COUNCIL OF MINISTRIES

DEVELOPMENT STRATEGY OF RENEWABLE ENERGY SECTOR

(The document prepared in compliance with an obligation following the resolution adopted by the Parliament of the Republic of Poland on 8 July 1999 concerning the development of utilisation of energy from renewable sources)

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1. INTRODUCTION

Reasonable utilisation of energy from renewable sources, such as energy of rivers, wind, solar radiation, geothermal energy and biomass, is one of the crucial components of sustainable development aimed to generate tangible environmental benefits and energy effects.

The growing share of renewable energy sources in the world s fuel and energy balance contributes to better efficiency in the utilisation of energy resources and to the saving of energy resources. Other effects include improved condition of the environment due to reduction of emissions into the atmosphere and waters as well as reduced volume of waste. Support of the development of renewable energy sources is therefore becoming a more and more serious challenge to almost all countries of the world.

Interest in renewable energy sources grew considerably in the 1990 s. It is estimated that since 1990 the world s utilisation of solar energy has doubled, and that of wind has increased four times. In the coming years, further development in the utilisation of renewable energy sources is to be expected. The growth is due to the benefits to both local communities and to the environment. The former include greater energy security, creation of new jobs, promotion of regional development and last but not the least, the reduction of CO_2 emissions. In particular, the need to fulfil international obligations following the Framework UN Convention concerning climate change and the Kyoto Protocol to that Convention concerning the reduction of CO_2 emissions creates an great opportunity for the development of the utilisation of renewable energy sources.

Renewables may provide a substantial share in the energy balance of individual communes and even of provinces in Poland. These sources of energy may improve energy security in the region and, in particular, improve energy supplies to areas with poor energy infrastructure. Potentially, agriculture, housing and transport are the biggest consumers of energy from renewable sources. The sources offer new opportunities of job creation, especially in unemployment-stricken areas. Further, land which due to heavy contamination is unsuitable for growing edible plants may be used for biofuel crops. Examples of effective utilisation of renewable energy in Polish conditions have been presented in Annex 1. By general consent, the development of the renewable energy sector may help resolve many environmental problems created by the energy sector in Poland as well as in other countries.

2. CURRENT SITUATION

The growing energy demand caused by fast economic development, limited resources of fossil fuels as well as excessive pollution of the environment have caused a big interest in renewable energy sources (RES) in recent years. The share of RES in the world s energy balance is around 18%, the figure being high due to both the development of new renewable technologies and to the fact that a large part of the world s population does not have access to conventional energy sources.

Support of the development of renewable energy sources has become an important objective of the policy of European Union. The goal was expressed in the EU s White Paper published in 1997 which formulated the development strategy of renewable energy sources in the EU member states. The strategy was deemed to be a basis for action at the European Union level. At the moment, the share of energy from renewable sources in the EU s demand for primary energy is 6%. In 1995, the share of renewable energy in selected countries of the European Union was as follows: Austria — 24.3%, Denmark — 7.3%, France — 7.1%, Germany — 1.8%, Holland —1.4%, Sweden — 25.4%. Large differences in the utilisation of renewable energy in the European countries are mainly due to the possibility of utilising hydro power in mountainous countries.

It is extremely difficult to evaluate the volume of renewable energy utilised in Poland as information may only become available through special fact-finding research techniques. The share of renewable energy in the fuel and energy balance has been estimated by various national institutions, such as the Main Statistical Office, Ministry of the Economy, EC Baltic Renewable Energy Centre (Annex 5). The figures given by the institutions vary, a fact which is a source of difficulties in the correct estimation of the actual utilisation of renewable energy in Poland. For example, in the statistical yearbook Fuel and Energy Economy in 1997-98 (published in Polish by the Main Statistical Office in 1999), the share of the remaining sources (firewood, peat, waste fuels, water energy and other renewable energy carriers) in the consumption of primary energy was around 4.06% in 1997. According to the Polish Energy Policy until 2020, renewable fuels had a 5.1% share in the consumption of primary energy in 1997. Further, in the expert appraisal Economic and Legal Aspects of Utilisation of Renewable Sources in Poland prepared by the EC Baltic Renewable Energy Centre (EC BREC 2000) it was estimated that the share of energy from renewable sources was 2.5% (being 104 PJ). The former two figures above 4% seem overestimated in view of the fact that combustion of non-renewable sources such as peat was included. One may therefore conclude that the current share of renewable energy in the consumption of primary energy is 2.5% while the total consumption of primary energy in Poland in 1998 being around 4,000 PJ.

At the moment, the basic sources of renewable energy in Poland are biomass and hydro. Geothermal energy, wind power and solar energy are of lower significance (estimated figures concerning the utilisation of renewable energy in Poland in 1999 have been give in tabulation 1). In the 1990 s we experienced a gradual increase of the share of RES. Among the contributing factors were:

- a significant increase in the utilisation of wood and waste wood mainly by rural population, the commissioning of local straw- and waste wood-fired district heating plants and the utilisation of waste wood from wood processing,
- the commissioning of two geothermal heating plants,
- the commissioning of a couple of wind power plants and of numerous small hydro power plants
- the commissioning of heating and power plants utilising biogas from municipal landfills and waste water treatment plants.

Tabulation 1. Utilisation of renewable energy in Poland in 1999. Source: EC Baltic Renewable Energy Centre

	Energy production from renewable sources in 1999	
	PJ	%
Biomass	101.8	98.05
Water energy	1.9	1.83
Geothermal energy	0.1	0.1
Wind energy	0.01	0.01
Solar energy	0.01	0.01
Total	103.82	100

Biomass is the most promising renewable source of energy. The share of biomass in the balance of renewable energy in Poland is growing. Biomass may be utilised in direct combustion processes in a solid (wood, straw) and gaseous form (biogas) as well as processed into liquid fuels (oil, alcohol)

In Polish conditions, one may expect considerable growth of interest in the utilisation of solid biofuels — wood and straw — in the coming years. Polish farms produce around 25 million tons of straw (mainly cereal and rape) and hay every year. Some straw is used as a bedding material and fodder in animal breeding and as a fertiliser. Since 1990, the amount of surplus straw is growing, particularly at farms in northern and western Poland, mainly at former state-owned ones. A sizeable portion of surplus straw is burnt on fields, a fact which poses a serious environmental and health hazard.

In Poland, forest areas occupy 28.8% of the country, the figure including state-owned forests with 7.4 million hectares. It is estimated that the forest areas will be developed to 33% in the year 2025. In 1997, 21.6 million m^3 of wood was obtained from the state-owned forests, including 2.5 million m^3 of firewood. The Main State Forest Management Board estimate that a further 2-2.5 million m^3 of waste wood remains in the forests due to limited demand. A considerable volume of waste wood is also a by-product from the wood processing industry.

Wood for heating purposes has been traditionally used in Poland for many years. The current number of wood-fired installations is estimated at over 100,000 units. The figure includes: small, state-of-the art wood gasification boilers with controlled combustion process (a few thousand units), the so-called 'multi-fuel' and coal boilers in which wood may be combusted as an alternative fuel (these being typical of homes and farms) and, last but not least, around 70 larger scale industrial boiler houses. The capacity of the latter varies from 0.1 to 40 MW; they are used in wood processing and furniture making. The biggest boilers and power units are found in the pulp and paper industry where the consumption of waste wood from production is the largest. In the municipalities, there are only a few heating plants utilising waste

from the forest (their capacity ranging from 0.5 to 2.5 MW). At the beginning of 1998 the total capacity of state-of-the-art wood-fired boilers in homes, wood processing industry and in the municipalities was estimated at around 600 MW.

The Polish market offers quite a large number of wood-fired boilers as there are some 20 manufacturers and importers of such boilers at the market. They offer automatic wood-fired boiler installations whose estimated investment cost is in the range of PLN 500-1,000/kW depending on the advancement of the technology. The number of small boilers sold for home use is increasing. There are around 10 manufacturers of low-temperature wood-fired boilers (their capacity ranging from 20 to 80 kW). The purchase cost of the installed power unit (without refurbishment of the boiler house) starts at PLN 130-150/kW.

Surplus straw may be utilised for energy production thus yielding additional profits or generating savings to farms. At the moment, straw is utilised in around 10 district heating plants supplying heat to local housing estates. The total installed capacity of these in 1999 was around 13 MW. The nominal installed capacity of the straw-fired boiler houses in operation ranges from 0.5 to 5.5 MW. It is estimated that until the end of 1998 circa 75 small and medium-size (30-500 kW) straw-fired boilers had been installed. There are around 10 manufacturers and suppliers of straw-fired boilers currently active on the Polish market. Prices of complete straw-fired systems are 1.5—2 times higher than those of wood-fired systems of equivalent capacity.

The utilisation of solid biofuels is the fastest growing branch of the renewable energy sector in Poland. The development usually advances in market conditions, without any significant support from the state, and is usually based on technologies available within Poland. Another conspicuous feature of the current utilisation of solid biomass is the use of non-standard and non-commercial waste fuels whose market prices are the lowest. This approach is fully justified in the short run as the majority of biomass available for energy purposes is not utilised. However, as resources of waste biomass are exhausted (as is the case in Denmark, for example), growing special energy crops must be considered. Experiments are being carried out in Poland with fast-growing trees, e.g. willow (*Salix vinimalis*). At present, there are a few plantations in Poland with a total area not exceeding 100 hectares. The majority of them are test plantations and none of them operates on the basis of commercial production of biomass for energy purposes. The plantations may be established at infertile and/or contaminated soil, thus offering chances for implementation of alternative farm production.

From a longer perspective, apart from direct combustion of biomass in energy boilers, thermal conversion by means of gasification or pyrolysis (thermal gasification of fuels in oxygen-deficient conditions) will become more and more important. During gasification and pyrolysis, gases are released and then combusted in internal combustion engines or gas turbines for combined generation of heat and power. Modern gasification technologies permit conversion efficiency of 25-40%, the exact figure depending on the size of the installation. Throughout the world, wood gasification technologies with power generation have not become fully commercialised yet, they are however regarded as a very promising alternative for wood utilisation.

There exist around 700 registered open landfills in Poland. At the majority of these landfills there is no control of gas emissions. Landfill gas escapes into the environment and poses many hazards to the health and lives of people, whilst it also

aggravates the greenhouse effect. The main technical potential of landfill gas in Poland exists at around 100 major municipal sites. Because of the frequent lack of adequate sealing of the landfill, the recoverable resource of the gas does not exceed 30-45% of its total technical potential generated at a landfill. The best way to mitigate environmental hazards posed by landfill gas emissions is to build an installation for gas recovery and its possible utilisation. In the present days, permitting landfill gas to escape into the atmosphere, without flaring or another method of disposal, is unacceptable in the light of international agreements and EU regulations. Typical examples of gas utilisation include generation of electricity mainly in reciprocating spark ignition engines, heat production in gas boilers adapted for the fuel and combined heat and power generation in CHP units. Other technically viable possibilities (not used in Poland) include the supply of landfill gas into a gas network, utilisation of gas as an engine fuel as well as utilisation of gas in technological processes, e.g. in methanol production.

At the moment, landfill gas utilisation technologies (mainly for the generation of electric energy or combined heat and power generation) are another fast growing branch of the renewable energy sector. As late as in 1996 only a few installations had been working in Poland but within the last two years the number of such installations grew quickly to 16. In the past, landfill gas projects implemented in Poland generated electricity only, and the capacity installed at a single landfill site generally did not exceed 200 kW. The current trends are to build larger installations (above 1 MW) or to increase the power output of existing ones. Thermal energy generated from landfill gas is usually on-site by a landfill operator or sometimes sold to municipal district heating networks or other consumers (e.g. large complexes of greenhouses). In May 1999, the total installed capacity of landfill gas installations was 5.44 MW electrical and around 3.5 MW thermal.

The technical potential of utilisation of biogas from waste water treatment plants is very high. Biological treatment installations incorporated in all municipal waste water treatment plants and in some industrial ones are best prepared for direct biogas generation. Waste water treatment plants require relatively large amounts of heat and electric energy, therefore utilisation of biogas from sewage sludge fermentation may significantly increase their profitability. Since 1994, 20 biogas plants have been installed in municipal waste water treatment plants with power units in Poland. New biogas plants are under way. At the moment, there are over 30 systems in operation. In November 1999, the total power of all biogas installations in waste water treatment plants in Poland was 14.5 MW electrical and ca. 24.4 MW thermal. Biogas installations at waste water treatment plants should generally work for over 8,000 hours per year. In practice, however, this result is only achieved by modern boilers with burners adapted for biogas combustion. According to the users, the purchase and installation of Polish biogas power generators or combined heat and power units would allow the reduction of investment costs. However, since Polish equipment has shown relatively high rate of failures, some of the users are considering the purchase of more expensive but more efficient equipment made by recognised foreign manufacturers. It is difficult to assess the investment cost in biogas recovery from sewage sludge as the cost is very much dependent on the specific nature of the site, and on the kind and volume of raw material.

Biogas produced from diluted animal manure is another source of energy. Animal farms produce a large amount of animal manure. Traditionally, this is used as a fertiliser and sometimes stored at landfills. Both ways may cause environmental

problems relating to pollution of rivers and underground water, odour emission and other health hazards. One of ecologically acceptable forms of utilisation of animal waste is anaerobic digestion. Around 10 farm biogas plants have been erected in Poland since the middle of the 1980 s. At the moment, the majority of them are not working for both economic and technical reasons. Prospective investors has been discouraged by high investment costs and the lack of adequately proven technological solutions.

The technical potential of liquid fuels obtained from biomass conversion, such as petrol with ethyl alcohol admixture and a fuel obtained from vegetable and animal fat, is estimated at 12-17 PJ/year. According to current Polish norms, only 5% of ethanol may be added to the traditional fuel. Ethanol may be produced from raw materials such as cereals, potatoes, sugar beets and molasses. As from 1996, almost the whole Polish production of bioethanol (dehydrated ethyl alcohol of vegetable origin) amounting to around 110 million litres has been used as a fuel admixture.

Among the various methods of energy generation, **hydro power** has the longest tradition in Poland. Polish hydro power resource is small due to the limited and unfavourably distributed precipitation, high soil permeability and relative flatness of the country. The total installed capacity of large hydro-electric power stations (without pumped-storage plants which are not included in the RES definition) is around 630 MW, and of the small ones 160 MW. It must be mentioned that the power output of existing hydro-electric power stations may be increased by 20-30% through the modernisation of their generators. In view of the small-scale utilisation of the existing technical potential, hydro power engineering in Poland has a chance of further development. Practically speaking, the only kind of water power engineering facilities whose number keeps increasing, mainly thanks to private investors, is small hydro-electric power stations usually built on existing (frequently ruined) water stages. In Poland small hydro include facilities with installed capacity below 5000 kW. However, due to limited water resources in Poland, the installed power of a considerable part of small hydro plants is below 100 kW. Such power stations offer a chance of improving a very poor runoff coefficient, particularly on small rivers. What is also important is the local retention of water. Small hydro take advantage of the local possibilities of electricity generation thus providing a source of income to a group of people, usually in areas with a high unemployment rate.

Thanks to the relatively dynamic development of small hydro-electric power stations (23 stations placed in service in 1996; 19 in 1997, 29 in 1998), a number of plant manufacturers, in particular of turbines and their components, operate at the market. There are also a number of companies specialising in the manufacture of control systems and hydraulic engineering constructions as well as a few consulting firms able to assist the investor in project management, from the obtaining of the necessary permits, loans etc, to the commissioning of a turn-key installation.

Geothermal waters have been used in Poland for a long time for therapeutic purposes. In recent years, the possibilities of using geothermal waters for heating purposes have been investigated. Whilst the technical potential of this resource has been examined in detail, there is a need for further investigation into the possibilities of re-injection of used geothermal waters back to the orogen. The resources of geothermal waters occur mainly in the Polish lowlands, particularly from Szczecin to _ d_, in the Grudzi_dz-Warsaw area and in the Carpathian Foreland. At the moment, two geothermal installations are working in Poland. These are located in Ba_ska at the Tatra Foothills (4,5 MW, 70 MW planed), and in Pyrzyce near Szczecin (15 MW,

50 MW planned). Another installation (7.3 MW) in Mszczon w near Warsaw is about to be commissioned.

Wind power only began to develop in Poland at the beginning of the 1990 s, and that was mainly on the Baltic seaside. The most privileged areas in terms of availability of wind power resource are the Baltic coast, Suwa_ki area and Mazovian lowland plain. Until the end of 1999, 14 wind farms with the total power over 3.5 MW had been connected to the grid and placed in service. Added to this, there are around 50 small independent wind turbines in operation in Poland now. Investors take keen interest in wind power installations, especially in north-western Poland, where over 10 projects of the total power exceeding 600 kW each are currently prepared.

Solar energy is the least popular form of energy. Poland has a very uneven distribution of solar radiation throughout the year, with around 80% of the total annual insolation falling within six months in spring and summer. The distribution of density of a solar radiation flux and its structure show that opportunities of its utilisation are somewhat limited, especially in winter. However, liquid and air solar collectors are used in a few areas in Poland. Air collectors are most frequently used at farms for crop drying. The total number of air collectors is estimated at 50-60 units, and their surface area at 6,000 m^2. They are operated for 300-600 hours per year on average. Liquid collectors are mainly used for heating water in homes, camping and summer cottages, sports and recreation facilities, livestock buildings and fodder stores. Also, liquid solar collectors heat up water in tanks and swimming pools as well as process water in small industrial plants. To date, around 1,000 solar installations for the heating of usable water have been installed in Poland with the total surface area of the collectors exceeding 10,000 m^2.

Photovoltaic cells in which solar energy is directly converted to electricity are virtually not used in Poland.

3. FORECASTS

3.1 Technical potential

Estimates of the technical potential of renewable energy sources in Poland vary considerably. According to the expert appraisal Economic and Legal Aspects of the Utilisation of Renewable Sources in Poland prepared by the EC Baltic Renewable Energy Centre (EC BREC 2000), the actual technical potential of renewable energy sources in Poland is around 2,514 PJ/year, this being almost 60% of the domestic primary energy requirement. It is ascertained in the Polish Energy Policy until 2020 that due to the lack of larger technical potential of renewable energy sources, RES will have a small direct influence on the energy security of the state. They may however play an important role in the local energy balance of primary fuels. In a national study concerning climate change and titled Reduction Strategies of Greenhouse Gas Emissions and Adaptation of Polish Economy to Climate Changes (1996) the technical potential of the renewable energy sector was estimated at 337 PJ. On the other hand, it was estimated in the report prepared for the World Bank (Hauff, 1996) that renewable sources might cover up to 30% of Poland s primary energy demand. The technical potential of renewable energy sources in Poland has been presented in table 2.

Table 2. Annual technical potential of renewable energy in Poland

Source of energy	EC BREC s expert appraisal Economic and Legal Aspects of Utilisation. . . (EC BREC, 2000) [PJ]	Reduction Strategies of Greenhouse Gas Emissions [PJ]	Report prepared for the World Bank (Hauff,1996) [PJ]
Biomass	895	128	810
Water	43	50	30
Geothermal resources	200	100	ca. 200
Wind	36	4	4 — 5
Solar radiation	1340	55	370
Total	2514	337	ca. 1414
Total primary energy consumption in Poland in 1998	4069.6		

It has been assumed, as stated in the expert appraisal Economic and Legal Aspects of Utilisation of Renewable Sources in Poland by the EC Baltic Renewable Energy Centre (EC BREC 2000), that the technical potential of renewable energy sources in Poland is around 2,500 PJ/year. In order to utilise the existing potential of these sources, adequate development conditions should be created. More spendings should be allocated to the research and development of technologies, and a system of financial support for renewable energy projects should be created. Actions should follow the model set by the European Union which has been supporting the development of renewable energy sector for a long period and issued Development Strategy of Renewable Energy Sources in the European Union Countries and the relating Action Plan in 1997.

According to forecasts prepared within the European Union, biomass will have the greatest contribution to the development of renewable energy, and next will come wind energy. It is also expected that while the growth of the use of thermal collectors will accelerate considerably, that of photovoltaic and geothermal technologies will not be so fast. On the other hand, hydro power will probably remain the second largest renewable energy source though with limited possibilities of further growth. The technical potential of renewable energy sources in two countries belonging to the European Union (Denmark and Sweden) has been compared with Poland in the table 3.

Table 3. Technical potential of renewable energy sources in Poland and in two EU member states (Denmark and Sweden)

Source of energy	POLAND EC BREC Economic and Legal Aspects of Utilisation . . . (EC BREC, 2000) [PJ/year]	DENMARK Dansk Energi Management (1999) [PJ/year]	SWEDEN Dansk Energi Management (1999) [PJ/year]
Biomass	895	216	638
Hydro	43	0.3	266
Geothermal resources	200	100	0
Wind	36	97	209
Solar radiation	1340	84	194
Total	2514	498.3	1307

By comparing the figures in the table above one may conclude that the technical potential of renewable energy sources in Poland is relatively high (much greater than in Denmark). The greatest technical potential is in solar radiation. Unfortunately, it is unrealistic to expect a considerable growth in the utilisation of solar energy in Poland in the nearest future. It must therefore be noted first of all that Poland has a large technical biomass potential compared to that of the presented EU countries.

3.2 Forecasts

The World Energy Council Committee estimates that by the year 2020 the share of renewable energy will grow, depending on a development scenario, to 21.3% (pessimistic) or even to 29.6% (optimistic). Energy experts invited to the World Renewable Energy Congress in Denver in 1996 forecast that in the year 2070 the share of renewable energy will reach 60-80%. In a shorter term, the European Union assumes that the share of renewable energy in the fuel and energy balance until 2010 will rise to 12%. For the EU requirements, scenarios for renewable energy sources have been prepared as part of the execution of the development policy of the utilisation of such sources up to the year 2010 and until 2020 (TERES II Programme). The forecasts included also European countries that are not members of the European Union. In 1994 it was stated that in Poland in the most optimistic scenario the share of renewable energy in primary energy consumption would reach 5.5% (248.8 PJ) in the year 2010. The forecasts showing the share of energy from renewable sources in the total consumption of primary energy in the EU countries and in Poland in 2010 have been presented in Annex 2.

The forecasts prepared by Polish experts (Poland s Energy Policy until 2020) that in 2010 the share of renewable energy in primary energy consumption will be between 5.06 and 5.74% (233.3 — 263.8 PJ), depending on a macro-economic scenario. The above percentage is around half of that recommended by the European Union. The document stated, however, that it is unlikely for Poland to achieve quantitative targets

of the European Union, especially in the short time before 2010. Such situation is first of all due to many years delay in the use of system support mechanisms in the development of renewable energy sources in Poland. On the other hand, in a long-term perspective, bearing in mind similar technical potential, Poland should endeavour to achieve a share of renewable energy in the national energy and fuel balance comparable with that intended at a European Union level.

The forecast on primary energy demand in relation to the macro-economic scenarios has been presented in Annex 3.

4. OBJECTIVES

The strategic objective is the increase of the share of energy from renewable sources in Poland's primary energy balance to 7.5% in 2010 and to 14% in 2020.

Analysis of information on the technical potential of renewable energy sources as well as of forecasts concerning the possibilities of utilisation thereof show that the European Union's target of 12% share of renewable energy sources by 2010 is not feasibly achievable in Poland. The strategy and action plan in the field of renewable energy sources as presented in the EU's White Paper have forced all member states to take steps in support of those sources. Such steps include investments in research, tax exemption, guaranteed energy prices for RES, investment subsidies and the like. The European Commission has been supporting research and development of renewable energy sources for over 10 years now under consecutive Framework Programmes on Research, Technological Development, Demonstration and Promotion. In contrast with the European Union, the development of renewable energy sources in Poland has been receiving much smaller support and encountering many barriers. This strategy aims to create a chance of faster development of renewable energy sector in Poland.

The objective set in this document is a political one which calls for further action in the development of the utilisation of renewable energy sources in Poland, a crucial matter in sustainable development. Since the Polish system solutions supporting the development of renewable energy sources are many years behind the EU, in the first phase of implementation by 2010 the main focus will be to adopt solutions proved in the European Union. In the period in question, the solutions proposed in this document should be checked and verified whilst concrete development programmes for individual kinds of renewable energy are formulated. On the basis of information presented in this document on both the utilisation and technical potential of renewable energy sources in Poland one may state that, first of all, the utilisation of biomass will grow in the first phase. However, in order to increase utilisation of biomass as well as other renewable sources of energy, the state will have to allocate certain budget. The expenditures required to achieve objectives of this strategy will be put forward in specific programmes for each source of renewable energy. From a longer perspective, until the year 2020, in view of Poland's technical potential of renewable energy sources comparable with that of the European Union countries, there is no reason why the share of renewable energy in the fuel and energy balance should be set at a different level than to in the EU.

5. SCENARIOS FOR IMPLEMENTATION OF RES TECHNOLOGIES INCLUDING ASSESSMENT OF COSTS

In the Polish Energy Policy by 2020 approved by the Government in February 2000 it has been assumed that the total energy demand in 2010 in the reference scenario will be 4570 PJ. With such assumption, in order to reach 7.5% share of renewable energy in the primary energy balance of the country will mean generation of 340 PJ of energy from renewable sources in 2010, which compared to the year 1999 will require increase of the operational capacity in the RES sector by additional 235 PJ. Achieving mentioned capacities will require implementation of many new investments in different RES sub-sub-sectors and a respective increase of invested capital.

A starting point for the determination of necessary capital investment and related support from the public sources is definition of the share of major technology groups utilising renewables in the total investments planned to deliver 340 PJ of renewable energy by 2010. These technology groups require different capital investment per unit of installed capacity and actually produced energy, different level and type of support mechanisms. The share of each technology group in the energy balance by 2010 will not, however, depend only on the cost parameters, but will be an equilibrium of the general situation on the market for fuel supply, strength and advancement in technologies, organisation and financing of each RES sub-sector and effectiveness of investors in obtaining financial support.

Based on the results of the Expert Appraisal on Economic and Legal Aspects of the Utilisation of Renewable Energy Sources in Poland (EC BREC, 2000) and other expert assessments, three development scenarios have been prepared, which assume certain increase of installed capacity in each group of technologies using renewable sources of energy. Principles of the three scenarios and a synthesis of the results of the simulations and analyses have been presented in the Annex 4.

Scenario 7.5% - assumes that the total share of electricity generation from RES will reach 7.5% of the total electricity generation in 2010 in Poland. The assumed share of electricity complies with the major points of the new regulation of the Minister of Economy on obligation of the power purchase from non-conventional sources of energy, including renewable energy sources.

Scenario 9% - assumes that the share of electricity generated from RES will reach 9% in the total electricity generation in 2010 in Poland; a scenario between the draft of the EU directive on Electricity from RES and the major points of the new regulation of the Polish Minister of Economy on obligation of the power purchase from non-conventional sources of energy, including renewable energy sources.

Scenario 12.5% - assumes that the share of electricity generated from RES will reach 12.5% in the total electricity generation in 2010 in Poland; a scenario following directions from the draft EU directive on Electricity from RES from 30 June 2000; the draft of the directive assumes 12.5% share of electricity generated from renewable energy sources in the total electricity balance of the EU in 2010.

All three scenarios assume the same increase of the utilisation of geothermal energy and liquid biofuels.

The criteria used for technology selection was minimisation of required investment subsidies and tax relief with simultaneous provision of favourable conditions for the consistent and rational development of each technology. The proposed increase of installed capacities and energy generated within major technology groups have been also compared with the targets included in the official documents of the European Union (EU White Paper). Based on the required capital investment per unit of installed capacity, the total value of new investments in the renewable energy sector in the years 2000-2010 has been assessed. Based on the known (year 1999) levels of average subsidies required to make investments in renewable economically attractive for investors, and taking into account expected decrease of investment costs and the increase of competitiveness of RES technologies by 2010, the total and yearly (within the period of 10 years) required public support has been determined. The public support analyses included grants, preferential loans, and some tax reliefs and exemptions.

In the case of liquid biofuels (rape oil methyloesthers and bioethanol), the impact on the state budget income due to decreased excise duty on petrol mixed with biofuels was also assessed. The starting point for the assessment was the current reduction of excise duty of petrol with 5% admixture of ethanol, which was 120 PLN/tonne of final petrol. It has been assumed that the reduced excise duty will be phased out by 30 PLN/tonne per year until 2004. At the same time, it has been assumed that the increase of the production of liquid biofuels will be linear until the stable maximum production level is reached in 2010. It has been also assumed that the increase of the utilisation on bioethanol will be such that the existing production capacities in the domestic ..... would be used without any investments.

In order to increase the production capacity of the RES technologies to the level of 340 PJ in 2010, the total installed capacity (thermal and electrical) will need to reach 19.6 GW (scenario 7.5%), 18.3 GW (scenario 9%) and 15.7 GW (scenario 12.5%) with the required additional production capacity of 235 PJ (the same in the three scenarios in order to reach 7.5% of RES in the primary energy balance). Differences between the scenarios in the required installed capacities at the same total energy production come from different outputs of RES technologies from a unit of installed capacity. In the proposed configuration of technologies required capital investment by 2010 for each scenario will result in (in prices in 1999):

Scenario **7.5%**	**14 508 million PLN**
Scenario **9%**	**15 263 million PLN**
Scenario **12.5%**	**19 103 million PLN**

It is estimated that the total average yearly (in the period of 10 years) share of public support in the required capital investments will be respectively:

Scenario **7.5%**	**288 million PLN/year**	in which public support covers 15.7% of the total necessary capital investment required over the period of 10 years
Scenario **9%**	**245 million PLN/year**	in which public support covers 16.1% of the total necessary capital

		investment required over the period of 10 years
Scenario **12.5%**	**312 million PLN/year**	in which public support covers 16.4% of the total necessary capital investment required over the period of 10 years

The estimated public support for the renewable energy investments includes investment subsidies at the level of 198 million PLN/year (including subsidies for the construction of agro-refineries producing biodiesel) in the scanerio 7.5%, or 215 million PLN/year in the scanario 9%, or 282 million PLN/year in scenario 12.5%.

Average reduction of the income to the state budget due to decreased excise duty on petrol with admixtures of liquid biofuels mean additional 30 million PLN/year for each scenario.

The average share of public funding in the total capital investments over the period of 10 years presented above will be decreasing as the market for RES technologies grows.

The results of the simulations and analyses showed that the increase of the share of electricity in the energy supply from RES in 2010 would increase the total required amount of funding from public sources and would require much larger utilisation of wind energy and biomass (in cogeneration). Planned development of the renewable energy sector in Poland in the years 2000-2010 would allow significant decrease of costs. An example is the United Kingdom, where within 9 years (18990-1999) state system support allowed average decrease of costs of energy generated from RES at the level of 45%, which in some areas made renewables fully competitive to energy generation from fossil fuels. As such, further development of renewable energy sector in Poland according to the objectives and targets set in this Strategy would require only a selective support to the new technologies coming to the market.

6. BARRIERS TO THE DEVELOPMENT OF RENEWABLE ENERGY SECTOR

Currently, systems utilising renewable energy sources are often not economically viable in Poland. Financial mechanisms addressed directly to the independent producers of energy from renewable sources are insufficient, neither. Existing law offers possibility of tax relief in case of investments in agricultural production related to the purchase and installation of equipment for the utilisation of renewable energy sources, such as wind, biogas, solar and hydro — Act on Agricultural Tax from 15 November 1984 (Official Journal from 1993, No. 94, point 431 with later amendments), but the addressees of this regulation are only the payers of the agricultural tax.

A traditional old-established custom of using coal as a main fuel, the former subsidising of the energy sector and low prices of conventional energy carriers significantly hindered the introduction of energy from renewable sources (with the exception of hydro power). Relatively high investment costs are a barrier difficult to

overcome. In consideration of an economic aspect (on which a noticeable share of energy from renewable sources in the energy balance is dependent), one must recognise that a higher price of energy produced from renewable sources (compared with conventional ones), if it is used locally, may at least partially be offset against the costs of redundant transmission. However, in a number of cases the costs of reserving energy supply from a grid and/or gas network must be kept in mind. From the point of view of production costs, renewable energy technologies may be divided into three groups:

- Technologies with energy production costs lower than/comparable with costs or prices of conventional energy carriers to be replaced. The groups includes: air solar collectors (heat production cost PLN 20.2/GJ), small manually operated wood- and straw-fired boilers (heat production cost PLN 20.2-25/GJ), automatic straw-fired heating plants (heat production cost PLN 29.1/GJ), small hydro-electric power stations erected on existing dams (electricity production cost PLN 0.23/kWh), and landfill gas installations for generation of electricity (electricity production cost PLN 0.22/kWh).
- Technologies which produce energy at costs higher than the national average price but may be competitive under the following conditions: available preferential loans and grants are taken advantage of, or projects are located in areas with the highest prices of conventional energy (caused by higher cost of transport, transfer and distribution of conventional energy carriers in rural and remote areas as well as by the higher costs of supplying energy to scattered consumers). The group comprises, inter alia, large wind power plants connected to the grid (electricity production cost PLN 0.51/kWh), automatic biomass heating plants (heat production cost PLN 33.2/GJ), and even the least economically viable photovoltaic technologies in special niche areas (e.g. power supply to marine navigational marking).
- The remaining technologies, which are unable to compete with the highest prices of energy generated in Poland in fossil fuel installations even if 50% of the total investment cost is covered by grants. The group includes: water solar collectors (heat production cost PLN 147.3/GJ), photovoltaic systems (electricity production cost PLN 8.89/kWh), small wind turbines connected to the grid (electricity production cost PLN 1.02/kWh), farm biogas plants for heat production (heat production cost PLN 51.1/GJ), geothermal heating plants (heat production cost PLN 61.8/GJ),

The following were the prices of heat and electricity in 1999 in Poland:

- electricity sold to households — PLN 0.261/kWh
- electricity sold to farms — PLN 0.266/kWh
- electricity sold to industry — PLN 0.123/kWh
- average grid selling price for electricity — PLN 0.215/kWh
- heat from the combined heat and power plants — PLN 26/GJ
- average selling price for centralised heat — PLN 24.90/GJ

There are a number of barriers hindering the development of the renewable energy sources. The barriers are a set of psychological, social, institutional, legal and economic factors.

The main barriers include:

Legal and financial barriers

- the lack of regulations clearly defining a programme and policy concerning the utilisation of renewable energy sources;
- insufficient economic mechanisms in the state budget, including particularly tax mechanisms permitting adequate benefits from relatively high capital-intensive investments in facilities, installations and plants for the generation of energy from renewable sources;
- the relatively high investment cost of renewable energy technology as well as high costs of works (e.g. hydro-geological surveys) necessary to obtain energy from renewable sources.

Lack of information

- the lack of easy access to information on the distribution of the usable energy potential of individual renewable energy sources;
- insufficient information on consulting, design and manufacturing companies involved in issues relating to renewable energy;
- the lack of easy access to information on procedures concerning the preparation and execution of investments in renewable energy sources and standard costs of an investment cycle on the one hand, the lack of information on economic, social and environmental benefits relating to the utilisation of renewable energy sources on the other;

Difficult access to new equipment and technologies

- insufficient number of domestic economic entities involved in the manufacturing of renewable energy equipment on a larger scale;
- the lack of tax preferences for import/export of equipment and components for the systems utilising renewable energy sources.

Educational barrier

- an inadequate primary and post-primary school syllabus which does not recognise renewable energy sources;
- the lack of education and training programmes concerning renewable energy sources and targeted at engineers, design engineers, architects, representatives of the energy sector, banks and decision makers.

Barrier arising from landscape protection

- the lack of proven methods of avoiding conflicts with nature and landscape protection objectives.

7. ACTIONS TO SUPPORT THE DEVELOPMENT OF THE RENEWABLE ENERGY SECTOR

In order to attain the goal set in this document, the actions and mechanisms listed below are required.

Some tasks have been already specified in the document on 'the Energy Policy of Poland by 2020 approved by the Council of Ministers on 22 February 2000. This policy document places specific obligations on the Government relating to renewable energy sources. The obligations include:

- The Minister of the Economy to draft an act defining the state policy concerning rational utilisation of energy, combined and renewable sources. The draft should be ready by the end of 2000 and recognise specific conditions of individual renewable energy sources.
- The Minister of the Economy to assess before the end of May 2000 the functioning of the Energy Law from the point of view of the utilisation of renewable energy, including the effectiveness of the obligation to purchase energy from those sources.
- The Minister of the Economy and the President of the Energy Regulation Office to take action aiming at the increase of the share of renewable energy sources in Poland's energy balance by consistent compliance with art. 9 and 45 section 3 of the Energy Law.
- The Minister of the Economy and the President of the Central Housing and Urban Development Office in agreement with the Minister or Internal Affairs and Administration to prepare a government programme concerning renewable energy sources for construction industry.

Organisational actions for the implementation of the Strategy

- Within the Government, the responsibility for the creation of a policy concerning renewable energy sources and for implementation of such a policy to be delegated. Implementation of the state policy concerning renewable energy sources to be to carried out by Europejskie Centrum Energii Odnawialnej (EC BREC) at the Institute for Building, Mechanisation and Electrification of Agriculture; necessary funds for the performance of new tasks by EC BREC to be secured.
- Execution of the strategy to be evaluated every three years and recommendations concerning necessary changes and new solutions proposed.
- Development programmes for specific renewable energy sub-sectors including their economic analysis to be prepared.
- A definition of biomass and liquid biofuels to be incorporated in the Energy Law.
- National standards concerning particular biofuels and equipment producing energy from renewable sources to be introduced.
- 'SWW' product classification numbers to be given to particular biofuels.
- Detailed inventory of renewable energy installations in Poland to be carried out and the results published in statistics yearly.

- A database of available renewable technologies to be created.

Formal and legal action to facilitate access to renewable energy sources and their better competitiveness

- An obligation to assess local resources of renewable energy and their economic viability at a commune level to be emphasised in the Energy Law. The possibilities offered by the Energy Law and executory regulations should encourage municipalities to prepare energy plans recognising their own technical potential regarding renewable energy sources.
- The flow of information to be created and assistance provided to the local authorities in the preparation of energy plans recognising rational use of renewable energy sources at the lowest environmental costs.
- Binding terms upon power companies to be defined for long-term power purchase contracts for renewables.
- An obligatory admixture of bioethanol to all petrol to be introduced and specific conditions for implementation of this regulation to be determined
- Licensing procedures for liquid biofuel production and electricity generation from renewable energy sources to be simplified.
- A problem relating to diversification of the prices of electricity from different energy utilities linked to the obligation for purchase of energy from renewable sources and relating to the uneven distribution of the technical potential of the sources in Poland to be resolved.
- A system of support to the renewable energy sector to be created and instruments such as certificates, competitions or calls for tenders used in it.
- Legal solutions ensuring reconciliation of landscape protection requirements with the development of the renewable energy sector to be created.

Economic instruments enhancing economic viability of renewable energy sources

- In the initial phase of the implementation of the Strategy investments in renewable energy sources should be supported mainly through earmarked funds, EU pre-accession funds and structural funds, foreign support programmes, which should comply with the current regulations on the public support to private entrepreneurs and regional development. Current tax relief to investments in agricultural production related to the purchase and installation of equipment for the utilisation of renewable energy sources, such as wind, biogas, solar and hydro — Act on Agricultural Tax from 15 November 1984, article No.13 (Official Journal from 1993, No. 94, point 431 with later amendments). Within state budget limitations when possible it should considered to provide support to renewable energy investments, mainly through direct grants to be systematically phased out and grants to reduce interest rates of commercial bank loans, guarantees and bank warranties. These instruments should be in place untill renewable energy sector is fully competitive on the market.

Actions to promote new renewable energy techniques and technologies

- Research and demonstration programmes aimed at the implementation of new techniques and technologies to be supported; in particular, participation of Polish industry in the Fifth Framework Research and Technology Development Programme of the European Commission should be supported.

Education and promotion of renewable energy sources

- More information on renewable energy sources in comparison with other sources of energy to be introduced into the syllabus at all levels of the educational system.
- Campaigns demonstrating the benefits of using renewable energy sources and the possibilities of financial and technical assistance available.
- An information programme to be prepared, including an implementation plan and specific actions targeted at farmers, in order to demonstrate the possibilities and benefits of using energy from renewable sources
- An information programme on renewable energy sources, including an implementation plan, targeted at environmental authorities and nature protection at all governmental levels.

International co-operation

- Collaboration with the European Union to lead to the exchange of experience in the utilisation of renewable energy sources; Poland to participate in the EU's assistance programmes, including Fifth Framework RTD Programme of the European Union.
- Specification of terms for actions undertaken as Joint Implementation projects in renewable energy sources as part of the programme of reduction of greenhouse gas emissions covered by the Kyoto Protocol.

Delegation of responsibilities for the implementation of specific tasks outlined in the Strategy has been presented in the Annex 7.

8. FINANCING RENEWABLE ENERGY PROJECTS

The development of renewable energy projects is facing financial problems. These problems relate to the high investment costs although operational costs are relatively low. Given the current level of prices of fossil fuels, the above cost structure is the reason why the payback time of renewable energy projects is long. Another problem is that renewable energy equipment is typically manufactured by small and medium enterprises with low capital, who are often unable to survive in the current bank loan system if their financial resources are frozen. The lack of necessary know-how and experience in the formulation and financing of projects are yet further problems.

At the moment, there are a number of financial institutions supporting renewable energy sources. These institutions include: the National Fund for Environmental Protection and Water Management, EcoFund, Thermal Renovation Fund, and provincial funds for environment protection and water management. There are also financial organisations which may support renewable energy projects if these contribute to the development of rural areas — such organisations include the Foundation for Assistance Funds for Agriculture, State Treasury Agency for Agricultural Property, Agricultural Foundation. These institutions give preferential loans and grants which usually do not exceed 50% of the costs of the project. Notwithstanding the funds for the development of the renewable energy sector which are available in Poland, the possibilities of utilising foreign financial sources are growing. Apart from the World Bank and recognised European banks financing large renewable energy projects, the European Commission programmes earmarked for specific purposes will become more and more important. The programmes in question include: Altener II, Synergy, Life, 5th Framework Programme on Research, Technological Development, Demonstration and Promotion. In many cases, the above funds and programmes make it possible to obtain grants for the preparation of investments and the construction of demonstration projects. In relation to the ongoing integration process with the European Union, the PHARE Programme as well as pre-accession funds such as ISPA and SAPARD may be important. Apart from international funds, money for the development of the renewable energy sector may be generated from bilateral programmes for co-operation with Western countries, e.g. Denmark, Germany, Sweden, etc. The possibilities of arranging financial support to the renewable energy sector in Poland have been presented in Annex 5.

9. RECAPITULATION

In the coming years, energy from renewable sources will constitute a significant component in the European Union's energy balance. The ongoing integration with the EU encourages Poland to undertake actions aimed to develop the utilisation of renewable energy sources on one hand. On the other hand, it offers a chance for substantial help from the EU in this area already in the pre-accession period. Poland's strategic goal concerning the share or renewable energy in the fuel and energy balance in the year 2010 is lower from the targets set by the European Union. However, the forecasts of the share of renewable energy in the fuel and energy balance of Poland do not envisage the share to exceed 7.5% until 2010. It is within that period that the mechanisms proposed in this strategy will be checked and verified and new solutions prepared. At the same time, in view of specific conditions, the preparation of development programmes for renewable energy sub-sectors must commence immediately. Such programmes would contribute to a greater success in the achieving strategic goals. These activities should allow the doubling of the share of renewable energy in Poland's primary energy balance until the year 2020 in comparison with 2010, which means reaching 14% in the year 2020.

Finally, it must be emphasised that the development of renewable energy sector creates opportunities especially to the local communities as regards local energy independence, regional development and creation of new jobs as well as environmentally-friendly modernisation of infrastructure, diversification and decentralisation of the Polish energy sector. It is estimated that achieving the goals

outlined in the Strategy will lead to reduction of greenhouse gases emissions by around 18 million tonnes and creation of additional 30-40 thousand jobs (in direct employment). One must remember that the sooner Poland gets involved in the development of renewable energy sources, the sooner the national renewable industry, in particular small and medium-sized enterprises, will become partners in the world's market for renewable energy technologies. Existing technical potential of renewable energy sources in Poland encourages undertaking actions aimed to the most effective utilisation of this potential. At the present stage, however, quick development in the renewable energy sector is impossible without state support.

10. CONCLUSIONS

- The domestic potential of renewable energy sources is comparable with that of the European Union countries. The technical potentials of particular kinds of energy in Poland and in member states may vary.
- System solutions supporting the development of renewable energy sector have been in operation in the European Union for fifteen years. Only recently has similar action been launched in Poland, which is the reason why it would be difficult to achieve the targets set by the European Union by the year 2010.
- Due to the long delay in the introduction of mechanisms encouraging wider utilisation of renewable energy sources, the first phase of the execution of the Strategy i.e. until the year 2010 should be regarded as the time for the implementation the proposed solutions, and for evaluation and verification of these solutions.
- In the first phase of the execution of the Strategy, specific development programmes for renewable energy sub-sectors will be prepared. The implementation of the programmes is an important element in the execution of the development strategy for the renewable energy sector. In the first phase, particulalry biomass utilisation is expected to increase.
- The actions to be undertaken should increase the share of renewable energy in Poland's fuel and energy balance to minimum 14% in the year 2020.

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