POLAND'S ALTERNATIVE ENERGY POLICY UNTIL 2030 (AEP)

A final report

The statements in the report express only the views of the Institute for Sustainable Development and do not have to be shared either by the institutions which have provided grants for the project or collaborators of the ISD

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In memory of Prof. Stefan Kozłowski,

our dear guide

through the meanders of environmental protection

and the initiator of the work on

"Poland's Alternative Energy Policy until 2030".

The grateful ISD's team

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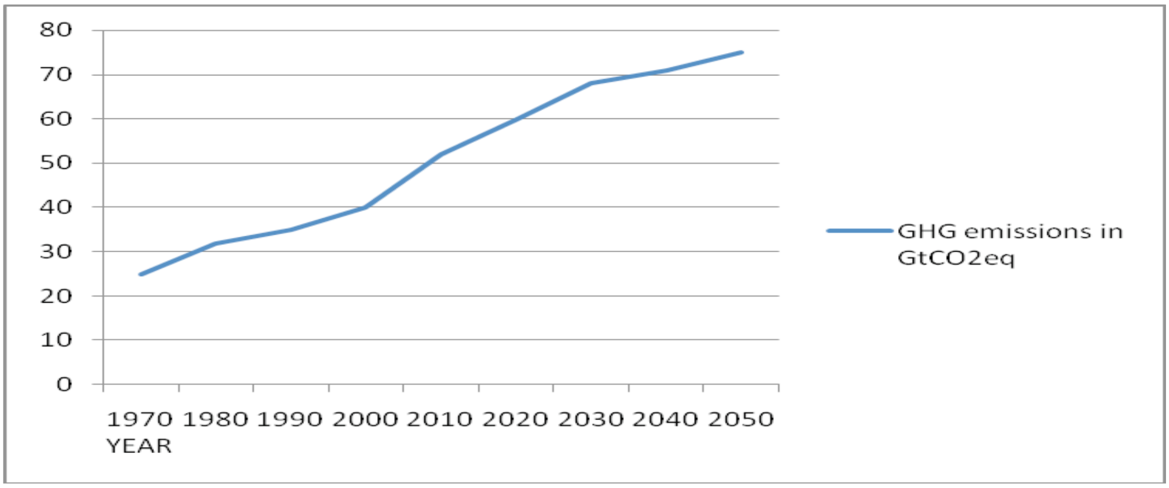
Abbreviations	Meaning
AEP	Poland's Alternative Energy Policy until 2030
BAT	Best Available Technique
BAU	Business As Usual
CAN Europe	Climate Action Network – Europe (a network of European organisations working for climate protection)
CCGT	Combined Cycle Gas Turbine (gas and steam power plants fired by natural gas)
CCS	Carbon Capture and Storage (CO_2 capture and storage in deep geological strata)
CDM	Clean Development Mechanism
CO_{2eq}	Equivalent emissions of greenhouse gases expressed in CO_2
DSM	Demand Side Management
ESCo	Energy Service Company
EU ETS	European Union Emission Trading Scheme (the European greenhouse gas allowance trading scheme)
FEWE	Polish Foundation for Energy Efficiency
gha	Global hectare
GHG	Greenhouse gases
GJ	Gigajoule
GW	Gigawattt
IGCC	Integrated Gasification Combined Cycle (gas and steam unit technology with integrated fuel gasification)
JI	Joint Implementation
kWh/m^2/year	Kilowatt hour per square metre per year
mt	Million tonnes
MWh	Megawatt hour
nN	Low voltage power lines
NN+WN	High voltage power lines
non-ETS	Non - Emission Trading Scheme (emissions from sources not covered by the European greenhouse gas allowance trading scheme)
OECD	Organization for Economic Co-operation and Development
RES	Renewable energy sources
PGNiG	Polish Oil and Gas Company
PJ/year	Petajoule/year
GDP	Gross Domestic Product
PTPiREE	Polish Society of Electricity Transmission and Distribution
RTV	Radio and television equipment
SN	Medium voltage power lines
Solar CST	Concentrating Solar Technologies (electricity and heat production based on concentrated solar energy)
TEN-Energy	Trans European Network – Energy
TEN-Gas	Trans European Network – Gas
TJ	Terajoule
TPA	Third party access
TPF	Third party financing
TWh/year	Terawatt hour per year
EU	European Union
WWF	Formerly World Wildlife Fund

Summary

The industrial revolution which began roughly in middle of XVIII century became possible due to the increasing availability of energy – in the form, too, which could be relatively easily transported over long distances. Electricity, crude oil, gas and, to a lesser extent, heat became generally accessible in the States which are now called developed countries. At present, developing countries are taking the same development pathway of an industrial revolution.

For many years no efforts were taken to rationally manage the decreasing quantities of non-renewable energy resources (coal, crude oil and gas), nor were the effects of their use on the natural environment and human health considered. In the second half of the 20th century, it turned out that in nature there was no free lunch. It is our generation that has come to pay for the wasting of resources and the neglect of the quality of the environment. The next generations will also have to pay the price of such development. Non-renewable energy resources are becoming increasingly scarce. According to different predictions, they will suffice for another 2 - 5 generations, i.e. 40 – 150 years. At the same time, pollutants generated by the power sector have become a global problem. Excessive greenhouse gas emissions are beginning to threaten the Earth's climatic stability and predictions – should no strong protective action be taken – are terrifying (Fig. 1).

Fig. 1. Global greenhouse gas (GHG) emissions in 1970 – 2050



Source: Netherlands Environmental Assessment Agency, IPCCSRES A1FI, HSBC after *A Climate for Recovery. The Colour of Stimulus Goes Green.* HSBC Bank. 25 February 2009.

The effects of human impacts on our planet are best illustrated by the so-called ecological footprint[1]. Despite its regeneration, the Earth's capacity to satisfy human consumption needs has been exceeded by 30%. The ecological footprint now amounts to 2.7

[1] Ecological footprint is the human demand for the natural resources of the biosphere. The consumption of natural resources is compared with the Earth's capacity to regenerate. The ecological footprint is the estimated number of hectares, weighted by the biological productivity of the particular land uses, of the surface area of land and sea needed to compensate for the resources used for consumption and waste absorption. The footprint is measured in global hectares (gha).

gha per person, while the biological capacity to regenerate the planet's resources is estimated at 2.1 gha/person. This means that unless fundamental changes take place in the management of the Earth's ecosystem, i.e. unless we change the production and consumption patterns, from the mid-2030s we will need the resources of two planets rather than one to meet our needs[2].

This means that it is indispensable to change the paradigm, i.e. man's approach to development. It is no longer possible to neglect the scarcity of non-renewable resources and disturbances of the life-supporting systems on the Earth, such as the global climate. The first step should be the integration of this fundamental change into strategic planning. The point of departure for long-term solutions must not be only the human needs or those of the economy. They should be:

- the limits of resources which may be available to each sector, country or region; and
- the caps of pollutant emissions corresponding to the capacity of the natural environment to absorb them.

The existing approach, consisting of the prior determination of the level of satisfaction of social and economic needs and the subsequent attempts to improve the efficiency of resource use and to minimise the environmental impacts, is unacceptable. This is a result of the finiteness of the Earth (its resources and capacity to cope with pollution) and the principles of inter-generations justice and precautionary principle.

It was exactly such philosophy and the resulting need to change the paradigm that triggered the work on *Poland's Alternative Energy Policy until 2030 (AEP).* Hence, too, the title of the report includes the term "alternative". This does not express a disapproval of the energy policy documents proposed by the authorities, nor does it represent support for the idea that the development of this sector should only be based on alternative sources, but it voices the necessity of changing the paradigm of the approach to strategic documents. This is not about the energy sector only, but also about other fields of the economy and the strategic documents developed for the countries, regions or particular cities and rural communities.

Another aspect, which to some extent represents an alternative approach to the creation (rather than consultation only) of such documents, is the wide public participation in their creation. The process of public involvement in AEP took the following course:

- The identification of the basic problems/dilemmas which should be resolved as a result of AEP, as expressed by the particular stakeholder groups: non-governmental organisations, in particular environmental ones, trade unions, entrepreneurs, representatives of the public administration and experts.
- The development of scenarios[3] which would make it possible to work towards resolving the identified problems/dilemmas, but would still fall within the pollution limits set out as part of the change of the paradigm, i.e. the caps of greenhouse gases.
- The subjecting of the scenarios developed to a public debate, within the framework of which they were discussed in terms of four dimensions: energy security, competitiveness,

[2] http://www.footprintnetwork.org/en/index.php/GFN/page/world_footprint/

[3] Given the scarcity of financial resource and the educational rather than a purely planning purpose of the study, the scenario analysis only covered electricity generation.

sustainable development and the social dimension. In the course of the debate, a scenario was selected for further work.

- The preparation, with reference to the scenario selected, of a preliminary working draft of the AEP report and its subjecting to the assessment of a chosen group of experts representing different fields and viewpoints.
- The subjecting of the working draft of AEP, following the necessary changes and supplements resulting from the experts' opinions, to wide public consultations in four cities, i.e. in Cracow, Katowice, Wrocław and Gdańsk.
- The preparation of three final publications (the report for decision-makers, a technical report and an information brochure addressed to the public) and the organisation of a summing-up conference.

As a total, about 550 persons were involved in the process of the public creation of AEP.

A point of departure for AEP was the analysis of the present energy situation in Poland, which can be represented as a transitional state between a centrally planned economy, characterised by: low energy efficiency, high energy intensity, high emission factors, coal monoculture and the State monopoly, and a highly developed free-market economy, involving: high energy efficiency, low energy intensity, low emission factors, diversification of fuels and energy sources as well as a well-developed energy market with many operators, mostly private ones. This is evidenced by the following:

- The basic problem of the Polish energy sector is its low efficiency (productivity), which is aggravated by the low efficiency of energy use. According to the Polish Foundation for Energy Efficiency (FEWE), the saving potential in the timeframe until 2020 amounts to 26.8 TWh/yr in electricity and 512.9 PJ/yr in fuels and other energies[4].
- In the light of the share of coal in excess of 90% in electricity generation, the energy sector is characterised by a high emission factor of about 950 kg CO_2/MWh.
- In the Polish energy sector, there are enormous technical disproportions; specifically, its technical structure does not adequately match the functional requirements and users' needs. This applies both to the generation capacities, their distribution and transmission networks. For example, in 2010, 39% of energy generating units will be more than 40 years old.
- The Polish energy sector is in a serious economic crisis, as evidenced by the persisting critical lack of investments.
- Non-reinforced or incomplete legislation hampers the functioning of the sector; some solutions are extremely unfinished, while others are lacking.
- In the energy sector, particular in its network part, the culture of a monopoly or that of an office still persists.
- The renewable energy potential is significant. At the present technological level, its share is estimated as 46% of the primary energy. The economic potential for 2020 is estimated

[4] *Report. The potential for energy efficiency and emission reductions in selected groups of energy uses. The way forward to the implementation of the climate and energy package.* Polish Ecological Club, Upper Silesian District, Foundation for Energy Efficiency, INFORSE, European Climate Foundation. Katowice, 2009.

at almost 22% of the final energy. Toady, Poland uses less than 1/5 of this economic potential.

- Changes in the transport sector have brought about the excessive domination of the car over the other forms of satisfying the transport needs and this has led to a large increase in the consumption of transport fuels. As the only one, in the period 1988[5] - 2006, this sector saw a substantial increase in the greenhouse gas emissions – by as much as more than 77%[6].

The national situation is additionally affected by external factors, primarily by the globalisation process, along with the intensifying financial crisis and the EU climate and energy policy, in the absence of a real (not just declarative) European integration in the area of the energy sector.

In order to build a sustainable energy sector, several important principles have to be observed:

- the high energy efficiency of a life style;
- the high efficiency of the final energy use;
- the high efficiency of energy generation and transmission;
- the incurring of the full costs of generation, distribution and use of energy and fuels;
- the promotion of sustainable mobility.

With reference to the proposed paradigm and the above principles, the following was adopted as the strategic goal of *Poland's Alternative Energy Policy until 2030* – the creation of the conditions for the efficient satisfaction of energy needs within the limits of determined and available natural resources as well as the caps for the release of pollutants into the environment.

Such a formulation of the strategic goal referred to the Constitutional principle of sustainable development. The greenhouse emission caps laid down by both the Government in (a 40% reduction in the period 1988-2020) and the EU climate and energy package (a reduction by 20 in the period 1990 – 2020) were adopted as the framework for determining the strategic goal.

In order to achieve this strategic goal expressed by the CO_2 emission caps, it was necessary to formulate the strategy for reaching this limit in the form of scenarios involving a different energy mix, with the assumed satisfaction of electricity needs. The fundamental assumption of the model which served for comparing the scenarios was that in 2020 the electricity sector would emit 40% less CO_2 than in 1988 and 20% less than in 2005. In order to achieve this, it was necessary to build an appropriate structure of the satisfaction of the electricity needs, the so-called energy mix or rather a reduction mix, with the use of zero-emission technologies. It was attempted to keep the share of renewable energy generation at a minimum level of 20% of the energy produced in consideration of the requirement of the

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[5] The base year for Poland for the fulfilment of the requirements under the Kyoto Protocol.

[6] *Poland's National Inventory Report 2008*. National Administration Of The Emissions Trading Scheme National Emission Centre. Submission under the United Nations Framework Convention on Climate Change and its Kyoto Protocol. May 2008

3x20 Package[7] and the related obligation for the 15% share of renewable energy in the total final energy balance in Poland in 2020. The basic parameters modelling the scenarios were an increase (as a result of investments) and a decrease (as a result of decapitalisation) of the capacity installed at the different types of electricity-generating installations. The analysis covered the following scenarios:

- a "versatile" scenario,
- without nuclear energy,
- without lignite,
- without gas,
- with the maximum renewable energy,
- with the maximum energy efficiency.

Taking into account many aspects, such as the costs, technological issues, social problems and environmental considerations, the scenario selected for further work involved the maximum energy efficiency changing in time and a substantial share of RES. This scenario was also supported at the conference which the ISD convened to select the scenario for further work. The choice of this scenario represents:

- the electricity production at a level of 172 TWh in 2020 and at a level of 192 TWh in 2030 compared with 156 TWh in 2005;
- the energy efficiency improvement at a mean annual rate of 2.5% until 2020 and subsequently at a mean annual rate of 2% until 2030;
- the share of renewable energy in electricity production at a level of 19% of the final energy in 2020 and at a level of 35% of the final energy in 2030 compared with 3% in 2006;
- a drop in CO_2 emissions from 147 million tonnes in 2005 to 117 in 2020 and to 71 million tonnes of CO_2 in 2030 (regarding the public power plants and public heat and power generating plants covered by the EU ETS).

Apart from electricity generation, the key issue is the satisfaction of the demand for heat. For the purposes of calculating this demand and the level of CO_2 emissions caused by its use, it was assumed that by 2020 the useful space in buildings would grow to 250 million m^2 and to 400 million m^2 by 2030. In order to meet the requirements of the strategic goal, it will be necessary to keep the CO_2 emission reduction rate by improving the energy efficiency and changing the fuel structure. In consequence, CO_2 emissions should fall by 48% by 2020 compared with 1996 and by 57% by 2030. In order to achieve such a reduction, strong action must be taken, comprising: the reduction of heat consumption, the limitation of the development of new buildings with high potential heat demand (in 2020, new buildings should consume no more than 25 kWh/m^2/yr of heat), the further promotion of thermal modernisation of buildings, the improvement of energy efficiency and the significant improvement of the efficiency of electricity and heat production.

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[7] The objectives set out by the EU Climate and Energy Package, i.e. a 20% reduction of energy consumption by 2020 compared with the business as usual scenario, a 20% share of RES in the final energy use and a 20% reduction of greenhouse gas emissions in the period 1990 – 2020.

It will be particularly difficult to accommodate within the limits of the strategic goal the increased energy consumption in transport, for which the *business as usual scenario* predicts an increase in the CO_{2eq} emissions by more than 56% by 2020 and by more than 67% in 2030 compared with 2005. A step towards a more sustainable transport will be to achieve a much smaller increase in the emission growth, which would be less than 22% in 2020 and about 27% in 2030. Radical measures should be taken to reduce energy consumption in transport by 25% with respect to the *business as usual scenario*. These measures can be divided into four groups:

1. measures to slow down the transport intensity growth rate of the economy and life (measured by the number of tonne-kilometres and passenger-kilometres);
2. measures to halt the growth or even to reduce the share of highly energy intensive means of transport, i.e. freight road transport, passenger transport (passenger cars) and air transport;
3. measures to improve the operational efficiency of transport, e.g. by improving the rate of utilisation of the loading capacity of means of transport in the transport of freight and passengers;
4. support for progress in the transport technology, primarily for the production of means of transport with higher energy efficiency and powered by energy sources alternative to crude oil and coal.

Such radical measures are necessary to ensure that in 2005–2020 in the sectors not covered by the emission allowance trading scheme - Non EU ETS - (construction, transport, waste management) an increase in greenhouse gas emissions does not exceed 14% such a commitment for Poland is laid down in the EU Climate and Energy Package.

In order to achieve the objectives set out for electricity production, heat supplies and transport, a whole set of instruments must be adopted. Here are the most important ones:

a) the establishment of an agency for energy and climate, responsible for policy-making and legislation;
b) the introduction of tax credits awarded to energy-saving procurement or investments;
c) the expansion of the system of tradable property rights related to certificates of origin, called coloured certificates:
   - green certificates – supporting the development of renewable electricity production,
   - red certificates – supporting highly efficient coal-based cogeneration (and micro-sources),
   - yellow certificates – supporting gas-based energy generation,
   - white certificates – supporting energy efficiency,
   - blue certificates – supporting highly efficient sources of electricity production with $\eta >$ 46%,
   - orange certificates – supporting "clean coal" technologies, e.g. CCS;
d) the conduct of a general educational campaign for energy saving both at households, public buildings and companies;

e) the establishment of a fund for supporting energy efficiency and renewable energy,

f) the introduction of demand side management on a wide scale in the transport sector, the building of spatial structures with low transport intensity, the promotion of public and non-motorised modes of transport and the substantial improvement in their efficiency.

The main aim of the AEP presented here was not to indicate the only possible or best solutions which would ensure safe and competitive energy supplies. With our study we only wanted to demonstrate that an alternative approach to energy policy development was possible and was based on the allowable load on the natural environment. The selected scenario would contribute to the greatest extent not only to ensuring safe and competitive energy supplies, but also to fulfilling the conditions of sustainable development, taking into account social objectives, too. We indicate that with appropriate resources this approach can be subjected to the optimisation procedure. Unfortunately, the latter task is still ahead of us – the citizens and the Government of the Republic of Poland.

New paradigm to create the strategic documents bases on AEP case need to take to account:

- ♦ environmental limits as a starting point;
- ♦ participatory way to prepare a document;
- ♦ the most profitable goal from social, economic and environmental point of view is to full feel the needs but not to build a new capacity for production or service delivery.

All these things provide us to be closer to implement the Constructional Statement about State responsibility to solve environmental problem following the sustainable principle.

1. Introduction

In recent years energy security became one of the most important political, economic, social and environmental issues in Poland. Due to the magnitude of these issues, energy policy cannot be developed exclusively by experts on energy generation and the energy market. The process of building this policy must involve the participation of experts from different sectors of the economy and representatives of self-governments, trade unions, non-governmental organisations, including environmental ones, and others.

The Institute for Sustainable Development (ISD) attempted to create such a policy. The main idea of this proposal was to ensure a wide participation of different social groups in the process of its preparation to ensure that it addressed all the most important economic, social and environmental challenges.

The different approach to energy policy development – hence the use of the term "alternative" – results from the adoption of a point of departure other than the traditional one. It is the need to limit greenhouse gas emissions to a predetermined level. Within the emission caps for these gases (limits), the most efficient ways (in economic, social and environmental terms) of the management of energy resources and the methods for meeting the demand for electricity, heat, gas and liquid fuels were sought.

In starting the work on *Poland's Alternative Energy Policy until 2030 (AEP)*, the following assumptions were adopted:

- Energy security – the justified and sufficient satisfaction of the energy needs in the context of the political security of the country and the security of individual energy users (households, companies and settlements).
- Competitiveness – the creation of equal conditions and market-based mechanisms for the different forms of energy generation, taking into account external costs, long-term calculation of loss and profit, reduction of subsidies and, at the same time, minimisation of the influence of political decisions.
- Sustainable development – the need to consider the interests of the future generations when developing economic policies and strategies. They should be taken into account, at least to the same extent to which the interests of the contemporary generations are respected. They should also be expressed by the levels of the caps of greenhouse gases, in particular those of CO_2.
- Social (and cultural) dimension of energy – the satisfaction of the energy needs, taking into account the opportunities to create jobs, particularly in rural areas, as well as the stimulation and creation of the conditions for supporting local entrepreneurship and human development.

The work on the alternative energy policy was carried out in three stages:

a) diagnosis and dilemmas facing the energy sector

The present situation of the energy sector was diagnosed. Four one-day seminars were organised for those interested in policy-making – representatives of non-governmental organisations, territorial self-governments, government administration, industry and the energy sector as well as trade unions. Their aim was to become acquainted with the objectives of the project, to identify the persons who would support the policy development process and to involve the largest possible group of participants in this process. Each of the seminars concluded with the identification of dilemmas of significance for particular groups. The seminars were attended by 90 persons and 125 problems and dilemmas of different types were raised in the course of them.

b) options serving to resolve the dilemmas identified, along with strategies for their implementation

Policy scenarios were developed taking into account the dilemmas identified in the course of the earlier seminars. They were presented in the course of a conference which, apart from the persons who had participated in the earlier seminars, was attended by politicians and representatives of government administration - as a total by 110 persons. The aim of the conference was to make a list of all the important issues which the alternative energy policy should address and to discuss the emerging dilemmas and problems related to its implementation.

c) the preparation of the final version of the document

A preliminary draft document was prepared, containing the analysis of the main dilemmas of the policy and proposals for their resolution as well as the possible and recommended measures to implement the policy objectives. The draft was the subject matter of a debate in the course of the verification seminar attended by 14 experts. The conclusions from the seminar served to develop the version of the document which took into account the comments and suggestions submitted in the course of the seminar. After consultations in the course of four meetings in Cracow, Katowice, Wrocław and Gdańsk, which were attended by 184 persons, the final version of the document presenting Poland's Alternative Energy Policy was prepared.

All the meetings where participants cooperated to develop AEP were attended as a total by almost 550 persons.

The work on AEP lasted from November 2007 to June 2009. It was chaired, as the main expert, by Prof. Krzysztof Żmijewski from the Warsaw University of Technology. Many experts and ISD collaborators took part in the preparation of the document.

- Mr. Stanisław Poręba, M.Sc. (advisor to the Management Board of PGE Mining and Energy S.A.)
- Mr Tomasz Chruszczow, M.Sc. (business association Forum CO_2)
- Dr. Tomasz Kaczor (Prevision);
- Dr. Zbigniew Karaczun (Warsaw University of Life Sciences);
- Dr. Andrzej Kassenberg (Institute for Sustainable Development);
- Prof. Jerzy Niewodniczański (former President of the State Atomic Energy Agency, now at AGH University of Science and Technology);
- Dr. Sławomir Pasierb (Polish Foundation for Energy Efficiency);
- Prof. Jan Popczyk (Silesian University of Technology);

- Dr. Janusz Steinhoff (former Deputy Prime Minister and Minister of Economy, Chairman of the Supervisory Board of the Regional Chamber of Commerce and Industry in Katowice);
- Dr. Marcin Stoczkiewicz (Environmental Law Center);
- Mr. Maciej Stryjecki, M.Sc. (independent expert on renewable energy sources)
- Dr. Marta Styrc (Warsaw School of Economics);
- Prof. Wojciech Suchorzewski (Warsaw University of Technology)
- Mr. Grzegorz Wiśniewski, M.Sc. (Institute for Renewable Energy).

Aleksandra Arcipowska and Aleksandra Stępniak were responsible for the organisational issues on behalf of the ISD.

The provisions of the report only express the views of the Institute for Sustainable Development and do not have to be shared by the persons who cooperate with the ISD.

The entire work would not have been possible without the financial support awarded primarily by the National Fund for Environmental Protection and Water Management as well as the Oak Foundation and the Böll Foundation. However, the views contained in the document do not necessarily reflect the positions of the institutions which supported the whole project financially.

The Institute for Sustainable Development would like to take this opportunity to express its cordial gratitude to both the experts who supported the work with their knowledge and experience and the persons who took part in the whole process of development of AEP for their involvement and willingness to cooperate and the financial institutions for the support which they have given to us.

Institute for Sustainable Development

2. A new paradigm of energy policy

The major focus of the strategic documents drawn up to date concerning not only energy policy, but also other economic sectors, or the entire country or regions, was primarily the satisfaction of needs. In the best case, in these documents, the issues of the management of resources or environmental protection were reduced to enhancing the productivity of resources and minimising the impacts on the environment. In practice, the environmental limits, i.e. the depletion of non-renewable resources and pollutant emission caps designed to ensure the effective functioning of the natural environment (in particular, the global systems sustaining life on the Earth) and the appropriate environmental quality, were not considered in them. The adoption of the concept of sustainable development – as the leading one – and the global scale of human impacts on the environment made it necessary to respect these limits in strategic documents.

This can be clearly seen from the Living Planet Report, prepared by the Global Footprint Network, WWF and the Zoological Society of London. This report states, inter alia, that[8]:

- the Earth's capacity to regenerate has been exceeded by 30% - the ecological footprint now amounts to 2.7 gha per person[9], while the present biological capacity to regenerate the planet's resources is estimated at 2.1 gha/person;
- the EU ecological footprint is twice as large as the capacity of the area it occupies to regenerate the resources – the co-called biological capacity;
- Poland's ecological footprint is 4 gha per person, almost twice as large as the average capacity to regenerate the resources per one Earth inhabitant.

If the demand for the Earth's resources continues to grow at the existing rate, from the mid-2030s on we will need the resources of two planets to sustain the present lifestyles (Fig. 2). What makes it so costly? The enhanced mobility of humans (the road construction and the preference for means of transport which emit relatively large quantities of carbon dioxide), the greater use of raw materials (e.g. as a result of the construction boom in China), the higher demand for food (satisfied through the clear-cutting of forests and their replacement by arable land) – all these are the causes of climate change.

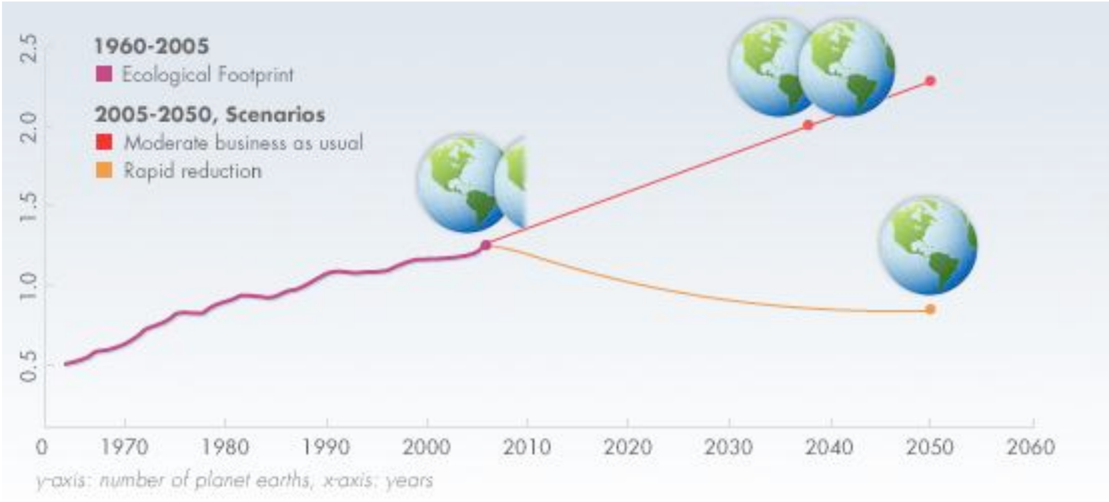
In connection with the point of departure presented above (the new paradigm), in preparing strategic documents it is necessary to define the following:

a) the resources available (destined) for a given sector of the economy or area;

b) the pollution caps for a given field of the sector of the economy or area resulting from the capacity of the environment to absorb pollutants and the need to ensure a high quality of life.

[8] http://www.panda.org/about_our_earth/all_publications/living_planet_report/
[9] The ecological footprint, op. cit.

Fig. 2. The global ecological footprint for 1960 – 2050



Source: http://www.footprintnetwork.org/en/index.php/GFN/page/world_footprint/

The essential feature of the discussions now underway on the development of the energy sector in Poland is the absence of integrated and long-term thinking about the effects of the proposed solutions. What overwhelmingly dominates is the sectoral interest of the energy sector and the short-sighted political interests of the ruling parties which are afraid of losing popularity in the event that (as a result of their actions) energy prices grow. There is no depth to be seen in analysis, nor is there the courage to take difficult decisions which would be beneficial for Poland on a comprehensive basis and in a longer term. Therefore, our country should primarily:

- integrate climate policy into the economic policies, in particular energy and transport policies, and take efforts to fulfil its own and international commitments. This would mean the need to set out e.g. caps for greenhouse gas emissions for the individual economic sectors as the points of departure for building development programmes;
- abandon sectoral and immediate thinking without taking into account the costs which would be incurred by our children and grandchildren. This means the need to consider the following in the decision-making process: the costs of inaction, external costs and the effects of the phase-out of subsidies that are harmful for the environment. For example, according to the paper by CAN Europe, WWF and the Health and Environment Alliance[10], the adoption of the Climate and Energy Package would contribute to a substantial reduction in the emissions of harmful air pollutants other than CO_2 (SO_2, NO_x and PM2.5[11]), and thereby in the expenditures on the health-care service (diseases, hospitals) and the costs of absence from work. As a result of a reduction in the number of premature deaths, a decrease in the number of ill persons and the losses caused by absence from work, in 2020 the following costs could be avoided:
  - EUR 13–52 billion in the case of a 20% reduction in GHG emissions in the EU with respect to 1990;

[10] *The Co-benefits to Health of a Strong EU Climate Change Policy.* http://www.climnet.org/Co-benefits%20to%20health%20report%20-september%202008.pdf
[11] Particulate matter with a diameter of up to 2.5 microns.

    - EUR 20–76 billion in the case of a 30% reduction in GHG emissions in the EU with respect to 1990;

- strongly support unconventional solutions in energy policy. They can trigger substantial reserves in innovative thinking (both in the economy and at households); this would lead to a dynamic improvement in energy efficiency, a substantial acceleration of the development of the use of renewable energy sources, the enhancement of the energy security of the country and the support for local development. All this would lead to job creation[12] and the limitation of greenhouse gas emissions. Due to the large scale of savings, the Gross Domestic Product could grow by a factor of 2–3, without an increase in energy consumption. In turn, this would reduce the need to build new capacity at utility power plants, limiting the investment projects to replace fixed assets in the existing plants which would also contribute to the more efficient production of electricity.

The new approach to energy policy is an opportunity for modernisation and greater innovation in the Polish economy, public institutions and households. It is an important opportunity, although it is not easy to use and requires not only a change in habits and mindsets, but also the adoption of novel solutions. We should not be afraid of another transition towards the building of a sustainable economy, taking into account the need to protect the climate which is system that sustains the life support system on the Earth; its serious disturbance may bring incalculable effects for mankind.

[12] According to FEWE, an energy saving programme could create, on an accruing basis, new 298,000 full-time jobs in Poland in 2011 to 2020. *Report. The potential for energy efficiency and emission reductions in selected groups of energy uses. The way forward to the implementation of the climate and energy package.* Polish Ecological Club, Upper Silesian District, Foundation for Energy Efficiency, INFORSE, European Climate Foundation. Katowice, 2009.

3. Strategic goal

With reference to the new paradigm, the following strategic goal of *Poland's Alternative Energy Policy until 2030* was adopted.

The creation of the conditions for the efficient satisfaction of energy needs within the limits of determined and available natural resources as well as the caps for the release of pollutants into the environment.

Such a formulation of the strategic goal refers to the Constitutional principle of sustainable development[13]. This approach requires the equal treatment of social, spatial and environmental aspects within the limits of the resources available for the present and future generations and the consideration of the capacity to release pollutants into the environment without its degradation and ensuring the effective functioning of the life-supporting systems on the Earth, such as the global climate.

Such a policy will require:

– in social terms:

- the socially equitable satisfaction of energy needs (the marginalisation of access to energy is not acceptable);
- ensuring the consideration of the interests of the future generations;

– in economic terms:

- the creation of opportunities for meeting energy needs on the condition of the most efficient energy use;
- ensuring the economic viability of the proposed solutions;
- the creation of equal competitive conditions for the individual modes of energy generation;

– in spatial terms:

- the creation of systems to efficiently satisfy energy needs while minimising the energy transmission (energy efficient spatial structures);

– in environmental terms:

- the limitation of the use of non-renewable resources in favour of renewable resources while preserving their capacity to regenerate and respecting the requirements of nature conservation;
- the adjustment of the magnitude, type and release time of pollutants to the bearing capacity of the environment in respect of pollutants.

The greenhouse gas emission levels under the Climate Policy adopted by the Government in 2003 (with a reduction of 40% in 1988–2020) and the EU Climate and Energy Package (with a reduction of 20 in 1990– 2020) were adopted as a framework for the implementation of the strategic goal. Table 1 lists the consequences of these decisions for AEP.

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[13] Article 5 of the Constitution of the Republic of Poland.

Table 1. Required greenhouse gas emissions in Poland in $mtCO_{2eq}$

Description		2020				APE 2030[14]
		Polish Climate Policy – 40% reduction (from 1988)	EU Climate Policy – reduction 20% (from 1990)	EU Climate Policy – reduction 30% (from 1990)	AEP[15]	
Total greenhouse gas emissions		338	353	309	x	x
Greenhouse gas emissions from fuel combustion, without transport		254	260	228	x	x
Emissions from EU ETS-covered utility power plants and heat and power generating plants[16]		128	116	102	116	71
Greenhouse gas emissions from transport	Increase no more than 14% - EU requirement to compare to 2005.	42				x
	Business as usual	58				62
	Sustainable way of transport	45				47

The adoption of the emission levels of such pollutants as greenhouse gases as the reference point for the preparation of energy policy does not exhaust the possibility of considering many other pollutants which are generated by this sector. According to the European Environment Agency, the production and use of energy consist primarily of the generation of electricity, heat, cold, crude oil refining and the use of energy in households, industry and transport. This gives rise to substantial pressures on the environment, as illustrated by the enumeration below, which, apart from the greenhouse gas emissions, include the emissions of other air pollutants (such acid pollutants as SO_2 and NO_x, particulate emissions, including particularly dangerous PM10 and PM2.5, as well as the emissions of precursors of tropospheric ozone), the impact on the quantity and quality of waters, land use change, waste generation or crude oil spills. Apart from the impact on global climate change, this also contributes to damage to natural ecosystems and economic losses and adversely affects human health.

Given the educational nature of this study rather than the proposal of a specific planning document and also in the light of scarce financial resources, as mentioned earlier, the detailed analysis was limited to greenhouse gas emissions and the electricity subsector. Other subsectors, such as heat generation and transport, were considered, but to a more general extent. However, from the methodological point of view, the choice of greenhouse gases and electricity generation is representative of the whole energy sector. Indeed, the limitation of

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[14] The pollutant emissions were calculated for the electricity sector (within EU ETS), recognising that it is the most important source of greenhouse gas emissions. Wider analysis would require additional resources which the ISD does not have. The values for transport were estimated after *The use of energy in transport* by W. Suchorzewski, prepared for the purposes of AEP.

[15] As above.

[16] The scope covered by the scenario analysis within AEP.

greenhouse gas emissions also causes the reduction of the emissions of other pollutants and broadly conceived pressures and impacts on the environment, while electricity generation is the greatest source of pollutants in the entire sector.

4. Detailed objectives

The detailed objectives of AEP were laid down in terms of four basic dimensions:

- Energy security:
  a) Avoiding the (economic and political) trap of becoming dependent on a monopolist supplier of gas and liquid fuels;
  b) Achieving the certainty of electricity, gas, heat and liquid fuel supplies for settlements – metropolies, towns and villages. Indeed e.g. a voltage decay in the electricity network automatically blocks the supplies of other media and water, stops mass transport and blocks information flow;
  c) Ensuring stable energy supplies at competitive prices compared with other European (and world) suppliers in order to create the conditions for the efficient and effective functioning of the economy – industry, transport and services.

  The situation in the scope of the last two detailed objectives is affected to a lesser extent by foreign supplies and to a greater extent by the technical condition, topology and the architecture of plants and networks.
- Competitiveness:
  a) The achievement of diversification of generation forms (utility, non-utility and dispersed);
  b) The achievement of ownership diversification to ensure a real possibility of choosing a product/service and its producer/provider. The possibility of choosing a product/service also means the ability to choose their quality; in the case of network media means the supply quality known in telecommunications as SLA (*Service Level Agreement*);
  c) Ensuring high energy efficiency and a high certainty of supplies at competitive prices.

  The issue of competitiveness should be considered more broadly in terms of the effect of energy policy on the competitiveness of the Polish economy with respect to the other economies in Europe and the world. In fact, this requirement is the need for an efficient functioning of the market. A well functioning market must apply fair rules of the game. They include e.g. the inclusion of external costs, the prohibition of subsidies incompatible with the principle of sustainable development and the pre-determined time-defined subsidisation limit, beyond which the beneficiary should operate without further support or cease its activities, since it would not be profitable under market conditions.
- Sustainable development:
  a) The minimisation of the consumption of non-renewable resources and, specifically, the achievement of at least a 15% share of renewable energy sources (RES) in the final energy balance in 2020[17]. The RES share must be broken down for sub-sectors: 10% in the sector of transport fuels, 20% in the electricity sector and 16.6% in the heat sector;
  b) The achievement of at least a 40-% reduction in greenhouse gas emissions in 2020 compared with 1988 and at least a 20–30% reduction in 2020 compared with 1990. In

[17] In the timeframe until 2030, if strong support is given to the development of renewable energy sources and if the rate of scientific and technological progress is sustained in this sub-sector of energy generation, a much higher share, of the order of 30-40%, should be assumed. Some experts speak of significant possibilities of its growth. *Energy [r]evolution for Poland: A scenario of a long-term supply of clean energy carriers to Poland*. Greenpeace Poland, October 2008.

the electricity sector and the centralised heat sector (EU-ETS) the reduction must be at least 21% in the period 2005–2020. In the non-ETS area, a 14% growth in emissions is allowed;

c) The consideration, in the long-term energy projections, of the expected extent of the greenhouse gas emission reductions by 60–80% which Poland must achieve in 2050 with respect to the base year (which is 1988 for Poland); in linear terms, this can be translated into: a GHG reduction to 306–246 $mtCO_{2eq}$ in 2030 from 399 $mtCO_{2eq}$ in 2007.

Due to the assumptions made (the point of departure for creating AEP), the highest priority is given to this dimension. This results from the need to take care of the Earth's resources being depleted (in particular, though not only, fossil fuels) and the concern about the natural environment the condition of which continues to deteriorate; and especially about the effective functioning of the systems sustaining life on the Earth systems (such as the global climate).

- Social dimension of energy
  a) Ensuring that all energy users are provided with services of appropriate quality (appropriate quantity and quality of energy supplied);
  b) The provision of such a quantity of energy to users that will ensure their access to the amenities of civilisation while keeping the high efficiency of its use;
  c) The stimulation of the development of local activity (entrepreneurship and services ensuring the improvement of living conditions);
  d) Job creation, particularly in rural areas.

5. Principles of AEP implementation

In order to achieve the strategic goal and detailed objectives of AEP, the following principles must be followed in meeting energy needs (Fig. 3), including transport-related ones.

5.1. The principles relating to energy

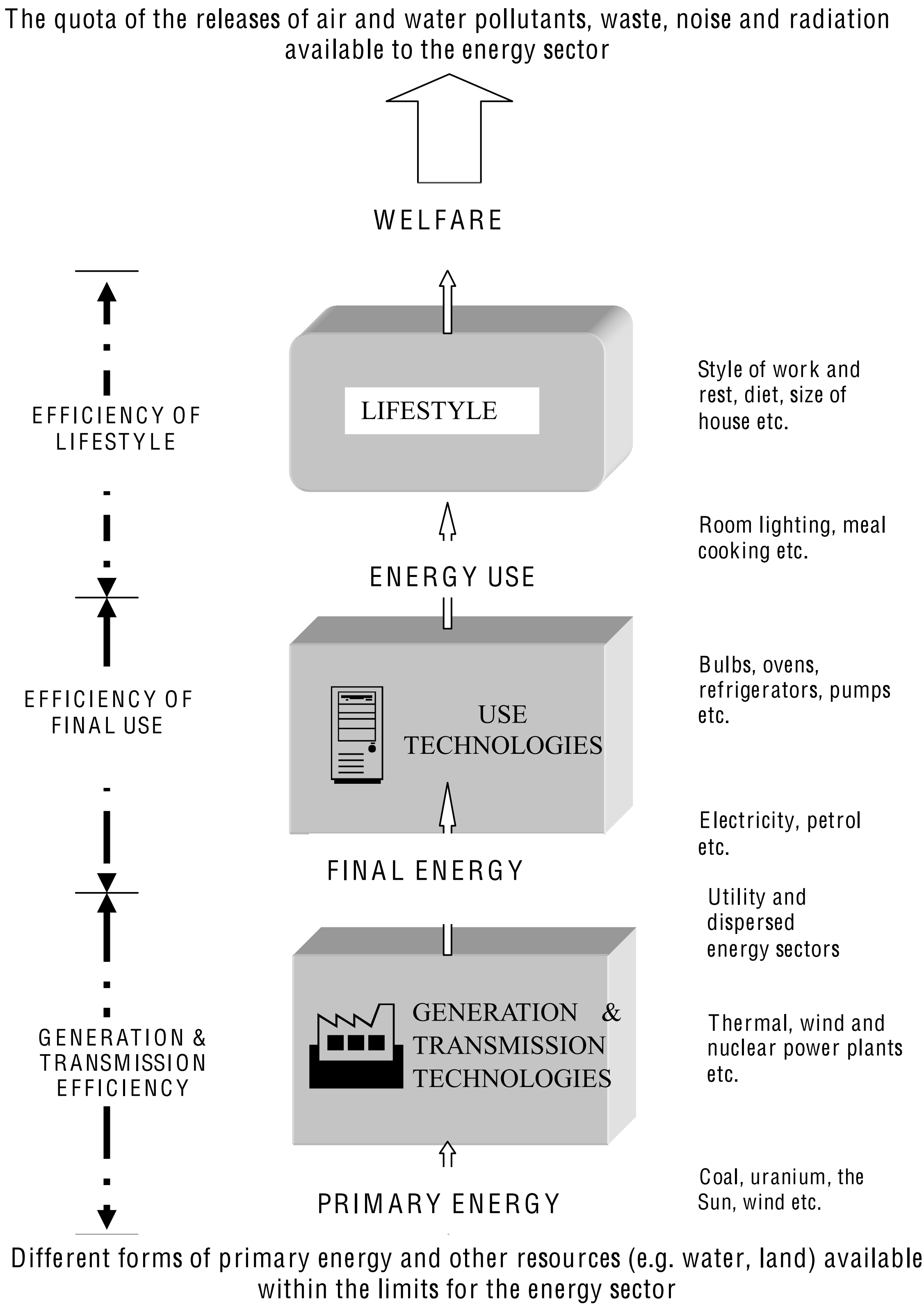
a) The high energy efficiency of a lifestyle

The first step is the environmentally friendly and energy-saving behaviour of the public and economic operators. Purchases of energy carriers and products or equipment which use energy require high environmental awareness which should be based on a selfless approach to life, but can also be an effect of a double, or perhaps a triple benefit. It is a double one, since the environmental effect is strengthened by financial benefits for households and economic operators; it is a triple one, since at the same time social objectives, e.g. to prevent unemployment, are achieved. If it does not originate from the family home, which still happens very seldom, such awareness can be built at a kindergarten, school, housing estate or locality. Such awareness has also the historical and cultural dimensions. Its creation and the development of such a lifestyle should become an element of education and economic policies, using a variety of instruments strengthened by appropriate financial resources and institutional measures in order to enable them to be effectively used. This imposes on the public administration the obligation to introduce educational programmes in this scope, within the framework of both formal and informal education.

b) The high efficiency of the final energy use

The next step is to create the conditions for using solutions and equipment enabling energy to be used efficiently. This should involve a whole system of incentives encouraging the production of such equipment and its purchase, or perhaps, to the greater extent, the use of such equipment. Indeed, in general, customers are not interested in having a bulb, oven, washing-machine, refrigerator or heater (with the exception of hobbyists), but they are interested in living in a warm apartment, which is lighted, if necessary; they wish to be able to wear clean clothes and eat food which is edible. The driver should be the satisfaction of customers' needs rather than encouraging them to buy electricity, heat, gas, heating oil or petrol. On the one hand, the key to this is the producers' commitment to continuously seeing to such satisfaction and, on the other, so is the conviction that in order to achieve it they do not have to be the owners of this equipment. Consideration should be given to the manner of selling heating comfort or lighting comfort rather than ovens or bulbs; to the manner of doing this so that the satisfaction of comfort would be less costly for customers, affect the environment to a lesser extent and bring general public benefits, e.g. new jobs, and, at the same time, generate profits for the company which provides such comfort. The public administration should lead the activities aimed at improving energy efficiency and thus create an example and climate for the performance of work in this scope by other entities.

Fig. 3. The system for meeting the energy needs in a society pursuing sustainable development



Source: J.S. Norgard, 2000a, *Models of Energy Saving Systems; the Battlefield of Environmental Planning*. International Journal of Global Energy Issues, vol.13, No. 1-3, pp. 102-122 + changes.

c) The high efficiency of energy generation and transmission

The final step, rather than the first one as is traditionally believed, is to create the production capacity to generate usable energy. Primarily, it is important to use energy resources as efficiently as possible and to gradually resign from non-renewable fossil fuels – this means support for combined heat and power generation and the dominating share of renewable raw materials in this respect. Indeed, fossil fuels are non-renewable and their use has a significant impact on the climate, causes climate change and also leads to other damage. In addition, it is necessary to bring energy sources close to the user (through the dissemination of dispersed energy facilities, i.e. the so-called small energy systems) and to ensure highly efficient energy transmission (minimising losses).

d) The incurring of the full costs of generation, distribution and use of energy and fuels

The point of departure for improving the efficiency of energy use and its correct structure (in terms of full costs) is the internalisation in fuel prices of all the so-called external costs related to degradation of the environment (e.g. the effects of climate change: floods, droughts and hurricanes) and the adverse impact of the energy sector on humans and property (e.g. medical treatment bills, the lost productivity, losses in agriculture and forestry, damaged buildings, roads, bridges and other facilities). These costs are and will be borne by taxpayers and future generations; in the form of losses, they disturb the functioning of the environment, in particular life-sustaining systems. This is partly done by the implementation of the "polluter pays principle", but the level of these charges is incommensurably low when compared with the level of external costs.

5.2. The principles of energy use in transport

The basic principle is the rationalisation of the need to travel and to transport goods (demand side management), which has been formulated in many documents of the European Union and OECD. The actions taken under this principle, which in consequence lead to reduced energy consumption in transport, cover a wide spectrum of activities:

- the curbing of suburbanisation processes (urban sprawl);
- the concentration of functions (domicile, work and services) in corridors served by efficient public transport;
- the tendency to mix functions (e.g. through the development of services in urban districts and housing estates);
- changes in the spatial organisation of production, storage and distribution which lead to the rationalisation of goods transport;
- the promotion of the "glocalisation" philosophy[18];
- the promotion of more energy-saving and environmentally sound technological solutions for means of transport. The development of road transport, in particular the number of passenger cars, justifies the measures to reduce emissions at source. This can be achieved

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[18] Glocalisation means global technologies and solutions using local raw materials and capabilities.

not only through technological progress, but also using legal and fiscal measures, e.g. through the restrictions imposed on the construction of vehicles and engines (less horsepower and vehicle weight, minimised fuel consumption, alternative energy sources etc.). It is important to point out that the adoption of more stringent technological standards must necessarily be coupled with tax policy to ensure that while reducing fuel costs and emissions technological progress does not encourage longer travels;

- encouraging the use of a combination of transport modes (inter-modal goods transport, the Park and Ride system) and the more intensive use of means of transport: advanced logistical solutions as well as car pooling/lift sharing;
- the rationalisation of the services rendered by the public transport through their adjustment to the needs which change in time and space, the use of different types of fleet (in terms of size, quantity and frequency of operation) to ensure that its capacity is fully used, without compromising the efficiency and comfort of travels.

The need to reduce energy consumption and the adverse impact on the natural environment and living conditions as well as the impossibility of ensuring the freedom of car use in intensely developed areas (particularly in big cities) justify the measures taken to limit road transport in the scope of passenger and goods transport. The measures include legal and organisational means, including an appropriate offer of alternative means of transport (rail, public transport, water transport), and fiscal ones (taxes, charges for road use etc.).

6. Synthetic assessment of the status and factors affecting the implementation of AEP[19]

When intending to achieve both the strategic goal and detailed objectives, account should be taken of the situation in the energy sector and the internal and external conditions under which this policy will be implemented. The present situation in the sector can be described in several points.

1. The basic problem of the Polish energy sector is its low efficiency (productivity), which is aggravated by the low efficiency of energy use. According to the Foundation for Energy Efficiency (FEWE), the saving potential in the timeframe until 2020 amounts to 26.8 TWh/yr in electricity and 512.9 PJ/yr in fuels and other energies[20].
2. The high share of coal in the primary energy balance and the extremely high share of coal in the energy mix of electricity generation. The share of coal in the primary energy balance still continues to be high, mainly as a result of the domination of this fuel in the electricity sector (92%) and the heat sector (80%). As a result of this, the Polish coal-fired power plants are characterised by a high emission factor of about 950 kg CO_2/MWh.
3. In the Polish energy sector, there are enormous technical disproportions; its technical structure does not adequately match the functional requirements and users' needs. This applies both to the generation capacities, their distribution and transmission networks. For example, in 2010, 39% of power generating units will be more than 40 years old; the loop of the north-eastern and north-western 400 kV transmission networks is unclosed and the topology of 15 and 3 kV distribution networks is open, causing very poor supply to rural areas (large voltage decays even down to 170 V, frequently interrupted supplies, unstable voltage).
4. The Polish energy sector is in a serious economic crisis, as evidenced by the persisting critical lack of replacement investment.
5. Non-enforced or incomplete legislation hampers the functioning of the sector; some solutions are extremely unfinished, while others are lacking.
6. In the energy sector, particularly in its network part, the culture of a monopoly or that of an office still persists.
7. The renewable energy potential is significant: at the present technological level, its share is estimated at 46% (the technological potential), whereas the economic potential for 2020 is estimated at almost 22%, of which less than 1/5 is used[21].
8. Changes in the transport sector have brought about the excessive domination of the car over the other forms of satisfying the travel needs; this has led to a large increase in the consumption of transport fuels. The State is unable to effectively regulate an increase in

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[19] Annex 1 contains a detailed description of the existing status and drivers.

[20] *Report. The potential for energy efficiency and emission reductions in selected groups of energy uses. The way forward to the implementation of the climate and energy package.* Polish Ecological Club, Upper Silesian District, Foundation for Energy Efficiency, INFORSE, European Climate Foundation. Katowice, 2009.

[21] *The capacity to use renewable energy sources in Poland until 2020*, Institute for Renewable Energy, in cooperation with the Institute for Sustainable Development, Warsaw, December 2007.

the transport intensity of the economy and the snowballing growth of private car ownership. In practice, pro-motorisation policy is pursued with no respect for any environmental restrictions. A consequence of this is (and will be in the future) a substantial increase in the greenhouse gas emissions (and those of other pollutants) from this sector.

The national situation is additionally affected by external factors, primarily by the globalisation process, along with the intensifying financial crisis and the EU climate and energy policy, in the absence of a real rather than just declarative European integration in the area of the energy sector.

With reference to the above assessment of the present status, within the framework of the first stage of the work on AEP (i.e. the meetings with representatives of different interest groups: non-governmental organisations, particularly environmental ones, trade unions, entrepreneurs, representatives of the public administration and experts), the relevant problematic areas were identified as including:

- the energy uses by individual and industrial users and the State administration;
- energy distribution using different technical means;
- the need to change the manner of energy generation from non-renewable and renewable sources: electricity, heat, gas, and the use of liquid fuels. For example, the energy from renewable sources satisfies the heat demand to a slight extent;
- ineffective institutional measures: legal grounds, financial instruments, distribution of information and institutions responsible for the implementation of energy policy. At present, the legislation does not confer unambiguous competence to build an energy order;
- cooperation (or its absence) within the EU with the neighbouring countries and others;
- the social aspect, as expressed e.g. in the problems faced by persons employed in the energy sector and the need to ensure an appropriate standard of the satisfaction of energy needs for all families. The development of local service companies and higher employment are just as important;
- the environmental dimension, particularly with respect to the need to limit CO_2 emissions and the environmental restrictions on the development of RES.

Knowledge of the public opinion is needed for taking the correct decisions concerning the directions of development of the energy sector in Poland. In April 2008, the Institute for Sustainable Development carried out a survey[22] on a 1000-person standardised respondent sample. They were asked which direction of development of the energy sector should prevail in Poland. The results of this survey are presented below: the number of respondents who gave a particular answer is given with each reply:

- renewable energy – 43.5%;
- energy saving – 22.6%;
- nuclear energy – 14.1%;

[22] The results and comments on the survey can be found on the website: http://www.ine-isd.org.pl/obrazki/file/ekoherkules/Swiadomosc_ekologiczna_Polakow_InE-2008.pdf.

- hard coal and lignite – 6.8%;
- crude oil and natural gas – 3.,6%;
- hard to say – 9.3%.

At the same time, more than 80% of respondents accept State budget support for renewable energies. In turn, when choosing household appliances, radio and television sets and the like, Poles primarily consider the product prices; subsequently, their reliability and durability; followed by their brand and only then by energy and water saving. It is important to emphasise the inadequate appreciation of energy efficiency which reduces costs; this indicates a relatively low economic awareness of the Polish public.

Analysis of the present status and its internal and external conditions makes it possible to indicate the **basic challenges involved in the development of the energy sector in Poland.** They are as follows:

- It will be very difficult, if possible at all, to maintain the existing structure of the energy sector, based mostly on coal combustion, in the light of the climate policies of Poland and the EU. Probably, the only possibility of maintaining coal-based energy generation will be the wide use of the CCS technology, if it is proves viable;
- It is necessary to support measures to improve energy efficiency, since this diminishes the dependence on supplies of energy raw materials and reduces the costs of energy comfort;
- It is necessary to shift from centralised energy generation to the creation of local energy systems with equal rights within the framework of dispersed energy production dominated by renewable energy sources;
- It is necessary to support the development, modernisation and maintenance of energy networks, since their condition determines the equal opportunities of the inhabitants of all the regions of Poland for meeting their energy needs;
- It is necessary to introduce innovative energy management methods, including those known in the world, such as:
  - *smart metering,* allowing for remote energy use management;
  - *demand side management (DSM),* allowing for active use management; hence, permitting daily use variations to be levelled out, optimising the operational costs of the system, improving its security and protecting it from excessive, unnecessary investments in the development of production capacity;
  - *smart grid,* allowing for dynamic grid management, including its (sensor-based) monitoring and the solutions described above;
- It is necessary to substantially change transport policy so that it integrates the environmental framework for transport development. The present policy in this respect leads to the following conclusions: unless basic changes take place the extent of traffic in the passenger transport will grow by almost 95% between 2005 and 2030, whereas goods transport will increase by more than 85%. This will cause an increase in greenhouse gas emissions by nearly 70%.

7. Activity areas, or the directions of activities under AEP

7.1 Electricity generation – the choice of the basic scenario

The adopted strategic goal, expressed by the CO_2 emission cap, provided the basis for formulating the strategy for reaching this ceiling in the form of scenarios involving a different energy mix, with the assumed satisfaction of electricity needs. The fundamental assumption of the model which served for comparing the scenarios was that in 2020 the electricity sector would emit 40% less CO_2 than in 1988 and 20% less than in 2005. In order to achieve this, it was necessary to build appropriate energy mixes (or rather reduction mixes), with the adequately large share of zero-emission technologies. It was attempted to keep the share of renewable energy in electricity generation at a approximately level of 20% of the energy produced, bearing in mind the requirement of the 3x20 Programme for a 15% share of renewable energy in the total final energy balance in Poland. The basic parameters modelling the scenarios were an increase (as a result of investments) and a decrease (as a result of decapitalisation) of the capacity installed in the particular technological segments of generation, specifically:

- hard coal;
- high-efficiency hard coal (CCS ready[23]);
- lignite;
- high-efficiency lignite (CCS ready);
- onshore wind;
- offshore wind;
- hydro-power;
- biomass (dry technologies);
- biogas (wet technologies);
- co-incineration;
- gas;
- nuclear;
- imports.

The following cost items were used in the model:

- the differentiated cost of CO_2 emission allowances (0, 39, 69 and 118 €/tCO_2, where 0 was the reference price);
- the financial investment cost of new capacity (equity, interest and repayment of capital instalments – with a credit for 20 years);
- fixed opex;

[23] This means that the CCS technology can be used on a commercial scale.

- variable opex, without fuel;
- the fuel cost; in the case of nuclear fuel, also the cost of its disposal or storage after its burnout.

In its final shape, the model gave the following quantities:

- the usable power level;
- the assumed energy generation level – the demand approach;
- the assumed energy generation level – the supply approach;
- the energy deficit/surplus level in the balance;
- CO_2 emission level;
- the investment cost level;
- the emission cost level.

Six pathways, i.e. scenarios for reaching the predetermined CO_2 emission cap were analysed, specifically:

- The name of the **"versatile" scenario** comes from an attempt to balance all the technological options at the same time. Such a solution proved to be impossible, since from 2020 permanent overproduction appeared the exports of which would need the implementation of large transboundary transmission investment projects, provided that the exports were viable at all in business terms. This scenario served to build the subsequent scenarios. As the first step, one of the technological options was dropped and then, if a deficit appeared, the share of the other options was increased. Gas and particularly imports were treated as the last resort options, with particular consideration given to the elasticity of imports, i.e. the ability to increase and decrease them. An attempt was made to conduct the modelling in such a way that in each case the share of RES would not fall below 20% of the electricity generation level.
- The **scenario "without nuclear energy"** was the previous scenario without investments in nuclear energy generation, where the development of biomass and biogas was slightly enhanced, but the share of gas and energy imports was reduced.
- In another **scenario "without gas"** the development of gas-based energy generation was dropped and imports were minimised, whereas the deficit was covered by a larger share of RES (biogas).
- In another scenario, lignite was resigned from and it was compensated for by a larger share of RES (biogas).
- In **the "maximum RES"** scenario, in accordance with the previous information, an attempt was made to maximise the share of energy from renewable sources; this required the resignation from the development of coal-based energy generation, even including the high-efficiency one.
- The possibility of developing nuclear energy was checked, by putting it in the **"nuclear"** scenario; just as in the previous case, its implementation required the resignation from the development of coal-based generation and a transitional launch of large energy or gas

exports from 2012 to 2030.

- The last **"maximum efficiency" sce**nario involved the time-variable coefficient for an increase in the energy efficiency of the national economy; it required the least power growth, due to larger investments in use efficiency.

The scenario analysis is discussed in Annex 2.

Taking into account many aspects, such as costs, technological issues, social problems and environmental considerations, the scenario selected for further work was the one involving the maximum energy efficiency changing in time and a substantial share of RES. This scenario was also supported at the conference which the ISD convened to select the scenario for further work. Taking into account the present situation and the factors affecting the development of energy generation using particular energy carriers, a simplified qualitative assessment can be carried out to determine the benefits and possibilities of implementing the individual modes of electricity generation. In the table below, 5 energy carriers (including savings as "negawatts"[24]) are compared in terms of 11 criteria, by estimating on a three-point scale the effects of the particular energy carriers on the different fields of life (Table 2).

Table 2. The qualitative assessment of the particular electricity carriers from the point of view of their implementation

Assessment criteria	Saving	Renewable raw materials	Coal	Gas	Nuclear energy
1. Effect on the ability to protect the climate	Good	Good	Poor	Medium	Good
2. Experience in implementation	Medium	Medium	Good	Medium	Poor
3. Effect on job creation	Good	Good	Medium	Medium	Poor
4. Effect on support for the development of own national companies	Good	Good	Good	Medium	Poor
5. Effect on the reduction of investment costs	Good	Medium/Poor	Medium	Good	Poor
6. Effect on the reduction of operating costs	Good	Good/Medium	Medium	Poor	Good
7. Effect on the attractiveness of investments	Good	Good	Medium	Medium	Poor
8. Effect on energy security	Good	Good	Good	Poor	Medium
9. Effect on the time needed to achieve significant results	Good	Good	Medium	Good	Poor
10. Effect on public or local approval	Good	Medium	Medium	Good	Poor
11. Preparation of legal and institutional framework	Medium	Medium	Good	Good /Medium	Poor
Synthetic assessment*	31	28	25	23.5	16

* Effects: good – 3 points; medium – 2 points; poor – 1 point.

[24] This term denotes saved power units.

7.2 Electricity generation – comparison of two scenarios: the efficiency scenario and the nuclear scenario

In order to compare the selected scenario with the proposals which correspond best to the present intentions of the Government, the results of the analysis of the scenario with enhanced efficiency represented by the letter E and the nuclear scenario represented by the letter A are presented below.

The choice of the latter for comparison was suggested by the Government's decisions concerning the development of nuclear energy in Poland. In July 2009, the Government adopted A Framework Action Programme for Nuclear Energy, [25] which provides as follows;:

- Stage I – until 31.12.2010: the development and adoption by the Council of Ministers of the Programme for the Polish Nuclear Energy, which would thus ultimately determine that nuclear energy would be implemented in Poland, based on the desirable scope and development rate of nuclear energy and the related infrastructure,
- Stage II - 1.01.2011 - 31.12.2013: the determination of the location and the conclusion of a contract to build the first nuclear power plant,
- Stage III - 1.01.2014 - 31.12.2015: the preparation of a technical design and the acquisition of all the approvals required by the law,
- Stage IV - 1.01.2016 - 31.12.2020: the construction of the first nuclear power plant.

To date, the Government has not presented a full analysis of costs and benefits related to the development of nuclear energy in Poland.

Both scenarios coincide until 2020, because it will not be possible to set nuclear power plants in operation in Poland until then. All the experts agree on this. As show by the tables below, the analysis covered the productivity of plants in h/year, the envisaged extent of investments and the shutdowns caused by decapitalisation of the assets (Tables 3 and 4). This gave the production level, the overnight net investments, the CO_2 emission levels achieved and the reductions of these emissions with respect to the levels in 2005 (Figs. 4, 5 and 6; Table 5)

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[25] http://www.mg.gov.pl/Wiadomosci/Waldemar+Pawlak/Ramowy+harmonogram+dla+energetyki+jadrowej+przyjety+przez+rzad.htm

Table 3. Comparison of the capacity of power plants and the electricity production under two scenarios: the efficiency scenario and the nuclear scenario

Production / Sources	Productivity in h/year	2020 in GW	2030 E[26] in GW	2030 A[27] in GW	2020 in TWh	2030 E in TWh	2030 A in TWh	Codes for Figs. 4,5,6
Shutdown	------	13.0	24.0	24.0	------	------	------	Shutdown
Old hard coal	4000	9.5	5.0	5.0	38.0	20.0	20.0	Old hc
Modernised hard coal	5000	3.0	3.0	3.0	15.0	15.0	15.0	Mod. hc
New hard coal	5500	5.2	5.2	5.2	28.6	28.6	28.6	New hc
New+CCS hard coal	6500		4.0	4.0	0.0	26.0	26.0	CCS hc
Old lignite	4500	8.5	2.0	2.0	38.3	9.0	9.0	Old lig.
Modernised lignite	5500	1.0	1.0	1.0	5.5	5.5	5.5	Mod. lig.
New lignite[28]	6000							New lig.
New+ CCS lignite	7000	0.8	1.8	1.8	5.6	12.6	12.6	CCS lig.
Gas CCGT	4000	2.0	2.0	2.0	8.0	8.0	8.0	Gas CCGT
Gas CCGT+CCS	5000							Gas CCS
Onshore wind	2000	5.0	8.0	5.5	10.0	16.0	11.0	Onshore
Offshore wind	3500	-----	1.4	1.0		4.9	3.5	Offshore
Biomass	5500	2.0	4.0	2.0	11.0	22.0	11.0	Biomass
Biogas	6000	2.0	4.0	2.0	12.0	24.0	12.0	Biogas
Nuclear	8000			4.0			32.0	Nuclear
Total		39.0	41.4	38.5	172.0	191.6	194.2	
RES total		9.0	17.4	10.5	33.0	66.9	37.5	
RES share					19%	35%	19%	
Mean production					4409	4628	5044	

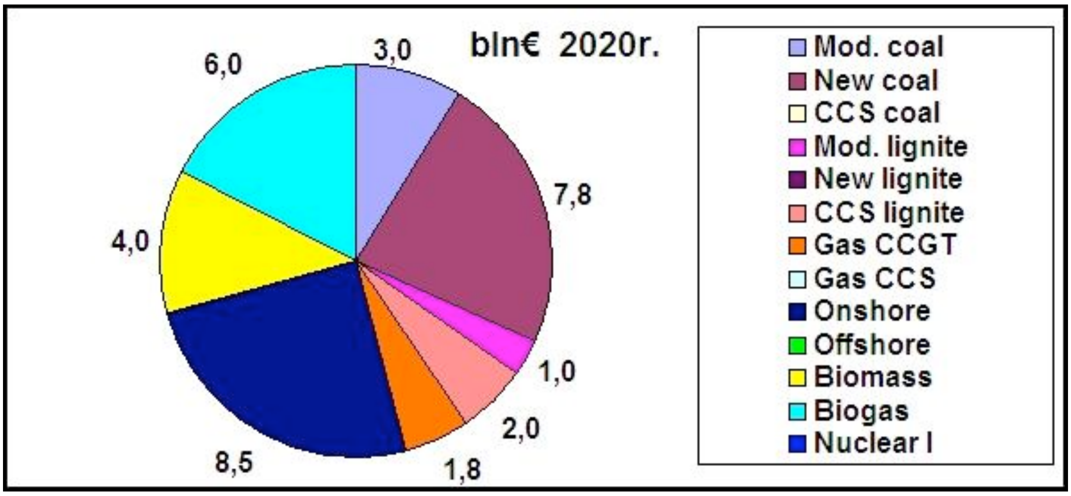
[26] E – the selected efficiency scenario.
[27] A – the scenario dominated by nuclear energy, presented for comparison. Until 2020 scenarios E and A are the same.
[28] In 2020 and later it will not be possible to build a lignite-fired power plant without CCS.

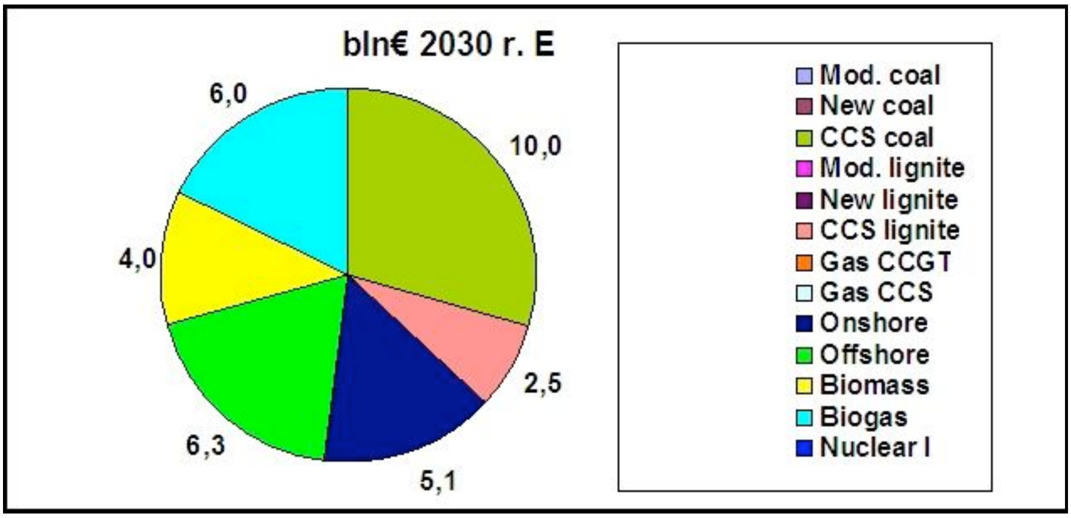
Table 4. Comparison of investment programmes in electricity generation under two scenarios: the efficiency scenario and the nuclear scenario

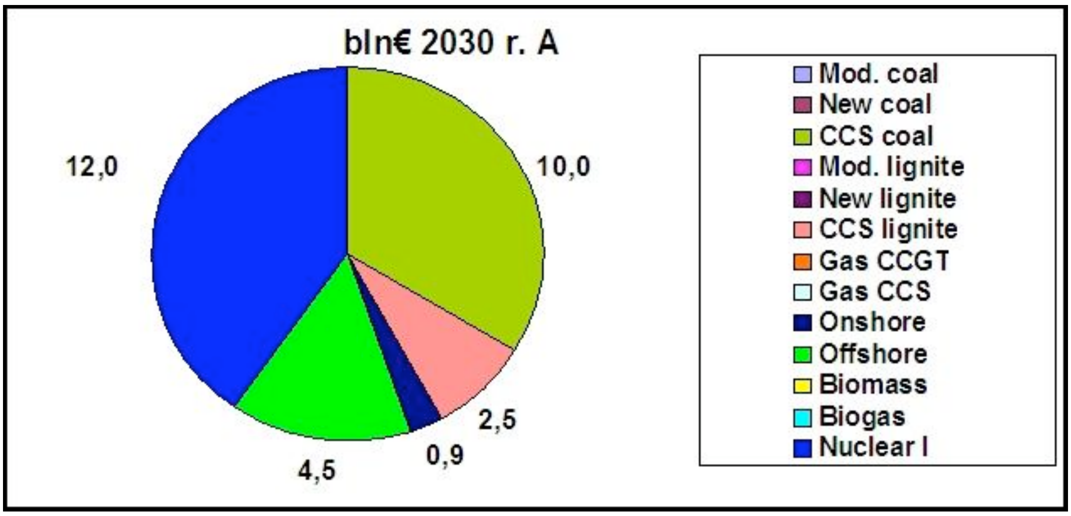
Investments / Sources	Cost in billion EUR /GW	Σ by 2020 in billion EUR	Σ 2021-2030 E[29] in billion EUR	Σ by 2030 E in billion EUR	Σ 2021-2030 A[30] in billion EUR	Σ by 2030 A in billion EUR	Codes for Figs. 4,5,6
Modernised hard coal	1.0	3.0		3.0		3.0	Mod. hc
New hard coal	1.5	7.8		7.8		7.8	New hc
New + CCS hard coal	2.5	0.0	10.0	10.0	10.0	10.0	CCS hc
Old lignite	-----						Old hc
Modernised lignite	1.0	1.0		1.0		1.0	Mod. lig.
New lignite[31]	1.5						New lig.
New+ CCS lignite	2.5	2.0	2.5	4.5	2.5	4.5	CCS lig.
Gas CCGT	0.9	1.8		1.8		1.8	Gas CCGT
Gas CCGT+CCS	1.2						Gas CCS
Onshore wind	1.7	8.5	5.1	13.6	0.9	9.4	Onshore
Offshore wind	3.2		4.5	4.5	3.2	3.2	Offshore
Biomass	2.0	4.0	4.0	8.0		4.0	Biomass
Biogas	3.0	6.0	6.0	12.0		6.0	Biogas
Nuclear plants I[32]	3.0				12.0	12.0	Nuclear I
Nuclear plants II	4.5				18.0	18.0	Nuclear II
Total I		34.1	32.1	66.2	28.6	62.7	
Total II		34.1	32.1	66.2	34.6	68.7	
RES		18.5	19.6	38.1	4.1	22.6	

[29] E – the selected efficiency scenario.
[30] A – the scenario dominated by nuclear energy, presented for comparison. Until 2020 scenarios E and A are the same.
[31] In 2020 and later it will not be possible to build a lignite-fired power plant without CCS.
[32] The items of nuclear plants I and II need to be clarified. Nuclear plants I represent investment prices from the published offers, whereas nuclear plants II are the real contractual prices (based on the data from the US Ministry of Energy). Detailed analysis of Internet-based data, including those on the history of the construction of the Finnish nuclear power plant Olikuoto 3 and the credit guarantees provided by the US Ministry of Energy for the United States nuclear energy programme, indicate the existence of large discrepancies between the investment prices offered by suppliers and business plans and the real investment costs. This issue requires more in-depth analysis.

Fig. 4. Alternative investment programmes in electricity generation under two scenarios: the efficiency scenario and the nuclear scenario[33]

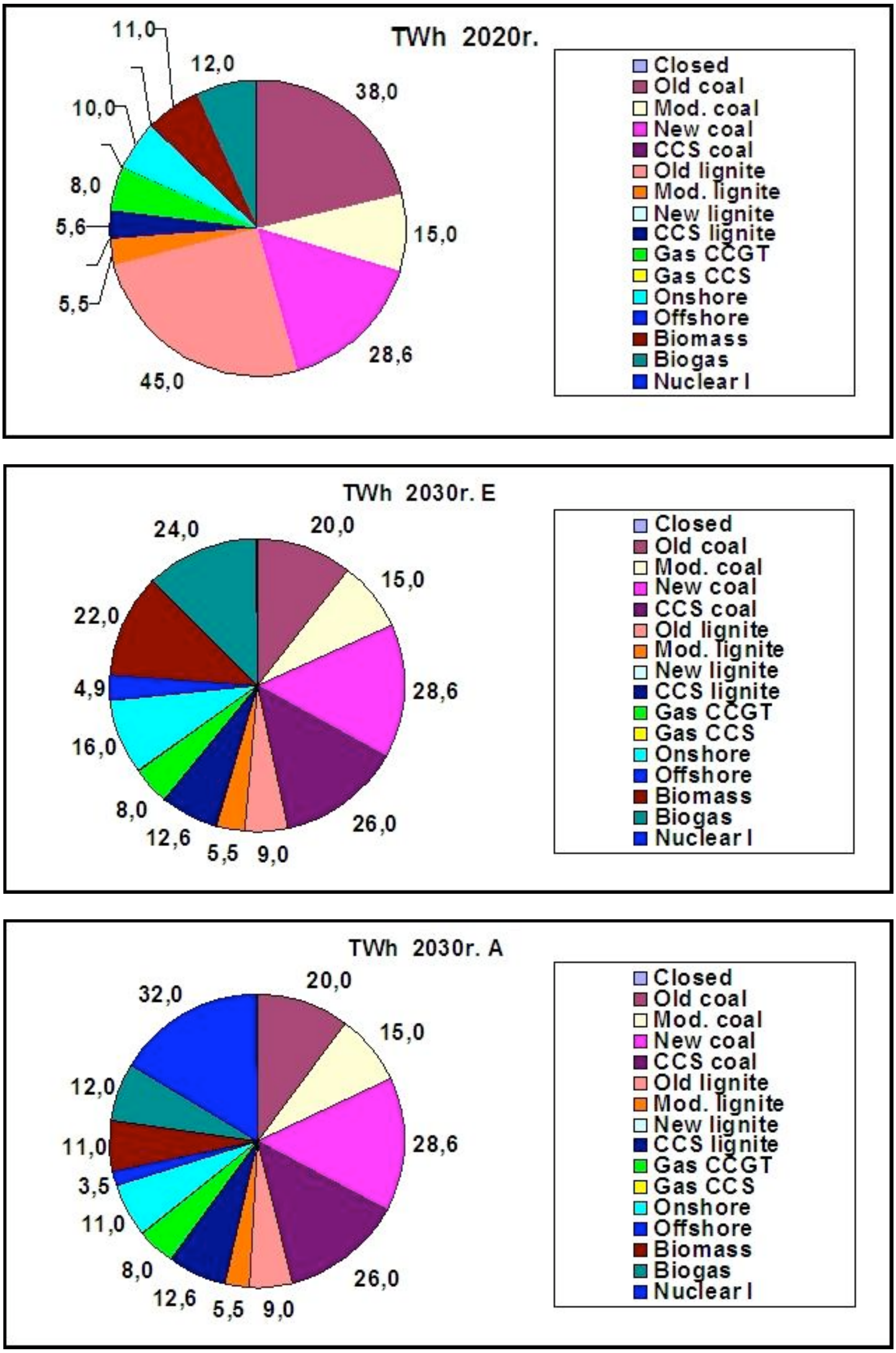






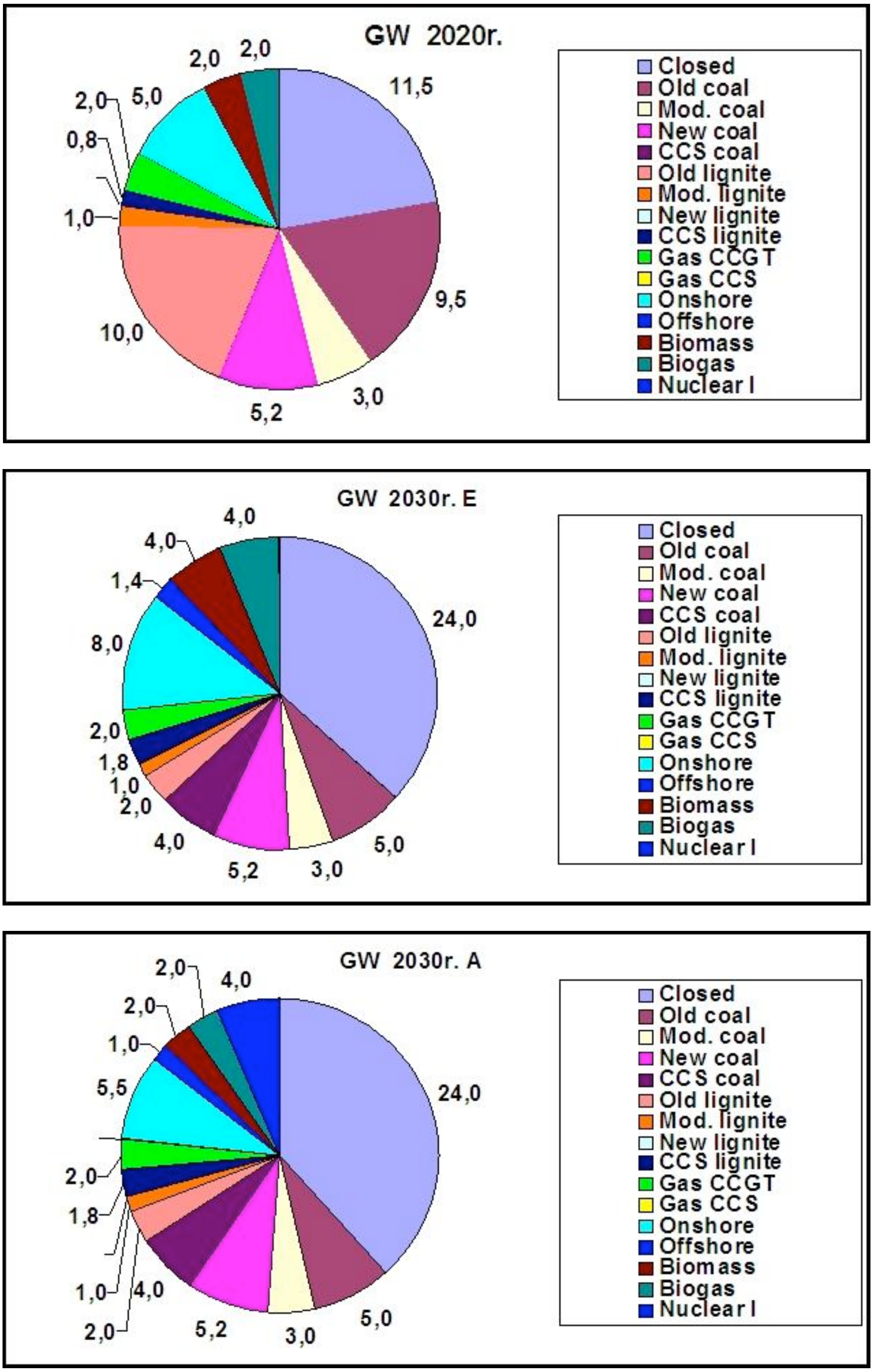
[33] E – the selected efficiency scenario; A – the scenario dominated by nuclear energy, presented for comparison. Until 2020 scenarios E and A are the same. The abbreviations are explained in Tables 3 and 4.

Fig. 5. Electricity production by sources under two scenarios: the efficiency scenario and the nuclear scenario[34]



[34] E – the selected efficiency scenario; A – the scenario dominated by nuclear energy, presented for comparison. Until 2020 scenarios E and A are the same. The abbreviations are explained in Tables 3 and 4.

Fig. 6. Power balance by sources under two scenarios: the efficiency scenario and the nuclear scenario[35]



[35] E – the selected efficiency scenario; A – the scenario dominated by nuclear energy, presented for comparison. Until 2020 scenarios E and A are the same. The abbreviations are explained in Tables 3 and 4.

Table 5. Comparison of CO_2 emissions under two scenarios: the efficiency scenario and the nuclear scenario[36]

Emissions / Sources	Emission factor in t CO_2/MWh	2020 w mtCO_2	2030 E w mtCO_2	2030 A in mtCO_2	Codes for Figs. 4,5,6
Shutdown	------	------	------	------	Shutdown
Old hard coal	0.900	34.2	18.0	18.0	Old hc
Modernised hard coal	0.790	11.9	11.9	11.9	Mod. Hc
New hard coal	0.704	20.1	20.1	20.1	New hc
New+CCS hard coal	0.070	0.0	1.8	1.8	CCS hc
Old lignite	1.100	42.1	9.9	9.9	Old lig.
Modernised lignite	0.966	5.3	5.3	5.3	Mod. lig.
New lignite[37]	0.861	0.0	0.0	0.0	New lig.
New+ CCS lignite	0.086	0.5	1.1	1.1	CCS lig.
Gas CCGT	0.329	2.6	2.6	2.6	Gas CCGT
Gas CCGT+CCS	0.033	0.00	0.00	0.00	Gas CCS
Onshore wind	0.0	0.0	0.0	0.0	Onshore
Offshore wind	0.0	0.0	0.0	0.0	Offshore
Biomass	0.0	0.0	0.0	0.0	Biomass
Biogas	0.0	0.0	0.0	0.0	Biogas
Nuclear plants I or II		0.0	0.0	0.0	Nuclear I or II
Total		116.7	70.8	70.8	
Reduction with respect to 2005	147.0 mtCO_2	20.62%	51.87%	51.87%	
Reduction with respect to 2006	151.0 mtCO_2	22.72%	53.14%	53.14%	

[36] E – the selected efficiency scenario; A – the scenario dominated by nuclear energy, presented for comparison. Until 2020 scenarios E and A are the same.
[37] In 2020 and later it will not be possible to build a lignite-fired power plant without CCS.

Analysis of the data presented in this Chapter and the results shown in Tables 3-5 and Figs. 4-6 allows for interesting conclusions to be drawn, specifically: first of all, both scenarios are technologically feasible, both assume the achievement of high energy efficiency and envisage the possibility of attaining high emission reductions, but they are different in the manner of achieving the above objectives. Their synthetic comparison is shown in Table 6 which presents the situation in 2030.

Table 6. Comparison of the investment scenarios in the areas where the scenarios are different

Scenario	Complemented power	Investment costs	Production	Summary capex	Capex 20 years	Capex 30 years	Capex 40 years
Units	GW	Billion EUR	TWh	EUR/(MWh/ year)	EUR/ MWh	EUR/ MWh	EUR/ MWh
E – Efficiency + RES	6.9 - RES	16.1	29.4	545.9	27.30	18.20	13.65
A – Efficiency + Nuclear	4.0 – Nuclear	18.0	32.0	562.5	28.13	18.75	14.06

In analysing the above table, two important facts should be noted: firstly, the overnight option is taken for the first investment costs, i.e. without financial costs, which can now be substantial, from 100% to 218% in addition; secondly, many analyses differentiate the period over which the summary capex is laid out. Such an operation, which is often applied by the supporters of nuclear energy (20 years for renewable sources versus 40 years, or even 60 years, for nuclear plants) can completely misrepresent the real costs. The only objective measure is the expected time of return of the capital (debt), which seldom exceeds 20 years and never reaches 60 years.

The development of the electricity subsector in next 10 years will be dominated, on the one hand, by efforts to overcome an energy crisis (a shortage of capacity power), which may threaten us already in 2015-2016 and, on the other hand, by the need to implement the Climate and Energy Package in the timeframe until 2020. This problem will not be solved either by nuclear energy, nor by the carbon dioxide capture and storage technologies known as CCS. In both cases, the reasons for this are similar. Firstly, the implementation times of such projects are longer; secondly, the relevant legislation has not been adopted yet; and, thirdly, there is the risk that the technology may not work. Until 2015-2016, no CCS will be implemented, since this is not feasible in physical terms. With regard to nuclear energy, in an extremely optimistic option, at least a 24 months long delay should be expected in relation to the Government's programme to set the first power plant in operation in 2020 and, most probably, this delay will take 4 years. This means that the first power from the nuclear power plant will flow in early 2025.

The conclusion from this analysis seems self-evident and independent of the attitude to the nuclear energy and CCS programmes: in the timeframe until 2015-2016 and also 2020 and later efficiency and renewable energy projects should be strongly developed in order to prevent the impeding shortage of capacity and to meet the requirements of EU climate policy.

The final conclusion which should be drawn depends on two factors which are not related to the energy sector, specifically: Is there in Poland a significant potential of renewable energy sources that can be used, particularly in the area of agro-energy (discussions on this issue continue even among its supporters), and what employment policy do we want to prefer in Poland? In the period considered, the nuclear scenario needs about 800-1000 very highly qualified experts – to a large extent, from aboard, particularly initially; whereas the efficiency + RES scenario involves 25,000 employees as a minimum, half of whom would have quite high skills and the other half would have low skills. In both cases the multiplier factor was not considered – i.e. the related additional jobs (internal services and agriculture). The agro-energy option would require the development of additional 0.44-0.5 million ha, involving 44,000-70,000 employees with 10-14 persons per 100 ha on average[38],[39]. However, this would require deep transformations in Polish rural areas, either in the land structure (integration and consolidation), or in the scope of the culture of cooperation (producer groups[40], agricultural circles and cooperatives etc.). In both the efficiency and nuclear scenarios, according to FEWE, it should be expected that a complete energy saving programme can create 298,000 full-time jobs on an accruing basis in the period 2001 – 2020[41].

7.3 Electricity networks

The minimum estimated modernisation needs of rural networks amount to about 50,000 km of medium voltage lines, 153,000 km of low voltage lines, 67,500 medium and low voltage stations as well as the construction of 1,500 new stations and the related medium and low voltage lines designed to connect new electricity users in the case of which the construction of an electricity network is not economically viable. The necessary outlays (estimated e.g. from the above data) to improve the distribution networks in Poland amount to EUR 8.9 billion.[42]

PSE-Operator estimates the scope of investments needed in transmission lines at 3,500–4,000 km, given the decapitalisation rate of assets up to 50%. The estimated cost is about EUR 2 billion. The scope of investments in medium voltage lines is 20%, whereas those in low voltage lines amount to almost 60%, with an average cost of 33,000 EUR/km (Table 7).

[38] www.regioset.pl/monitor.php?lg=0&art=41&unit=6 -
[39] www.farmer.pl/.../byt_ekologiczny,4fce1d9c55a297ef6693.html -
[40] Krystyna Krzyżanowska, *The status and functioning of agricultural producer groups in Poland*, Association of Agricultural and Agrobusiness Economists, Scientific Yearbooks 2006 Vol. VIII No 1, pp. 90-94.
[41] *Report. The potential for energy efficiency and emission reductions in selected groups of energy uses. The way forward to the implementation of the climate and energy package.* Polish Ecological Club, Upper Silesian District, Foundation for Energy Efficiency, INFORSE, European Climate Foundation. Katowice, 2009.
[42] The report of PTPiREE for the Ministry of Regional Development 2008.

Table 7. The scope of necessary investments in transmission networks

Network types	Present status		Total estimated network modernisation needs in km
	Total in km	Including cable networks in km	
Extra high and high voltage (NN+WN)	45,457	79	Ensuring backup supply for each station
Medium voltage (SN)	295,843	61,988	60,056
Low voltage (nN)	412,770	125,776	236,930
Total	754,070	187,843	296 986 (SN and nN)

Source: Estimates by PSE-Operator.

7.4 Total investments in electricity generation

The total investments in electricity networks by 2020 can be estimated at about EUR 11 billion. This represents about 1/3 of the investments in the production capacity in this period. About EUR 3 billion of the systemic costs of the promotion of energy efficiency should be added to this. Hence, the total amount needed for investments in 2010–2020 to ensure the safe functioning of the electricity sector is about EUR 50 billion, representing about EUR 5 billion/year – without capital costs. A similar amount will have to be invested in 2020–2030. As a total, in 2010–2030 investments at a level of EUR 103 billon will be necessary, including EUR 67 billion worth investments in plants, EUR 22 billion worth of network investments and at least in EUR 14 billion worth investments in the efficiency of the entire system, primarily on the use side. The financial costs should be added to these costs, depending on the adopted financing model and the market-based capital costs. It should be emphasised that with debt-based financing the financial costs will exceed 100% of the investment costs even when the credit interest rate falls to 6% in the nearest years.

It is interesting to note that the investment cost presented above only slightly results from the adoption of the climate and energy package. For the most part, i.e. to an extent of 68–75%, this is caused by the poor condition of the Polish electricity sector as a result of the long-term failure to make modernisation investments.

7.5 Heat supply[43]

No research has been done in Poland to date in the scope of the projection of energy consumption and greenhouse gas emissions in the domestic and municipal sector. Since in

[43] Prepared on the basis of the study by S. Pasierb and T. Bańkowski, "*Heat management problems in the Alternative Energy Policy*".

this sector, the life of residents and the operations of companies concentrate in dwelling, administrative and public buildings and workshops, some estimates can be provided by the projected increase in total usable space in buildings by 250 million m^2 until 2020 and by 400 million m^2 until 2030, assuming that new buildings will be constructed in accordance with the current energy quality standard (of 2007), i.e. – approximately – with a unit energy consumption of 0.4 GJ/m^2year. The results of the calculations are shown in Table 8.

Table 8. Basic data under the emission projection for the domestic and municipal sector

Effect	Units	2020	2030
Increase in usable space from 2007	Million m^3	250	400
Increase in energy consumption from 2007	PJ/year	100	160
Increase in CO_2 emissions from 2007	Million tonnes CO^2/year	9.0	14.4
Increase in CO_2 emissions compared with 2007	%	12.9	20.6
Mean annual increase in CO_2 emissions, r_n	%	1.1	0.9
Mean annual improvement in energy efficiency, $_r$	%	3.0	2.8
Emission levels compared with 2007	%	77.6	63.9
Emission decrease compared with 2007	%	22.4	36.1
Projected emission reductions with respect to 1996	%	48.2	57.3
Adopted targets of CO_2 reductions with respect to 1996	%	45	55

Assuming that the CO_2 emission reduction rate will be maintained by improving energy efficiency and a change in the fuel mix – provided that the CO_2 emissions change in the following manner:

$$\frac{\Delta EMCO_{2,2007+t}}{EMCO_{2,2007}} = (1+r_n)^t(1-r_r)^t, \quad \text{where}$$

$\Delta EMCO_{2,2007+t}$ - emission increase after "t" years compared with 2007,
$EMCO_{2,\,2007,}$– CO2 emissions, respectively, in 2007,
r_n = the rate of increase in needs,
r_r = the rate of efficiency improvement,
t = 13 years until 2020 and t = 23 years until 2030, and

assuming the data as in Table 1, the following is obtained:

$$\frac{\Delta EMCO_2}{EMCO_{2,2007}} = 0.776 \quad \text{and} \quad \frac{\Delta EMCO_2}{EMCO_{2,2007}} = 0.639$$

i.e. the CO_2 emissions in 2020 will fall by 22.4% compared with 2007. Respectively, the CO_2 emissions will fall 36.1% in 2030.

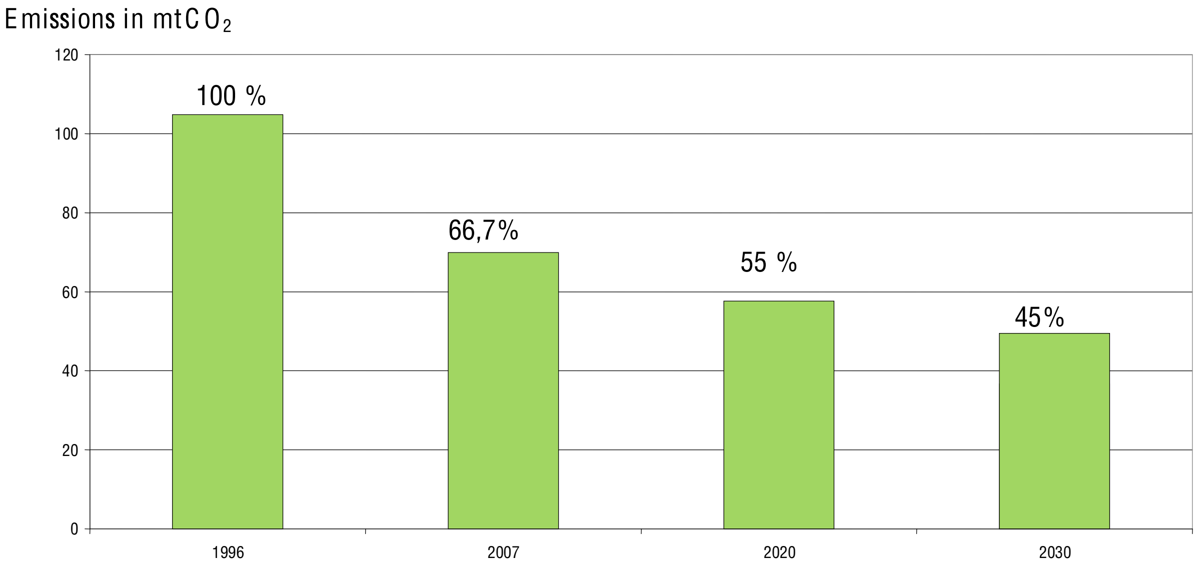
Since in 1996 – 2007 the CO_2 emissions related to the heat demand in the domestic and municipal sector fell by 33.3%, the projected CO_2 emission levels by 1996, with the above assumptions, can amount to:

- 33.3 + 14.9 = 48.2% in 2020;
- 33.3% + 24.1% = 57.4% in 2030.

Accordingly, the following CO_2 reduction target in the sector is adopted for the sustainable scenario (Fig. 7):

- by 45% in 2020 compared with 1996;
- by 55% in 2030 compared with 1996.

Fig. 7. The strategic goal of the CO_2 emission reduction in the domestic and municipal sector



Source: FEWE, after the data from the Fuel and Energy Management in 1996 – 2007. GUS. Warsaw 2008.

The achievement of such reductions will need strong measures:

a) The limitation of heat consumption; the Polish society is not very affluent, therefore, in order to limit heat consumption, price increases must be connected with a support system;

b) The limitation of the development of new buildings with high potential heat demand; as a target, the final heat consumption rate of 25 kWh/m^2/year should be achieved in new buildings in 2020. Following successes related to the labelling of household appliances, the time has come to label buildings, promoting a very wide approach to the issues of the energy efficiency on the part of the end-users. It is necessary to further promote the thermal modernisation of buildings and the legislation governing both of these areas needs improvement;

c) The enhancement of energy efficiency. It is proposed to establish funds for subsidising the implementation of programmes to improve energy efficiency. It is necessary to popularise simple energy audits, which would allow for them to be carried out on one's own, as proposed within the framework of the initiative aimed at establishing the General Internet-based Energy Efficiency Platform;

d) The improvement in the efficiency of electricity and heat generation;

e) It is necessary to create a system for financing investments in energy efficiency and sustainable development, particularly those serving small and medium-sized investors. For this purpose, it is important to analyse and promote the best examples. It is necessary to prepare a ranking of energy efficiency (the cheapest energy effect and the effect in terms of sustainable development) to demonstrate which investment project has reduced energy losses at the lowest cost and which one has boosted the regional economy to the largest extent.

The measures should focus primarily:

- in centralised heat generation, on:

a) the modernisation and construction of heat generation units (cogeneration systems and boilers) at power plants, heat and power generating plants, utility and industrial heating plants;

b) the increase of the share of CHP-based heat generation in the heat production;

c) the increase of the share of biomass in its generation;

- in local decentralised heat generation, on:

a) the modernisation and replacement of boilers by high-efficiency, low-emission ones;

b) the construction of small and medium-sized co- and tri-generation units at the existing boiler-houses (the combined production of electricity, heat and possibly cooling); at the same time, there is large demand for electricity or close access to electrical networks (insular boiler-houses of heating systems, hospitals etc.);

c) the construction of local energy supply systems, including the promotion of cogeneration, based on the local resources of fuels and energies, including biogas, other types of biomass and geothermal energy;

- in heat transmission and distribution networks, on:

a) the modernisation of heating networks, the replacement of inefficient and old pipelines by pre-insulated ones adapted to the current and future heating needs;

b) the verification of the economic viability and desirability of supplies to distant users (heat and hot water), justified supply decentralisation;

c) the introduction of systems for controlling and managing heat supplies, ensuring the optimum load curves (in production and use), the verification of the legal construction of tariffs with a view to allowing for an elastic and efficient control of heating systems;

- in buildings, on:

a) the replacement of low-efficiency, environmentally harmful boilers by high-efficiency, environmentally friendly ones;

b) the creation of local biomass preparation systems and the increase of the share of this fuel in the heating of buildings;

c) the improvement of thermal insulation of buildings: the insulation of external partitions, the replacement of windows, the recovery of heat from ventilation;

d) the installation of solar collectors (as promotion and economically viable projects);

e) the promotion of low energy-intensive and passive buildings;

f) the conduct of demonstration projects for the use of photovoltaic cells (PV).

When looking comprehensively at the economy, there is no doubt that it makes greater sense to co-finance the costs of energy-saving projects than to pay for CO_2 emission allowances. The emission reduction level resembles the one set out for the electricity sector, i.e. 53.4 $mtCO_2$ in 2020 and 70 $mtCO_2$ in 2030 (Table 9); the value of investments is also similar – amounting to about EUR 95 billion.

Table 9. Capacity and its efficiency

No.	Description	Unit	Value
1.	Capacity to reduce the final energy consumption	PJ/year	502.0
2.	Capacity to reduce CO_2 emissions	$mtCO_2$/year	47.46
3.	Efficiency of capacity: - unit energy saving costs[44] - unit costs of CO_2 emissions	PLN/GJ PLN/tCO_2	23.6 246.6
4.	Investment outlays	PLN million	426,338

7.6 Sustainable mobility[45]

The analysis of trends and projections of the development of transport in Poland indicates that two options of the development of the transport sector should be considered in the work on AEP:

- ♦ Option I (CT) – assuming the continuation of trends,
- ♦ Option II (ST) – towards sustainable development – with a slowdown in the growth of transport and energy intensity and greenhouse gas emissions to ensure that in 2020 and 2030 it does not exceed the target values with respect to 2005.

The adoption of the two options would represent the following transport work projections in the timeframes of 2020 and 2030 (Table 10).

Table 10. Transport work projected until 2030 – Option CT[46] and Option ST

Transport mode	CT			ST		
	2005	2020	2030	2005	2020	2030
Passengers in passenger transport in billion						
Private transport	262	433	570	262	346	371
Public transport	61	58	57	61	64	66
Total	323	491	627	323	410	436
Goods in freight transport in billion tonne-km						
Road transport	120	193	237	120	164	166

[44] Including the lifecycle costs (LCA), i.e. both the capital and operational costs.

[45] This section was prepared using the study *Energy consumption in transport* by W. Suchorzewski, carried out for the purposes of AEP.

[46] In the case of the projections of the transport work and energy consumption in 2030 under Option CT, it is proposed that the minimum option of the projection for 2025 according to J. Burnewicz should be adopted and that the values of 2017 should be used for 2025, since these values were prepared prior to the period of the economic crisis. The high values of the rates of economic growth and consumption under these projections are outdated and hardly feasible.

Rail transport	50	67	82	50	74	94
Total	170	260	319	170	238	260

Sources: J. Burnewicz, *The vision of the transport structure and the development of transport networks until 2033 with particular consideration given to the target model of the transport structure [in Polish].* Expert study carried out within the framework of the work on the national spatial development concept on commission from the Ministry of Regional Development. 2008. W. Suchorzewski, *Energy consumption in transport,* study performed for the purposes of AEP.

This will give rise to higher energy consumption and higher greenhouse gas emissions, as illustrated in Table 11.

Table 11. Energy consumption projected under Options CT and ST in billion MJ and the corresponding greenhouse gas emissions

	CT			ST		
	2005	2020	2030	2005	2020	2030
Passengers	329	493	551	329	412	383
Goods	280	421	478	280	385	390
Total	609	914	1029	609	797	773
GHG emissions in $mtCO_{2eq}$	37	58	62	37	45	47
Increase in GHG emissions compared with 2005 in %	x	57	68	x	22	27

Source: W. Suchorzewski *Energy consumption in transport,* study carried out for the purposes of AEP.

The continuation of the existing trends would practically prevent the implementation of the strategic goals to limit energy consumption and pollutant emissions into the environment. Radical measures are necessary; they can be divided into four groups:

1. Measures to slow down the transport intensity growth rate of the economy and life (measured by the number of tonne-kilometres and passenger-kilometres);
2. Measures to halt the growth or even to reduce the share of highly energy-intensive means of transport, i.e. goods road transport, private passenger transport (passenger cars) and air transport;
3. Measures to improve the operational efficiency of transport, e.g. by improving the rate of utilisation of the loading capacity of means of transport in the transport of goods and passengers;
4. Support for progress in the transport technology, primarily for the production of means of transport with higher energy efficiency and powered by energy sources alternative to crude oil and coal.

7.7 Strategy and hierarchy of measures to implement AEP

Taking into account the above possibilities and the challenges related to the need to achieve a further substantial reduction in greenhouse gas emissions until 2020, the following strategy seems to be necessary in the energy sector:

- A substantial improvement of efficiency, which is possible immediately; first of all, as a result of reduction in heat use, higher energy efficiency and an essential improvement of the efficiency of electricity and heat generation and transmission. At the same time, the higher efficiency generates jobs and promotes domestic entrepreneurship, with low capital costs and the absence of operating costs, along with substantial public support;

- Stimulation of the active RES development, which is possible already within two years. In addition to the benefits arising from the development of dispersed energy generation and the limitation of greenhouse gas emissions, the RES development also generates new jobs and promotes domestic entrepreneurship, with relatively high capital costs and quite low operating costs, along with very high public support;
- Capacity replacement (not earlier than in several years) based on gas and hard coal. The development of the energy sector based on lignite combustion should be considered controversial. The application of technologies for CO2 capture and injection into deep geological formations (CCS) could substantially limit greenhouse gas emissions into the air provided that it turns out to be a en effective and economically viable solution;
- No economic viability of the development of nuclear energy – it will not be an economically viable option until 2030 and it will take 15 years to build the first power plant. The development of this mode of energy production generates high capital and related costs, reduces financing for the development of other cheaper energy sources, fails to promote the development of domestic companies, does not generate new jobs and enjoys low support from local communities, although it is supported by many local politicians. On the other hand, it contributes to climate protection and entails low operating costs;
- A substantial change in transport policy – measures should be taken immediately to slow down the increase in transport intensity, energy intensity and greenhouse gas emissions; a long-term policy to ensure sustainable mobility should be pursued. The emission reduction in transport must not involve only the improvement of the energy efficiency of vehicles.

8. The instrumentation framework for AEP implementation

8.1 The electricity sector

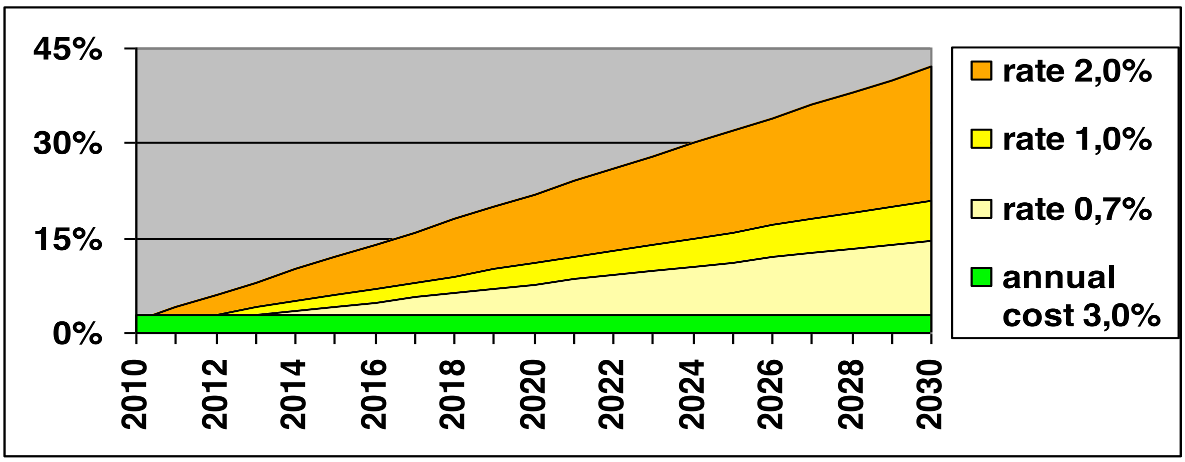
The implementation of the AEP objectives requires the development of an effective set of relevant instruments for this purpose. Given the multidimensional nature of the objectives, the tools making up this set of instruments should also be multipurpose.

The basic instruments include administrative measures. They comprise legal regulations at the level of Acts of Parliament, Regulations and instructions. Their special category consists of standards, including first of all energy efficiency standards (for buildings, vehicles, equipment etc.). This category also comprises mandatory tariffs (e.g. regulated transmission and distribution) and taxes, also including the so-called green and black carbon tax that is neutral for the budget, serving to compensate for the costs of "green" fuels, particularly in the heating sector.

Incentives are extremely important for the implementation of AEP. Tax credits, awarded for energy-saving procurement or investments, can play a certain role in this respect. They are effective in the case of small investment activities on a mass scale, such as the purchase of energy-saving bulbs and household appliances. The mechanisms which are effective in investment projects with a larger financial dimension include systems of tradable ownership rights related to certificates of origin, which are commonly called colour certificates. Green certificates support the development of renewable electricity production, red certificates – highly efficient coal-based cogeneration (and micro-sources), while yellow certificates - gas-based energy generation.

The Government promises to introduce white certificates as a tool to support investments into energy efficiency, i.e. in the so-called negawatts. At the expense of an increase in energy prices by 2–3%, it is possible to achieve savings greater by a factor of about 15 in the timeframe until 2030. This instrument is absolutely indispensable for the achievement of the targets of Poland's Climate Policy and the EU Climate and Energy Package (Fig. 8).

Fig. 8. Comparison of the costs of the system of white certificates with the possible savings for different annual saving rates



Source: The functioning of a system of white certificates in Poland as a mechanism to stimulate energy-saving behaviour – the principles and a detailed action concept. Procesy Inwestycyjne in cooperation with the Institute for Sustainable Development. Warsaw October 2007.

A system of "blue certificates" should be introduced as a mechanism to stimulate investments in new, high-efficiency sources (with efficiency exceeding 46%); just as "white certificates, they would be investment certificates gained through tenders. The "clean coal" energy generation, specifically CCS, should be supported by "orange certificates" of investment and operating nature: they would be short-term (3–5 years) in the investment phase and long-term (about 10 years) in the operating phase.

The division into investment and operating certificates should also be adopted for the already existing certificates: green, red and yellow ones. The right to combine certificates should be adopted if an investment project meets several conditions. The ultimate aim should be to unify the certification system (mutual conversion) and to integrate this system with the EU – ETS emissions trading scheme. The last measure needs a decision at EU level. An initial step towards this measure could be the nomination of certificates in tonnes of CO_2 emissions avoided.

Incentives can also include subsidies to support the most important investment programmes, e.g. the programme for thermal modernisation of buildings and the programme for supporting agro-energy (specifically, energy crops).

Practice demonstrates that administrative measures and incentives are not effective without being supported by information and education measures. An information programme should be addressed to the public in order to win its support for pro-efficiency activities and to allow for its access to necessary information. An education programme should be addressed to a specific addressee to be chosen (youth, self-government activists and industrial operators) and have a more active character.

Cost optimisation is impossible if market-based mechanisms are not introduced. The vertical consolidation of the concern type practically eliminated the electricity market. The converse process – i.e. fragmentation – would be a difficult, costly, painstaking and time-consuming solution. Probably, a better idea would be to introduce at least a partly mandatory obligation to participate in exchange-based trading for the individual power plants, since this would lead to a much higher level of competitiveness.

A fully competitive market requires the operations of many, at least several, operators which really belong to different owners. Therefore, after necessary market-based mechanisms have been quickly set in operation, the privatisation of the sector must be completed.

The functional mechanisms are complemented with institutional mechanisms: the Plenipotentiary of the Government for (the Implementation) of the Climate and Energy Package, following the pattern of similar positions in other States of the European Union (Plenipotentiaries or Ministers). The Plenipotentiary would carry out political and coordinating tasks (legislation, strategy etc.). The executive institution should be the Agency for Energy and Climate etc.), which would be responsible for the practical implementation of the Climate and Energy Package and the execution of the emission reduction programme. Such an Agency should combine the competence of several existing institutions: the National Agency for Energy Saving, the Energy Market Agency, the Institute of Fuels and Renewable

Energy, and serve as the implementer of domestic and European programmes. It should play an extremely important role in the system of white certificates – as a repository of all the projects being implemented (specifically, their audits).

In accordance with the Directive, the energy certificates of buildings should be mandatory, enforceable and publicised on the Internet.

The President of the Energy Regulatory Agency should be the institution which controls and monitors the situation in the energy sectors, given its statutory responsibility for the promotion of energy efficiency and the principles of sustainable development as provided for directly by the Constitution of the Republic of Poland.

8.2 The heat sector[47]

The introduction of financial mechanisms is the most important initiative which provides the basis for improving energy efficiency and enhancing the share of RES. When used in accordance with the projected allocations of public resources under the operational programmes of the EU assistance funds, the national assistance institutions of the environmental protection market and the Fund for Energy Efficiency and Renewable Energy[48] as well as commercial market-based instruments, such as Performance Contracting[49], a set of instruments will contribute to higher energy efficiency. The limitation of heat consumption as a result of the improvement of energy efficiency will make it possible to increase it by 10% as well as to enlarge by 5% the share of renewable energy in the gross final energy demand – all this with respect to 2006, taking into account the assumed 10% growth of needs as a result of the emergence of new users and services by 2020. For the second planning period for financial instruments, over the subsequent 10 years (in the period 2021—2030), on the basis of the budget predicted for the programming timeframes for the use of domestic and EU assistance resources and market-based instruments in the periods 2014–2020 and 2021–2026, it is assumed that heat consumption will decrease as a result of the further improvement of energy efficiency by another 12% and the 4.5% growth of the RES share in the gross final energy demand by 2020.

Therefore, in implementing only financial instruments in the heat sector (heat generation and use), the total share of renewable energy in the total demand for the gross final

[47] Prepared on the basis of the study by S. Pasierb and T. Bańkowski, "*Heat management problems in the Alternative Energy Policy*".

[48] The Fund should focus on facilitating private investment projects by providing venture capital, since in a longer term this will be of key significance for the effective implementation of sustainable energy projects. The support for individual projects and the choice of technologies should depend on the satisfaction of comprehensive sustainability criteria, on their contribution to sustainable development as well as on the geographical location and the regional resources available.

[49] In *Performance Contracting,* the contractor grants a guarantee to the investor that the energy effects will be achieved as a result of modernisation. If the energy effects are lower than the guaranteed ones, the contractor covers the difference in energy cost between the guaranteed and real levels; this means that the investor shifts to the contractor the risk related to failure to comply with the planned operational parameters of the system and, as an effect, higher operating costs than those planned. This form of contracting radically improves the implementation of he financial plan of a project in terms of rolling costs. Although it is often underappreciated, in the market-based economy the latter measure is a basic parameter applied in making investment decisions.

energy in 2030 compared with 2006, taking into account the improvement of energy efficiency and the enhanced share of RES, can be estimated at 10.77% in 2020 and 13.18% in 2030.

Education and information instruments provide the necessary support for other incentives. They should take the form of:

a) Information campaigns. The aim of these actions is to improve awareness by teaching how to make a rational consumer choice. The task is to provide complete information on energy efficient behaviour and equipment use. Measures include sponsored articles in the press, publicity campaigns on TV and the participation of non-governmental organisations in local campaigns;
b) General education system. The purpose of the system will be to improve awareness concerning rational energy use in buildings. It will be based on the implementation of the measures of a general education programme in the scope of efficient and environmentally friendly use of renewable energies and energy efficiency. The target group of the education programme consists of: household owners, building owners, small and medium-sized entrepreneurs, principals, teachers and students in schools at different education levels;
c) Vocational training system. The purpose of the system is to improve skills and competences to apply standards and to provide advice. Measures include the preparation of a training system for particular chosen vocational groups and the use of the resources of the Operational Programme "Human Capital" to create new professions and set up new companies;
d) Information and education service. The purpose is to teach the public how to make a conscious and rational choice and to purchase energy-saving appliances and other equipment. Measures include the implementation and promotion of a nationwide service to provide general information concerning energy efficiency. The creation of the General Internet-based Energy Efficiency Platform, designed to interactively provide and exchange information on solutions serving to ensure efficient energy saving.

Legal instruments provide an important basis for quickly changing the thermal needs of buildings; unfortunately, they do not guarantee the cost-effectiveness of these changes. Certainly, these instruments are most effective from the point of view of the public administration, since they generate costs mostly at the stage of drawing up their provisions. Unfortunately, it is possible to prepare the budget for the implementation of proposed provisions only at the last stage of the process of amending or creating legislative instruments. It is particularly important to amend the construction law towards energy saving buildings. The proposed legislative instruments are listed below:

- The amended Construction Act providing for energy efficient buildings. One of the objectives of the new construction law would be to improve the energy quality of the existing and new buildings. It is proposed to ensure within the framework of the amendment the complete implementation of Directive 2002/91/EC on the energy performance of buildings. The first amendment to the Construction Act should be adopted in 2001 at the latest and provide for the obligation to apply relevant thermal requirements for multi-family buildings at the level of E_0 = 50 kWh/m^{2}year for the gross dwelling space. The second amendment to the Construction Act should be adopted 10 years latter, i.e. in 2020, and provide for the further limitation of heat requirements of buildings to E_0 = 25 kWh/m^{2}year for the gross dwelling space.

- New legal regulations to limit the emissions of air pollutants from heat sources with local significance. New regulations would provide for the equal legal responsibility of all the users for the use of energy resources and the release of pollutants into the environment (the polluter pays principle). The major changes include the limitation of trading in low-quality fuels on the retail market and the appropriate management of these fuels in order to use them and adapt them for combustion in utility power plants. Other measures include e.g. the definition of new quality standards for boilers placed on the market, the introduction of a system for controlling and enforcing the use of fuels with adequate quality in small heating facilities, the prohibition of the burning of household rubbish and waste at house-based boilers, the establishment in the new legislation of a programme for limiting air pollutant emissions from so-called low emission sources, which would be implemented by a project involving the use of many financial instruments.
- The Act on Energy Efficiency. Its aim is to consolidate the national programme for the improvement of energy efficiency. The assumptions of the work on the new Act are based on the implementation of the objectives and tasks of the Climate and Energy Package by the provisions of the Act. The Act would e.g. launch the system of "white certificates" and the scheme of "voluntary commitments". It would establish an institution responsible for the implementation of the National Energy Efficiency Programme, i.e. the Agency for Energy and Climate. It is proposed that intensive work should begin on the Act in 2009 to ensure that the legal standards contained in it can enter into force in 2010.
- New legal regulations for the market of energy-saving measures in the form of a public-private partnership (PPP). The aim of these regulations should be to create a legal framework enabling the involvement of private capital in a partnership with the public administration in energy-saving actions. It is important to overcome the barriers consisting of the lack of competences and fears about the use of the services of private companies in the public sector. It is envisaged that a catalogue of projects where the PPP formula is recommended would be developed, along with standard contracts. Within these regulations, consideration should be given to the model of self-financed investment projects, i.e. Performance Contracting, a form of contracting used for many years, mostly for modernisation contracts, in the EU and the United States.

8.3 Development of renewable energy – basic requirements

The development of renewable energy, repeatedly mentioned above, requires the creation of favourable development conditions, including primarily:[50]

a) The maintenance of stable and competitive principles of support for RES plants with respect to other energy sources, particularly at the investment stage.

[50] After M. Stryjecki, *The prospects for the development of the RES market in Poland until 2020*. Foundation for Sustainable Energy.

b) Ensuring an intensive development of electricity networks – transmission ones for the purposes of offshore wind farms and onshore large farms; and distribution ones for the purposes of dispersed sources.

c) An amendment to the Act on the Sea Areas of the Republic of Poland and the Maritime Administration which would allow for the preparation and implementation of offshore wind farms.

d) The creation of a legislative framework for agricultural biogas plants, particularly regarding fire safety, localisation and disposal of post-digestion waste.

e) The effective management of resources to support investment projects which come from substitute charges, EU funds and sales of surpluses under the Kyoto Protocol. These resources should be spent mostly on:

- network projects, which for economic reasons cannot be implemented by RES developers and network operators (transmission and offshore lines);
- the reduction of the capital costs of innovative projects, such as e.g. biogas plants or offshore wind farms;

f) The adoption of a transparent and predictable approach to renewable energy by environmental services.

g) The imposition of a mandatory annual scope of RES connection offers on distribution and transmission companies (following the State's commitment to increase the share of renewable energy in the final energy balance).

8.4 Transport[51]

In order to achieve the target caps of greenhouse gas emissions from transport and to implement sustainable mobility, it is necessary to:

a) in the scope of space management (land use):

- raise the rank of spatial planning as an instrument for the protection of the environment against the impact of transport pollution;
- limit urban sprawl, to keep the appropriate land development intensity and to protect open landscapes;
- localise office and commercial activities in city centres or other places well served by public transport;
- limit car traffic to new activity areas (offices) by setting out the maximum allowable number of parking slots;
- intensify residential housing in central and inner-city areas, to transfer the places where parking lots concentrate from the inner-city areas to outer areas (the park and ride principle);

[51] This section was prepared using the study *Energy consumption in transport* by W. Suchorzewski, carried out for the purposes of AEP.

- reserve areas in the vicinity of the existing transport network for the construction of goods distribution facilities;
- mix different urban functions related to the development of local centres in urban areas and in other urbanised areas;
- extend new tramway lines to housing concentrations in suburban areas;
- increase the intensity of space use in the vicinity of stops, particularly close to service facilities;
- allow for more intense building round public transport routes, particularly stops and stations; incentives to encourage this direction of development;
- build a network of pedestrian and cycling paths, with car traffic allowed on a subordination basis;
- limit road construction to newly developed areas and establish car-free zones;

b) in the scope of financial mechanisms:

- use taxes on fuels and car purchases as an instrument in order to promote lees fuel-intensive vehicles;
- use parking charges (in and off streets) in order to balance supply and demand for street space and to improve public transport;
- use congestion charges and the perimeter charges collected for entry into a designated area in order to limit traffic intensity and raise funds to cover the costs of new infrastructure;
- introduce a system of electronically collected congestion charges wherever traffic jams affecting safety and air quality require the reduction of traffic; these charges could practically eliminate such congestion, thus improving the quality of services provided by public transport;

c) in the scope of investment and traffic management:

- limit road investment projects in sensitive areas to bypass roads, along with the measures to calm traffic and other measures to improve the environmental conditions in the areas to be bypassed;
- use separate lanes and control systems in order to implement priorities for public transport as well as for the participants in the car-pool system; the development of streets and passages for pedestrians; the division of cities into sectors with varied accessibility;
- use telematics for traffic control in order to minimise traffic congestion, to improve air quality and the conditions for pedestrian traffic; the provision of complete information on the real arrival and departure times of the means of public transport;
- improve the quality of public transport by separating tramway tracks as well as bus-only lanes or streets;
- use telematics to build integrated transport management systems;

- keep the supply and demand balance due to advanced traffic control systems;
- inform passengers on the traffic conditions on the travel routes;
- launch large-scale measures to calm vehicle traffic in cities;
- introduce mandatory plans for workplaces to be served by public transport;

d) in the scope of environmental protection:

- adopt more stringent standards in order to reduce waste gas and noise emissions from new vehicles;
- phase in standards providing for lower fuel consumption by new vehicles;
- introduce more frequent and demanding tests to control emissions from vehicles in use;
- promote the use of low-emission buses and to ban or limit lorry traffic at night in sensitive areas;
- use of fiscal instruments to promote environmentally friendly fuels and less polluting passenger cars, lorries and buses;
- use telematics and traffic engineering in order to maintain traffic intensity in inter-estate streets at the level of environmentally sound capacity;
- steadily increase fuel taxes in order to save energy and limit CO_2 emissions;
- internalise external costs in charges or petrol prices related to vehicle traffic.

9. The risks related to the implementation of AEP

The greatest risk is posed by the possible failure to make a strategic shift in the development trends of the Polish economy from an extensive, energy- and material-intensive pathway to an intensive, energy efficient and (somehow occasionally) environmentally friendly one. In other words, the greatest risk posed by failure to implement AEP is the continuation of the Business As Usual (BAU) Scenario instead of the Change Scenario. Despite appearances, the BAU Scenario is very easy to implement; it is sufficient to block the mechanisms to support the measures to improve energy efficiency and saving. Indeed, this is actually taking place now.

Another risk is the adoption of an inappropriate manner of financing the indispensable investment projects. In connection with the global crisis, there may be willingness and even pressures to postpone investments until the "better times". High financial costs may cause a breakdown of the investment process and the economy as a whole. With a high discount rate exceeding 10%, direct financing, i.e. directly from the revenues gained from investment certificates, seems to be the best one.

The technological risk is also important. It consists of the wide use of immature and unproven technologies. Geothermal energy is such a technology in the Polish conditions and CCS may be such a technology, too.

A serious risk is posed by carbon leakage, which may cause a drastic reduction of energy consumption in Poland and, in consequence, the suspension of the programme to modernise the sector.

10. Knowledge gaps

The aim of this Chapter is to take stock of these areas of knowledge gaps which it proved possible to identify. In this respect, three groups can be distinguished: (1) a group of scientific and technological issues, (2) a group of political and legislative issues and (3) a group of financial and economic issues.

We seek to answer the following questions concerning technology development:

- To what extent will the CCS technology be effective in terms of both the capture of CO_2 (efficiency, costs) and its long-term storage in the Polish lithosphere (costs, tightness of reservoirs)?
- What will be the development rate of the third-generation coal gasification and, in particular, the IGCC technology?
- Will the third-generation coal liquefaction technology develop to integrate indirect and direct liquefaction?
- How much will the nuclear technologies of generations III+ (after 2020) and IV (after 2030) develop, e.g. the breeder or high-temperature technologies?
- How effective will the second-generation biofuel technologies be, e.g. those based on cellulose and lignin? The concept of the second-generation biofuels is based on the assumption that the raw materials for their production should include: biomass, waste vegetal oils and animal fats as well as all types of organic waste which cannot be used in the food or forest industries. The third-generation biofuels include biohydrogen and biomethanol produced by gasification e.g. of lignin, and the synthesis of gasification products or as a result of biochemical processes.
- At what rate will the direct use of solar energy develop, in particular the photovoltaic cell technology? The development of thin-layer second-generation cells from semiconductor compounds CdTe (cadmium telluride) and CuInSe2 (copper indium diselenide) and high-efficiency cells from gallium arsenide as well as the development of the third-generation cells from conducting polymers (so-called organic metals).
- Is the development of "artificial photosynthesis" feasible, i.e. the synthesis of hydrocarbons or simple sugars from carbon dioxide and water using solar energy?

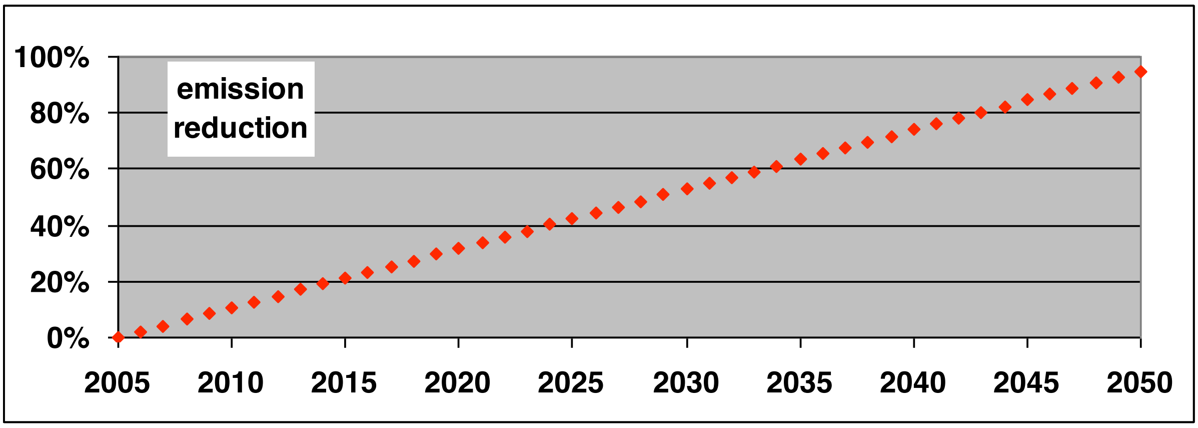
All these questions can be reduced to one issue: At what rate can the process of decarbonisation of fuels, the energy sector and the economy develop; i.e. to what extent can hydrogen and "fuels" derived from hydrogen, such as hydrides of metals, or storage technologies, e.g. nanotubes and fullerenes, be energy carriers and condensers?

Another group of questions consists of issues related to politics and legislation, i.e. the future regulations, including mostly European and global ones.

- A fundamental issue is the likelihood of adopting an international agreement, the so-called post-Kyoto, on the reductions of greenhouse gas emissions by developed countries in the timeframes of 2020 (-30%), 2030 (-50%) and 2050 (-95%) (Fig. 9).
- Another issue is the final content of the commitments of the European Union in both cases, i.e. if the international agreement is reached and if it is not reached.

- The third issue is the burden sharing under the programme of assistance to developing countries – will it be proportional to the strength of the economies of the EU Member States (i.e. their wealth and consumption levels), or will it be proportional to the emission levels (i.e. the extent of backwardness of their economies, i.e. their poverty levels).

Fig. 9. The projected GHG reduction levels until 2050 for developed countries



- The detailed provisions of the EU Climate and Energy Package are not known, either.
  - The issues related to carbon leakage:
    - a catalogue of industries vulnerable to carbon leakage;
    - the level and manner of grandfathering allowances to the above industries;
    - the treatment of industries directly vulnerable to carbon leakage through electricity use;
  - The detailed manner of controlling and calculating the mandatory share of RES in the final energy balance;
  - The detailed rules for the auctioning CO emission allowances;
    - the mechanisms to protect small emitters against the domination of large and rich emitters;
    - the mechanisms to protect against the potential allowance speculation, conducted e.g. by aggressive NWFs[52];
    - the mechanisms to protect against the politically-motivated buyout of a large number of allowances in order to slow down the European economy;
  - The possible modification of the principles governing the award of State aid, e.g. to sensitive, vulnerable or strategic sectors.
- Domestic problems also need clarification:
  - The manner of financing the investment projects required by the Package – with own funds or credits?
  - The level of capital cost (a credit and equity);

[52] The National Welfare Funds.

- The functioning of incentive and support systems, such as colour certificates, tax credits and voluntary agreements; the existence and competence of the Agency for Energy and Climate;
- The autonomy, the scope of powers and responsibilities of the regulator, i.e. the President of the Energy Regulatory Agency.

♦ A global problem is the depth of the global crisis, its duration and the way in which it will end. Failure to know such detailed issues means the lack of knowledge concerning the availability of capital and the levels of its cost, thus also the levels of financial investment costs.

We seek the answers to questions related to the economics of the energy sector:

♦ The economic investment parameters, such as the capital cost, the required level of equity, the costs of securities etc. are not known.

♦ The real investment costs of such new technologies as conventional power plants using CCS and nuclear power plants of generation III+ are not known.

♦ The trends in the costs of fossil fuels, gas, crude oil and coal are hard to predict.

♦ The price levels of CO_2 emission allowances from 2013 are not known.

Most probably, there are more areas of knowledge gaps; still, those listed above seem to be the most important ones.

11. Conclusion

The main goal of Poland's Alternative Energy Policy until 2030 presented here was not to indicate the only possible or best solutions ensuring safe and competitive energy supplies. We intended to demonstrate the possibility of an alternative approach to the creation of energy policy, starting with the allowable loads on the natural environment; in addition, with appropriate resources, such an approach could be subjected to the optimisation procedure.

The recommended scenario not only contributes to the greatest extent to ensuring safe and competitive energy supplies, but it also meets the conditions of sustainable development and takes into account the social objectives. We indicate that, with appropriate resources, such an approach could be subjected to the optimisation procedure. Unfortunately, the latter task is still ahead of us – the citizens and the Government of the Republic of Poland.

The purpose of the example of AEP is also to create a new approach to all strategic documents at the level of the State, region or locality – an approach considering the shrinking natural resources and the need to share them with the future generations and to adapt the scale, type and pace of development to the environmental requirements. Indeed, these requirements should provide a framework for future activities. The approach consisting of the minimisation of the impact on the environment is no longer sufficient and it is also inconsistent with the philosophy of sustainable development.

Annex 1. An assessment of the situation in the energy sector and the factors likely to affect the implementation of AEP

An assessment of the situation in the energy sector

I. The basic problem of the Polish energy sector is its low efficiency (productivity), which is aggravated by the low efficiency of energy use.

- According to EUROSTAT, the energy consumption per unit GDP in Poland is higher by a factor of 3.5 than in the EU15 ((574 koe/1000 EUR vs.180 koe/1000 EUR in 2006.).
- The efficiency of power plants in Poland is 36.5% compared with 46.5% in the EU, while the net value is, respectively, 32.5% vs. 41.5%.
- The coal share in the primary energy balance still continues to be high, mainly as a result of the domination of this fuel in the electricity sector (92%) and the heat sector (80%).

II. In the Polish energy sector, there are enormous technical disproportions; specifically, its technical structure does not match the functional requirements and users' needs.

The electricity sector

- The surplus in installed real power is 34 GW compared with 25 GW of indispensable peak demand power, i.e. the surplus is 155% compared with 125% required by UCTE[53] and the European trends towards 110%. At the same time, an enormous part of this surplus is technologically obsolete; in 2010, 39% of units will be more than 40 years old;
- The energy consumption per capita in Poland is lower by a factor of almost 2 compared with the EU15 (with inefficient energy use, this does not mean the need to increase its production, but primarily to ensure its general saving);
- The topology[54] of the 400 kV transmission network is incorrect – the north-eastern loop (Olsztyn/Mątki – Ełk – Białystok/Narew) and the north-western loop (Szczecin/Krajnik – Poznań/Plewiska – Ostrów Wlkp.) are unclosed;
- The generation topology is poor, with the lack of plants in the North and their concentration in the South;
- There is no backup system to measure flows between power plants through 110 kV networks;
- The topology of 15 and 3 kV distribution networks is open, causing very poor supply to rural areas (large voltage decays even down to 170 V, frequently interrupted supplies, unstable voltage);
- In the case of electricity networks, there are two basic problems. One of them is the poor technological condition caused by very advanced decapitalisation and technical wear. In certain areas (e.g. the eastern part of the country), with no exaggeration this condition is tragic. The situation of distribution networks is illustrated in Fig. 10.
  Transmission lines are in a condition which is not much better (Fig. 11); still, they demonstrate the European discipline in terms of frequency and usually in terms of voltage, too, which cannot be said about the distribution lines.
  There is the growing problem of decapitalisation of rural networks; their share in the assets of companies is about 70%, but their sale to rural users represents only 30-35%. In recent years, there were no significant changes in the structure of the distribution network in rural areas. More than 70% of the lines are decapitalised (about 260,000 km of low voltage lines and 207,000 of medium voltage lines) and so are about 80% of stations (out of about 150,000). The decapitalisation worsens, since only about 3,000 km are modernised in a year – instead of 25,000 km. There are

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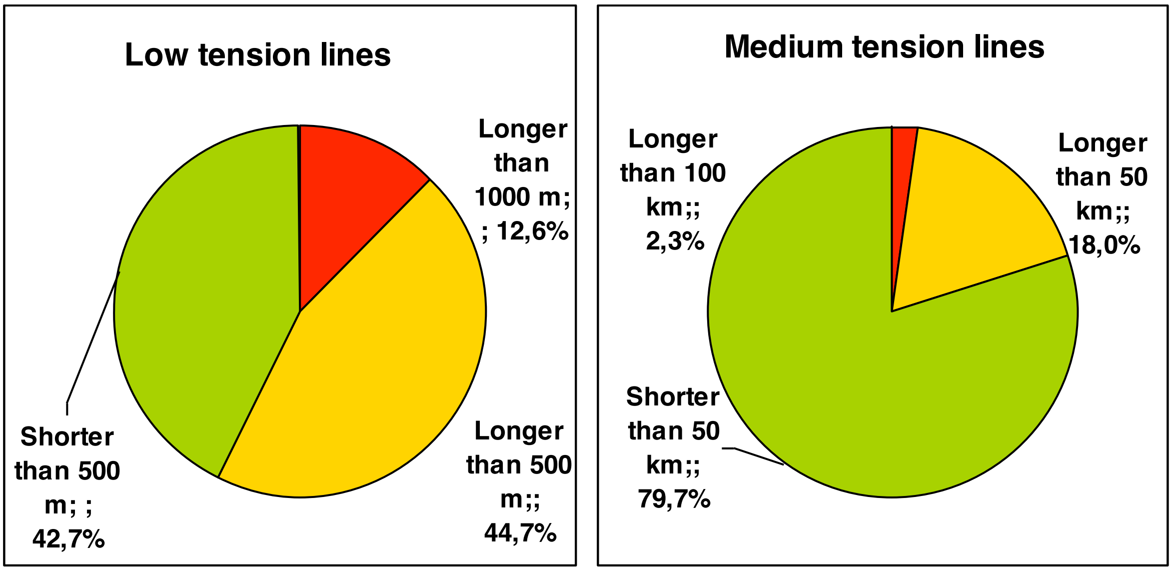
[53] Union for the Co-ordination of Transmission of Electricity.
[54] The topology of a network, i.e. its configuration, is the position of mutual connections among the nodes where transformer and distribution stations and/or plants are situated.

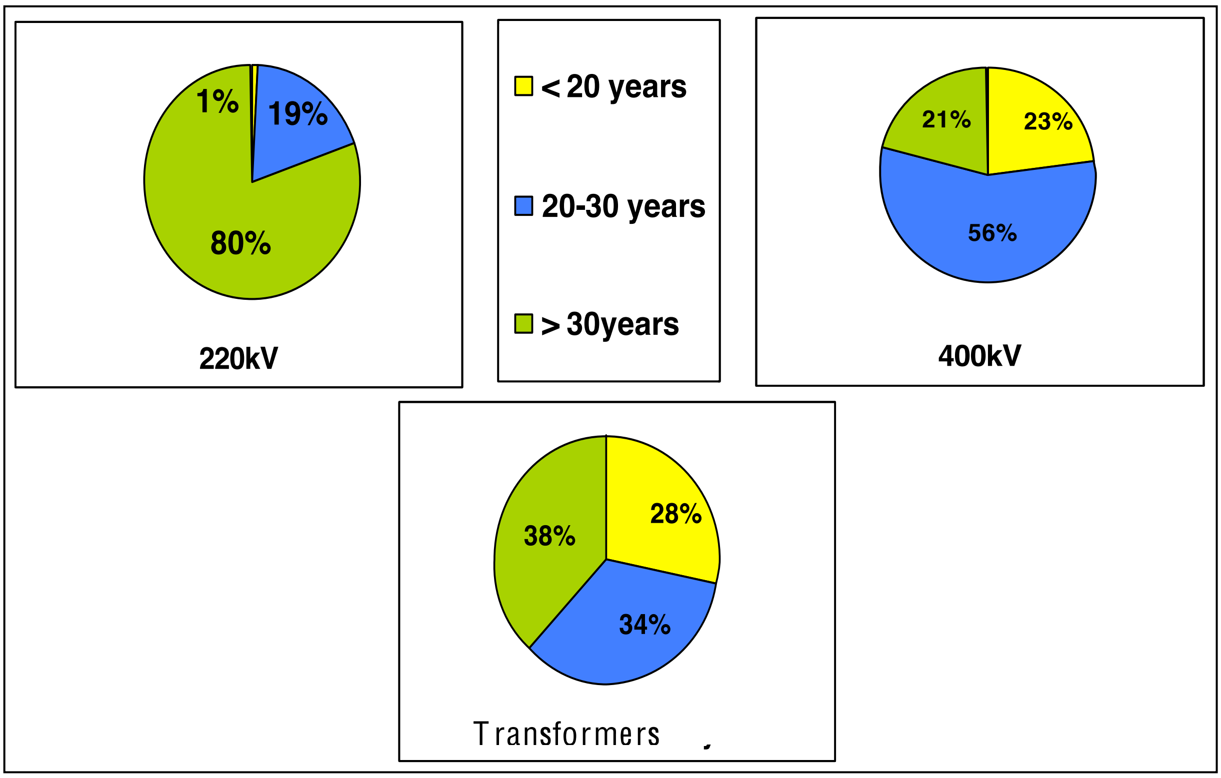
slight differences among regions in the depreciation of assets, varying between 64 and 87%. At the same time, the proportions distinctly change in favour of urban networks due to their much higher profitability. With the asset proportions of 1 to 2 between urban and rural areas, the investment proportions are 5 to 1 (Table 12).

Fig. 10. The condition of medium voltage (SN) and low voltage (nN) distribution networks



Source: The report of PTPiREE for the Ministry of Regional Development in 2008.

Fig. 11. The average age of transmission networks in Poland



Source: PSE-Operator

Table 12. Comparison of rural and urban areas

Areas	SN lines (1-20 kV) in km	nN lines in km	Stations in units	Users in thousands
Urban	71 390	144 746	3 942	10 326
Rural	207 407	260 618	54 391	5 405
Poland	278 797	405 364	58 433	15 721

Source: The report of PTPiREE for the Ministry of Regional Development in 2008.

The gas sector
- One-sided trade contracts, no diversification – the one-sided network supply (practically only from the East);
- The inadequate capacity of border connections, the absence of connections between Poland and the EU (Germany) and the so-called reverse capacity, i.e. the ability to change the direction of gas flows from western to eastern one;
- The absence of "Polish sovereignty" over a section of the Jamal pipeline (e.g. the lack of technical access to the first line of the pipeline, which means that in practice this pipeline is an exterritorial gas corridor);
- Poland's consent to the resignation from the construction of the second line of the Jamal pipeline through Poland, although Poland paid for this in the "take or pay" contract";
- The insufficient development of distribution (low-pressure) networks – many areas in Poland have no access to distribution networks;
- Insufficient retention – a shortage of gas storage facilities and, hence, appropriate reserves;
- The failure of the Baltic Pipe project from Norway and, hence, the loss of one of the opportunities for diversification of gas supplies.

The heat sector
- The structure of heating networks (in terms of their technology, capacity and topology) comes from the period of greater heat demand and past urban investment programmes which were not always completed;
- The absence of the possibility of applying the correct regulation measures enhances heat losses;
- The flow rates are much different from the design flow rates, causing heat losses;
- Effective quality and quantity control is infrequent;
- Pipes were replaced by pre-insulated ones only in 20% of networks;
- Peak demand plants and own cogeneration plants are infrequent;
- The efficiency of heating plants is 50–93% (vs. 75 – 93% in the EU);
- Water losses in heating networks amount to 7 exchanges/year (1–3 exchanges/year in the EU15);
- The efficiency of heating systems is 50–86% (70–91% in the EU).

III. The Polish energy sector is in a serious economic crisis.

The electricity sector
- The domestic electricity price is higher than those in the neighbouring countries to the East (this is affected by the cost of the maintenance of unproductive capacity and the high energy prices under LTCs[55], resulting from compensation charges concealed in the transmission charge);
- Exports are only possible at prices resulting from the marginal costs of the electricity and mining sectors; this may give rise to accusations of dumping; after the charges for CO_2 emissions have been introduced the profitability of exports becomes doubtful;
- Cheaper energy may flow in from abroad up to about 20 TWh/year;

[55] LTCs – long-term contracts.

- The rate of return of capital in the electricity sector did not reach the minimum 7%, but in 2008 the rate of return increased;
- Tariffs are regulated mostly on the basis of social considerations;
- A free market where better operators could win does not operate; competition is blocked by the tough mechanism of the balancing market (which serves the system rather than the market), the large share of energy from former LTCs and primarily by the vertical consolidation of the market and the related arbitrary transactions within the groups;
- The low employment efficiency; at least 60–80% of employees should be outplaced;
- The lack of advanced investment plans for 2009–2015.

The gas sector

- The domestic gas cost, e.g. for the heavy chemical and electricity sectors, is high (considering the low energy efficiency);
- The market and, hence, competition are non-existent;
- PGNiG is a monopolist with respect to domestic users, but it is very weak in negotiations with its foreign supplier, while the absence of alternative supply sources increases its vulnerability to the political supply management by the Eastern supplier;
- There is no motivation for the development of the domestic gas extraction and storage construction.

The heat sector

- The improved heat management has brought an effect – lower heat demand – but there still remains a substantial capacity to reduce supplies of fuels and energy from foreign and domestic sources. In 1996–2007, the network heat production fell from 444.4 PJ/year to 321.0 PJ/year, i.e. by 27.8%, so it decreased on average at a rate of 2.9% a year. The greatest drop came in utility heating plants and non-utility ones, i.e. smaller heat sources which feed medium-sized and smaller heating systems, this is caused by a sustained trend for customers to resign from network heat;
- There is limited competition on the heat market; it is present where there are opportunities or an economic basis for network-based energy carriers to be replaced by electricity, network heat or natural gas. At the stage of energy planning in cities and municipalities as well as investment decisions concerning the expansion of local energy networks, a large role should be played by the competitiveness and efficiency of heat supply systems. The present legislation does not provide for clear competence to build such an energy order;
- The high burden of energy costs on household budgets, particularly those of heating; the share of energy costs in these budgets is about 10% (3–5% in the EU15);
- A very low rate of return of capital;
- Lack of resources for modernisation and replacement investment projects, while the existing resources (depreciation and profit) are not always fully used;
- The poor diversification of revenue sources (about 5%)[56];
- At least 50% of employees should be outplaced;
- At utility heating plants, a tendency to modernise generating units can be seen, since the energy efficiency of boilers improved from 72.0% to 76.8% in 1996–2007. Considering the fact that 90% energy efficiency is possible at large heat sources and so is 85% efficiency at smaller ones, this suggests the capacity to reduce the consumption of primary fuels by 6–8% and to cut CO_2 emissions to the same extent (see Fig. 12).

The mining sector

- There is an alarming lack of replacement investment projects (the period of high coal prices was not used);
- Only some mines enjoy operating profits;
- Zero or negative profitability;
- The domestic price (loco ports) is higher than the price of foreign coal;

[56] 95% of the revenues of heating companies come from heat sales; due to the lack of offers to provide other services, their economic situation is very dependent on the weather conditions, e.g. mild or harsh winters.

Renewable energy sources (RES)

- With the present technological level, renewable energy sources offer a substantial potential; its share is estimated at 46% of the primary energy used today (the technological potential), whereas the market potential for 2020 is estimated at almost 22% of the final energy, of which less than one fifth is used (see Table 13);

Table 13. The economic potential of renewable energy resources and the extent of its use in 2006

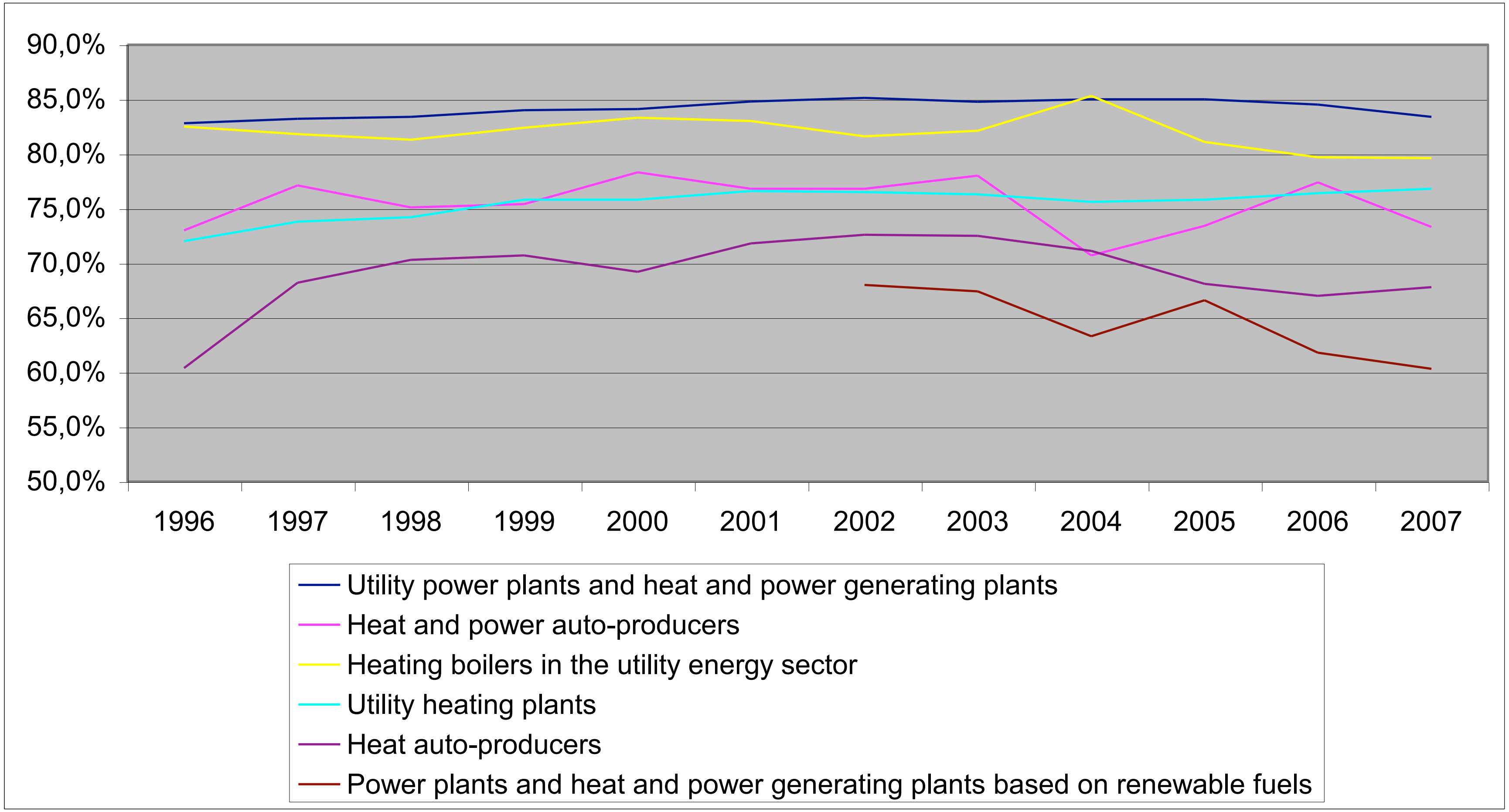
Potential of renewable energy resources	Real economic potential – final energy	Extent of the use of the economic potential of RES in 2006	
	[TJ]	[TJ]	[%]
Solar energy	83 312.2	149.8	0.18
Geothermal energy	12 367.0	1535.0	12.4
Biomass[57]	600 167.8	192 097.0	32.0
Hydro-energy	17 974.4	7351.2	40.90
Wind energy	444 647.6	921.6	0.21
Total	1158 469	202 055	17.4%

Source: The capacity to use renewable energy sources in Poland until 2020, Institute for Renewable Energy, in cooperation with the Institute for Sustainable Development, Warsaw, December 2007.

- Despite the introduction of green certificates, the support system is insufficient to achieve the RES share in the final energy as provided for in the *Strategy for the Development of Renewable Energy* (14% in 2020) and that under the Climate and Energy Package (15% in 2020). The system does not effectively support all the types of renewable energy, ensuring the economic viability only for wind energy;
- The basic barriers impeding the development of RES are administrative and legal procedures, which have a hampering rather than facilitating effect, as a result of the ignorance and hostility on the part of offices; there is no network in place to distribute the energy generated and a stable biomass market is absent; despite favourable changes, sources of financing for renewable energies still continue to be insufficient;
- As to the scale and forms of support required for them, it is at a level of 1000 MW/year, while the National Fund for Environmental Protection and Water Management supports about 200 MW/year;
- There is no appreciation and promotion of dispersed energy generation, including small local energy systems, as equal to the "large" utility plants;
- The extent to which renewable energy sources cover the heat demand is slight.

[57] Its potential is limited by the current formal and legal conditions, the extent of farmers' preparedness to ensure sustained raw material supplies and the present capacity to connect as declared by network operators. In turn, the technological potential is estimated at 926,950 TJ.

Fig.12. The efficiency of network heat production at individual plants in 1996 – 2007



Source: FEWE, according to the data from the Fuel and Energy Management in 1996 – 2007.

IV. The Polish energy sector faces great challenges related to the need to adjust to the requirements of environmental protection (originating from the Kyoto and Sulphur Protocols and the EU legislation, particularly relating to energy efficiency).

- The difficult requirements related to the Climate and Energy Package impose many new obligations on the State and the operators which emit greenhouse gases, with no coordination by the State; the time for preparations is short, since the new EU-ETS scheme will come into effect as early as in 2013; in addition, until then 30 urgent tasks have to be carried out, particularly in the scope of: auctions, CCS, allowance grandfathering, heat production, the investment plan, the use of units from JI/CDM, small installations, the adjustment of national regulations to the EU legislation, reporting, assessments and reviews;
- The system of green certificates still has shortcomings;
- Conservative tax systems (e.g. the absence of a energy and carbon tax and the environmental tax reform);
- A large delay in the implementation of the schemes for trading in SO_2 and NO_x emissions (trading in CO_2 was only implemented by the EU), despite the fact that in the early 1990s Poland carried a successful pilot project in this field;
- The absence of mechanisms to support BAT;
- The implementation of Directive 2006/32/EC on energy efficiency is only at its initial stage; the concept of white certificates has been developed, but even at this stage it meets with counter-lobbying from energy companies;
- Voluntary commitments or any other similar schemes are not in place; they are to be introduced by the Act on Energy Efficiency, which has not been adopted yet;
- ESCO type companies (implementing TPF) are discriminated against;
- A serious problem is mass-scale motorisation, particularly the imports of old cars from the West in the period from 2004 to 2008 (about 1 million vehicles every year). The greenhouse gas emissions in the period from 1988 to 2006 grew from 22 to 39 $mtCO_{2eq}$ and projections predict their further substantial growth to 58 $mtCO_{2eq}$ in 2020, unless strong action is taken to promote sustainable mobility;
- The limitation of pollutant emissions from the so-called low-emission sources (local boiler-houses, private-house boilers, stoves and means of transport) should be a priority of consistent energy, environmental and social policies. The situation may deteriorate if "clean" energy carriers, covered by the provisions of the Climate and Energy Package, such as electricity and network heat, become more expensive and are partly pushed out by local boilers and coal-fired stoves (which are not subject to charges for the emissions of air pollutants and CO_2).

V. Non-enforced or incomplete legislation hampers the functioning of the sector; some solutions are extremely unfinished, while others are lacking.

Energy planning in municipalities	In effect, but not implemented
The TPA principle in electricity, gas and heat networks	In effect, but not implemented
Network codes were introduced "through the backdoor" (not through regulations)	Without being in effect, they were implemented and blocked the market; now they are partly controlled by the ERA
The balancing market	In place, but the "*intra day"* market does not operate and does not exist for gas
The energy exchange	In place, but hardly operates and does not exist for gas
DSM, ESCO	In effect, but not implemented
Stranded costs – long-term contracts	The LTCs were eliminated on 1 January; the "compensation charge" has remained
Transparency of regulation	Non-existent

Mechanisms to support energy efficiency	Non-existent, or not implemented
Energy labels and certificates	Not fully implemented or not in place
Energy certification of buildings	In place, but hardly implemented
Modern energy management systems in buildings and industry	Non-existent
Legislation regulating linear investment projects	Non-existent

VI. In the energy sector, particularly in its network part, the culture of a monopoly or even that of an office still persists.

- Energy companies are not customer oriented;
- Distribution has not been fully separated from trading; joint information-technology, management and billing systems etc. still persist;
- Marketing services and techniques, such as Customer Relation Management, Call Centres, Key Account Managers are non-existent or do not operate;
- There is no segmented offer responding to customer expectations; the segmentation depends only on the volume and voltage (pressure) at the connection;
- Loyalty and promotion programmes are not implemented[58].

VII. Changes in the transport sector have brought about the domination of the car over the other forms of travel; this has led to a large increase in the consumption of fuels.

- In last 20 years, the growth of passenger and goods transport and that of the transport intensity of the economy and social life (mobility) as well as the share of road transport in haulages were greater than desirable from the point of view of the implementation of the principle of sustainable development, as provided for in the Alternative Transport Policy[59];
- The growth rate of energy consumption by transport in 2000–2004 (6% annually) placed Poland in the EU countries leading in this respect. Higher growth rates could be observed in Latvia (9%), the Czech Republic (6.9%) and Bulgaria (6.5%). The average values for the EU25, EU15 and EU-10 are respectively, 1.3%, 1% and 5%;
- In 1990–2006, the transport work in the goods transport fell by almost 37% in rail transport and increased by almost 300% in road transport;
- In 1990–2006, the number of passengers in rail transport fell by 63%;
- A significant increase in fuel consumption occurred in the group of passenger cars (by almost 100%), while the number of vehicles per 1 thousand residents exceeded 350 in 2006;
- The fuel consumption in road transport is stable; with an increase in the number of tonne-kilometres by about 80% and a decrease in the number of passenger-kilometres by about 30%, this indicates progress in the reduction of the energy intensity of transport; in rail transport, there was a distinct shift in energy consumption from liquid fuels to electricity (with a drop, respectively, by about 20% and almost 80%); this was partly connected to a faster drop in the volume of regional passenger transport served by internal combustion units;
- In electrified urban transport, the electricity consumption only fell by about 5%, with a decrease of about 8% in the fleet of tramways and trolleybuses and a decrease in total passenger travels in the entire urban transport by about 25%; this suggests the potential significance of the replacement of bus and private transport by the tramway network and the underground.

[58] Loyalty programmes are extremely popular e.g. in telecommunications, particularly cellular ones, where there is a large customer migration, the so-called churn, and promotion programmes mainly serve to win new customers and buy them from other companies.

[59] The *Alternative Transport Policy Following the Principles of Sustainable Development*, Report 4/99, Institute for Sustainable Development, Warsaw 1999.

The factors which affect the implementation of AEP

External factors

The basic external factors (unfolding processes and their effects) determine the changing conditions in which AEP can be implemented. They include:

- The globalisation process that generates strong interactions among regional markets at continental level, which are sometimes quite distant from one another, and causes in practice the decline of isolated local markets;
- The climate and energy crisis which causes societies to focus on the effects of global warming and the results of the depletion of non-renewable resources;
- The crisis of financial markets which generates significant problems – the lack of liquidity and the shortage of investment capital on the market.

The events at the level of the European Union and its closest neighbourhood complement the world trends listed above:

- The implementation of the process of European enlargement is far from the intentions and declarations. The difficulties related to the signing of the Lisbon Treaty are only a symbolic example of how the enlargement is halted;
- The European integration of natural gas and electricity markets, which has been promised for many years, proceeds extremely slowly, both in terms of physical transboundary connections (TEN-E[60], TEN-G[61]) and in terms of commercial unblocking of cross-border exchange (by introducing the market coupling mechanism);
- The real internal opening of markets is extremely slow and blocked quite successfully by vertical consolidation processes, administrative obstacles related to the change of the seller, the slowing down of technological change processes (such as smart metering and a smart grid) and, at present, by the financial crisis;
- The practical resignation from the European integration of special, so-called colour markets, designed to support preferred solutions (technologies), such as RES, cogeneration, energy efficiency, high-efficiency generation, the so-called clean coal. These markets remain local, strongly different ones, leading to a "sabotage" of the concept of the European integration;
- The absence of a concept of consistency among certificates with different colours, the integration of the special markets and their integration with the market of CO_2 emission allowances, although it is possible in technical terms, at least in the scope of unification of nomination units; it would be natural to nominate all the certificates in tonnes of reduced or avoided CO_2.

The only market which has been integrated at European level, is the market of CO_2 emission allowances; it prefers high allowance prices and, in consequence, high energy prices. This will create preferences for energy saving, the development of the gas and nuclear energy sectors as well for renewable energy sources. Another effect on the European scene will be a deterioration of the position of European energy-intensive industries, caused partly by higher energy prices (as an indirect effect of the adoption of a more stringent Community climate policy) and partly by the global recession (the financial crisis). This deterioration of their position may lead to the relocation of emissions to regions with less stringent environmental regulations (e.g. China, India, Brazil and Mexico) rather than their reduction. This effect has been called *carbon leakage*, exactly because of such relocation. Its scope and effects are difficult to assess. The only solution to this situation is to achieve a global, worldwide agreement on this issue in the course of the Conference of the Parties to the Climate Convention.

[60] Trans European Networks – Energy.
[61] Trans European Networks – Gas.

The commitments made at the December Summit in Brussels in 2008 are some of the European factors which are of extreme significance for Poland:

- ♦ The achievement of a 21% reduction of greenhouse gas emissions from installations covered by the EU ETS scheme in 2020 with respect to 2005, in which Poland must participate;
- ♦ Compliance with the 14% cap for the emission growth in 2005–2020 in the non-ETS areas, including e.g. transport, which is a sector where emissions are difficult to control and where they continue to grow;
- ♦ The participation in the effects of the enhancement of the European reduction commitment from 20% to 30%, if progressive post-Kyoto agreement will be achieved. It is likely that the higher emission reduction will be achieved using CDM[62], i.e. a flexible mechanism under the Kyoto Protocol, involving investment projects in developing countries. The emission credits generated in this way can be used in the EU ETS scheme;
- ♦ The achievement of a 15% share of energy from renewable sources in the final energy balance, along with a 10% share of biofuels in transport fuels;
- ♦ The expected 20% improvement in energy efficiency in 2005–2020, which has so far been an "indicative" commitment. In other words, it would be good to do so, but there is no obligation. The improvement is to be calculated with respect to the BAU Scenario, but, however, it has not been clearly defined to date by the European Commission.

<u>Internal factors</u>

The global factors and European commitments complement the national factors affecting the sector and the economy as a whole. The most important ones include:

- ♦ The high energy and electricity intensity of the economy, which reduces its competitiveness on the world market. High market energy prices exert a pressure on the reduction of the payroll and, in practice, salaries;
- ♦ The high share of coal in the primary energy balance and the extremely high share of coal in the energy mix of the Polish electricity sector;
- ♦ The high emission intensity of the Polish economy, as a result of both its high energy intensity and the highly carbon-intensive energy mix in Poland;
- ♦ The extremely high direct share of coal in the final energy balance, i.e. the coal which is delivered to the retail consumer.

The problems originating from the structure of the economy and the structure of the energy mix, which are partly the heritage from the past political system and which are partly caused by natural factors, are aggravated by the technical condition of the Polish energy sector.

- ♦ Most energy generating units in Poland are obsolete. The average generation efficiency is about 10 GJ/MWh, while new technological solutions ensure an efficiency of 7.5 GJ/MWh. Thus, the specific emission factor of Polish coal-fired power plants is about 950 kgCO_2/MWh, while it could be 700 kgCO_2/MWh. Cutting–edge technologies include solutions with parameters of 5 GJ/MWh and 475 kgCO_2/MWh.
- ♦ There is not enough peak demand power in the Polish energy sector; as a result of which, coal-fired power plants are used for regulating purposes, increasing its emission factor.
- ♦ The transmission system in Poland is incomplete. The north-western loop is not closed, nor is the north-eastern one, which waits for the construction of the Poland-Lithuania power bridge. The meridional connections are poor; given the absence of plants in the North, this part of the country

[62] Clean Development Mechanism.

is exposed to a shortage of energy. Meridional lines are lacking, including the so-called northern rail needed to serve wind energy generation and the central rail (along the motorway) needed to integrate the Polish market with the European (German) market.

- The level of Poland's integration with the European networks is clearly insufficient. This applies to all the neighbours – western, eastern and southern ones. In practice, in energy terms Poland is almost an island.
- The condition of medium voltage distribution networks is far from desirable. Many lines are radial – 5,384 km of lines are longer than 100 km (2.3%) and more than 4,200 km of lines are longer than 50 km (18%). Their breakdowns cause local blackouts[63]. The unclosed eye of the loop is one of the major shortcomings of the system.
- An even worse situation can be found for low voltage distribution networks, which supply households, farms, small industries, crafts and services. In poorly urbanised areas, 12.6% of lines are shorter than 1 km and 44% are longer than 500 m. This means that 56.6% of power lines of this type do not meet the basic standards for the voltage levels delivered. Due to this tragic quality gap, modern, optimised equipment breaks down, is damaged or refuses to operate, since it is adapted to the European voltage standard of 230 V rather than 180 V, which is often the "standard" in Polish rural areas.
- As a rule, Polish metropolies are not surrounded by supply rings and most of supply lines are overhead, as cable lines represent 2.8‰ (per mille!). There is no system to monitor sensitive sections.
- The underdevelopment of the transmission network and the 110kV distribution networks is now the major barrier to the development of dispersed generation facilities, particularly those using wind. The right of access to the network has become subject to commercial trading. As indicated by the data of PSE-Operator, the achievement of the target 15% share of RES in the national electricity balance would require the construction of about 1,220 km of transmission lines and at least 5 new extra high voltage (NN) stations. The estimated cost of these investment projects is about PLN 3.3 billion.
- It is necessary to expand electricity transmission networks, particularly in Northern Poland, where there are the best conditions for the development of wind energy on land and at sea. It is most important to build at least two 400 kV North-South lines, to take off the load from the existing Krajnik–Dunowo–Słupsk–Żarnowiec and Gdańsk Błonia–Grudziądz lines. It is necessary to increase the capacity of the Plewiska–-Dunowo and Gdańsk–Jasiniec lines (from 220 kV to 400 kV).
- The creation of the transmission capacity to take the energy generated by wind farms in the sea areas of the Republic of Poland is of key importance. In the Polish sea areas, it is probably possible to implement projects to build marine wind farms with the total power of 5,000 MW, making it possible to produce the same amount of energy as is generated from 10,000 – 12,000 MW on land from wind energy facilities. It is also necessary to participate in the European plans to build undersea power lines designed to transmit the energy generated by marine wind farms (e.g. the Supergrid project).
- Some of household installations still fail to meet the safety requirements and cause overvoltages and, in consequence, fires.

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[63] An interruption in the operation of an electrical system or its substantial part has come to be called a blackout type system breakdown. Such a breakdown is defined as the loss of voltage in an electrical network over a large area. The causes and the course of such an effect are different in each case, but it is possible to speak of the same general pattern whereby a blackout occurs. As a result of the coincidence of several random events (network breakdowns, shutdowns at power plants, extreme weather conditions), the critical values of the basic parameters of the system (frequency, pressure) are exceeded, a power plant automatically disconnects from the network and voltage is lost throughout the area affected by the disturbance (www.biodisel.pl).

- The culture of energy use in many workplaces, institutions and households is far from satisfactory.

Annex 2. Analysis of scenarios with a different energy mix assuming the satisfaction of the electricity demand

In order to fully present the effect of the choice of a scenario on the investment project and costs, the needs in this respect were estimated. The creation of a consistent investment programme requires the collection of many data and the adoption of many assumptions (Table 14 and Fig. 13). The data mainly concern the technological aspect and come from many domestic and foreign sources. The assumptions mostly relate to the financial aspect of the investment project and, in the light of the worldwide financial crisis, they could not be based on historical data.

Table 14. The structure of capex/opex[64]

Type of energy	Cost in EUR/MWh	Capex in EUR/MWh	Opex in EUR/MWh	Capex %	Opex %
Natural gas	77	10.01	66.99	13%	87%
Hard coal	68	14.28	53.72	21%	79%
Pumped-storage power stations	100	40	60	40%	60%
Biomass	87	35.67	51.33	41%	59%
Offshore wind	113	77.97	35.03	69%	31%
Onshore wind	92	66.24	25.76	72%	28%
Solar CSP	160	121.6	38.4	76%	24%
Hydro-power plants	70	53.2	16.8	76%	24%
Nuclear power plants	62	42.5	19.75	68%	32%
Photovoltaics	390	366.6	23.4	94%	6%

Sources: Analysis by AT Kerney and own calculations

The analysis of the cost structure carried out by AT Kerney (2008) indicates a large differentiation of the elements of fixed and variable costs; in addition, for zero-emission technologies the share of fixed capital costs is much greater than for technologies causing emissions.

Finance

The basic financial parameter is the ratio between equity and debt (a credit or bonds). The credit programmes guaranteed by the State (e.g. the programme of the US Department of Energy) make it possible to limit the equity even to 20%, whereas Project Finance type investment projects require equity at a level of 45%. In the analysis, the 30%/70% ratios were used.

One of the most important investment parameter is the discount rate. As a rule, business plans apply different discount rates; the discount rate for equity is higher, often greater by a factor of more than one and half (e.g. 8% for a credit and 14% for equity, which gives a factor of 1.75). For the purposes of this paper, a factor of 1.5 was assumed; with the adopted equity/debt ratio, this gives a composite discount rate equal to:

[illegible] where r is the credit interest rate.

In AEP, the rate r = 10% and the equity rate r_e = 15%; thus, in consequence the composite rate r_c = 11.5% were assumed.

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[64] Capex means capital expenditures and opex is operating expenditures.

The last but extremely important parameter is the payback period to recover the investment or rather the credit which generates the financial cost of the investment project. The length of this period falls within the interval of 20÷40 years, with a period of 20 years used e.g. in the analysis of renewable sources and a period of 40 years applied in the analysis of nuclear power plants. In the option presented, a uniform period of 30 years is used.

In the credit model with a fixed capital instalment and 30% equity, the capital cost is given by the formula:

[illegible] where:

$$K_n = K_{n-1} - 70\% K / 30 \qquad K_0 = 70\% K$$

or

[illegible]

The elements of financial costs are illustrated in Fig. 14 (30% equity) and Fig. 15 (20% equity). Table 15 shows synthetically the financing effects for a 30-year credit and a discount rate of 10%, whereas the option with a historical rate of 5% is presented in Table 16.

Table 15. Financing effects for a rate of 10%.

Equity/debt	Average interest rate	**Bank's rate of return**	**Investor's rate of** return
20/80	9.53%	116%	90%
30/70	10.22%	102%	135%

Source: Own calculations

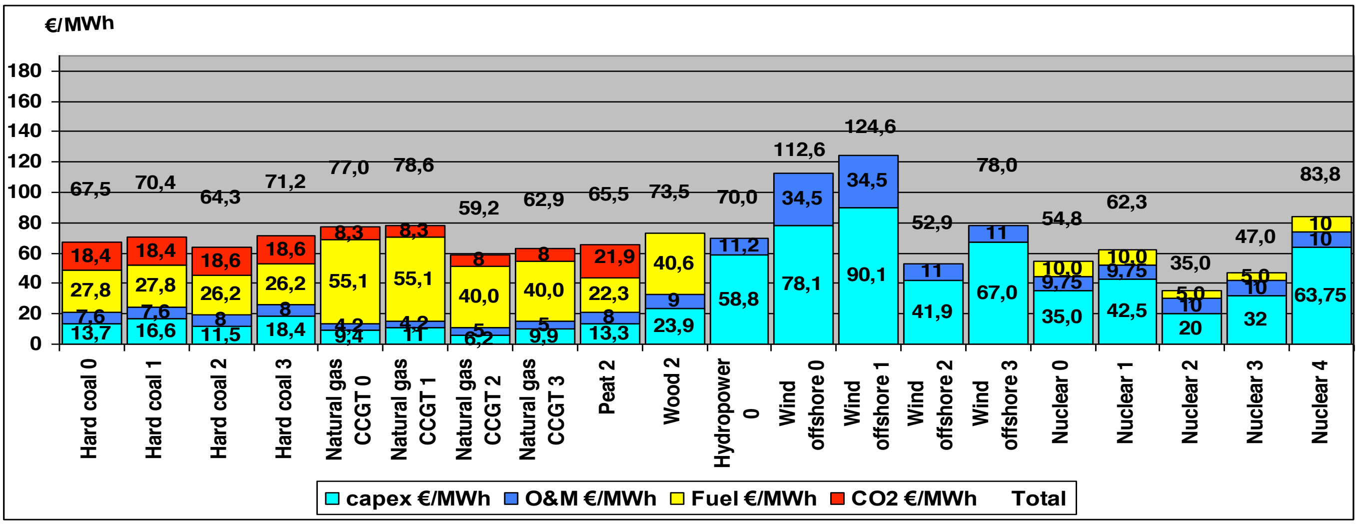
Table 16. Financing effects for a rate of 5%.

Equity/debt	Average interest rate	**Bank's rate of return**	**Investor's rate of** return
20/80	6.10%	58%	45%
30/70	6.28%	51%	68%

Source: Own calculations

The distinct increase in the value of discount rates causes the capital costs of investment projects – and, hence, the level of investment risk – to grow substantially.

Fig. 13. The price structure of different energy sources

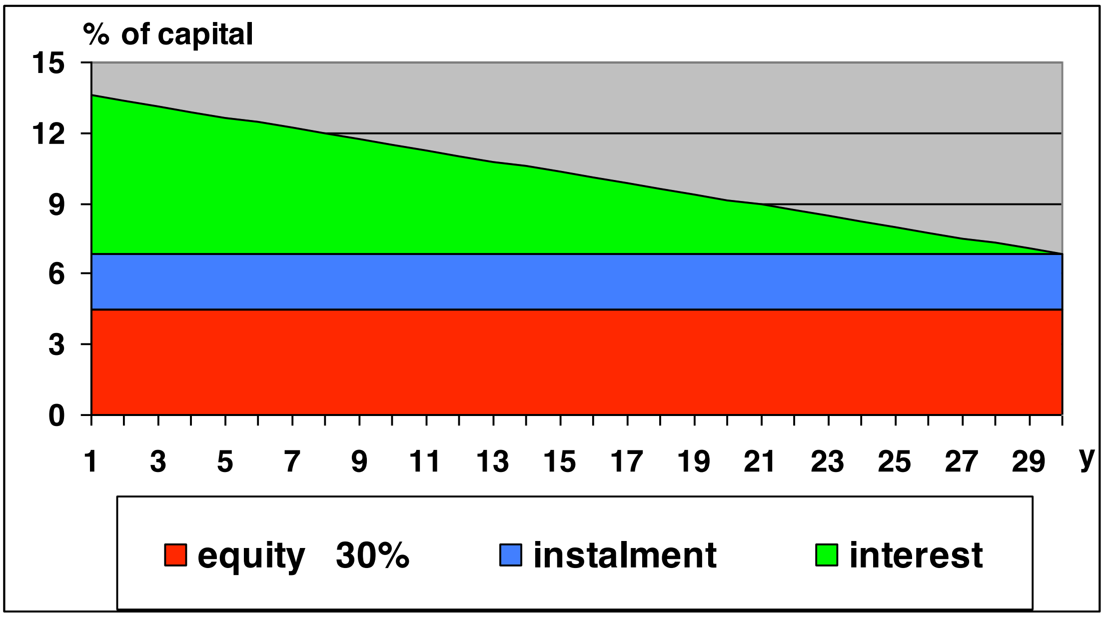


Source: Energate, EEX, EWEA, AT Kerney, Internet, own calculations

<u>Legends for different types of energy sources within the scope of the same energy carrier:</u>

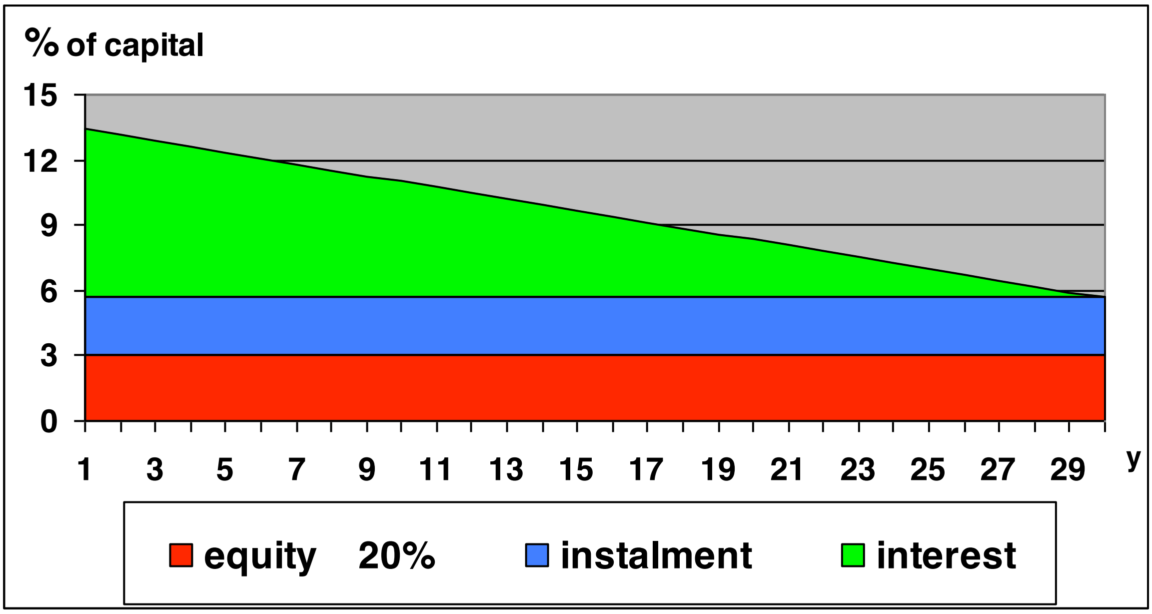
0) Energate, EEX, EWEA, Report by AT Kearney 2008, a discount rate of 6%
1) As above, a discount rate of 8%
2) Tarjanne Risto, Kivistö Aija 2003: Comparison of electricity generation costs, Lappeenranta University of Technology Research report EN A-56, a discount rate of 5%
3) As above, a discount rate of 8%

Fig. 14. Elements of financial costs – 30% equity and a discount rate of 10%.



Source: Own calculations

Fig. 15. Elements of financial costs – 20% equity and a discount rate of 10%.



Source: Own calculations

Technologies

Table 17 presents the basic technical parameters for different sources of electricity: the average planned productivity of plants (h/year), their efficiency (%), emission factors (tCO_2/MWh) and unit capital costs (G€/GW). The capital cost includes the basic construction cost and the additional costs incurred by the investor, such as the purchase and preparation of the site. Many references call it the overnight cost (and sometimes – the all-in cost). This cost does not include the cost of capital (as mentioned earlier), nor the cost of the expansion of the transmission and distribution networks (where necessary). The estimated additional costs of network modernisation represent at least one third of the costs of investments to build a plant.

Table 17. Basic investment parameters

Plant type	Productivity in h/year	Efficiency in w %	Cost in billion EUR/GW	Emission factor tCO_2/MWh	Codes for Figs. 4,5,6
Shutdown	------	------	------	------	Shutdown
Old hard coal	4000	36%	------	0.900	Old hc
Modernised hard coal	5000	41%	1.0	0.790	Mod. hc
New hard coal	5500	46%	1.5	0.704	New hc
New+CCS hard coal	6500	36%	2.5	0.070	CCS hc
Old lignite	4500	36%	-----	1.100	Old lig.
Modernised lignite	5500	41%	1.0	0.966	Mod. lig.

New lignite	6000	46%	1.5	0.861	New lig.
New+ CCS lignite	7000	36%	2.5	0.086	CCS lig.
Gas CCGT	4000	56%	0.9	0.329	Gas CCGT
Gas CCGT+CCS	5000	46%	1.2	0.033	Gas CCS
Onshore wind	2000	-----	1.7	-----	Onshore
Offshore wind	3500	-----	3.2	-----	Offshore
Biomass	5500	-----	2.0	-----	Biomass
Biogas	6000	-----	3.0	-----	Biogas
Nuclear plants I[65]	8000	37%	3.0	-----	Nuclear I
Nuclear plants II	8000	37%	4.5	-----	Nuclear II

Source: Energate, EEX, EWEA, AT Kerney, Internet, own calculations

[65] The items of nuclear plants I and II need to be clarified. Nuclear plants I represent investment prices from the published offers, whereas nuclear plants II are the real contractual prices (based on the data from the US Ministry of Energy). Detailed analysis of Internet-based data, including those on the history of the construction of the Finnish nuclear power plant Olikuoto 3 and the credit guarantees provided by the US Ministry of Energy for the United States nuclear energy programme, indicate the existence of large discrepancies between the investment prices offered by suppliers and business plans and the real investment costs. This issue requires more in-depth analysis.