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## **DEVELOPMENT OF RENEWABLE SOURCES OF ENERGY UTILIZATION IN PRODUCTION OF ELECTRIC ENERGY IN POLAND IN THE ASPECT OF REQUIREMENTS OF THE EUROPEAN UNION**

**Abstract.** The paper presents the basic directions of renewable energy sources utilization in Poland according to requirements of the European Union. The attention was paid to economic and ecological effects of energy production from renewable sources and to possibility of measurement of eco-development level in the field of renewable energy sources utilization.

**Key words:** renewable energy sources, sustainable development, eco-development ratio

### **1. LEGAL ASPECTS OF RENEWABLE SOURCES OF ENERGY UTILIZATION IN POLAND**

Process of electric energy production causes the big pollution of the environment. The carbon dioxide, the sulphur dioxide and dust are basic air pollution emitted as a result of electric energy production. The environmental protection against negative results of activities connected with energy production is one of purposes of the Polish energy policy, realized by power stations. The energy policy of Poland assumes the consideration of following action directions in power state activity (Polityka energetyczna 2005):

- full adapting of source of energy combustion to legal requirements in the field of the environmental protection – obligation to adapt of existing sources to emission standards of pollution specified in the Directive 2001/80/EC of the European Parliament and of the Council of 23 October 2001 on the limitation of emissions of certain pollutants into the air from large combustion plants,

- change of energy sources structure - achievement the 7.5% level of share of electric energy produced from renewable sources in total consumption of gross electric energy in accordance to the indicative purpose determined for Poland in the Directive 2001/77/EC of the European Parliament and of the

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- Council of 27 September 2001 on the promotion of electricity produced from renewable energy sources in the internal electricity market,
  - applying of Clean Coal Technology,
  - introduction of mechanisms making air pollutants emission limit possible
- introduction of market mechanisms consist in trade of greenhouse gas emission allowance in accordance with the Directive 2003/87/EC of the European Parliament and of the Council of 13 October 2003 establishing a scheme for greenhouse gas emission allowance trading within the Community and amending Council Directive 96/61/EC.

The basic deeds regulating turnover of energy from renewable sources and their main decisions in this range are presented in Table 1.

Table 1

The basic legal regulations concerning renewable sources of energy in Poland

| Source   | Requirements  |
|--|---|
| 1  | 2   |
| The Act of 10 April 1997 Energy Law (Journal of Laws, No. 89 pos. 625)   | Regulations regulating turnover of energy from unconventional and renewable sources: <ul style="list-style-type: none"> <li>- determining of the method of dealing with transmission and distribution energy and heat produced in renewable sources by the energy company</li> <li>- imposing the duty of the purchase of energy and heat from unconventional and renewable sources on energy companies deal with transmission and distribution of electric energy</li> <li>- possibility to take co-financing costs of activities connected with development of renewable power industry by energy companies in price rates for gas fuels, electric energy and heat</li> <li>- imposing financial penalty on entities not doing regulations regarding purchase of electric energy from renewable sources</li> </ul>  |
| The Act of 2 April 2004 on amendment to the Act of Energy Law and the Act of Environmental Law („Journal of Laws”, No. 91, pos. 875) | Introduction of additional regulations: <ul style="list-style-type: none"> <li>- of institution of certificates of origin as a solution guaranteeing that given electric energy has actually been produced in the renewable source of energy</li> <li>- of obligation of obtaining the concession for business activity in the field of production of electric energy in renewable sources independently of source power</li> <li>- imposing the obligation of the reception of whole amount of electric energy produced in joined in energy network of given energy companies renewable sources by the energy companies dealing with transmission and distribution of electric energy, if the purchases contracts are concluded</li> <li>- of obligation to ensure the priority in provision of transmission services for electric energy produced in renewable sources by the operator of the electric system if it does not influence the reliability and safety of the national electricity system</li> </ul> |

Table 1 (cont.)

| 1  | 2  |
|--|--|
|  | <ul style="list-style-type: none"> <li>- of determining the minimal level of money penalty for non-observance of the obligation of purchase or production of electric energy in renewable sources of energy</li> <li>- of unequivocal determination of obligations for commune governments in the field of taking local renewable energy sources into consideration in assumptions for plans of supply of heat, electric energy and the fuel gas</li> </ul>  |
| <p>The ordinance of 15 December 2000 on obligation of purchase of electricity from unconventional and renewable sources and produced in co-generation with heat production as well heat from unconventional and renewable sources and range of the obligations (Journal of Laws, No. 122, pos. 1336)</p> | <ul style="list-style-type: none"> <li>- determining from which renewable and unconventional sources (independently of the source power) electric energy and heat should origin which are included in obligation of the purchase</li> <li>- determining of share of energy produced in renewable and unconventional sources in total year-long sale of energy company guaranteeing to fulfil the obligation of the purchase of energy from these sources in each years (in 2001- 2.4%; 2002 - 2.5%; 2003 - 2.65%)</li> <li>- determining the manner of purchases financing of energy produced in renewable sources depending on this that the planning justified cost of obligatory purchase of energy are taken in price and payment rates calculation into consideration, and every energy units sold by given energy company is in an equal degree burdened with these costs</li> <li>- introducing the definition of "biomass" as fuel of whom utilizing to energy production causes to rate the source among renewable energy sources (in accordance with recommendation of the Directive 2001/77/EC of the European Parliament and of the Council of 27 September 2001 on the promotion of electricity produced from renewable energy sources in the internal electricity market)</li> <li>- rating the proportional part of energy produced from combustion of biomass or biogas with other fuels among energy produced in renewable sources</li> </ul> |

Source: own study based on basic legal acts.

Guidelines in the field of renewable energy sources utilization are included in many documents of the European Union. On Polish regulations it is imposed the obligation of compatibility with European requirements. Principles of the energy policy with reference to renewable energy sources are included in Green Paper:

- Energy for future: resources of renewable energy
- In the direction of the European strategy in aid of safety of energy supply,
- Energy efficiency, i.e. how to achieve more by less consumption,
- European strategy of balanced, competitive and safe energy.

The White Paper – “Energy for the future: renewable sources of energy” – is the basic document determining direction of the long-term policy and laying the quantitative purpose regarding the renewable energy sources utilization.

In order to ensure of realization of obligations included in white and green papers in the field of usage of renewable sources of energy following instructions are accepted (P. Gradziuk [2006], p. 67):

- Directive 2001/77/EC of the European Parliament and of the Council of 27 September 2001 on the promotion of electricity produced from renewable energy sources in the internal electricity market,

- Directive 2002/91/EC of the European Parliament and of the Council of 16 December 2002 on the energy performance of buildings,

- Directive 2003/30/EC of the European Parliament and of the Council of 8 May 2003 on the promotion of the use of biofuels or other renewable fuels for transport,

- Directive 2003/54/EC of the European Parliament and of the Council of 26 June 2003 concerning common rules for the internal market in electricity and repealing Directive 96/92/EC – Statements made with regard to decommissioning and waste management activities,

- Directive 2004/8/EC of the European Parliament and of the Council of 11 February 2004 on the promotion of cogeneration based on a useful heat demand in the internal energy market and amending Directive 92/42/EEC,

- Directive 2005/32/EC of the European Parliament and of the Council of 6 July 2005 establishing a framework for the setting of ecodesign requirements for energy-using products and amending Council Directive 92/42/EEC and Directives 96/57/EC and 2000/55/EC of the European Parliament and of the Council,

- Directive 2006/32/EC of the European Parliament and of the Council of 5 April 2006 on energy end-use efficiency and energy services and repealing Council Directive 93/76/EEC.

On 7<sup>th</sup> December 2005 the Commission of European Communities accepted the plan of action in case of biomass. In this document were specified the manners of thanks which degree of energy production from biomass received from wood, waste and arable plants will be increased. In this end the UE commits itself to create market encouragement of utilizing renewable sources of energy and removing hindering barriers of their usage in the power industry.

## **2. RENEWABLE ENERGY POWER INDUSTRY AND SUSTAINABILITY**

On 8<sup>th</sup> July 1999 the Sejm of the Polish Republic adopted the Resolution in the matter of the growth of utilization of power from renewable sources in which

the postulate was included that the growth of the renewable energy utilization should become the integral element of sustainable development of the state. The usage of renewable sources of energy became the same one of assumptions of eco-development of Poland. In Fig. 1. interdependence between various aspects of sustainable development and the usage of renewable sources of energy was presented.

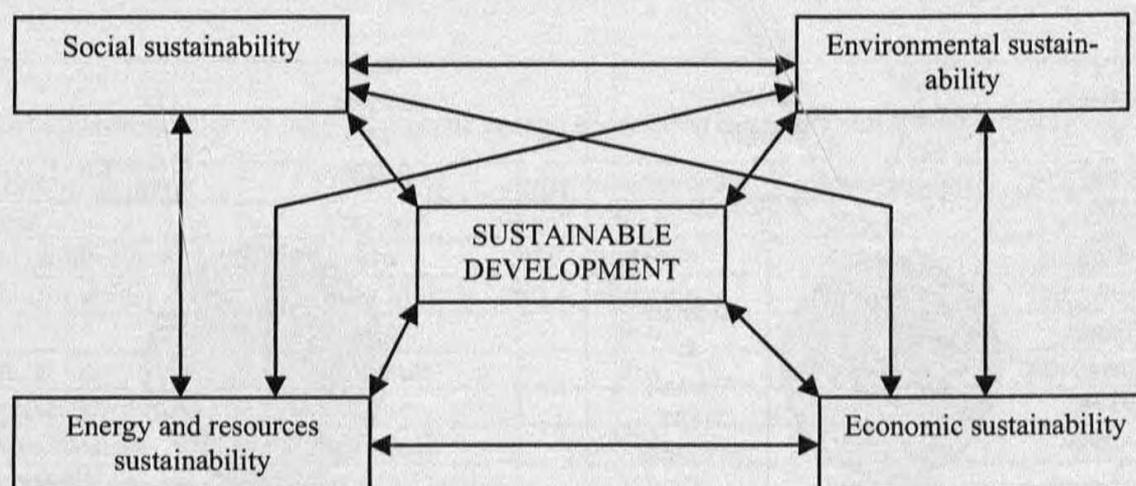


Fig. 1. Factors affecting sustainable development and their interdependences

Source: Midillia A. 2006, p. 3625.

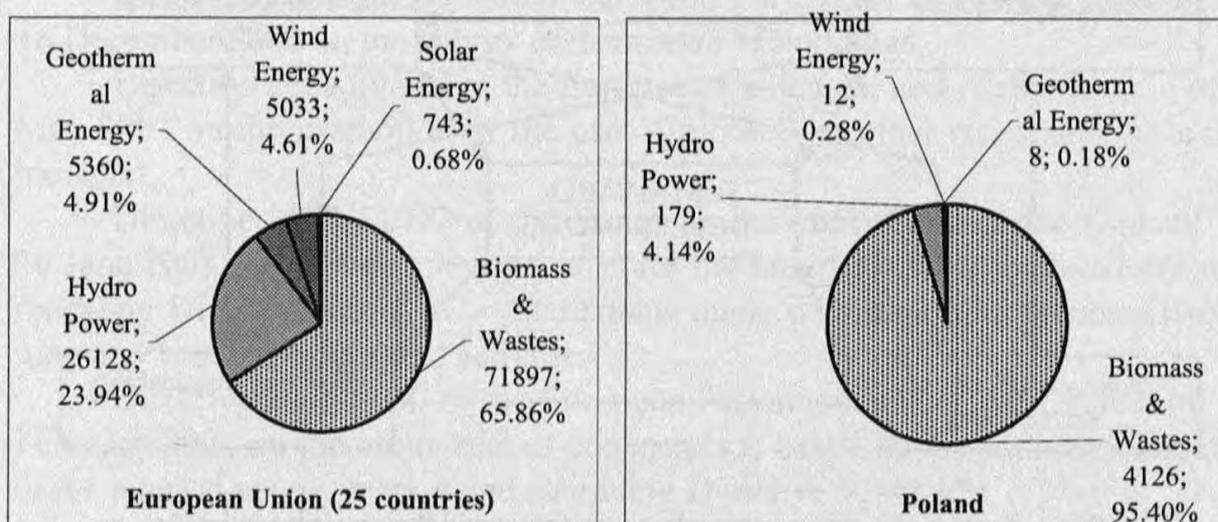
Production of electric energy from renewable sources is the requirement put by the legislation of the European Union. Therefore the need to ensure the basics of renewable power industry development (creating the industry of biomass and biofuels in commune governments and development of local generation) is one of the priorities of the energy policy (Popczyk 2005, p. 476). Among energy produced from renewable sources, regardless of capacity of source, electric energy or heat are rated, in particular produced (Rozporządzenie MGIP z 9.12. 2005):

- in hydro and wind power stations;
- from sources producing energy from biomass and biogas;
- from solar photovoltaic cells and collectors for heat production;
- from geothermal sources.

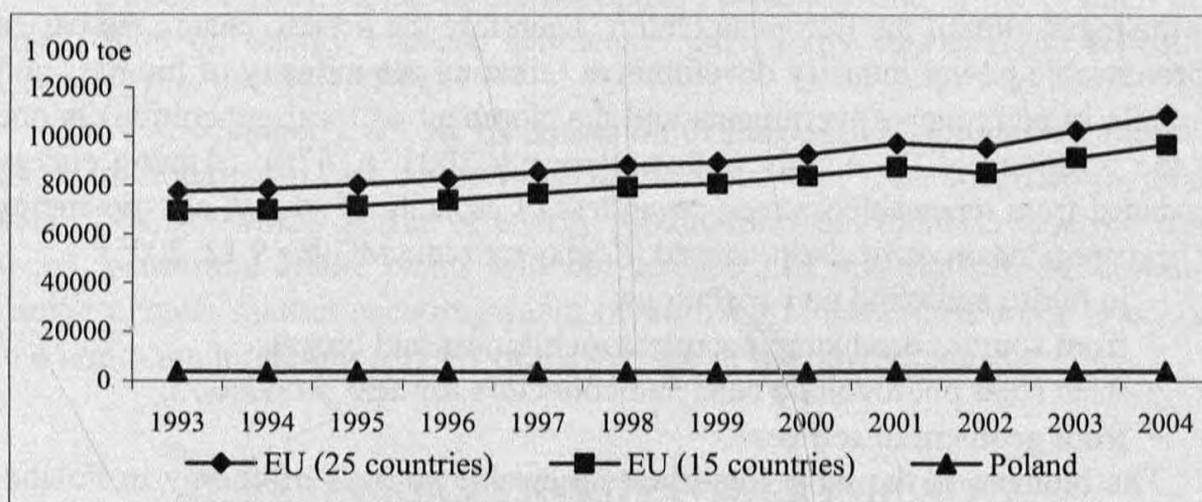
The biomass is the most important renewable sources of energy in Poland. The biomass is defined as constants or liquid substances of origin from vegetable or animal which undergo biodegradation, from products, waste and remainder from agricultural and forest production and industry processing their products, as well as from other waste which undergo biodegradation (Rozporz-

adzenie MGiP z 9.12. 2005). The structure of utilizing renewable sources of energy in Poland and in the European Union in 2004 was presented on Graph 1.

The biomass has the biggest participation in consumption of energy renewable sources (about 65% in the UE and about 95% in Poland). The second place with regard to utilization size takes water energy. Share of wind and geothermal energy consumption is quite slight in Poland – under 1% of total consumption of renewable energy. Dynamics of the usage of renewable sources of energy in the European Union and in Poland was presented on graph 2.



Graph 1. The structure of renewable energy sources utilization in the UE and in Poland in 2004  
Source: own calculations on the basis of Eurostat.



Graph 2. Dynamics of renewable energy sources utilization in the UE and in Poland in years 1993–2004

Source: own calculations.

The increase in the renewable sources of energy utilization has been significant in the European Union since 2001. The constant level of consumption of renewable energy sources has been observed in Poland. Average growth rate in this range has amounted 1,032 for 25 EU countries and 1,031 for 15 EU countries, and 1,009 for Poland.

The utilization of biomass to electric energy production amounts to applying the technology of co-combustion of biomass and fossil fuels in Poland. It is the most inexpensive method of production of energy from renewable sources (Table 2).

Table 2

Qualitative evaluation of costs of electric energy production from different primary energy sources

| Energy sources      | Total costs            | Investment costs | Operating costs | Fuel costs  |
|---------------------|------------------------|------------------|-----------------|-------------|
| Water               | very low               | high             | very low        | no costs    |
| Coal (mine close)   | low                    | moderate         | fairly low      | moderate    |
| Coal (mine far)     | fairly high            | moderate         | moderate        | fairly high |
| Oil                 | high                   | low              | low             | high        |
| Natural Gas         | moderate               | low              | low             | fairly high |
| Nuclear energy:     |                        |                  |                 |             |
| thermal reactor     | fairly high            | high             | moderate        | low         |
| duplicating reactor | at present ineffective | very high        | moderate        | „negative”  |
| Geothermal energy   | low                    | moderate         | fairly low      | no costs    |
| Wind energy         | high                   | high             | very low        | no costs    |
| Solar energy        | very high              | very high        | very low        | no costs    |
| Biomass             | low                    | moderate         | low             | moderate    |

Source: Paska 2005, p. 321.

Production of energy from renewable sources is more expensive than production from conventional sources. High costs of production of energy from renewable sources are the consequence of expenses borne for development of the technology of renewable resources utilization. However expenses of conventional energy don't take external costs of activity into consideration. Therefore decrease of renewable energy costs will be observed along with technology development and diffusion of renewable electricity technologies, thanks to reducing prices of materials utilized for renewable energy production.

The part of electric energy produced by co-combustion can be classified as energy from renewable sources. The quantity of electric energy produced by co-combustion and qualified as energy from renewable sources, can be calculated according to legally binding legislative acts with the use of this formula: (M. Liszka 2005, p. 138)

$$E_{elOZE} = \frac{\sum_{i=1}^n M_{bi} W_{dbi}}{\sum_{i=1}^n M_{bi} W_{dbi} + \sum_{i=1}^m M_{ki} W_{dki}} E_{elN}$$

where:

$E_{elOZE}$  – amount of electric energy or heat rated among energy produced from renewable sources, MWh or GJ,

$E_{elN}$  – amount of electric energy or heat generated in production unit, where biomass or biogas are combusted with other fuels, in MWh or GJ,

$M_{bi}$  – mass of biomass or biogas combusted in production unit, Mg,

$M_{ki}$  – mass of other fuels combusted in production unit, Mg,

$W_{dbi}$  – calorific values of biomass or biogas combusted in production unit and calculated in the method determined in Polish Standards, MJ/Mg,

$W_{dki}$  – calorific values of other than in formula used fuels combusted in production unit and calculated in the method determined in Polish Standards, MJ/Mg,

$n$  – number of arts of biomass or biogas combusted in production unit,

$m$  – number of arts of other fuels combusted in production unit.

It is necessary to assume that significance share of biomass from agricultural or waste and remainder from agricultural production and the industry processing its products, as well other waste undergoing biodegradation, excluding waste and remainder from forest production and industry processing its products, in total mass of biomass delivered to combustion process will be not less than (Rozporządzenie MGiP z 9.12. 2005):

- 1) 5 % – in 2008;
- 2) 10 % – in 2009;
- 3) 20 % – in 2010;
- 4) 30 % – in 2011;
- 5) 40 % – in 2012;
- 6) 50 % – in 2013;
- 7) 60 % – in 2014.

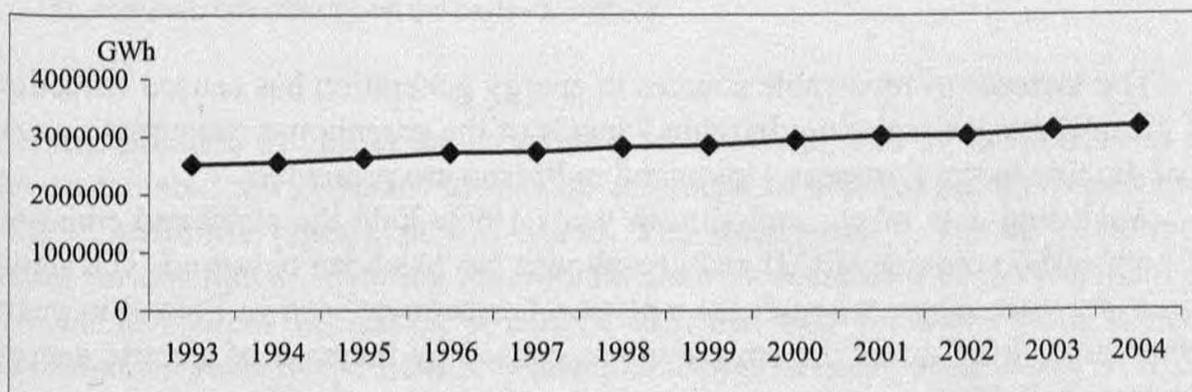
Energy production in existing energy installations in standard process of coal combustion is the cheapest method of renewable energy production. Strategy of the realization of environmental goals by production of renewable energy by adding the biomass to conventional fuel was adopted by the most of power plants in Poland. In this strategy assumptions to increasing renewable energy production are accepted in order to satisfy not only own needs but also the possibility of sale of the surplus on the market of renewable energy. It is possible to achieve environmental as well as economic goals thanks to such realized strategy.

### 3. ENVIRONMENTAL AND ECONOMIC RESULTS OF DEVELOPMENT OF RENEWABLE ENERGY SOURCES IN POLAND

Electric energy production process with the use of renewable energy sources brings environmental effects which are so significant because of the bad condition of the environment, as well as economic effects what is especially important in point of view of energy companies. Among basic ecological effects of applying renewable energy sources we can rate:

- reducing of consumption of non-renewable energy sources – fossil fuels,
- reducing of the emission of greenhouse gases, in which carbon dioxide first of all,
- reducing the pollution of the environment.

In the European Union it is estimated that electric energy production will be still on the increase (graph 3). Average growth rate of production for years 1993-2004 has been amounted 1,021 in case of 25 EU countries. It is indispensable to search of such technologies of energy generation which will be friendly for the environment.

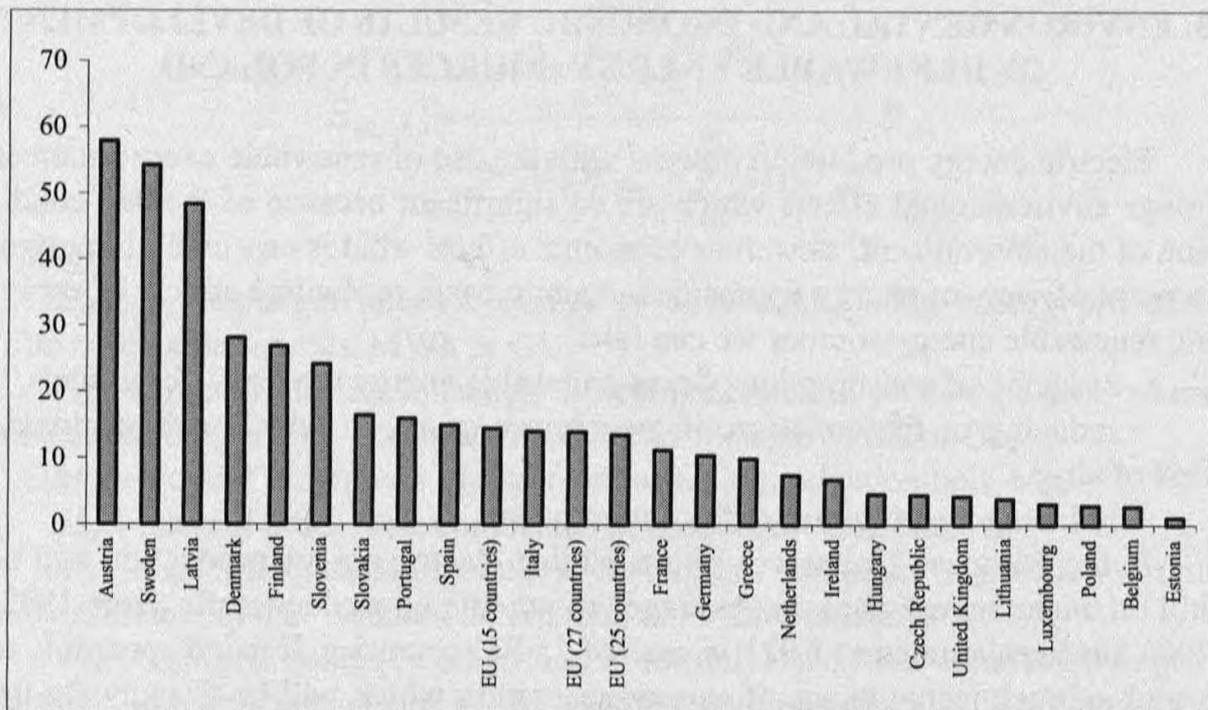


Graph 3. Dynamics of electric energy production in 25 countries of the EU

Source: own calculations on the basis of Eurostat.

The use of renewable sources in energy production process is the solution for generation of clean energy. The level of their has increased, and the biggest share of renewable energy in total energy production can be observed in Austria and Sweden – about 50% and in Latvia – about 48% (Graph 4).

The achievement of 21% of electric energy in gross energy consumption and of 12% in primary energy balance from renewable sources until 2010 is the quantitative goal in the field of production of electric energy from renewable sources in the EU countries (Kostecka 2006).



Graph 4. Share of renewable energy in total energy production in the EU countries in 2005  
 Source: own calculations on the basis of Eurostat.

The increase of renewable sources in energy generation has caused reduction of greenhouse gas emission. In table 3 levels of the greenhouse gas emission and coal dioxide in the European Union and in Poland are presented.

Analysing data of gas emission in years 1993–2004 the stabilized emission of both carbon dioxide (CO<sub>2</sub>) and greenhouse gas has been observed. The significant decrease of greenhouse gas emission has been noticed in Poland in years 1993–2003. Increase of the emission was caused by increase of electric energy production in 2004.

Among economic effects connected with production of energy from renewable sources following profits can be rated:

- environmental bonus in the form of the certificate of origin of renewable energy,
- decrease of level of fees for industrial use of the environment and its transformation thanks to reducing the level of pollutants emission,
- income from emissions allowance trading (the CO<sub>2</sub> emission rising from the co-combustion of biomass is regarded as the zero emission, the same quantity of CO<sub>2</sub> is absorbed by the increasing biomass in the photosynthesis process).

Table 3

## Coal dioxide and greenhouse gas emissions in the EU and in Poland

| Year   | CO <sub>2</sub> emission <i>per capita</i> (in tonnes) |                           |        | Total greenhouse gas emissions<br>(Actual base year = 100*) |                           |        |
|--------|--|---------------------------|--------|---|---------------------------|--------|
|        | UE<br>(25 coun-<br>tries)                              | UE<br>(15 coun-<br>tries) | Poland | UE<br>(25 coun-<br>tries)                                   | UE<br>(15 coun-<br>tries) | Poland |
| 1993   | 8.6  | 8.5                       | 9.4    | 91.9  | 96.3                      | 77.8   |
| 1994   | 8.4  | 8.3                       | 9.2    | 92.1  | 97.1                      | 73.8   |
| 1995   | 8.3  | 8.2                       | 9.4    | 94.2  | 99.2                      | 77.4   |
| 1996   | 8.3  | 8.3                       | 8.8    | 92.8  | 97.8                      | 75.6   |
| 1997   | 8.6  | 8.5                       | 9.4    | 92.3  | 98.1                      | 71.4   |
| 1998   | 8.4  | 8.3                       | 9.1    | 90.8  | 96.5                      | 71.0   |
| 1999   | 8.4  | 8.4                       | 8.5    | 90.7  | 96.8                      | 68.2   |
| 2000   | 8.2  | 8.3                       | 8.3    | 91.7  | 97.8                      | 67.7   |
| 2001   | 8.2  | 8.3                       | 7.9    | 90.9  | 97.4                      | 65.5   |
| 2002   | 8.4  | 8.5                       | 8.0    | 92.4  | 98.8                      | 67.7   |
| 2003   | 8.3  | 8.5                       | 7.8    | 92.7  | 99.1                      | 68.4   |
| 2004   | 8.5  | 8.6                       | 8.1    | b.d.  | 92.0                      | 94.0   |
| target | –  | –                         | –      | 91.9  | 96.3                      | 77.8   |

\* Actual base year – 2005; in CO<sub>2</sub> equivalents.

Source: own calculations on the basis of Eurostat.

It is possible to find in the literature a lot of methods of the measurement of the sustainable development level with reference to electric energy production (e.g. A. Midillia [2006], p.3627-3628). The measurement can be performed using various ratios. Adapting these methods to measurement of development of renewable sources utilization it can be affirmed that the basic ratio is eco-development ratio in the field of renewable energy sources utilization (WOZE). This ratio can be measured with use of following formula:

$$W_{OZE} = W_{E,OZE} \cdot W_{ZE,OZE}$$

$$W_{ZE,OZE} = 1 - W_{ZE,KOP}$$

$$W_{ZE,KOP} = Z_{E,KOP} / Z_E$$

$$W_{E,OZE} = W_{R,OZE} + W_{BiR,OZE} + W_{W,OZE}$$

$$W_{R,OZE} = P_{R,OZE} / P_{O\acute{S}}$$

$$W_{BiR,OZE} = P_{BiR,OZE} / P_{O\acute{S}}$$

$$W_{W,OZE} = P_{W,OZE} / P_{O\acute{S}}$$

where:

$W_{E,OZE}$  – ratio of green energy produced from renewable sources,

$W_{ZE,OZE}$  – ratio of utilization of energy from renewable sources,

$W_{R,OZE}$  – ratio of utilization of provided financial supports for increasing of renewable energy sources usage,

$W_{BIR,OZE}$  – ratio of utilization of provided financial supports for research and development renewable energy sources,

$W_{W,OZE}$  – ratio of utilization of provided financial supports for transition to green energy based technologies in the field of renewable energy sources,

$W_{ZE,KOP}$  – ratio of fossil fuels utilization,

$Z_{E,KOP}$  – total consumption of energy from fossil fuels,

$Z_E$  – total consumption of energy from primary sources (fossil and renewable),

$P_{R,OZE}$  – provided financial supports for increasing of renewable energy sources usage,

$P_{BIR,OZE}$  – provided financial supports for research and development renewable energy sources,

$P_{W,OZE}$  – provided financial supports for applying to green energy based technologies in the field of renewable energy sources,

$P_{O\acute{S}}$  – provided financial supports for environmental protection in the sector of energy generation and distribution,

The WOZE ratio amounted to:

0,00199 – in 2004,

0,00187 – in 2005

in Poland.

The further development of renewable sources utilization is assumed in Poland. In Table 4 forecast of demand for renewable energy primary sources was presented for various scenarios.

Table 4

Forecast of demand for energy primary sources

| Scenario      | Specification       | Unit     | 1997 | 2005 | 2010 | 2015 | 2020 |
|---------------|---------------------|----------|------|------|------|------|------|
| SURVIVE       | Renewable energy ** | Mtoe *** |      | 5.3  | 5.5  | 5.7  | 5.9  |
| REFERENCE     | Renewable energy ** | Mtoe *** | 5.5  | 5.5  | 6.0  | 6.5  | 7.1  |
| PROGRESS-PLUS | Renewable energy ** | Mtoe *** |      | 5.8  | 6.3  | 6.9  | 7.7  |

\*\* water, wind solar, geothermal energy, biomass, rape oil, ethanol, energy from waste

\*\*\* 1 toe = 41,868 GJ; toe–ton of oil equivalent

S o u r c e: Strategia rozwoju... [2000].

Renewable energy level presents currently about 5% of total demand of energy. Every of three scenarios assume the increase in this share until 2020. Promoting of energy production from renewable sources aims to reduction of the environment pollution. Renewable energy sources utilization can produce financial effects. Search of such technologies of energy production from renewable sources which will support realization of both environmental and economic goals is the basic purpose in the field of energy production.

#### 4. CONCLUSION

The obligation of generation of energy and heat from renewable sources was imposed on the energy sector. Cost of alternative sources utilization with the necessary capacity is very high. Energy company has realized the obligation of winning determined share of renewable energy in sale of electric energy and heat to final consumers through production in own sources, the purchase of certificates of origin on the market or by paying the replacement fee. Technology of energy production in existing energy installations by normal, standard coal combustion process but with adding biomass to conventional fuel has been the cheapest method of renewable energy generation. Both in Poland and in the European Union it is estimated that renewable energy sources utilization will be still on the increase. In this way the UE has aimed at the limit its dependence on import of fuels, at reducing greenhouse gas emission and at stimulating the activity in rural areas. Moreover renewable energy sources utilization has led to reducing negative impact of energy production process on the environment and has produced financial effects. Financial effects are possible thanks to the ecological bonus in the form of the certificate of origin and of emission allowance trading, ecological effects – thanks to improvement of the environment condition.

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### **ROZWÓJ WYKORZYSTANIA ODNAWIALNYCH ŹRÓDEŁ ENERGII W PRODUKCJI ENERGII ELEKTRYCZNEJ W POLSCE W ASPEKcie WYMOGÓW UNII EUROPEJSKIEJ**

W referacie przedstawiono podstawowe kierunki rozwoju wykorzystania odnawialnych źródeł energii w Polsce zgodnie z wymogami Unii Europejskiej. Zwrócono uwagę na ekonomiczne i ekologiczne efekty produkcji energii ze źródeł odnawialnych, a także dokonano próby pomiaru poziomu ekorozwoju w zakresie wykorzystania odnawialnych źródeł energii.

**Słowa kluczowe:** odnawialne źródła energii, zrównoważony rozwój, współczynnik ekorozwoju.