Pellet – a Key to Biomass Energy

by
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Abstract: Pellet production is rapidly growing business in many European countries. This fact is strongly connected with increasing role of biomass as a resource of clean energy. Future of pellet market is influenced by different political, economical, environmental and social aspects which create complex relations between suppliers of raw material, pellet producers and consumers. That is why standardization and quality control is being introduced in many countries, that allows to deliver better product which can compete with other fuels in terms of efficiency and impact on environment .

Key words: biomass, energy, pellet, renewable resources, sustainable development
JEL classification: Q27, Q42, Q48, Q56

1 Introduction

The biomass was the first type of fuel ever used by humans to generate energy. For centuries it has evolved into current form of pellets. The aim of the following paper is to reveal the characteristics of pellet as a specific type of fuel. Various stages of the manufacturing process will be analysed. The paper will also bring closer the shape of European and Polish pellet market. It will also make an attempt to confront the positive and negative aspects of producing biomass pellets.

2 Biomass as a source of energy from nature

Reduction of greenhouse gas emissions to the atmosphere and independence of global economy from fossil fuels are the main reasons to use renewable resources for energy production. Biomass plays dominant role in the production of "green" energy. Biomass was responsible for approximately 68% of energy generated from renewable resources in the European Union in 2009 (Eurostat 2009).
Latent energy potential of biomass derives from solar energy. Biomass consists of the organic matter created during photosynthesis process from water and carbon dioxide, with a participation of the sun. There are three forms of energy that can be extracted from biomass (The Schumacher Centre of Technology & Development 2005):

- biogas - methane, obtained in the process of anaerobic fermentation of plant feedstock, animal waste and municipal waste;
- liquid biofuels - organic matter derived from production waste (bagasse) or energy crops (e.g. rape), that undergo chemical and physical processes in order to obtain ethanol and vegetable oils, which can be used as motor fuel;
- fuel in solid form - dry mass collected from the trees, plantations of energy crops, grasses, crop residues and other consumer and industrial waste of organic origin, that is treated and used for direct combustion.

Combustion of biomass in solid form and its co-firing with coal are currently the predominant techniques for generating energy from biomass (Jakubiak and Kordylewski 2008). In order to improve this process, biomass obtained from the environment is subjected to treatments of cutting, grinding, briquetting and pellet formation.

3 The pellet - form of energy carrier

Processing biomass and shaping it into pellets allows to convert organic matter into a standard form of fuel, which can be easily obtained, transported and used. The types of biomass used in the production of pellets are quite varied, which affects the physicochemical properties of the final product. The most desirable are the pellets produced from biomass with high content of cellulose and lignin, which are extracted, among others from wood (including chips from the acquisition and care of forest trees or energy crops like willow from dedicated plantations), bark, straw, grasses (energy crops such as *Miscanthus sp.*, *Panicum virgatum*, *Phalaris arundinacea*, *Bambus sp.*), litter meadows and rushes, husks (as production waste from rice, tamarind, coffee, cotton), pips and seeds (such as olive, corn), shells (including nuts), and maize cobs (Grover and Mishra, 1996, University of Vermont in 2011).

A large variety of raw materials used to produce pellets, forced attempts to unify the products patterns in individual national markets. The most common forms of certification standards and guidelines are one referring to wood pellet characteristics. The rules of standardizing the quality of the product were developed, among others in United States (American Pellet Fuels Institute Standards), France (NF Granules Biocombustibles), Italy (Gold Pellet), Sweden (SS 187 120), Austria (Ö NORM M 7135) and Germany (DIN 51731) (Hiegl et al. 2009). The most popular form of certification, adopted in different countries, is the norm that was based on the experiences of German and Austrian - DIN plus (table 1).

The main characteristics that determine the quality of pellets are the energy value, the emission of combustion gases (sulphur oxides, nitrogen oxides, hydrogen chloride, volatile dust) and factors that affect proper functioning of furnace (Hiegl et al. 2009). Level of sulphur, chlorine and nitrogen are particularly relevant to the individual recipients, because of the health aspects of consumers and the longevity of heating systems, which are exposed to excessive corrosion.

European Union attempts to establish an international standard of quality for pellets. Committee for Standardization CEN TC 335 Solid Biofuels has proposed a set of definitions of different types of this fuel, the standard of sample testing and evaluation of quality of the production process, called prEN 14 961 (Hiegl et al. 2009). This standard consists of a general

Table 1. Comparison of selected wood pellets standards

Features	Certification name		
	DIN plus	**DIN 51731**	**Ö NORM M 7135**
Diameter [mm]	4 - 10	4 - 10	4 - 10
Length [mm]	< 5 x diameter	< 50	< 5 x diameter
Density [kg/dm^3]	> 1,12	1,0 - 1,4	> 1,12
Water content [%]	< 10	< 12	< 10
Abrasion [%]	< 2,3	–	< 2,3
Ash content [%]	< 0,5	< 1,5	< 0,5
Energy potential [MJ/kg]	> 18	17,5 - 19,5	> 18
Sulphur [%]	< 0,04	< 0,08	< 0,04
Chlorine[%]	< 0,02	< 0,03	< 0,02
Nitrogen [%]	< 0,3	< 0,3	< 0,3
Heavy metals [%]	regulated	regulated	not regulated

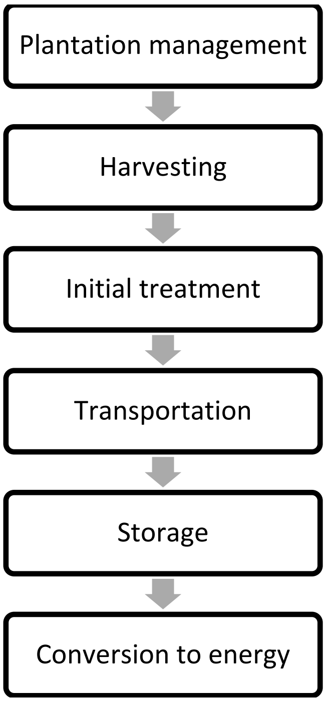
Source: www.as-plus.at, www.din.de

and specific standards for the various forms of biomass processing. The first part refers to the classification of the origin and sources of biomass derived from the environment and its processed forms that enter the market. The second part, characterise six groups of products: Wood pellets, Wood briquettes, Wood chips, Fire wood, Non-wood pellets. The purpose of this actions, taken by the European Commission, is to create a common nomenclature for communication between the suppliers of biomass, processors, consumers and producers of equipment associated with its treatment.

4 Pellet production process

Extraction of dormant energy from biomass is a complex process. There are three stages of converting organic matter into heat or electricity: obtaining the biomass from the environment, biomass processing - in this particular case it is pellet production, thermal treatment - usually burning.

The first phase in the production process is preparation of raw materials. The diversity of materials that can be used in this process was mentioned earlier. Biomass can therefore be obtained directly from the environment, may be a waste in the production of other goods or can be harvested from dedicated plantations. Scheme 1 gives an overview of the preparation of material for further processing.

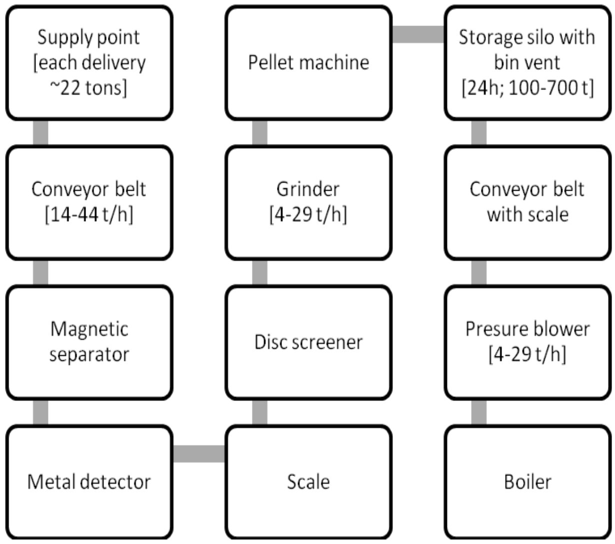


Scheme 1. Biomass supply chain

Suppliers of raw biomass take care of good condition of the material source. Plantations for example require appropriate use of fertilizers or pesticides. Biomass, which reached the appropriate age and properties, is collected and shredded for easier transportation.

The next step in the pellet supply chain is a manufacturing plant (scheme 2). A key aspect is its location (Hoeldrich et al. 2009), since logistics is an important role in the whole process. The facility should be located within a radius of 15 km from the origin of raw material, in order to prevent excessive losses of fresh biomass. Transportation time of already produced pellets is also crucial. That is why vicinity of highway, railroad or river/sea port is desired. The length of the production cycle is largely dependent on the level of automation of individual processes (Naik-Dhungel 2007).

Conveyors collect fresh biomass from new delivery. The raw material is then weighed, cleared of contaminants and dried. The next step is the fragmentation of biomass using hammer mills. Then the material in loose form, under air pressure, is placed in a device that forms pellets. In some cases, depending on the material properties used to create pellets, adding a special binder, which increases hardness and density of pellets, is needed. The final product is stored and cooled, which helps to improve its properties.



Scheme 2. Automatic biomass processing system

Source: Antares Group Inc., Assessment of Power Production at Rural Utilities Using Forest Thinnings and Commercially Available Biomass Power Technologies. Prepared for the U.S. Department of Agriculture, U.S. Department of Energy and National Renewable Energy Laboratory, 2003.

Pellet production plants, are often situated in the proximity of the power plants, which enables the direct use of the product for the combustion process.

Type of furnace plays an important role in generation of heat and electricity from the pellet fuel (Jakubiak and Kordylewski 2008). In practice, two types of boilers are used: a grate with power to 100 MWt and fluid bed - up to 600 MWt. For pellets used to co-fire with coal, water content in the product is an important indicator. Mostly desired is the closest match to the properties of coal not exceeding 15%. Too much water and other elements, which were already mentioned, increases the cost of depreciation of boilers. Another important aspect is the amount and melting point of ash which is a by-product of combustion. Ashes accumulated in the furnace chamber can easily damage the installation.

The best measure of the competitiveness of energy generated from the pellet is its price (figure 1).

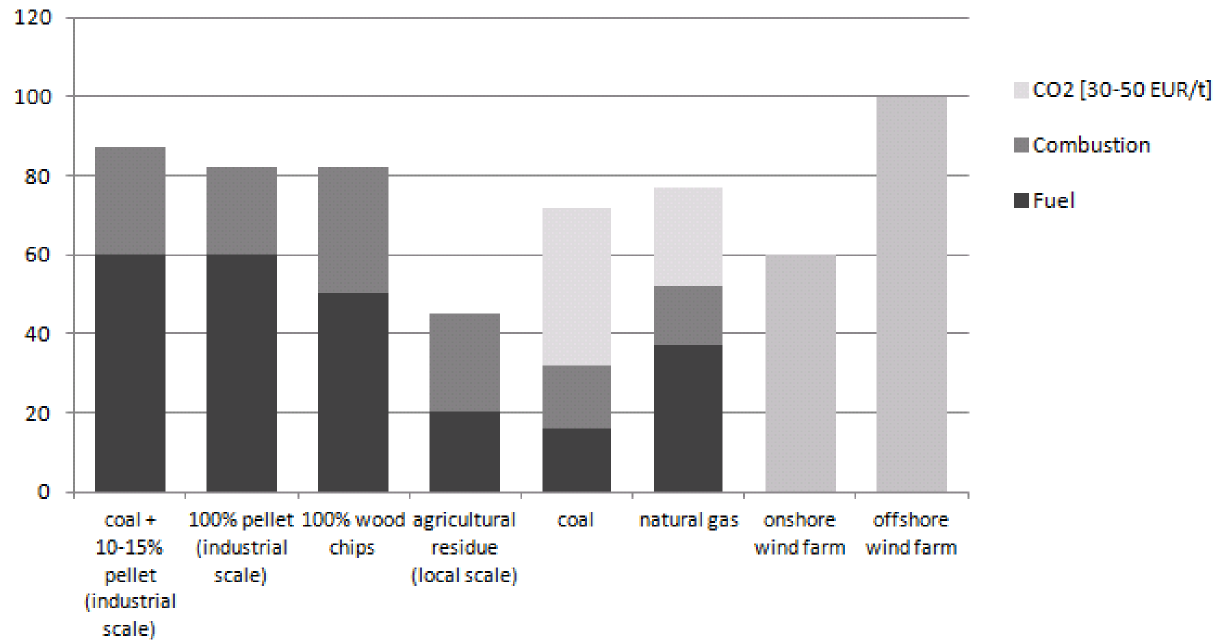


Figure 1. Cost competitiveness of different energy sources [EUR/MWh]

Source: P. Donaj, W. Yang, W. Blasiak, High-temperature steam gasification of straw pellets, Royal Institute of Technology, Stockholm 2010

The costs of fuel production from biomass is significantly higher than the prices of conventional fuels such as coal or natural gas. Carbon dioxide emissions, which is accompanied by fossil fuel burning, however, makes the final cost of energy production ranks at a similar level. This fact is of crucial importance in the promotion of pellets from biomass as an environmentally friendly energy source.

The structure of costs is shaped differently for individual consumers (figure 2).

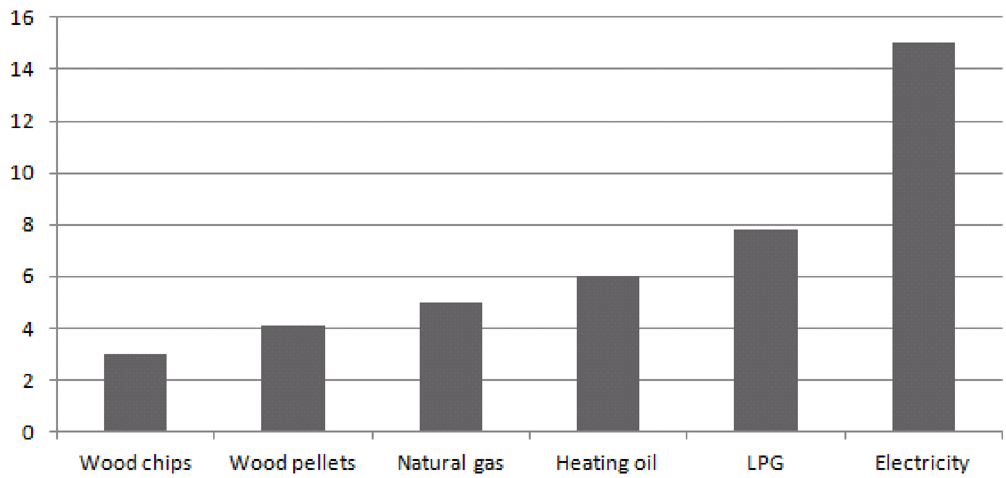


Figure 2. Fuel prices[GBP] (February 2012)

Source: www.biomassenergycentre.org.uk

Households that use pellets for heating, can significantly reduce their costs. Also in such small scale, the increasing importance of private biomass heating systems, can have a big impact on the environment (Jakubiak and Kordylewski 2008). It reduces level of low emissions, caused by the use of coal as main fuel.

5 Pellet market in Poland and Europe

The European Union countries are designated to achieve 20% share of renewables in overall energy consumption by 2020. This threshold stimulated the European pellet market to rapid growth. In the 2008 year, 630 plants producing 8 million tons of pellets per year operated in the EU countries, Norway, Switzerland, Russia, Belarus and Ukraine, (Sikkema et al. 2009). Imports of pellets from North America exceeded 1 million tons. The vast majority, 95% of produced and imported pellets is consumed for energy production purposes, which corresponds to 0.1% of total energy consumption in the EU (figure 3).

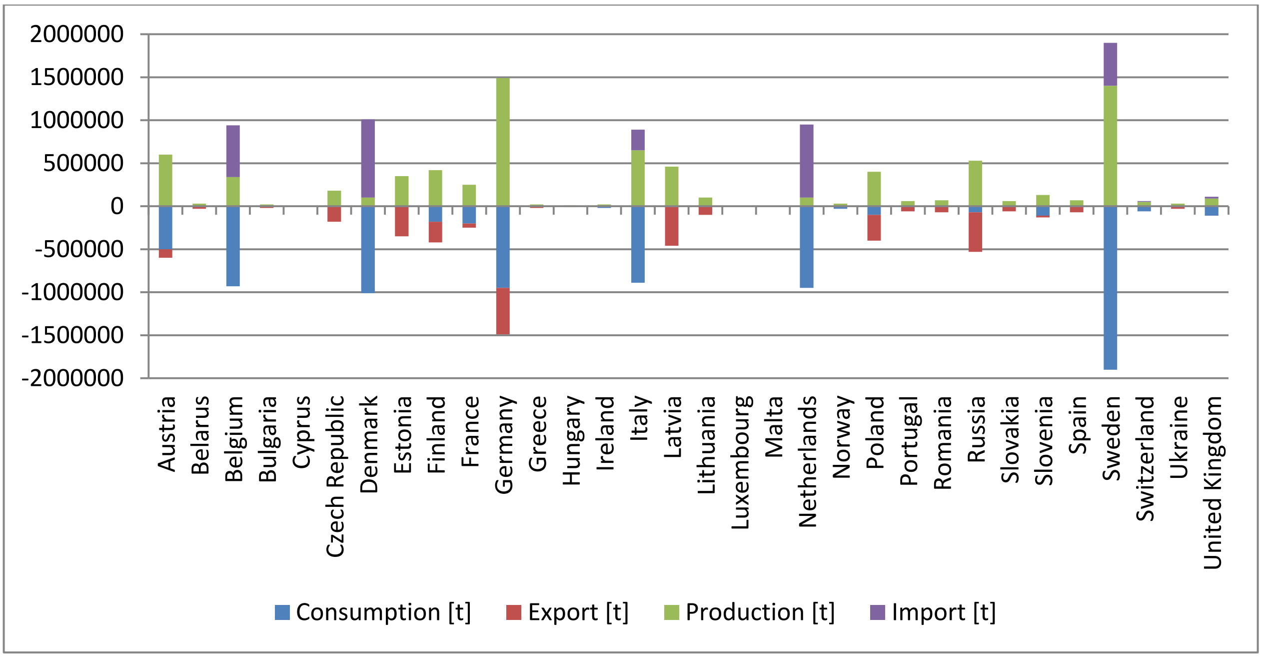


Figure 3. Pellet market balance in Europe in 2008

Source: R. Sikkema, M. Steiner, M. Junginger, W. Hiegl, *Final report on producers, traders and consumer of wood pellets*, Vienna 2009

The largest pellet producers in Europe are Germany (1460000 tonnes produced in 2008) and Sweden (1405000 tonnes) (Sikkema et al. 2009). These countries are also characterized by high consumption of this commodity (in case of Sweden, consumption excess domestic production capacity). Denmark and the Netherlands also are among the leading importers. Pellets are usually imported from other European countries, but also from Canada through the port of Rotterdam. Other raw material suppliers are Russia, Latvia and Estonia, which has contributed to the development of St. Petersburg and Riga as pellet exports centres to western Europe.

Another important factor that determines the pellet market is its price (figure 4).

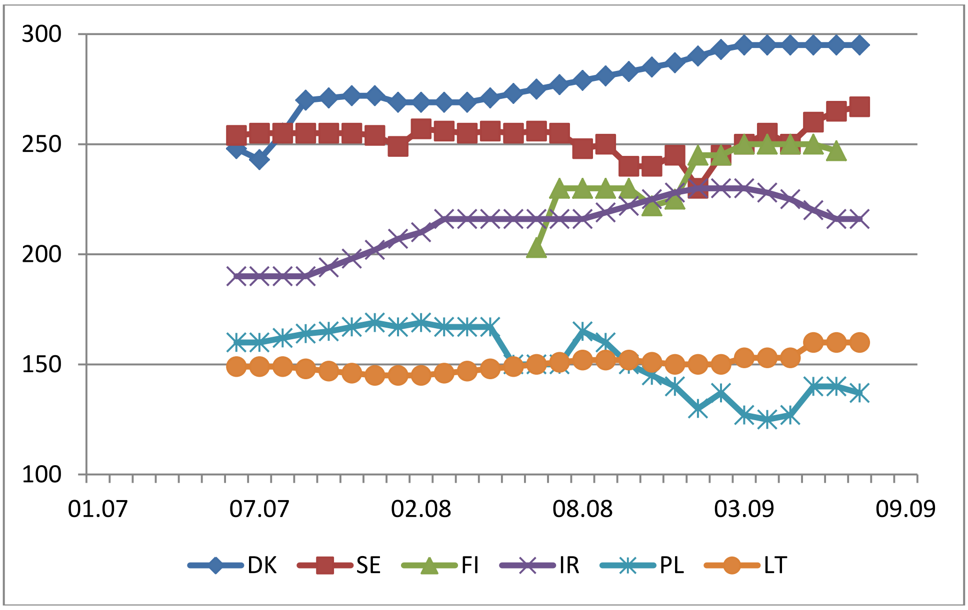


Figure 4. Pellet prices for individual consumers [EUR/t]

Source: R. Sikkema, M. Steiner, M. Junginger, W. Hiegl, Final report on producers, traders and consumer of wood pellets, Vienna 2009

Clear disparity can be spotted between prices in countries - consumers (Scandinavia, Ireland) and countries that are providers of goods (Lithuania, Poland). In German-speaking countries (Germany, Austria, Switzerland), that can be perceived as self-sufficient markets, pellet prices reach level of 210-230 EUR/t (Sikkema et al. 2009). It is difficult to define other factors that influence the prices of pellets on the market, as presented trends are mainly due to currency fluctuations in individual countries against the Euro.

Poland is among the emerging pellet markets (Capacciolo and Viverelli 2009). The production of this good was launched in 2003. Currently there are several companies producing an average of 30 thousand tons of pellets annually. Total production in 2008 reached 340 thousand tonnes. The largest share of the market are companies operating in the timber industry (including Barlinek). The main raw material used to manufacture pellets is wood.

Table 2 shows the components of the Polish market of energy from renewable sources. Plants using biomass-based technology are steadily gaining higher market share. However, comparing those data with countries of Western Europe, these values are still low. Therefore most part of the pellet production is allocated for export. Domestic consumption reaches the level of 120 thousand tonnes per year.

Table 2. Generators of renewable energy in Poland (July 2012)

Power plant type	Number	Power [MW]
Solar power	6	1.124
Biomass	21	485.409
Co-firing	46	–
Biogas	178	111.815
Wind farm	590	1968.305
Hydropower	750	951.460

Source: Energy Regulatory Authority, www.ure.gov.pl

Poland is estimated to have high potential of energy produced from biomass and is mentioned as one of the leaders of development in this field in Europe after France, Germany and Spain (Jasiulewicz 2010).

Another country with good perspectives of pellet market for the future is Romania. In 2009 total consumption exceeded 25000 t/a and price of pellets is fluctuating around 150 EUR/t. Production capacity is gauged for 21 plants reached 260000 t/a, so Romania can shortly became one of the important exporters in

European market (Capacciolo and Viverelli 2009).

6 Opportunities and threats for the development of pellet market

The future of pellet as a carrier of energy from biomass appears to be promising. This is influenced by many factors. Popularity of biomass is motivated by aspects of various types, such as (Jakubiak and Kordylewski 2008, Gostomczyk 2011):

- policy - European Union defines the share of renewables in the energy balance of the Member States (Poland should achieve a 15% share of renewables by 2020), also in the United States pellet is expected to significantly increase its importance (in the next decade up to several tens of percent) (Strauss and Colnes 2010);
- economic - energy production from biomass is the least capital-intensive process compared with other forms of renewable energy; important role play also European Commission subsidies; the EU, production of pellets can help to stimulate economic activity and reduce unemployment, for example, in areas where traditional farming ceased to be profitable (Dunn 2010) or in the poor countries of Africa, where the production of good quality goods, will not require large investments (Ferguson 2012);
- social - growing environmental awareness of citizens contributes to the popularisation of biofuels in industrial and individual scale;
- ecological - zero balance of carbon emissions to the atmosphere and lower emissions of harmful elements in comparison with the use of fossil fuels and the use of infertile soils for plantation of energy crops and utilization of wasteland overgrown with spontaneous plant communities as a source of natural raw materials for production of pellet;
- energy - a large, stable technical potential of biomass as a energy source (in Poland, estimated to be 400-800 PJ/a).

Preparation of pellets from biomass, also carries some disadvantages and risks. The fuel of this type is less caloric than coal, and therefore it is required to use the larger amount in order to achieve a similar effect. This raises issues related to transportation and the availability of larger storage areas, regular combustion equipment control and ash removal. Pellet production also consumes more energy than the direct burning of unprocessed biomass. Excessive implementation of energy crops could lead to the crowding out of the fields designed food production.

7 Conclusions

Increased efficiency in use of raw materials also applies to such basic resources as biomass. Intensifying its acquisition strengthen its position in the energy sector. Appropriate treatment that allows to form pellets, made biomass a resource that is competitive with other energy fuels.

References

Antares Group Inc. (2003), *Assessment of Power Production at Rural Utilities Using Forest Thinnings and Commercially Available Biomass Power Technologies*, U.S. Department of Agriculture, U.S. Department of Energy and National Renewable Energy Laboratory.

Capaccioli S., Viverelli F. (2009), *Analysis of new, emerging and developed European pellet markets*, ETA Florence Renewable Energies, Florence, http://www.pelletsatlas.info/pelletsatlas_docs/showdoc.asp?id=091027155248&type=doc&pdf=true

Donaj P., Yang W., Blasiak W. (2010), *High-temperature steam gasification of straw pellets*, Royal Institute of Technology, Stockholm,

Dunn K.L. (2010), *Grass pellets to burn*, American Agriculturalist, http://magissues.farmprogress.com/AMA/AM08Aug10/ama012.pdf

Ferguson H. (2012), *Briquette business in Uganda*, GVEP International, London, http://www.gvepinternational.org/sites/default/files/briquette_businesses_in_uganda.pdf

Gostomczyk W. (2011), *Influence and significance of energy biomass in sustainable development*, [in:] *Use of biomass in power engineering*, Jasiulewicz

M. (Ed.), Polskie Towarzystwo Ekonomiczne, Koszalin.

Grover P.D., Mishra S.K. (1996), *Biomass briquietting: technology and practices*, Field Doc. No. 46, FAO, Bangkok.

Hiegl W., Janssen R., Pichler W. (2009), *Advancement of pellets-related European standards*, WIP Renewable Energies, Munich/Vienna, http://bape.com.pl/LinkClick.aspx?fileticket=zv64RqEj-5E%3D&tabid=312&mid=697

Hoeldrich A., Epp C., Witzelsperger J. (2009), *Feasibility study for mixed biomass pellets production*, WIP Renewable Energies, Munich, http://www.pelletsatlas.info/pelletsatlas_docs/showdoc.asp?id=100927124659&type=doc&pdf=true

Jakubiak M., Kordylewski W. (2008), *Pelety podstawowym biopaliwem dla energetyki*, Archiwum Spalania , Vol.8, No 3-4.

Jasiulewicz M. (2010), *Potencjał biomasy w Polsce*, Wydawnictwo Uczelniane Politechniki Koszalińskiej, Koszalin

Naik-Dhungel N. (2007), *Biomass combined heat and power catalog of technologies*, U.S. Environmental Protection Agency.

Sikkema R., Steiner M., Junginger M., Hiegl W. (2009), *Final report on producers, traders and consumer of wood pellets*, HFA Holzforschung, Vienna, http://www.pelletsatlas.info/pelletsatlas_docs/showdoc.asp?id=091222195350&type=doc&pdf=true

Strauss W., Colnes A. (2010), *Heating the Northeast with renewable biomass – a vision for 2025*, Biomass Thermal Energy Council, Washington.

The Schumacher Centre of Technology & Development (2005), *Biomass. Practical Action*, Intermediate Technology Development Group, London, http://www.mtec.or.th/images/users/78/55E.coli/biomass.pdf

Vermont Grass Energy Partnership (2011), *Technical Assessment of Grass Pellets as Boiler Fuel in Vermont*, University of Vermont, Montpelier.

www.as-plus.at

www.biomassenergycentre.org.uk

www.din.de

ec.europa.eu/eurostat

www.ure.gov.pl

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