EUSUSTEL

European Sustainable Electricity; Comprehensive Analysis of Future European Demand and Generation of European Electricity and its Security of Supply

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WORK PACKAGE 1

County-wise Analysis

Subtask 1.13.b

POLAND

ir. L. Cosijns - KUL
Prof. Dr. Ir. W. D'haeseleer - KUL
Prof. P. Capros - NTUA

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1. Energy-related and socio-economic analysis: past, present and future

1.1. Factual information

1.1.1. Geography & population

Poland has a surface area of 312685 km², which is mainly flat. There are only mountains at the Southern borders. Heights vary from -2 m to 2499m. The coastline with the Baltic Sea extends over 491 km. Poland's winters are cold and moderately severe, with frequent precipitation. Its summers are mild.

Poland counts 38.6 x 10^6 inhabitants and approximately 14 x 10^6 households. The resulting number of persons per households is higher than the EU-average.

1.1.2. Economy

Liberalisation started in 1990, which replaced gradually the historical central planned economy. Among the several transition economies in the Central European region, Poland did a good effort, but there is still a lot of work to do.

Over the last few years unemployment was persisting reaching a rate of 20% but economic growth was rather fast, reaching 5% in 2004. GDP[1] in 2005 is estimated to exceed 230 x 10^9 EUR, but GDP per capita remains small (around 5850 EUR/capita) if compared with the average of EU-15 (around 25000 EUR/capita). Since 1990, the share of industry in the GDP has decreased dramatically (around 25% in 2005), while the share of services is growing, account for the major part to the GDP (exceeding 65% in 2005). Agriculture's share in GDP is rather stable at 5%.

1.1.3. Energy

The trends in the energy demand are closely related to the economic evolution. The decline of industrial activity was more pronounced in the energy-intensive industry, a trend which explains the drop of the share of industrial energy demand in total final energy demand (from 40% in 1990 to less than 28% in 2005).

The restructuring of the Polish economy further explains the fast growing energy demand in the transportation sector and in the services buildings. Similarly, given that electricity demand per capita is still one third compared to EU-15, electricity demand grows fast, reaching an average growth rate higher than 2.5% yearly in average.

The use of primary energy per capita is only 58% of the EU-15 in average, but is expected to grow twice faster than in the EU-15. On the contrary, Poland's primary energy use per GDP is two and a

[1] A list with abbreviations can be found at the end of this document.

half times higher than at the EU-15 in average, which is due to the low level of GDP, as compared with EU-15, and the relative inefficient use and conversion of energy in Poland. However, since 1990, all energy efficiency indicators for industry and houses have been halved, reflecting the restructuring away from energy intensive industries and the improvement in terms of rational use of energy in houses which has been also influenced by the increase of end-use energy prices. The energy efficiency indicators in the transportation and tertiary sectors also showed progress over the last fifteen years, but at a lesser degree since energy needs in these sectors grow fast driven by the overall changes in the economy. Despite this progress, a significant potential for further improvement in terms of energy efficiency exists in Poland.

On the energy supply side, Poland has large endowments of coal (both hard coal as lignite) and has natural gas as well. These coal endowments have a large influence on the energy balance, and as a consequence on the environmental issues as well.

Estimations of Polish fossil reserves:

- Coal: 65 Gt (8^{th} coal exporter on world scale) which implies more than 450 years of reserve at current utilisation level; however at current coal prices and given the considerable needs of investment in new coal mines, the economically exploitable reserves might only last for approximately 30 year (till 2030);
- Lignite: 14 Gt which also may last long (200 years) which are produced at lower cost than coal but need considerable investment for mining and environmental protection; therefore the economically exploitable potential heavily depends on environmental considerations;
- Oil: 15 Mt which is very small compared with annual consumption;
- Gas: 150 Gm^3 the exploitation of which also depends on investment and the prices of gas imported from Russia and other origins; currently annual production of gas does not exceed 4 bcm, but the government seeks for increasing domestic production over the next years.

In Poland, district heating is an important factor in the energy balance. Up to 70% of the heat demand in towns is supplied by district heating. As a result, in combination with more local heat sources in the rural areas, up to 40% of the residential houses are heated by district heating. This is three times more than EU-average. However, the heat supply sector requires considerable investment for modernization, efficient pricing and energy efficiency improvement.

Although endowed with large domestic energy resources, Poland is expected to increasingly depend on imported energy over the next future. This is a combined result of the slowdown of domestic coal production and the increase in the use of oil and gas. Poland, being a transit country in the commerce of oil and gas from the East to West, would be well placed to obtain economically attractive contracts for gas supply. In fact, Poland has been already engaged in long term contracts for imports of more than 8 bcm per year, of which 5.7 bcm will be supplied by Gazprom and 2 bcm by Gasunie. According to the Polish energy plan, careful consideration is given to develop an LNG supply facility and open a gas storage site. These actions illustrate concern about security of gas supply and seek to diversify the future imports of gas to Poland.

Import dependency of Poland, being 11% in 2000, may quadruple over the next twenty years. This explains the policy priorities in the national energy plan which emphasize on the development of modern infrastructure (mines, gas exploitation, biomass, refinery, etc.) in order to maintain the domestic energy supply levels.

The main energy balances and indicators are summarised in the table below (based on baseline scenario from [1]).

[PJ][2]	2000	2005	[PJ]	2000	2005
Gross Inland Consumption (=TPES)	**3779.58**	**3752.7**	**Final Energy Demand (TFC) by Sector**	**2363.34**	**2344.02**
Solids	2365.86	2106.72	Industry	823.62	733.74
Oil	840.42	904.68	Residential	722.82	732.9
Natural gas	417.9	540.96	Tertiary	420.42	445.62
Nuclear	0	0	Transport	396.48	396.48
Electricity	-23.1	-23.1	**Final Energy Demand (TFC) by Fuel**	**2363.34**	**2344.02**
Renewable energy forms	178.5	223.86	Solids	560.7	445.2
Net Imports	**9.63**	**18.30**	Oil	663.18	689.22
Import Dependency [%]	**10.7**	**20.4**	Gas	307.02	357
Energy Intensity Indicators (1990 = 100)			Electricity	349.44	380.1
Industry (Energy on Value Added)	58.6	43.9	Heat	288.96	275.94
Residential (Energy on Private Income)	67.6	59.7	Other	193.62	196.14
Tertiary (Energy on Value Added)	72.6	65.8			
Transport (Energy on GDP)	86.9	81.9			

1.1.4. Electricity

In 2004, 147 TWh of electricity were produced in Poland of which 11 TWh were exported. In the same year, 4.3 TWh were imported, making Poland a net exporter of electricity (6.7 TWh in 2004). Domestic electricity consumption was 140.3 TWh in 2003, and final electricity consumption was 111 TWh. The installed power generation capacity of about 32.3 GW is mainly based on coal and lignite firing plants (88%). The capacity of hydro plants parties less than 1 GW and the rest is mainly covered by gas-fired plants, including two new gas combined cycle plants. Electricity produced by RES is negligible.

Although, there are currently no nuclear power plants in Poland, and despite the lack of experience, the nuclear option is seriously considered in Poland, given the prospects for a slowdown of domestic coal/lignite production and the stringent environmental restrictions imposed after the adhesion to the EU.

[2] Based on conversion 1toe = 42×10^9 J

A part of 32% of installed power capacity produces electricity and heat. At present, 19% of electricity produced comes from cogeneration plants which supply the 58% of total heat/steam delivered.

January peak amounts to 23 GW and the overall load factor of electricity demand is just above 55%. It is expected that the load factor will decrease over the next future as a result of the changing structure of electricity uses.

The existing Polish generation park is really antiquated with more than 50% of the park built before 1970. The combination of the age and the use of coal/lignite in most of the plants imply severe overload of the environment by Poland's electricity production. Because of resource abundance and its low cost, coal/lignite plants are of course attractive for Poland, nevertheless considerable amounts would be needed for investment to improve over the environmental implications (in particular the regional pollutants), given also the capital intensiveness of environmental friendly solid fuels plants.

The main electricity balances and indicators are summarised in the table below [1].

	2000	**2005**
Electricity Generation [TWhe]	**143.17**	**154.19**
Nuclear	0.00	0.00
Hydro & wind	2.11	3.82
Thermal (incl. biomass)	141.06	150.37
Electricity Generation [Gwe]	**33.12**	**36.04**
Nuclear	0.00	0.00
Hydro (pumping excluded)	0.87	0.96
Wind and solar	0.00	0.82
Thermal	32.25	34.26
Of which cogeneration units	8.60	8.18
Open cycle	32.13	30.11
Supercritical Polyvalent/Clean Coal and Lignite	0.00	0.00
Gas Turbines Combined Cycle	0.12	3.31
Small Gas Turbines	0.00	0.84
Fuel Cells	0.00	0.00
Geothermal Heat	0.00	0.00
Average efficiency for thermal electricity production [%]	**35.0**	**38.7**

1.1.5. Environmental issues

As mentioned before, the rich coal endowments put a huge load on the environment, both by the mining industry as by the electricity production. Moreover, Poland has still a lot of heavy industry, which is not an advantage for energy efficiency and use.

Poland is one of the biggest emitters of SO_x in the EU and comes after the Czech Republic with the 2nd biggest energy intensity of the 12 most populated EU countries. Poland's high CO_2-emissions, compared to its relatively low GDP, puts it on a 4th place on the EU-ladder.

The main balances and indicators concerning the CO_2-emissions are summarised in the table below [1].

	2000	2005
CO_2-emissions [Mt of CO_2]	**290.2**	**272.5**
Electricity and Steam production	159.9	149.7
Energy Branch	10.9	10.4
Industry	46.4	38.9
Residential	26.7	24.9
Tertiary	19.7	19.5
Transport	26.5	29.1
CO_2-emissions Index (1990 = 100)	**85.3**	**80.1**
Carbon intensity [t of CO_2/toe of GIC]	**3.22**	**3.05**
CO_2-emissions/Capita [t of CO_2/inhabitant]	**7.51**	**7.08**
CO_2-emissions to GDP [t of CO_2/MEUR '00]	**1.5**	**1.2**
Carbon Intensity indicators		
Electricity and Steam production [t of CO_2/MWh]	0.67	0.61
Final energy demand [t of CO_2/toe]	2.12	2.01
Industry	2.37	2.23
Residential	1.55	1.43
Tertiary	1.97	1.83
Transport	2.81	2.83

1.2. Trends [2]

Growth rates [% per year]	'73-'90	'90-'03
TPES	**0.4**	**-0.6**
Coal	0.1	-2.3
Oil	1.2	3.8
Gas	2.1	1.8
Comb. Renewables & Wastes	3.4	5.5
Nuclear	-	-
Hydro	-0.2	1.3
Geothermal	-	-
Solar/Wind/Other	-	-
TFC	**0.1**	**-0.7**
GDP	0.8	3.2

2. Policy

2.1. General framework

Poland's energy policy fits in the EU-integration and the fulfilment of international obligations concerning environmental issues on air, water, river… pollution. The recent study "Polish Power to 2030" [15] stresses on the five pillars for Polish energy policy:

- Security of supply
- Economic efficiency
- Environmental efficiency
- Social involvement (counting on a big DSM-potential)
- Technological excellence (development of clean coal-technologies which put Poland at the front)

An integrated policy which combines environmental, economic and social issues is necessary. Without threatening the competitiveness of Poland, economic and energetic growth needs to uncouple.

Because of the huge coal reserves of Poland, security of supply is less an issue compared to other EU-countries (which will be heavily dependent on Russian gas). The "dash to gas" fails to occur and the government keeps on promoting the use of coal. But as a result, the reversal to a low carbon economy becomes more and more difficult (financially, socially…). Policy makers postpone decisions which make it harder and harder to take them.

On the energy front, several players are responsible for different issues. The Ministry of economy, labour and social policy is responsible for the general energy policy (including energy-efficiency), where the Ministry of environment is in charge of the creation and implementation on climate policy. In 1994, the Polish National Energy Conservation Agency (KAPE) was founded. This non-profit organisation is active on RUE- and RES-issues and links non-governmental and governmental organisations with regulatory bodies, energy distribution sector and other energy users. Its strategy is to develop and promote governmental, regional, local and individual initiatives on energy-efficiency and RES. The Executive Office for the Climate Convention (EOUNFCCC) monitors among others the commitments concerning Kyoto and the National Atomic Energy Agency (NAEA) is responsible for issues on atomic energy.

In the light of the liberalisation of the energy market, the Energy Regulatory Office (URE) was founded in 1996. It searches for equilibrium between market control and liberalisation. With its regulations, it has to offer security to the incumbent players, but with enough incentives to maintain the reliability of the energy supply, with protection of the consumers and without to high threshold for newcomers to enter the sector.

The URE is active on different energy markets: electricity, gas, heat and liquid fuels. For all different branches, it is responsible for licensing, tariffication, network access, control of quality and reliability (by putting standards, investment obligations, charges, penalties…), protection of the final consumer interests… The latter is of major importance as households in Poland (as in other Central European countries) use 10 to 15% of their monthly budget for energy services[3].

With the foreseen Polish market evolutions on transport, "tertiary comfort", appliances in the service sector… and in combination with the current low energy prices (which gives not the right incentive to save on energy), a strong, coherent energy policy will be necessary to put Poland on the right track.

2.2. Electricity policy

Since August 1998, liberalisation started in the electricity sector. Depending on their consumption, consumers are free to choose their supplier. In December 2005, all consumers become eligible. As liberalisation takes place in all energy branches, it is worth shortly mentioning the situation on gas, liquid fuels and heat production, before treating the electricity sector in detail.

In the gas market, one player stays dominantly present. The Polish Oil and Gas Company (PGNiG S.A.) controls - by itself or by subsidiaries – the exploration, mining, fuel production, transport, distribution and trade (both wholesale as import). Even though some competition arises on all the different branches, PGNiG remains the dominant player.

At the transmission level of liquid fuels, there is only one company which has access to the grid, which is dependent of high security constraints. On the lower level of trade (both on national as on trans-national" level) there is a lot of competition, which can be explained by the lower financial threshold.

Since 1990, local authorities have taken over the heat production by district heating. At some places even privatisation occurs. CHP-installations play both a role in district heating as in electricity production. The have to be retained, but upgrading of the CHP-plants, as well as of the heat distribution network, is necessary. Even though the liberalisation process is happening, it takes off laboriously. Heat sector faces the challenge to match heat and power demand to react on people's tendency to local heat sources.

In the electricity sector, production, transmission, distribution and trade are unbundled. At the production level, there are two main players (PKE and BOT) in charge of the power plants. PSE S.A. is the operator of the Polish transmission grid. At the same time, it is the main wholesaler of electricity in Poland. On the distribution level, there are more players. At the beginning of liberalisation, there were more than 30 distribution companies, but consolidation among several companies takes place more and more. In this way, the resulting larger companies become more cost efficient by which they can challenge large foreign companies. Funds are raised for further investments in the consolidation process.

[3] In EU-15, this is only a rate of 3 to 5%. By this, price levels can only by changed gradually (e.g. internalisation of all costs) and the most vulnerable consumers need to be protected.

Trade happens on three levels. The first and the biggest level is the *contract market*. Up to 85% of the energy production is treated by long term (existing bilateral) contracts. Discussion is going on on how to change those non-competitive long term contracts in more competitive ones.

In 2000, a power *exchange market* was established. It only deals with 10 to 15% of the energy production, which means that its turnover stays very modest. The remaining 5% is treated on the hourly-based balancing market. The transmission system operator (PSE S.A.) matches the differences between the contract and exchange market.

Poland and other Central European countries have more overcapacity compared the EU-15 member states (38% of the total installed capacity versus 26%). As a result, incumbents can provide the market of cheap electricity, which makes it hard for newcomers to enter the electricity market. It is the URE's responsibility to prevent abuse by dominant incumbent players by a good regulation.

As mentioned before the Polish electricity park is mostly outdated. Huge investments (up to 10 to 40 billion euro [15]) in production, transmission and distribution capacity are necessary to fulfil the current and future demand while accounting the stringent environmental regulations. Demand is expected to rise to 300 TWhe in 2030 (which means a needed installed capacity of 70 to 100 GWe). This is a challenge for Poland, but it can result in a technological leap, which puts Poland at the front of clean coal technologies, high efficiency…

Investments in nuclear capacity are not foreseen in the current context, but if environmental regulations become more stringent and demand keeps on rising, the option in not excluded just like that.

2.3. Environmental policy

Because of the central planned economy (with a five year scope on energy matters), as mentioned in the report of WWF [8], Poland's energy housekeeping is very inefficient and it suffers with a high energy intensity. Due to the combination of a transition to a market economy, more services and less heavy industry, energy intensity will automatically decrease[4]. Anyhow, the WWF stresses on more political initiatives to reduce the inefficiency even more. It states that according to a conservative study of the European Commission, Poland can economicly reduce its energy consumption by 30% by making use of best available technologies (even with the current low energy prices). To stimulate this, both Polish government as the European Commission will have to invest in energy efficiency programs.

[4] Between 1990 and 1995, total energy consumption has decreased 12% and 40% for the industry. At the same time, energy consumption has risen 30% in the transport sector. According to [15], primary energy use has declined by 37% between 1990 and 2000, while at the same period GDP has increased by 44.6%.

In the “Guidelines for Poland’s Energy Policy until the year 2020 [14]”, written in 2000 and confirmed in 2002, increasing energy efficiency is set as a target. By direct regulations and standards, economic and fiscal market stimulation and other supporting instruments (e.g. information, education, R&D…), promotion of efficient power machines, of rational heat and electricity consumption and of RES and other non-conventional energy sources is envisaged.

Poland aims for a use of renewable energy sources of 7.5% in 2010 and 14% in 2020 (in its “Development Strategy for the Renewable Energy Sector” at [14]). A first step towards this target was the 2003 ordinance of the minister of economy, labour and social policy, in which he obliged the acquisition of RES and CHP-power. Neither the form of the RES, nor the price to pay for it, was specified. Consumer and producer were free to negotiate. Since 2004, a green certificate system is operational.

Regarding the supply potential of renewable energy resources, Poland is endowed with significant resources of biomass and energy from waste and has a rather high wind potential. The hydro resources are rather limited.

The additional potential of hydroelectric energy concerns the exploitation of micro hydro stations not exceeding 5 MW each. The potential for hydro would not be higher than 1000 GWh per year.

Biomass is the most promising renewable energy source for Poland. At present more than 1000 GWh of electricity are generated from cogeneration plants using biomass/waste of a total capacity of 150 MW. The technico-economic potential would theoretically be higher than 40,000 GWh per year (almost 10 GW capacity of power generation) from biomass related to paper and pulp, forest, wood processing, urban waste and mainly new crops.

The development of wind power is rather limited, at present (98 MW in 2005). However the potential is considerable, according to the wind atlas for Poland which indicate that up to 10 GW on shore and 10 GW offshore wind power plants may be built under mildly favourable economic conditions. The potential for offshore wind power plants is particularly promising, provided that the technical feasibility in terms of grid connectivity is ensured.

Between 1988 and 1999, CO_2-emissions have increased by 33%. Even before (since 1980), emissions have declined. As a consequence, Poland does not have to fulfil stringent Kyoto targets, and even more, it has been granted emission rights. Within the European Emission Trading System, Poland can sell those rights and use the revenues as an investment source for RES, energy efficiency programs… [15]. Up till now, in contrast with some other Central European countries, Poland has not profit of this opportunity.

Concerning the SO_x and NO_x-emissions, Poland suffers with the stringent EU-regulations. It has already done good efforts, but one expects more regulations in the future. To treat this issue in a cost effective way, maybe an emission trading system (similar to the CO_2-ETS) is an option, but nothing has been decided yet as studies are going on.

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4. Abbreviations

bcm – billion (10^9) cubic meter
CHP - Combined Heat Power
DSM – Demand Side Management
EOUNFCCC - Executive Office for the Climate Convention (EOUNFCCC)
ETS – Emission Trading System
GDP – Gross Domestic Product
GIC – Gross Inland Consumption
KAPE - Polish National Energy Conservation Agency
NAEA – (Polish) National Atomic Energy Agency
PGNiG S.A. - Polish Oil and Gas Company
RES - Renewable Energy Sources
RUE - Rational Use of Energy
TFC – Total Final Consumption
TPES – Total Primary Energy Supply
URE – (Polish) Energy Regulatory Office
WWF – World Wide Fund