MINISTRY
OF ENERGY

Impact assessment of planned policies and measures

Extract of Annex 2
to the draft of Poland's
National Energy and Climate Plan for the years 2021-2030

Please note that this document is short version translated into English

PROJECT – v. 3.1 from 04.01.2019

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Introduction

This document presents an extract of the analytical annex to the draft of "National Plan for Energy and Climate for the years 2021-2030" (NECP) prepared by the Ministry of Energy of Poland. Full version is available in Polish.

The study contains an assessment of the impact of policies and measures from NECP, which indicate how and with what effects the objectives in five dimensions of the Energy Union will be implemented. This document present a multi-aspect analysis of the impact of the implementation effects up to 2030, with the horizon up to 2040. This includes the comparison of so-called WEM scenario (with measures existing until the end of 2017) with so-called WAM scenario (with additional measures).

The content of this part of the report and the scope of the information presented therein are in accordance with the guidelines contained in Regulation (EU) 2018/1999 of the European Parliament and of the Council of 11 December 2018 on the management of the Energy Union and Climate Action, 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, Council Directive 2009/119 / EC, Directive 2010/31 / EU, Directive 2012/27 / EU, Directive 2013/30 / EU and Council Directive (EU) 2015/652 and repealing Regulation (EU) No 525/2013.

ASSESSMENT OF EFFECTS OF PLANNED POLICIES AND MEASURES

1. Effects of planned policies and measures, regarding the energy system and greenhouse gas emissions and their absorption

This document presents the results of analytical and forecasting work aimed at describing the future state of fuel and energy sector determined by economic, environmental and resource constraints, taking into account the planned policies and measures. The analysis covers all sectors of the national economy as well as current and prospective energy carriers throughout the entire supply chain. Relevant comparisons of forecast results for the two scenarios (WEM and WAM) were prepared. The purpose of these comparisons was to estimate the impact of parameters distinguishing these scenarios and to capture mutual interactions between existing and planned policies and measures within the analyzed five main dimensions of the Energy Union.

The calculation methods are based on widely used in the world methods for the preparation of sectoral analysis and forecasts (model CGE PL, computable general equilibrium), taking into account the conditions of economic development and enabling preparation of scenarios and analysis in following areas:

- effects of changes in the energy sector on the country's economy,
- changes in the structure of electricity generation under the influence of changes in internal/external factors and regulations (global trends in energy, international fuel prices, prices of carbon dioxide emission allowances in the EU trade system, changes in technology costs, macroeconomic indicators, the cost of raising capital for investments),
- share of energy from renewable energy sources in gross final consumption and in various sectors (heating and cooling, electricity, transport), divided into renewable energy technologies, taking into account the technical and economic potential, availability of resources, investment outlays and operating costs, functioning and planned support systems,
- changes in the volume of carbon dioxide emissions in the entire economy and individual sectors (taking into account the possibility of absorbing emissions), the situation in the heating sector and refrigeration, in particular the development of cogeneration and renewable sources,
- changes in electricity prices on the wholesale and retail market under the influence of changes in the power sector and external factors,
- changes in the demand for final energy under the influence of variables (including GDP growth and value added in sectors, changes in the production of energy-consuming products),
- potential savings of primary and final energy consumption by sectors of the economy,
- development of the situation on the natural gas market, including changes in the use of this fuel, including energy and heating,
- development of the situation on the liquid fuel market, taking into account trends in the transport sector, including the increase in the importance of electromobility.

1.1. General parameters and variables

1.1.1. GDP

The projection of energy demand in Poland until 2040 was made on the basis of the macroeconomic scenario based on GDP growth forecasts published by the Ministry of Finance (MF) in May 2017. The projection of GDP growth for Poland in absolute terms adopted for model calculations was presented in Table 1 while projections of average annual increases - in Table 2

Table 1 Gross domestic product [mln EUR'2016]

	2005	2010	2015	2020	2025	2030	2035	2040
GDP	317 010	400 114	462 370	551 249	649 661	748 029	843 849	938 089

Source: Eurostat, MF

Table 2 GDP forecast in 2016-2040 (average annual growth rate)

	2016-2020	2021-2025	2026-2030	2031-2035	2036-2040	2016-2040
GDP	103,6	103,3	102,9	102,4	102,1	102,9

Source: MF, ARE SA

In the presented projections, the average annual GDP growth rate in Poland in 2016-2040 is 2.9%. This is a rate higher than assumed in the PRIMES Reference scenario by approx. 0.7%. An important factor for economic growth in the future is the reindustrialization of the economy and the expected increase in the wealth of the society (vide: governmental "Strategy for responsible development until 2020").

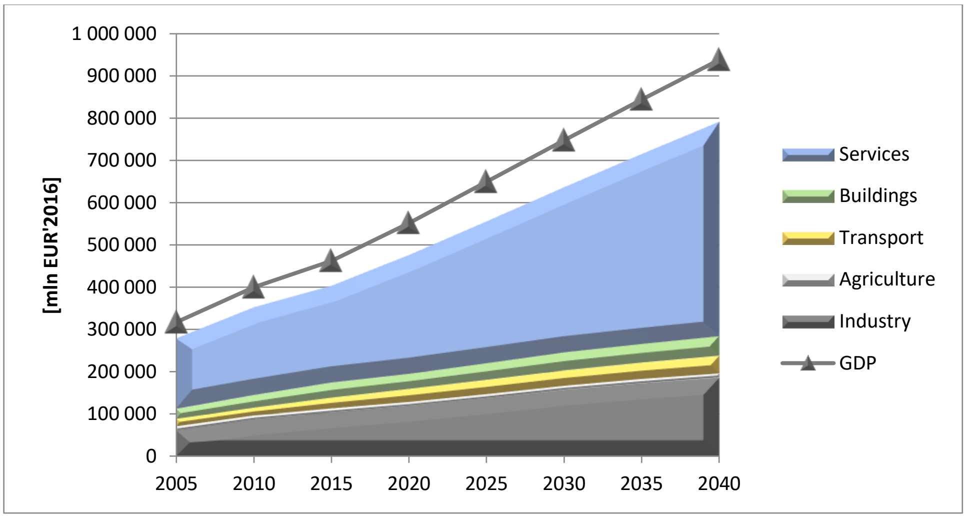


Figure 1 GDP and the structure of gross value added in Poland

1.1.2. International import prices of fuels

The projections of fuel prices in imports to the EU presented in the table and figure below, come from the projection of the International Energy Agency (IEA) - World Energy Outlook 2017, the scenario "New Policies." These projections served as the basis for determining trends in projections fuel prices on the domestic market.

Table 3 Fuel prices in imports to the EU [EUR'2016/GJ (NCV)]

	2005	2010	2015	2020	2025	2030	2035	2040
Crude oil	7,73	9,94	6,83	8,0	10,7	12,1	13,3	14,3
Natural gas	5,17	6,28	6,64	5,5	6,9	7,6	8,0	8,4
Hard coal	2,18	2,66	1,97	2,2	2,6	2,7	2,7	2,7

Source: ARE SA based on the World Bank, IMF, EC and the "New Policies" scenario of the IEA in 2016.

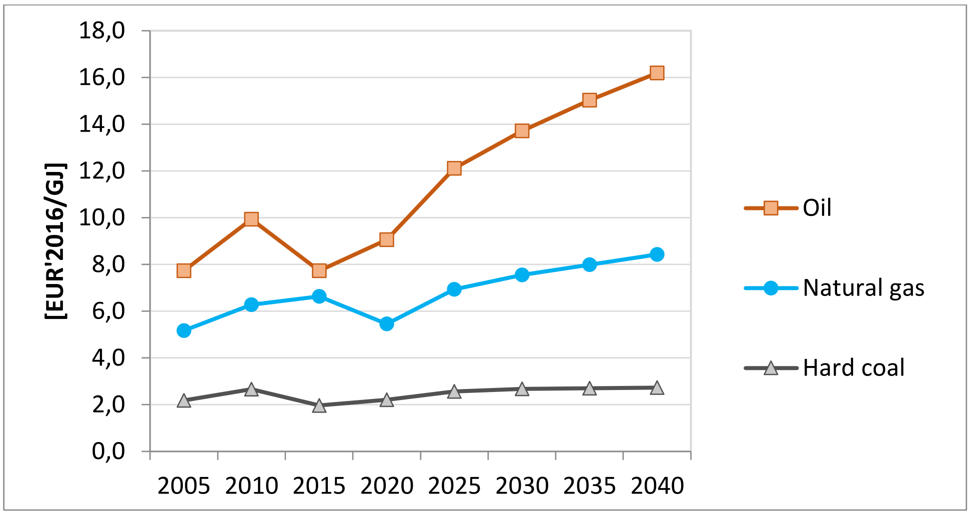


Figure 2 Fuel prices in imports to the EU

1.1.3. Prices of CO2 emission allowances in EU ETS system

For consistency, price projections for CO2 allowances in the EU ETS (EUA) system, were also adopted on the basis of the long-term forecast of the International Energy Agency (World Energy Outlook 2017, the scenario 'New Policies'). In the periods between the end years, a linear increase was assumed.

Table 4 Prices of CO2 emission rights in the EU ETS system [EUR'2016 / tCO2]

	2005	2010	2015	2020	2025	2030	2035	2040
Price for 1 allowance	0	12	8	17	21	30	35	40

Source: ARE SA based on MAE, KE, Thomson Reuters, KfW Bankengruppe

It was assumed that the price of CO2 emission allowances will gradually increase to 40 EUR'2016 /t CO2 in 2040, serving as a tool to achieve the EU's target of reducing greenhouse gas emissions by 40% by 2030 and the long-term ambitious goal of reducing greenhouse gas emissions by 80-95% by 2050 in relation to the level of emissions in 1990. One of the mechanisms exerting pressure on the increase in prices of CO2 emission allowances is market stability reserve (MSR) to be implemented from the beginning of 2019. The assumed prices of allowances are in line with the European Commission recommendations regarding the use of indicators for the preparation of national plans (up to 2030). In the years 2030-2040, the increase in prices of CO2 emission allowances adopted by IEA is slightly slower than in the EC reference scenario (which may, for example, be the result of an increase in volumes offered at auction auctions, as a result of lowering emission levels due to price pressure in previous years).

1.1.4. Assumptions regarding technical and economic parameters of energy technologies

The parameters of the new generation units presented in Table 5 have been prepared based on the latest publications of renowned research centres available at the moment of NECP publication.

Explanations for the table below:

CHP – *combined heat and power*
PC – *pulverized coal*
PL – *pulverized lignite*
CCS – *carbon capture and storage*
GTCC – *gas turbine combined cycle*
IGCC – *integrated gasification combined cycle*
FBC – *fluidized bed combustion*

PWR – *pressurized water reactor*
MV – medium voltage
EHV – extra high voltage
HV – high voltage

Table 5 Technical and economic parameters of production and transmission technologies

Fuel / Technology	**Operation**	**Overnight investment costs**	**Costs**		**Efficiency**	**Eq. work time with full power**	**Life time**
			fixed	**variable**			
		Thousand EUR/MW_{net}	**Thousand EUR/MW_{net}**	**EUR $/MWh_{net}$**	**%**	**h/y**	**years**
Combined heat and power							
1.1 PL	2016-2040	1800	48	3,4	44	7000	40
1.2 PL+CCS	2030-2040	3250	72	8.6*	38	7000	40
1.3 FBC	2020-2040	2050	50	3,4	40	7000	40
2.1 PC	2016-2040	1650	44	3,2	46	7000	40
2.2 IGCC	2025-2040	2250	58	5,0	48	7000	40
2.3 IGCC+CCS	2030-2040	3250	78	7.2*	40	7000	40
2.4 CHP	2016-2040	2250	48	3,2	30/80	7000	40
2.5 CHP+CCS	2030-2040	3500	76	10*	22/75	7000	40
3.1 GTCC	2016-2040	750	18	1,8	58 ↑ 62	7000	30
3.2 GTCC+CCS	2030-2040	1350	38	4.0*	50 ↑ 52	7000	30
3.3 GTCC_CHP	2016-2040	1050	32	1,8	50 ↑ 75	6000	30
3.4 TG	2025-2040	500	16	1,4	40	1500	30
3.5 Micro CHP	2016-2040	2350	97	-	20/90	3500	25
4.1 PWR	2030-2040	4500	85	0,8	36	7500	60
Renewables							
5.1 Wind on-shore	2016-2020	1350	50	-	-	2300↑2400	25
5.1 Wind on-shore	2021-2040	1350↓1250	50	-	-	2400↑2600	25
5.2 Wind off-shore	2020-2030	2450↓2250	90	-	-	3700↑3800	25
5.2 Wind off-shore	2031-2040	2250↓2100	90	-	-	3800	25
5.3 Big hydro	2020-2040	2500	35	-	-	2000	60
5.4 Small hydro	2016-2040	3000	75	-	-	3500	60
5.5 Geothermal	2020-2040	7000↓5500	160	-	0,12	7500	30
5.6 Photovoltaics	2016-2020	1100↓900	16	-	-	750↑850	25
5.6 Photovoltaics	2021-2040	900↓700	16	-	-	850↑1000	25
5.70 Roof photovoltaics	2016-2020	1250↓1150	20	-	-	750 ↑ 850	25
5.7 Roof photovoltaics	2021-2040	1150↓800	20	-	-	850 ↑ 1000	25
5.8 Agricultural biogas	2016-2040	3250↓2750	220	-	40/80	5250	25
5.9 Biogas sewage treatment plants	2016-2040	3500	135	-	45/75	4400	25
5.10 Biogas landill	2016-2040	1800	80	-	40/45	4000	25
5.11 Solid biomass	2016-2040	2500	100	-	35	6000	30
5.12 Solid biomass CHP	20161-2040	2950↓2750	120	-	25/80	5500	30
5.13 Waste - CHP	2021-2040	10000	150	-	16/60	6000	25
Heating plants							
6.1 Coal	2016-2040	350	1	1,4	0,9	2500	30
6.2 Natural gas	2016-2040	150	1	0,4	0,96	2500	30
6.3 Heating oil	2016-2040	200	1	0,5	0,95	2500	30
6.4 Biomass	2016-2040	500	1	1,4	0,9	2500	30
Connecting to / strengthening of grid							
7.1 System power plants	2016-2040	250					
7.2 Wind on-shore	2016-2040	350					
7.3 Wind off-shore	2016-2040	800					
7.3 Other plants and CHP	2016-2040	50 - 250					

* *Including transport and storage of CO2*

Source of the following data: ARE SA based on:
World Energy Outlook, International Energy Agency, Paris 2016;
WEIO 2014-Power Generation Investment Assumptions, International Energy Agency, Paris 2014;
The Power to Change: Solar and Wind Cost Reduction Potential to 2025", International Renewable Energy Agency, Bonn 2016;
Energy and Environmental Economics – "Recommendations for WECC's 10- and 20-Year Studies", San Francisco 2014;
World Energy Perspective Cost of Energy Technologies, World Energy Council, Project Partner: Bloomberg New Energy Finance, 2013;
Lazard's Levelized Cost of Energy Analysis – Version 9.0, Lazard, New York 2015;
Scenarios for the Dutch electricity supply system, Frontier Economics, London 2015;
Energy Technology Reference Indicator projections for 2010-2050, European Commission JRC Institute for Energy and Transport, Brussels 2014;
Projected Cost of Generating Electricity 2015 Edition, International Energy Agency, Nuclear Energy Agency, Organization for Economic Co-operation and Deployment, Paris, 2015;
Cost and Performance Characteristics of New Generating Technologies, Annual Energy Outlook 2016, U.S. Energy Information Administration, Washington 2016.

1.2. Dimension „decarbonisation"

1.2.1. Emissions and absorption of greenhouse gases

1.2.1.1. Forecasts of greenhouse gas (GHG) emissions and GHG absorption

Table 6 and Figure 3 present synthetic results of greenhouse gas emissions forecast for the years 2020-2040 in Poland (divided by IPCC sectors), with comparison to the years 2005-2015.

Table 6 Greenhouse gas emission projections for the WAM scenario by sector

Source category	GHG emissions [ktCO$_{2eq}$]							
	2005	2010	2015	2020	2025	2030	2035	2040
Total without LULUCF	**398 942,56**	**406 973,16**	**385 842,89**	**391 243,71**	**383 420,96**	**366 536,38**	**332 176,15**	**298 762,49**
Total including LULUCF	**353 281,62**	**376 248,79**	**356 997,90**	**369 423,49**	**364 974,46**	**352 740,00**	**320 371,30**	**289 262,29**
1. Energy	330 166,84	339 152,32	316 109,87	319 111,51	308 566,70	290 509,99	255 774,63	221 637,02
2. Industrial processes and use of products	25 450,80	24 897,11	28 525,12	29 180,59	30 880,64	31 903,33	32 572,93	33 360,15
3. Agriculture	29 511,99	29 717,72	29 649,89	31 029,39	32 027,68	32 320,47	32 140,06	32 158,36
4. LULUCF	-45 660,94	-30 724,36	-28 844,99	-21 820,22	-18 446,49	-13 796,38	-11 804,84	-9 500,20
5. Waste	13 812,94	13 206,01	11 558,01	11 922,22	11 945,93	11 802,59	11 688,53	11 606,97

Source: ATMOTERM SA, based on KOBIZE data for the years 2005-2015 and for the years 2020-2040 in the scope of greenhouse gas emissions for the following sectors: 2. Industrial processes and product use, 3. Agriculture, 4. Land use, land use change and forestry (LULUCF) and 5. Waste

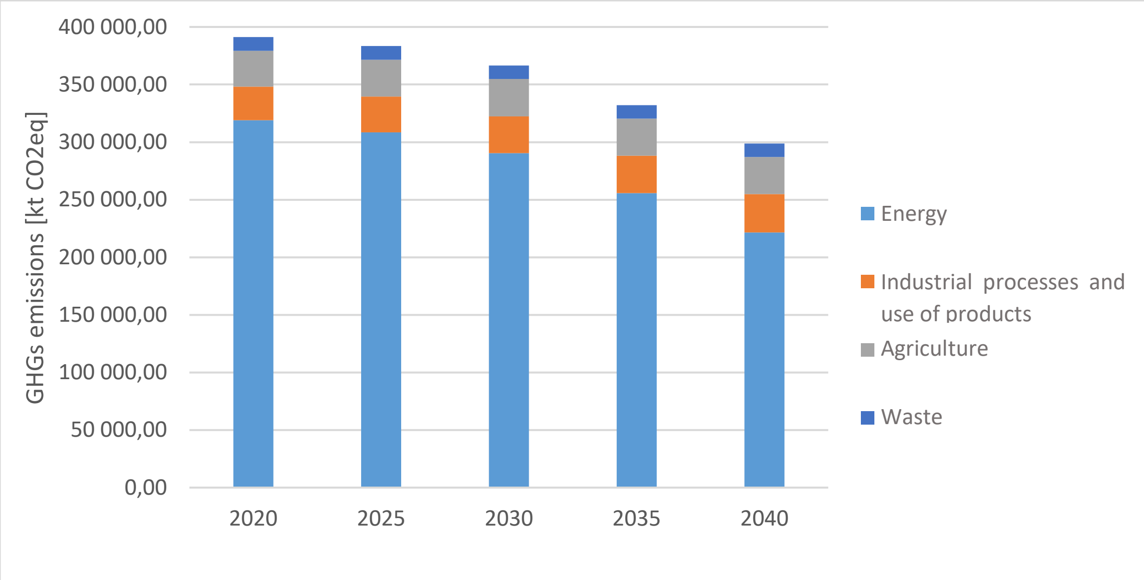


Figure 3 Greenhouse gas emission projections for the WAM scenario by sector, without the LULUCF

According to the data presented above, a systematic reduction of greenhouse gas emissions is expected, particularly in 2035 and 2040. **As a result, emissions in 2040 reach around 290 million tons of CO2eq (including LULUCF), which means a reduction in 2005-2040 period by about 18%.**

In 2040, the largest emission volumes will still come from the energy sector, including fuel combustion, although emissions in this sector will gradually and clearly decline (Table 7). The predicted trends of emission changes divided into ETS and non-ETS (ESD) are presented in Table 8 and Figure 4.

Table 7 Projections of greenhouse gas emissions by ETS and non-ETS sectors for the WAM scenario

Emission	**GHGs emissions [kt $CO_{2eq.}$]**							
	2005	**2010**	**2015**	**2020**	**2025**	**2030**	**2035**	**2040**
Total without LULUCF	**398 943**	**406 973**	**385 843**	**391 244**	**383 421**	**366 536**	**332 176**	**298 762**
EU ETS	203 150	199 727	198 696	192 876	193 438	185 010	160 501	135 234
Non-ETS (ESD)	195 715	207 143	187 022	198 368	189 983	181 527	171 676	163 528

Source: Own study ATMOTERM

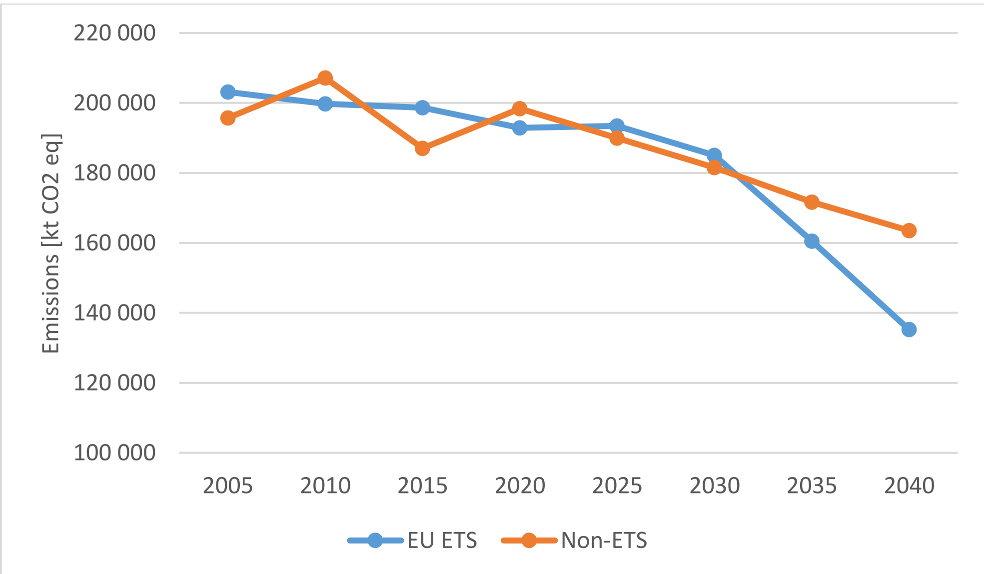


Figure 4 Projections of greenhouse gas emissions broken down into ETS and non-ETS for the WAM scenario

Both ETS and non-ETS sectors are expected to reduce greenhouse gas emissions. Over the years 2015-2020 in the non-ETS sector moderate growth is forecasted. **By 2030 projected reduction of greenhouse gas emissions from the non-ETS sector will amount to approx. -7%** compared to the level in 2005**.**

In terms of share in the emission of particular types of greenhouse gases, the projected situation for the WAM scenario is presented below - in Table 8 and in Figure 5.

The largest volume of CO2 emissions will come from the energy sector. Nevertheless the level of energy emissions is expected to decrease systematically by 2040. The next place is the emission from industrial processes and the use of products, which will grow slightly by 2040.

Table 8 Forecasted CO2 emissions by sectors for the WAM scenario

Source	CO_2 emissions [kt]							
	2005	2010	2015	2020	2025	2030	2035	2040
Total without LULUCF	**321 670,63**	**332 132,43**	**310 638,59**	**304 092,68**	**286 711,14**	**269 577,36**	**237 368,99**	**205 711,78**
Total including LULUCF	**275 525,14**	**300 746,11**	**280 665,84**	**281 732,98**	**267 662,73**	**255 116,67**	**224 837,41**	**195 422,35**
1. Energy	**303 913,91**	**314 263,19**	**290 841,09**	**281 452,03**	**262 930,68**	**245 149,70**	**212 619,84**	**180 482,60**
A. Combustion	301 208,53	312 010,45	287 305,83	277 895,47	259 479,30	241 789,55	209 339,34	177 272,63
1. Energy industry	177 392,29	172 325,82	162 689,57	146 196,54	138 737,31	131 295,81	106 290,50	80 712,95
2. Manufacturing and construction industries	33 936,71	29 555,26	27 827,37	25 662,05	23 354,32	21 170,43	19 515,73	18 107,89
3. Transport	34 718,34	47 491,50	46 033,81	55 800,19	54 973,91	53 110,49	51 024,80	48 710,75
4. Other sectors	55 161,19	62 637,88	50 755,08	50 236,69	42 413,76	36 212,82	32 508,31	29 741,04
B. Emission from fuels	2 705,38	2 252,73	3 535,26	3 556,56	3 451,38	3 360,15	3 280,50	3 209,97
1. Solids	1 566,41	1 201,76	1 678,68	1 812,22	1 707,03	1 615,81	1 536,16	1 465,62
2. Oil and natural gas	1 138,97	1 050,97	1 856,58	1 744,34	1 744,34	1 744,34	1 744,34	1 744,34
2. Industrial processes and use of products	**16 042,68**	**16 643,73**	**18 539,33**	**19 985,74**	**21 045,91**	**21 675,10**	**22 000,05**	**22 483,64**
A. Mineral products	8 355,79	9 849,54	10 088,56	10 554,14	11 061,04	11 569,50	11 899,01	12 393,28
B. Chemical industry	4 886,78	4 335,42	5 141,13	5 473,54	5 894,83	5 872,39	5 872,39	5 872,39
C. Metallurgy	2 216,99	1 784,33	2 592,10	3 261,14	3 393,12	3 536,29	3 531,73	3 521,05
D. Non-energy products from the consumption of fuels and solvents	583,11	674,45	717,54	696,92	696,92	696,92	696,92	696,92
3. Agriculture	**1 291,94**	**790,01**	**770,57**	**843,84**	**870,87**	**888,89**	**888,89**	**888,89**
G. Liming	944,90	391,55	373,84	420,43	420,43	420,43	420,43	420,43
H. Urea	347,04	398,46	396,73	423,41	450,44	468,46	468,46	468,46
4. LULUCF	**-46 145,49**	**-31 386,32**	**-29 972,75**	**-22 359,70**	**-19 048,41**	**-14 460,69**	**-12 531,59**	**-10 289,43**
5. Wastes	**422,11**	**435,50**	**487,60**	**1 811,08**	**1 863,68**	**1 863,68**	**1 860,21**	**1 856,65**
C. Ashing and open waste incineration	422,11	435,50	487,60	1 811,08	1 863,68	1 863,68	1 860,21	1 856,65
Biomass emissions	**19 804,99**	**30 353,35**	**34 767,31**	**40 891,10**	**48 220,15**	**51 630,04**	**53 359,09**	**55 119,83**

Source: Own study ATMOTERM

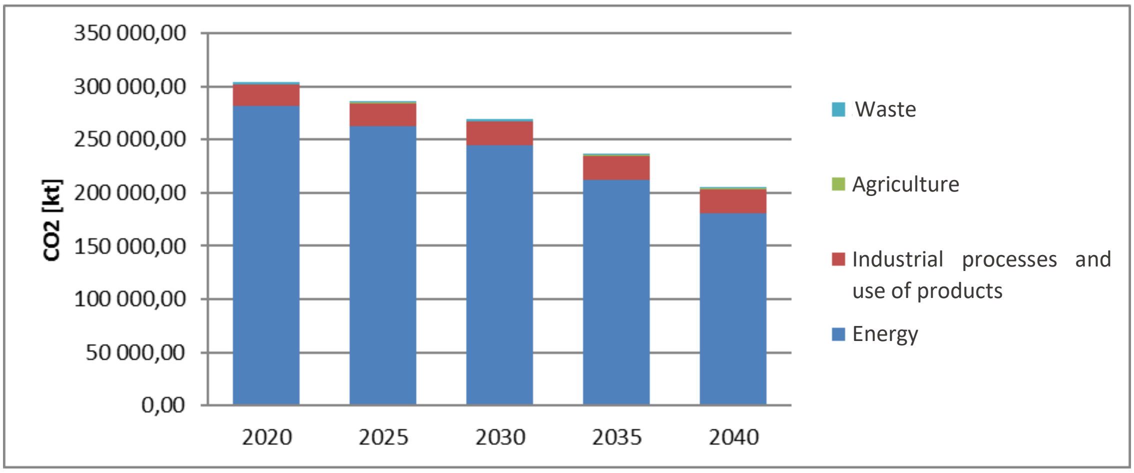


Figure 5 CO2 emissions by sector for the WAM scenario, without the LULUCF

<u>Comparison WEM with WAM scenario:</u>

The comparison of emission projections by ETS and non-ETS sectors (ESD) for scenarios WAM and WEM is presented in Table 9 and Figure 6.

Total GHG emissions in the WEM scenario is higher than the emissions calculated for the WAM scenario. The difference in emissions between scenarios is the highest in 2035 and amounts to approximately 43.7 million t CO2eq. As a result of the implementation of activities assumed for the WAM scenario, we obtain a reduction of emissions (with LULUCF) in relation to the WEM scenario at the level of approx. 11% in 2030 to approx. 12% in 2040.

The largest reduction of CO2 emissions between the WAM and WEM scenarios will take place in the sector of fuel combustion, in particular in the area of energy industries. In addition, a significant difference also applies to other sectors, including housing and services, as well as transport.

Table 9 Projections of greenhouse gas emissions by ETS and non-ETS sectors, for the WAM and WEM scenarios

Source	GHGs emissions [ktCO2eq]									
	WEM scenario					WAM scenario				
	2020	2025	2030	2035	2040	2020	2025	2030	2035	2040
Total without LULUCF	**398865,0**	**407566,3**	**409875,6**	**375922,6**	**339939,0**	**391 244**	**383 420**	**366 536**	**332 176**	**298 762**
Total including LULUCF	**377044,8**	**389119,8**	**396079,2**	**364117,7**	**330438,8**	**369 423**	**364 974**	**352 740**	**320 371**	**289 262**
EU ETS	193 218,5	199 553,6	204 703,9	171 546,4	141 378,8	192 876	193 438	185 010	160 501	135 234
Non-ETS (ESD)	205 646,5	208 012,6	205 171,7	204 376,2	198 560,2	198 368	189 983	181 527	171 676	163 528

Source: Own study ATMOTERM

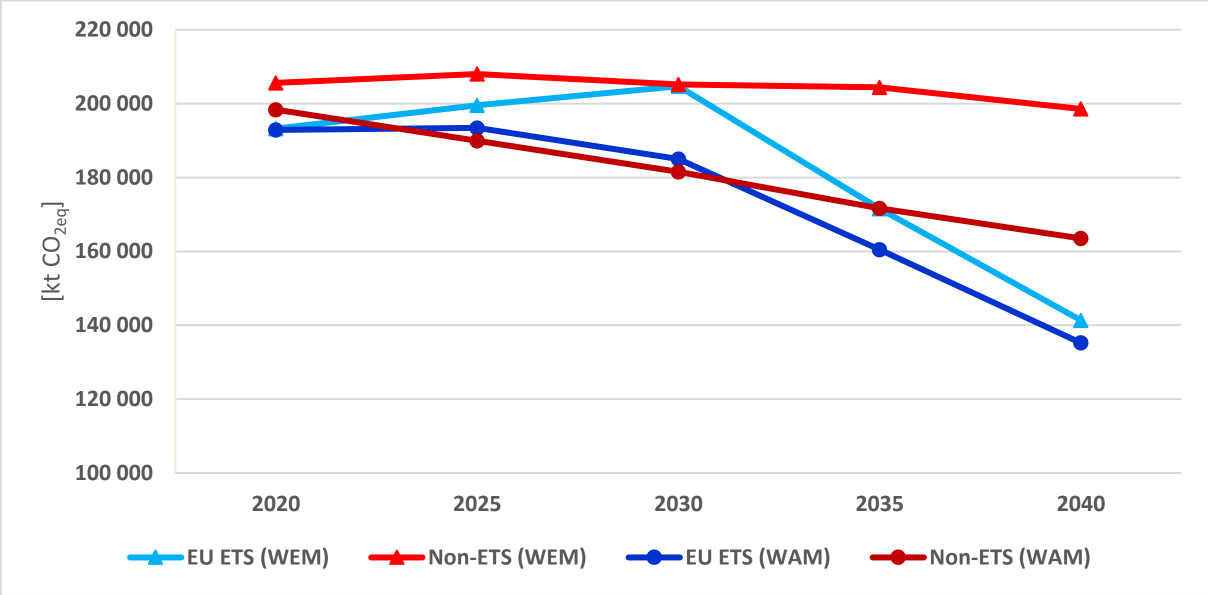


Figure 6 GHG emission by sector for the WAM scenario, without the LULUCF

For the WEM scenario within ETS sector, the initial increase in greenhouse gas emissions by 2030 is predicted, and then their decrease. A similar trend is foreseen for non-ETS, with the drop in emissions after 2025. For the WAM scenario, both ETS and non-ETS show a general downward trend.

However, taking into account the non-ETS reduction target for Poland set at -7% in 2030 compared to the level in 2005, it should be stated that it will be achieved only in the case of the WAM scenario.

1.2.2. Renewables

1.2.2.1. Predictions of energy consumption from renewable sources

Table 10 presents national and sectoral forecasts for the share of RES, for the scenario taking into account the planned policies and measures (WAM). The obtained shares were compared to those obtained for the Reference scenario (WEM).

The prediction results point **to the possibility of achieving the overall 21% target for renewables in final energy consumption in 2030**. However, this requires commitment and decisive action in all sectors under consideration (power, heating&cooling and transport). It is assessed that technological development and economic maturity of individual sources will allow a fast growth rate of RES share after 2020.

In the years 2021-2030 it is expected further intensification of actions for the development of the national renewable energy potential. In particular, it will be necessary to effectively create additional volumes of RES energy production through support mechanisms for electricity generation (wind farms, including offshore wind farms, large solar, biomass and biogas installations).

The obtained results indicate the need to ensure a gradual RES increase in the **electricity production.** In the years 2020-2030, **the share of RES in this sector grows at a rate of more than 1 percentage point annually, to a level of approx. 29.5% in 2030, and in 2040 can reach approx. 34%.**

Gradual increase of heat production from RES will also play a special role. In calculations, an important role of the biomass was assumed both in CHP plants as well as in heat plants as part of the process of transforming district heating systems into effective systems. Wide application of biomass, heat pumps and geothermal in heat generation (also in sectors such as communal housing) is necessary to meet the requirement of increasing by 2030 the share of renewable energy in heating by 1 point. percent. on average, as well as obtaining a specific contribution to the goal of a 21% share of RES in the final gross energy consumption. Due to limited biomass resources, it will probably require the implementation of mechanisms encouraging the use of this resource in the units with the highest production efficiency, i.e. first in cogeneration units and heating units.

According to the presented projections for the WAM scenario**, the share of energy from RES in the heating and cooling sector increases from 14.5% in 2015 to 25.2% in 2030**. This means an increase of 10.7 percentage points.

In the transport sector in 2030, the share of renewable energy is expected to reach 15.5%. This objective is primarily based on biocomponents used in liquid fuels, as well as through increasing the use of electricity (especially in road transport) and the development of biofuels from waste materials (mainly 2nd generation). These predictions indicate that a 10% share of RES in transport in 2020 will be achieved, in accordance with the EU regulations.

Regarding the prospects for the development of renewable energy in transport in 2040, the results of the analysis indicate the possibility of obtaining the RES share of 25.9%, although it will require a significant development of the alternative fuels market, including electromobility.

Table 10 Forecast of total and sectoral gross final energy consumption from renewable sources [ktoe] and share of renewable energy consumption - total and in the [%] sectors - WAM scenario

[ktoe]	2005	2010	2015	2020	2025	2030	2035	2040
Final gross energy consumption (denominator RES-E)	**61488,8**	**69146,5**	**65261,7**	**71382**	**69937**	**68449**	**68008**	**67923**
gross final energy consumption from RES	4248,7	6399,3	7790,9	9871	11801	14347	16138	17225
consumption of RES in electricity generation	282,6	841,5	1826,5	2359	3143	4646	5576	5861
consumption of RES in heating and cooling	3867,6	4641,6	5116,3	6084	7155	8096	8840	9466
consumption of RES in transport	98,4	916,2	848,1	1427	1503	1606	1722	1897

[%]	2005	2010	2015	2020	2025	2030	2035	2040
RES share in final gross energy consumption	**6,9%**	**9,3%**	**11,9%**	**13,8%**	**16,9%**	**21,0%**	**23,7%**	**25,4%**
share of energy from RES in electricity generation	2,7%	6,6%	13,0%	16,4%	21,0%	29,5%	34,0%	34,6%
Share of energy from RES in heating and cooling	10,2%	11,7%	14,5%	16,7%	21,0%	25,2%	28,1%	30,5%
share of energy from RES in transport (with multipliers)	1,6%	6,6%	6,4%	10,0%	12,2%	15,5%	19,7%	25,9%

Source: Own study ARE S.A., Eurostat

1.2.2.2. Comparison of forecasts for the consumption of renewable energy sources - WAM vs. WEM

Table 11 and Figure 7 summarize the results of comparisons for the WAM and WEM scenarios considered in the scope of obtained national and sectoral renewable energy shares by 2030 (with prospects until 2040). The presented differences in this comparison are a consequence of implementation additional measures for RES development and the assumption that the share of RES will increase significantly in the perspective of 2030 in the WAM scenario. Results obtained for 2040 shows maintaining the pace of development of renewable energy technologies within individual sectors and applied technologies after 2030.

Table 11 Comparison of domestic and sectoral renewable energy shares - WAM vs. WEM scenarios

	2005	2010	2015	2020	2025	2030	2035	2040
Domestic RES share (WAM)	**6,9%**	**9,3%**	**11,9%**	**13,8%**	**16,9%**	**21,0%**	**23,7%**	**25,4%**
Domestic RES share (WEM)	**6,9%**	**9,3%**	**11,9%**	**13,2%**	**13,9%**	**15,2%**	**16,9%**	**18,0%**

	2005	2010	2015	2020	2025	2030	2035	2040
RES share in electricity generation (WAM)	2,7%	6,6%	13,0%	16,4%	21,0%	29,5%	34,0%	34,6%
RES share in electricity generation (WEM)	2,7%	6,6%	13,0%	15,0%	16,5%	19,4%	23,9%	25,9%

	2005	2010	2015	2020	2025	2030	2035	2040
RES share in heating and cooling (WAM)	10,2%	11,7%	14,5%	16,7%	21,0%	25,2%	28,1%	30,5%
RES share in heating and cooling (WEM)	10,2%	11,7%	14,5%	15,6%	16,5%	17,7%	18,8%	19,7%

	2005	2010	2015	2020	2025	2030	2035	2040
RES share in transport (WAM)	1,6%	6,6%	6,4%	10,0%	12,2%	15,5%	19,7%	25,9%
RES share in transport (WEM)	1,6%	6,6%	6,4%	10,0%	10,4%	11,2%	12,1%	13,0%

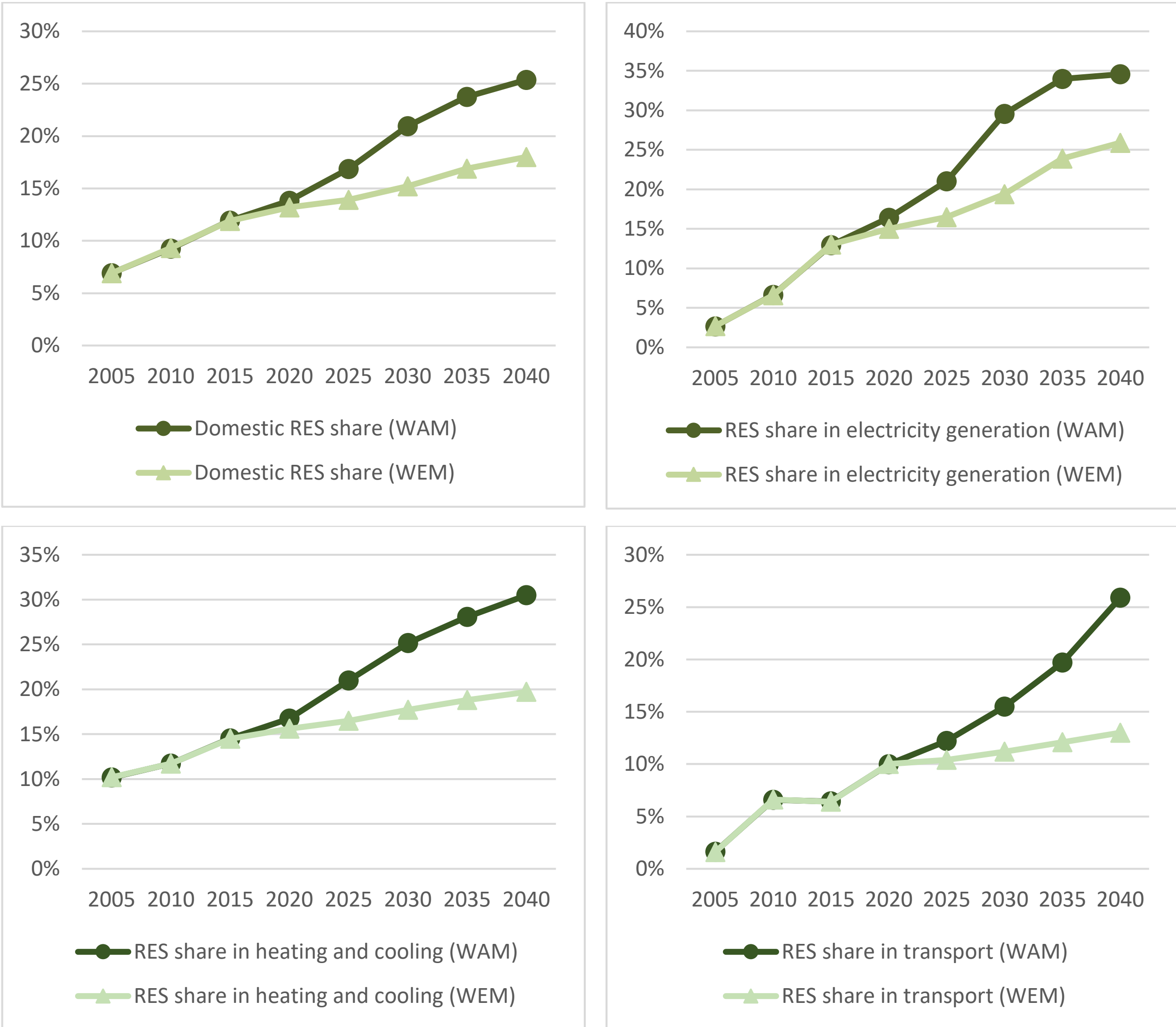


Figure 7 Comparison of domestic and sectoral renewable energy shares - WAM vs. WEM scenarios

1.3. Dimension „energy efficiency”

Poland intends to continue the trends that contribute to the growth of the energy efficiency of the economy, because it gives tangible benefits to the economy and the environment. It is also one of the main pillars of sustainable development. The energy intensity of the Polish economy, despite the progress that has been made in this area, still differ from the average in the EU. Primary energy consumption of GDP including purchasing power parity (PPP) decreased in 2015 compared to 2005 by 29% (Figure 8). This index calculated with the climatic correction and expressed in constant prices in 2005 amounted to 0.15 kgoe / EUR'05ppp in 2015 and was 15% higher than the European average (0.131) [1].

The distance of Poland to the European average has been significantly reduced, however, it still remains significant in relation to the most effective economies.

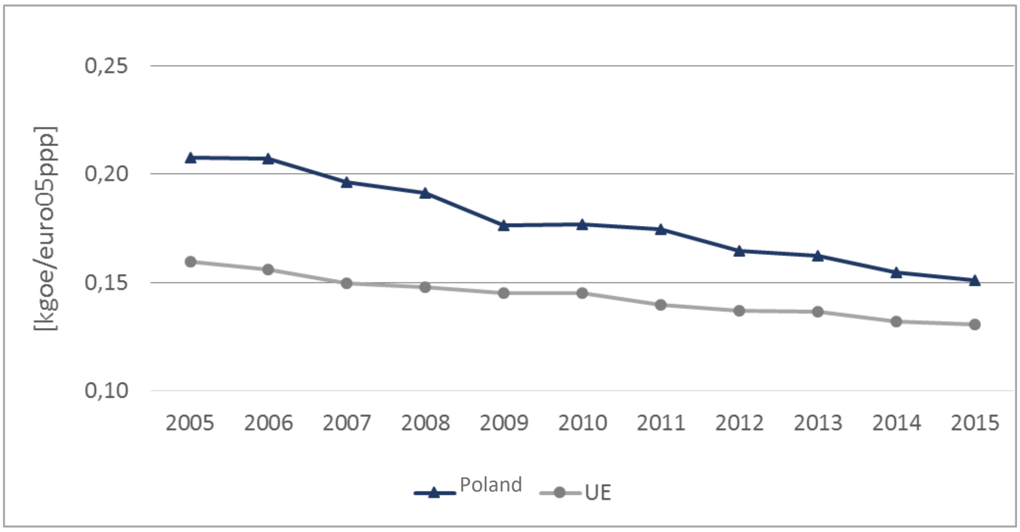


Figure 8 Primary energy intensity of GDP with climatic correction

Reducing energy consumption one of the priorities in the EU and Poland. Actions to improve energy efficiency are considered not only as a means to ensure sustainable energy supply, reduce greenhouse gas emissions, increase security of supply and reduce energy import expenditure, but also as a means to promote competitiveness.

In 2007, EU leaders set a target of reducing the EU's annual energy consumption by 20% by 2020, while in 2018 the EU-wide 2030 target was set at 32.5%.

1.3.1. Primary and final energy consumption

The table and the figure below summarize the historical and predicted primary and final energy consumption in Poland. From the presented WAM projections, there is a decrease in the demand for both primary and final energy. The obtained forecast results are derivative of a number of assumptions, in particular referring to the possibilities of improving energy in individual sectors of the national economy but also the pace of RES development.

[1] "Energy consumption efficiency in 2006-2016", Central Statistical Office, Warsaw 2017.

Table 12 Total and final energy consumption [ktoe]

	2005	2010	2015	2020	2025	2030	2035	2040
Primary energy consumption *	92 223	100 680	95 434	100 958	99 327	96 488	94 697	94 306
Final energy consumption + non-energy consumption	63 039	71 241	67 732	74 054	72 888	71 736	71 582	71 690
Consumption of final energy	58 475	66 288	62 304	68 568	67 374	66 186	65 980	66 025

with non-energy consumption

Source: Own study ARE SA (STEAM-PL, MESSAGE-PL), EUROSTAT

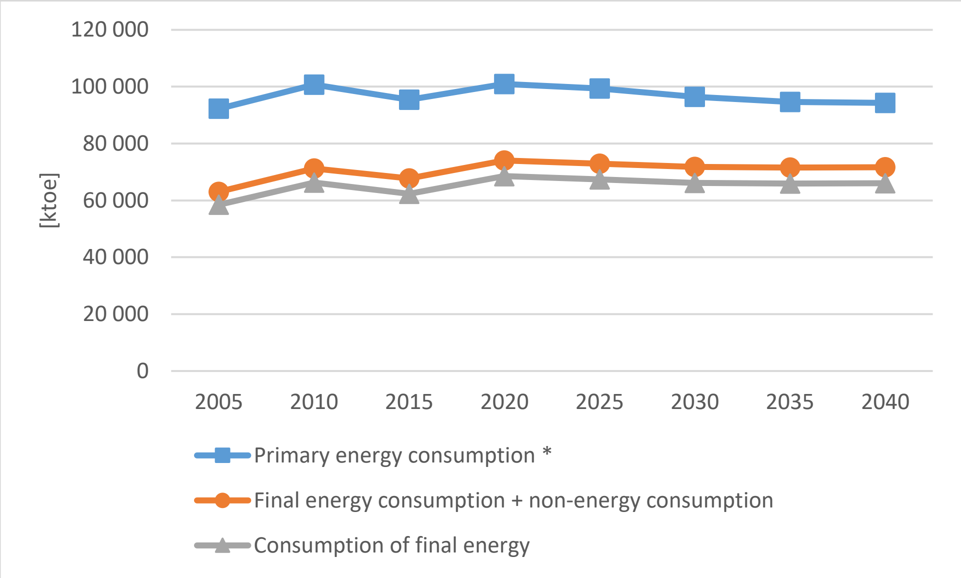


Figure 9 Total and final energy consumption - WAM scenario

While developing these projections, following assumptions in favour of improving energy efficiency in individual sectors of Polish economy were made:

- policy aimed at increasing the energy efficiency of the economy will be continued, influencing on lowering its energy intensity,
- the national potential for improving energy efficiency will be used,
- the planned activities will be based on market mechanisms (to maximum extend),
- the objectives will be implemented according to the principle of the lowest costs, that is, among others, by using existing mechanisms and organizational infrastructure[2],
- all available energy efficiency improvement measures will be used (horizontal measures, energy efficiency measures in buildings and in public institutions, in industry, in small and medium-sized enterprises (SMEs), in transport, in the electricity and heating sectors, etc.).

In order to set targets for improving energy efficiency in the EU, as a reference point were used the primary and final energy projections commissioned by the European Commission in 2007 (scenario PRIMES - Baseline 2007). According to these forecasts, primary and final energy consumption in Poland

[2] "National Action Plan on energy efficiency for Poland", Ministry of Energy, Warsaw 2017.

in 2030 is respectively: 118.6 and 85.5 Mtoe (for 2020 - 109.8 and 77.4 Mtoe). The figure below presents the results of projections of primary and final energy consumption in Poland compared to the 2007 PRIMES scenario. In 2030, the amount of primary energy saved is 22.1 Mtoe, which in relation to the estimated 188.6 Mtoe of the PRIMES 2007 reference scenario, gives a 18.6% reduction.

The presented projections show that the target for the improvement of energy efficiency for 2020 determined on the basis of art. 3 (1) of Directive 2012/27 / EU may not be achieved. In absolute terms, fulfillment of the obligation means primary energy consumption at the level not exceeding 96.4 Mtoe (primary energy saving of 12.4%), while the projection for the WAM scenario results in the value of this consumption at 101 Mtoe, which is the result of forecasted economic growth . One of the reasons for the abrupt increase in domestic energy demand recorded in statistics between 2015 and 2017 was the implementation (August 2016) of the so-called fuel package. The main purpose of this act was to counteract tax (VAT) fraud in the intra-community trade in liquid fuels and to limit the negative impact of this practice on the functioning of the liquid fuels market. As a result of the introduction of these regulations, a significant volume of liquid fuels consumed in the country (diesel, gasoline and LPG) appeared in the legal turnover. This applies to approximately 3 Mtoe of liquid fuels additionally shown in national statistics.

The target for the final energy savings set in 2020 at a level not exceeding 71.6 Mtoe[3] is likely to be achieved. From the projection for the WAM scenario, it results that the final energy consumption will amount to approx. 68.6 Mtoe.

The WAM scenario calculations verified the practical possibilities of achieving the energy efficiency objective. This verification indicated the possibility of reduction of primary energy in the 2030 perspective to a maximum of 18.6% and final energy to 22.6%. Nevertheless, Poland wants to pursue higher goals - **in the scope of reduction of primary energy consumption, the target was defined at the level of 23%**. *It should be noted that the challenges in reducing energy consumption are related to the economic development of the country, which entails an increase in energy demand.*

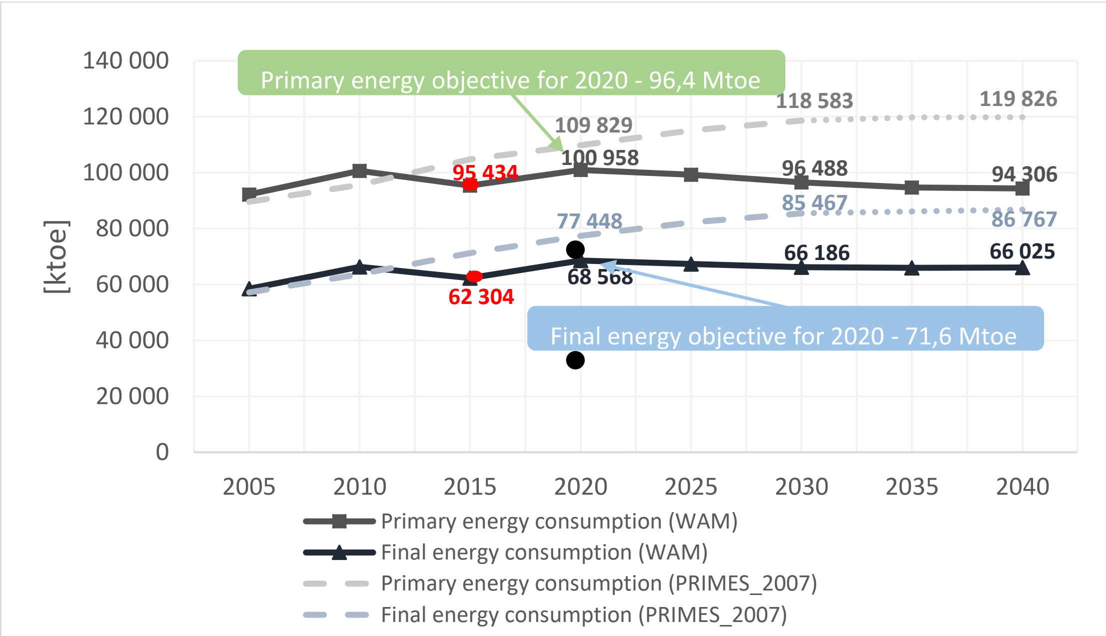


Figure 10 Forecasted primary and final energy consumption compared to the 2007 PRIMES scenario projections

[3] "National Action Plan on energy efficiency for Poland", Ministry of Energy, Warsaw 2017.

The forecast for the PRIMES scenario from 2007 was prepared only in the horizon until 2030, for this reason the trajectories of domestic primary and final energy consumption presented for the year 2040 are the result of extrapolation of the numerical values from the period 2005-2030. Obtained results of extrapolations served as reference points for determining the percentage of reduction of energy consumption for 2040. They are equal to 21.3% and 23.4% for primary and final energy.

1.3.2. Final energy consumption by fuel

In the final energy consumption, significant changes in the fuel structure are observed. Above all, there is a significant reduction in coal consumption in the domestic economy (the share of this resource decreases from 19% in 2015 to less than 9% in 2030 and about 6% in 2040). On the other hand, the consumption of electricity, natural gas and energy from renewable energy sources is gradually increasing, which is a natural consequence of policies aimed at reducing emissions. Based on the adopted assumptions, a relatively small decrease in the district heat demand is expected, which is a consequence of the adopted assumptions regarding the pace and scope of thermal modernization of buildings and the EC recommendation regarding the projection of the number of heating days.

The decrease in hard coal consumption is mainly related to the slow, but gradual progress of power plants modernization and partly as a result of functioning the EU ETS system, which results in switching to low-emission fuels and carriers (such as RES, gas, nuclear). Next, the decline in coal consumption will also be influenced by the process of replacement of old, ineffective boilers in households, supported by subsidies from the Clean Air Program and other dedicated systems, incl. regulation which introduce restrictions for furnaces manufactured and installed in Poland with a capacity below 500 kW. Sold solid fuel furnace must meet the requirements of the emissivity class 5 according to PN-EN 303-5: 2012. The forecast takes into account the assumption that all new boilers meet the criteria specified in the above mentioned regulation.

Table 13 Final energy consumption by fuel and carriers [ktoe]

	2005	**2010**	**2015**	**2020**	**2025**	**2030**	**2035**	**2040**
Electricity	9 029	10 206	10 990	11 977	12 955	13 996	15 075	16 222
District heat	6 638	6 547	5 462	5 705	5 404	5 077	5 071	5 123
Coal	13 055	14 338	12 177	10 756	8 184	6 252	5 078	4 184
Oil products	17 849	20 678	19 196	22 762	22 466	21 887	21 148	20 357
Natural gas	7 919	8 894	8 506	9 868	10 233	10 390	10 479	10 494
Biogas	40	48	78	93	124	157	191	226
Solid biomass	3 755	4 303	4 489	5 084	5 380	5 506	5 794	6 143
Biofuels	55	867	786	1303	1267	1233	1199	1167
Waste	136	380	526	777	857	870	882	895
Solar collectors, heat pumps, geothermal	0	27	93	243	503	818	1 065	1 216
TOTAL	**58 475**	**66 288**	**62 304**	**68 568**	**67 374**	**66 186**	**65 980**	**66 025**

Source: Own study ARE SA (STEAM-PL), EUROSTAT

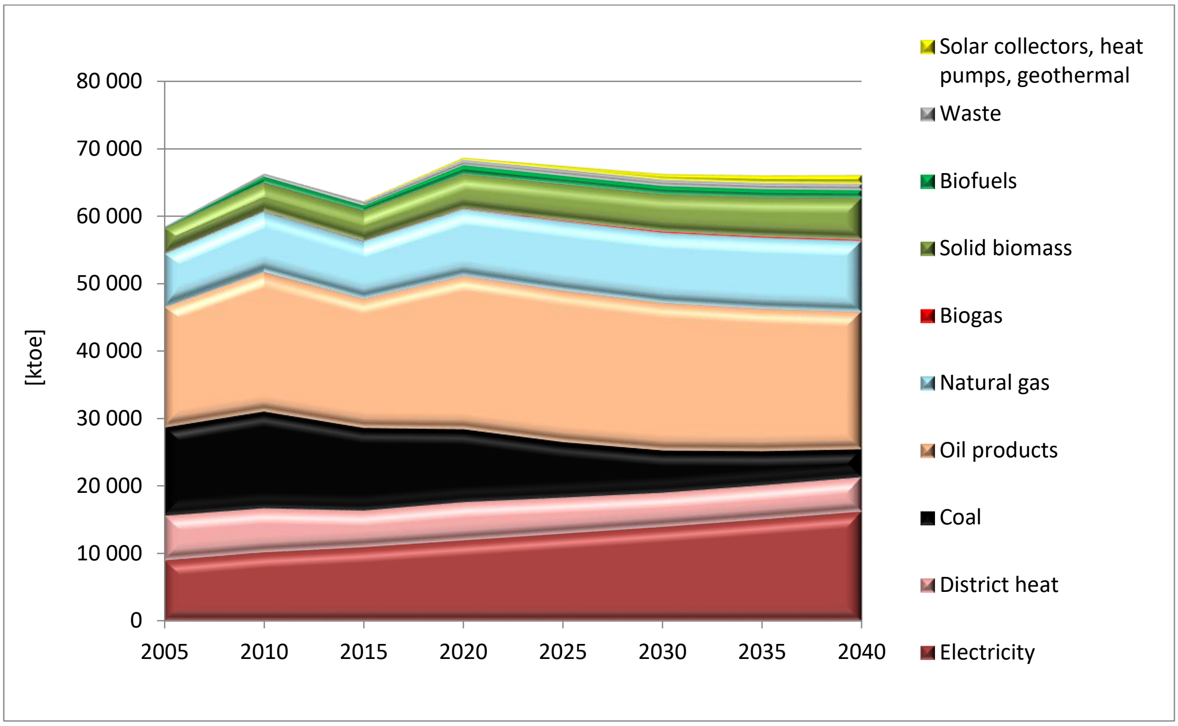


Figure 11 Final energy consumption divided into fuels and carriers

1.3.3. Comparison of primary and final energy consumption forecasts - scenario of WAM vs. WEM

A comparison of the results of forecasts of primary and final energy demand in Poland obtained for the scenario of WAM and WEM is presented below.

Energy savings within individual energy efficiency improvement measures accumulate over time, which means that saving in a given year is a saving from the previous year, increased by the savings achieved from new activities implemented in a given year.

Table 14 Total and final energy consumption - WAM vs. WEM scenario [ktoe]

	2005	2010	2015	2020	2025	2030	2035	2040
Primary energy consumption (WAM)	92 223	100 680	95 434	100 958	99 327	96 488	94 697	94 306
Primary energy consumption (WEM)	92 223	100 680	95 434	104 301	107 720	110 417	111 606	116 543
Savings				3 343	8 393	13 929	16 909	22 237
Final energy consumption (WAM)	58 475	66 288	62 304	68 568	67 374	66 186	65 980	66 025
Final energy consumption (WEM)	58 475	66 288	62 304	72 117	75 078	77 327	78 300	78 784
Savings				3 549	7 704	11 142	12 320	12 758

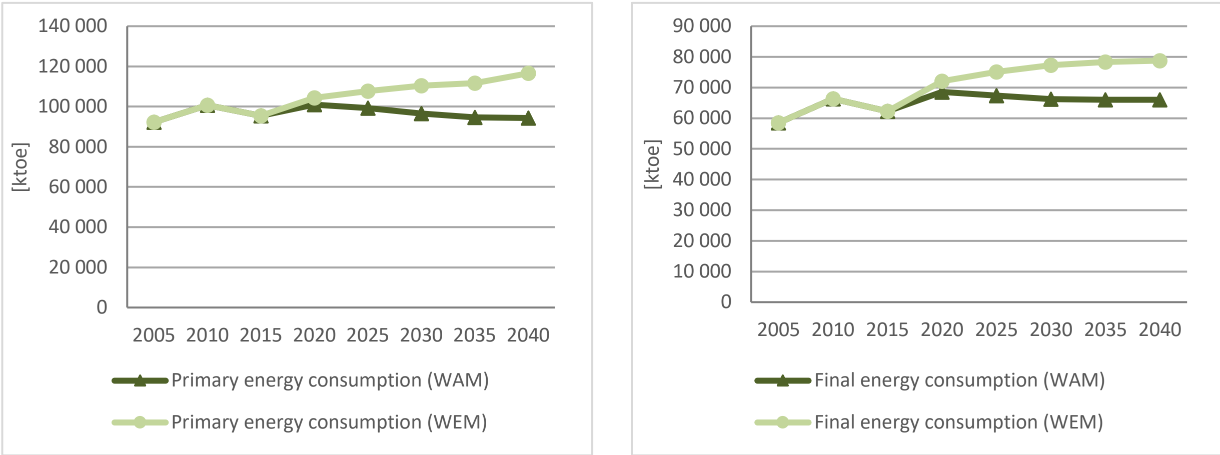


Figure 12 Total and final energy consumption - WAM vs. WEM scenario

Table 15 Reduction of final energy consumption in the [ktoe] sectors - WAM scenario vs. WEM

	2020	**2025**	**2030**	**2035**	**2040**
Industry	676	1 199	1 587	1 836	2 055
Transport	1 921	3 260	4 447	4 799	5 004
Households	482	2 573	4 332	4 876	5 171
Services	480	907	1 355	1 605	1 660
Agriculture	87	195	299	398	492
Final energy consumption reduction	**3 647**	**8 134**	**12 020**	**13 515**	**14 382**

Source: Own study ARE SA

1.4. Dimension „energy security”

1.4.1. Net imports by type of fuel

The value of the import and export balance plays an important role in defining methods of covering demand and determining the structure of electricity generation, as well as affecting the price level of this carrier on the wholesale market.

The National Electricity System (KSE) has been observing tendencies to increase cross-border flows and trade. This is a result of growing import and export capacity and intensive subsidization of RES in neighboring countries.

It is probable that in the period up to 2023 Poland will be a net importer of electricity (unless there are extraordinary circumstances resulting in a change of the existing price relations on interconnections).

The planned nuclear phase-out in Germany in 2023 and the general reduction of overcapacity in Central and Western Europe as a result of replacement of conventional generating capacities will lead to an increase in prices on the European energy markets. In addition, the introduction of the capacity market in Poland and the commissioning of new investments (Opole, Turów, and Ostrołęka) will most likely improve the competitiveness of electricity produced in Poland. The analysis shows that around 2020 net import will amount to at least 1 TWh. In strategic analyzes it is assumed to base the country's energy security on domestic sources. Therefore, in the remaining period of the forecast, the import-export balance of electricity was set at a level close to zero, according to the assumption of maintaining energy self-sufficiency at the highest possible level.

However, it should be emphasized that the exact determination of future exchange volumes on existing and planned connections is associated with a high level of uncertainty, especially in relation to forecasted price levels of electricity on wholesale markets in neighboring countries that determine the direction and volume of intersystem exchange - they are strongly dependent on weather conditions, legal and regulatory conditions and many other factors of a random nature.

Table 16 Net import-export balance of electricity [ktoe]

	2005	2010	2015	2020	2025	2030	2035	2040
Electricity	-962	-116	-29	83	0	0	0	0

the "-" before the value means export

the "+" before the value means import

Source: Own study ARE SA (MESSAGE-PL), Eurostat

The table below presents current status and forecasts for net imports of other energy carriers. The presented data show the need to increase crude oil imports to a relatively small extent. Thanks to efforts to improve energy efficiency, a very dynamic rate of consumption of petroleum products in transport is slowed down.

The consequence of the policies and measures of the WAM scenario is an increase in gas imports.

Table 17 Net import and export balance [ktoe]

	2005	2010	2015	2020	2025	2030	2035	2040
Hard coal	-8 161	489	-1 588	-547	-3 132	-3 174	-3 087	-3 019
Coking coal	-1 801	944	275	57	148	223	286	342
Coke	-3 068	-4 227	-4 333	-4 597	-4 759	-4 893	-5 006	-5 105
Lignite	-2	-19	16	15	15	14	7	3
Crude oil	17 751	22 491	26 103	25 981	26 420	26 475	26 366	26 138
Natural gas	8 531	8 874	9 947	12 435	13 574	14 639	15 726	17 578
Nuclear fuel	0	0	0	0	0	0	4 080	8 160
Biofules	-65	427	-144	210	204	199	193	188
Solid biomass	0	0	506	505	611	684	739	800

Source: Own study ARE SA (STEAM-PL, MESSAGE-PL), Eurostat

The level of dependence on imports from third countries has been defined as the total volume of energy imports from non-EU countries compared to national gross energy consumption.

Table 18 Dependence on imports from third countries

	2005	2010	2015	2020	2025	2030	2035	2040
Electricity	1,4%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%
Hard coal	4,2%	13,1%	8,6%	9,2%	0,9%	0,5%	0,5%	0,5%
Coking coal	0,3%	18,2%	17,2%	14,8%	15,8%	16,6%	17,2%	17,7%
Coke	0,5%	1,2%	2,1%	3,7%	4,1%	4,5%	4,7%	4,9%
Lignite	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%
Crude oil	98,0%	98,2%	101,2%	97,1%	97,2%	97,2%	97,2%	97,2%
Natural gas	67,7%	61,7%	52,5%	58,7%	62,9%	65,5%	68,1%	70,1%
Nuclear fuel	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	100,0%	100,0%
Biofuel	0,0%	0,0%	5,4%	3,0%	3,0%	3,0%	3,0%	3,0%
Solid biomass	0,0%	0,0%	8,7%	8,0%	8,0%	8,0%	8,0%	8,0%

Source: Own study ARE SA

Poland's dependence on energy imports in 2015 was 32.6%. According to the forecast, the energy dependence will be increasing mainly caused by growth of fossil fuels import.

1.4.2. Electricity and heat production

The table and figure below present data on gross electricity and district heating production in Poland. According to the forecast results, domestic electricity production is expected to increase from the level of 164.9 TWh in 2015 up to 197.9 TWh in 2030 and up to 221.6 TWh in 2040. The percentage increase in the period 2015-2030 is 20% and 34% in the period 2015-2040.

The demand for district heating increases from 281.4 PJ in 2015 to 294.4 PJ in 2020 and then decreases to the level of 258.4 PJ in 2030 with maintenance on a relatively stable level - 257.1 PJ in 2040 (which means a decrease by 8% during the considered period). The results of the forecasts are based on the intensification of activities for joining new customers to district heating networks and the rate of thermo-modernization of buildings.

Table 19 Production of electricity and gross district heating

	2005	2010	2015	2020	2025	2030	2035	2040
Electricity [GWh]	156 935	157 658	164 944	174 886	186 616	197 398	208 690	221 601
District heating [TJ]	336 292	335 831	281 393	294 433	276 761	258 365	256 182	257 063

Source: Own study ARE SA (STEAM-PL, MESSAGE-PL), Eurostat

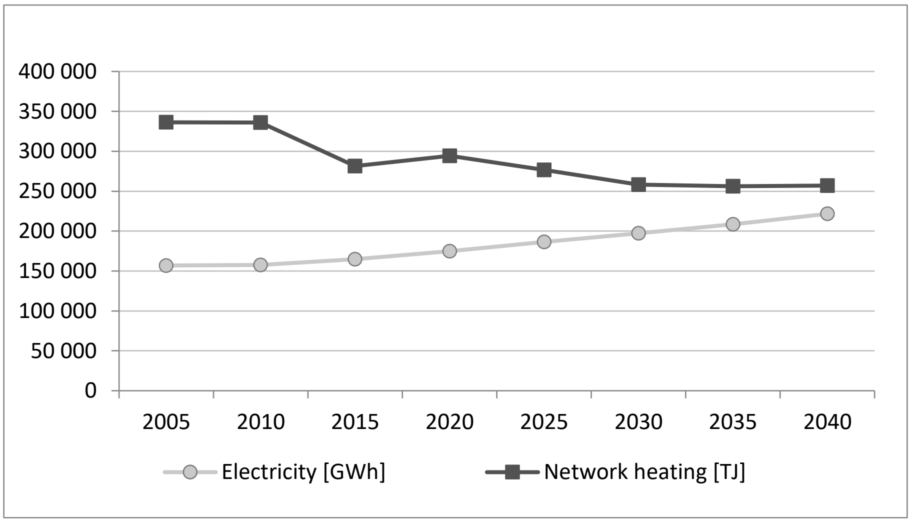


Figure 13 Production of electricity and gross district heating

1.4.3. Comparison of the demand for electricity and district heating – scenario WAM vs. WEM

The comparison of the forecast's results of electricity and heat demand in Poland for the WAM and WEM scenario is presented below. The small differences occurring in the production of electricity result from the forecasted economic growth.

The heat forecasts differ to a large extent, which is due to the increase in the efficiency of buildings and the implementation of the Clean Air Program. The decline occurs despite stricter regulations regarding the obligation to connect customers to the network, as well as the distribution of network heating.

Table 20 Gross electricity and heat generation - the WAM vs. WEM scenario

		2015	2020	2025	2030	2035	2040
Electricity (WAM)	GWh	164 944	174 886	186 616	197 398	208 690	221 601
Electricity (WEM)	GWh	164 944	178 374	192 875	204 915	212 924	220 887
Difference (WAM-WEM)	%	-	-2,0%	-3,2%	-3,7%	-2,0%	0,3%
		2015	2020	2025	2030	2035	2040
District heat (WAM)	TJ	281 393	294 433	276 761	258 365	256 182	257 063
District heat (WEM)	TJ	281 393	293 722	305 532	313 902	321 635	329 578
Difference (WAM-WEM)	%	-	0,2%	-9,4%	-17,7%	-20,4%	-22,0%

1.4.4. Gross electricity production by fuel

Electricity production by fuels is presented in table and figure below. The results of the analysis of possible directions of the domestic power sector indicate gradual changes that will occur in the structure of electricity production, resulting from legal and market conditions, mainly determined by the EU energy-climate policy. The development of renewable energy sources and obligation of purchasing CO2 emission allowances for power units based of fossil fuels will cause a gradual decrease in the share of coal in the structure of electricity production.

- In the future, the **share of coal** (hard coal and lignite) in the generation structure is expected to decrease from around 80% in 2015 to around 60% in 2030. Despite a significant decrease in the share, coal-fired power plants will remain a significant producer of electricity in the country and the base of the energy mix. The new block in Kozienice and the current units under constructions in Opole, Jaworzno, Turów as well as the planned block in Ostrołęka are based on HELE (high-efficient and low-emission) technologies.
- The role of **gas units** (new units will be mainly high efficiency cogeneration steam-gas blocks and condensing units after 2025) increases with time from approx. 3.9% in 2015 to approx. 8% in 2030, and then up to approx. 19% in the perspective of 2040. The climate and energy policy will enforce the implementation of new low-emission sources, of which a large proportion will be made up of renewable sources characterized by production variability (wind and solar). Increasing share of such units will require investing in flexible sources, energy storage, etc. necessary for their integration in the power system. For this reason, the presence of gas units is of great importance for the operational security of the power system - gas units are flexible enough to meet the increased requirements in the field of RES balancing.
- **The share of RES** in electricity production in 2015 (13%, 23 TWh) will increase significantly - in 2030 it will be approx. 29.5%, and in 2040 it may reach 34.6%, most of which is production from wind farms, but also photovoltaic and biomass units,
- A very important element of CO2 reduction policy is the development of nuclear energy in Poland. It is expected that the first unit of the nuclear power plant will be launched by 2033, two more in the years 2035-37, the fourth block - around 2040. In 2035, nuclear generation will reach approx. 18 TWh, while in 2040 approx. 36 TWh.

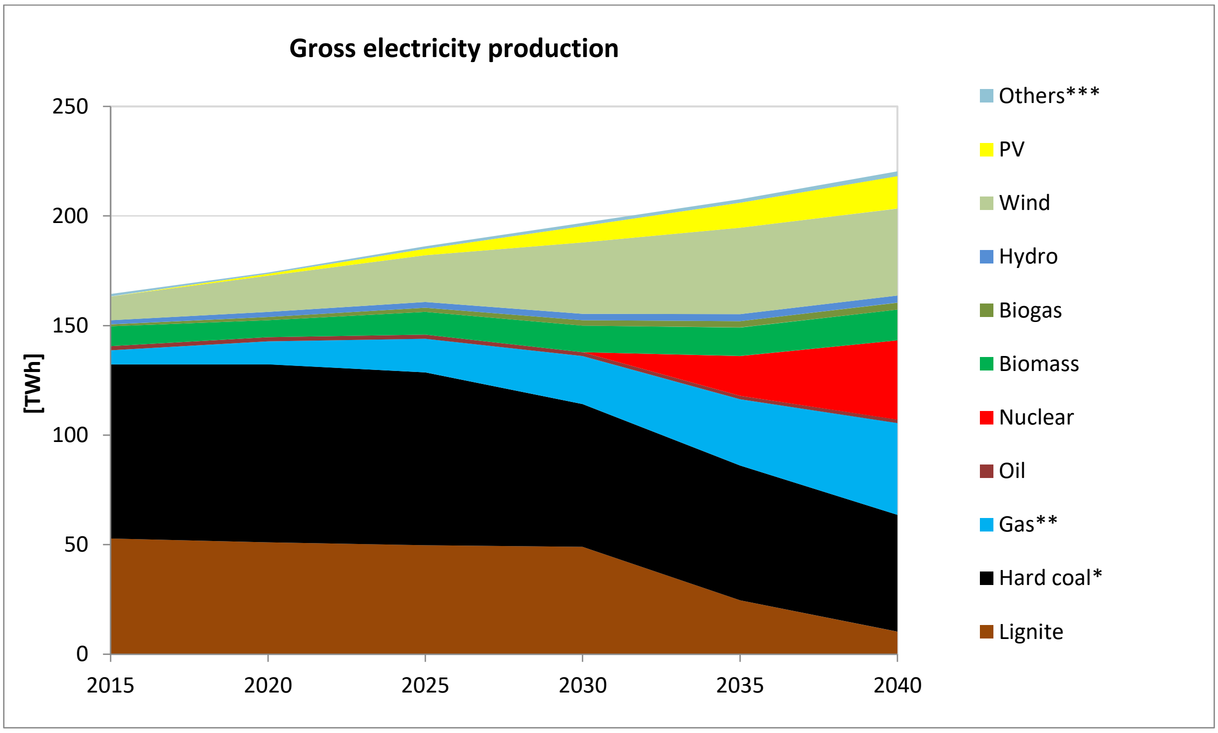
The transformation process of the Polish energy sector towards a low-emission one will be a long-term and very costly process, which is why it must be spread over time in such a way that it is possible to mitigate the negative economic and social consequences resulting from it.

Table 21 Gross electricity production [TWh]

	2005	2010	2015	2020	2025	2030	2035	2040
Lignite	54,8	48,7	52,8	51,0	49,7	49,1	24,6	10,3
Hard coal*	88,2	89,2	79,4	81,3	78,9	65,1	61,5	53,3
Gas**	5,2	4,8	6,4	10,5	15,4	21,9	30,2	41,9
Oil	2,6	2,5	2,0	1,9	1,9	1,8	1,7	1,6
Nuclear	0,0	0,0	0,0	0,0	0,0	0,0	18,1	36,2
Biomass	1,4	5,9	9,0	7,7	10,4	12,1	13,0	14,0
Biogas	0,1	0,4	0,9	1,5	1,9	2,4	2,9	3,2
Hydro	2,2	2,9	1,8	2,4	2,6	3,0	3,1	3,3
Pumped storage hydropower	1,6	0,6	0,6	0,7	0,5	0,6	1,0	1,3
Wind	0,1	1,7	10,9	16,5	21,3	32,6	39,5	39,7
PV	0,0	0,0	0,1	0,8	3,1	7,5	11,3	14,9
Others***	0,7	1,1	1,0	0,7	1,1	1,4	1,7	2,2
Total	**156,9**	**157,7**	**165,0**	**174,9**	**186,6**	**197,4**	**208,7**	**221,6**

** Including coal gas and blast furnace gas*
*** High-methane and nitrogen-rich natural gas, gas from demethanized mines, gas accompanying crude oil*
**** Inorganic industrial and municipal waste*

Source: Own study ARE SA (MESSAGE-PL), Eurostat



** Including coal gas and blast furnace gas*
*** High-methane and nitrogen-rich natural gas, gas from demethanized mines, gas accompanying crude oil*
**** Inorganic industrial and municipal waste*

Figure 14 Gross electricity production in Poland, broken down by fuel

1.4.5. Electricity generating capacity by source

The results of the analyzes indicate that it is expected far-reaching changes in the structure of electricity generation in Poland in the perspective of 2040 (table and figure below). The available capacity of electricity generation will increase from 37.3 GW in 2015 to approx. 62.6 GW in 2040. The role of system units fueled with coal will significantly decrease - their share in net installed capacity will be reduced. The share of renewable sources and installations powered by natural gas will clearly increase. In the power generation structure between 2033, the first unit of a nuclear power plant with a capacity of approx. 1000-1500 MW will be put into operation. Three more until the end of 2040.

Table 22 The available capacity of electricity generation by technology [MW]

	2005	2010	2015	2020	2025	2030	2035	2040
Lignite power plants – old	8 197	8 145	8 643	7 476	7 180	7 180	3 414	1 030
Lignite power plants – new	0	0	0	448	448	448	448	448
Hard coal power plants – old	14 613	14 655	13 617	12 003	11 094	6 872	4 561	1 744
Hard coal power plants – new	0	0	0	3 504	4 434	4 434	4 434	4 434
Natural gas power plants	0	0	0	0	536	1 072	2 761	3 561
Nuclear power plants	0	0	0	0	0	0	2 600	5 200
Hydroelectric power plant	1 064	935	964	987	1 039	1 191	1 249	1 289
Pumped storage power plant	1 256	1 405	1 405	1 405	1 405	1 405	1 405	1 405
Industry CHP	6140	6126	1 925	1 906	1 869	1 862	2 012	1 959
Hard coal CHP			4 046	4 555	3 973	3 935	3 615	3 196
Natural has CHP	760	807	928	2 687	3 177	3 042	2 409	4 625
Biomass power plants and CHP	102	140	553	577	769	1 002	1 311	1 572
Biogass CHP			216	298	383	482	572	621
Wind energy	121	1 108	4 886	6 522	7 822	10 839	12 426	11 399
Photovoltaics	0	0	108	1 067	3 567	8 167	12 017	15 671
Gas turbine/Cold reserve/Import	0	0	0	0	0	224	2 541	4 509
Total	**32 253**	**33 320**	**37 290**	**43 435**	**47 695**	**52 154**	**57 775**	**62 662**

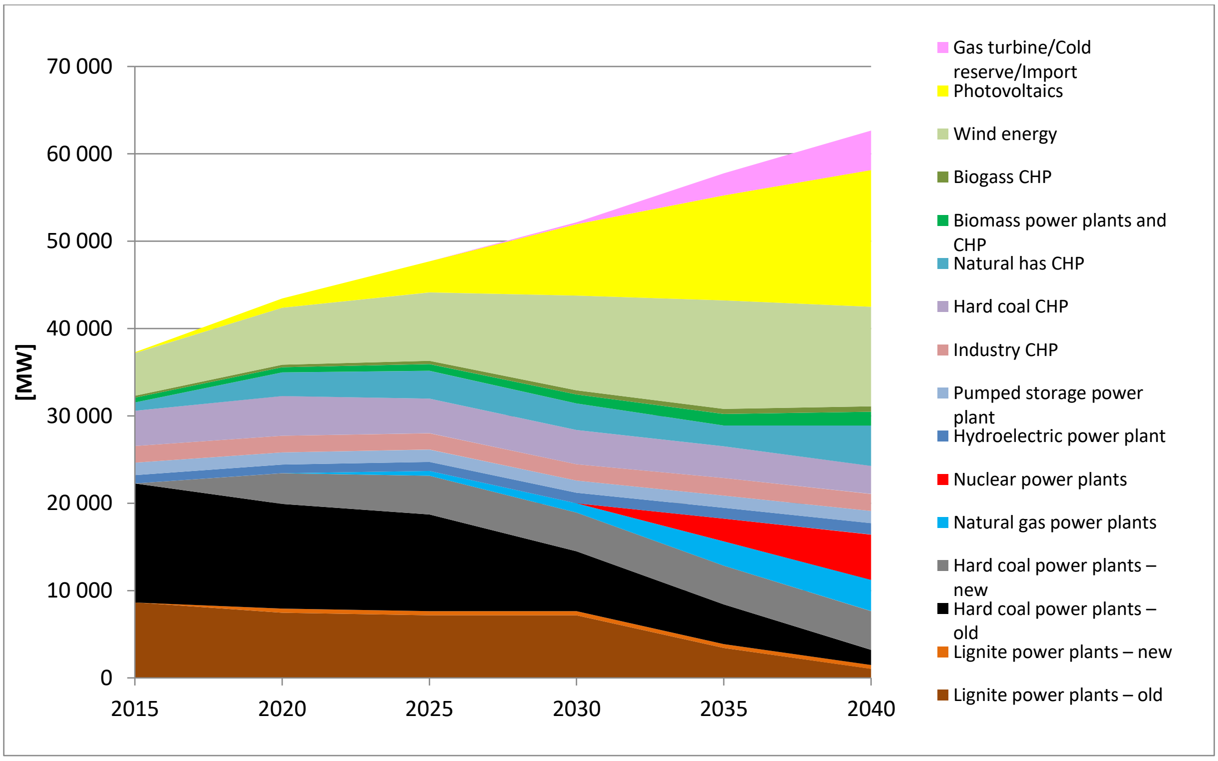


Figure 15 The available capacity of electricity generation by technology

1.5. Dimension „internal energy market"

1.5.1. Electricity interconnectivity

From the point of view of the expansion of cross-border connections - in order to build a single energy market - for Poland the key is to not undermine the safety of our grid system, including avoiding the problem of circular flows. Increasing the capacity of cross-border connections should be realized inter alia through optimal use of existing connections and removing barriers blocking access to the network to market participants, incl. building missing lines within national systems, optimizing the methods of making these capacities available for market participants (introduction of FBA) and, where necessary, installation of phase shifters. In the perspective of 2030, a Union-wide 10-year network development plan assumes:

- improved flow on a synchronous cross-section incl. Germany, Czech Republic and Slovakia (GerPol Investments, GerPol Power Bridge projects);
- synchronization of transmission systems of the Baltic States.

Table 23 Net transmission capacities of electricity interconnections [MW]

PL export	**500/1000**	**1000/1500**	**3300**	**5100**	**5100**	**5100**
PL import	**820**	**1320**	**1820**	**4320**	**4320**	**4320**

1.5.2. Energy transmission infrastructure

1.5.2.1. Electricity transmission infrastructure

Stable and secure electricity supplies depend on a developed national power system (KSE).

The high and the highest voltage transmission network consists of over 250 lines with a length exceeding 14,000 km and 100 highest voltage stations. Currently, Poland has active connections with Germany, the Czech Republic, Slovakia, Lithuania and Sweden (undersea cable), as well as four connections with third countries of which three are closed.

Cross-border connections and the European energy market will constitute an additional source of supply for market development and reduction of energy prices and deliveries in situations of threats and limitations. The security of electricity supply will be based on developed domestic generation infrastructure.

In order to achieve its goals, the TSO will implement activities consisting in the construction, extension and modernization of stations, switching stations, lines and other devices, including reactive power compensation, in the high and the highest voltage range (110, 220-400 kV). In the perspective of 2025, as a result of the implementation of 7 investment programs the key investments are:

- possibility of deriving power from the following power plants: Kozienice, Turów, Bełchatów and efficient power transmission from the Dolna Odra Power Plant, as well as balancing wind farms;
- extension of the network in the north, north-west (where wind farms are particularly eager to be located due to good wind conditions), north-eastern part of Poland as well as above and below the Warszawa-Poznań line;

- better use of the reconstructed Krajnik-Vierraden cross-border connection (improvement of cross-border exchange conditions on the synchronous cross-section - Poland-Germany-Czech Republic-Slovakia).

The certainty of electricity supplies to final consumers depends on efficient and secure distribution. The distribution network (mainly of a radial nature) is longer and much denser than the transmission network, making it more vulnerable to failures. To ensure the highest quality of electricity supply, the following tasks will be implemented:

- By 2025, energy supply quality indicators, i.e. the time and frequency of interruptions in supply (SAIDI, SAIFI) should reach the EU average
- In the perspective of 2022, the reconstruction rate was set at the level of approx. 1.4% per annum (average over the period)
- To achieve greater reliability of network operation, it is necessary to successively implement the medium voltage underground electricity cables. For this purpose, an adequate plan will be developed.

1.5.2.2. Infrastructure for gas transmission

Poland remains largely dependent on gas supplies from abroad, mainly from the east but also from Germany and Czech Republic (in 2017, 78% of consumed natural gas came from imports, 52% from the east). In mid-2016 the regasification terminal in Świnoujście received the first deliveries of liquefied natural gas, which was a huge step towards diversifying both directions and gas suppliers to Poland. In the coming years, the share of LNG in consumption may reach up to 30%. The Polish terminal is a key infrastructure from the point of view of gas supply security not only for Poland but also for neighboring countries.

For further development, it is important to expand the national transmission, distribution and storage infrastructure. The existing Yamalski Contract will end in 2022, therefore actions aimed at diversification of supplies must be completed before the beginning of the gas year 2022/2023.

Further diversification of directions and sources of gas supply will take place through the implementation of two key projects - (I) construction of the Northern Gate and (II) expansion of connections with neighboring countries. Thanks to this, it will be possible to create conditions for the creation in Poland a gas transmission and trading center for the countries of Central and Eastern Europe and the Baltic States. The favorable geographical location of Poland justifies plans to obtain the status of a transit country in the scope of gas transmission in the east-west and north-south axes.

The North Gate is part of the EU infrastructure priority concept, ie the North-South Corridor, which is to connect the gas transmission networks of the countries of Central and South-Eastern Europe and enable gas supplies to this part of Europe from a direction other than the eastern one. It also increases the integration of gas markets and strengthens the security of gas supply in the region. The North Gate is a concept consisting of two elements:

- construction of the Norwegian Corridor - which aims to connect the Polish transmission network with deposits in Norway via the Danish transmission system and submarine connection from Denmark to Poland, which will ensure the possibility of gas transmission from the Norwegian continental shelf. The construction of the connections between Norway and Denmark (Nordic Pipe - Tie-in), Denmark-Poland (Baltic Pipe) and the development of the Danish transmission system will be included in the implementation of this investment. The project will be completed by 2022, it will enable the import of approximately 10 billion m3 of natural gas.

- extension of the LNG terminal - the regasification capacity of the LNG terminal opened in 2016 in Świnoujście is 5 billion m3 / year, which allowed for real diversification. A decision was made to expand the terminal to capacity (collection and regasification) of 7.5 billion m3 annually.

The development of connections with neighboring countries along with the development of the national transmission network and the expansion of gas storage facilities is the second element of the diversification strategy for natural gas supplies, which will also create conditions for market development and the growing importance of Poland as a regional center of gas trade. To increase the possibilities of import and export, Poland will strive to build or expand connections with:

- Slovakia - up to the import capacity of 5.7 bcm and export 4.7 bcm annually (until 2021),
- Lithuania (GIPL) - up to the import capacity of 1.7 bcm and export of 2.4 bcm annually (until 2021),
- Czech (Stork II) - for import capacity 6.5 bcm and exports 5 bcm annually (until 2022),
- Ukraine - up to import and export capacity of 5 bcm annually (by 2020).

The implementation of cross-border objectives must be related to the simultaneous expansion of the national network and storage infrastructure.

The length of the natural gas transmission network is nearly 12,000 km. The national transmission network must allow full use of the import infrastructure. The development of the national gas transmission system in the next few years (until 2022, with the perspective of 2027) focuses on the development of the network:

- in the western, southern and south-eastern part of Poland (from Świnoujście to connections with the Czech Republic, Slovakia, Ukraine) - it will enable gas transmission from the LNG terminal and Baltic Pipe - the pipeline will ensure the use of resources in the country and will also be included in the concept the construction of a regional gas transmission center in Poland and the European North-South gas corridor, which is also a potential opportunity to import gas from the southern direction from new suppliers;
- in the north-eastern part of Poland - it will enable the development of gasification in this part of the country, and will also strengthen the energy integration of the Baltic States with continental Europe.

The expansion of distribution is another element of the development of the domestic network. Currently, Poland is gasified in 58%, the goal for 2022 is to provide access to gas in 61% of communes. In the longer term, the distribution network will be expanded and modernized accordingly to market needs.

From the point of view of energy security, the adequate capacity of underground gas storage (UGS) is very important. The current total capacity of the seven underground gas storage facilities (PMG) is nearly 3 bcm, which is approx. 1/5 of the annual national consumption. The diversified geographic location of existing storage facilities is an advantage that allows the flexibility of the gas system. In order to further increase energy security, it is important to continue expanding UGS to the level of approx. 4 bcm up to the winter season 2030/2031 (increase by 1/3 capacity) and increase the current maximum gas collection capacity from storage facilities - from 48.8 m m^3/day to approx. 60 million m3/day (increase by approx. 1/4 of the power).

1.5.2.3. Electricity and gas markets, energy prices

One of the fundamental changes with regard to the electricity market was the implementation of the Capacity Market Act of 8 December 2017, which aims to ensure medium and long-term security of electricity supply in a cost-effective, non-discriminatory and sustainable way. The capacity market is a kind of public aid in which energy producers receive money not only for the energy they provide, but also for the readiness to supply it. It is to create an incentive to make investment and modernization decisions. The capacity market operates parallel to the electricity market and does not introduce restrictions on price on the wholesale market. The capacity market is technologically neutral, which creates the same competition conditions for all electricity production technologies and DSR services. There have been three auctions so far with delivery dates for 2021, 2022 and 2023. The model calculations take into account the functioning of the capacity market in Poland in the period 2021-2030.

1.5.2.3.1. – Electricity prices by sector

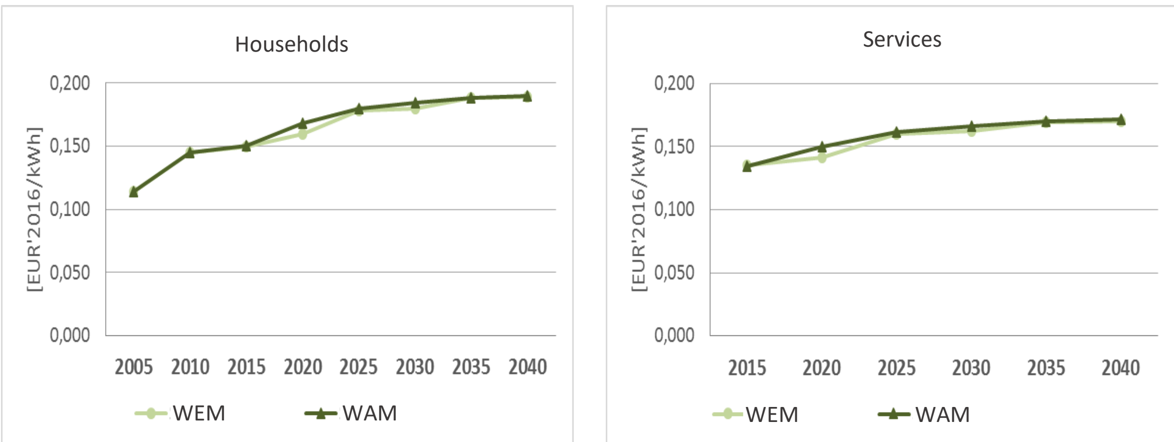
The table below presents electricity price projections of three defined groups of final customers. The shown prices are average prices offered under comprehensive and separated agreements, including taxes (in the calculations the amount of excise duty was set at 0.02 PLN / kWh in current prices and VAT at 23% throughout the forecast horizon). According to the obtained results, a gradual increase in electricity prices is expected in all three considered groups of final consumers. The price increase spreads evenly across sectors, which is a consequence of the assumption of a proportional distribution of the operating costs of all support schemes, with the exception of support for renewable energy (currently the industry is partially exempted from the costs of renewable energy). The main factor determining the forecasted growth are the growing costs of purchasing CO2 emission allowances, as well as the costs of construction and modernization of generating units and transmission infrastructure.

Table 24 Electricity prices by sector [EUR'2016 / kWh]

	2005	2010	2015	2020	2025	2030	2035	2040
Households	0,1142	0,1453	0,1504	0,168	0,180	0,184	0,189	0,190
Services	-	-	0,1346	0,150	0,162	0,166	0,170	0,171
Industry	0,066	0,1001	0,0823	0,109	0,117	0,120	0,124	0,120

1.5.2.3.2. – Comparison of electricity prices - scenario of WAM vs. WEM

The figure below presents a comparison of electricity price projections for individual groups of end users for the WAM scenario and for the WEM scenario. It results in relatively small differences, which leads to the conclusion that the implemented additional policies and measures within the WAM scenario do not significantly affect the increase in prices for end users. A relatively small increase in prices compared to the WEM scenario is the implication of higher costs related to the construction and strengthening of energy infrastructure in terms of development of offshore energy, distributed energy, electromobility, as well as the implementation of smart grid solutions.



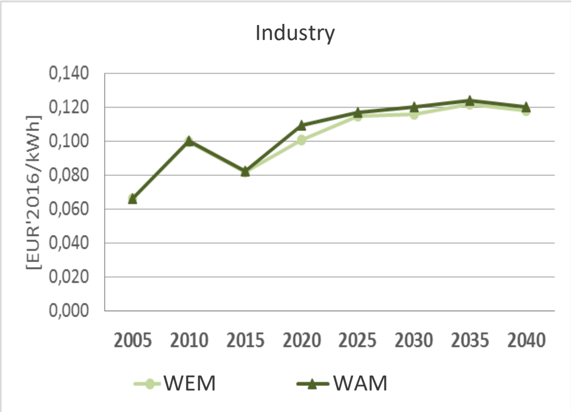


Figure 16 Price comparison for end users - WAM vs. WEM scenario

2. Overview of investment needs

2.1. Current investment flows and assumed future investments in relation to planned policies and measures

Among investment expenditures for the development of the energy sector, were taken into account investments in the electricity, heating, gas, mining and liquid fuels sectors. In the case of the electricity sector, both expenditures for the construction and modernization of the power plant and CHP plants as well as the strengthening of the distribution network for new installations and the development of e-Mobility were taken into account. In addition, the costs related to the installation of meters in 80% of households up to 2026 were taken into account. In the heating sector, in addition to new generation capacities, the development of the distribution network as well as modernization and expansion of heating one were also taken into account. The gas sector includes expenditures related to the development of the distribution network as a result of gasification of subsequent areas of Poland as well as planned investments in the area of transmission network development based on the National Transmission System Development Plan for 2018-2027 for GAZ-SYSTEM. Investment expenditures in the liquid fuels sector are determined, inter alia, by the change in the structure of energy demand in the domestic economy as a result of the development of alternative fuels and an increase in the use of electricity and biocomponents in transport. The development of storage infrastructure and measures to increase production capacity in the petrochemical area was also included. Investment expenditures in mining are based on the programs of the hard coal and lignite mining sectors for Poland. The table below presents the estimated capital expenditure for energy purposes in the domestic economy in 2016-2040. The planned total investment outlays for energy purposes in the horizon up to 2040 amount to approx. EUR 382 billion'2016. Both scenarios (WAM and WEM) are characterized by a similar trend of distribution of investment outlays over the years, however, the level of outlays is higher in the WAM scenario. The next table compares capital expenditures in the electricity generation sector.

Table 25 Projected capital investments for energy purposes in the national economy [EUR million'2016]

	2016-2020	2021-2025	2025-2030	2031-2035	2036-2040	2016-2040
Expeditures in the energy sector	80 147	79 330	78 284	74 543	69 683	381 988

Table 26 Projected capital investments in the electricity generation sector by fuels in the years 2016-2040 [EUR million'2016]

Generation sector	2016-2020	2021-2025	2025-2030	2031-2035	2036-2040	2016-2040
Expenditure in the electricity generation sector	**14 991**	**9 900**	**14 034**	**24 105**	**26 256**	**89 287**
Power plants	10 053	7 085	12 032	22 126	21 625	**72 921**
CHP plants	3 239	2 415	2 002	1 980	4 631	**14 266**
Adjusted to IED/BREF	1 700	400	0	0	0	**2 100**
By fuel						
Coal	9 088	2 418	376	108	0	**11 989**
Gas	1 723	891	458	2 034	3 253	**8 358**
Nuclear	0	0	0	11 700	11 700	**23 400**
Other	423	634	663	440	500	**2 660**
Renewables	3 758	5 957	12 537	9 824	10 481	**42 558**
– Hydro	*77*	*156*	*406*	*167*	*120*	***926***
– Wind	*2 126*	*2 407*	*6 950*	*5 456*	*5 658*	***22 597***
– Photovoltaics	*1 107*	*2 582*	*4 218*	*2 957*	*2 733*	***13 597***
– Biomass	*159*	*440*	*522*	*746*	*1 336*	***3 205***
– Biogas	*289*	*372*	*441*	*498*	*634*	***2 234***

3. Assessment of the impact of the planned policies and measures on regional cooperation and on other Member States

3.1. Impact on the energy system in neighboring countries and on other Member States in the region

3.1.1. Power systems

The development and enhancement of transmission capacities of cross-border connections in Europe is crucial for future energy security. Poland intends to continue active cooperation with neighbouring countries in this regard.

The construction of a power bridge between Poland and Lithuania is one of the most important investments completed in recent years by PSE SA. The main element of the project was the construction of a connection between Ełk Bis station and Alytus station in Lithuania. The total capacity of the connection is 1000 MW (the DC inset installed on the Lithuanian side limits the available capacity to 500 MW). The full use of the link will be possible after the synchronization of the Lithuanian system with the system of Western Europe. In 2017, according to the ERO trade balance, 1,560 GWh of electricity was imported and 498 GWh were exported from the Lithuanian direction.

In September 2018, PSE SA sent an official application to ENTSO-E for synchronization of Lithuania, Latvia and Estonia with the European electricity system. It is assumed that the synchronization project is to be completed by 2025, and the total amount of the project cost will be over EUR 1 billion. The European Union co-financing of investments will be approx. 75% of the value of the project. Signing the agreement between countries was the first step to get funds under the CEF project.

The "LitPol Link" line is currently the only electricity connection between the Baltic States and the Western European grid. The launch of the line made it possible to close the so-called the Baltic Ring. Thanks to this, Lithuania, Latvia and Estonia have gained the possibility of trade with Western Europe. This was the first step towards desynchronizing the Baltic States system from the IPS / UPS system. An EU research center - JRC (Joint Research Center) in February 2017 presented three variants of desynchronization. JRC economic analyzes have shown that the most effective option will be the synchronization of the Baltic countries with continental Europe.

The key role in this scenario will be played by the merger of Poland and Lithuania, and it will be necessary to build a second line between these countries for full synchronization (so called "Harmony Link").

In June 2018, the agreement on the synchronization of the Baltic states with the electricity system of continental Europe in the form of a political road map (Political Road Map) was signed at the level of the Prime Ministers of Poland and the Baltic States and the President of the European Commission.

In the years 2021-2022 it is planned to expand the internal network in the west of Poland. The investments will be part of the "GerPol Improvements" project. An additional benefit resulting from the expansion of the internal network is the improvement of certainty of power output from domestic generation sources.

– The common principle of determining transmission capacity

The division of Europe into the CCR (Capacity Calculation Region) market areas was established in accordance with the ACER decision, and aims to ensure the stability of the connections between the Western and Eastern Europe region in the coming years. In individual regions of CCR, transmission grid operators will jointly determine transmission capacity for the next day. The boundaries of the Polish market area have been assigned to three independent CCRs (Hansa, Core, Baltic). The cooperation of national regulatory authorities is conducted according to working structures, developed on the basis of documents and adopted by regulatory bodies of a given CCR.

Core CCR is the ongoing cooperative activities of 16 TSOs from countries located in the center of Europe, whose task is to connect the Eastern and Western energy markets into one combined system. Poland has electricity interconnections with Germany, Czech Republic, Slovakia, Sweden (connection of Hansa) and Lithuania (the Baltic connection).

In the perspective of 2025, within the CORE area, the FBA (Flow-based approach) methodology should be introduced as a mandatory method for determining transmission capacity. The FBA approach is a method of determining transmission capacity, in which energy exchanges between market areas are limited by the coefficients of energy distribution and available margins on critical network elements. In calculating the level of interconnections of electric power, uncontrolled loop flows should be taken into account.

Currently, the level of capacity measured as the ratio of the transmission capacities available to the installed capacity in generating units in a given Member State, does not take into account structural conditions, which may lead to erroneous conclusions that may suggest the need to build new cross-border connections in places where such capacities already exist. Ultimately, Poland will make an effort to approach the EU target level of 15% of interconnections by 2030. The goal will be achieved, among others thanks to the implementation of projects of common interest to PCI. The European Commission has created a group of 15 top experts from across Europe who will advise on the achievement and operationalization of the target. The report created by this group recommends making the necessary assessment of further capacity increase, using various indicators. Member States (transmission operators), regulatory authorities and European institutions should take the necessary action when one of the three indicators is triggered:

1. Price spread measured on average annual differences in wholesale prices in 2020 - Member States should strive to minimize differences in wholesale market prices. The priority should be the construction of new interconnectors if the price difference exceeds the indicative level of 2 EUR / MWh between Member States, regions or market areas.
2. The ratio of the rated transmission capacity to the expected maximum power demand in 2030,

3. Ratio of rated transmission capacity to installed capacity of renewable sources in 2030.

Poland supports the efforts to create a competitive electricity market within the European Union. At the same time, activities are continuing to ensure that the implementation of the energy union priorities is accompanied by simultaneous maintaining the highest possible level of energy security and ensuring effective use of the existing power infrastructure in the European Union.

In terms of improving the operation of the transmission network by 2030, three projects included in TYNDP2016 are planned (Ten year network development plan):

- GerPol Improvements
- GerPol Power Bridge
- „LitPol Link Stage II"

The currently valid 3rd PCI list of 24 November 2017 covers a total of 173 projects, of which 110 relate to electricity infrastructure and smart grids, 53 to natural gas, 6 to crude oil, 4 to CCS. In the case of projects planned for implementation in Poland, these are Poland's gas connections with Denmark, Lithuania, Slovakia and the Czech Republic, extension of the internal transmission network in the western and eastern part of Poland and expansion of the LNG terminal in Świnoujście. Projects in the field of electricity include electricity interconnections with Germany (with the installation of phase shifters) and connection with Lithuania.

The Stanisławów-Ostrołęka line was in the List of Projects of Common Interest (PCI) within the framework of the Baltic Energy Market Interconnection Plan (BEMIP Electricity). The investment will create conditions for the exchange of electricity with the Lithuanian power system, while ensuring safe operation of this connection. In the first list announced in 2018, eight projects were qualified, for a total maximum amount of EUR 48.4 million. Four of them are power projects, including the line between Stanisławów and Ostrołęka (approx. EUR 3,5 million).

3.1.2. Gas systems

In order to reduce the environmental impact of energy sector, measures have been taken to increase the use of natural gas. Therefore, in order to ensure energy independence and security of supply, regulations have been introduced in accordance with which, starting from 2023, an energy company importing gas from abroad will be obligated to import a maximum of 33% of gas from one direction. Diversification will also apply to gas imported in any other form, including imported CNG and LNG gas, with the exception of gas imported by the LNG terminal in Świnoujście. In 2017, 78% of consumed natural gas came from imports, mainly from the east. Currently, natural gas is imported from Belarus, Ukraine, Germany, the Czech Republic, and through the LNG terminal in Świnoujście from the USA, Norway and Qatar.

In order to increase energy independence and achieve the goals of diversification of gas fuel sources, it is necessary to take regional measures. Such activities should include the development of connections with gas systems of neighbouring countries. To increase the possibilities of import and export, Poland strives to build or expand connections with its neighbours:

- Slovakia - up to the import capacity of 5.7 bcm and export 4.7 bcm annually
- Lithuania - up to the import capacity of 1.7 bcm and export of 2.4 bcm annually
- Czech Republic - up to the import capacity of 6.5 bcm and export of 5 bcm annually
- Ukraine - for the import capacity of 5 billion m3 and exports 5 billion m3 per year

These projects require close cooperation between Poland and neighbouring countries and operators of natural gas transmission systems. In addition, projects are being implemented to increase the possibilities of importing gas from directions other than eastern, such as the LNG terminal and the Baltic Pipe. They fit into the infrastructure concept of the Northern Gate, which is to connect the gas transmission networks of the countries of Central and Southeastern Europe.

All these projects are aimed at making Poland the center of gas transmission and trade, allowing for efficient supply of fuel to Central and Southeastern Europe from the north. For example - according to Naftogaz data, Ukraine has imported on average less than 14 billion m3 of gas annually over the last three years. After completing the above investments, the connection Ukraine with Poland will allow covering 1/3 of this demand, which will positively result in the competitiveness of the gas market in Ukraine. In the case of Slovakia, gas imports in recent years amounted to approximately 4.5 billion m3 per year. The connection with Poland will significantly increase the possibilities of supply diversification. The Czech Republic and Lithuania imports are respectively: 7-8 billion m3 of gas annually and 2.5 billion m3 of gas annually. The above countries mainly import gas originating in Russia. Therefore, regional activities (the Northern Gate) in the gas sector are an important element in diversification of import directions and strengthening regional gas supply security.

In addition, the expansion of cross-border gas connections will allow countries in the region to increase commercial use of natural gas storage facilities. Ukraine has the largest storage potential in Europe (over 30 billion m3) of natural gas. Among the aforementioned countries, Slovakia has storage facilities with a capacity of almost 4 billion m3, the Czech Republic has over 3 billion m3, and in Lithuania there is the possibility of storage of 3.2 billion m3 of natural gas. As a result of the increased capacity of cross-border gas transmission, it will be possible to make commercial storage capacities available.

It is in the common interest of all countries in the region to expand the gas network in order to increase the diversification of natural gas supply directions for the needs of the national economies of the Central and Southeastern Europe. Such activities will allow for increasing energy security in the region and will help stabilize energy prices.

3.1.3. Impact on gas market

The measures taken in the field of gas systems will have a significant impact on the structure of the gas market. Enhanced availability of supply directions in the region will lead to increased competitiveness and stability of gas fuel prices. The investment burden that must be incurred in the gas sector will be partially reduced by the support from European Funds, and in particular by the funds granted as part of the support for common interest projects PCI. This support will allow for partial mitigation of costs in order to rationalize the increase in gas prices for end users.

Currently, natural gas prices for non-industrial customers in the region are very diverse. According to Eurostat data, in the last three years the average prices of natural gas (not including taxation) differed twice in extreme cases. With the exception of the Czech Republic (where the price of gas for the largest non-industrial end users oscillated around EUR 12/GJ), gas prices in the region are lower than the European average. For several years, gas prices in Lithuania have been falling (to the level of 6 EUR/GJ in the first half of 2018), similarly in Slovakia (to 9.6 EUR/GJ). Gas supplies from the Norwegian shelf will allow, in a long-term perspective, to align wholesale prices of gaseous fuel in the region.

3.1.4. Nuclear energy

Nuclear energy is important in Polish energy policy which was emphasized in the document "Energy Policy of Poland until 2030", and then in the draft of "Energy Policy of Poland until 2040" published in November 2018. In addition, in 2014 a multi-annual program was issued under the name "Program of the Polish nuclear energy", which defines the directions of nuclear energy development. Due to the necessity to replace aging generating capacities in the national power system, as well as to cover the increasing demand for energy, it is necessary to invest in new power units. Construction of nuclear power plant in Poland will bring benefits in terms of energy security, diversification of energy mix and reducing the impact of the energy sector on the environment. The nuclear investment will slow down the pace of energy price growth (caused by the CO2 prices) and, in the long run, keep them at a stable level. Nuclear power plants ensure predictability and stability of energy supply. The implementation of nuclear energy will affect the export potential of energy to neighbouring countries, connected by power systems with Poland.

3.1.5. Capacity market

The capacity market mechanism was introduced in Poland on the basis of the Act of 8 December 2017 on the capacity market. In power market auctions may, apart from domestic entities, participate foreign physical generating units and demand reduction located in EU Member States whose electricity systems are connected to the Polish system, i.e. from Czech Republic, Germany, Lithuania, Slovakia and Sweden. Foreign entities must submit to the preliminary auction, which will be held time in 2019. Therefore, the units will join the main auction for 2024 for the first time. For periods from 2021 to 2023, foreign units might participate only in additional auctions. Three geographical zones have been designated in the Act, for which the maximum volumes of Capacity Obligations will be determined each time. The pre-set level is approx. 1 GW.

The possibility of foreign entities participating in the capacity market contributes to the creation of an internal European market.

Poland has ensured the openness of the mechanism for all types of generation capacity suppliers - including for foreign ones, as well as the regularity of conducting and competitiveness of the auction. The capacity market mechanism has been approved by the European Commission, which clearly indicates that it does not threaten the integration of Poland's energy markets with neighbouring countries. It contributes to guaranteeing the security of energy supply, while at the same time ensuring the protection of single market competition, as well as not hindering cross-border electricity flows in the EU.

The capacity market was developed to create an investment impulse to ensure the stability of electricity supply. The development of the current status of generation capacity, in a situation of significant withdrawals of currently operating (old and low-efficient) power units, is of key importance for the reliability of supply and coverage of demand growth. Disturbances in the operation of the power system in Poland could have consequences also for neighbouring countries connected to the National Power System through interconnectors. The capacity market mechanism is designed to prevent such distortions. Support for cross-border power is one of the foundations of integration of the European Union's energy markets.

Ensuring security of supply is based on maintaining a balanced system, continuity and reliability of supplies, but also transparency and competitiveness of the wholesale market. The creation of new and modernization of existing units will contribute to the improvement of technical infrastructure and maintenance of the required power levels. In addition, it will enable stabilization of energy prices on the wholesale market. Maintaining a safe, required level of power in the system will contribute to the construction of a stable European energy market.

The electricity supply in the connected European energy markets support the construction of the energy union. The use of the electricity production potential of neighbouring countries and cross-border trade can bring benefits to all countries concerned, such as increased technological competitiveness and, consequently, a reduction in production costs. The condition for the effective use of production capacities is the elimination of distortions in cross-border trade, the development of transmission networks and the modernization of distribution networks. To better coordinate physical flows and increase trade opportunities between systems, cooperation of neighbouring countries' operators is necessary.

3.2. Impact on regional cooperation

Paris Agreement

Since 2020, developed countries have committed to provide developing countries 100 billion USD a year for investments in energy efficiency and the fight against harmful emissions. Poland is in the group of developed countries and declared at the conference a contribution of 8 million USD. The countries have committed themselves to verify the goals in 5-year cycles. Poland actively cooperates with all states that have ratified the agreement, implementing measures to reduce greenhouse gas emissions, while respecting their socio-economic specifics. He also actively participates in the organization of subsequent climate summits (Poznań, Warsaw, Katowice), whose aim is to achieve progress in creating principles and obligations of implementing the Agreement.

SET PLAN

Poland is currently actively participating in two teams of Temporary Working Groups (TWG) as part of SET (Strategic Energy Technology) Plan. These are TWG Action 6 'Energy efficiency in industry' and TWG Action 10 'Nuclear'. Active participation in the work of other TWG depends on Poland's energy priorities, which will be consistent with the SET-Plan priorities. This means that Poland's priority areas in SET-Plan will be selected based on the state's energy policy.

Baltic Energy Market Interconnection Plan

For activities carried out continuously throughout the period covered by this plan, it is necessary to indicate the monitoring activities regarding the diversification of gas supply sources. Poland assumes further cooperation at the European level as part of BEMIP (Baltic Energy Market Interconnection Plan). The investment projects mentioned above will allow for the implementation of the strategic assumptions of this plan. For this purpose, continuous communication will be carried out between the participants of this initiative. The expected effect will be tightening regional cooperation in the field of energy.

Nuclear Energy

The National Atomic Energy Agency (Państwowa Agencja Atomistyki) is the government administration body established to ensure nuclear safety and radiological protection of the country. This body participates in the creation of international standards and legal acts by exchanging information on nuclear safety with neighbouring countries. Due to the operation of nuclear power plants in close proximity to Polish borders, as well as the planned investment in Poland, cooperation with nuclear regulatory authorities of neighbouring countries is carried out, based on intergovernmental agreements on early notification of nuclear accidents and cooperation in the field of nuclear safety and radiological protection. The National Atomic Energy Agency has concluded agreements with all countries bordering Poland, as well as with Austria, Denmark and Norway.

Poland is an active member of communities, groups, societies such as: European Atomic Energy Community (Euratom), International Atomic Energy Agency (IAEA), Nuclear Energy Agency of the Organization for Economic Cooperation and Development (NEA OECD), Group of Heads of European Radiological Supervisors (HERCA), Western European Nuclear Regulatory Association (WENRA) Council of the Baltic Sea States (CBSR), European Nuclear Security Regulators Association (ENSRA), European Safeguards Research and Development Association (ESARDA).

Open international cooperation in increasing the safety of nuclear power plants allows us to draw on knowledge and experience from other countries and to adopt good practices. Poland believes that international cooperation and the learning process ensure the ability to quickly and effectively implement the best solutions in nuclear power plants. It is planned to further develop cooperation with partners who have extensive experience in supervising large nuclear facilities and continuous development of research and development facilities for nuclear energy.

Within the European Union, Poland participates in the work of the EU Council Working Group on Nuclear Affairs, where legislative and non-legislative documents are discussed. Poland participates in a coalition of pro - nuclear states and performs positions supporting the development of nuclear energy in the EU, investment conditions in the sector and an increase in funds for nuclear research and development.

Poland is also a member of working groups dedicated to Task 10 of the SET-Plan, which is a technological pillar of the European climate and energy policy, ensuring visibility and access to financing for Polish research projects in the field of new technologies (HTR), nuclear safety and radioactive waste management.

Visegrad Group (V4)

In the energy area, Poland also works as part of the Visegrad Group. Joint initiatives are undertaken to create a regional cooperation in the energy field. In order to ensure diversification of gas supplies for the region, cooperation was established for the supply of liquefied gas from the USA. Additionally, as part of the gas project of the north-south corridor, construction of gas interconnectors is planned: Poland - Slovakia, Poland - Czech Republic and Slovakia - Hungary. All four countries of the group take a solidary position in connection with the use of nuclear energy and cooperate in the field of power engineering. These activities are conducive to building energy security in the V4 countries. Coherent definition of goals and their solidarity support the creation of European Union integration and harmonization.

3.3. Next steps

The draft if Poland's *National Energy and Climate Plan for the years 2021-2030* was submitted to the European Commission in January, 2019.

Final version of the Polish NECP will be elaborated taking into account:

- the outcomes of interministerial, public and regional consultations,
- the actualization of national sectoral strategies which are currently under public consultations,
- the European Commissions' recommendations, if applicable.

According to the Article 3 of the Governance Regulation, the final NECP will be submitted to the European Commission by 31st of December 2019.