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A contribution of the centralised energy sector to the preparation of the Polish long-term energy vision

Key words

Energy sector, emission of NO_x, SO_x, CO_2, modelling

Abstract

The Polish centralized energy sector is at a major crossroad: it should meet the rocketing energy demand while most of the power production fleet has to be retrofitted in the next 20 years. This tremendous challenge should be perceived as a real opportunity to construct the new sustainable energy sector that will fulfil the future generation needs while securing the economical competitiveness, meeting the environmental European requirements and insuring the social cohesion.

Thus, Poland should elaborate a long-term energy policy to deal optimally with the two major environmental issues

"Traditional pollutants" emissions' reduction (i.e. SO_x, NO_x) and dust. Poland should meet the requirement from the LCP Directive and the associated Accession Treaty targets which are inadequate with the Polish power sector idiosyncrasy. Contrary to its European peers, it still exists in Poland many Small Coal Combustion Installations (SCIs: less than 50 MWth) such as individual boilers or local district heating ones, which are not taken into account by these European policies. As a consequence and to economically and environmentally optimised the investments to be done, both LCPs and SCIs have to be taken into account not only for the targets to be reached in the 2008–2012 period, but also for the mid 2015–2020 term for which new NEC and LCP Directives are nowadays being prepared. As a large share of the existing capacities will have to be replaced after 2012, it would be especially counterproductive to put the effort in the 2008–2012 period only on the LCP units and doubtless more relevant to centre the efforts on the SCIs. In other words both versions (from 2001 and the new ones in preparation at EU level) of the LCP and NEC Directives should be analysed together as their implementations in Poland are strongly connected.

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CO_2 emissions' reduction: the challenge is quite similar, as the European Union Emissions Trading Scheme (EUETS) only refers to installations larger than 20 MWth. It could be likewise more efficient to deal with the innumerable SCIs which are outside of the embraced field but of course covered by the Kyoto protocol targets.

All the stakeholders of the energy sector will benefit from such a common policy negotiated with the European Union under the control of the Polish Administration. As explained in this paper, such a policy could enable to save up to €67 billion – compared with a Business-As-Usual scenario – and to gain €16.8 billion thanks to the Kyoto allowances surplus which could be sold on the international carbon market. This could fund and generate self-financing to take up the energy challenge outlined above.

It can be concluded that relaxation of short-term constraints on Polish $SO_x$and NO_x and CO_2 emissions for the centralised heat and power sectors will avoid non-justified expenditures in these sectors. The comprehensive long-term energy policy to be established should allow these cost savings to be invested in long-term retrofits that will consider the different options to reduce CO_2 emissions in the power sector and as well the other gases emissions in the domestic heating sector, which generates the most harmful low-stack emissions. This global approach is likely to generate better development scenarios meeting the European as well as the Kyoto targets.

This paper was first drafted in the first quarter of 2006 thanks to a collaboration of the stakeholders: F. Pchełka (TGPE), M. Niewiadomski, S. Poręba (BOT), K. Szynol, G. Paluch (PKE), G. Wolf, B. Decourt, S. Błach, Z. Krzemień (EDF), I. Grela, D. Taras (Electrabel). It was finally decided to publish the present version which is slightly updated in order to speed-up the discussion with other stakeholders from: the centralised energy sector, the gas and mining industries, the National Administration and the Academician sector.

Executive summary

Despite its radical transformation since the late 1980s, the Polish energy sector still faces a major crossroad: during this phase of economic convergence with its European peers, the demand for power is rocketing while simultaneously a large part of the existing power production fleet has to be decommissioned.

Moreover, Poland remains highly dependent from solid fuels: 63% of primary energy and 97% of national power are produced from solid fuels. If huge resources of hard coal and lignite still exist, the country should deal with two major environmental challenges: SO_x/$NO_x$and CO_2 emissions' reduction.

Both Large Combustion Plants and Small Combustion Installations should be taken into account to optimise the reduction of traditional pollutants (SO_x, NO_x and Dust) and CO_2 within the framework of an Integrated Environment Impact Assessment Analysis.

SO_x and NO_x emissions

Despite the huge environmental efforts that have been done and continue to be implemented in Poland, constraints still exist on Large Combustion Plants (the LCPs units, i.e larger capacity than 50 MWth), which have to fulfil the SO_x and NO_x targets from the Accession Treaty to be reached in 2008, 2010 and 2012. These policies are not enough taken into account the Polish power sector idiosyncrasy: contrary to its European partners, it still exist in Poland many small combustion installations (SCIs, lower than 50 MWth) which are not embraced in the above mentioned targets.

Therefore, an Integrated Environment Impact Assessment Analysis (IEIAA) taking into account both LCPs and SCIs should be carried out to clearly present the relative environment and health benefits which could be achieved by implementing more or less stringent emission constraint scenarios for the LCP sector only, and for the total emitters. In other words, both the LCP and the National Emission Ceiling (NEC) Directives should be considered together to optimise the short- and long-term investments to be done in different sectors. This should avoid large non-justified expenses that could be done immediately in the LCP sector which will burden the national economy.

What's more, the higher costs of energy that would be generated by these non-justified investments done in the old LCP units that have to be retrofitted anyway, will as well make the poorest people to switch back again to cheaper and more polluting heating fuels in their individual boilers, and will then burden health and environment which for sure is not the aim of the LCP Directive.

CO_2 emissions

The challenge is quite similar regarding CO_2 emissions' reduction. The CO_2 allowances allocated within the framework of the 2008–2012 National Allocation Plan (NAP2) only refer to installations covered by the EU Emission Trading System (i.e with a capacity larger than 20 MWth). Though, the installations with a capacity below 20 MWth emit CO_2 too, especially in Poland, as they are still using huge amounts of coal. Therefore, a global approach of these installations is likely to generate better development scenarios, meeting the European as well as the Kyoto targets.

Significant possibility exists in Poland to decrease specific CO_2 emissions. However, to avoid heavy distortion of the national economy, the CO_2 emissions cutting should be achieved in a foreseeable future, mainly between 2012 and 2025 when the existing plants will have to be decommissioned, in other words after the first Kyoto period of 2008–2012.

So in our mind, this IEIAA should simultaneously take into account:

— the four main pollutant emitted into the atmosphere i.e. SO_2, NO_2, dust (while differentiating the PM 10 & 2.5 shares which are the most health harmful) and CO_2,
— all sectors i.e. not only the large combustion plants (LCPs), but also the small combustion installations (SCIs) and other emitters from transport and agriculture.
— the technical-economical timetable for the decommissioning of the existing capacities versus the market availability of the new technologies, such as those allowing CO_2 capture & sequestration (CCS) and nuclear.

These IEIAA could result in reviewing the long-term energy policy, in order to make the required political choices regarding the preferred future primary energy mix, and to achieve the energy safety and social cohesion goals, while meeting the environmental objectives. On this basis, a comprehensive long-term and stable energy development strategy, which is essential to create the confident climate to secure the huge investments, could be elaborate.

This policy should clarify the direction foreseen by the National Authorities in agreement with the EU policies and give the right signals to investor. At least, it should contain:

— a thematic Strategy on Air Pollution (TSAP) up to 2020, taking into account the revision of the National Emission Ceiling (NEC) and the Large Combustion Plant (LCP) Directives. In our mind, this TSAP should propose a revision of the calendar and/or ceilings for the yearly fluxes of SO_x and NO_x emissions allowed for LCPs in 2008, 2010, and 2012 in the Accession Treaty of Poland to European Union,
— a long-term climate change policy that will:
  – help primary energy savings (PES) through efficient production, transport, and use of energy,
  – foster the development of CHP and renewable energy sources (RES),
  – promote the development of CCS technologies and consider the nuclear power option.

Moreover, the paper is quantifying this strategy. It also presents potential development scenarios, which cumulated will make possible to reduce CO_2 emissions to c.a. 250 Mt in 2030 compared to the 600 Mt that will occur in the Business As Usual (BAU) case. This will result in a yearly average CO_2 cost saving for the Polish economy of c.a. €2.4 billion per year for the next 25 years, or €67 billion for the 25 years period (see Table 1 hereafter). The paper shows also that these scenarios could enable the Polish Government to sell for €16.8 billion of CO_2 Kyoto allowances (AAUs) on the world carbon market.

Through adequate legal instruments and/or market rules these revenues could be partly or totally used to subsidise the expected measures required to implement such a policy. For instance, they could be redistributed for:
— longer-term investments within the public transmission & distribution infrastructures or the new clean technologies in the LCP sector,
— switching the local coal-fired SCIs to more efficient systems, such as further connections to centralised CHP plants or retrofitting to new technologies
— replacement to gas or even electricity heating when other options are not economically viable
— …

Unfortunately, such an integrated long-term energy policy as well as the associated clear and steady regulations and market rules could not be ready before the next 2008–2012 NAP period. In any case it’s nevertheless worth working on it and we do hope this paper will serve to pave the way in fulfilling this objective.

For a quick executive overview of the document, please read as well the three first paragraphs and the conclusion.

Aim of the document

This paper proposes a draft of a long-term development vision for the Polish energy sector, which is needed to tackle the challenges that Poland is facing, especially to fit with the European policies.

The main aim of this paper is to share such a common vision between the main stakeholders of the energy sector and other industry associations if possible (steel, chemical, cement, paper, glass…) in this phase of preparation of the 2008–2012 CO_2 National Allocation Plan (NAP) as requested by the European Emission Trading Scheme (ETS). As far as possible, the long-term vision presented here tries to cover as well the other key topics for which the Polish Administration will have to present its policy to the European Commission in the next months or years. They mainly concern:

— the elaboration of the Thematic Strategy on Air Pollution for 2020 (TSAP),
— as requested in the Accession Treaty, the strategy to be prepared in 2008 to reduce SO_x and NO_x emissions at lower levels than those requested for the LCPs into the Accession Treaty,
— as requested by the "Quality Cogeneration" Directive, the strategy to be prepared by the beginning of 2007 for the cogeneration (CHP) development,
— the status of development of renewable energy sources (RES),
— …

Once validated by the main associations which represent the centralised energy sector in Poland, i.e. TGPE, PTEZ and if possible IGCP, the aim will be to improve and validate this draft by an expert consulting company or association. Final aim will be to forward this vision to the national authorities (Polish Ministries of the Economy and Environment…) in order to serve as a base of discussions to establish the official long-term integrated energy policy and stable regulations that will help creating the confident enough climate for long-term investments either for the EU structural funds or for the public and private investors.

1. Introduction

The economic convergence of Poland with its European peers will indispensably result in a growth of energy consumption. Nowadays consumption of gas and electricity per capita in Poland is 40 to 50% below the European average. In a period of such intensive economic development, actions aiming at separating the GDP growth from the growth of total primary energy demand would allow, among others, improving Poland's energy security as wished by the European policy.

Savings in primary energy could mainly result from a better use of energy for heating and transport purposes. It will be difficult to reduce much the increasingly growing demand for electricity as the economic convergence will likely be accompanied by the mutation of the today economy, mainly based on heavy industry, towards a more service-based economy, which is more electricity demanding (see Jestin, Wolf et al. 2004a. 2004b).

That is why it is estimated, hereafter in the Business As Usual (BAU) scenario, that in 2030 Poles could consume 60% more primary energy (from 90 Mtoe in 2000 to 140 Mtoe in 2030) and more than twice more electricity. Then taking into account the electricity efficiency achievements, i.e. –1.2% per year up to 2030 (see Jestin, Wolf at al. 2004b), the domestic production of electricity could be limited to 330 TWhe in 2030 which should be compared to the 156 TWhe produced in 2005.

During the same period, a large share of the existing power fleet will have to be retrofitted and new capacities to be built. Today Poland is at a crucial crossroad, for which decisions that will be taken will influence the few next generations. This challenge can be seen as an opportunity if a comprehensive energy policy is prepared to propose solutions for the mid-term problems without burdening the longer term.

2. European policy orientations

Nowadays numbers of discussions are going on to set a European energy policy that embraces issues and goals of all Member States. This policy aims mainly at guarantying the European economic competitiveness and energy security of supply while keeping the social cohesion in and between the Member States.

— The economic competitiveness should be served by the liberalisation of gas and electricity markets and the Lisbon strategy by fostering research and development, technology transfer, etc.
— Energy security will be notably served by primary energy savings (PES) through an efficient use of energy by finding a better Demand Side Management (DSM) and by a production from new power plants (supercritical, gasification…);
— Efficient transmission energy systems for electricity gas and heat: transfer and use of energy
— Development of cogeneration (CHP) and renewable energy sources (RES).

Last but not least, this European policy aims as well at protecting the environment, with its three main components: climate change, biodiversity and air quality. Mitigation of the climate change is treated through the UNFCCC and its Kyoto Protocol, which led as well to the European Directive on the CO_2 Emission Trading Scheme (ETS). Concerning the biodiversity preservation, the energy sector is mainly impacted by the UNCLRTAP and its 8 international protocols and set of European Directives. The LCP and NEC Directives have a major impact on the Polish energy sector as regards the $SO_x$and NO_xemissions that have to be tackled for a reduction of acidification and eutrophisation of soils and water. The improvement of air quality, which mainly impacts our health, is driven by the European programme CAFE (Clean Air For Europe) whose conclusions will help defining the TSAP. It might result, on one hand, amending the 2001 versions of LCP and NEC Directives by proposing – likely in 2007 – new ceilings for already regulated pollutants (SO_x, NO_x and dust) and by introducing limitations for new pollutants (heavy metals and fine particle matters PM2.5 & PM10); on the other hand, it may lead to adoption of new Directives, on SCIs for example.

In Poland, the implementation of these European policies must be carefully analysed in parallel with the small emitters in order to avoid huge non-justified short-term investment costs, Directives which mainly cover the larger emitters of pollutants and as a result a high price of the energy for customers without any improvements from an environment protection point of view. For this purpose, a study should be made to prepare the long-term energy development policy that will integrate all these topics. Then, a clear and shared strategy should be prepared with the needed regulations and market rules to be implemented.

3. Global energy demand

The Figure 1 below describes the 2000 energy flows in Poland and EU-15. Thanks to its production based on domestic solid fuels, Poland enjoys a better energy self-sufficiency than the EU-15 (88% versus 53%). In 2000, 63% of the total Polish primary energy consumption and 97% of the electricity produced, came from hard coal and lignite.

A Polish specific feature is the large share of electricity produced in cogeneration in Poland, which is close to 20%. Thanks to that, the centralized production sector (heat, electricity) reaches an average efficiency of 52%, above the EU-15 average, which is 46%.

Beside, still 15 million tonnes of coal are burnt for direct domestic purposes (i.e. households, agriculture…), which correspond to approx. 20% of the domestic demand for coal, and generate a large part of the total national pollutants emitted in the atmosphere.

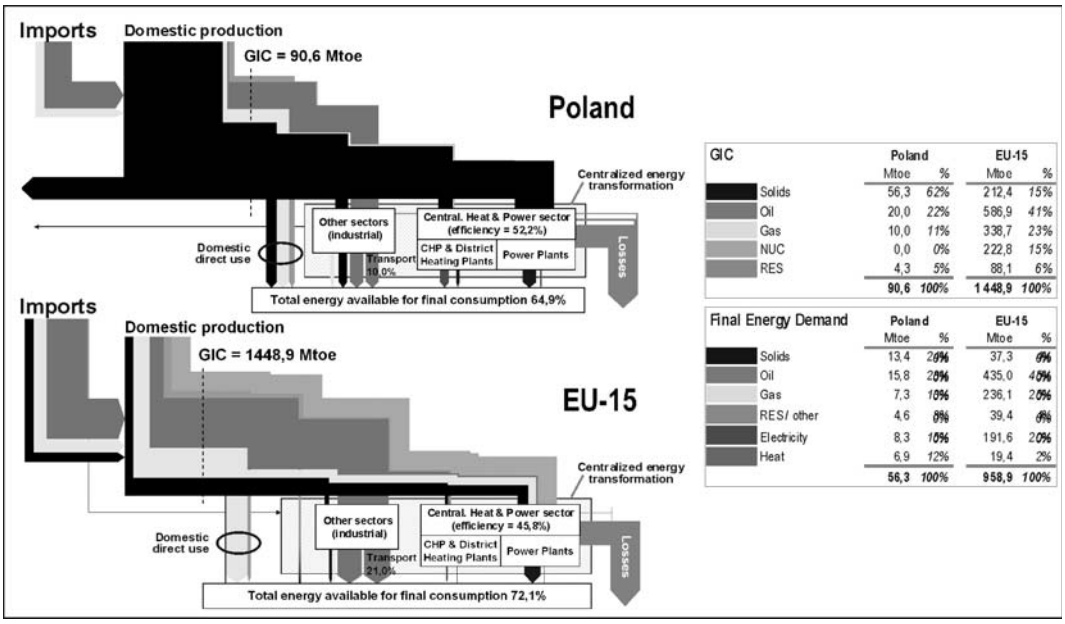


Fig. 1. Flow of primary and secondary energy for Poland and EU-15 average in 2000, million toe (sources: EDF Polska, ARE, GUS, Jestin, L., Wolf, G.& Al., 2004b; European Energy and Transport, 2003)

Rys. 1. Przypływy strumieni energii pierwotnej i wtórnej dla Polski i 15. Krajów UE w roku 2000, miliony toe

4. Status of Polish power sector and future needs

The Figure 2 below shows the historical power production in Poland since 1930 till today, with breakdown into plant types: hydro power plants, SCIs, and LCPs including hard coal fired CHP plants, hard coal fired power plants, and lignite fired power plants. It shows as well how around 60% of the LCP units have been transformed into “clean” units in the late 90’s, based on the various technologies available for desulphurisation such as: circulating fluidized bed boilers (CFB), dry flue gas desulphurisation systems (DFGD), semi-dry FGD (SDFGD) or wet FGD (WFGD). At the same time, most of the units were as well equipped with low-NO_xburners.

Despite these huge efforts made over the last decade to reduce pollutant emissions in order to comply with the first version of the LCP Directive of 1988 (€8 billion were invested in LCPs), Poland remained at the very beginning of the 21st century the largest SO_xemitter in Europe with 1.5 million tonnes emitted yearly. But efforts are being pursued now during the preparation of the CO_2 NAP-II, especially in the power sector where the less SO_xemitting units are proposed to be allocated with more CO_2 credits, according to the brand new allocation method proposed by the power sector.

The Figure 2 also indicates forecasts of decommissioning of the production plants. The study is based on a detailed analysis of technical parameters of nearly 450 units. Calculations are based either upon a 40-year or 50-year period of plants operation. It is assumed as well that the construction of desulphurisation systems was accompanied by retrofits that allow prolonging the lifecycle of the plants by 15 years, which makes a total period of either 55 or 65 years of operation for these modernised units. The study also assumes the commissioning of additional 2.2 GWe before 2010 (with the latest available information now we likely except most of these new plants to on line by 2012 or later): 833 MWe in Bełchatów, 450 MWe in Pątnów, 460 MWe in Łagisza, 240 MWe in Halemba and 250 MWe in Ostrołęka A. These two latter units will retrofit existing ones.

As it can be seen in the Figure 2, it is expected that all the power plants, which are not equipped with desulphurisation systems, will be decommissioned before 2020. This is in agreement with the derogations that most of these installations have got into the Accession Treaty. These derogations allow not fulfilling the LCP Directive 2001/80/EC requirements up to 2016 or 2018, respectively for SO_x and NO_x emissions.

Cutting power production or SO_x& NO_x emissions!

The Figure 3 shows the power generated by the existing power fleet, which is nowadays operated with a power capacity factor of c.a. 57%. One will notice that the plant lifetime assumed in this Figure 3 is 50 years and not 40 years as it was as well presented in the Figure 2. From 2005 the power that could be generated by the existing power fleet and the few new units to be commissioned before 2010 (i.e. 2.2 GWe) is calculated for three capacity factors (i.e. 57% as previously, 40% and 75%). The associated levels of $SO_x$and NO_x emissions that this power generation will produce for these three capacity factors in the period 2005–2030 is as well shown.

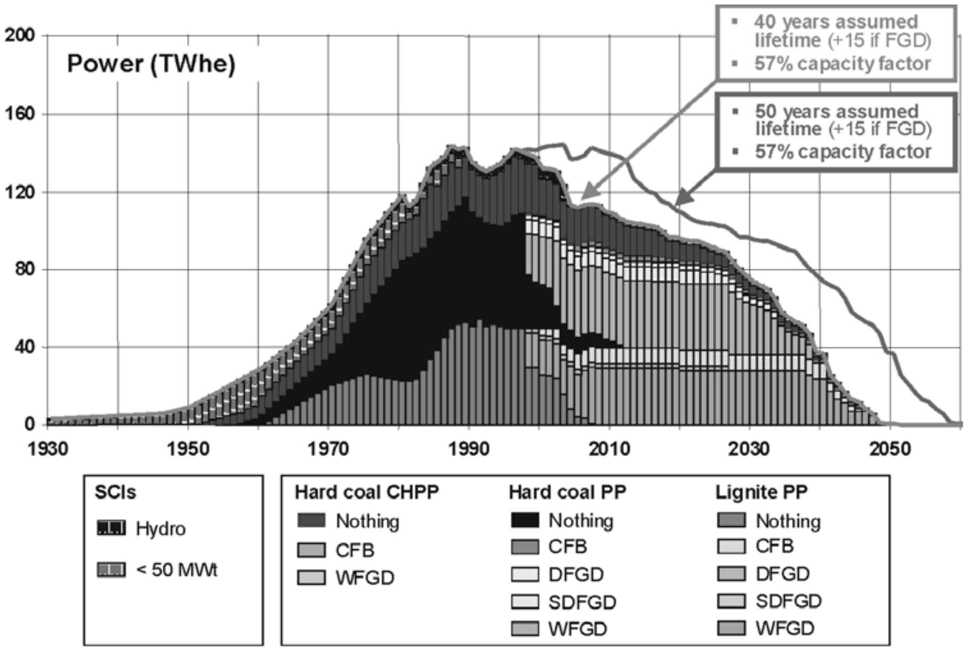


Fig. 2. Historical power production and planned natural decommissioning of plants (source: EDF Polska calculations)

Rys. 2. Produkcja energii w przeszłości i planowane w przeszłości wycofanie instalacji z użycia

As it can be seen in the Figure 3, it seems to be possible to meet the national electricity demand up to approx. 2010–2012 only with (i) reduction of international power export and (ii) a large increase of the capacity factors for power and CHP plants from about 57% today up to, if possible, an estimated maximum of c.a. 75%. Since such a high capacity factor will be really difficult to reach, it is likely to happen a shortage in power production before 2010, unless additional new capacities will be built. In that respect, the only possibility will be to construct gas-fired units, for which the erection duration could fit the timetable. But then the electricity production cost is likely to double compared to the production cost associated with the existing units. Today we can no more expect to have long-term contracts to guaranty the paybacks of these investments, and the market power price does not allow at all such gas-fired units to become profitable, especially with today high price of gas. In any case some gas units will probably be needed to feed the power demand during the peak hours. Fortunately Poland is well equipped with CHP units, which could as well contribute more to this peak demand if associated investments needed are engaged.

On the contrary, and as it can be seen in the Figure 3, a drastic reduction in the power generation would be needed to meet the SO_x and NO_x limits from the Accession Treaty.

Complying with the SO_x and NO_x targets stated in the Accession Treaty creates a major burden for Poland. For example the 2008 target for SO_x is 454 thousand tonnes while emissions in 2005 are at the level of c.a. 750 thousand tonnes; similarly for NO_x, the 2008

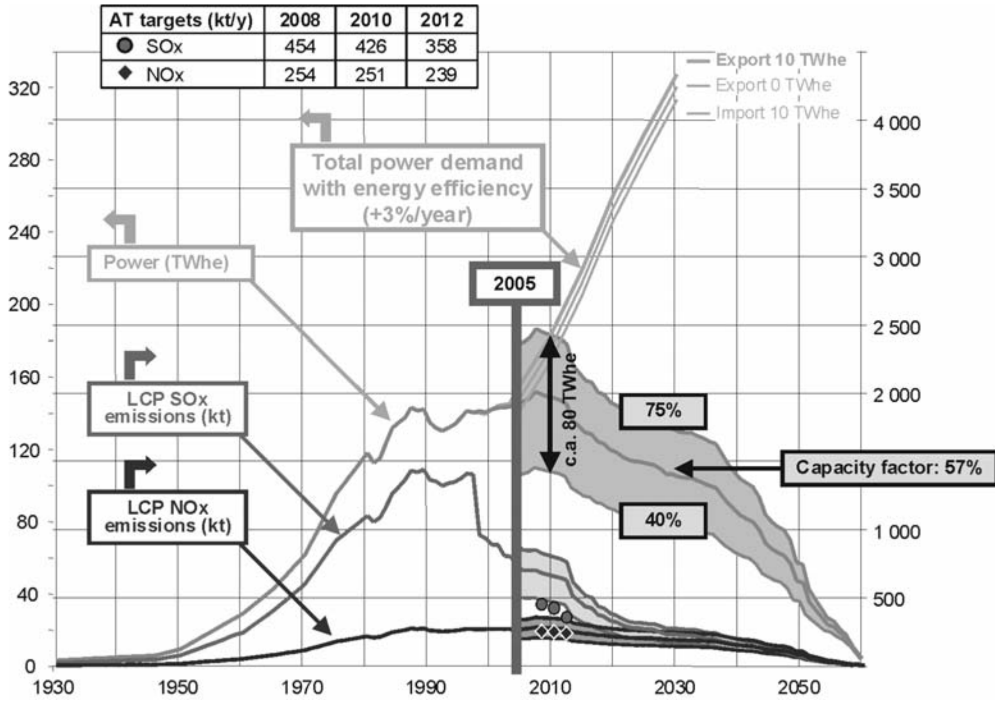


Fig. 3. Power production versus power demand and pollutants emissions (source: EDF Polska calculations)

Rys. 3. Produkcja energii w funkcji popytu i emisji zanieczyszczeń

target is 254 thousand tonnes while today emissions amount to c.a. 260 thousand tonnes. Additional cutting in NO_x emissions would require construction of Selective Catalytic Reduction systems as today nearly all units are already equipped with low-NO_x burners. Time is now over to be able to build these new de-Sox systems to reach the Accession Treaty targets on time in 2008. Matching these limits for SO_x and NO_x would require further investments of about €15 billion up to 2017, and induce increase of power and district heating prices by c.a. 20% and 40% respectively.

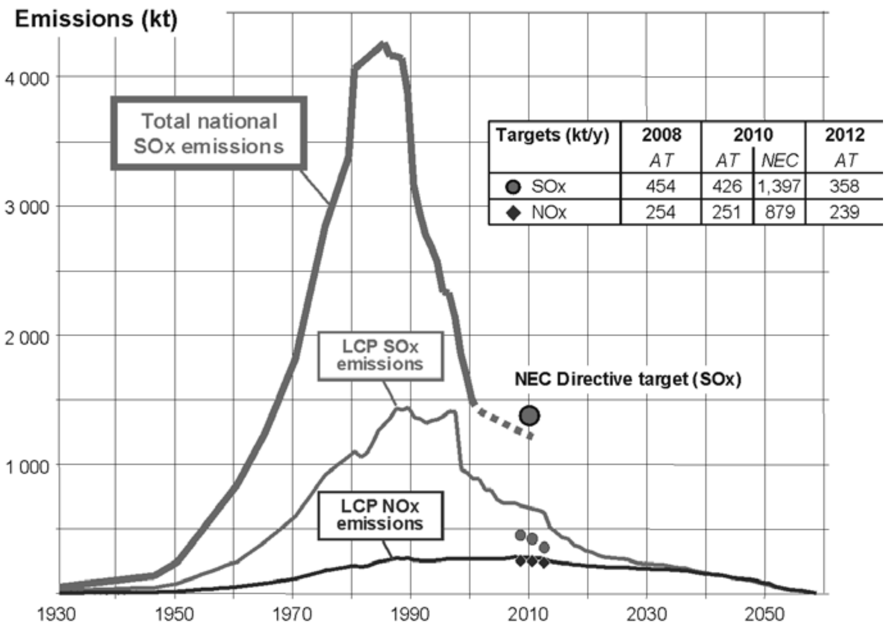
Despite the huge efforts that are being done today to fulfil the Accession Treaty targets, no guaranties exist upon the final achievements. In addition, and not to burden even more the national economy, it is compulsory to optimise investments within the energy sector, while bearing in mind that a large part of production capacities not equipped with flue gas desulphurisation systems will be shut down in the coming decade. Some of these investments were already shown as not justified as soon as the mid 90's during the implementation of the first version of the 1988 LCP Directive. Implementation of this first LCP Directive led to an global investment of c.a. €8 billion and requested a huge amount of long-term contracts for power to be established between the Polish power grid company (PSE) and the producers.

Today Poland is facing a cruel dilemma: either to be able to fulfil the rocketing national demand for power or to comply with the Accession Treaty environmental targets for SO_x and No_x.

Integrated impact study (NEC Directive versus LCP Directive ceilings)

The Figure 4 shows once again the SO_x and NO_x that would be emitted by the existing LCP units by adopting the production scenario of the Figure 2 (capacity factor of 57% and plant lifetime of 50 years). This Figure 4 presents as well the total national emissions of SO_x up to 2002. It should be noticed the huge efforts done during the last 20 years, which have led to a reduction of total SO_x emissions of about 65% (from 4.3 million tonnes in 1985 to less than 1.5 million tonnes in 2002). It seems that the national limit resulting from the 2001 NEC Directive (1.397 million tonnes of SO_x by 2010) could be attained without any problem.

If care is not taken to avoid the huge investment costs on LCPs, which would be generated by fulfilling the SO_x and NO_x burdens of the Accession Treaty targets, the poorest people – not able to afford these higher power and heat prices – will continue to use more and more cheap solids or alternative fuels of poor quality in house boilers. Therefore the reduction of long-range trans-boundary pollution by investing in flue gas treatment systems for LCP units to reduce SO_x and NO_x will result to the deterioration of the local environment, which directly impacts human health and which for sure is not the objective of the LCP Directive.



Targets (kt/y)	2008	2010		2012
	AT	AT	NEC	AT
● SOx	454	426	1,397	358
◆ NOx	254	251	879	239

Fig. 4. NEC and LCP Directives targets fixed to Poland into the Accession Treaty (AT) (source: EDF Polska calculations)

Rys. 4. Cele dyrektyw NEC i LCP określone dla Polski w Traktacie Akcesyjnym

Therefore it seems that the Accession Treaty targets for LCPs should be re-discussed between Polish Administration and European Union in order to able the LCPs to produce more power to fulfil the growing demand. Acceleration of SCIs replacement will reduce the emissions from the low-stack sources, which are more harmful for health and environment as their pollutants fall down in the direct vicinity of the source where the people live. When CHP plants will not be an economically justified option, then legal instruments should be prepared to help cutting the low-stack emissions by promoting heating based on gas and/or even electricity.

An integrated analysis of the total costs and benefits (from health, natural environment and architecture savings point of view), which would be generated by various scenarios aiming at cutting emissions from the different sectors (mainly LCPs, SCIs, transport and agriculture), will help clarifying the 2020 Thematic Strategy on Air Pollution (TSAP) targets that the European Union wants to implement. Such an analysis will serve as well to feed the discussions between the Polish National Administration and the European Commission in order to fix the content, ceilings and pollutants to be taken into account in the next version of the LCP and NEC Directives, which are being revised in the framework of the CAFE programme.

A quick implementation of a SO_x and NO_x emission trading schemes, that would cover both LCPs and SCIs, will certainly foster the reduction of these pollutants emissions at a much lower cost than through the implementation of command and control legislative instruments.

As previously discussed in material Ref. 2, it can be concluded as well that the fleet of power plants and large CHP plants, of total installed electrical capacity of about 34 GWe, is getting older and a large part of those plants will have to be replaced by 2020. Thus, depending on the future technologies to be used and on the replacement rate, meeting the future power demand will require erection of about 40–60 GWe by 2030, with an investment cost roughly estimated at c.a. €50–70 billion. This cost doesn't take into account the expenditures required to reinforce the electricity grid. This corresponds to a need of construction of c.a. 2 GWe of new facilities every year from 2005 up to 2030, while only 2.2 GWe are planned to be commissioned before 2010.

Apart from the mid-term challenges which have been discussed above to reduce the SO_x and NO_x emissions in the next 5–15 years, in the next paragraph, we are going to present a few potential scenarios aiming at fulfilling the rocketing demand for power in Poland from 2005 to 2030, while trying to mitigate the climate change with such a coal-based power sector.

These SO_x and CO_2 emissions reductions are the two interrelated key challenges that Poland has to face with its energy sector nearly only based on solid fuels. To optimally solve this problem in a long-term perspective, the solutions to be proposed have to integrate:

— the 2 different technical-economical mid and long-term timescales, respectively for SO_x and CO_2,

— at least two sectors, i.e. the centralised heat and power one and the domestic & agriculture one.

This document aims only at making a first analysis to see if these long-term CO_2 emissions reduction solutions exist and could be implemented. The full SO_x and CO_2 integrated analysis, inter-timescale and inter-sectors, still needs to be done in a specific study.

5. Climate change and CO_2 emissions

Hereafter it is proposed step-by-step 6 alternative scenarios to the reference one so called "business-as-usual" (BAU). These scenarios are increasingly efficient in terms of CO_2 emissions cutting, thanks to more efficient use of energy and as well to the use of lower carbon intensive fuels and technologies. Such a low carbon economy will take profit from the worldwide Kyoto and European CO_2 Emission Trading Scheme to help the Polish economy to develop.

Each of these scenarios is based on a GDP growth of c.a. 4.5% per year from 2005 to 2030 to make Polish economy to converge with its Western and Northern European peers, which experience a much lower growth, i.e. less than 2% in average.

Description of the reference scenario: business-as-usual (BAU)

In the BAU scenario the energy intensity decreases by –1.8% per year. Such a decrease would require a very voluntary policy to be implemented. As an example, it can be mentioned that the most successful policies in the most advanced countries, such as Denmark, allowed reaching –2.0%/year in the period 1990–2000; in the same period, EU-15 average energy intensity decrease was only –1.1% per year.

Compared to their European peers, Poles travel much less (5,865 km/capita/year in 2000 compared to 12,174 in the EU-15) and live in less than half space (in m2/capita) than in the EU-15. So especially growth in transport and housing could dramatically rocket the need for primary energy if care is not taken to mitigate it (see materials Ref. 1 and 2). Consequently it is considered in this BAU scenario that primary energy consumption for individual heating and transport purposes will double by 2030 compared to 2000.

From the power sector point of view, an elasticity factor to the GDP growth of about 0.9 is considered, which leads to a power production need of 430 TWhe in 2030, including 10 TWhe of export as for today. Of course these figures have only the aim to serve as reference starting point and could be revised to take into account other trends – but this will not change the principles discussed hereafter.

To fulfil this total power production, it is estimated that in 2030 the quantity of fossil fuels from domestic origin will remain as in 2000. This quantity of fuel will allow a total power generation of about 160 TWhe, which is significantly larger than in 2000 thanks to the better efficiency of the new plants to be built up to 2030. However the share of production of those units fuelled with domestic fuels will probably go down to about 40% in 2030, mainly because of the increase of power demand and of the exhaustion of some coal resources no more suitable from an economic mining point of view. This does not apply to lignite whose resources fitting the required economic mining performances should be sufficient till 2070 if new mines are opened in the area of Legnica. It means that in 2030 more than 60% of the power to be produced (i.e. about 270 TWhe) would have to be generated on the basis of renewable energy sources, imported gas and coal and/or nuclear power.

The estimated shares in the power demand by type of customers are indicated in the Figure 5. It can be seen that the demand for low and medium voltages customers will increase faster than the demand for high voltage customers. This tendency reflects the fact that the Polish economy, mainly based today on heavy industry, will move toward a more service--based economy.

Description of the other scenarios

— Electricity efficiency:. Compared to "BAU scenario", this scenario allows reducing electricity demand from 430 TWhe to 330 TWhe in 2030 thanks to electricity efficiency improvement (–1.2% per year from 2005 to 2030), which is in line with the European Green Paper targets (compare Figure 5 with Figure 6). These global efficiencies targets will cut CO_2 emissions by c.a. 78.2 Mt in 2030 compared to BAU scenario (see Figure 8 and Table 1).

— Transport and heating efficiency: this scenario is similar to the previous "Electricity Efficiency" scenario, except that by 2030 biofuels will cover 50% of primary energy

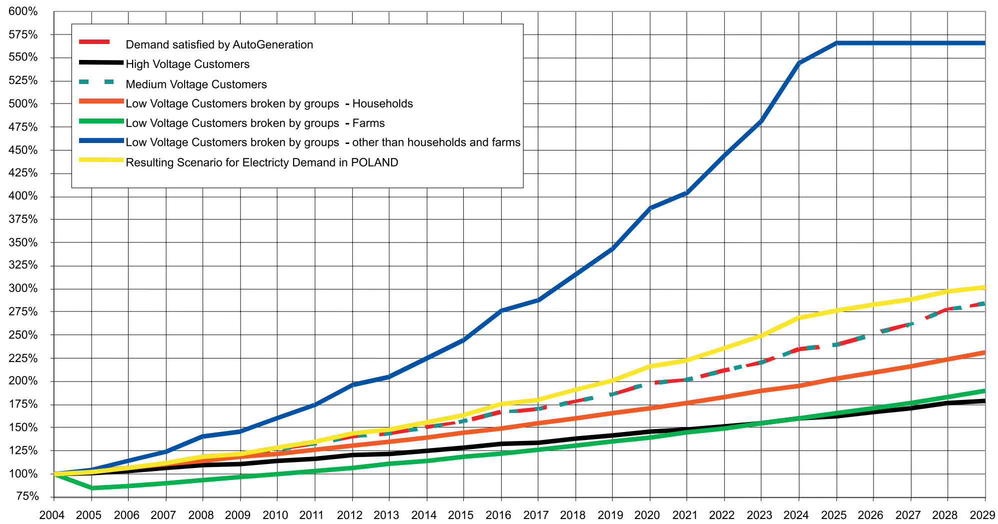


Fig. 5. Aggregated power demand scenarios broken per customers' groups with no energy efficiency imposed i.e.: 430 TWhe of electricity production in 2030 (source: Electrabel)

Rys. 5. Scenariusze łącznego zapotrzebowania na moc, rozbite na grupy klientów bez narzuconych wymogów efektywności energetycznej, tj. 430TWhe wytworzonej elektryczności w 2030 r.

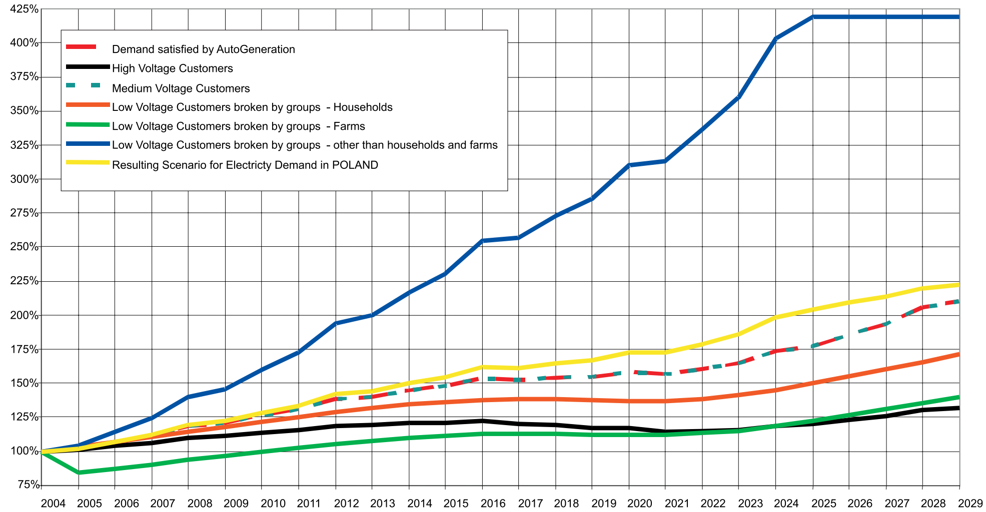


Fig. 6. Aggregated power demand scenarios broken per customers' groups with energy efficiency imposed (source: Electrabel)

Rys. 6. Scenariusze łącznego zapotrzebowania na moc, rozbite na grupy klientów z narzuconymi wymaganiami efektywności energetycznej

consumption in the transport sector, and a +0.7%/year energy efficiency improvement will be achieved in the individual heating sector.

— RES in PP: this scenario is similar to the previous "Transport and heating efficiency" scenario, except that RES will contribute to a large share in power generation (13% in

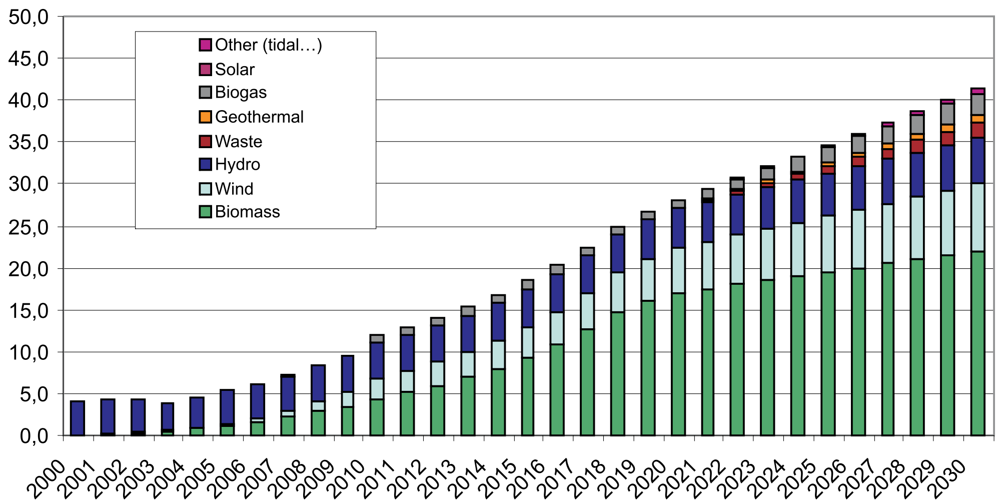


Fig. 7. Generation prognoses for Poland – renewable energy sources in power plants (TWhe/year)

Rys. 7. Prognozy produkcji energii dla Polski – źródła energii odnawialnych w siłowniach (TWhe/rok)

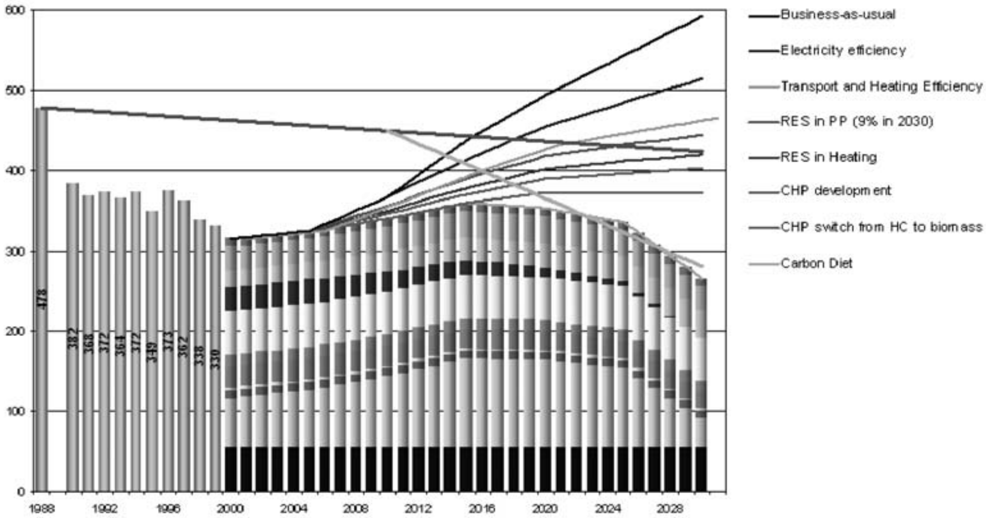


Fig. 8. Modelling outputs of the scenarios in terms of CO_2 emissions (million tonnes)
(source: EDF Polska calculations)

Rys. 8. Wyniki modelowania dla scenariuszy w Polsce pod kątem emisji CO_2 (miliony ton)

TABLE 1

CO_2 costs variations for different scenarios (source: EDF Polska calculations)

TABELA 1

Zmiana kosztów CO_2 dla różnych scenariuszy

CO2 costs variations for different scenarios	CO2 in 2030 (Mt/y)	2008-2030 yearly average (€ bn/y)		
		Total cost*	Savings	Cumul.
Business-as-usual	592,1	10,0	*0,0*	*0,0*
Electricity efficiency	513,9	9,2	*0,8*	*0,8*
Transport and Heating efficiency	464,8	8,7	*0,5*	*1,3*
RES in PP	444,0	8,4	*0,3*	*1,6*
RES in Heating	419,2	8,1	*0,3*	*1,9*
CHP development	401,4	7,9	*0,2*	*2,1*
CHP switch from HC to biomass	371,1	7,6	*0,3*	*2,4*
Carbon Diet	265,2	7,0	*0,5*	*2,9*
Total reduction	326,9			
CHP Best Way	240,4	6,6	*0,1*	*2,0*
RES Best Way	229,6	6,5	*0,1*	*2,1*
Total reduction	**326,9**			

* This cost represents the yearly cost generated by CO_2 emissions valued at € 20/tCO_2.

2030, i.e. 41,3 TWhe), in line with European orientations. In comparison to the previous scenario, it allows for a decrease in electricity generation from hard coal fired power plants, and therefore cuts CO_2 emissions by c.a. 20.8 Mt in 2030 (see Figure 8 and Table 1).

— RES in heating sector: this scenario is similar to the previous "RES in PP" scenario, except that 50% of individual heating is switched from hard coal to biomass (i.e. 6.4 Mtoe in 2030). It cuts CO_2 emissions by c.a. 24.8 Mt in 2030 compared to the previous scenario (see Figure 8 and Table 1).

— CHP development: this scenario is similar to the previous "RES in heating sector" scenario, except that the electricity production from CHPs increases as much as possible to achieve about 45 TWhe in 2030 (this corresponds to a +2.5%/year average from 2005 to 2030). It should not be forgotten that these CHPs do not only include the professional CHP plants mainly included into PTEZ association, but as well the industrial CHP plants and some power plants which as well produce heat (it means that this definition is in compliance with the Quality CHP Directive as defined by the European Union).
Such a development would be possible only by implementing relevant policy with corresponding legal instruments and market rules. Heat supply from individual boilers (SCIs) will gradually be transformed into CHP plants. Connections of the new buildings to the centralized district heating systems will as well be incentivized by the transposition of European regulations being nowadays prepared to force the building developers to consider the cogeneration option as the base option for heating, as it is the case in the most energy efficient Scandinavian countries. Thus by 2030 there would not be anymore individual boilers using hard coal. As a whole, it allows cutting CO_2 emissions by c.a. 17.8 Mt in 2030 compared to the previous scenario.

— CHP switch from hard coal to biomass and gas: this scenario is similar to the previous "CHP development" scenario, except that CO_2 emissions from CHP plants are divided by 2 in 2030, by switching either 50% of hard coal (i.e. 5.4 Mtoe) to biomass or 70% of hard coal to gas (40%) and biomass (30%). It cuts CO_2 emissions by c.a. 30.3 Mt in 2030 compared to the previous scenario.
As seen in Figure 8, compared to the BAU scenario, the above-mentioned evolutions regarding both the energy efficiency and the energy mix allow in 2030 decreasing the primary energy consumption by c.a. 10% and cutting the CO_2 emissions by almost 59%.

— Carbon diet: this scenario is similar to the previous "CHP switch…" scenario, except that 140 TWhe produced by 2030 from hard coal fired power plants are switched to CO_2 – free production technologies using CO_2 capture and sequestration (CCS) and/or nuclear energy. It cuts CO_2 emissions by c.a105.9 Mt in 2030 compared to the previous scenario.

CO_2 emissions savings from the BAU scenario to the less carbon intensive ones are summarised in the Table 1 below. For a rough average estimation, the cost savings are valued at €20/tCO_2 over the 2005–2030 period. The complete implementation of this set of scenarios will allow cost savings of c.a. €2,4 billion per year, which will allow financing most of the measures to be taken to make these CO_2 emissions savings to happen. Besides, the table 1 shows as well the two best scenarios which can be achieved if the maximum technical and economical potential of RES and CHP are developed.

6. Synthesis

As seen in the Figure 9, thanks to a more efficient use of energy and as well as use of lower carbon intensive fuels and technologies, the carbon diet scenario allows cutting CO_2 emissions by 3.3 billion tonnes in the period 2008–2030 compared to the BAU scenario. Taking into account a cost of €20 per tonne of CO_2, this reduction in CO_2 emissions allow savings of €67 billion over that period.

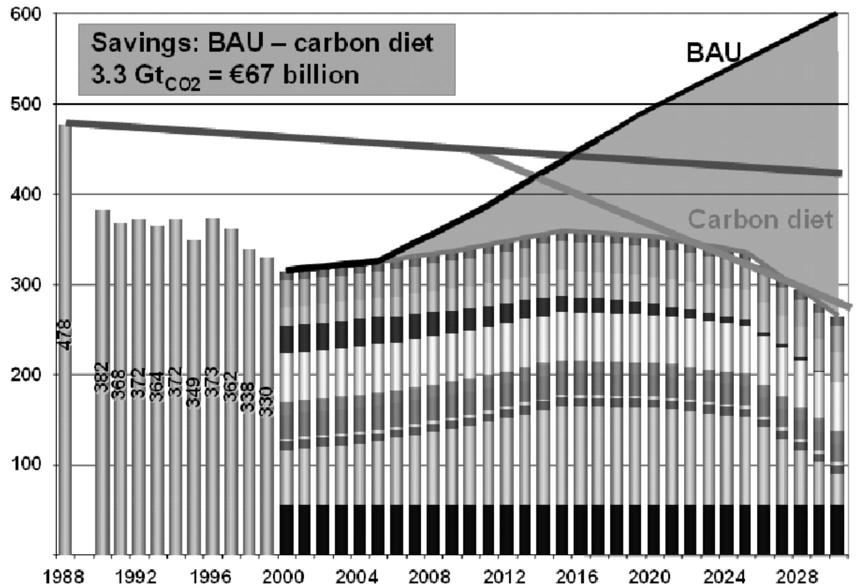


Fig. 9. Savings between BAU and the carbon diet scenarios (source: EDF Polska calculations)

Rys. 9. Scenariusze oszczędności z uwzględnieniem normalnie spodziewanych zysków (interes jak zwykle) i opat węglowych

Achieving such a result needs to make a detailed study that will result in proposing a very well prepared and shared long-term energy policy. That will enable preparing the legislative and market instruments in order to promote the primary energy savings to be developed (DSM, RES, CHP...), as well as the CO_2 capture and sequestration (CCS) technologies and even the nuclear power.

As it can be seen in Figure 10, the carbon diet scenario allows to reach a surplus of 0.84billion tonnes of CO_2 over 2005–2030 compared to the Kyoto and post-Kyoto caps. It represents a €16.8 billion lump sum (at €20 per tonne of CO_2) of AAUs that could be sold by the polish Government on the world carbon market. Such an income that will profit to the national economy might be achieved by implementing well documented Joint Implementation (JI) programmes and even better a global Green Innovation Scheme (GIS) by the National Polish Administration. Only such clear JI and GIS programmes will make

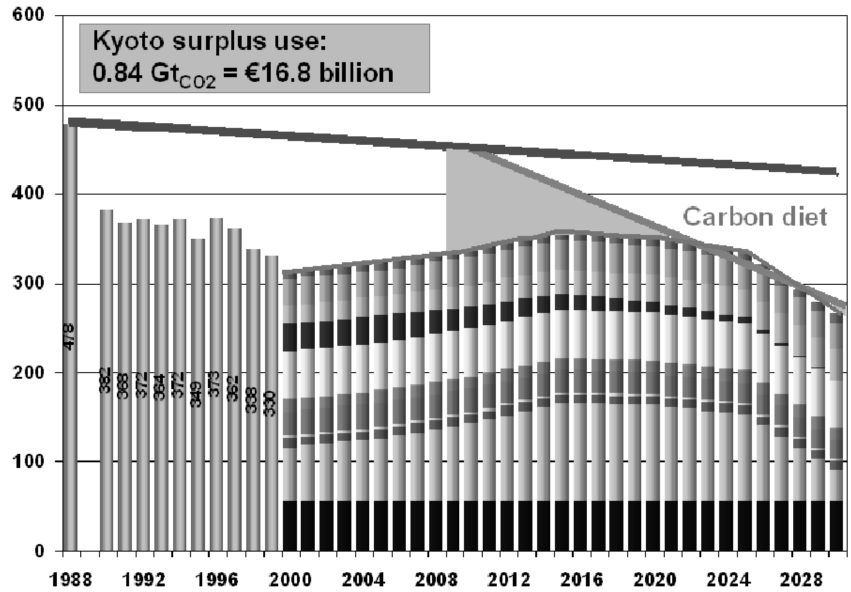


Fig. 10. Kyoto surplus thanks to the carbon diet scenario (source: EDF Polska calculations)

Rys. 10. Nadwyżki wynikające z Protokołu w Kioto i opłat węglowych

foreign investors confident enough to develop projects in Poland from which they will recover the associated Emission Reduction Units (ERUs) to be used to comply with their own targets in their countries of origin. Development of such programs and associated regulations need a task force to be settled at the national administration level.

7. CO_2 reduction policy

As it has been seen, the cumulated CO_2 emissions reduction presented above as the carbon diet scenario will never happen without a clear and transparent long-term climate change policy. This policy should be implemented immediately in order the 2008–2012 CO_2 allocations into the European ETS for the 1st Kyoto commitment period will give the right signals to the investors.

First the industrial installations which have to compete with their products at a global scale should not be constrained in order to avoid to burden the European economy by any potential delocalisation of these industries outside Europe, where there are no CO_2 caps. Consequently the exact needs of these industries should be clearly established by a precise monitoring of both their emissions and production levels, along with their development plans. To do so the rules should be clearly defined in order to promote the most efficient production. In Poland, the associations covering these industries set up a CO_2 FORUM, which is dealing with such issues.

In the Figure 11, the CO_2 needs indicated for the period 2008–2012 for the three sectors (i.e. power plants (PP), professional CHP plants (CHP), and other industries (ind)) correspond to the amount of allowances allocated in the previous period 2005–2007 increased by the expected rough growth of each sectorial economic activity as indicated in the Figure 11. It should be noticed that the sector classified as Professional CHP cover over 80 installations from which those in PTEZ association represent c.a. 80% of CO_2 emissions. This definition does not correspond to that one discussed above into the CHP development scenario. Above the base allocations that will be distributed to the installations covered by the European CO_2 ETS, a reserve should be created to serve at least the new entrants and to cover as well the needs of the actors that will increase their production levels to fulfil the rocketing demand for power. This reserve could be partly auctioned and partly distributed freely to the most efficient actors through a benchmarking methodology of allocation based on outputs.

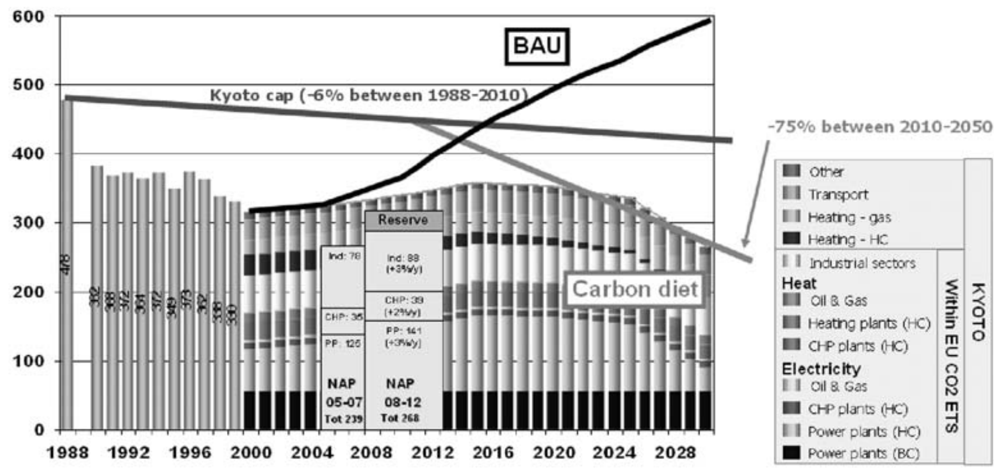


Fig. 11. CO_2 NAP for period 2005–2007 and proposal for 2008–2012 (source: EDF Polska)

Rys. 11. CO_2 zgodnie z Krajowym Planem Rozdziału Uprawnień w okresie 2005–2007 i propozycja na lata 2008–2012

Conclusion

During the next decades the Polish demand for electricity will be rocketing while a large share of the production fleet will have to be retrofitted. This opportunity should be seized to implement in the present years a retrofit strategy that will affect the few next generations.

Therefore, to secure the future energy needs it is urgent to prepare a long-term integrated energy policy, which will help moving from the traditional system, nearly only based on solid fuels and emitting all its CO_2 and still a large part of traditional pollutants (SO_2, NO_x, dust) into the air, to a more diversified energy mix, more favourable for environmental protection. Such a policy should promote energy savings, help the development of cogeneration and renewable sources of energy, in line with the direction of the European energy policy, while fulfilling the sustainable development (SD) criteria and securing energy:

— economy development: power demand increase, transfer of knowledge and technology,
— environment protection: climate change, biodiversity, health impact,
— social cohesion: reduce unemployment, affordable energy prices.

Such a policy will allow establishing the stable legal instruments and clear market rules that will create the confident atmosphere to attract both public and private investments to erect the new capacities that will fulfil this power demand. In this solid fossil fuels based energy country, the short-term key topics that this policy has to address are:

— the preparation of the Thematic Strategy on Air Pollution (TSAP) and the corresponding need of revision of the LCP and NEC Directives, which will have to clearly take into account the Polish LCP Accession Treaty limits for $SO_x$and NO_xthat, it seems obvious today, will never be fulfilled,
— the creation of a long-term clear and transparent climate change policy with its implementation instruments, in the framework of the European CO_2 ETS and its Directives, including the Joint Implementation Linking one.

It was stated as well that these two approaches (TSAP and climate change) should be analysed together, not only from SO_x, NO_x, and CO_2 emissions point of view, but also from the timetable and sectors concerned points of view. Especially the short-term decisions driven by recent European policies that could generate huge costs in the power and heat sectors should not jeopardise the national economy and, even worst, make then the longer-term optimisation impossible. Some key risks to be avoided are as following:

— To too quickly cut $SO_x$and NO_xemissions from large combustion plants (LCPs), as requested by the Accession Treaty (AT) instead of reducing those pollutants emissions from the main contributors, i.e. respectively small combustion installations (SCIs) and transport (which is skyrocketing). This too quick cutting of $SO_x$and NO_xemissions from LCPs will generate huge non-justified costs that will strongly increase the price of energy and will then generate more pollution to be emitted from the local boilers, which was not at all the aim of the LCP Directive.
— To simultaneously solve the SO_x, NO_x, and CO_2 emissions problems due to the solid fuels combustion in the power sector, the temptation to switch to gas could be high, especially regarding the recent relative gas competitiveness improvement compared to coal, which is induced by the European CO_2 Emission Trading Scheme (ETS). Of course this will enable to cover the short-term power demand together with the associated peak-load needs. However, and without talking about the consequences on the energy price in Poland, such a choice would jeopardise the Polish energy self-sufficiency and will not make possible to use the benefits that CHP plants can provide from a peak-load production point of view. Of course this remark does not

apply to the modest domestic Polish reserves of gas, which most probably should be developed soon.

— The large amount of biomass, which can be produced quite soon from energy crops in Poland to make the transport, power and heat sector fulfilling their European targets of production from renewable (i.e. 9% in 2010), should not unable the future use of land for production of more valuable crops for biofuels production.

It can be concluded that relaxation of short-term constraints on Polish $SO_x$and $NO_x$and CO_2 emissions for the centralised heat and power sectors will avoid non-justified expenditures in these sectors. The comprehensive long-term energy policy to be established should allow these cost savings to be invested in long-term retrofits that will consider the different options to reduce CO_2 emissions in the power sector and as well the other gases emissions in the domestic heating sector, which generates the most harmful low-stack emissions.

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LOUIS JESTIN

UDZIAŁ SCENTRALIZOWANEGO SEKTORA ENERGETYCZNEGO W PLANOWANIU DŁUGOTERMINOWEJ WIZJI ENERGETYCZNEJ DLA POLSKI

Słowa kluczowe

Sektor energetyczny, emisja NO_x, SO_x, CO_2, modelowanie

Streszczenie

Polski scentralizowany sektor energetyczny znalazł się na rozdrożu: powinien zaspokoić rosnące gwałtownie zapotrzebowanie na energię podczas gdy większość jego zakładów wymaga modernizacji w następnych 20 latach. To olbrzymie wyzwanie powinno być dostrzegane jako rzeczywista możliwość stworzenia nowego, zrównoważonego systemu energetycznego, który zaspokoi potrzeby przyszłych pokoleń przy jednoczesnym spełnieniu wymogów ekonomicznych, ekologicznych (zgodnych ze standardami europejskimi) oraz zapewnieniu zgody społecznej.

Tak więc Polska powinna opracować długoterminową politykę energetyczną, która uwzględniłaby dwa główne problemy ochrony środowiska: redukcję emisji NO_x, SO_x i pyłów oraz redukcję emisji CO_2.

Jeśli chodzi o redukcję emisji „tradycyjnych zanieczyszczeń" (NO_x, SO_x) oraz pyłów, Polska powinna spełnić wymagania Dyrektywy LCP i powiązanymi z nią celami zawartymi w Traktacie Akcesyjnym, które nie odnoszą się do specyficznych cech polskiego sektora energetycznego. W przeciwieństwie do swoich europejskich odpowiedników, w Polsce stale istnieje wiele małych instalacji spalających węgiel (SCI: poniżej 50 MW), takich jak pojedyncze kotły oraz lokalne jednostki ogrzewnicze, które nie są uwzględniane przez strategię europejską. Planując nowe inwestycje z uwzględnianiem optymalizacji ekonomicznej i ochrony środowiska, powinno się wziąć pod uwagę zarówno LCP (duże jednostki) jak i SCI, nie tylko dla celów określonych na lata 2008–2012, ale również na okres 2015–2020, dla którego nowe dyrektywy NEC i LCP są obecnie przygotowywane. Ponieważ i tak znaczna część istniejących urządzeń powinna zostać wymieniona po roku 2012, wysoce nieefektywne byłoby więc skoncentrowanie wysiłków w okresie 2008–2012 wyłącznie na jednostkach LCP. Znacznie bardziej racjonalne byłoby je zogniskować na SCI. Innymi słowami, obydwie wersje dyrektyw LCP i NEC (ta z roku 2001 i nowoprzygotowywane na poziomie UE) powinny być rozpatrywane razem, jako że ich wprowadzenie w Polsce jest z sobą ściśle powiązane.

W przypadku redukcji emisji CO_2 problem jest całkiem podobny do opisanego poprzednio, ponieważ European Union Emissions Trading Scheme (EUETS) odnosi się wyłącznie do instalacji powyżej 20 MW. Bardziej realne byłoby uwzględnienie skutków działania ogromnej liczby SCI, które nie są objęte tym rozporządzeniem, a które wliczają się do kwot celowych Protokołu z Kioto. Wszyscy ludzie zaangażowani w sprawy sektora energetycznego odnieśliby korzyści z takiej wspólnej polityki negocjacji z Unią Europejską, prowadzonej pod kontrola polskiej administracji. Jak to zostało wyjaśnione w tym artykule, taka polityka pozwoliłaby na zaoszczędzenie do 67 miliardów euro – w porównaniu ze scenariuszem zwykle osiąganych zysków – i uzyskać 16,8 miliardów euro nadwyżki dzięki dodatkom wynikającym z Protokołu w Kioto, które mogą być sprzedane na międzynarodowym rynku węglowym. Mogłoby to sfinansować i wygenerować samofinansujący się mechanizm realizacji celów energetycznych opisanych powyżej.

W podsumowaniu można stwierdzić, że rozluźnienie krótkoterminowych ograniczeń na emisje SO_x, NO_x i CO_2 pochodzące ze scentralizowanego sektora energetyczno-ogrzewczego w Polsce pozwoliłoby na unikniecie nieuzasadnionych nakładów w tych sektorach. Należy prowadzić wszechstronna i długofalowa politykę, która powinna pozwolić inwestować oszczędności w działania modernizacyjne, prowadzącą w dłuższym okresie czasu do redukcji emisji CO_2 w sektorze energetycznym jak i innych gazów w krajowym sektorze grzewczym, który jest źródłem najbardziej szkodliwej niskiej emisji. Takie światowe podejście do zagadnienia prawdopodobnie prowadziłoby do lepszych scenariuszy rozwoju, pozwalających na osiągnięcie celów UE i Protokołu w Kioto.

Ten artykuł był wstępnie napisany w pierwszym kwartale 2006 roku, dzięki współpracy z bukmacherami: F. Pchełka (TGPE), M. Niewiadomski, S. Poręba (BOT), K. Szynol, G. Paluch (PKE), G. Wolf, B. Decourt, S. Błach, Z. Krzemień (EDF), I. Grela, D. Taras (Electrabel). W końcu zdecydowano się na jego publikację w obecnej formie, która jest nieco uaktualniona, dla przyspieszenia dyskusji z innymi osobami zainteresowanymi ze scentralizowanego sektora energetycznego, przemysłu gazowego i wydobywczego, administracji państwowej i uniwersytetów.