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Prerequisites for increased consumption of biofuels for heating purposes in Poland

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Abstract: *Prerequisites for increased consumption of biofuels for heating purposes in Poland.* The need to meet Union obligations regarding reaching the national target for the share of renewable energy sources in gross energy consumption at the level of 15% by 2020 requires increasing the use of biomass for heating purposes. Its components include fuels based on wood and agro-biomass. An increase in the consumption of these fuels in Poland will help to resolve the problem of air pollution with dangerous dust emitted during household heating with poor quality coal. This paper presents the prerequisites for increased consumption of biofuels: pellets and briquettes made of wood by-products and agro-biomass. The aspects examined include: the availability of biofuels and prospects for their production development; investment outlays necessary to change the heating methods; price competitiveness of various energy carriers; legal regulations favoring substitution of conventional energy sources with biofuels. An analysis of the initially identified conditions was carried out with particular emphasis on economic aspects in order to diagnose the situation and identify key problems affecting the consumption of biofuels in Poland.

Keywords: pellets, wood briquettes, agro-biomass, ecology, biofuel consumption, Poland

INTRODUCTION

Directive 2009/28/EC [Directive 2009] requires the member states to achieve a defined share of renewable energy sources in gross final consumption of energy by 2020. Compulsory national targets were set for each country separately to ensure that the 20% share of gross final energy consumption from renewable sources is achieved across the entire Community. For Poland, that target is set at 15%.

According to data published by EUROSTAT [Eurostat 2018], 11 out of 28 European Union countries attained their national targets for 2020 in 2016: Bulgaria, Czech Republic, Denmark, Estonia, Croatia, Italy, Lithuania, Hungary, Romania, Finland and Sweden. Austria is also close to its target. Note the large share of the former Eastern Bloc countries, however without Poland being among them.

Worryingly, in 2016, the share of RES in final energy consumption in Poland (11.3%) was below the level recorded in 2015 (11.7%), 2014 (11.5%) and 2013 (11.4%) [Eurostat 2018]. In these circumstances, there is a risk the 15% target might not be reached in 2020.

Air quality indicators in Poland are also alarming. As shown by the long-term air quality monitoring program, the limits are greatly exceeded, especially when it comes to $PM_{2.5}$ and PM_{10} particulates, including the extremely noxious benzo(a)pyrene. Within the European Union, air quality assessment in terms of PM_{10} pollution is based on two indicators [Directive 2008]:

1) the annual average concentration cannot exceed 40 $\mu g/m^3$,
2) the number of days with an average daily concentration > 50 $\mu g/m^3$ cannot be greater than 35 within a year.

The top ten European cities with maximum daily PM_{10} concentrations[1] include, in addition to Bulgarian cities, as much as six Polish cities (Krakow, NowySącz, Zabrze, Gliwice, Sosnowiec, Katowice). In Krakow and in other cities, the maximum daily PM_{10} concentration was exceeded for 151 days and over 120 days, respectively [EEA Report 2017].

[1] PM_{10} is suspended particulate matter composed of a mix of organic and inorganic substances.It may contain toxic substances such aspolycyclic aromatic hydrocarbons (e.g. benzo(a)pyrene, a carcinogen substance), transition metals, heavy metals and their compounds, as well as dioxins and furans.

Equally worrying is the concentration of smaller $PM_{2.5}$ particles which have particularly adverse health effects as they smoothly make their way to pulmonary alveoli and, afterwards, into the bloodstream. Each year, more than 46,000 people die prematurely from contamination by this type of particulates. The maximum annual average concentration of $PM_{2.5}$ particulates provided for in the CAFE Directive is 25 $\mu g/m^3$. Southern Poland is among the regions affected by the highest $PM_{2.5}$ concentrations. The top 50 EU cities with the highest $PM_{2.5}$ concentration include as many as 33 Polish towns (31.8–45.02 $\mu g/m^3$). This can be compared with the largest European metropolises where $PM_{2.5}$ concentration is more than twice lower: London: 14 $\mu g/m^3$; Berlin: 18 $\mu g/m^3$; Paris: 19 $\mu g/m^3$ [Dworakowska A. 2016]. The primary source of $PM_{2.5}$ emissions are "non-industrial combustion processes" (Figure 1) to which the emissions related to household coal combustion contribute the most (ca. 80%). In 2016, coal combustion emissions were 6.8% higher than in 2015. While the share of coal in the mix of heating fuels exceeds 75% in Poland, it decreased by nearly 8% between 2002 and 2016 [National emission balance sheet 2018].

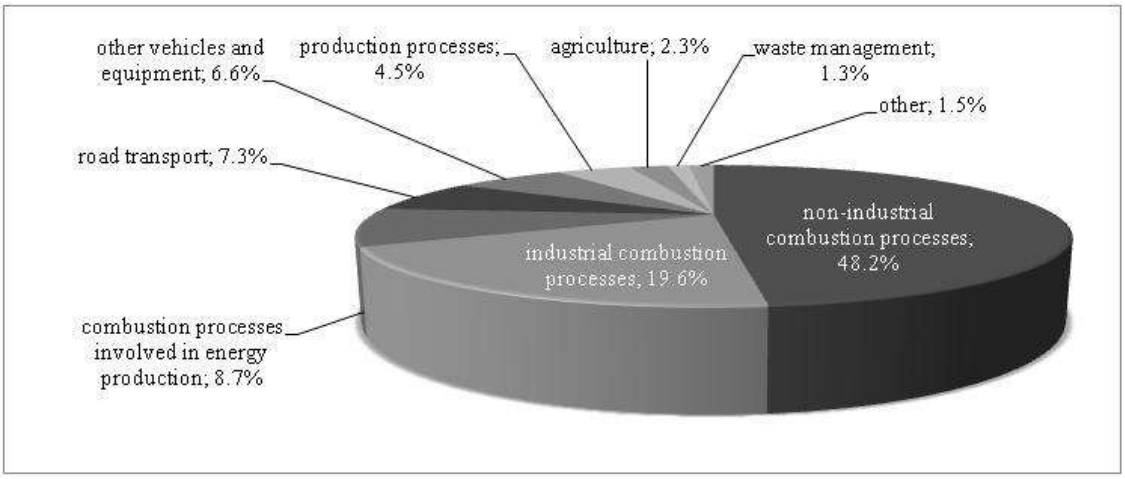

Figure 1. Share of specific sectors in national $PM_{2.5}$ emissions in 2016; municipal and household sector
Source: National emission balance sheet 2018

Poland also reports the highest annual average concentration of benzo(a)pyrene (a carcinogen substance) in the European Union (at a current level of 5 ng/m^3). The maximum level provided for in the European law is 1 ng/m^3, but the limit recommended by the World Health Organization is even lower (0.12 ng/m^3). Croatia (2.5 ng/m^3) and Bulgaria (ca. 1 ng/m^3) are ranked second and third, respectively [EEA Report 2017]. Benzo(a)pyrene is released during the combustion of solid fuels at low temperatures in unclassified boilers used by ca. 2 million Polish households.

In view of the above, household heating methods should be changed dramatically. Biofuels made of wood by-products and agro-biomass provide an alternative to poor quality coal. In addition to environmental aspects, the increased use of biofuels will help meeting the national target share of RES in gross energy consumption as they are biomass components. Table 1 shows the basic types of biofuels with a brief characteristic.

MATERIAL AND METHODS

This paper identified and analyzed the selected determinants of an increase in the consumption of the most popular biofuels: pellets and briquettes made of wood by-products and other biomass types. Three groups of determinants were identified:

1. availability of biofuels and development potential of biofuel production,

2. investment expenditure needed to shift to another energy carrier; financing opportunities; and ease of use of the energy carrier concerned,
3. price competitiveness compared to other utilities,
4. legal regulations encouraging the users to replace their heating systems.

Table 1. Characteristics of basic biofuel types

Fuel type	Material	Size [mm]	Net calorific value [MJ/kg]	Water content [%]	Ash content [%]	Key advantages
Pellets compliant with DIN PLUS/EN A1	sawdust, chips	∅ 6-8 L: 3.15-4.01	16.5-19.0	≤ 10.00	≤ 0.70	- easy to transport, store and distribute, - high stability and homogeneity of the product, enabling a full automation of the combustion process; a tank stores enough fuel for 3–7 days
Agri-pellets	Hay, biomass from energy crops, cereal grains, green stems	∅ 6-12 L=8	12.0-17.0	3.00-7.00	1.00-4.00	- permanent availability and low harvesting costs of raw materials because the biomass is rapidly renewable and agricultural production is a continuous process
Sunflower husk pellets	sunflower husk	∅ 6-12 L=8-12	17.0	≤ 10.00	≤ 3.00	- low price
Wood briquettes RUF	sawdust, chips	briquette: 15x9x6.5	16.0-18.0	≤ 10.00	≤ 0.70	- easy to transport, store and distribute, - problems with loosening structure - need for manual work
Straw briquettes	straw	∅ 80 L: random	15.5-17.5	≤ 10.00	2.00-4.00	- low price
Firewood	wood logs chunk wood		7.8-10.6	15.00-20.00	0.3-3.0	the crackling wood effect

Source: own elaboration

RESULTS AND DISCUSSION

Availability of energy carriers and development potential of their production

The global production of pellets grows consistently. In 2016, it was 36.2 million tons (11% more than in 2015), with Europe accounting for 16.6 million tons, i.e. nearly 59% of pellets manufactured around the world [AEBIOM 2017].

In Poland too, the production volume of pellets grows each year. According to research by the Baltic Energy Conservation Agency (BECA), a 40% increase in production was recorded between 2013 and 2016. In 2016, 52 plants with a production capacity of 1.1 million tons delivered a total of 0.9 million tons of pellets [AEBIOM 2017].

Ca. 7% of pellets manufactured in the entire European Union originates from Poland which is the Europe's seventh largest producer of pellets, after Germany (1.8 million tons), Sweden (1.7 million tons), Latvia (1.4 million tons), Estonia (1.2 million tons), France (1.2 million tons) and Austria (1.0 million tons). However, only one third of the domestic production is sold on the domestic market while the remaining part is exported, mainly to Germany (36%) and Denmark (35%). In 2016, Poland exported over 276,000 tons of pellets, which means an increase by nearly 28% compared to 2015 [AEBIOM 2017].

The global production of pellets is mostly (62%) consumed in European Union countries (22.3 million tons in 2016) [AEBIOM 2017]. The consumption follows a consistent

growth trend (by 23% in 2013–2016). Ca. 65% of pellets are used for heating purposes while 35% are used for energy production. European countries which commonly use pellets for heating purposes are Sweden, the Netherlands, Italy, Germany, Austria and Denmark.

A similar trend can be observed in the domestic market. In 2016, 200,000 tons of pellets were purchased by households for heating purposes, which means a 25% increase compared to previous year [AEBIOM 2017]. Of the total consumption volume of 266,667 tons, 75% and 18.7% was used for heating purposes in households and commercial buildings, respectively, while 6.3% was used for cogeneration of heat and power (Combined Heat and Power, CHP) [AEBIOM 2017]. The boom in the Polish pellets market is confirmed by a rapid increase in sales of home pellet boilers (by 150% between 2014 and 2016).

As the interest in pellets grows, so does the number of biofuel producers. Usually, these are timber processors who rely on their resource base (wood by-products) to extend their facilities with pellet production lines. Several leading companies have an annual output of 100,000+ tons of pellet; these include: Stelmet (140,000 t), Barlinek (140,000 t), Ikea (130,000 t) and the Olczyk sawmill (120,000 t) [Forestor Report 2015].

Investment expenditure needed to shift to another energy carrier; financing opportunities

The Polish population's interest in heating their homes with pellet boilers grows along with greater environmental awareness, and is also driven by economic reasons. In the case of a new single-family home, the relevant investment expenditure must be specified in the cost estimate, whatever the energy carrier is. In turn, as regards existing houses, the investment comes down to replacing the boiler and upgrading the related facilities, where needed. For a 120 m^2 house, the estimated cost ranges from PLN 8,000 to PLN 10,000. The investment may be co-financed with funds disbursed under Union programs or low-interest loans. Financing may be applied for by natural persons and legal persons, i.e. housing communities, cooperatives, foundations and entrepreneurs.

Usually, the principles for financing the replacement of boilers slightly differ from one municipality to another. They may require the applicant to shift to gas heating or to connect to distance heating networks, but may also provide for a subsidized purchase of a state-of-the-art automatic pellet boiler.For instance, in the Poznań district, boiler replacement subsidies (as of February 14, 2018) amount to PLN 7,000 for natural persons and PLN 14,000 for economic operators and housing cooperatives.

If the municipality does not offer boiler replacement subsidies, soft loans may be accessed from Bank OchronyŚrodowiska and some other cooperative banks. If the requirements are complied with, 50% of the loan may be written off thanks to funds from the Voivodeship Fund for Environmental Protection and Water Management.

Price competitiveness compared to other utilities

The unit price criterion is not enough to assess the economic viability of an energy carrier. By determining the total unit cost of generated heat, it is possible to specify the operating cost of a heat unit, also referred to as the generation cost of a useful heat unit [Bal, Piechocki 2006]. It is calculated as:

$$K_u = \frac{c_{jp}}{Q_w \times \eta_k} \tag{1}$$

where:

K_u – generation cost of a useful heat unit [PLN/GJ],
c_{jp} – unit price of fuel [PLN/t] or [PLN/m^3],
Q_w – net calorific value of the fuel [GJ/t] or [GJ/m^3],
η_k – efficiency of the heating unit [%]

Table 2 compares the operating costs of heat units generated from various fuels. As shown by this compilation, the cheapest heat energy carrier is cob coal. Heating with straw

briquettes, pea coal or firewood is only slightly more expensive. However, it requires constant supervision of the boiler. Wood briquettes and pellets are 16% more expensive than wood; due to environmental concerns, they could become an alternative to coal (24% cheaper, on average) or, because of economic aspects, an alternative to natural gas (17% more expensive) combusted in traditional boilers. Pellets—the most stable and homogenous fuel—are competitive to wood briquettes. A price comparable to that of briquettes and the ability to fully automate the combustion process make them even more competitive.

The price competitiveness of pellets could be boosted by a decrease in VAT rates, which is a common practice in European Union countries. For instance, in Belgium and Germany, the relevant VAT rates are 6% and 7%, respectively.

Table 2. Cost of heat units generated from various types of fuels in the 2017/2018 heating season

Fuel type [unit]		Unit price of fuel [PLN/fuel unit]	Net calorific value of the fuel [GJ/fuel unit]	Efficiency of the heating installation [%]	Generation cost of a useful heat unit [PLN/GJ]	Price equivalent of a pellet heat unit
firewood (water content: 15%) [m^3]		330	11.2	70	42.09	0.86
wood briquettes [t]		740	18.0	84	48.94	1.00
pellets [t]		840	19.0	90	49.12	1.00
straw briquettes [t]		550	16.5	84	39.68	0.81
coal [t]	pea coal	800	26	75	41.02	0,84
	cob coal	750	28	70	38.27	0,78
	pulverized coal	560	19	65	45.34	0,92
natural gas [m^3] GZ 35/GZ 50	condensing boiler	2.00	0.039	104	49.31	1,00
	traditional boiler	2.00	0.039	88	58.28	1,19
	old boiler	2.00	0.039	70	73.26	1,49
heating oil [l]	condensing boiler	3.05	0.037	96	85.86	1,75
	traditional boiler	3.05	0.037	84	98.13	2,00
liquid gas [l]	condensing boiler	1.90	0.025	104	73.07	1,49
electric power, 24h tariff [kWh]		0.50	0.0036	100	138.89	2.83

Source: own elaboration based on average producer prices

Legal regulations encouraging the users to replace their heating systems

Measures taken to reduce air pollution include appropriate legislative initiatives, such as the Regulation of the Ministry of Development and Finance of August 1, 2017 concerning requirements for solid-fuel boilers [Regulation 2017]. It became the basis for anti-smog resolutions adopted by local councils at voivodeship level; their key objective is to prohibit the combustion of low-quality fuels and to replace low-end boilers with standards-compliant equipment. For instance, on December 18, 2017, the local council of the Wielkopolskievoivodeship adopted three "anti-smog" resolutions [Resolution XXXIX/941/17, Resolution XXXIX/942/17, Resolution XXXIX/943/17] prohibiting the use of lowest-quality solid fuels (e.g. extremely pulverized coal, lignite or coal flotation concentrate) from May 1, 2018. Some requirements for boilers were also introduced. From May 1, 2018, all new boilers must: enable automatic fuel feeding; demonstrate high levels of energy efficiency; and comply with emission standards. Boilers installed before the entry into force of the above resolutions which fail to comply with requirements set out therein must be replaced:

a) by January 1, 2024, in the case of unclassified boilers;
b) by January 1, 2026, in the case of local boilers (furnaces, fireplaces, belly stoves);
c) by January 1, 2028, in the case of boilers compliant with class 3 or 4 requirements as per PN-EN 303-5:2012.

The amendment to the Act on the monitoring and inspection system for fuel quality, as adopted by the parliament on July 5, 2018 [Act 2006, Notice 2018] also holds some promise for an improvement in this area. The Act introduces a system which truly controls the quality of coal sold at retail level. Each batch of coal will be required to be provided with a quality certificate. In the event of any discrepancy between the declared and actual quality of coal, the seller may be fined up to PLN 200,000. The objective is to eliminate lowest-quality fuels from the market: coal sludge, coal flotation concentrate and any mixtures with coal content below 85%.

RESULTS

1. In the era of growing wealth, the important factors which affect the choice of the heating method include not only the economic aspects (boiler replacement costs, operating cost of a heat unit) but also fuel cleanness, ease of equipment use, ability to automate the heating processes, and environmental aspects. Fuel availability and stability of fuel deliveries also play an important role.
2. According to the comparison of operating costs of heat units derived from various fuels, wood pellets have a strong competitive edge. In the 2017/2018 heating season, coal, firewood and straw briquettes were the only cheaper (though more arduous) heating options than pellets. An additional argument in favor of pellets is the comfortable use of boilers, automated combustion process (the tank stores enough fuel to feed the boiler for 3 to 7 days) and better reliability.
3. The economic aspect, together with the growing awareness of health threats posed by hazardous emissions from coal combustion, resulted in a rapid increase (150% in 3 years) in sales of home pellet boilers. As a consequence, in 2016, pellets consumption in households increased by 25% compared to previous year.
4. As the Polish population's interest in biofuels grew, so did the number of biofuel producers. Usually, these are timber processors who rely on their resource base (wood by-products) to extend their facilities with pellet production lines.
5. The continued development of the pellets market will be driven by legal regulations adopted in 2017–2018 to reduce air pollution by:
   - implementing a system which truly controls the quality of coal sold at retail level,
   - prohibiting the combustion of low-quality solid fuels,
   - making it compulsory to replace low-end boilers with standards-compliant equipment.

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Streszczenie: *Uwarunkowania rozwoju konsumpcji paliw ekologicznych wykorzystywanych na cele grzewcze w Polsce*. Konieczność wypełnienia zobowiązań unijnych w zakresie osiągnięcia w roku 2020 krajowego celu udziału odnawialnych źródeł energii w zużyciu energii brutto na poziomie 15% wymaga wzrostu wykorzystania na cele grzewcze biomasy. Do jej składników zalicza się paliwa powstałe na bazie drewna i agrobiomasy. Rozwój konsumpcji tych paliw w Polsce pomoże rozwiązać problem zanieczyszczenia powietrza niebezpiecznymi pyłami, emitowanymi podczas ogrzewania gospodarstw domowych złej jakości węglem. W opracowaniu przedstawiono uwarunkowania rozwoju konsumpcji paliw ekologicznych: granulatu i brykietów, wytwarzanych z drzewnych produktów ubocznych oraz agrobiomasy. Zbadano między innymi: dostępność paliw ekologicznych i perspektywy rozwoju ich produkcji, nakłady inwestycyjne, niezbędne do zmiany sposobu ogrzewania, konkurencyjność cenową różnych nośników energii, uregulowania prawne sprzyjające zastępowaniu konwencjonalnych źródeł energii paliwami ekologicznymi. W celu zdiagnozowania sytuacji i określenia kluczowych problemów rozwoju konsumpcji paliw ekologicznych w Polsce, przeprowadzono analizę zidentyfikowanych pierwotnie uwarunkowań ze szczególnym uwzględnieniem aspektów ekonomicznych.

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