Ministry of Economy

PROJECTION OF DEMAND FOR FUELS AND ENERGY UNTIL 2030

Appendix 2

to draft "Energy Policy of Poland until 2030"

Warsaw, 10 November 2009

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Introduction

This projection has been drawn up by Agencja Rynku Energii S.A. commissioned by the Ministry of Economy. Only one possibility was considered, namely active implementation of measures provided for in "Energy Policy of Poland until 2030." The main objective of the projection was to confirm if the projected effects of the measures' implementation would allow achieving the assumed objectives between 2020 and 2030. The projection is based on the most recent macroeconomic, strategic, and price assumptions as at the beginning of 2008. As the Council of Ministers approved the document over six months after its assumptions were drawn up, some of them may have expired. Nevertheless, as changes to the assumptions did not impact long term trends and projections, they are considered valid.

The Government does not treat the results of projections of demand for fuels and energy as target values which must be met when implementing the energy policy. Their value is analytical; they confirm appropriateness of policy directions adopted. The energy policy envisages this projection periodically updated with a view to adjusting to new economic conditions.

1. Assumptions of the projection

Strategic assumptions

The projection assumes that the following primary directions of Poland's energy policy, including the European Union's requirements, would be implemented:

- To improve energy efficiency;
- To enhance security of fuel and energy supplies;
- To diversify the electricity generation structure by introducing nuclear energy;
- To develop the use of renewable energy sources, including biofuels;
- To develop competitive fuel and energy markets;
- To reduce the environmental impact of the power industry.

As concerns energy efficiency, the following goals of the energy policy, essential to the projection, have been taken into account:

- To achieve zero-energy economic growth, i.e. economic growth with no extra demand for primary energy;
- Reducing the energy intensity of Polish economy to the EU-15 level.

Both the application was predicted and the impact on the demand for energy was assessed for existing capacity reserves resulting from the market reform of the economy and from other instruments to increase energy efficiency, *inter alia*:

- Extension of the application of energy audits;
- Introduction of energy management systems in industry;
- Introduction of sustainable traffic and infrastructure management in the transport industry;

- Introduction of energy efficiency standards for public utility buildings and facilities;
- Intensification of replacing lighting systems with energy-saving ones;
- Introduction of the white certificates system.

In the area of security of fuel and energy supplies:

- Generally, implementation of the strategic direction which consists in diversification of both primary energy carriers and directions of supplies of these carriers has been taken into account, as well as the development of all available energy generation technologies with reasonable costs, especially of the nuclear energy industry as an important technology of zero emission of greenhouse gases and low sensitivity to an increase in nuclear fuel prices;
- It has been assumed that domestic resources of hard coal and lignite would remain important stabilisers of Poland's energy security. It has been assumed that coal energy sources which are being withdrawn from use would be reconstructed on the basis of the same fuel[1] by 2017 and that a part of baseload CHP plants to be built will be fired with hard coal. Simultaneously, no restrictions were imposed on the increase in the share of gas in the power industry, both in gas-fired units generating electricity in cogeneration with heat as well as in peak sources and reserve for wind power plants.

According to the European Union's expected requirements, it has been assumed that the renewable energy's share in the final energy structure would increase to 15% in 2020 and that the 10% share of biofuels in the transport fuel market would be achieved in 2020. In addition, it has been assumed that forests are to be protected against excessive acquisition of biomass and that agricultural areas would be used in a sustainable way to generate renewable energy, including biofuels, so that no competition between the renewable energy industry and agriculture could occur.

To draw up the projection, the capacity of renewable energy resources according to an expert evaluation by EC BREC IEO[2], commissioned by the Ministry of Economy, was taken into account. The evaluation is a critical synthesis of Polish and foreign estimations of Poland's renewable energy resources to-date. Table 1 sums up the economic potential and plausibility of use (i.e. the market potential) of renewable energy resources to generate electricity, district heating, and produce transport fuels in Poland. Values for 2030 were derived from the expert evaluation by Agencja Rynku Energii S.A., commissioned by the Ministry of Economy, based on assumptions and limitations for respective types of renewable energy sources featured in the study by EC BREC IEO.

[1] With the exception of two units in Dolna Odra Power Plant and one unit in Skawina Power Plant. It is planned that they would be natural gas-fired.

[2] EC BREC IEO, Plausibility of use of renewable energy sources in Poland until 2020, Warsaw, December 2007.

Table 1. Economic potential and plausibility of its use, i.e. the market potential, of renewable energy resources

Potentials of renewable energy resources	Economic potential EC BREC IEO	Market potential until 2020 EC BREC IEO		Market potential until 2030 ARE S.A.	
Hydro power generation	5 TWh	3.1 TWh	1015 MW_e	3.1 TWh	1,015 MW_e
Wind power generation	124 TWh	33.5 TWh_e	15,250 MW_e	40 TWh_e	17,450 MW_e
- inland	105 TWh	31.5 TWh_e	15,750 MW_e	35 TWh_e	17,500 MW_e
- offshore	19 TWh	1.7 TWh_e	550 MW_e	5 TWh_e	1,650 MW_e
Photovoltaics	-	0.005 TWh_e	7 MW_p	0.05 TWh	70 MW_p
Solar thermal	83,153 TJ	19,263 TJ	10,848 MW_t	25,250 TJ	14,145 MW_t
- preparing domestic hot water	36,492 TJ	14,597 TJ	8,100 MW_t	18,250 TJ	10,100 MW_t
- heating	46,661 TJ	4,666 TJ	2,150 MW_t	7,000 TJ	3,250 MW_t
Geothermal power	-	12,367 TJ	1,067 MW_t	20,000 TJ	1,700 MW_t
- deep	-	4,050 TJ	250 MW_t	8,100 TJ	500 MW_t
- heat pumps	-	8,167 TJ	755 MW_t	12,000 TJ	1,100 MW_t
Biomass					
- fuel wood (heat plants)	24,452 TJ	24,452 TJ	1,540 MW_t	24,452 TJ	1,540 MW_t
- dry solid waste (small boilers)	165,931 TJ	149,338 TJ	16,000 MW_t	150,000 TJ	16,000 MW_t
- wet waste – biogas[*)] (cogeneration)	123,066 TJ	72,609 TJ		80,000 TJ	
		8.3 TWh_e	1,510 MW_e	9 TWh_e	1,640 MW_e
		42,711 TJ	2,150 MW_t	47,060 TJ	2,340 MW_t
- energy crops	286,719 TJ	250,307 TJ		286,719 TJ	
- cellulose – cogeneration[*)]	145,600 TJ	109,188 TJ		120,600 TJ	
		7 TWh_e	1,075 MW_e	7,7 TWh_e	1,180 MW_e
		83,990 TJ	3,585 MW_t	92,768 TJ	3,940 MW_t
- corn silage – biogas	81,638 TJ	81,638 TJ		81,638 TJ	

(cogeneration)		9.3 TWh_e	1,690 MW_e	9,3 TWh_e	1,690 MW_e
		48,022 TJ	2,410 MW_t	48,022 TJ	2,410 MW_t
- sugar-starch bioethanol	21,501 TJ	21,501 TJ		21,501 TJ	
- rape biodiesel	37,980 TJ	37,980 TJ		37,980 TJ	
-2nd generation cellulose biofuels	-	-		25,000 TJ	

*) Assumed combination coefficients (relation of generated electricity to heat):

for solid fuel-fired cogeneration systems – 0.3

for biogas-fired cogeneration systems – 0.7

As it was assumed that the market of fuel and energy as well as the system regulating the operation of power enterprises function efficiently, rational behaviour of customers when selecting energy suppliers was used for the calculation model.

In the domain of environmental protection, general assumptions were adopted which take into account the following:

- Charges for CO_2 emissions consistent with arrangements of the European Council and the Parliament of December 2008;Restrictions on SO_2 and NO_x emissions to the levels resulting from current international regulations;Development of low-emission generation technologies as well as combined and dispersed sources.

Macroeconomic projection

The adopted projection of economic growth until 2030, prepared in 2007 by the Gdańsk Institute for Market Economics, has been adjusted due to the current financial crisis and the predicted economic slowdown in the coming years. Both the lower rate of GDP growth in the years 2008–2011, namely: in 2008 – 4.8% (preliminary estimate by GUS), in 2009 – 1.7%, 2010 – 2.4% and in 2011 – 3.0%, and gradual increases over 2012–2020 have been taken into account so that in the years 2020-2030 the GDP would be compliant with the projection by the Gdańsk Institute for Market Economics (Table 2).

Table 2. Synthesis of the projected pace of changes in Gross Domestic Product and value added

	2007-2010	2011-2015	2016-2020	2021-2025	2026-2030	2007-2030
GDP	103.9	105.8	105.2	105.7	104.6	105.1
Value added	103.7	105.6	105.0	105.4	104.4	104.9

It was assumed that in the projection period, services would be the most rapidly developing sector of the Polish economy (Table 3). Its share in value added would increase from 51.7% in 2006 to 65.8% in 2030. The share of industry in value added would decrease from 25.1% in 2006 to 19.3% in 2030. Over the period, the construction industry would retain its share of about 6%. The share of transport would be slightly lower and the share of agriculture would decrease from 4.2% to ca. 2.2%.

Table 3. Share of selected sectors in total value added (%)

	2006*)	2010	2015	2020	2025	2030
Industry	25.1	23.2	22.1	21.3	20.8	19.3
Agriculture	4.2	4.9	3.9	3.5	2.6	2.2
Transport	7.2	6.9	7.2	6.8	6.7	6.4
Construction	6.4	7.4	6.3	8.5	7.2	6.4
Services	57.1	57.6	60.4	59.9	62.7	65.8

*) *Statistical data.*

Projection of fuel prices and taxes on energy

It was assumed that following an adjustment over the years 2009–2010, prices of fuels imported to Poland would be increasing at a moderate pace (Table 4). In addition, it was assumed that in 2010, domestic prices of Polish hard coal would reach the 2010 level of import prices.

Table 4. Projection of prices of basic fuels imported to Poland (fixed prices in USD in 2007)

	Unit	2007*)	2010	2015	2020	2025	2030
Crude oil	USD/BOE	68.5	89.0	94.4	124.6	121.8	141.4
Natural gas	USD/1000m^3	291.7	406.9	376.9	435.1	462.5	488.3
Power coal	USD/t	101.3	140.5	121.0	133.5	136.9	140.3

*) *Statistical data.*

Taxation on energy carriers will be adapted to the requirements of the European Union. Taxes on hydrocarbon fuels and energy will reflect the current structure and increase along with inflation. The excise tax will also be imposed on coal and coke as well as on natural gas, with simultaneous exemption of coal and coke from the excise tax from 1 January 2012 and of natural gas from 31 October 2013.[3]

Availability of primary energy carriers

Despite the limited domestic hard coal extraction capacity in operating deposits, no limitations as to supplies of this energy carrier from large global resources have been

[3] Act of 6 December 2008 on excise tax (Dz.U. [Journal of Laws] of 2009, No 3, item 11).

assumed. Similarly, no limitations as to import of crude oil and natural gas have been assumed. In the projection, both the extraction capacity of lignite in existing mines and prospective deposits of lignite have been taken into account. It has been assumed that over the period under analysis, gradual exploitation of unused deposits would start.

It has been assumed that nuclear fuel would be widely available on the global market, both with regard to supplies of uranium ore and processing capacities of enrichment plants as well as the production capacity of fuel elements of water reactors.

Polish resources of renewable energy including, first of all, wind energy and biomass (energy crops, agricultural, industrial and forest waste, and biogas) have been taken into account during the execution of Poland's commitments foreseen in the draft Directive on the development of the renewable energy industry. Geothermal energy has been taken into account insofar as it may be a reasonable potential of renewable energy for heat generation.

It has been assumed that the balance of electricity exchange with foreign countries would amount to zero.

Environmental requirements

In the projection, it has been assumed that power generation devices of the utility and industrial energy industry would undergo complete technical and environmental modernisation to comply with standards of dust, sulphur dioxide, and nitrogen oxides emission consistent with the Regulation of the Minister of the Environment of 20 December 2005 on standards of emission from fuel combustion installations (Dz.U. [Journal of Laws] No 260, item 2181). Both transitional periods granted as a result of negotiations with the European Union, included in the Treaty of Accession to the EU, and emission caps for all sources covered by the LCP Directive have been taken into consideration. The new draft Directive on industrial emissions (IED Directive), which will make emission norms significantly more stringent, particularly as concerns existing sources, has not been taken into account. Compliance with emission norms for engine vehicles and for sulphur content in transport fuels and heating oils, required pursuant to European Union's regulations, has been assumed.

With reference to CO_2 emission for power generation plants covered by the ETS (Emission Trading Scheme) system, it has been predicted that by 2012 free CO_2 emission allowances would be granted to the extent specified by the Decision of the European Commission of 26 March 2007 and the Regulation of the Council of Ministers of 1 July 2008 on the adoption of the National Allocation Plan concerning Allowances for emission of carbon dioxide for the years 2008-2012 for the Community emission allowance trading system (Dz.U. [Journal of Laws] No 202, item 1248). In this period, the purchase of missing allowances on the ETS market, at the projected price amounting to EUR 25/tCO_2, has been envisaged.

For the period beyond 2013 – according to proposals included in the Climate and Energy Package and in arrangements of the European Council of 11–12 December 2008 as well as in arrangements of the European Parliament on the amendment of the Directive on emission trading of 17 December 2008 – it has been assumed that:

- For electricity sources, both existing ones and those whose construction started before the end of 2008, an obligation to purchase CO_2 emission allowances on auctions will

be introduced and gradually increasing from 30% in 2013 to 100% in 2020; it has been assumed that the rate of the increase would be 1% per year; 10% per year?????

- The power industry would meet the requirements which are essential in order to obtain the European Commission's consent for derogation from the full obligation of purchasing allowances for sources, both existing and under construction, by way of implementation of projects reducing CO_2 emissions at costs comparable to the value of the allowances for which derogations have been obtained;

- For new electricity sources, an obligation to purchase allowances for 100% of CO_2 emission will be introduced;

- Free CO_2 emission allowances will be provided for combined district heat generation in electricity generation plants and in high-efficiency cogeneration installations which generate heat for the heat industry's purposes whose scope would be reduced to 30% in 2020 and to zero in 2027;

- In case of other plants, an obligation to purchase allowances for district heat generation, increasing to 100% in 2027, will be introduced.

It has been assumed that after 2012, the prices of CO_2 emission allowances sold on auctions would amount to ca. EUR 60/tCO_2.

Determined losses and gains in generation capacity in the power industry

The power consumption plan included withdrawals forecast by power companies (Table 5) and determined gains and recovery of generation capacity in base-load power plants (Table 6).

Table 5. Planned and forecast withdrawals of gross generation capacity in base-load power plants [MW]

	2008-2010	2011-2015	2016-2020	2021-2025	2026-2030
Total					
- withdrawals	570	2,898	4,125	2,805	4,527
- deep modernisation	1,702	4,204			
Hard coal					
- withdrawals	330	1,825	2,785	2,805	4,527
- deep modernisation	222	444			
Lignite					
- withdrawals	240	1,073	1,340		
- deep modernisation	1,480	3,760			

Table 6. Determined gains/recoveries of gross generation capacity in base-load power plants [MW]

	2008-2010	2011-2015	2016-2020

Total			
- new capacity/recoveries	1,778	1,980	2,600
- after deep modernisation	992	5,332	
Hard coal			
- new capacity/recoveries	460	1,380	1,700
- after deep modernisation	232	1,392	
Lignite			
- new capacity/recoveries	1,318		500
- after deep modernisation	760	3,940	
Natural gas		200	400

Technological assumptions of the power industry

Technologies which are currently included in published commercial offers have been taken into account during the selection of the optimum structure of new base-load electricity sources. Model calculations for coal units included purchase costs of CO_2 emission allowances. Apart from demonstration facilities, no power plants with CCS installations have been envisaged to be put into operation in the projection period. For nuclear power plants, it has been assumed that they would be equipped with 3rd generation water reactors. It has been assumed that the first unit of the nuclear power plant would be put into operation not sooner than in 2020. Launching further nuclear power plants is to take place at intervals of minimum three years.

The projection assumed the development of high-efficiency heat and electricity cogeneration in utility, industrial, and local heat and power plants. It has been assumed that the system of cogeneration support based on "red" and "yellow" certificates would remain in force. In addition, it has been assumed that:

- Increased demand for heat in industry would be covered in ca. 60% by increased cogeneration of heat in industrial heat and power plants and in ca. 40% by the development of gas and biomass heat plants as well as by the purchase of district heat in accordance with economic criteria;

- Increased demand for district heat in other sectors of the economy would be covered mainly by cogeneration, whereby it has been assumed that the average annual increase in capacity of commercial heat and power plants would not exceed 200 MWe. MWt (heat)?????

2. Methodology behind the projection

To prepare the projection, the methodology used worldwide in studies on energy has been adopted, in which economic growth, described by means of macroeconomic variables, is considered the general driving force behind the increased demand for power.

To prepare the projection of the demand for effective energy, the end-use model called MAED has been applied. In this model, projections of demand for effective energy are created for each direction of the use of energy within each sector of the economy.

The MAED model results are a batch for the simulation energy and environmental model called BALANCE, which determines demand for final energy divided by individual carriers as well as national power consumption plans and pollution emission volumes. The idea behind this model consists in market approach: the activity of each type of energy producers and customers on the energy market is simulated. The effect of the BALANCE model operation consists in the most probable projection of the energy economy's future status with the assumptions adopted and boundary conditions related to primary fuel prices, the state energy policy, technological progress, and limitations in access to energy carriers as well as time limitations in investment processes.

The projection of the demand for individual final energy carriers has been prepared assuming the continuation of the market reform in the national economy and in the energy sector, with consideration given to additional efficiency measures foreseen in Directive 2006/32/EC and in the Green Paper on Energy Efficiency. The draft Act on energy efficiency has also been taken into account.

The projection of the structure of electricity sources with the lowest discounted generation costs has been determined using the WASP IV model. The real discount rate has been adopted at 7.5%.

3. Projection results

3.1. Demand for final energy

The projected increase in final energy use over the period covered with the projection (Table 7) amounts to ca. 29%, whereby the highest increase of 90% is expected in the sector of services. In the industry sector, this increase would amount to ca. 15%.

Over the period covered with the projection, it is expected that final electricity use would increase by 55%, of gas by 29%, of district heat by 50%, of oil products by 27%, and of renewable energy for direct use by 60% (Table 8). Such a high increase in renewable energy use results from the necessity to meet the requirements of the Climate and Energy Package.

Table 7. Demand for final energy by sectors of the economy [Mtoe]

	2006	2010	2015	2020	2025	2030
Industry	20.9	18.2	19.0	20.9	23.0	24.0
Transport	14.2	15.5	16.5	18.7	21.2	23.3
Agriculture	4.4	5.1	4.9	5.0	4.5	4.2

Services	6.7	6.6	7.7	8.8	10.7	12.8
Households	19.3	19.0	19.1	19.4	19.9	20.1
TOTAL	65.5	64.4	67.3	72.7	79.3	84.4

Table 8. Demand for final energy by carriers [Mtoe]

	2006	2010	2015	2020	2025	2030
Coal	12.3	10.9	10.1	10.3	10.4	10.5
Oil products	21.9	22.4	23.1	24.3	26.3	27.9
Natural gas	10.0	9.5	10.3	11.1	12.2	12.9
Renewable energy	4.2	4.6	5.0	5.9	6.2	6.7
Electricity	9.5	9.0	9.9	11.2	13.1	14.8
District heat	7.0	7.4	8.2	9.1	10.0	10.5
Other fuels	0.6	0.5	0.6	0.8	1.0	1.2
TOTAL	65.5	64.4	67.3	72.7	79.3	84.4

Demand for final energy generated from renewable sources will be presented separately in Table 9 divided into electricity, heat, and transport fuels. It is projected that in the period under analysis, the volume of all energy carriers from renewable sources would increase (electricity – almost tenfold, heat – almost twofold, and liquid fuels – by twenty times).

Table 9. Demand for gross final energy from RES by types of energy [ktoe]

	2006	2010	2015	2020	2025	2030
Electricity	370.6	715.0	1,516.1	2,686.6	3,256.3	3,396.3
Solid biomass	159.2	298.5	503.2	892.3	953.0	994.9
Biogas	13.8	31.4	140.7	344.5	555.6	592.6
Wind	22.0	174.0	631.9	1,178.4	1470.0	1530.0
Water	175.6	211.0	240.3	271.4	276.7	276.7
Photovoltaics	0.0	0.0	0.0	0.1	1.1	2.1
Heat	4,312.7	4,481.7	5,046.3	6,255.9	7,048.7	7,618.4
Solid biomass	4,249.8	4,315.1	4,595.7	5,405.9	5,870.8	6,333.2
Biogas	27.1	72.2	256.5	503.1	750.0	800.0
Geothermal	32.2	80.1	147.5	221.5	298.5	348.1
Solar	3.6	14.2	46.7	125.4	129.4	137.1
Transport biofuels	96.9	549.0	884.1	1,444.1	1,632.6	1,881.9
Sugar and starch bioethanol	61.1	150.7	247.6	425.2	443.0	490.1
Rape biodiesel	35.8	398.3	636.5	696.8	645.9	643.5
2nd generation bioethanol	0.0	0.0	0.0	210.0	240.0	250.0
2nd generation biodiesel	0.0	0.0	0.0	112.1	213.0	250.0
Biohydrogen	0.0	0.0	0.0	0.0	90.8	248.3
TOTAL gross final energy from RES	4,780	5,746	7,447	10,387	11,938	12,897
Gross final energy	61,815	61,316	63,979	69,203	75,480	80,551
% share in renewable energy	7.7	9.4	11.6	15.0	15.8	16.0

Meeting the energy policy objective with regard to the 15% share of renewable energy in the structure of gross final energy[4] in 2020 is plausible provided that the development in the use of all types of renewable energy sources, especially wind energy, accelerates. The additional goal regarding the increase of the share of RES in gross national final energy use to 20% in 2030, included in the energy policy draft, will not be plausible due to natural limitations to the development rate of these sources.

In 2030, the share of biofuels in consumption of petrol and diesel oil in 2020 would amount to 10% and ca. 10.4%.

3.2. Demand for primary energy

The projected increase in demand for primary energy until 2030 amounts to ca. 21% (Table 10), whereby this increase is to occur mainly after 2020 due to higher projected GDP increases in absolute terms and the introduction of nuclear power plants whose electricity generation capacity would be lower than that of coal-fired ones. Therefore, it is possible to maintain zero-energy economic growth until ca. 2020, after which a moderate increase in demand for primary energy is expected.

The prices of greenhouse gas emission allowances assumed at the level of EUR 60 '07/tCO_2 are the reason for which the use of hard coal within the structure of primary energy carriers would decrease by ca. 16.5% and of lignite by 23%, whereas consumption of gas would increase by ca. 40%. The increase in demand for gas is the result of the expected civilization-related increase in consumption of this carrier by final customers, expected development of high-efficiency steam and gas technology sources, and the necessity to build gas sources for the power industry to provide peak capacity and reserve capacity for wind power plants.

The share of renewable energy in total primary energy use is expected to increase from ca. 5% in 2006 to 12% in 2020 and 12.4% in 2030.

As concerns the expected developments in the nuclear energy industry, in 2020 nuclear energy is to be included in primary energy structure and in 2030 its share in total primary energy is expected to reach ca. 6.5%.

[4] Gross final energy has been defined in the European Commission's proposal of a new RES Directive as: final use of energy carriers for energy purposes + grid loss of electricity and heat + own use of electricity and heat for generation of electricity and heat.

Table 10. Demand for primary energy divided by carriers [Mtoe, natural units]

	Unit	2006	2010	2015	2020	2025	2030
Lignite*)	Mtoe	12.6	11.22	12.16	9.39	11.21	9.72
	million tons	59.4	52.8	57.2	44.2	52.7	45.7
Hard coal**)	Mtoe	43.8	37.9	35.3	34.6	34.0	36.7
	million tons	76.5	66.1	61.7	60.4	59.3	64.0
Oil and oil products	Mtoe	24.3	25.1	26.1	27.4	29.5	31.1
	million tons	24.3	25.1	26.1	27.4	29.5	31.1
Natural gas***)	Mtoe	12.3	12.0	13.0	14.5	16.1	17.2
	billion cubic metres	14.5	14.1	15.4	17.1	19.0	20.2
Renewable energy	Mtoe	5.0	6.3	8.4	12.2	13.8	14.7
Other fuels	Mtoe	0.7	0.7	0.9	1.1	1.4	1.6
Nuclear fuel	Mtoe	0.0	0	0	2.5	5.0	7.5
Electricity exports	Mtoe	-0.9	0.0	0.0	0.0	0.0	0.0
TOTAL PRIMARY ENERGY	Mtoe	97.8	93.2	95.8	101.7	111.0	118.5

*) *– calorific value of lignite 8.9 MJ/kg*
**) *– calorific value of hard coal 24 MJ/kg*
***) *– calorific value of natural gas 35.5 MJ/m3.*

3.3 Demand for electricity

Table 11 presents gross domestic demand for electricity divided by components. It is expected that the final demand for electricity would moderately increase from ca. 111 TWh in 2006 to ca. 172 TWh in 2030, i.e. by ca. 55%, due to the projected use of the existing market transformation reserves and efficiency-oriented measures in the economy. The demand for peak capacity would increase from 23.5 MW in 2006 to ca. 34.5 MW in 2030. The demand for gross electricity would increase from ca. 151 TWh in 2006 to ca. 217 TWh in 2030.

Table 11. Domestic demand for electricity [TWh]

	2006	2010	2015	2020	2025	2030
Final energy	111.0	104.6	115.2	130.8	152.7	171.6
Power sector	11.6	11.3	11.6	12.1	12.7	13.3
Grid loss	14.1	12.9	13.2	13.2	15.0	16.8
Net demand	136.6	128.7	140.0	156.1	180.4	201.7
Own needs	14.1	12.3	12.8	13.2	14.2	15.7

Gross demand	**150.7**	**141.0**	**152.8**	**169.3**	**194.6**	**217.4**

Due to environmental requirements, nuclear power plants, whose development pace is limited for organisational and technical reasons, are expected to be included in the optimum structure of electricity sources in terms of costs (Tables 12–14). It has been assumed that the first nuclear power unit would be ready in 2020. By 2030, three nuclear power units would operate at total net capacity amounting to 4,500 MW (4,800 MW gross).

Meeting European Union objectives with regard to renewable energy would require generation of gross electricity from RES of ca. 31 TWh in 2020, which would account for 18.4% of total generation, and 39.5 TWh in 2030, which accounts for ca. 18.2% of total generation. The largest share would be achieved by energy from wind power plants – ca. 18 TWh in 2030, which would account for ca. 8.2% of projected total gross generation.

Generation of electricity by way of high-efficiency cogeneration is expected to increase from 24.4 TWh in 2006 to 47.9 TWh in 2030. The share of generation of electricity by high-efficiency cogeneration in domestic gross demand for electricity would increase from 16.2% in 2006 to 22% in 2030.

Table 12. Generation of net electricity divided by fuels [TWh])

	2006	2010	2015	2020	2025	2030
Hard coal	86.1	68.2	62.9	62.7	58.4	71.8
Lignite	49.9	44.7	51.1	40.0	48.4	42.3
Natural gas	4.6	4.4	5.0	8.4	11.4	13.4
Oil products	1.6	1.9	2.5	2.8	2.9	3.0
Nuclear fuel	0.00	0.00	0.00	10.5	21.1	31.6
Renewable energy	3.9	8.0	17.0	30.1	36.5	38.0
Pump water	0.97	1.00	1.00	1.00	1.00	1.00
Waste	0.6	0.6	0.6	0.6	0.7	0.7
TOTAL	**147.7**	**128.7**	**140.1**	**156.1**	**180.3**	**201.8**
Share of RES energy [%]	2.7	6.2	12.2	19.3	20.2	18.8

Table 13. Consumption of fuels for electricity generation (including combined electricity and heat generation) [ktoe]

	2006	2010	2015	2020	2025	2030
Hard coal	25,084	20,665	18,897	17,722	16,327	18,331
Lignite	12,517	11,091	12,036	9,266	11,095	9,615
Natural gas	961	970	1,094	1,623	2,114	2,473
Oil products	533	591	732	791	806	837
Nuclear power	0	0	0	2,515	5,030	7,546
Renewable energy	703	1,461	2,912	5,128	5,995	6,212
- *Water*	174	209	239	270	275	275
- *Wind*	22	174	632	1,178	1,470	1,530
- *Biomass*	458	943	1,566	2,693	2,749	2,805
- *Biogas*	48	135	475	986	1,500	1,600
- *Solar*	0	0	0	0	1	2
Waste	144	154	162	168	185	201
Total fuel consumption	39,942	34,933	35,832	37,213	41,552	45,215

Table 14. Generation capacity of gross electricity [MW]

Fuel/technology	2006	2010	2015	2020	2025	2030
Lignite – PC boiler/fluidized-bed furnace	8,819	9,177	9,024	8,184	10,344	10,884
Hard coal – PC boiler/fluidized-bed furnace	15,878	15,796	15,673	15,012	11,360	10,703
Hard coal – CHP	4,845	4,950	5,394	5,658	5,835	5,807
Natural gas – CHP	704	710	810	873	964	1,090
Natural gas – GTCC	0	0	400	600	1,010	2,240
Large water	853	853	853	853	853	853
Pump water	1,406	1,406	1,406	1,406	1,406	1,406
Nuclear	0	0	0	1600	3200	4800
Industrial Coal – CHP	1,516	1,411	1,416	1,447	1,514	1,555
Industrial Gas – CHP	51	50	63	79	85	92
Industrial Other – CHP	671	730	834	882	896	910
Local Gas	0	0	22	72	167	278
Small, water	69	107	192	282	298	298
Wind	173	976	3,396	6,089	7,564	7,867
Solid biomass – CHP	25	40	196	623	958	1,218
Biogas CHP	33	74	328	802	1,293	1,379
Photovoltaics	0	0	0	2	16	32
TOTAL	35,043	36,280	40,007	44,464	47,763	51,412

3.4. Projection of electricity and district heat prices

It is expected that prices of electricity and district heat would increase significantly due to enhanced environmental requirements, particularly charges for CO_2 emission allowances and higher prices of primary energy carriers (Tables 15 and 16).

Table 15. Prices of electricity [PLN'07/MWh]

	2006	2010	2015	2020	2025	2030
Industry	233.5	300.9	364.4	474.2	485.4	483.3
Households	344.5	422.7	490.9	605.1	615.1	611.5

Table 16. Prices of district heat [PLN'07/GJ]

	2006	2010	2015	2020	2025	2030
Industry	24.6	30.3	32.2	36.4	40.4	42.3
Households	29.4	36.5	39.2	44.6	50.5	52.1

Costs of electricity generation are expected to increase rapidly in 2013 and 2020 as 30% of energy generated in 2013 and 100% of that generated in 2020 will be subject to the obligation to purchase greenhouse gas emission allowances. If this increase is transferred to electricity prices, then, at the assumed price of allowances amounting to EUR 60'07/tCO_2, it is expected that prices for the industry would increase from ca. PLN 304 '07/MWh in 2012 to ca. PLN 356 '07/MWh in 2013 and from ca. PLN 400 '07/MWh in 2019 to ca. PLN 474 '07/MWh in 2020. After 2021, the price would remain unchanged or decrease slightly thanks to the introduction of nuclear energy.

District heat prices are expected to rise more monotonically as generation of district heat for the heat industry will gradually be subject to the commitment to purchase greenhouse gas emission allowances.

3.5. Energy intensity of the economy

Table 17 presents the projected energy intensity and electricity intensity of the GDP.[5] It is expected that primary energy intensity per GDP unit would significantly decrease from ca. 89.4 toe/PLN million '07 in 2006 to ca. 33.0 toe/PLN million '07 in 2030. Moreover, electricity intensity of GDP would decrease from 137.7 MWh/PLN'07 in 2006 to 60.6 MWh/PLN'07.

The level of the economy's energy efficiency corresponding to the average level of efficiency in EU-15 countries in 2005 (177.4 toe/$ million '00) will be reached at the very end of the projection period.

[5] According to Eurostat methodology, energy intensity of GDP is the quotient of the use of primary energy and GDP, while electricity intensity of GDP is the quotient of the use of gross electricity and GDP.

Table 17. Energy intensity and electricity intensity of GDP

	2006	2010	2015	2020	2025	2030
Energy intensity [toe/PLN million '07]	89.4	73.1	56.7	46.6	38.6	33.0
Electricity intensity [MWh/PLN million '07]	137.7	110.4	90.4	77.8	67.8	60.6

3.6. Emissions of CO_2 and air pollutants: SO_2, NO_x, and dust

Table 18 summarises projected domestic emissions of three main air pollutants (sulphur dioxide – SO_2, nitrogen oxides – NO_x, and dust) as well as carbon dioxide – CO_2 related to combustion of fuels as charge during industrial processes.[6]

Emission of CO_2 will be significantly decreasing from ca. 332 million tons in 2006 to ca. 280 million tons in 2020. The decrease in emission, when compared to emission in 1990,[7] amounts to ca. 15% despite the 11% increase in demand for final energy over the period. It will result from increasing use of energy from renewable sources and cogeneration, from the increase in consumption of biofuels by the transport industry, from the increase in consumption of natural gas in all sectors, from the improved efficiency of electricity and heat generation, transmission and distribution, as well as from the launch of the first nuclear power plant in 2020. After 2020, emission of CO_2 would be gradually increasing, however, owing to introduction of further nuclear power units, emission would exceed 300 million tons only in 2030, still remaining about 8.5% lower than 1990 emission.

It is projected that the decrease in emission of SO_2 in the next decade would be high – by more than 60% when compared to 2006. With the adopted assumptions, emission of SO_2 would decrease from 1,216 kt in 2006 to ca. 480 kt in 2020 and further to 450 kt in 2030. The emission cap resulting from the 2nd Sulphur Protocol (national emission of sulphur oxides below 1,398 kt by 2010) is easy to achieve. Nevertheless, the SO_2 emission cap for large combustion plants, adopted as a result of accession negotiations pursuant to Directive No 2001/80/EC (reduction of sulphur dioxide emission to the level below 454 kt in 2008, 426 kt in 2010, and 358 kt in 2012), will not be reached in 2008 even in spite of all measures taken. It is possible, however, that it would be reached in the following years.

The emission cap for nitrogen oxides resulting from the 2nd Nitrogen Protocol (national emission below 880 kt by 2010) will be achieved. On the other hand, maintaining emission of NO_x from large combustion plants below the caps specified in the Treaty of Accession to EU (254 kt in 2008, 251 kt in 2010, and 239 kt in 2012) would be more difficult to achieve – in 2008, the cap would not be achieved, whereas in the years 2010–2012 achieving required caps will probably be a consequence of lower demand for energy as a result of the projected economic slowdown. Ensuring achieving of required caps, similarly as in the case of SO_2 emission, in fact means shortening the derogation periods provided for in the Treaty of Accession. Significant decrease in emission from large sources may be expected only after 2015. National emission of NO_x would decrease from 857 kt in 2006 to ca. 650 kt in 2020 and further to 630 kt in 2030.

[6] Data after the *Projection of demand for fuels and energy until 2030*, ARE, March 2009.

[7] CO_2 emission in Poland amounted to ca. 368 million tons in 1990.

Emission of volatile dusts will be significantly decreasing as factors positively influencing reduction in sulphur emission are also conducive to reducing dust emission; this relates in particular to reduction in coal use in small combustion sources. The decrease in emission after 2015 would also be a result of tightening emission norms planned by the European Commission (proposal for a new IPPC directive).

Table 18. Emissions of CO_2, SO_2, NO_x, and dust

CO_2 emission [million tons]	**2006**	**2010**	**2015**	**2020**	**2025**	**2030**
Country	331.9	299.1	295.7	280.3	294.7	303.9
- growth rate (2006=100)	*100.0*	*90.1*	*89.1*	*84.5*	*88.8*	*91.6*
Energy industries	188.5	170.3	167.7	148.7	154.1	157.2
including Utility electrical power industry	151.0	131.7	130.1	110.6	114.2	115.7
Heat plants	13.1	13.7	13.7	12.9	13.9	14.8
SO_2 emission [thousand tons]	**2006**	**2010**	**2015**	**2020**	**2025**	**2030**
Country	1,216.4	733.1	588.6	477.8	451.3	447.5
- growth rate (2006=100)	*100.0*	*60.3*	*48.4*	*39.3*	*37.1*	*36.8*
Energy industries	866.2	460.4	357.4	268.2	252.4	253.2
including Utility electrical power industry	717.0	337.7	267.9	193.4	182.0	180.7
Heat plants	69.1	53.3	35.1	24.4	23.6	25.2
Large combustion sources	784.1	392.1	311.4	228.0	213.3	213.0
NO_x emission [thousand tons]	**2006**	**2010**	**2015**	**2020**	**2025**	**2030**
Country	857.4	786.7	725.6	651.6	636.5	628.6
- growth rate (2006=100)	*100.0*	*91.7*	*84.6*	*76.0*	*74.2*	*73.3*
Energy industries	316.8	266.8	240.9	197.6	203.5	203.0
including Utility electrical power industry	252.7	207.1	176.9	124.8	121.5	117.2
Heat plants	28.5	27.6	29.9	26.8	29.1	31.3
Large combustion sources	284.5	235.0	204.3	152.5	150.1	146.7
Dust emission [thousand tons]	**2006**	**2010**	**2015**	**2020**	**2025**	**2030**
Country	279.5	246.1	218.2	196.7	187.7	182.8
- growth rate (2006=100)	*100.0*	*88.0*	*78.1*	*70.3*	*67.1*	*65.4*
Energy industries	56.7	46.7	39.8	35.0	31.5	29.7
including Utility electrical power industry	38.9	29.2	26.5	22.5	20.9	18.7
Heat plants	8.1	7.8	6.3	5.3	3.1	3.4

Data for 2006 provided by Agencja Rynku Energii S.A.