gas emissions in agriculture will be slowly increasing until 2030, when it will stabilize. Whereas the emissions in the waste sector will be decreasing, after an increase in 2020. The greatest reductions are expected within the energy sector.

In order to determine the emissions for EU ETS and non-ETS (ESD) sectors, due to the absence of detailed forecasts in the field of activity, broken down into these sectors, their shares in the total emissions of greenhouse gases for the forecast years were adopted as for 2015, that is, at a level of 52% for EU ETS and 48% for non-ETS (fig. 56).

Fig. 56. The volume of greenhouse gas emissions in Poland for the period 2005-2040, broken down into EU ETS and non-ETS sectors, according to a study by ARE-ATMOTERM



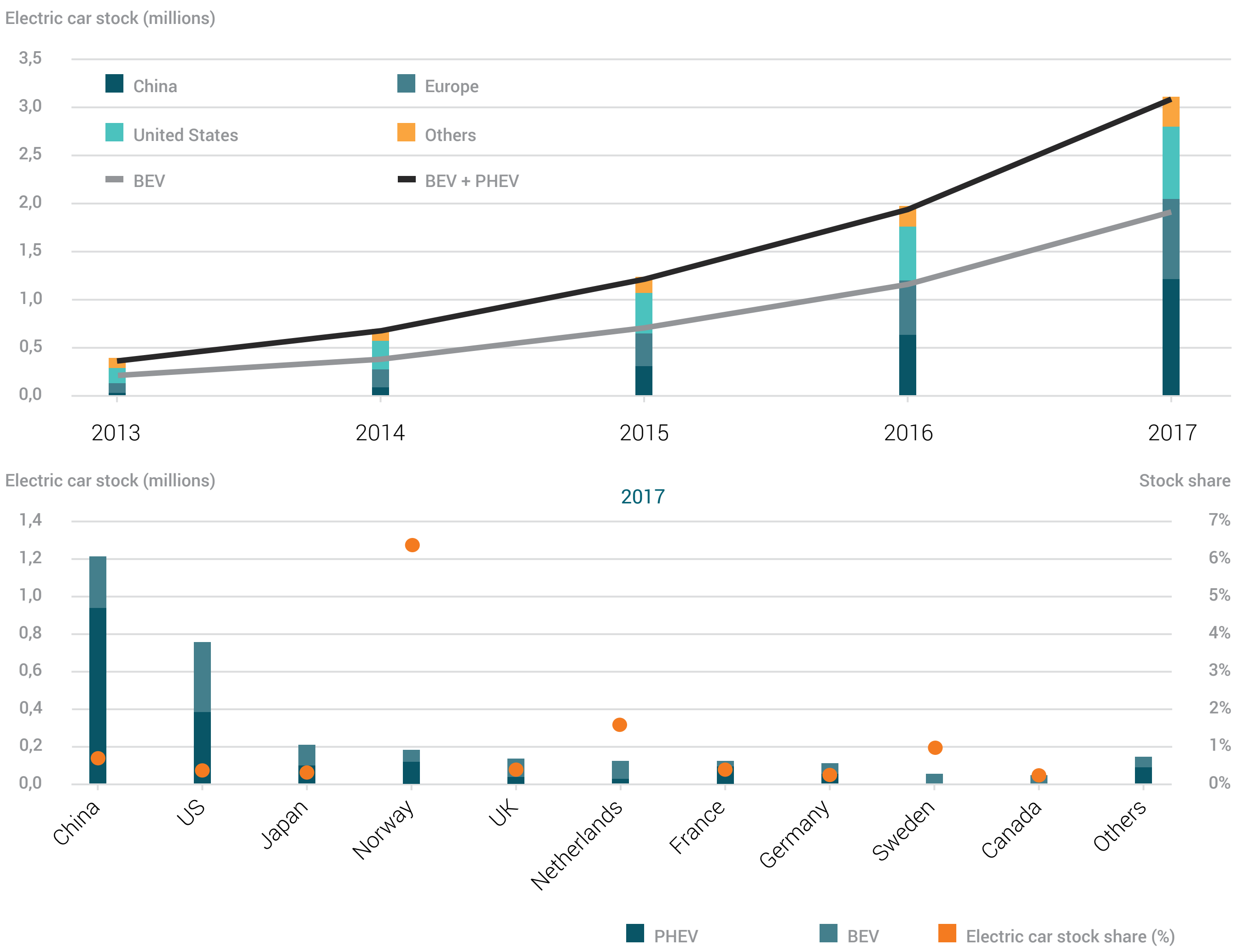
Source: own study based on ARE-ATMOTERM report.

Selected cross-sectional areas – challenges

Transport and the development of electromobility

The European Council, in its conclusions of October 2014, emphasized the reduction of the dependence of the transport sector on fossil fuels and mitigating greenhouse gas emissions. The common reduction target for 2030, covering all non-ETS sectors is 30% compared to the year 2005. In addition, this sector is to include a 14% consumption of renewable energy. The task of reducing sectoral emissions is even more of a challenge, in the light of the fact that both in Poland, as well as around the world, further significant increase in the transport of passengers and cargo is expected, as a result of further economic growth. The development of transport infrastructure is determined by the competitiveness of the economy, quality of life, as well as the availability of labour markets. The use of electromobility seems to be an opportunity to limit emissions coming from the transport sector, even in the face of its significant growth.

Fig. 57. Number of electric cars in the main regions of the world[31]



Source: Global Ev Outlook 2018, OECD/IEA 2018, p. 19

[31] PHEV - plug-in hybrid electric vehicle, BEV – battery electric vehicle..

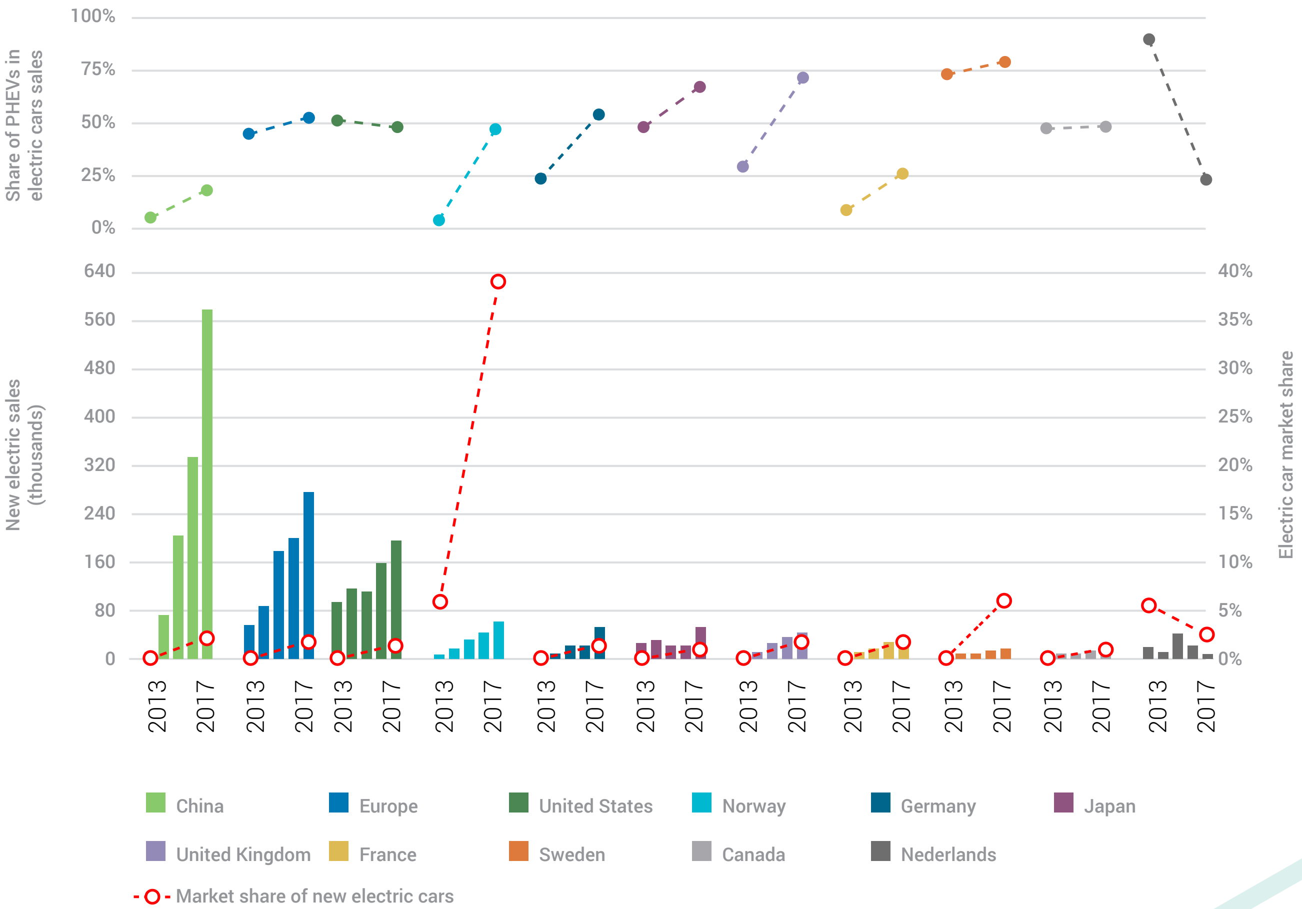
Global trends for the development of electric cars

Number of EE cars in recent years
The number of electrically-powered passenger cars reached 3.1mn in 2017. A growth of 57% compared to the previous year was recorded for this market segment. Most electric cars are driven in China (ca. 40% - more than 1.2mn vehicles). The share of USA and EU in the global number of electric cars is very similar and amounts to approximately 25% each. The situation in Norway is interesting, with the share of electric cars in the total number of cars is at a level of almost 6.5%, which is the best result in the world. A second country in this ranking is the Netherlands, with a share of just below 2%. Fig. 57 graphically presents this data.

In 2017, the global sales of electrically-powered cars exceeded 1 million. Most new cars were purchased in China (approx. 580 000 vehicles), which meant a sales increase of 72% compared to the previous year. On the other hand, Norway is an undisputed leader from the perspective of the share of electric cars in the market of newly registered vehicles. In 2017 this number amounted to 39%, which is almost three times more than in Iceland (12%) and more than six times the result in Sweden (6%). Those are the three global leaders in the sales of new electric cars. The biggest sales growth rates are recorded in countries such as Germany and Japan, where the sales of new cars has doubled.

As shown in fig. 57, almost 2/3 of all electric cars are BEV cars (battery electric vehicles). On the other hand, some countries exhibit a large share of PHEV cars (plug-in hybrid electric vehicle). These include, most of all, Japan, Sweden and Great Britain.

Fig. 58. Electric car sales and market share in the years 2013-2017 (10 leading countries)



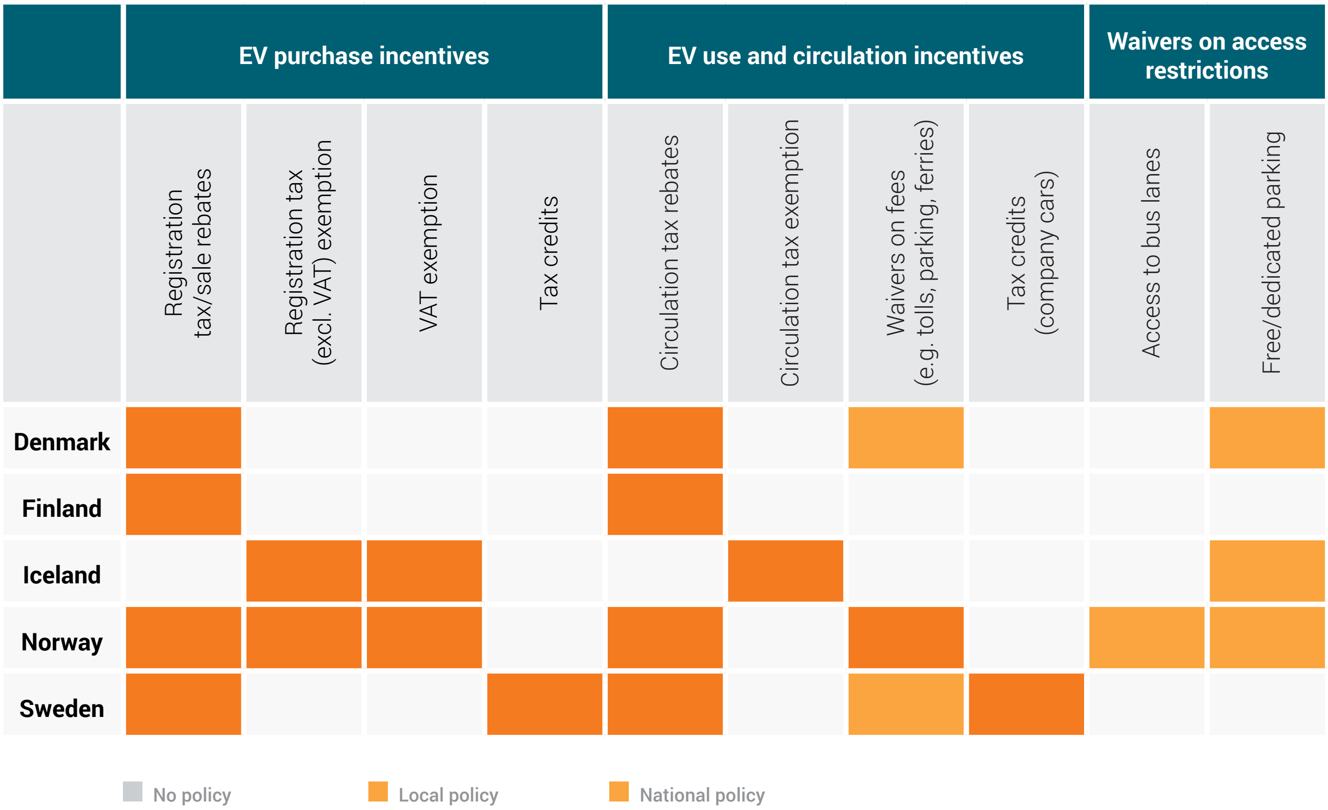
Source: Global Ev Outlook 2018, OECD/IEA 2018, p. 21

National policies

The growth of the electric vehicle market share is largely driven by environmental regulations and a purchase incentive system. Ten leading countries in this field have a number of strategies aimed at promoting their usage. The solutions in the field of policies and measures (PaMs) have proven to be crucial in increasing production and the purchase of new electrically-powered vehicles. This translated to a decreased risk for the investors and encouraging the manufactures to increase production capacities. The main types of instruments used in this regard at the national and local levels include, among others:

- public procurement programmes promoting EV,
- financial incentives facilitating the purchase of electric vehicles,
- decreasing operating costs (e.g. by offering free parking or free highways)
- regulatory measures, such as standard regarding fuel consumptions and restrictions in the movement of conventionally-powered cars (apart from exhaust gas emissions).

Fig. 59. An overview of support for electric cars in Nordic countries in 2017



Source: Nordic Ev Outlook 2018, OECD/IEA 2018, p. 19

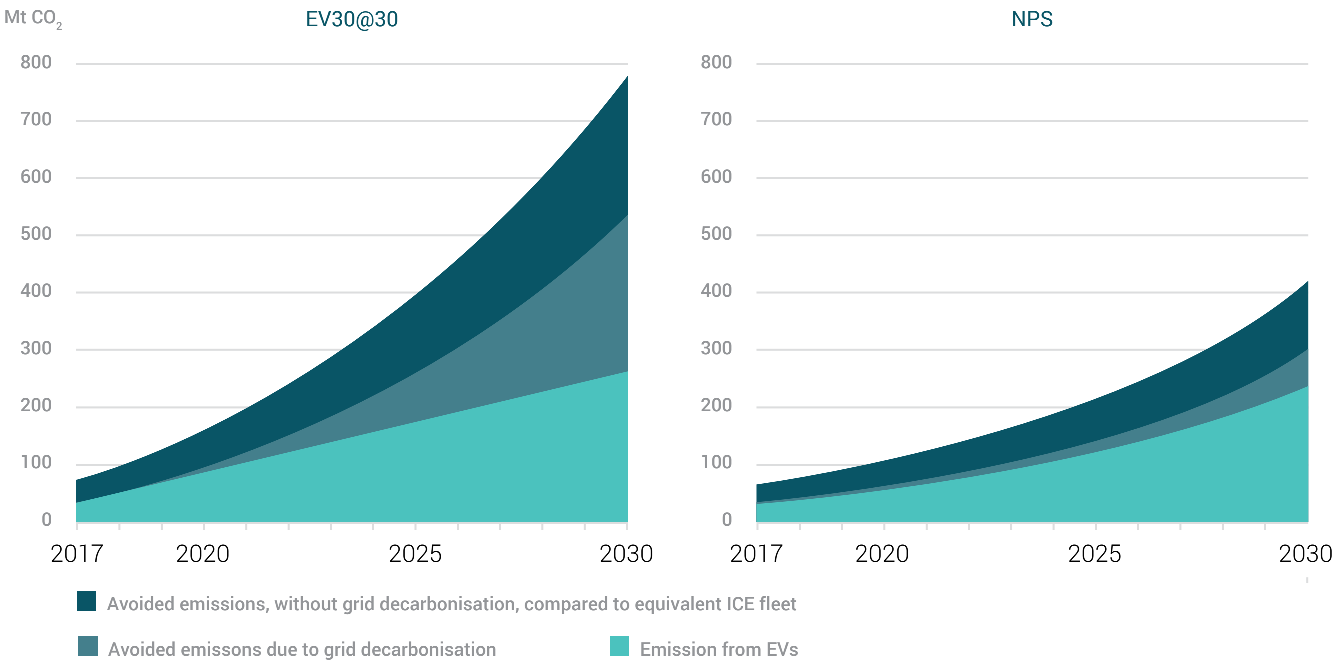
On the example of Norway, it can be seen that financial incentives, such as decreased VAT tax, lower vehicle registration fees or free access to roads and tax abatement, significantly impacted consumer decisions regarding the purchase of cars with an electric drive. On the other hand, changes in the field of financial benefits for plug-in hybrids in the Netherlands resulted in their decrease share in the market (fig. 58). Norway, as shown in fig. 59, has implemented all kinds of incentives, both at central, as well as local level. Norway and Sweden have the broadest range of introduced incentives among Nordic countries. In Denmark, changes in the registration tax for electric cars in 2016, made the sales of electric cars in this year plummet. These cases show that financial incentives, especially the ones lowering the purchase price are the most important factors, which determine the increase in the market share of electric cars. Decisions on buying electrically-powered cars largely depend on the available support systems, but also on their characteristics and range. BEV cars are mainly available in the segment of small and medium cars, while PHEVs rather in the medium and large car segment.

Recently there appears to be a clear tendency of gradual withdrawal from economic incentives towards the development of standards (e.g. emission-wise) and the introduction of restrictions in the movement of vehicles most burdensome for the environment (e.g. urban zones, available only for "clean" cars).

Impact of electric cars on CO_2 emissions

Future CO_2 emissions associated with the share of electric cars in the market are a resultant of the number of cars and CO_2 emissivity in the power system. Forecasts anticipate the positive effects associated with the share of such vehicles until 2030, resulting from their characteristics, as well as the changes in the emissivity of the electricity generation sector. According to the projections of the International Energy Agency in its New Policies scenario, the use of electric cars will be associated with CO_2 emissions at a level of 297 Mt CO_2 in 2030, under the assumption of the same energy mix, as in 2017. The authors of the report assumed significant improvement of electricity generation emissivity by 2030, which would contribute to avoiding additional emissions of 56 Mt CO_2. In an additional scenario of increasing share of electric cars (EV30@30), reductions in CO_2 emissions would amount to 241 Mt CO_2 in 2030, under the assumption of no changes to the energy mix. In the event of energy mix changes, additional benefits would come with a reduction in the emission of almost 273 Mt CO_2. The above data is depicted in fig. 60. The growth of the market share of electric cars, with a simultaneous reduction of emissions due to electricity generation, may lead to doubling the benefits in the form of CO_2 emission reductions.

Fig. 60. Global CO_2 emissions from electric cars in 2030, in the EV30 and New Policies scenarios



Source: Global Ev Outlook 2018, OECD/IEA 2018, p. 94

Transport - Electromobility Development Plan in Poland

Transport-related emissions are mainly a result of direct fuel combustion within road transport, non- electrified railway transport and inland navigation; the emissions from international aviation (included in EU ETS) or international navigation are not taken into account. The increase and significant share of transport-related GHG emissions coming almost solely from the road transport sector (97.6% in 2016), even despite the increasing emission efficiency of the vehicle, mainly results from the constantly growing demand for passenger and cargo transport.

As noted in the strategic document "Strategia na rzecz Odpowiedzialnego Rozwoju do roku 2020 (z perspektywą do 2030 r.) [Strategy for Sustainable Development until 2020 (with a perspective up to 2030)]", Poland, thanks to the utilization of EU funds, has experience additional highways and expressways but not a coherent transport system. As a result of underinvestment, railway lost its importance, and road transport, much more harmful to the environment, is now dominating. At the same time, which is noted by SOR (Strategy for Sustainable Development), the average age of cars used in Poland is higher than the EU average, which is a source of additional negative pressure on the natural environment - as per ACEA data, the average age of the Polish fleet of passenger cars was 17.3 years in 2016, which was the worst result in the entire EU[32]. Increasing transport accessibility and improving the quality of provided services associated with the transport of cargo and passengers were defined by SOR as a strategic direction of development for the transport sector in Poland.

The Polish Government, recognizing the potential in electric cars and alternative fuels, and the global trends of dynamic development for this part of the automotive industry, developed a policy supporting the development of electric cars. The Plan Rozwoju Elektromobilności "Energia dla Przyszłości" [Electromobility Development Plan "Energy for the Future"] was adopted by the Council of Ministers on 16 March 2017. It describes the main assumptions, objectives, mechanisms and effects of a large-scale introduction of electric cars.

The most important assumption of the Electromobility Development Plan is reaching 1mn electric cars in Poland by 2025. The accomplishment of this objective would enable achieving environmental benefits associated with decreased transport-related pollutant emissions in agglomerations. Additional outcomes would include decreased national energy dependence, through limiting the demand for liquid fuels, hence, decreased import of crude oil. A side effect of the development of electric vehicle may be the improved stability of the power system through increased demand during low power-demand periods - provided that electric vehicles are charged at night time. Another element of the scheme is the stimulation of conditions for the production of electric cars in Poland, which would positively affect a number of economy branches associated with the automotive industry. An important aspect of the Electromobility Development Plan is the proper synchronization in time of activities for supporting the industry and scientific-research institutions, stimulating the demand, and developing the infrastructure and the legislation.

Targets and expected effects of the Electromobility Development Plan

Environmental effects

Road transport, apart from individual heating systems is one of the main sources of pollution in big agglomerations. In cities with a large share of centralized heating, transport can even be the main source of pollutants such as dust, benzopyrene, nitrous oxides. This is why, using electric cars is, above all, of great significance in the attempts to reduce harmful pollution in large agglomerations, where they directly impact a large population and the use of electric cars has the biggest positive impact on human life. For this reason, the main focus in developing the infrastructure supporting electric cars will be related to agglomerations. In relation to climate effects of the plan, their thorough calculation, especially in the short term, is difficult due to the fact that a comprehensive effect associated with replacing internal combustion vehicles with electric ones, strongly depends on the electricity generating technology used for charging and from the real energy intensity of electric vehicles in road traffic conditions. However, the Electromobility Development Plan should be considered in the long-term, taking into account the current and future processes for the modernization of the energy sector, including the growing use of renewable sources and low-carbon fuels, improved energy efficiency in the field of electricity generation, transmission, as well as distribution. From this point of view, there is no doubt that greenhouse gas emission reductions will be a long-term effect of the development of electromobility.

Furthermore, it should be noted that the development of electromobility also entails changes in the method of controlling GHG emissions, due to shifting the burden of emissions from transport, which is governed by non-ETS regulations, indirectly to the energy sector, which is covered by the EU ETS system. The outcome will be a possibility for better monitoring of the emissions, and at the same time increased chances of Poland meeting the non-ETS targets by 2030.

Development of the industry and research

According to the authors of the Electromobility Development Plan, due to the fact that the manufacturing of electric cars is at a relatively early stage of advancement, the entry barrier into this industry is not as high, as in the case of internal combustion cars manufacturing. Moreover, there are companies in Poland with experience in a similar area - manufacturing of electric buses, which may facilitate commencing works on an electric car of domestic origin. The authors of the plan are aware that the majority of the components necessary to produce the cars will be manufactured abroad, however, they assume that implementing support mechanisms for the manufacturing of electric cars will lead to a situation, in which at least 30% of the added value associated with this operation will be produced in Poland.

In October 2016, four Polish power concerns - PGE Polska Grupa Energetyczna SA, Energa SA, Enea SA and Tauron Polska Energia SA - established the ElectroMobility Poland SA (EMP) company. Each of the companies acquired 25% of the share capital, hence obtaining 25% of the votes at the general meeting of the shareholders. Its purpose is the broadly understood creation of conditions for the development of electromobility in Poland. The activities of the company contribute to increased innovation and competitiveness of the Polish economy. The task of EMP is to coordinate the actions of NCBR and NFOŚiGW and other institutions for the cooperation between the industry and research institutions, financial support of implementation projects associated with the construction of electric vehicles and the necessary infrastructure, undertaking promotional activities, and finally, coordination of local activities aimed at developing the infrastructure for charging and servicing electric cars. The development of electromobility in Poland can bring benefits exceeding the field of transport.

[32] https://www.acea.be/statistics/tag/category/average-vehicle-age

Apart from limiting the emissions of harmful substances to the atmosphere, it can create new job within the entire chain of supply and give impetus for the development of Polish economy.

Improving the stability of energy consumption

The planned increase in the share of electric vehicles in transport will also result in a significant increase in the demand for electricity (acc. to the authors of the plan, approx. 4.3 TWh annually, under the assumption of reaching 1mn electric cars). This is a significant additional burden for the power grid, since it amounts to ca. 3% of the final domestic electricity demand. On the other hand, the fact that it will be mostly possible to charge the cars at night, in the hours of low electricity demand, gives the charging of electric cars the potential, under appropriate technical and legal solutions, to positively impact the power grid, improving the economic efficiency of energy sources, which must decrease the output during the night off-peak hours. An element necessary for the correct operation of this system is the introduction of a system of variable tariffs in individual load zones and I&C for electric car charging systems incorporated into a comprehensive system of intelligent metering and demand management, maybe also connected with energy storage systems. Moreover, given the demand for energy associated with charging stations, it might prove necessary to modernize a part of the grid infrastructure (regardless of the modernizations associated with maintaining the existing transmission capacities). This is why the aspects associated with the development of the infrastructure for the purposes of charging electric cars must be taken into account in feasibility studies and future development plans for transmission and distribution system operators.

Decreasing the dependence on crude oil import

Most of the crude oil currently used for liquid fuel production for transport is imported. Domestic extraction covers less than 4% of the demand. Approx. 77% of the imported crude oil comes from Russia, although the share of import from other directions (mainly Saudi Arabia) has been increasing over the recent years. The growing use of electric cars may constitute an opportunity to decrease the dependence on imported raw materials, hence, improve the energy security of the country. The scale of this effect, however, depends not only on the success of the Electromobility Development Plan but also on the changes, to undergo in the energy generation sector.

Barriers and risks for the implementation of the Electromobility Development Plan

The main barriers in the development of electromobility are currently the costs of electric vehicles, still greatly exceeding their internal combustion equivalents. This is an element, which is particularly important in countries such as Poland, with relatively low average incomes per capita, compared to Western European countries. Moreover, about 30-35% in the costs of an electric car are batteries, an element, which wears down in the course of operation, with time causing actual decrease of the range and a relatively quick loss of the vehicle value. This is why, it seems that the development of electric cars will greatly depend on the rate of development of the battery technologies and a decline of the manufacturing costs, and potentially, on the solutions associated with the utilization of used car batteries as stationary electricity storage systems.

Despite the fact that the range of electric cars on a single charge usually is inferior compared to their internal combustion equivalents, it seems that this issue is not a big problem in the case of a city car, which can be regularly charge from a socket next to the parking spot. In contrast, a significant barrier against the development of electric vehicles may be the insufficient development rate of the charging infrastructure, with its absence discouraging to use this form of transport. Undoubtedly, the progress of electric cars is determined by appropriate development of the technical infrastructure associated with electric vehicles. This is why support for local projects related to the development of such infrastructure is one of the crucial elements of the Electromobility Development Plan.

Action plan and support mechanisms

The Electromobility Development Plan contains an initial list of instruments, the implementation of which is intended to support the development of electric cars in Poland. The most important include:

- Launching pilot projects in selected cities, which would cover the development of the charging infrastructure for individual electric communications, as well as financial support of the local government electrifying fleets of city buses.
- Introducing a requirement of a specific share of electric cars when purchasing vehicles for the public administration and introducing a requirement for the public administration to construct appropriate infrastructure.
- Developing and implementing changes in the tax system, enabling the introduction of tax abatements (excise tax, VAT, other kind of amortization) for users of electric vehicles.
- Implementing legal regulations enabling dynamic tariffs and the development of intelligent electricity consumption metering systems, which is necessary for the smooth operation of an electric vehicle charging station system and billing of the consumed energy.
- Introducing the changes in the regulations, which would enable the local governments to establish low-carbon zones and restrictions of internal combustion vehicle traffic, as well as introduce fees associated with the emissions from internal combustion cars.
- Soft instruments for the promotion of electric vehicles,

such as the possibility to use bus lanes, free parking in city centres, the option to enter restricted traffic zones, etc.

In its current form, the Electromobility Development Plan determines further stages of the implementation in a rather generic manner. Individual elements – particularly the ones associated with supporting the industry and specific initiatives in the field of designing and constructing electric vehicles will be fine-tuned in cooperation between the leaders in the implementation of the plan, namely, the Ministry of Energy with the Ministry of Development, and the Ministry of the Environment and scientific institutions (NFOŚiGW, NCBR) under the leadership of EMP, established specifically to coordinate the activities.

On 29 March 2017, the Council of Ministers adopted the "Krajowe ramy polityki rozwoju infrastruktury paliw alternatywnych" [National framework for the alternative fuel infrastructure development policy]. This document is crucial in the support of the market and infrastructure in relation to electricity and natural gas in the form of CNG and LNG, used in road and water transport.

The frameworks include:

- assessment of the current status and the possibilities of future development of the market in relation to alternative fuels in the transport sector,
- general and detailed national targets regarding the development of the infrastructure for charging electric vehicles and filling of natural gas in the form of CNG and LNG, as well as the market of vehicles powered by these fuels,
- instruments supporting the achievement of the aforementioned targets and necessary for the implementation of the Electromobility Development Plan,
- list of urban and densely populated areas, where publicly accessible charging points for electric vehicles and CNG filling stations are planned.

In 2020, in 32 selected agglomerations:

- in the electricity-powered vehicle segment:
  - there will be 50 thousand vehicles on the roads,
  - 6k point with normal charging power will be created,
  - 400 points with high capacity power;
- in the CNG-powered vehicle car segment:
  - there will be 3 thousand vehicles on the roads,
  - 70 filling points will be created;

in 2025, at the nationwide level:

- there will be 32 available CNG filling points along the TEN-T base network;
- 14 LNG filling points will be created along the TEN-T base network;
- there will be LNG tanker bunkering systems functioning in the ports of: Gdańsk, Gdynia, Szczecin, Świnoujście.

Accomplishing the targets of the National policy framework will enable the development of innovative and eco-friendly transport throughout Poland, and the scheme itself is coherent with the Electromobility Development Plan.

The act of 11 January 2018 on electromobility and alternative fuels (OJ 2018 item 317) creates comprehensive legal framework for the development of the entire electromobility and alternative fuels sector. New legal regulation are supposed to stimulate the development of electromobility in Poland and the use of alternative fuels in transport. It is mostly about electricity and natural gas – both liquefied (LNG), as well as compressed (CNG). The act also expands the Polish legislation with the provision of the European directive on the development of alternative fuels infrastructure 2014/94/EU.

The act provides for an incentive system:

- abolishment of excise tax for electric cars and plug-in hybrids (PHEV),
- exempting them from parking fees,
- higher amortization write-offs for companies.

It also assumes the construction of a core infrastructure for alternative fuels in urban and densely populated areas, as well as along trans-European road transport corridors, which is to enable free movement of vehicles powered by these fuels.

The act assumes, by 2020, the construction of:

- 6k normal capacity electricity charging points,
- 400k high capacity electricity charging points,
- 70 CNG filling stations.

Clean transport zones

The act also assumes a possibility for the local government to establish clean transport zones. An appropriate stipulation states that within a compacted residential area with concentrated public utility buildings, it is possible to establish a clean transport zone, with restricted entry of vehicles other than electric or hydrogen-powered and - under certain conditions - the ones powered by natural gas.

The document introduces a mandatory share of electric cars in the fleet of some central administration agencies and selected local government units.

The act of 6 June 2018 on amending the act on biocomponents, liquid biofuels and certain other acts (OJ 2018 item 1356) is aimed at, above all, establishing special purpose fund - Low-carbon Transport Fund.

The administrator of the Fund is the Minister of Energy, and it is managed by NFOŚiGW. Resources from the fund are intended to support the expansion of the alternative fuels infrastructure and create a market for vehicles powered by these fuels.

Potential effects of increased share of electric cars in passenger transport in Poland

Increased consumption of electricity by passenger cars will simultaneously result in a decreased demand for liquid fuels. Achieving the target of a million electric passenger cars by 2025 would result in liquid fuel consumption in the passenger car group decrease by ca. 4%, as well as other important savings, taking into account the annual cost of crude oil import at a level of 10 to 20 billion American dollars, depending on the raw material price.

Estimating emission-related effects of using electric cars is more difficult and requires adopting a series of additional assumptions. Without a doubt, due to decreased traffic intensity of internal combustion vehicles, large urban areas will experience decreased low emissions of dust pollutants, nitrogen oxides, benzopyrene. This is an effect very important from the perspective of exposing people to the direct impact of the pollution. The cumulative effect in the form of greenhouse gas emission changes due to the implementation of electromobility is associated with the energy mix structure, while in the long run, this effect will be definitely positive, and its scale will be correlated with the decreasing electricity generation emissivity and the growth rate of the electric car market. It should be emphasized that according to the latest report by the European Environment Agency, the current electric vehicles, throughout their entire life cycle, emit approximately 17-30% less greenhouse gases than internal combustion vehicles.

The conducted analyses confirm that apart from reducing local emissions of pollutant, electromobility will be an important element in decreasing domestic emission of greenhouse gases in the future. A prerequisite for achieving this effect in the form of CO_2 emission reduction is (besides the quick introduction of electric vehicles), the evolution of the national electricity generation structure towards a larger share of low or zero-carbon sources.

The impact of introducing electric cars on CO_2 emissions was estimated for two scenarios of electromobility development in Poland, which assume reaching a share of 30% or 50% electric cars, respectively, in the passenger car structure by 2050. The calculation results indicate a possibility of reaching CO_2 emission reductions at a level between 2.4 and 3.7mn t in 2040, and between 5.1 and 8.3mn t in 2050, depending on the degree of saturation of the passenger car fleet with electric vehicles.

The aforementioned estimations of emission-related effects are based on a comparison of unit energy consumption by internal combustion and electric passenger cars in Polish conditions. The analysis of unit CO_2 emissions associated with the operation of the vehicle was conducted for both groups of cars, wherein:

- in the case of internal combustion cars, both direct emissions, as well as emission from refining processes were taken into account,
- whereas in the case of electric cars, the emissions associated with generating electricity - according to the current and forecast fuel structure - were estimated, taking into account the losses at the stage of energy transmission and distribution.

It should be stressed that the presented results are very sensitive to changes of the assumed technical parameters, in particular:

- level of fuel consumption in internal combustion cars;
- the volume of direct and indirect unit emissions from internal combustion cars (taking into
- account the content of biocomponents in fuels);
- energy intensity of electric cars;
- assumptions regarding future changes in the efficiency of individual groups of vehicles;
- electricity generation structures and quantities of grid losses.

Below you can find the critical assumptions and data sources, adopted in this analysis:

- The consumption of liquid fuels per travelled kilometre as per ITS estimations[33], electricity consumption in electric cars according to data from ITS, IEA[34], EPA[35];
- Emission factors for gasoline, diesel and liquid gas as per KOBiZE reports[36];

[33] Instytut Transportu Samochodowego (ITS), Prognozy eksperckie zmian aktywności sektora transportu drogowego. [Road Transport Institute - ITS. Expert prognoses regarding the changes in the activity of the road transport segment], Warsaw 2017.

[34] International Energy Agency (IEA), Global EV Outlook 2018, 2018.

[35] Environmental Protection Agency (EPA), Light-Duty Automotive Technology, Carbon Dioxide Emissions, and Fuel Economy Trends: 1975 Through 2017.

[36] National Centre for Emissions Management (KOBIZE), Wartości opałowe (WO) i wskaźni kiemisji CO_2 (WE) w roku 2015 do raportowania w ramach Wspólnotowego Systemu Handlu Uprawnieniami do Emisjizarok 2018 [Calorific values (CV) and CO_2 emission factors (EF) in 2015 for reporting within the EU Emissions Trading Scheme for 2018]. Warsaw 2017.

- Unit emissions from oil refining processes according to EPA and IJEE estimates[37];
- CO_2 emissions at the stage of electricity production, taking into account the fuel mix changes – according to ARE Prognosis[38] by 20[40], with a further extrapolation according to own assumptions;
- Decreasing the energy intensity by 25% until 2050 both in relation to internal combustion cars, as well as electric cars (these estimates are more conservative than the ones shown in IJEE, which assume intensity improved by as much as 35% by 2050).

Development of RES and improving energy efficiency in Poland

The regulation on the governance of the Energy Union (COM (2016) 759 final)[39] orders individual Member States to develop National Energy and Climate Plans, to be supervised by the European Union. This is a regulation of break-through importance for the energy sectors in individual countries because the European Union, after the regulation entered into force, will have the right to coordinate the activities of individual countries in this field. The previous National Action Plans for Renewable Energy Sources and National Action Plans on Energy Efficiency will be combined with a thorough analysis of the impact of the commitments on the economy and the environment in one document, coordinated and approved at the level of the entire EU.

The climate-energy framework until 2030 approved in October 2014, defined common EU targets until the year 2030. The mandatory target in the scope of RES was set at a level of 27%, in the scope of energy efficiency the indicative target was set at a level of 27% (with an announcement of a target review by 2020 and raising it to 30%). In the course of developing the KPEiK, Poland committed to achieve a RES share of 21% and improve energy efficiency at a level of 23%. As a result of further evolution of EU targets - EP, European Council and EC consensus in the scope of raising them - the share of RES was increased to a level of 32% and the energy efficiency target was improved to 32.5%. Higher common targets will surely require Poland to make more ambitious national commitments. Furthermore, EU emission reduction targets provide strong grounds to believe that after 2030 the commitments made at the national level will still be increase in the field of energy efficiency and RES.

Challenges - „Large" energy sector – potential GHG emission reductions in 2040

An activity impacting greenhouse gas emission reductions is a change in the fuel structure towards limiting coal consumptions and replacing it with natural gas or energy from renewable sources. In the categories: 1.A.1 Power industries and 1.A.2 Manufacturing and construction industries, which includes combustion processes in these sectors, significant reduction in the share of coal is anticipated. Changes in GHG emissions resulting from a change in the fuel structure are depicted in figures 61 and 62. In category 1.A.1, which includes, i.a., commercial power, the share of the main fuels in 2016 was as follows: hard coal – 53%, brown coal – 27%, natural gas – 6%, solid biomass – 4%. According to the ARE- ATMOTERM scenario, the share of hard coal will be gradually decreasing until 2040 - to a level of 41 and brown coal - to a level of 8%. On the other hand, projections for 2040 estimate that the share of natural gas consumption will increase to 30%, and of solid biomass to 10%. The aforementioned changes in the fuel structure will result in the reduction of emissions. Figure 61 shows the emissions of greenhouse gases for category 1.A.1 (commercial power) projected in the ARE-ATMOTERM scenario, compared to the emissions, which would be, assuming the same demand for fuel-fired energy, but with a 2016 fuel structure (mix in 2016). The expected emission reductions resulting only from the aforementioned fuel structure change can, in this category, amount to over 29 Mt CO_2eq for 2040.

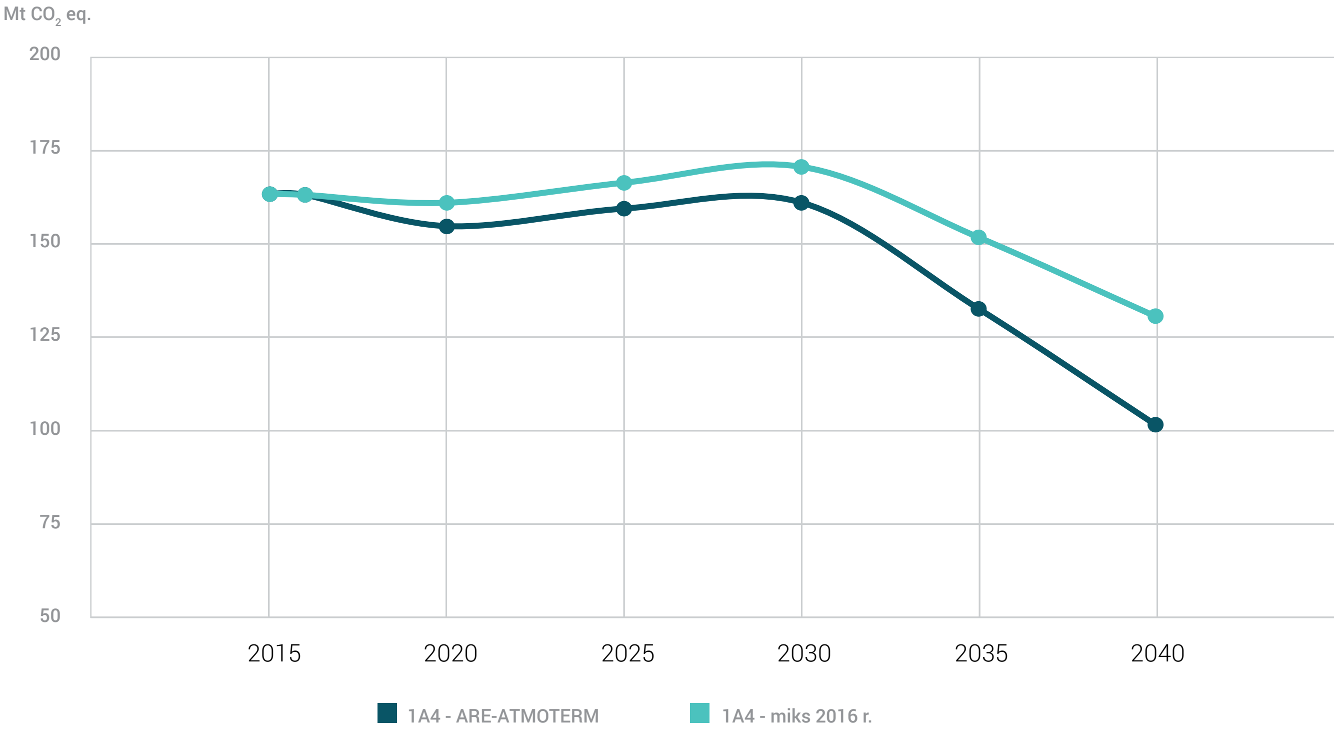
In category 1.A.2 (manufacturing and construction industries), the share of the main fuels in 2016 was as follows: hard coal – 25%, natural gas – 35%, solid biomass – 15% According to the ARE-ATMOTERM scenario, the share of hard coal will be gradually decreasing until 2040 - to a level of 15%. On the other hand, projections for 2040 estimate that the share of natural gas consumption will increase to 42%, and of solid biomass to 19%. Figure 62 shows the emissions of greenhouse gases for category 1.A.2 projected in the ARE-ATMOTERM scenario, compared to the emissions, which would be, assuming the same demand for fuel-fired energy, but with a 2016 fuel structure (mix in 2016). Emission reductions resulting from a change in the fuel structure for this category is estimated at over 2 Mt CO_2eq for 2040.

[37] International Journal of Energy and Environment (IJEE) Life cycle analysis and environmental effect of electric vehicles market evolution in Portugal, Volume 5, Issue 5, 2014 pp. 535-558

[38] Agencja Rynku Energii, Atmoterm, "Analizy i prognozy na potrzeby opracowania "Krajowego planu na rzecz energii i klimatu na lata 2021-2030 [Analyses and forecasts for the purposes of developing a National Energy and Climate Plan for the years 2021-2030]", Warsaw, December 2017

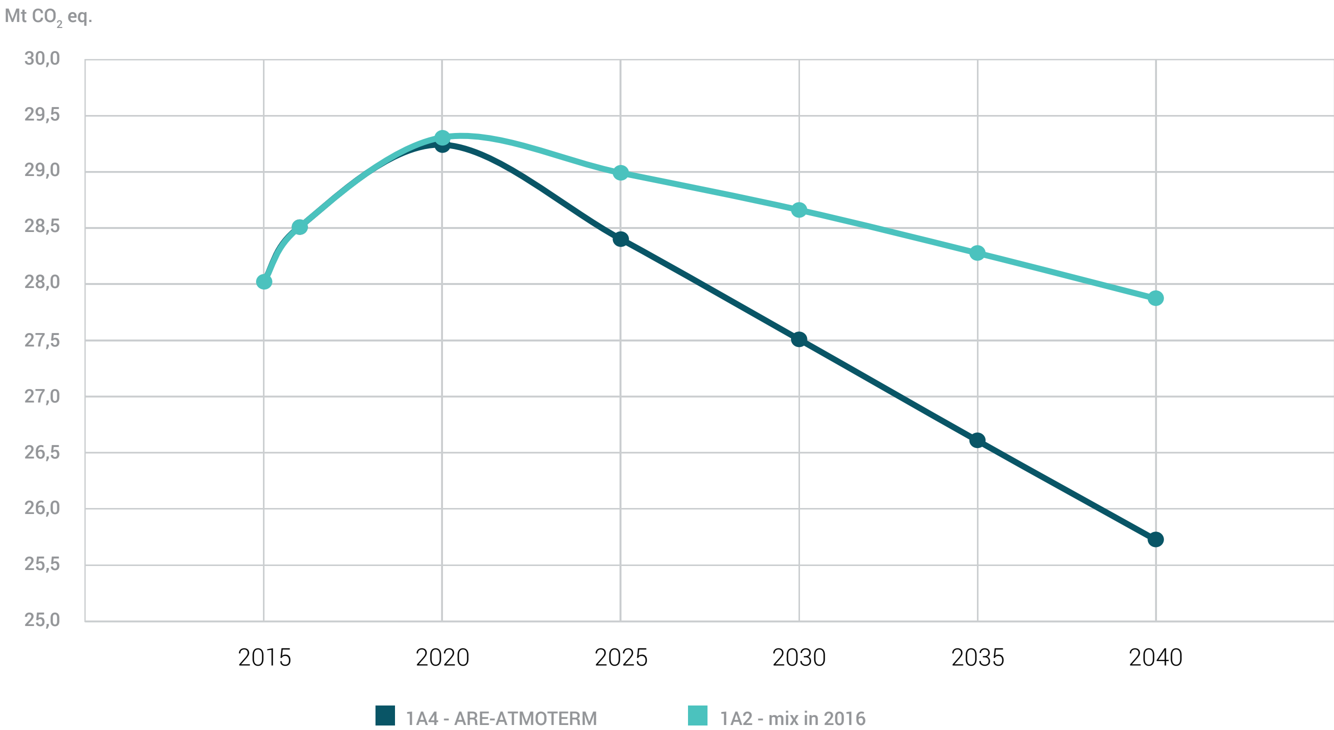
[38] Regulation of the European Parliament on the governance of the Energy Union, amending directive 94/22/EC, directive 98/70/EC, directive 2009/31/EC, regulation (EC) no. 663/2009, regulation (EC) no. 715/2009, directive 2009/73/EC, directive of the Council 2009/119/EC, directive 2010/31/EU, directive 2012/27/EU, directive 2013/30/UE and directive of the Council (EU) 2015/652 and repealing regulation (EU) no. 525/201

Fig. 61. Change in the greenhouse gas emissions resulting from the alteration of the fuel mix in the commercial power industry (sector 1.A.1.)



Source: KOBiZE calculations based on ARE-ATMOTERM data.

Fig. 62. Change in the greenhouse gas emissions resulting from the alteration of the fuel mix in the manufacturing and construction industries (sector 1.A.2.)



Source: KOBiZE calculations based on ARE-ATMOTERM data.

Challenges – emissions from the municipal-housing sector and potential GHG emission reductions in 2040

Emissions from the municipal-housing sector are emissions from fuel combustion, generated as a result of consuming energy for heating and cooling buildings, lighting and powering household appliances or equipment used to provide services. Carbon dioxide constitutes a major part of greenhouse gas emissions in this sector, while the emissions of other gases are negligible. The most significant emissions in the municipal-housing sector in Poland are the ones associated with the demand for energy, mostly originating in households and the residential sector and, to a much lesser extent - commerce, services and public utility buildings.

Only direct carbon dioxide emissions associated with burning fuel in domestic furnaces or small boiler houses with installed capacity below 20 MW are attributable to this sector. Indirect emissions resulting from the households and service providers using electricity in buildings, as well as emissions from heat generation in CHPs and heating plants with installed capacity above 20 MW are emissions for which the energy sector (EU ETS) is responsible. Throughout the entire EU, the municipal-housing sector is responsible for 40% of final energy consumptions and for 36% of CO_2 emissions, and its development is associated with a further increase in the energy demand[40]. In Poland, this sector is responsible for ca. 30% of domestic greenhouse gas emission volumes in the non-ETS sector.

Limiting the consumption of thermal energy and electricity among individual consumers, commerce and service is a prerequisite for achieving the reduction targets both in the municipal-housing sector, as the ETS-covered energy sector. It requires implementing solutions leading to a reduction of the energy demand resulting from increased energy efficiency of the buildings and household appliances, electrical equipment used in services and commerce, as well as the efficiency of such equipment elements as furnaces and heating/cooling devices. It also requires changes in consumer behaviour, leading to conscious energy consumption. In the light of the obligation to provide the European Commission with reports based on directive 2006/32/EC efficiency of energy end-use and energy services, and directive 2012/27/EU on energy efficiency, since 2007 the Polish Government has been adopting further National Action Plans on energy efficiency. The Fourth National Action Plan on energy efficiency for Poland (2017) was adopted by the Government in January of 2018.[41]

The European Union adopted energy efficiency improvement targets for the municipal-housing sector in a perspective until 2020[42] and 2050[43] r., taking into account milestones in 2030 and 2040, introducing corresponding legal regulations[44]. By the end of 2020, all new buildings constructed in the EU, and thus in Poland, shall be buildings with a near-zero energy consumption, which is to be guaranteed by the gradual introduction of more stringent technical requirements in the field of building energy performance[45] and increasing the share of energy from renewable sources in the end-use of energy, as well as the dissemination of distributed RES. At the same time Poland, just like other EU Member States, is implementing a scheme to improve the energy performance of already existing buildings, including the ones owned by governmental institutions and not rented, and the housing resources, through their general renovations and introducing measures impacting the change of building user behaviour[46]. This is a problem for the entire EU, since approximately 35% of the buildings in Member States is more than 50 years old and almost 75% of the residential-utility resources does not meet the minimum energy efficiency standards. At the same time, only from 0.4 to 1.2% of the buildings is renovated every year[47].

Buildings subject to legal transactions must be equipped with energy performance certificates, which contain information on the amount of energy consumed in course of the operation, which is intended to influence the awareness of the users and buyers and is to be an impetus for thermomodernization. These issues are governed by an act of 29 August 2014 on the energy performance of buildings (cons. text. OJ 2018 item 1984) introducing directive 2012/27/EU, subject to amending in the near future, as a result of amending the aforementioned act in May 2018.

[40] Report from the Commission to the EP and the Council – Progress by Member States towards nearly zero-energy buildings , COM(2013) 483 final/2, 7/10/2013; https://ec.europa.eu/energy/en/topics/energy-efficiency/buildings

[41] https://www.gov.pl/documents/33372/436746/KPDzEE2017_wer_16.pdf/cb2c16f7-7b0a-1485-7073- 381dcb0a69ee

[42] Directive of the European Parliament and the Council 2012/27/EU of 25 October 2012 on energy efficiency, amendments to directives 2009/125/EC and 2010/30/EU and repeals of directives 2004/8/EC and 2006/32/EC

[43] Directive of the European Parliament and the Council 2018/844/UE of 30 May 2018 amending directive 2010/31/EU on the energy performance of buildings and directive 2012/27/EU on energy efficiency

[44] According to the justifications for adopting the target of energy efficiency for all buildings in the EU by 2050, at a level of near-zero emissions under the amended EPDB in 2018, reaching a near-zero emissions of all buildings in the EU, will contribute to reducing greenhouse gas emissions in the EU in 2050 by 80-85% compared to the emissions level in 1990. Member States were obliged to develop long-term national plans for the renovation of public and private buildings.

[45] Pursuant to the Regulation amending the regulation on technical conditions to be fulfilled by buildings and their location (O J 2013, item 926), a change in the permissible values of EP indicators (annual demand for non- renewable primary energy [kWh/(m2·year)] for newly constructed buildings and certain U factors (factor defining the requirements in terms of thermal-moisture protection) for external building partitions.

[46] The "National plan for improving the number of low energy consuming buildings" was adopted in June 2015 (Resolution no. 91 of the Council of Ministers of 22 June 2015).

[47] https://ec.europa.eu/energy/en/topics/energy-efficiency/buildings

An additional impulse for the thermomodernization and limit energy consumption in the municipal- housing sector in Poland will become the governmental plan for tackling air pollution called “Clean Air”, to be implemented in 2018-2029. This plan falls in line with the implementation of the guidelines from the National Air Protection Plan, which assumes that Poland will reach WHO standards defining permissible air pollutant concentrations by 2030. The reason for adopting this plan was the low air quality, especially in the cities, with the contributors being transport and emissions from the construction sector, especially single-family dwellings. The “Clean Air” programme assumes allocating PLN 103bn to support thermomodernization, including the determination of quality and replacement or purchase of new CO_2 boilers, determination of fuel quality and thermal insulation of residential buildings. These funds will be distributed in the form of grants and loans by the Provincial Funds for Environmental Protection and Water Management.

Smog in Poland differs from acidic smog (London smog) and photochemical Californian, Los Angeles- type) in terms of composition, primarily formed by dust particles PM10, PM2.5, as well as the most harmful to health PM 1 - soot (BC) and numerous polycyclic aromatic hydrocarbons, including benzo(a)pyrene, which is why it can be called a “particulate smog”. Dust pollution is associated with the process of burning solid fuels, in low-efficiency furnaces. This smog is formed under a high-pressure weather and negative air temperatures. Low temperature results in an increasing demand for heat, which leads to growing pollutant emissions from individual heating equipment. The particulate smog occurring in Poland does not entail exceeded values of permissible SO2 and CO concentrations.

Air pollution, causing the phenomenon of smog, comes from the so-called “low- emissions”. Low emissions mean emissions of pollutants into the atmosphere via emitters with a height below 40m. This is why it applies to individual heating equipment used in the municipal-housing sector, including single- family or multi-family dwellings, local boiler houses with low capacity, public utility buildings, service workshops, commerce, etc. Low emissions also include emissions from the road transport sector.

Low emissions are associated with heating houses through individual heating equipment, which is why appropriate actions by the owners of such house are of greatest significance in tackling smog. In the case of a large number of households, the basic fuel used for heating is hard coal, which combined with old, low-efficiency combustion sources results in increased emissions of solid particulates having a large impact on air pollution.

The “Clean Air” programme is a financial tool, directed at the owners of residential buildings. The objective of the Programme is to improve energy efficiency and decrease the emissions of particulates or other pollutants to the atmosphere from existing single-family dwellings or to avoid the emissions of pollutants coming from newly built single-family housing.

Beneficiaries of the programme include owners of single-family buildings, which are used to satisfy housing demands, is a structurally individual unit, allowing for the designation of no more than two apartments or one apartment and one business premise with a total area of no more than 30% of the total building area.

The form of financing from the programme applies to a grant or loan by the Provincial Funds for Environmental Protection and Water Management in the scope of investment projects.

The types of projects implemented with the use of funds from the programme aimed at limiting or avoiding low emissions, associated with increasing energy efficiency and the utilization of renewable energy sources in single-family dwelling are, in particular:

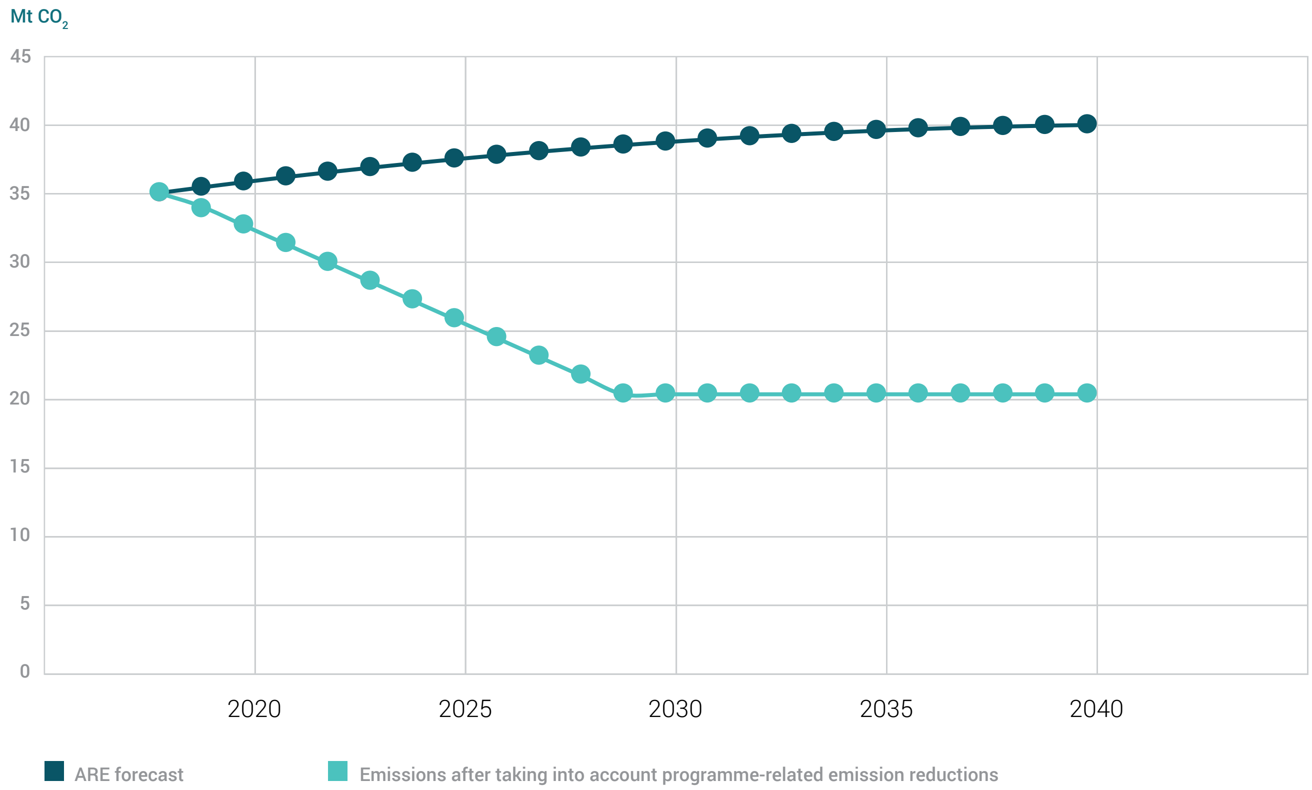
- Replacing old-gen heat sources failing to meet the requirements stipulated in the annex to the Resolution of the Minister of Development and Finances of 1 August 2017 on requirements for solid fuel boilers (OJ 2017 item 1690).
- Installation of devices and systems meeting the technical requirements stipulated in annex 1 to the Priority programme: solid fuel boilers, heat centres, electric heating systems, oil boilers, gas condensing boilers, air heat pumps, heat pumps receiving heat from the ground or water, together with the connections.
- Utilization of renewable energy sources (solar panels, photovoltaic microsystems).
- Thermomodernization of single-family dwellings.

Implementation of the “Clean Air” programme is planned for a period of 10 years. The scope of the programme is to cover 4 000 000 residential buildings, out of which - the existing buildings (an estimated number of 3 000 000) will have the non-efficient heat sources replaced (old-gen boiler replacement) with low-carbon ones, and the newly constructed buildings (at least 1 000 000) will have low-carbon heat sources installed. Another activity included in the programme is the thermomodernization, which will contribute to decreasing the demand for primary energy, in turn, leading to decreased emissions.

The budget for the implementation of the “Clean Air” programme is PLN 103bn, and the beneficiaries of the programme may apply for non-returnable grants in the total amount of PLN 63.3bn or loans, in the total amount of PLN 39.7bn.

The results of these activities will be an improvement of building energy efficiency. The programme will involve the thermomodernization and replacement of heating equipment in about 4 million single- family dwellings, resulting in the reductions of dust, including PM10 and PM2.5, as well as mitigating CO_2 emissions. This stems from the improvement of energy efficiency of residential buildings, improving heat generation effectiveness, and above all, as a result of replacing the heating equipment, the used fuel is often changed, and the combustion system itself in the new devices is more low-carbon. This translates to mitigating dust emissions, including PM10 - 31.523 kt, PM2.5 - 25.218 kt, and CO_2 emission reductions amounting to approximately 13 Mt, which is shown on the graph. Bear in mind that emission reductions apply only and solely to the emissions from residential buildings, with their emissions being a part of the municipal-housing sector.

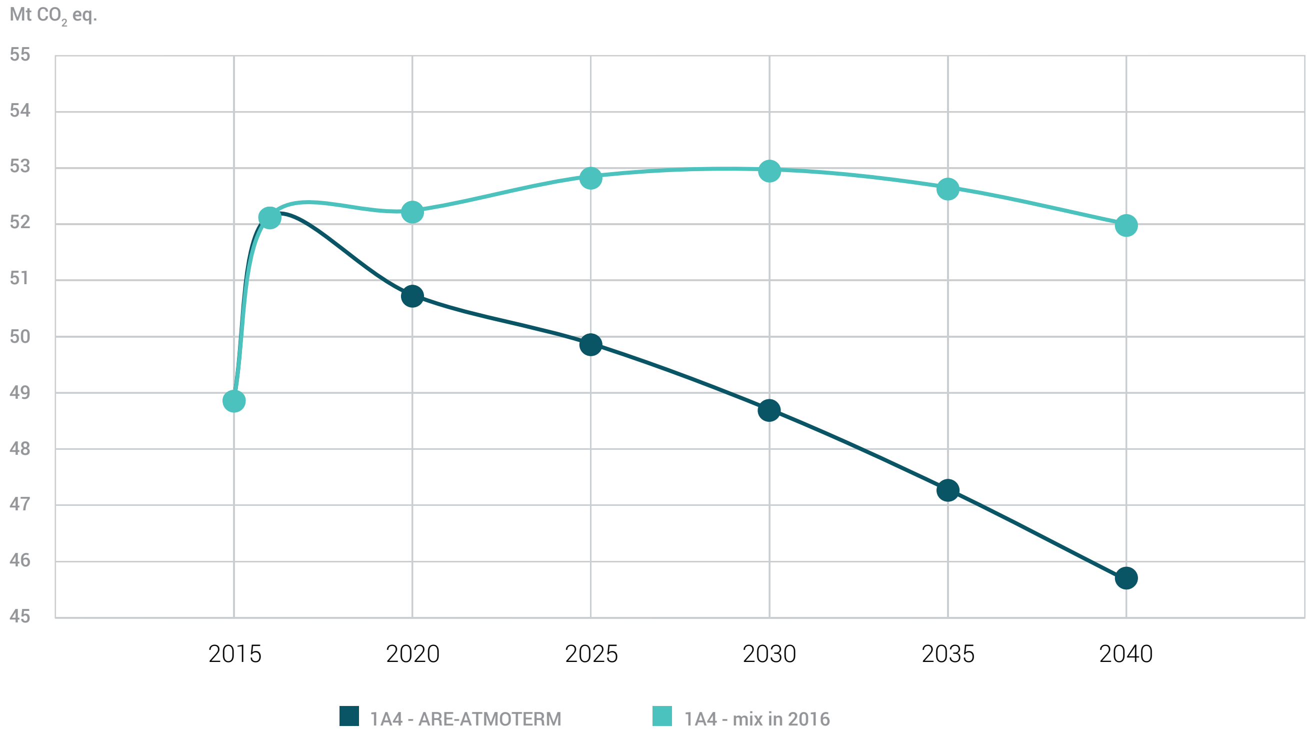
Fig. 63. Assumed emission reductions resulting from the activities within the „Clean Air" programme



Source: KOBiZE own study

Another activity with a purpose to limit greenhouse gas emissions in the municipal-housing sector is a change of the fuel structure towards a decreased share of coal in favour of gas and RES. In 2016, within the entire category covering small combustion sources (sector 1.A.4), the hard coal consumption was at a level of about 24% of the total fuel combusted domestically. The shares of fuels in this sector in 2016 were as follows: hard coal – 44%, natural gas – 30%, solid biomass – 18%. According to the ARE- ATMOTERM scenario, the share of hard coal will be gradually decreasing until 2040 - to a level of 30%. On the other hand, projections for 2040 estimate that the share of natural gas consumption will increase to 41%, and of solid biomass to 22%. Figure 64 shows the projected emissions in the ARE- ATMOTERM scenario, compared to the emissions, which would be, assuming the same demand for fuel- fired energy, but with a 2016 fuel structure (mix in 2016). It is estimated that the aforementioned changes in the fuel structure will result in an emissions reduction by over 6 Mt CO_2eq.

Fig. 64. Change in the greenhouse gas emissions resulting from the alteration of the fuel mix in the small combustion sources (sector 1.A.4.)



Source: KOBiZE calculations based on ARE-ATMOTERM data.

The main challenges ahead of the municipal-housing sector in a 2050 perspective are associated with the need to achieve a significant improvement in the energy performance of old buildings as a contribution of this sector in reaching the global temperature target, which is, limiting the growth of global temperature by the end of the century by less than 2 degrees Celsius, compared to the pre- industrial era. If the international community adopts a long-term global temperature target at a level of 1.5 degrees, the greenhouse gas global emissions should reach a zero level by 2050, which impose on the municipal-housing sector the need to significantly accelerate the modernization or the replacement with zero-emission, existing resources48. The concept of zero-emissions assumes the use of renewable energy by the municipal-housing sector, which intensifies the challenge ahead of this sector and conditions the success of the necessary activities on a total, accelerated transformation of the energy sector.

[48] The analysis of the scenarios considered by the scientists indicates that limiting the global temperature growth to a level below 1.5oC would be possible, provided that the global emissions would fall in 2030 by 45% compared to the level in 2010. The CO_2 global emissions have to decrease to zero by 2050 and in the second half of the century become negative, based on CO_2 reduction technologies, such as Carbon Capture and Storage Comp. http://report.ipcc.ch/sr15/pdf/sr15_ts.pdf

Agriculture

In terms of the emissions, the agricultural sector in Poland is responsible for ca. 15-16% of domestic volumes of non-EU ETS greenhouse gas emissions. The greatest importance in this sector is attributed to soil emissions (nitrous oxide coming primarily from mineral and organic fertilizers) and enteric fermentation emissions (methane, which is almost entirely cattle-related) and from animal faeces (methane and nitrous oxide emissions). Other emission sources are of minor importance, just like carbon dioxide emissions released during liming and urea application, with their combined volumes not exceeding 3% of the total sectoral emissions (2015).

Agriculture is one of the sectors of the economy undergoing major changes, which began during the transformation period, intensified together with the Polish membership in the European Union and access to EU funds allocated to Common Agricultural Policy. The most visible socio-economic changes in the Polish agriculture were mainly manifested by the departure from a centrally planned economy towards a market economy, which resulted in agriculture becoming a largely goods-oriented branch of the economy, producing both for the internal market, as well as export. The number of people employed in agriculture has significantly decreased, while production intensification has significantly increased, manifested by, i.a., the development of specializations, marketability, the application of new agrotechnical and technological solutions, as well as an increasing demand not only for production measures (e.g. fertilizers and feed) but also for energy (in the form of electricity and fuels). The structure of farmsteads is also gradually changing, with their number decreasing and the average area increasing, although still more than half of those does not have an area of more than 5 ha with most of them maintained solely for the purposes of self-feeding. The agricultural production of some farms intensified, e.g., the ones specializing in livestock husbandry on an industrial scale. Plant production has also partially changed, e.g. the acreage of traditional Polish crops, such as potatoes, rye and oats significantly decreased, while the acreage of corn increased several-fold. In general, it can be concluded that through the increase of production marketability, agriculture became an important element of the market economy, both domestically (internal market), as well as internationally (import and export).

However, Polish agriculture – compared to Western EU countries – is still characterized by relatively greater fragmentation, underinvestment, lower productivity and innovation.49 The fact that makes Polish agriculture similar to the Western model is the increasing energy consumption, associated with progressing mechanization. Although production modernization and the application of more energy- efficient machines decrease energy intensity in agriculture, it applies only to some farmsteads. It seems that the agricultural sector – just like previously – too little attention was paid to improving energy intensity and the use of own power resources, such as biogas and crop residues. In a similar manner, there is a lack of the dissemination of modern and eco-friendly cultivation and breeding methods. Although the changes in agriculture are slow, they are clearly heading towards the consolidation of the farms and a further marketization of the production, through increasing its marketability. At the same time the number of people working in agriculture is decreasing, hence, productivity increases, entailed by growing demand for energy, machines, fertilizers, crop protection measures and animal feed.

Most probably, the agricultural sector will still be undergoing changes, and their intensity will depend on the governmental agriculture support policies and the availability of funds allocated to agricultural production in the form of direct subsidies, loans, etc. SOR (Strategy for Sustainable Development) 50 assumes the effects of attempted action should be, i.a., an improvement of the area structure within the agriculture through increasing the acreage of farmsteads and the loss of the smallest ones, with an area up to 5ha, along with decreasing the number of employed people and increased profitability within the sector. According to SOR, the key intervention of the State in relation to farmstead will be a further support for the transformations within the agri-food sector, especially for the activities stimulating the increase of its competitiveness, ensuring the national food security and taking environmental requirements into account.51

After a period of slight fluctuations in the GHG emission volume of the sector in the years 2005-2016, its minor yet gradual growth can be observed. A further growth trend is expected, until at least 2030, which results from the aforementioned conditions. In the light of such forecasts, limiting the growth of emissions with a simultaneous, assumed growth of sector productivity will be a challenge. Since the emissions from agricultural soils and the used fertilizers are of crucial significance, further intensification of plant production should take into account good agricultural practices, which should also take into account the aspect of climate protection. The consequence is the expected rationalization of the application of fertilizers, including nitrogen-related, according to the regulations incorporated into the Water law and the act on fertilizers and fertilizing, as well as according to the so-called nitrate plan52. The requirements of this plan will require the entities conducting agricultural production to make necessary, yet long-term investments. According to the draft of the nitrate plan, agricultural producers will be obliged to adapt their acreage

[49] 2050.pl Podróż do niskoemisyjnej przyszłości [2050.pl - Journey to a low-carbon future]. Bukowski M. (ed.), Warsaw, 2013, p. 96.

[50] SOR – Strategy for Responsible Development until 2020 (with a perspective until 2030). Document adopted by a resolution of the Council of Ministers on 14 February 2017

[51] SOR, p. 103.

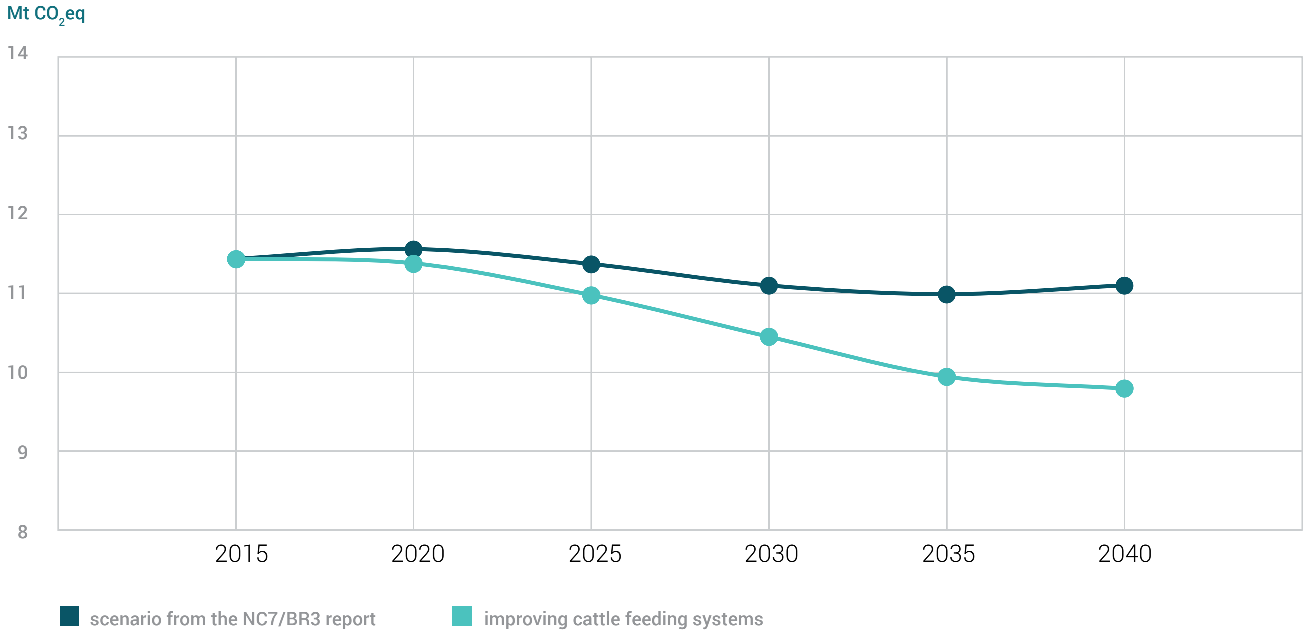
[52] Draft of a resolution of the Council of Ministers: "Action plan aimed at mitigating water pollution with nitrates derived from agricultural sources and preventing further pollution" – so-called nitrate plan, issued on the basis of art. 106 of the act – Water law.

or the capacity of their storage facilities for natural fertilizers (animal faeces) to the requirements set out in the programme. Just like soil cultivation, also breeding, which contributes to the emissions as a result of enteric fermentation and from animal manure, should take into account the most effective emission reducing processes, with their application disseminated as necessary. This is why the nitrate plan will find wide application in limiting emissions derived exactly from animal production, especially in terms of governance of storing liquid and solid animal manure.

Therefore, the change in the manner of managing the agricultural production, above all, seems to be a challenge, with the decisions therein taken by hundreds of thousands of individual farmers, covering large areas of Poland, which is important for the efficiency of the efforts to protect the climate in a nationwide scale. Reconciling the intensification of agricultural production with emission reductions will require both economic resources, as well as an appropriate dissemination of ecological awareness among the farmers. A manifestation of changes in the right direction is the development of eco-farming, supported by the Government within the Rural Development Programme 2014-2020, through payments for the transition to eco-friendly practices, agricultural methods and their maintenance. Ecological practices and methods are eco-friendly, and at the same time serve the protection of waters, soils, biodiversity and climate, and involve, i.a., abandoning the use of agricultural, veterinary and food chemistry in favour of using non-processed agents of biological and mineral origin.

Recognizing the changes ongoing in the Polish countryside, including the generational change in the farmsteads, it can be seen as an opportunity to increase the success of the implementation of actions aimed at climate protection within the agricultural sector. Such activities may include the rationalization of the use of mineral nitrogen fertilizers, involving precise dosage of the fertilizers in appropriate soil- climatic conditions, which can contribute to reducing nitrous oxide emissions in the period of 1989 2040 by ca. 1 Mt CO_2eq. Moreover, further improvement of cattle feeding (responsible for 95% of CH_4 emissions due to enteric fermentation) affecting the improvement of animal feed digestibility may contribute to reducing methane emissions by 0.55 Mt CO_2eq in 2030 and by 1.1 Mt CO_2eq in 2040 (fig. 66).

Fig. 65. Cattle-related enteric fermentation greenhouse gas emission reductions resulting from additional activities introduced within the agriculture



Source: own KOBiZE calculations.

An additional activity, which directly contributes to CO_2 sequestration, as well to the adaptation to climate change is afforestation within the Rural Development Plan 2004-2006 and the Rural Development Plan for the years 2007-2013 and 2014-2020 as a task of investing in the development of forest areas and improving forest vitality. Planned afforestation on agricultural lands by 2020 will contribute to absorbing 1.4 Mt CO_2.

Social issues (mining, carbon leakage)

Economic situation of the mining sector – critical issues of concern and possible solutions

The transformation of Polish economy towards low-carbon economy in the perspective of the year 2050, according to the current European policy, requires taking a number of actions, which will lead to achieving emission reduction targets, while simultaneously increasing the level of generated energy from RES and energy efficiency growth. The European Union has committed to a 40% greenhouse gas reduction by 2030, compared to 1990, and according to the suggested higher targets of 32% for RES and 32.5% for energy efficiency by 2030, will require taking a series of actions at the national level. Striving to meet these requirements, in accordance with the need to implement the stipulations of the Paris Agreement and the latest EU proposals in the scope of the "Clean Energy for all Europeans" package[53] will require a series of changes, mainly in the energy sector, which will have a great impact on the mining sector and its employment level. Currently, this issue is present in the discussions at an international level in the form of the "Just Transition" phrase, hence, according to the provisions in the preamble to the Paris Agreement, striving to limit adverse climate change should take into account the issues of fair transformation when creating decent and high-quality jobs with defined national priorities[54]. In order to implement the ambitious climate-energy policy and the need to adapt Polish energy mix to the carbon dioxide emission reduction requirements, it is necessary to prepare and utilize all possibilities of co-financing the activities associated with economic transformation.

Hard coal

Approx. 78.2% of electricity and 82.4% of heat in Poland is still coal-related (Eurostat data for 2016). The level of hard coal output in Poland has been gradually decreasing since 1990. The hard coal output in Poland in 1990 amounted to 147.5mn tonnes, and only 70.4 million tonnes in 2016[55]. Despite decreasing hard coal output, Poland is still one of the largest hard coal producers in the European Union. Other European countries with a significant share in coal production are: Great Britain, Germany, the Czech Republic and Spain, which is shown in fig. 66. The main hard coal producers in the world are currently China, India, Australia, Indonesia, South Africa, Russia and Colombia.[56]

Fig. 66. Hard coal production in the EU and its structure by country for the years 2007-2016 [Mt] and its structure by country in 2016

Country	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Poland	87	83	78	77	76	79	76	73	72	70
Great Britain	17	18	18	18	18	17	13	12	9	4
Germany	22	19	15	14	13	11	8	8	7	4
Czech Rep.	13	13	11	12	11	11	9	9	8	7
Spain	11	10	9	9	7	6	4	4	3	2
Romania	3	3	4	4	4	4	4	0	1	0
EU	153	146	135	134	129	128	114	106	100	100

Structure in 2016 [%]

Source: Own study based on: Plan for the Polish hard coal mining sector, Ministry of Energy 2018, p. 9

[53] https://ec.europa.eu/energy/en/news/commission-proposes-new-rules-consumer-centred-clean-energy- transition

[54] Paris Agreement, https://unfccc.int/process-and-meetings/the-paris-agreement/the-paris-agreement

[55] Eurostat, Supply, transformation and consumption of solid fuels – annual data.

[56] Program dla sektora górnictwa węgla kamiennego w Polsce w latach 2018-2030 [Plan for the Polish hard coal mining sector for the years 2018-2030], Ministry of Energy, Warsaw 2018, p. 9.

Employment in the hard coal sector in 1990 was 391k people, and in 2016 only 84.6 thousand people. Despite such a large decline, the employment level in Poland in this sector is still high, compared to other European countries[57]. At this point, attention should be drawn to the increase of coal output efficiency per one person employed in the hard coal mining sector over the recent years, as it amounted to 377 t/person in 1990 and already 832 t/person in 2016 (fig. 67).

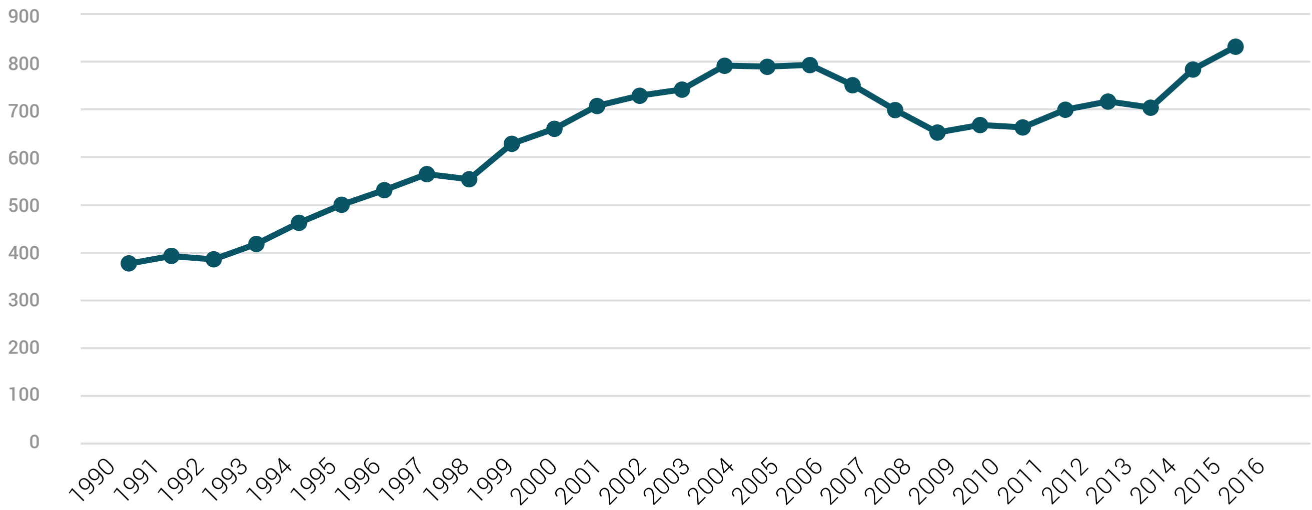
In 2018, in order to develop activities associated with the future of the coal sector, the Polish Government adopted two special plans, i.e., for the hard and brown coal sectors, which cover the perspective up to 2030.

Employment in the hard coal sector in 1990 was 391 000 people, and in 2016 only 84.6 thousand people. Despite such a large decline, the employment level in Poland in this sector is still high, compared to other European countries[57]. At this point, attention should be drawn to the increase of coal output efficiency per one person employed in the hard coal mining sector over the recent years, as it amounted to 377 t/person in 1990 and already 832 t/person in 2016 (fig. 67).

According to the "Plan for the Polish hard coal mining sector for the years 2018-2030[58]", it is planned to create a modern hard coal mining sector in Poland, which thanks to the incorporated innovations and the use of own resources, will support Polish energy independence and economic competitiveness.

Coal will still be the basic energy source in Poland, also thanks to ensuring an appropriate level of energy security for our country. It should also be noted that despite the fact that Poland still has 32bn tonnes of hard coal deposits, a part of these resources cannot be utilized due to adverse technical conditions.[59] For this purpose, Poland is also importing coal, mainly from Russia, followed by Australia. As stated by the scenarios analysed in the plan – i.e., low, reference and high, the share of hard coal electricity in the total electricity generation is supposed to maintain its high level of 40% until 2030. The hard coal output is expected to maintain a similar level until 2030, depending on the adopted scenario.

Fig. 67. Hard coal output per person employed in HC mining in Poland, 1990-2016 [tonne/person]



Source: Own study based on: Eurostat database; Bednorz J., 2015: Politykaspołeczno- gospodarczapaństwawobecpolskiegosektoragórnictwawęglakamiennegopo 1989 r. [Post-1989 socio-economic policy relating to the Polish hard coal mining sector], Doctoral dissertation, University of Silesia, 2015; J.Olszowski 2017: Znaczenie górnictwa węgla kamiennego dla gospodarki i regionów oraz bariery jego funkcjonowania [Importance of hard coal mining for the economy and regions, and its functional barriers], Conference "Raw material for the Polish economy", Cracow 2017

Brown coal

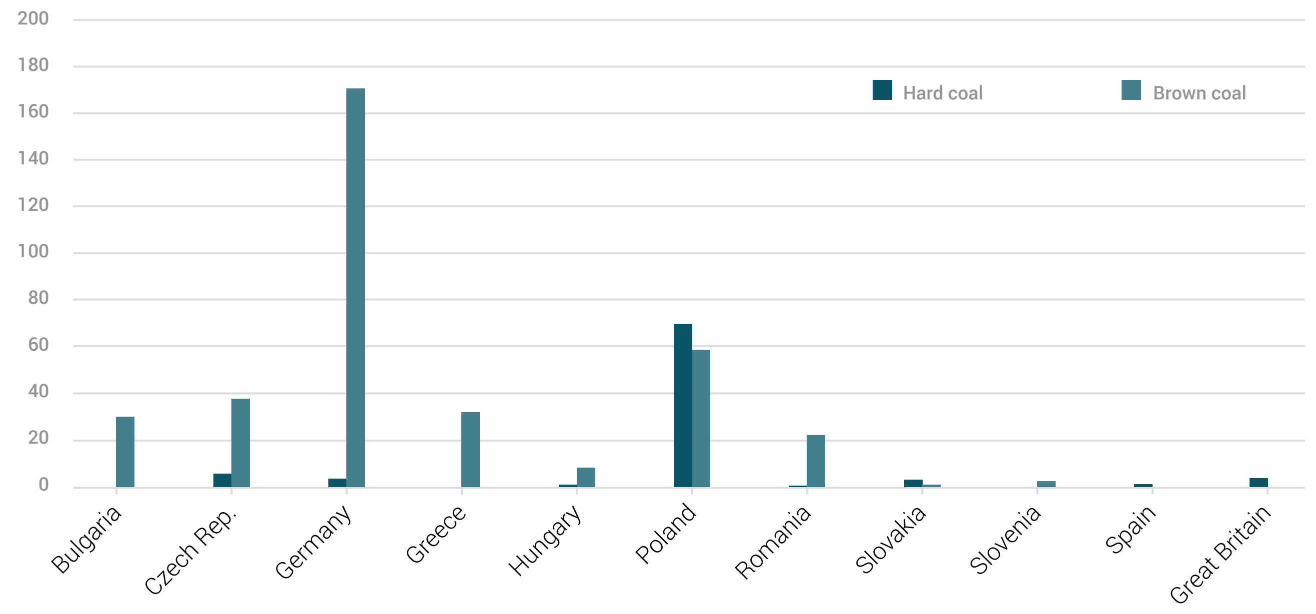
Poland is the second country, after Germany, with the highest level of brown coal output in the EU. Other countries extracting the largest amount of brown coal within the EU are, i.a., the Czech Republic, Greece, Bulgaria, Romania, Hungary, Slovakia and Slovenia, as shown in fig. 68.

[57] J. Bednorz., Politykaspołeczno-gospodarczapaństwawobecpolskiegosektoragórnictwawęglakamiennegopo 1989 r.[Post-1989 socio-economic policy relating to the Polish hard coal mining sector], Doctoral dissertation, University of Silesia, 2015; J. Olszowski 2017: Znaczeniegórnictwawęglakamiennegodlagospodarkiiregionóworazbarieryjegofunkcjonowania[Importance of hard coal mining for the economy and regions, and its functional barriers], Conference "Raw material for the Polish economy", Cracow 2017

[58] Plan for the Polish hard coal mining sector

[59] Plan for the Polish hard coal mining sector, p.7

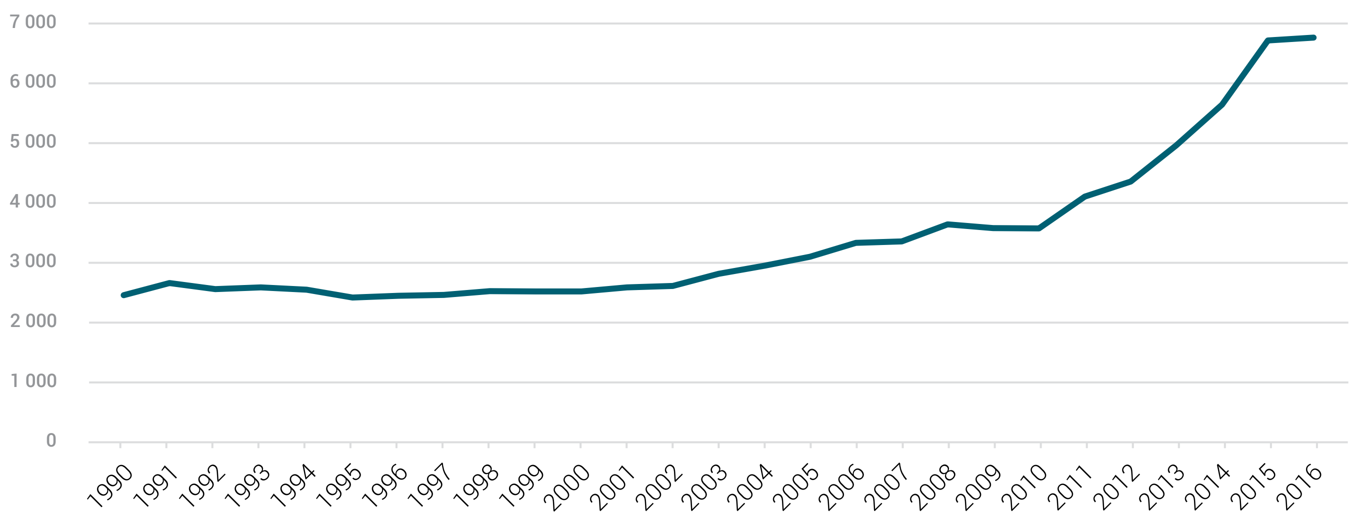
Fig. 68. Brown and hard coal output in individual European Union countries in 2016



Source: Program dla sektora górnictwa węgla brunatnego w Polsce [Plan for the Polish hard coal mining sector], Ministry of Energy, 2018

Brown coal output in Poland has decreased since 1990 from 67.6 Mt to 60.2 Mt in 2016.[60] The decrease in coal output was not as significant in this case as with hard coal, yet the employment level in this sector decreased three-fold, from a level of 28 800 people in 1990 to 9 100 in 2016.[61] (however, outsourcing should be taken into account)[62]. Brown coal extraction efficiency in Poland has increased over the last thirty years almost trebled, if we compare the data regarding the level of output per one person employed in the mining sector, with 2351 t/person in 1990 and 6639 t/person in 2016 (bear in mind the high level of outsourcing in this sector).

Fig. 69. Brown coal output per person employed in BC mining in Poland, 1990-2016 [tonne/person]



Source: Own study based on: Eurostat database; Kasztelewicz Z., 2018: Raport o stanie branży węgla brunatnego w Polsce i w Niemczech wraz z diagnozą działań dla rozwoju tej branży w I połowie XXI wieku [Report on the condition of the brown coal industry in Poland and Germany, along with a diagnosis of the action its development in the 1st half of the 21st century] Cracow 2018

[60] Eurostat, Supply, transformation and consumption of solid fuels – annual data.

[61] Raport o stanie branży węgla brunatnego w Polscei w Niemczech wraz z diagnozą działań dla rozwoju tej branży w I połowie XXI wieku [Report on the condition of the brown coal industry in Poland and Germany, along with a diagnosis of the action its development in the 1st half of the 21st century], Z. Kasztelewicz, Cracow 2018

[62] According to the data stated in the Plan for the brown coal mining sector, the mining industry employs ca. 23.5k people, and around 10k people in the auxiliary services.

On 30 May 2018, the Polish Government adopted the Plan for the Polish brown coal mining sector, which is supposed to be a kind of a "roadmap for investment implementation".[63] The main objective of this plan is to create appropriate investment conditions, as well as the utilization of coal for the production of liquid and gaseous fuels. According to the adopted plan, it will be possible to maintain the current coal output level by 2030. However, due to the need to modernize and shut down previously exploited deposits and without investing in new one, it is possible for the loss of production capacity in 2040-2050, which will result in the shutting down of the industry and the absence of demand for qualified workers in this sector. Further activities for the development of this sector will depend on the adopted energy mix, however, as was emphasized in the plan, brown coal is of significant importance in ensuring the country's energy security and the utilization of potential deposits of this raw material in the future.

Pursuant to the assumptions adopted in the plan, the share of brown coal electricity in the total electricity generation will decrease to a level of ca. 20% in 2030. According to the strategies outlined in the aforementioned plan, it will be necessary to develop new technologies, e.g. raw material gasification. According to the information given by the Prime Minister, Mr Mateusz Morawiecki, gas is[64].

Mining sector transformation issue vs unemployment level

The issue of transformation was addressed during a European debate and currently, within the activities initiated by the EC, resulting in the publication of a special report by the Joint Research Centre (JRC) "EU coal regions: opportunities and challenges ahead" on the possibilities and challenges for coal regions facing the challenge of transition to low-carbon economy.

According to the estimates shown in the JRC report and elaborated based on national reports of the European Association for Coal and Lignite for 2017, the mining sector currently employs 237 000 people, out of which 185 000 are employed in mining and the extraction sector, and the remaining 52 000 are employed in coal-fired power plants.[65] It should be stressed that in this case, the number of workers employed in within the Polish mining sector is the highest, since it amounts to around a half of the total number of mining sector employees in Europe.

The EC study indicates that the European Union has 108 regions with coal mining infrastructure, however the level of employment directly associated with the mining sector covers 200k people, working in more than twenty regions. Poland is a significant example since six of these twenty regions are located there, with Silesia being a particular example (with ca. 82 500 workers employed in 2015). In terms of employment within the mining sector Poland is followed by Germany, the Czech Republic, Romania, Bulgaria, Greece and Spain. However, the employment therein is at a level of ca. 10 000 people.

Furthermore, according to the data provided in the report, 215 thousand jobs are currently associated with the coal-production activity and the supply chain (in such sectors as energy generation, services, servicing or innovations). Four regions in Poland, Bulgaria and the Czech Republic employ the most people.

The results of the JRC report indicate that by 2025, 77 thousand, and by 2030 as many as 160 thousand jobs associated with extraction, namely, in the mining and energy sectors, will be at risk in the EU. In this context, it should be noted that the costs, which can be incurred by Poland will in this case be much higher than in other countries, due to a higher level of employment within the mining sector itself and sectors associated with mining[66]. Below you can find a map from the report showing the mining job loss risk until 2030.

The first wave of curbing the employment, associated with shutting down the operation of old units, according to the report may occur in 2020-2025, potentially leading to a loss of 15 000 jobs in power plants. The countries affected by it will be Poland, Great Britain, Germany, the Czech Republic and Spain. In the course of the next wave in the years 2025-2030, as stipulated by the EC report, a further 18k jobs is at risk, with Germany, Poland, Great Britain, Bulgaria and Romania affected this time.

According to the EC report, the most severe effects of introducing the climate-energy policy may affect as many as 10 EU Member States: Bulgaria, Poland, Germany, Czech Republic, Greece, Hungary, Romania, Slovakia, Slovenia and Spain. However, it should be emphasized that the regions with the highest level of employment include Poland, with 41 000 jobs at risk by 2030 and regions in Bulgaria, the Czech Republic and Romania, with 10 000 jobs at risk in each of these. For this reason, the scale and costs for these countries can be disproportionately higher.

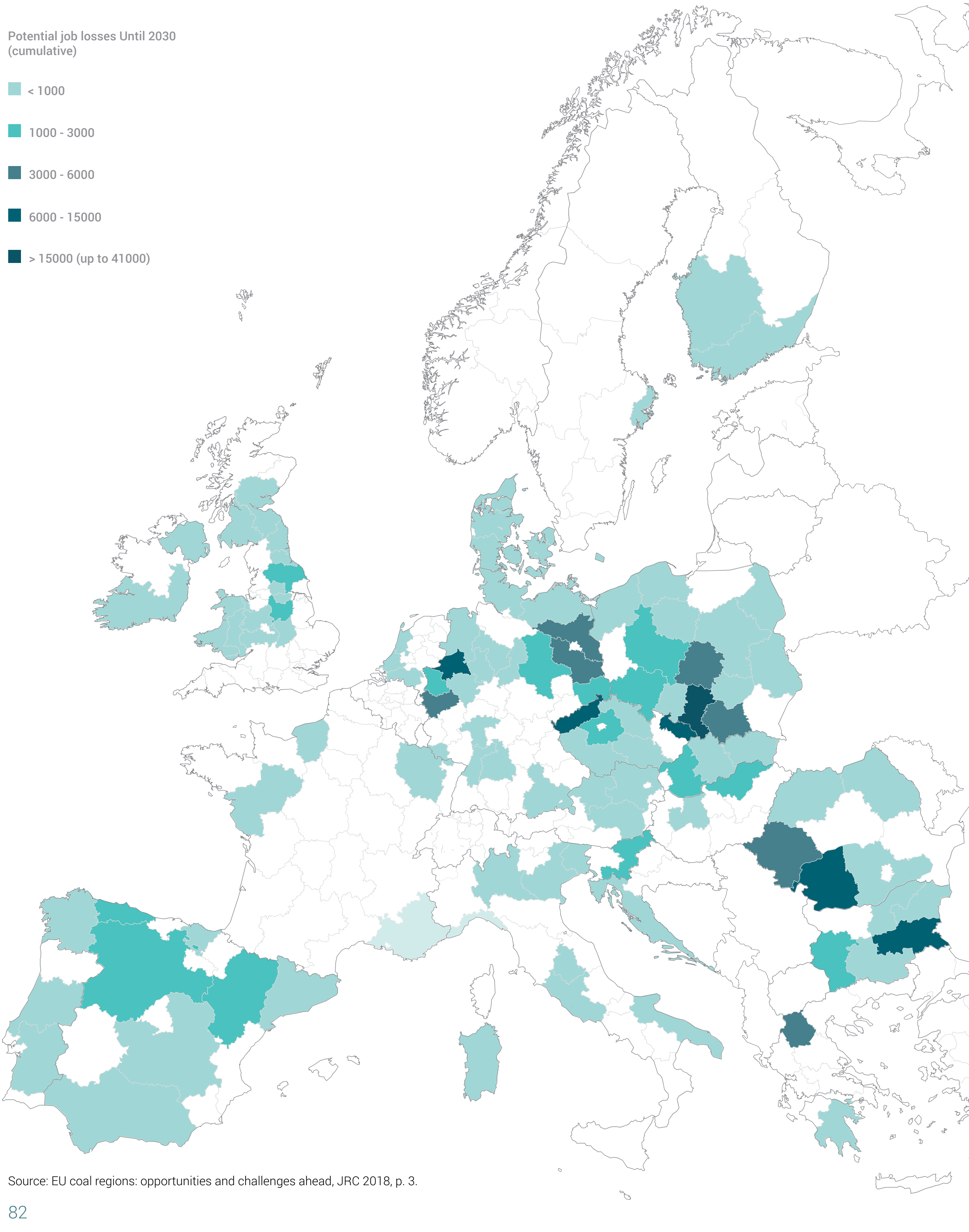
[63] Program dla sektora górnictwa węgla brunatnego w Polsce [Plan for the Polish brown coal mining sector]. The Plan covers the years of 2018-2030 with a perspective of 2050 and presents the direction of development for the Polish brown coal mining sector, together with the objectives and activities necessary to achieve them, Ministry of Energy 2018.

[64] https://www.premier.gov.pl/wydarzenia/aktualnosci/premier-mateusz-morawiecki-o-programie-przyspieszonej- gazyfikacji-w-polsce.html

[65] The estimates in the JRC report were elaborated based on national reports from the European Association for Hard Coal and Lignite EURACOAL, Euracoal for 2017.

[66] *EU coal regions: opportunities and challenges ahead, JRC Science for Policy Report,* 2018.

Fig. 70. Regions at risk of losing the most jobs directly associated with the mining sector (power plants and extraction) until 2030



Source: EU coal regions: opportunities and challenges ahead, JRC 2018, p. 3.

Do not forget about the result of increased unemployment associated with impact on other sectors of the economy, i.e., the iron and steel sectors, which are dependent on domestic coal and the labour market associated with coal production and coal-related activities, which includes more than 100 000 jobs according to the EC.

In order to accomplish the targets of the EU climate-energy policy, it is necessary to prepare the most vulnerable regions for the activities associated with retraining a broad group of employees related to the mining sector. There will be potential opportunities to employ some of the current mining sector employees in the RES sector, the industry or the developing electromobility sector.

The future and possible solutions

The issue of ensuring employment for eliminated jobs within the mining and associated sectors is currently widely discussed, with various solutions sought after and presented for discussion.

According to an IBS report titled "Coal Transitions: Research and Dialogue on Future of Coal" it is necessary to develop a coal sector transformation strategy, not only due to the climate policy targets but also due to the decreasing profitability of mining. For this purpose, cooperation is required at various administration levels, so as to appropriately prepare the mining staff for the changes, which will result from adopting the new energy policy. In the light of the above, it will be required to develop plans associated with employment reduction, retraining and creating a next generation of personnel. The problem in this sector is, however, the low mobility of this group of employees and the specificity of socially accepted traditional role of men, as the ones responsible for providing for the family. In this context, it is worth to refer to the example of Wałbrzych, where closing three mines in 1990 meant a loss of 14 000 jobs in the mining sector, which resulted in a high unemployment level and the social problem of exclusion. Due to the education level of miners, which is lower than the national average, their situation on the labour market will be significantly more difficult than for other employees, but according to the report, it is possible to retrain them and ensure new jobs, e.g., in the construction sector and car manufacturing.[67]

It is also worth to mention the latest IBS report "Managing coal sector transition under the ambitious emission reduction scenario in Poland. Focus on labour". According to this report, employment within the mining sector will have to be reduced in order to achieve the objectives of the Paris Agreement and the greenhouse gas emission reductions.[68] Decreasing coal output will entail a reduction of employment in mines, however, it will not result in mass redundancies, since, as stated by the report, it will be achieved over a long period of time and the natural retirements of the employees, as well as decreasing the inflow of new workers. In addition, the demand for labour in other sectors is supposed to grow, with employment opportunities expected in the sectors of industry, transport, vehicle repair and construction. One of the solutions suggested in the report is, i.a., to decrease the number of students trained in the field of mining and adapting them to the planned employment reduction within the sector. It also suggests all kinds of incentives both for current miners, as well as future talent, so that new career paths are selected, enabling efficient transformation of the system.[69]

Another example in the EC report titled "EU coal regions: opportunities and challenges ahead" are the solutions involving the transformation of mines into facilities generating energy from renewable sources. The examples included the possibility to develop, e.g., wind power in several regions of Poland, the Czech Republic and Hungary, and the use of solar power in Greece, Spain and Bulgaria.

The importance of coal for energy generation will be falling, however changes associated with altering the energy mix will entail adjustments at the level of the entire economy and, in consequence, the level of employment and development in regions traditionally linked with brown and hard coal production, and with operating coal-fired power plants. In the light of the issues arising from the changing energy policy and decreasing the share of coal consumption, the preparations for a transformation involving the employment sector should be commenced as soon as possible, both at the domestic, as well as regional level.

[67] Coal Transitions: Research and Dialogue on Future of Coal, IBS, 2018.

[68] According to IBS estimates, in order to meet the Paris Agreement targets, it will be necessary to reduce employment in this sector to 63k jobs in 2030 and to 27k in 2050.

[69] Managing coal sector transition under the ambitious emission reduction scenario in Poland. Focus on labour, Research Report, 04/2018, IBS, 2018.

Carbon leakage

One of the most important changes to the EU ETS implemented since 2013 has been the departure from free allocation of allowances, in favour of purchasing them at auctions. In principle, this obligation leads to a significant increase in the production costs for EU producers, compared to non-EU producers. Not incurring costs of the implementation of the climate policy by non-EU producers, often using high- carbon technologies and not facing similar GHG emissions constraints may lead to the loss of competitiveness of certain industrial sectors within the European Union. Consequently, such a situation may lead to replacing production in the European Union with import from third countries or relocating the production of international companies outside of the EU. Such a risk is called carbon leakage.

The available literature and the results of model analyses[70] recognize the possibility of the carbon leakage risk in the case of the absence of comparable climate policy and reduction efforts at the global level. Given the real situation and the experience associated with the III trading period of the EU ETS since 2013, it is difficult to assess the scale of the risk due to the lack of analyses based on actual data. An additional difficulty stems from the lack of data in the event of relocating production outside of the EU, within the same capital groups, in order to optimize the manufacturing process and cut costs.

The effects of carbon leakage within industrial sectors, affecting the trade intensity can be identified as:

- **production leakage** - also defined as operating leakage - replacing the entire or partial domestic production with import from non-EU countries (in a short-term perspective). In a region without aclimate policy, business entities within a given sector will have a competitive advantage over entities in regions with emission reduction constraints. This may lead to a loss of output markets.
- **investment leakag**e - cessation of planned investments within an EU ETS sector (in a long-term perspective). This results competitiveness losses in sectors with noticeable lack of investment decision-making (new or modernizations), compared to regions with no climate constraints;
- **changes in global prices of fossil fuels** and their impact on the level of production, consumption and trade balance.

From the point of view of costs incurred by facilities in the industrial sectors, there are two types of carbon leakage:

- **Direct** - associated with increasing production costs due to high costs of purchasing allowances to cover the production process emissions;
- **Indirect** - associated with increased production costs due to increased purchasing costs of electricity used for the manufacturing process.

Depending on the specificity of a given industry covered by the climate policy, these two types of carbon leakage may occur jointly or separately.

Risk and effects of carbon leakage in Poland and the European Union by 2030

Both in the case of the risk of direct, as well as indirect carbon leakage, one of the important factors is the increase in production costs, caused by high emissivity or energy intensity of the production. A summary of energy intensity in relation to previously defined sectors and products was developed, for the purposes of this study, in order to compare individual branches of the Polish economy, in which the cost of purchasing CO_2 emission allowances and an increase of the electricity costs has a significant impact on the production costs.

A summary of sectoral energy intensity (based on the data from the Central Statistical Office) is shown in table 7. Energy intensity is an indicator, which is a product of the final energy use in oil equivalent kilograms (kgoe)[71] and the added value[72] (as per the EUR exchange rate from 2005).

Based on data for 2016, the sectors with the highest energy consumption index include the metallurgical, chemical and mineral industries, while the lowest energy consumption, according to this index, was recorded in the machinery, means of transport and other industries.

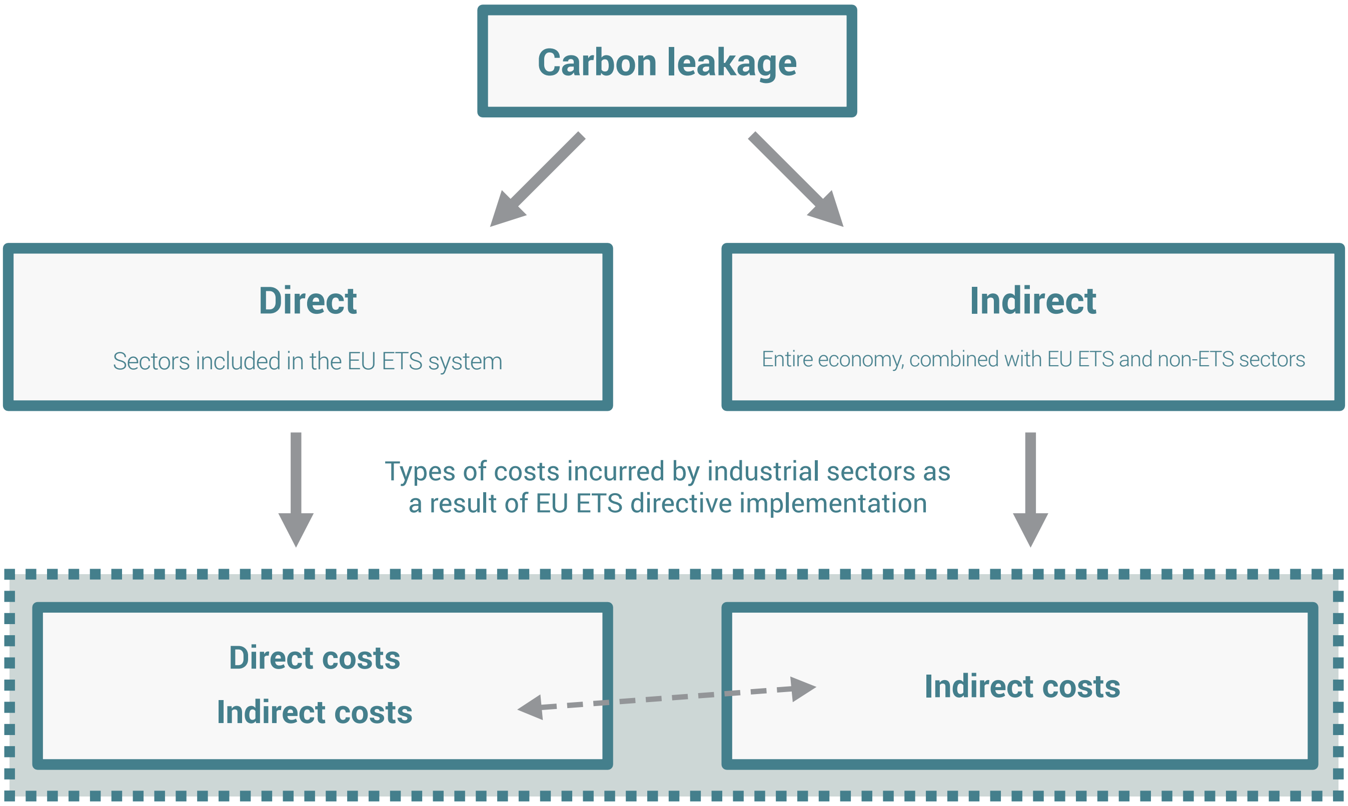
Table 8 contains information on the energy intensity of production for the years 2014-2016 for three selected products: steel, cement, paper. The summary of energy intensity was developed with the use of a unit energy consumption indicator expressed in oil equivalent consumption per a mass unit of manufactured product. This index enables comparing the situation in selected industry branches in Poland and other EU countries.

[70] i.a., KOBiZE analysis: "Ucieczka emisji jako efekt europejskiej polityki klimatycznej [Carbon leakage as an effect of the climate policy]" published in the Przemysł Chemiczny monthly in 2016 or the analysis by A. Marcu "Carbon leakage. An overview, CEPS Special report" of 2013 and an analysis by E. Lanzi: "Addressing competitiveness and carbon leakage impacts arising from multiple carbon markets. A modelling assessment, OECD Environment Working Papers" of 2013

[71] One oil equivalent tonne is defined as an equivalent to one metric tonne of crude oil, with a calorific value of 10 000 kcal/kg or 41.868 GJ and 11.630 MWh, according to the International Energy Agency (IEA).

[72] The GUS data source does not state whether the added value is expressed in gross or net quantities.

Fig. 71. Breakdown of CO_2 carbon leakage and classification criteria for industrial sectors exposed to carbon leakage.



Source: KOBiZE study titled: "Zjawisko ucieczki emisji w sektorach energochłonnych w Polsce w kontekście zmian wprowadzonych w systemie EU ETS na lata 2013-2020 [The carbon leakage risk in energy-intensive sectors in Poland, in the context of the changes introduced in the EU ETS in 2013-2020]", August 2009

Cement production energy intensity increased in 2016 to 0.092 toe/t. The lowest energy intensity was recorded in 2012, when it amounted to 0.087 toe/t. In the case of steel, production energy intensity was recorded at a level of 0.197 toe/t, rising from 0.188 toe/t in the previous year. Steel production energy intensity reached the lowest value during the presented period in 2015. The energy intensity of the paper-making industry decreased in 2016 by 11%, to a level of 0.45 toe/t.

In 2016, compared to 2006, the production intensity of crude steel decreased by 16% (1.7%/year), of paper by 18.5% (2.0%/year) and of cement by 15.6% (1.7%year).

In 2016, KOBiZE prepared an analysis, which concentrates on the scenario reflecting the EU climate policy until 2030 corresponding to the conclusions of the European Council of 23 October 201413. The potential effects of carbon leakage scope were studied, in a hypothetical situation of the absence of current mechanisms counteracting the risk (in the EU ETS there would be no allocation of free emission allowances for companies exposed to carbon leakage) - so-called auction scenario. The reference level for studying potential effects of carbon leakage is a scenario, which assumes the existing protective activities, i.e., allocation of free allowances based on the current rules - so-called historical scenario. The presented results show the difference between the auction and historical scenarios, which depicts the potential effects for sectors exposed to carbon leakage, in the event of a situation, in which the mechanism of free allocations is not used.

Table 7. Energy intensity of the industry in Poland, 2014-2016

Industry	Energy intensity of the industry [kgoe/€]		
	2014	2015	2016
Iron & Steel	1,057	1,138	1,061
Chemical	0,742	0,655	0,635
Mineral	0,570	0,503	0,522
Paper	0,412	0,405	0,400
Wood	0,360	0,372	0,388
Food	0,185	0,168	0,174
Means of transport	0,038	0,038	0,038
Textile	0,051	0,045	0,046
Other	0,080	0,076	0,076
Machines	0,027	0,028	0,027

Source: Efektywność wykorzystania Energii w latach 2006 – 2016 [Energy consumption efficiency in the years 2006-2016], GUS, Warsaw 2018

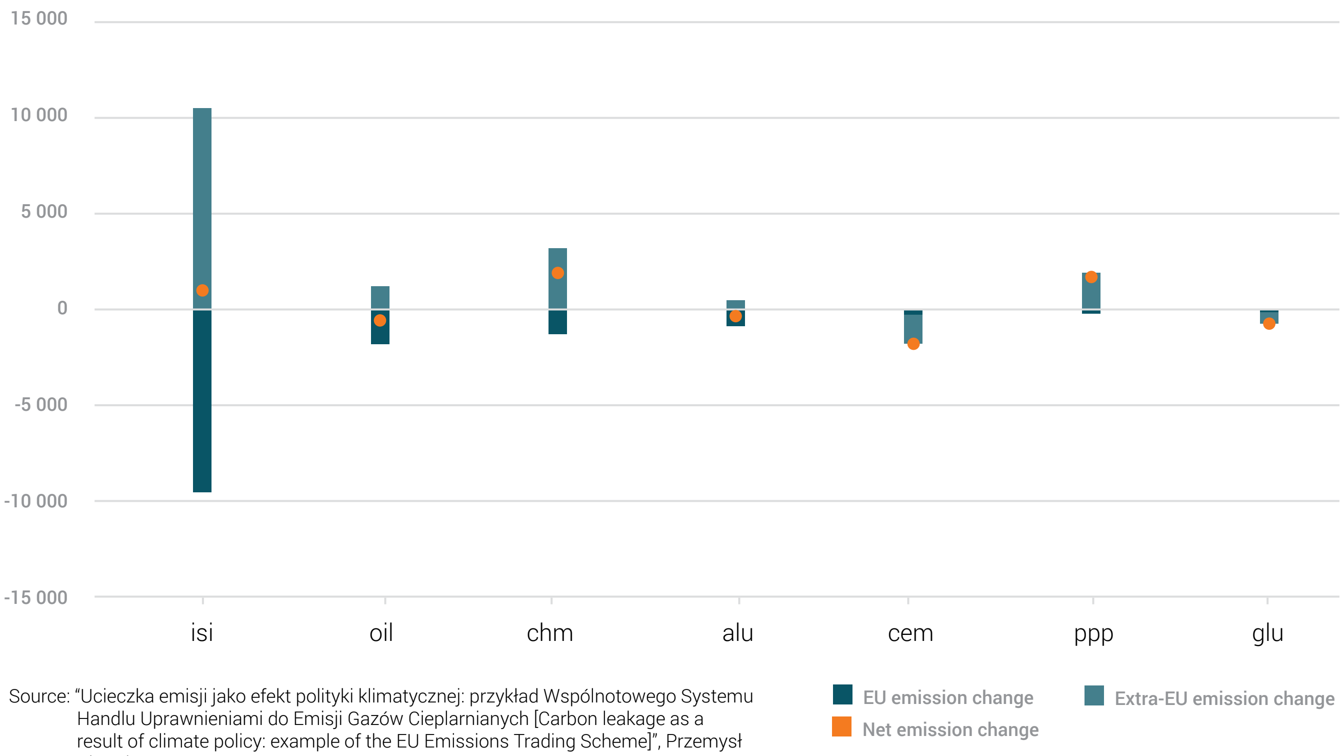
Table 8. Energy intensity of production in Poland, 2014-2016

Production	Energy intensity of production [toe/t]		
	2014	2015	2016
Paper	0,479	0,506	0,450
Steel	0,197	0,188	0,197
Cement	0,095	0,091	0,092

Source: Efektywność wykorzystania Energii w latach 2006 – 2016 [Energy consumption efficiency in the years 2006-2016, GUS, Warsaw 2018

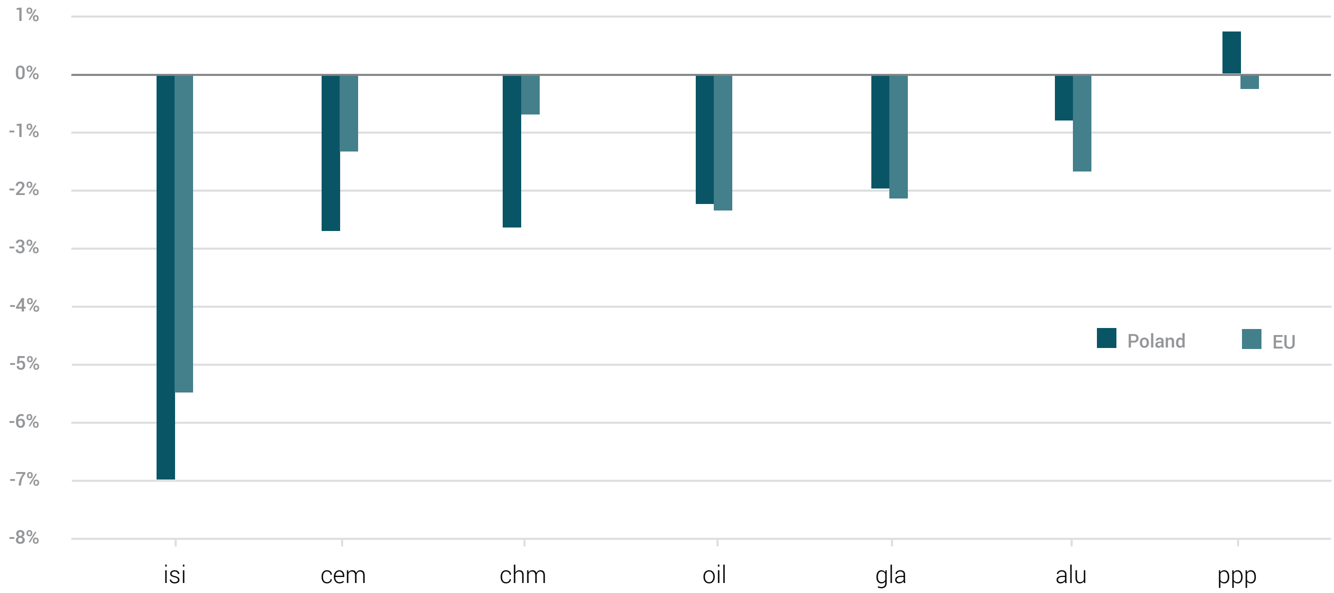
Fig. 72 shows the expected scale of carbon leakage in 2030 in the situation of no protective mechanisms (auction scenario). In terms of the effectiveness of the European climate policy, which is pursuance for global emission reductions, the greatest effect would be achieved, under the adopted assumption, in the iron and steel metallurgical industry, where the reduction of CO_2 emissions in the EU area would approach 10 Mt CO_2eq. This reduction would be fully transferred onto emission increase in non-EU regions, and furthermore – there would be a net emission increase in the global scale (the result of transferring onto less effective systems). A similar effect, on a smaller scale, can be noted in the case of the chemical and paper-making industries. In other sectors, EU emission reduction is not accompanied by a proportional non-EU growth, therefore, the global net emissions are expected to decrease.

Fig. 72. Scale of carbon leakage in 2030 in the situation of no protective mechanisms (auction scenario)



Source: "Ucieczka emisji jako efekt polityki klimatycznej: przykład Wspólnotowego Systemu Handlu Uprawnieniami do Emisji Gazów Cieplarnianych [Carbon leakage as a result of climate policy: example of the EU Emissions Trading Scheme]", Przemysł Chemiczny 2016

Fig. 73. Change of production within individual sectors of the industry in 2030

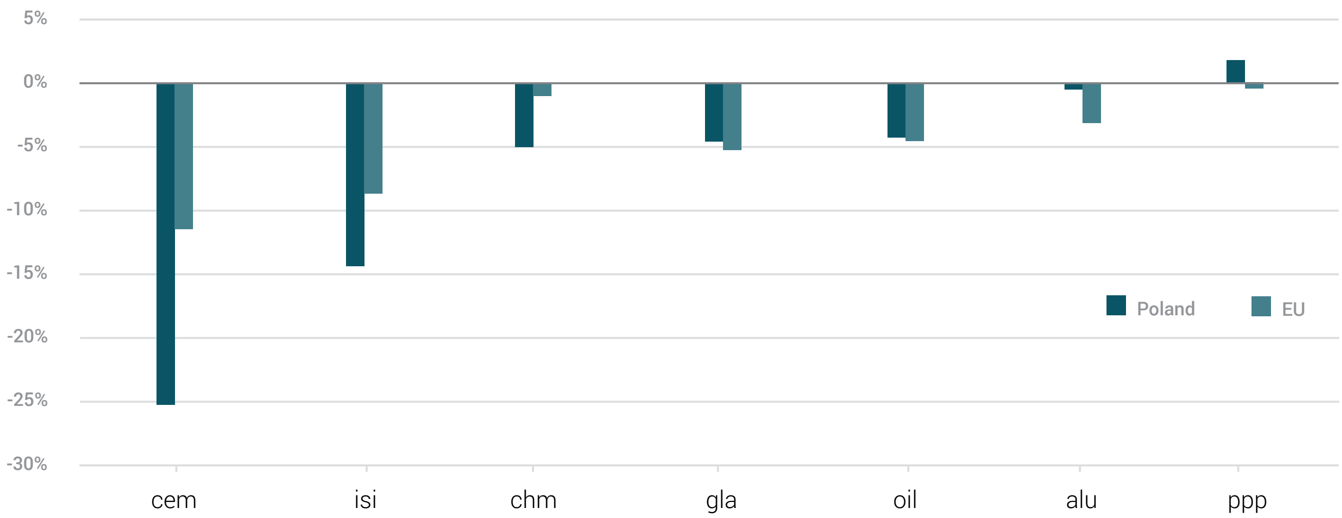


Source: "Ucieczka emisji jako efekt polityki klimatycznej: przykład Wspólnotowego Systemu Handlu Uprawnieniami do Emisji Gazów Cieplarnianych [Carbon leakage as a result of climate policy: example of the EU Emissions Trading Scheme]", Przemysł Chemiczny 2

Fig. 73 shows the expected changes in the production, to take place in 2030 as a result of carbon leakage. This indicator can be treated as one of the measures of the sectoral sensitivity to the risk of carbon leakage. The most vulnerable branches in Poland are Iron and steel industry, cement production, chemical industry, refined oil products, coke, nuclear fuels and glass industry. The production in these sectors would decline by 2 to 7% in 2030, in comparison to the historical scenario (reference level). Interestingly, it does not always correspond to the expected results for a given sector in a EU scale. The cement and chemical industries would not record such a significant production decrease in the EU scale, while it turns out that in terms of the refined oil products, coke, nuclear fuels, glass industry and aluminium industries, the companies in Poland are less vulnerable to increasing allowance purchasing costs than the EU average.

In addition to the carbon leakage effect measure, which the production index is, the expected changes in export were also presented (fig. 74). The direction of the changes is similar, although, their scale is slightly larger. The export of Polish cement plant would decline by approx. 25%, iron and steel industryby almost 15% and the export from the chemical industry by 5%. This decline in the EU scale would not be so high. Export changes at a similar level in Poland and the EU is expected to occur in the case of the glass industry and refined oil products, coke, nuclear fuels. In the case of aluminium and the paper industry, Polish companies turn out to be less vulnerable to changes than in the entire EU.

Fig. 74. Anticipated changes of export in 2030



Source: "Ucieczka emisji jako efekt polityki klimatycznej: przykład Wspólnotowego Systemu Handlu Uprawnieniami do Emisji Gazów Cieplarnianych [Carbon leakage as a result of climate policy: example of the EU Emissions Trading Scheme]", Przemysł Chemiczny 2016

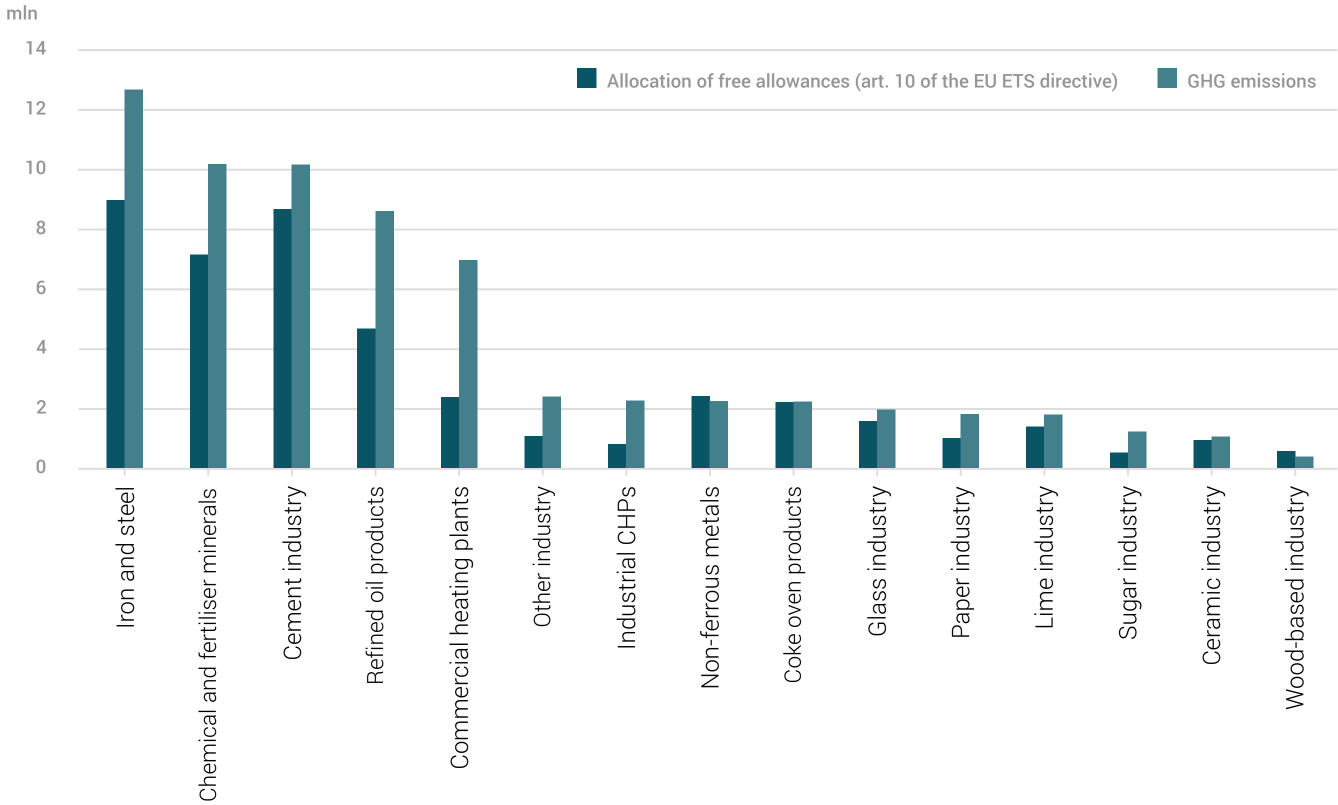
Counteracting carbon leakage in Europe

In consequence to the reform of the EU ETS during the IV trading period, i.e., the years 2021-2030, the European Commission is working on determining a list of sectors and sub-sectors exposed to carbon leakage, to be valid throughout this period. Within the so-called "first-level assessment", based on defined criteria[73], the European Commission initially qualified 44 sector for the list of sectors exposed to carbon leakage[74]. Additionally, the CL list can include a maximum of 28 sectors or sub-sectors after the second-level assessment[75]). This means that, compared to the one applicable in the current settlement period, the list of sectors will be significantly shortened (used to contain 175 sectors[76]). Placing a given sector or sub-sector on the list of sectors exposed to carbon leakage is associated with receiving 100% free allocation by such sectors calculated based on benchmarks[77], whereas the ones not mentioned in the list receive a 30% allocation (by 2026), gradually declined until 2030.

It should be noted that regardless of the EU ETS period, even if a given industrial sector is on the aforementioned list, in reality it will not be allocated 100% free allowances since the allocation is corrected with the benchmark (or a linear correction factor). This means that energy-intensive industryin the EU, and particularly in Poland, receives much less allowances than required by its needs (see: fig. 75).

In May, KOBiZE conducted an analysis, which indicates how would the allocation of free allowances change solely as a result of an adjusted list of the CL list, comparing the currently applicable CL list for the period of 2015-2019 with the proposal of the EC of May 2018 (taking into account the 44 sectors, which will surely be on the list). The estimates were made based on the initial allocation of allowances for the period of 2013-2020, which is a result of multiplying an appropriate factor by an appropriate production level for a given subsector[78]. The results of the analysis (table 9) indicate that a change of

Fig. 75. The allocation of free allowances and EU ETS industrial emissions in Poland in 2017



Source: KOBiZE own study na podstawie danych z EUTL

[73] The EC modified the assessment criteria in relation to the previous list of sectors. For example, the need for arbitrarily setting the allowance price was abolished, as a result of transforming the cost factor into the emission factor, and the need to determine the threshold value of the quantitative criterion was eliminated.

[74] https://ec.europa.eu/clima/sites/clima/files/events/docs/0127/2_overview_en.pdf

[75] Which can apply for qualitative assessment or disaggregated qualitative assessment

[76] Decision 2014/746/EU of 27 October 2014, determining, pursuant to Directive 2003/87/EC of the European Parliament and of the Council, a list of sectors and sub-sectors which are deemed to be exposed to a significant risk of carbon leakage

[77] Free Allocation = [Benchmark] x [Historical Activity Level] x [Carbon Leakage Exposure Factor] x [Correction Factor]

the CL list most adversely impacts (allocations of free allowances will significantly change) the following industrial sectors[79] in PL:

- Ceramic industry;
- Other industry;
- Industrial CHPs;
- Commercial power plants;
- Commercial CHPs;

Positive impact of a revised CL list was recorded in the case of one sector – the wood-related industry.

Table 9. List of sectors in Poland with changes as a result of a revised CL list [change of % EUA, compared to the hypothetical allocation]

Sectors*	Cumulative impact on the allocation volume in the years 2021-2030, as a result of a revised CL list**
Ceramic industry	-29,52%
Other industry	-21,55%
Industrial CHPs	-18,30%
Commercial power plants	-4,54%
Commercial CHPs	-4,51%
Commercial heating plants	-3,59%
Glass industry	-2,06%
Non-ferrous metals	-0,74%
Chemical and fertiliser minerals	-0,27%
Iron and steel	-0,16%
Refined oil products	-0,01%
Cement industry	0,00%
Sugar industry	0,00%
Coke oven products	0,00%
Mineral industry	0,00%
Lime industry	0,00%
Paper industry	0,00%
Wood-based industry	+335,43%

* Individual sectors may include several or a dozen or so NACE sectors, e.g., 5 NACE sectors included in the CL list were defined within the ceramic industry. The wood-related sector is the exception, since it includes only one NACE sector on the CL list.

** the analysis was conducted in relation to 44 sectors (as per the NACE classification) meeting the quantitative criterion (carbon leakage indicator>0.2)

Source: KOBiZE own study

[78] When calculating the hypothetical allocation, the following was also considered: linear reduction factor 2.2% (LF), cross-sectoral correction factor (CSCF) equal to 1, BM value change – for product BMs at a level of 0.7% (average value arising from the EU ETS directive); for heat and fuel BM at a level of 1.6% (maximum value arising from the EU ETS directive).

In order to determine the impact of CL list change on the free allocation, the initial allocation of the allowances was conducted using a correction resulting from the carbon leakage exposure factor (CLF), as per the amended EU ETS directive. The aforementioned carbon leakage exposure factor (CLF) differentiates between the allocation of free allowances for sectors exposed to carbon leakage (on the CL list) and not exposed to carbon leakage (not on the CL list). According to the current rules, the sectors exposed to carbon leakage receive 100% free allowances, which means that CLF = 1. According to the current rules, each installation in that (sub) sector is granted free allocation at 100 % of its relevant benchmark level. Those not on the list will receive 30 %, up to 2026, with the free allocation to be gradually phased out by 2030.

[79] Most important categories of the sectors were selected – at the overall level. The idea of a detailed list of sectors with assigned individual NACE code was abandoned.

Consequences of the carbon leakage risk for the Polish and EU economy

The carbon leakage risk entails a number of adverse economic and business consequences for the European Union. The restriction or cessation of production within the area of the Community associated with this risk may result in the relocation of jobs to other regions of the world ("job leakage") or cash outflow ("capital leakage"), with their consequence being increasing unemployment rates and the intensification of negative social sentiments. Another economic risk, which can appear is the relocation of production within the EU, in order for the businesses to reduce production costs. Because the magnitude of the production costs is determined by the cost of allowances contained in the energy price (and it was not uncommon for the EUA price to exceed 25 Euro this year), hence the energy sector emissivity in a given Member State, the share of high-carbon fuels (e.g. coal) in the national fuel-energy balance is a very important element, since it can determine the competitiveness of the industry. In the case of Poland, such a risk brings in negative effects, because we occupy the second place in the EU, in terms of the share of coal in the domestic fuel-energy balance.

In the light of the above, it is necessary to apply measures preventing carbon leakage as long, as non-EU countries will not be implementing climate policy tools of similar impact intensity (resulting in a similar cost of emissions). Therefore, it seems necessary for the manner of mitigating the carbon leakage risk chosen in EU ETS, i.e., the allocation of free allowances for non-exposed sectors to continue functioning, and its effectiveness to be regularly verified, while simultaneously striving to achieve a better reflection of the operational specificity of companies in individual Member States. However, we also need to remember that the introduced mechanisms for preventing carbon leakage should not weaken the role of EU ETS as an instrument stimulating emission reductions in energy-consuming sectors. Moreover, it seems desirable to start with the best possible matching of all policies implemented within the EU, which aim for building a low-carbon economy, in particular: EU ETS, RES and energy efficiency.

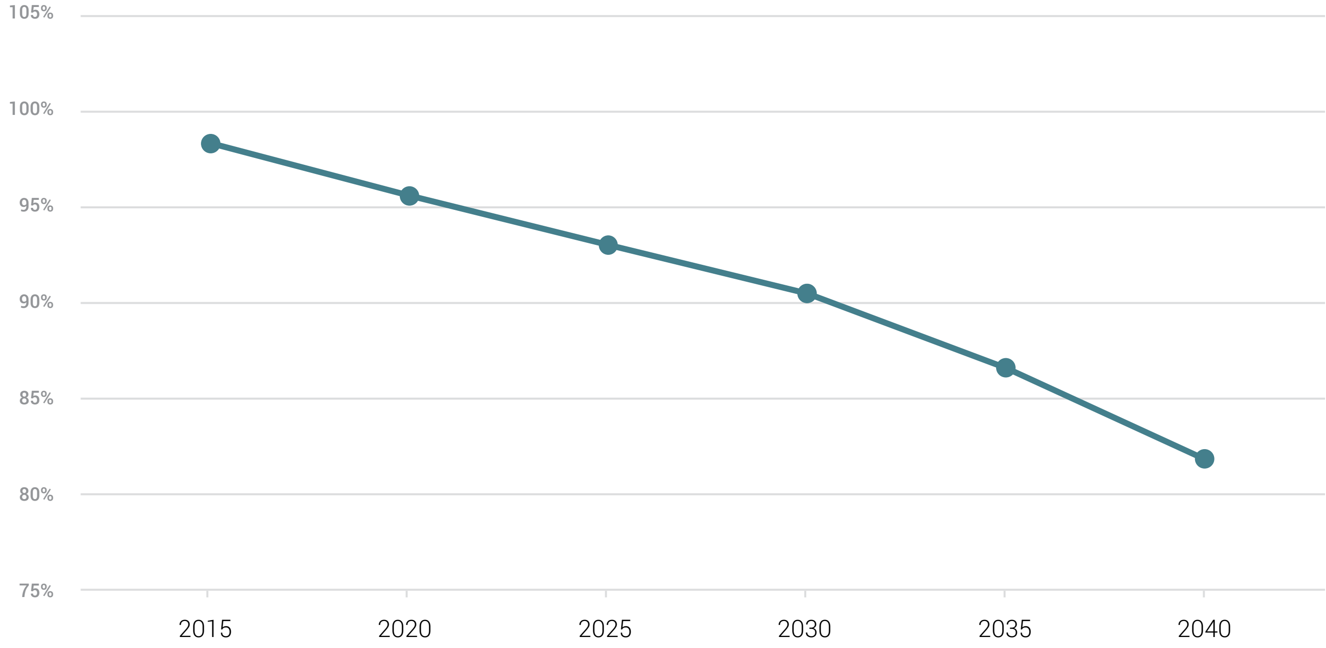
Potential emission reductions

This study presents a number of activities in the most important sectors of the economy, which have a positive impact on reducing greenhouses in Poland. They include, among others: change of the energy mix (towards limiting coal consumption and replacing it with natural gas or energy from renewable sources), reductions involving changes in the production processes or improving energy efficiency in the sectors of economy, i.e., building or agriculture, as well as the introduction of new flagship programmes, i.e., electromobility and "Clean Air". All suggested solutions ultimately lead to significant emission reduction in the national scale.

Fig. 76 shows a cumulative percentage change of GHG emissions, taking into account the introduction of analysed reduction scenarios described in part II of the elaboration, compared to the predicted total emissions for Poland in the scenario based on the fuel mix from 2016. The calculations show gradually declining emissions, from -5% in relation to the scenario based on the mix from 2016 in 2025, reaching - 16% in 2040. The presented total reductions are most significantly impacted by a change of the energy mix and the introduction of the "Clean Air" programme, which contains activities relating to the energy household sectors. Activities within the industry, agriculture or transport contribute to reductions to a lesser extent.

Keep in mind that the analysed reduction measures apply only to selected sectors of the economy, and the calculations are approximative, because the ultimately applied solutions will depend on the decisions regarding the direction of the national climate-energy policy. Nonetheless, the analysis shows that introducing only selected reduction measures will result in significantly positive changes in the emission volume at the national level, both in the short-term, as well as long-term perspective.

Fig. 76. Total percentage GHG emission reduction, taking into account the reduction scenarios described in the analysis, compared to the emissions projected for the 2016-mix scenario



Source: KOBiZE own study

Epilog

Poland has been implementing an active climate policy since the economic transformation period at the beginning of the 1990s. Poland significantly reduced greenhouse gas emissions in the years 1988-2000. Since 2000, the emissions have stayed at a similar level (ca. 400 Mt CO_2eq, w/o LULUCF), despite significant economic growth. During the post-1989 transformation period, Poland witnessed one of the largest progresses in Europe in the field of effective energy utilization and improving the quality of the environment. The largest contributors were the energy and industry sectors. For many years we have been observing a energy sector transformation towards reduced consumption of hard and brown coal as energy sources, in favour of petroleum fuels, while the RES energy share in the final gross energy consumption has been systematically rising. Poland has been meeting the previous international targets, i.e., the Kyoto Protocol and is on the right path to meet its targets for successive periods, i.e., within the climate and energy package by 2020, both in terms of greenhouse gas reductions, as well as improving energy efficiency and the development of renewable energy sources.

Poland also has a good perspective in terms of implementing the EU climate policy by 2030 and 2050 in a longer term, however, it will have to meet ambitious reduction objectives in the non-ETS field, in such sectors as: transport, municipal-housing or agriculture. Let us not however, forget about further transformation of the Polish energy sector and the industry, which is advocated by very important aspects, such as, e.g., energy security of the country, stable and new jobs, significant added value, and recently, the development of innovative technologies; also the ones impacting emission reductions.

The Polish national economy, in the 2050 horizon, will experience the growth of demand for primary energy and electricity. The demand will continue to increase, despite the significant progress in terms of energy efficiency. Great challenges are ahead of Poland in the energy sector, where the emission reduction potential is the highest and is strictly associated with energy policy of the country. For various reasons, coal will remain the basis for the energy security of Poland, however, its share will be significantly reduced. Currently, 79% of Polish electricity is generated from hard and brown coal. High prices of CO_2 emission allowance determine the profitability of replacing coal-fired units with new, highly efficient ones, and the volume of the share of natural gas and RES. In order to reduce greenhouse gas emissions, it will be necessary to diversify the activities directed at low-carbon energy generation sources, supporting energy efficiency, developing cogeneration, electromobility or a prosumer energy sector.

- **Energy efficiency. Cogeneration. Heating systems.** Energy efficiency has the highest potential for reducing greenhouse gas emissions. Moreover, the entire municipal-housing system exhibits a high reduction potential, with the most important measures including: the construction of energy-efficient new buildings, thermomodernization of residential and commercial buildings, replacing obsolete furnaces, development of the heating infrastructure and connections to the district heating network. These activities will contribute to a significant improvement of air quality. Poland has declared that the share of insulated residential buildings among all residential resources in 2030 will reach 70%. Another important aspect will be the improvement of efficiency in industrial sectors consuming electricity, which will contribute to decreasing the demand for its generation. The activities in this scope include, i.a.: development of electricity and heat production via cogeneration in the industry and heating sector, development of energy-efficient heating and cooling systems, and the improvement of industrial energy-efficiency.

- **Development of renewable energy sources.** RES development will depend on its economic competitiveness, compared to other energy generation technologies. In order to achieve the objectives in the field of RES it will be necessary to launch a full-scale support system for modern, distributed and economically effective investments, which would increase the safety and flexibility of the Polish electric energy system. It is anticipated that the share of RES energy in the ultimate gross energy consumption in Poland will be gradually rising until 2050, i.a., due to the implementation of EU's climate policy. The greatest potential for the development in RES is seen in offshore wind power. RES share in the final energy consumption in transport and the district heating sector will also be gradually increasing.

- **Electromobility.** Electric transport may prove to be one of the most breakthrough technologies in the Polish energy sector, apart from improving the energy efficiency. The Polish Government, recognizing the huge potential in electric vehicles and alternative fuels, and the global trends of dynamic development of the automotive industry, developed the Electromobility Development Plan "Energy for the Future". The most important assumption of the Plan is reaching 1mn electric cars in Poland by 2025. The accomplishment of this objective would enable achieving environmental benefits associated with decreased transport-related pollutant emissions in urban areas. Additional outcomes would include decreased national energy dependence, through limiting the demand for liquid fuels, hence, decreased import of crude oil. An important function of the scheme will be the stimulating the conditions for the production of electric cars in Poland, which would positively affect a number of economy branches associated with the automotive industry. An important element of the Electromobility Development Plan is the proper time-related synchronization of activities in the field of supporting the industry and scientific-research institutions, stimulating demand (e.g. through the introduction of tax abatements, higher depreciation write-offs for companies) and the development of infrastructure and legal regulations (e.g. the expansion of charging points or filling stations for alternative fuels, as well as the possibility to use bus lanes and free parking).

- **Development of nuclear energy.** The nuclear energy sector and its development depends both on power safety aspects, as well as becomes an economically justified energy generation source, particularly in the light of increasing CO_2 emission allowances. It is expected for the first nuclear power plant unit to be launched in Poland already in 2035. Over the last several years, some European countries exhibited a desire to decrease the share and to fully withdraw from nuclear energy, which was also undoubtedly strengthened by the Fukushima NPP disaster in 2011. One of these countries is Germany, which announced to close all, even the most modern nuclear power plants until 2022 (although they cover as much as 25% of the demand for electricity). A gap in the production of energy was created and is supposed to be filled by energy coming from RES and gas turbines fired with natural gas[80]. The second European country planning to limit energy from nuclear power plants from 75% to 50% until 2025 is France, which requires shutting down 17 reactors (although this will be hard to accomplish, given the decreasing French capacity of coal-fired energy and the technological issues associated with RES development). Other European countries, like Belgium and Switzerland intend to shut down all nuclear reactors until 202581 and 2034, respectively.[82] It would seem that this path would be followed by a country, which suffered the most during the recent years from having nuclear power plants - Japan, which changed its original course of action (of shutting down the power plants) and once again plans to utilize nuclear energy. China, which also falls within the trend of constructing new nuclear facilities, currently has 45 power plants of this kind and a further 15 under construction (by 2030, nuclear energy will account for 8-10% of the total electricity production in China). There are currently around 50 nuclear power plants under construction in 15 countries around the world (most of them in China, Russia, India and South Korea).[83]
- **Prosumer energy sector.** The national energy policy should also significantly include the development of distributed generation sources, i.e., numerous small energy sources covering local energy demands of municipalities or even individual buildings. It will be very important to develop appropriate legal regulations and invest in the infrastructure (grid, reserve capacity), enabling current electricity consumers (prosumers) to sell locally generated electricity surplus to the grid.

It should be noted that the energy sector transformation in Poland will be associated with incurring additional social costs. The sector to experience it the most will be mining. The current number of employees in the Polish mining sector amounts to almost a half of the total mining sector employees in the entire Europe.

Another challenge for Poland and the whole EU, which entails a number of adverse economic and business consequences is the phenomenon of carbon leakage. The restriction or cessation of production within the area of the Community associated with this phenomenon may result in the relocation of jobs to other regions of the world or cash outflow, with their consequence being increasing unemployment rates and the intensification of negative social sentiments. Another economic phenomenon, which can appear in this regard is the relocation of production within the EU, in order for the businesses to reduce production costs. Because the magnitude of the production costs is determined by the cost of allowances contained in the energy price, hence the energy sector emissivity in a given Member State, the share of high-carbon fuels (e.g. coal) in the national fuel-energy balance is a very important element, since it will determine the competitiveness of the industry, which is particularly important in the case of Poland.

Over the last 30 years, Poland has come a long way from an economy based on central planning, with an inefficient industry and agriculture, and a poorly developed service sector, to a market economy. During that period the country went through a number of institutional, economic and environmental changes - joining the EU Member States, implementing and actively participating in reduction commitments at the global level, tackling the results of the economic crisis, where it avoided GDP decline as one of the few European countries or just recently being welcomed in the group of developed countries. A wide package of structural, legislative and economic changes and the inflow of funds allocated directly to environmental protection resulted in a simultaneous economic growth and emission reductions. However, still a number of barriers, obligations and objectives impact the development of the national climate-energy policy.

[80] https://book.energytransition.org/pl/node/36.

[81] http://www.world-nuclear-news.org/NP-Belgian-government-approves-life-extensions-1912145.html

[82] https://derstandard.at/1304552826299/Ab-2019-Schweiz-plant-Atomausstieg

[83] http://www.world-nuclear.org/information-library/current-and-future-generation/plans-for-new-reactors- worldwide.aspx

The specific raw material situation, the need for further infrastructural development, high level of demand for energy associated with economic progress or external requirements in the scope of environmental policy. Poland set itself the goal of synergy between actions with a positive outcome on sustainable development or emission reductions, while simultaneously maintaining the competitiveness of the economy and enterprises and ensuring energy security and economic growth. In a longer perspective, diversification of the activities and the development direction is a crucial response to the current challenges, because only in such a case, it is possible to ensure stabilization and reduce the risk of the middle income trap. On one hand, Poland awaits the inevitable in the form of a need to decrease fossil fuel consumption, on the other, it is important to focus on innovative solutions, such as electromobility. Moreover, given the conclusions from the special report by IPCC84 from October 2018, which indicates a need to limit global warming to no more than 1.5°C, the actions in this field shall be taken as soon as possible and apply to all sectors. This results from a conclusion that the rise of average temperature by 1.5°C will bring much less adverse changes than by 2°C. It should be noted that the measures to be taken, still do not exclude the development of a stable economy. According to "World Energy Outlook 2018", a study by the International Energy Agency, global investments in the energy sector will reach a level of USD 2.2tn a year by 2025 and USD 2.8tn a year in the years 2026-2040 and will be mainly directed to renewable energy, with investments in coal capacities cut by a half by 2040[85].

Meeting the environmental requirements and the transformation of the energy sector and the industry are huge challenges, which the European Union and the international community present us with. Previous Polish experience shows that transformation provides a great opportunity to increase the effectiveness of the industry, energy efficiency and structural changes. However, bear in mind that the Polish economy still has to compete against producers from around the world, which is why it is so important to equalize the emission reduction obligation level at the global level. Other important aspects include ensuring appropriate and stable financing for pro-environmental investments, as well as establishing legal framework and standards for the maintenance of competitiveness.

[84] IPCC, 2018: Global warming of 1.5°C. An IPCC Special Report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty [V. Masson-Delmotte, P. Zhai, H. O. Pörtner, D. Roberts, J. Skea, P.R. Shukla, A. Pirani, W. Moufouma-Okia, C. Péan, R. Pidcock, S. Connors, J. B. R. Matthews, Y. Chen, X. Zhou, M. I. Gomis, E. Lonnoy, T. Maycock, M. Tignor, T. Waterfield (eds.)].

[85] World Energy Outlook 2018, International Energy Agency, 2018

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Funded by
National Fund
for Environmental Protection
and Water Management

ISBN 978-83-60312-83-4