



# Ecological and economic aspects of electric energy production using the biomass co-firing method: The case of Poland



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## ABSTRACT

The article describes the most important aspects related to electric energy production using the method of biomass co-firing with lignite and coal in Poland. We emphasise the potential of biomass co-firing for electric energy production in the country. We also describe the current use of the method in Poland and present the most important technological and economic aspects of its use in Polish coal-fired power plants. In the article, we use the Life Cycle Assessment (LCA) method to evaluate the environmental impact of electric energy production from coal using the biomass co-firing method. We present the analysis of data obtained from large coal and lignite coal-fired Polish power plants. The LCA describes the current environmental impact of energy production and potential ways of limiting it by the extended use of the biomass co-firing method in the analysed power plants. The performed simulation also confirms the possibility of limiting negative environmental impact of electric energy production by extending the use of this method. We also describe the negative aspects of the biomass co-firing with coal and indicate the direction of changes aimed at improving the efficiency of the method in electric energy production. The last part of the article contains conclusions related to the presented research that summarise the analysis.

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## 1. Introduction

Poland is a country where the electric energy is obtained mainly by means of lignite and coal firing. This way of obtaining energy has a considerable environmental impact, as considerable amounts of coal-firing emissions are produced. Poland should aim to decrease the share of fossil fuels used in electric energy

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production and increase the share of the renewable energy resources [1]. The negative environmental impact related to the use of lignite and coal in energy production also forces Poland to undertake actions aimed at increasing the share of renewable energy resources [2]. The biomass co-firing method is one of the ways that can be used in large coal-fired plants to limit the use of the non-renewable resources. A rational use of renewable sources of energy is one of the elements contributing to the balanced development of the country. Currently, the biomass co-firing method is viewed in Poland as one of the most economically viable methods of limiting the use of non-renewable energy sources. Biomass co-firing with fuel seems a promising alternative

allowing an increase in the share of renewable sources of energy in the total energy balance in the country [3].

The aim of the article is to emphasise the potential of biomass as currently the most important renewable energy resource in Poland. Biomass co-firing allows the reduction of coal use during electric energy production. The article describes the ecological and economic importance of development of the method of biomass co-firing with coal for electricity production in Poland. The article contains the results of LCA (Life Cycle Assessment) analysis of the use of biomass co-firing with lignite in Turów Power Plant and of biomass co-firing with coal in Dolna Odra Power Plant. The LCA method is used to determine the environmental impact of electric energy production by coal firing and the environmental and economic benefits related to the increase in biomass share in the chosen coal-fired Polish power plants [4]. Negative aspects related to the use of biomass co-firing.

Every production process generates emissions, having a negative environmental impact. This is especially true for the energy production processes. Together with the rising contamination of environment resulting from energy production related to the increase in overall energy requirements, one observes a move towards new and innovative ways of limiting this negative impact. Life Cycle Assessment is one of the tools, based on the ISO series 14040 standards, allowing the evaluation and comparison of environmental impact of various modes of energy production [5]. With the growing importance of effective energy use, an LCA analysis of data from Turów and Dolna Odra power plants.

## 2. Biomass and energy production in Poland – technical and economic aspects

Bioenergy obtained from agricultural and forest resources can have a significant impact on improving the energy safety of a country. It is a significant, renewable source of energy, next to wind, sun, water and geothermal resources. Bio-energy is created from solid biomass, bio-gas [6] or liquid fuels, found in abundance all over Europe. Forestry and agriculture are the main sources of biomass, which comes from refuse and organic waste, with bio-fuels being produced predominantly from farming crops. Biomass, biogas and biofuels are easy to store, allowing the creation of bioenergy depending on the current requirements [7]. These resources allow the production of electric and thermal energy and can be used as fuel for transportation purposes. Bioenergy comprises roughly a half of the renewable sources of energy in the EU [8].

The data presented in Table 1 indicates that biomass has the highest share among the renewable energy resources in Poland and that its share has been steadily growing.

**Table 1**  
Electric energy production level and structure in Poland depending on energy carrier. Source: The Energy Market Agency [9].

Specification	2010		2011		2012	
	GW h	%	GW h	%	GW h	%
Coal	87 941	55.8	87 326	53.4	80 596	49.7
Lignite	48 651	30.9	52 529	32.1	54 054	33.3
Natural gas	4 797	3.0	5 821	3.6	6 259	3.9
<b>Biomass</b>	<b>6 305</b>	<b>4.0</b>	<b>7601</b>	<b>4.6</b>	<b>10094</b>	<b>6.2</b>
Other fuels (oil and gas, liquid gas)	4 812	3.0	4305	2.6	3923	2.4
Hydro power	2 920	1.8	2331	1.4	2037	1.3
Wind energy	1 664	1.1	3205	2.0	4747	2.9
Total	157 658	100.0	163 548	100.0	162 139	100.0

Biomass is also one of the renewable energy resources that can be relatively easy used in electric energy production in Poland, which is based on fossil fuels [10]. This is especially important, since using biomass reduces emissions of CO<sub>2</sub> into the atmosphere [11]. This is related to the fact that during the growth, biomass absorbs amounts of CO<sub>2</sub> comparable to the amounts of this compound released when it is burned. The growing share of biomass in the structure of fuels used in energy production will contribute to the reduction of costs related to CO<sub>2</sub> emissions [12]. Moreover, biomass firing has a positive impact on energy security, since it contributes to the shrinking share of non-renewable energy resources, such as coal or natural gas. The commercial power industry, based predominantly on coal-fired plants, in order to meet the requirements of the respective law regulations dealing with the use of renewable energy sources in energy production and limits on greenhouse gases emission levels, saw the potential of adding biomass to coal [13].

Notwithstanding a number of advantages of this solution, the use of biomass in energy production has some important technological limitations [14]. On top of that, there are also problems related to the justification of spending large amounts of money on non-dry biomass, nearly a half of which is imported. Polish power plants predominantly use forest biomass that to a large degree comes from the Polish forests. Yet, more and more biomass utilised in Polish plants comes from abroad, including Africa. Such long-distance transportation and related pollution means that the co-firing biomass with coal becomes ecologically and economically unsustainable. A detailed analysis is required, aimed at determining whether the financial expenses related to wet biomass firing in commercial power industry would not be much more effective, ecologically and economically speaking, if these instead were to be used for the development of photovoltaic methods, water-related solutions or other alternative methods. This could prove beneficial for the local job markets and could enable the use of the forest biomass in furniture or construction industries rather than for energy generation purposes.

We also emphasise that Polish energy plants use several million tonnes of wood mixed with coal annually. If the same amount of biomass were used in smaller cogeneration boiler houses, it would yield twice as much energy. Such a solution would have a real impact on lowering the greenhouse gases emission levels [15,16].

The economic mechanisms supporting the development of renewable energy resources are important from the point of view of the development of bioenergetic solutions in Poland, including the use of biomass. The system of the so-called green certificates is the predominant means of supporting the production of energy from renewable resources in the country. It is important to notice that Poland also implemented a mechanism of supporting the production of electric energy using the cogeneration method (the red certificates) [17]. In the Polish legal system, the green certificates constitute property rights that can be sold to generate profits [18]. The main mechanism, through which the renewable energy resources within the green certificates system are being supported, relies on requiring the energy companies to obtain the proof of origin or to pay a compensatory fee otherwise. Polish Power Exchange in Warsaw is responsible for managing the certificate system on a national level. The system has been in use since 2005 and has been described in detail e.g. by the Regulation of the Minister of Economy from 14 August 2008 on the specific range of duties related to obtaining and remission of certificates of origin, paying the compensatory fee, purchase of electric energy and heat produced using renewable energy resources and the requirement to confirm data related to the electric energy produced using renewable energy resources [19].

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