Annals of Warsaw University of Life Sciences – SGGW
Agriculture No 65 (Agricultural and Forest Engineering) 2015: 71–77
(Ann. Warsaw Univ. Life Sci. – SGGW, Agricult. 65, 2015)

Estimation of electricity production from biomass power plants for next three years

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Abstract: *Estimation of electricity production from biomass power plants for next three years*. Biomass in Poland has the greatest technical potential of all domestic sources of renewable energy. Solid biomass from forestry, agriculture (energy crops and vegetable waste), food processing and biogas summary potential is estimate at 610 PJ·year^{-1}. Biomass in Poland has the best chance of development. The use of biomass as a fuel, especially in large combustion plants with a capacity of 50 MW, allows you to limit (in Poland, about 90 objects) of CO_2 emissions in the national balance sheet. This is an important element of the CO_2 reduction potential, while maintaining the desired level of electricity production.

Key words: RES Act, biomass, estimation

INTRODUCTION

According to the newest Renewable Energy Sources Act[1] (RES Act), biomass is defined as solid or liquid biodegradable waste (vegetable or animal origin) derived from products, waste and residues from agricultural and forestry production and related industries, and also cereal grains that do not esteem the quality requirements for cereals in buying intervention (referred to the Article 7 of Commission Regulation (EC) 1272/2009 of 11 December 2009 and the implementation of Council Regulation (EC) 1234/2007 as regards the buying and selling of agricultural products under public intervention). Moreover, there are included grains, which are not subject to the purchase of an intervention, as well as the biodegradable fraction of industrial and municipal waste, vegetable or animal waste in the waste treatment plant and from wastewater treatment, in particular sludge (according to the Waste Regulations concerning eligibility part of the energy recovered from waste incineration). Many aspects concerning biomass utilization are undertaken in specialist literature including mathematical approach to model system of complex use of renewable energy sources [Syrotyuk 2011], energy shortage [Barwicki and Gach 2010], energetic quality of biomass material [Gendek and Zychowicz 2004] and the others.

Biomass in Poland has the greatest technical potential of all domestic sources of renewable energy. Solid biomass from forestry, agriculture (energy crops and vegetable waste), food processing and biogas summary potential is estimate at 610 PJ·year^{-1} in 2020 and 910 PJ·year^{-1} in 2030 [Popławski, 2013]. Real economic potential of biomass in Poland is estimate at more than

[1]Polish Act of 20 February 2015 on renewable energy sources.

600 PJ·year^{-1} in 2020, and the market potential at 533.1 PJ·year^{-1} [IEO 2007].

In 2012 the production of electricity from biomass was dominated by co-firing technology, which stands for 76% of the volume of total RES electricity production. In 2013 this trend has changed, mainly due to the rising cost of biomass – which can easily opt for co-firing – as well in 2012 eight new biomass power plants units were opened and in 2013 another three.

The government document[2] established for the implementation of the indicative target of 15% share of energy from renewable sources in gross final energy consumption following quantities of solid biomass, which must be processed in the electricity sector: 167,305 TJ in 2015 and 194,100 TJ in 2020.

On the contrary energy generation from RES depends on two factors: weather and stock prices of certificates of origin. For example, wind turbines with favorable weather conditions produce very large amounts of green energy. Also hydropowers in the so-called wet years significantly increase their production.

TABLE 1. Electricity generation in Polish RES (ARE S.A.)

Specification	Unit	2005	2006	2007	2008	2009	2010	2011	2012	2013
Co-firing	GWh	1 237	1 645	2 127	2 963	4 664	5 597	6 391	7 241	4 342
Solid biomass		163	180	234	236	244	313	759	2 290	3 596
Hydropower		2 201	2 042	2 352	2 152	2 375	2 920	2 331	2 037	2 439
Wind		135	256	522	837	1 077	1 664	3 205	4 747	5 986
Biogas		110	116	195	254	319	395	450	563	620
PV		0	0	0	0	0	0	0	1.14	1.46
Total		3 847	4 240	5 429	6 442	8 679	10 889	13 137	16 879	16 984
Dynamic index	%	–	110.2	128.1	118.7	134.7	125.5	120.6	128.5	100.6

Source: Mikołajuk et al. [2013].

Despite the current dominance of biomass in the structure of electricity generation from renewable sources in 2013 the trend changed and wind energy led, for which the dynamics compares with the year 2012 amounts 126.1%. In 2013 wind farms generated electricity accounted for approximately 35.2% of the total volume of green energy in Poland. According to data from the Energy Regulatory Office, the largest increase of wind power plants installed capacity between 2010 and 2011 declines by over 436 MW and between 2011 and 2012 by more than 880 MW.

Renewables while energy is producing because of natural forces generates point-blank green certificates, regardless of their current stock on the exchange in contrast of co-firing biomass with coal [Chmielewski 2013].

In case when green certificates given the low prices the production in co-firing technology becomes less profitable in as-

[2]National Renewable Energy Surces Plan (NREAP) implemented in 2010.

sociation with the purchase of fuel price this occurrence was observed in 2013 as a result of collapsing prices of green certificates. Since 2013, the co-firing biomass units were a kind of "buffer" for the green certificate market. When the prices of property rights in the stock market falls, co-firing power plants limited production of green energy and reduce the supply of certificates. In correctly working support system further demand for certificates should moulding development of renewable energy sources. In Polish reality it is not so obvious.

MATERIAL AND METHODS

Estimation of energetic biomass demand for next three years was prepared in correlation with forecasting of green certificates of origin and national RES aims. The most important factor impact on the result is demand for certificates which is directly related with final energy consumption.

Analyzing the behavior of the market in the last few years the range, you can with a high degree of probability to estimate the volume of energy sold in the following years. Since 2010 electricity sales remained stable with a slight upward trend. This trend occurs despite the decline in the 2012 and 2013 years of GDP growth.

To prepare a forecast of demand for final energy was used a simulation model operates on a user-built network of energy flows. The network consists of nodes mapping processes – acquisition, conversion, transportation, energy consumption – and links (bonds) connecting nodes. The model simulates the behavior of consumers and producers of energy, each of which operates so as to achieve the most benefit. The balance (equilibrium) to "the market" is determined if any of the actors considers that the price of a particular type of energy is for him most of all. Market share of energy coming from different sources the model defines the following formula:

$$S_i = \frac{\left(\frac{1}{P_i \cdot P_{m_i}}\right)^{\gamma}}{\sum_i^n \left(\frac{1}{P_i \cdot P_{m_i}}\right)^{\gamma}}$$

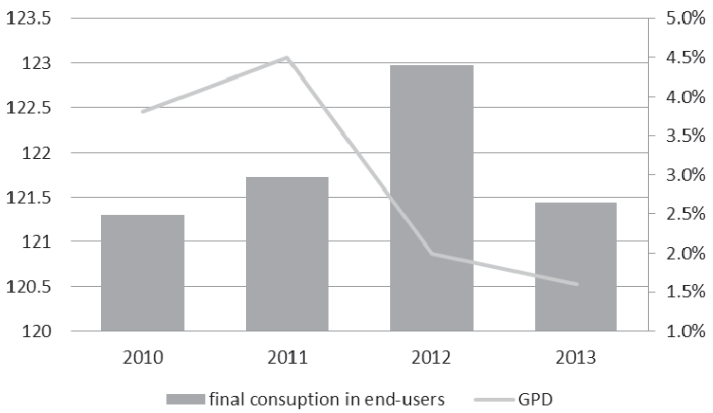

FIGURE 1. Final energy consumption in end-users with relation to GPD

where:
S_i – share of energy coming from the direction i;
P_i – price of energy coming from direction i;
P_{m_i} – aversion factor;
γ – sensitivity price ratio;
n – number of energy directions;

P_m coefficient in the formula given a reflect of other (except costs) factors influencing the consumer's choice of energy. That factors may be accustomed to certain solutions and distrusted others or related to comfort (or discomfort) associated with certain technologies of energy conversions. In addition, delay parameter algorithm is used due to the fact that the high investment change in technology cannot take place immediately.

Estimation of the RES electricity production was done in accordance of two assumptions: promises of grid connections, and the newest act for RES.

According to Polish Power System Operator (PSE) and the individual Distribution System Operators (OSD), until 2018 Poland green market will enrich with 4,812 MW of new renewable energy power sources. Most of new installations (up to 94.3%) are plan as wind farms.

At the beginning of 2016 it is plan to implement a new law on renewable energy sources. In its project contains provisions relating to the limitation of support for biomass co-firing technology decrease the value of received certificates of 50% which will automatically reduce production from co-fining.

To link the two assumptions the correlation method is used which effect was to determine the correlation coefficient r for different sets of data (it determine the extent to which variables are interdependent). Correlation between variables (conventionally X and Y) characterized in values of one variable (X) is associated with meaningful value of the other variable (Y). Fit of the model is the better the value of r is closer to 1. Matching of the model bases on the quantitative description of regression function relation ($E\ (Y \mid X = x) = f\ (x)$) as each case composes classic example of a two-dimensional normal distribution. To carry out regression analysis, the form of the function f must be specified.

$$f\,(x) = \propto + \beta x$$

where:
$f\,(x)$ – regression function;
$\propto$ – constant of regression;
β – unknown parameters, denoted as β, which may represent a scalar or a vector.

TABLE 2. RES with a promise of grid connection

Year	Wind	Biogas	Hydropower	PV	Solid biomass	Total
	MW					
2014	3,867.5	170.8	970.2	26.6	995.2	6,030.4
2015	4,805.8	172.8	970.2	36.3	995.2	6,980.3
2016	5.468.3	172.8	970.2	36.3	995.2	7,642.9
2017	6,699.3	172.8	970.2	36.3	995.2	8,873.9
2018	8,154.3	172.8	970.2	36.3	995.2	10,328.9

Source: Michalik-Bartoszewska and Wrońska [2014].

Next step was values predicting by the model prediction results were expert evaluated. This approach is most useful in the short-term estimation, when the structure are relatively stable economic policy decisions predetermined, and demand-side mechanisms dominate the supply-side mechanisms (which operate in the long term).

RESULTS AND DISCUSSION

With each MW of installed capacity in various renewable energy technologies are produced different amounts of electricity. In the period 2012–2013, with an installed capacity of 1 MW of electricity most was obtained from biomass in boilers dedicated (6.1 GWh). This is a conventional – heat, electricity production method, which in comparison to other types of renewable energy does not depend on the forces of nature. Another technology that is characterized by a high rate of production of electricity from is biogas power unit. Average production in the reporting period amounted to 4.5 GWh from this technology. Production of renewable energy sources in the other depends on the weather conditions. This means that in subsequent years, with the same power unit can receive different amounts of energy.

Determine the well-data's fitting to the model coefficient of determination (R^2): R_p^2 for biomass and total RES electricity production amounts 0.948 and R_b^2 for final consumption and co-firing electricity production amounts 0.987.

Despite the increase in 2012, the minimum share of renewable energy in the total volume of energy sold to end users, in each subsequent year will be an excess of green certificates. The world, as close to 5.8 TWh, occurs in 2014 and will be related to the production of energy from biomass co-firing [Ekstowicz 2011]. Created the model assumes that the new law will take effect RES from 1 January 2016. Each month of delay, will continue the co-firing of biomass, which will help to increase the oversupply of certificates on the market. In the case of an annual delay the introduction of the new law, oversupply in 2016 could reach 6.3T Wh.

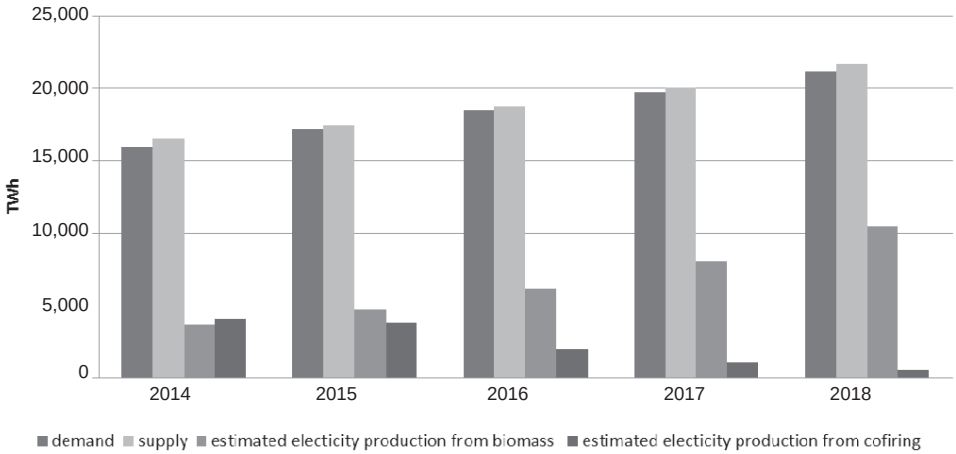

FIGURE 2. Results of estimation (own elaboration)

CONCLUSIONS

It is worth noticing that the market for renewable energy support system, based also on the uncertain level of demand for electricity, does not guarantee the stability of the level of support for investors, and thus the stability of the development of the electricity sector.

Biomass in Poland has the best chance of development. Determinants of this development is the untapped potential of Polish agriculture high for the production of energy crops, the possibility of using agricultural waste, supply potential of public and private forests in terms of wood assortments intended for energy purposes.

The use of biomass as a fuel, especially in large combustion plants with a capacity of 50 MW allows you to limit (in Poland, about 90 objects) of CO_2 emissions in the national balance sheet. This is an important element of the CO_2 reduction potential, while maintaining the desired level of electricity production. But the new act for RES will hold back development of solid biomass production.

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Streszczenie: *Ocena produkcji energii elektrycznej z plantacji roślin energetycznych w okresie najbliższych trzech lat*. Produkcja biomasy w Polsce wyróżnia się największym potencjałem pod względem technicznym spośród krajowych źródeł energii odnawialnej. Biomasa pochodząca z leśnictwa, rolnictwa (roślin energetycznych i pozostałości po uprawie), przetwarzania żywności i produkcji biogazu stanowi potencjał

energetyczny na poziomie około 610 PJ rocznie. Produkcja biomasy w Polsce wykazuje tendencje do systematycznego rozwoju. Przeprowadzone analizy wskazały, że wykorzystanie biomasy jako paliwa, szczególnie w dużych spalarniach masy roślinnej o mocy 50 MW, pozwala ograniczyć emisję CO_2 w łącznym bilansie emisji w skali kraju. Jest to szczególnie istotne w kontekście oceny i perspektyw produkcji energii elektrycznej.

MS received April 2015

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