
ELEMENTS CONCERNING THE ENERGY CHARACTERISTICS OF BIOMASS AND TECHNOLOGIES FOR CONVERTING IT INTO PELLETS

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Abstract: *The European Commission appreciates that the role of biomass used for heat and electricity production in the EU Member States will increase, so that 20% of the produced energy will come from renewable sources by 2020. Biomass is considered to be neutral on greenhouse gas emissions because, while burning biomass generates carbon dioxide as well as burning fossil fuels, at the time of recurrence, it will re-absorb a quantity of carbon dioxide equivalent to that released during burning. Bioenergy is based on a wide range of potential raw materials: forestry and agricultural residues, waste and also materials grown for energy purposes. Raw materials can be converted into heat, electricity or transport fuels. Biomass has the highest degree of flexibility among all forms of renewable energy.*

Keywords: *Biomass, pellets, pelletizing equipment, heat power*

1. Introduction

The Earth's major challenge in the third millennium in the field of energy is the orientation towards renewable energy production systems in conditions of sustainable energy development that will provide the population with the energy they need without altering the planet's major ecosystem.

Renewable energy is one of the alternatives to the replacement of fossil fuels, with great prospects for future development. According to SRE-SEC (2008) estimates, a 34.9 Mtoe (million tons of oil equivalent) energy consumption forecast in Romania is projected by 2020 [1]. Biomass covers more than 60% of total Renewable Energy Sources (RES), namely 190 -200 PJ / year (Gheorghiescu et al. 2007, quoted by [2]). One of the main strategic directions that Romania has to implement is to mobilize all efforts to introduce and implement the RES.

Biomass reserves differ across the European Union and globally. The forest area ranges from 27.6 million hectares in Sweden to 117 ha in Cyprus (Panoutsou, 2011). Worldwide, the forest fund occupies approximately 4 billion ha, with the largest amount being distributed on the territory of the Russian Federation - 809 million ha, Brazil - 478 million ha, Canada - 310 million ha, the US - 303 million ha, China - 197 million Ha.

Of the 27 countries of the European Union, Romania ranks 8th in terms of its forestry fund, and globally Romania owns only 0.15% of the total area of forest land in the world. Biomass resources can also be determined by the degree of usage of the land that each country holds. Thus, approximately 50.1% of the area of 4 303 401 km² is used in the European Union, 1 041 423.04 km² being used for agricultural purposes and 309 844.87 km² for forestry (Eurostat 2012).

Increasing energy efficiency has a major contribution to achieving security in the field of energy and sustainable energy development, competitiveness in saving primary energy resources and reducing greenhouse gas emissions [2].

2. Combustible characteristics and energy potential of the biomass

The combustible characteristics of wood biomass differ from one material to another and of course they differ from those of fossil fuels. Biomass, in addition to the main advantage of being renewable, has a number of disadvantages compared to fossil fuels, which must be taken into consideration: biomass density and calorific value of wood species is lower compared to fossil fuels; some biomass sources are mostly generated only seasonally, requiring material storage in optimum conditions to avoid biodegradation; the thermal systems used for the conversion of

biomass must have high capacities, leading to an acceptable level of energy efficiency; unmanaged biomass usually has a high moisture content, which is the main factor that results in low heat output from combustion processes; the thermo-chemical characteristics of the biomass are inferior to those of fossil fuels because of the high oxygen content, alkaline substances and chlorides.

In industrial practice, manufacturing waste is produced from all the industrialized wood species: Horse chestnut (*Aesculus hippocastanus* L.), Hornbeam (*Carpinus betulus* L.), Turkey oak (*Quercus cerris* L.), Sweet cherry (*Prunus avium* L.), Beech (*Fagus silvatica* L.), Ash (*Fraxinus excelsior* L.), Birch (*Betula pendula* Roth.), Sycamore maple (*Acer pseudoplatanus* L.), Wild pear (*Pyrus pyraster* L.), Acacia (*Robinia pseudacacia* L.), Willow (*Salix alba* L.), Elderberry (*Sambucus nigra* L.), Oak (*Quercus rubur* L.), whose heat power is shown in Figure 1. [2]

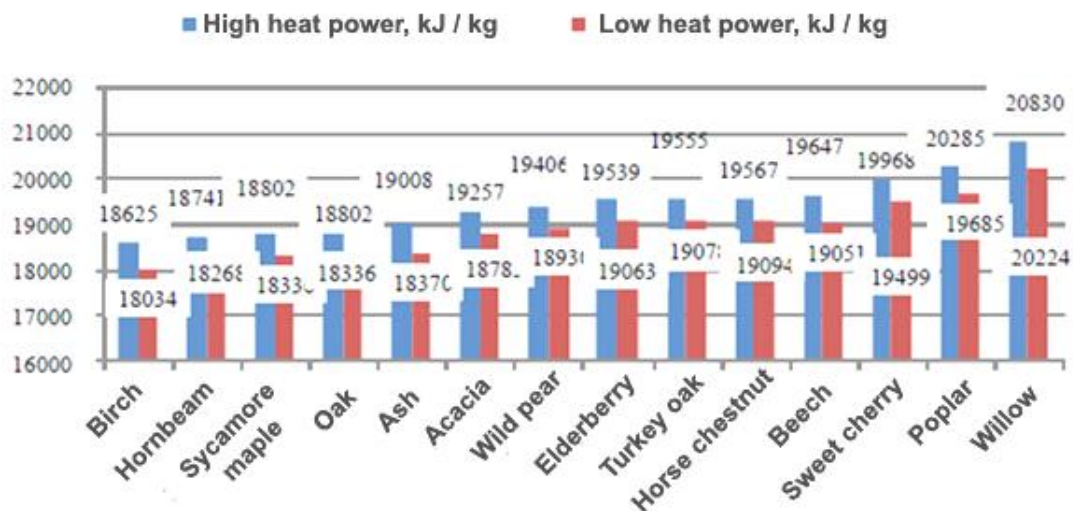
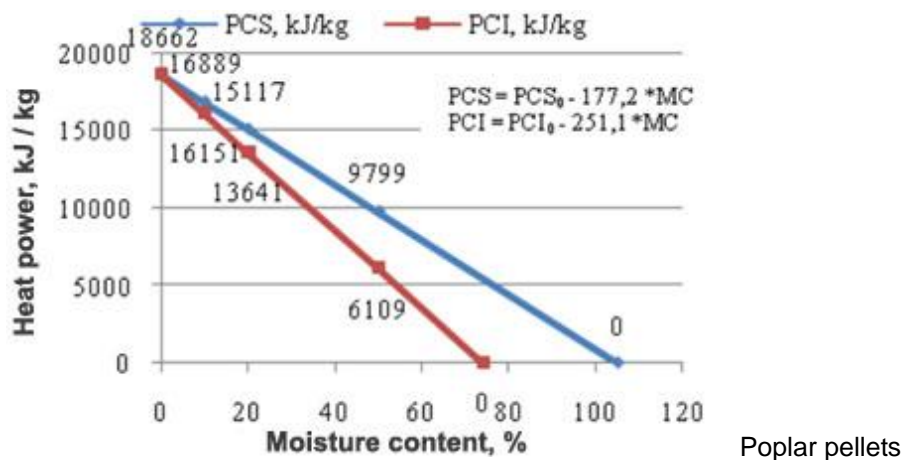


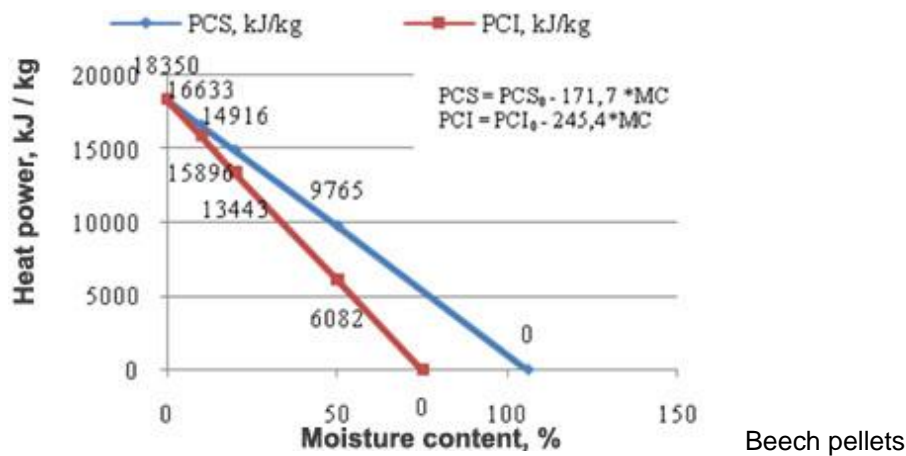
Fig. 1. Heat power of indigenous deciduous species

One of the possibilities of using wood biomass as fuel is in the form of briquettes and pellets. Wood biomass briquettes and pellets are superior products made from shredded wood, by compression and without additional additives.

Figure 2 shows the influence of moisture on calorific value of briquettes and pellets of poplar and beech species [2].



a.

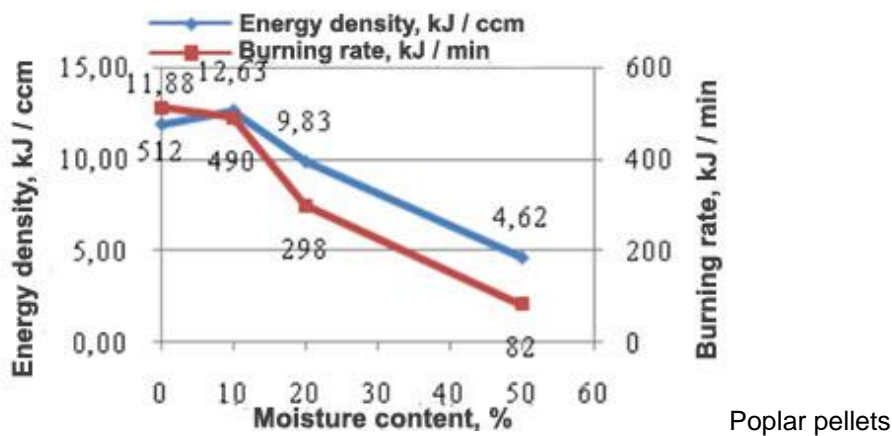


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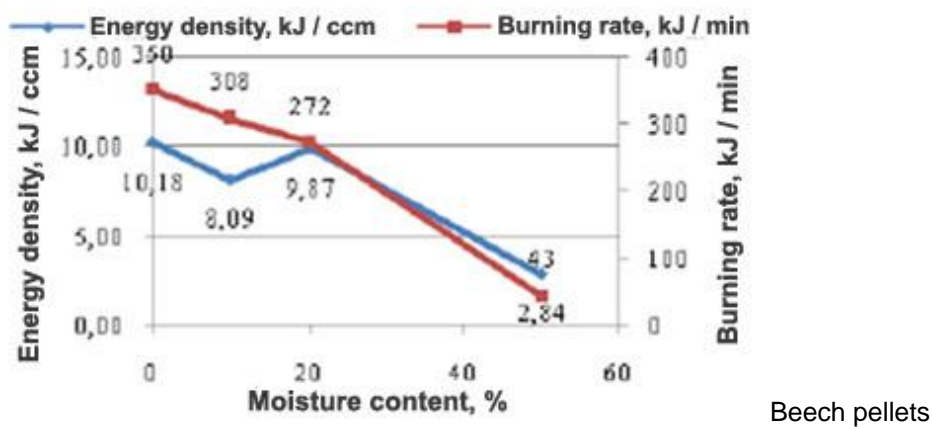
Fig. 2. Influence of humidity on calorific value of briquettes and pellets made out of poplar (a.) and beech (b.)

The importance of their use compared to massive firewood is due to the fact that the products are dried to 10% moisture content and keep this constant moisture up to the moment of use due to the polyethylene packaging they are stored in.

Figure 3 shows the influence of moisture on the energy density and burning rate of pellets and briquettes made out of poplar and beech species [2].



a.



b.

Fig. 3. Influence of humidity on energy density and burning rate of pellets and briquettes made out of poplar (a.) and beech (b.)

Figure 4 shows the influence of humidity on the energy efficiency of pellets and briquettes made out of spruce and oak tree species [2].

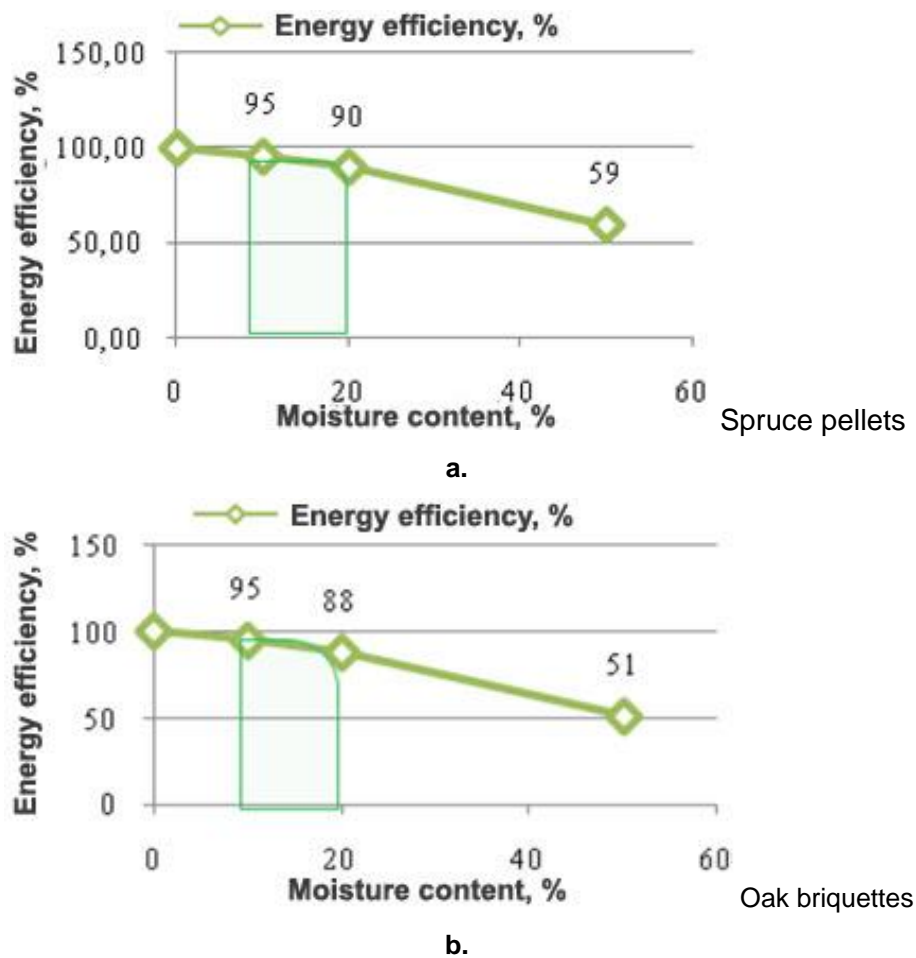


Fig. 4. Influence of humidity on energy efficiency of pellets and briquettes made out of spruce (a.) and oak (b.)

3. Increasing calorific value of pellets and briquettes by torrefaction

The calorific density of the pellets and briquettes is better than the wood species actually used as fuel, in that they are used at 10% humidity and have a high compaction degree.

Thermal treatment is increasingly being used in processes for improving the mechanical or physico-chemical characteristics of wood biomass. Changing the structure and properties of biomass is achieved by changing the chemical composition, providing enrichment of carbon content. Biomass thermal treatment or torrefaction is a method by which its energy characteristics approach those of fossil fuels such as coal and pit coal.

Torrefaction is a process similar to pyrolysis, differing by a shorter treatment period which takes place in the low temperature range (200-300°C), (Chen et al., 2010, quoted by [2]).

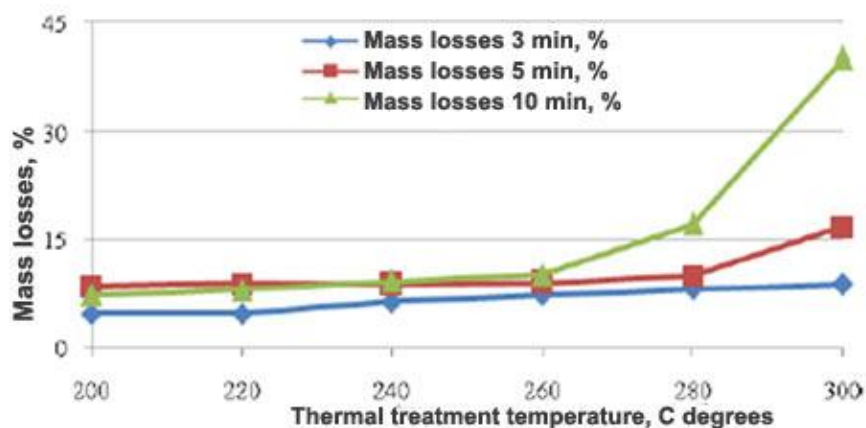
The torrefaction treatment is carried out at constant parameters: thermal treatment temperature of 200-300°C and treatment time of 3-10 minutes. The fixed values of the duration and temperature of the thermal treatment are top limiting, because by overcoming these values, even if the heat power increases, the cohesion of pellets and briquettes decreases significantly.

The calorific value of wood biomass is directly dependent on the elemental chemical composition (carbon, hydrogen and oxygen), but also on the main chemical compounds of wood (lignin, cellulose and hemicellulose).

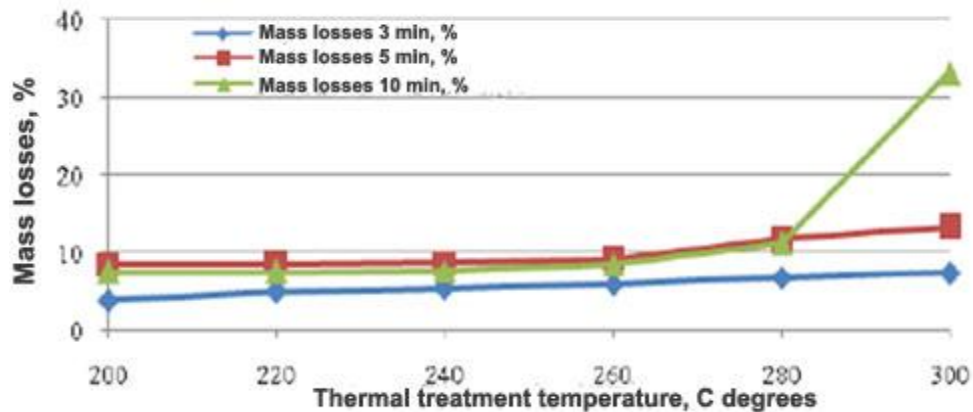
By torrefaction, there occur significant mass losses and chromatic changes of process materials, regardless of the studied species - starting from a yellowish colour (the control sample), continuing with light brown (at 240°C) and reaching a dark brown to black (at 300°C). The loss of mass recorded after thermal treatment, Figure 5, is due to the decomposition of the main chemical compounds of wood, namely cellulose, hemicellulose and lignin [2].

Decompositions begin at a temperature of 150°C, at which point water evaporates from the wood; in the range of 150-250°C the volatile substances in the material are eliminated; after 250°C there takes place decomposition of chemical compounds formed such as CO₂ and H₂O (Aghamohammadi et al., 2011; Chen et al., 2012 and 2011, Serrano et al., 2013; Bates et al., 2013 - quoted by [2]).

According to Aghmonammadi's research (2011), one can notice massive mass losses occurring at temperatures above 405°C, and at 570°C there is no mass loss. Mass losses ranged from 0-4% to 8-15%, the results directly depending on the moisture content of the pellets in the treatment process.

Oak (*Quercus robur* L.)

a.

Beech (*Fagus sylvatica* L.)

b.

Fig. 5. Mass loss of oak (a.) and beech (b.) depending on the heat treatment temperature

In the description of Phanphanich et al. (2011) quoted by [2] biomass shows a loss of 10-20% through volatile substances and other chemical elements that are eliminated. Following the heat treatment process, the carbon content is greatly increased compared to the control sample. Mass losses occur in the initial phase on the temperature range of 150 - 220°C, at the time the material is heated and until the ignition takes place (Chen et al., 2011a, Chen et al., 2012, quoted by [2]).

4. Presses for the manufacturing of pellets

The pellets are manufactured by pressing without binders wood waste or secondary agricultural production (straw, sunflower stems, soybeans and rape, corn cobs and corn husks, grains, beans, branches resulting from maintenance works in orchards, leaves, seeds and wheat shells from the food industry).

The pelletised material has to fulfil two essential conditions: the size of chips ranges between 30-50 mm and the maximum moisture is 15%. In this regard, a pellet manufacturing line will comprise equipment for raw material drying, chopping and pelletizing.

Pellet presses, Fig. 6, which will be referred to below, consist of a chassis, drive group (garmotor or electric motor, coupling and conical reducer), press body, feed basket.



Fig. 6. Pellet making press

The press, which is the main assembly of the pelletizing equipment, consists of a body in which the mold and the presser roller shaft are mounted, Fig. 7a, b.

The pelletizing presses are made in two constructive variants: with rotary mold and fixed axle of the presser rollers, and respectively with fixed mold and rotary axle of the presser rollers.

The fixed mold design [3] offers increased rigidity, allows for more precise and simple tuning; it allows also the use of larger presser rollers, which increase the machine's working capacity and reliability.

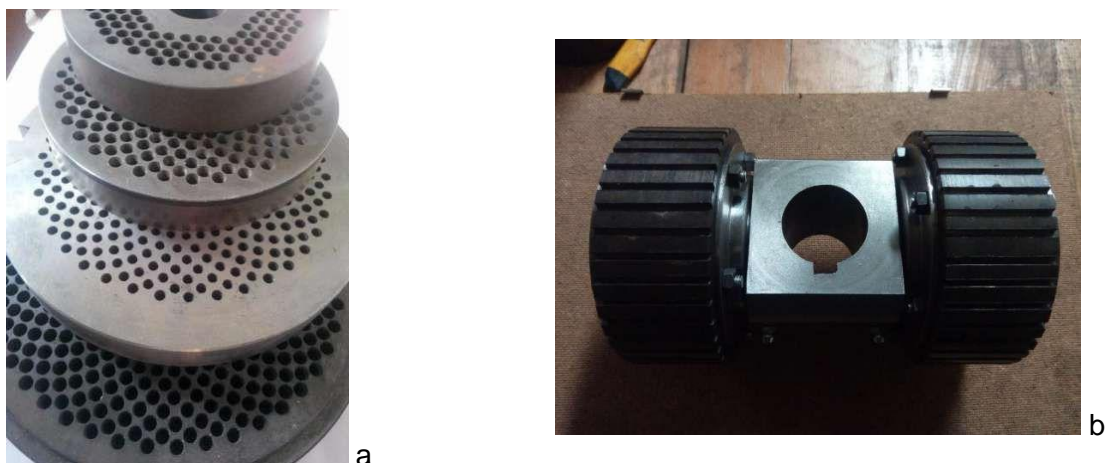


Fig. 7. Pelletizing press: a-mold; b-axle with presser rollers

Of the pelletizing equipment available on the Romanian market, the KRONPELLET brand covers a wide range of powers and working capacities, Table 1.

Table 1: Technical characteristics of the KRONPELLET pelletizing equipment

Pressure Type	Engine power, kW	Diameter of mold, mm	Working capacity, kg / h (wood)
KPP - 120	2.5- monophase	120	30
KPP - 150	4- three phase	150	50
KPP - 200	10-three phase	200	150
KPP - 250	15- three phase	250	250
KPP - 275	18- three phase	275	300
KPP - 300	30- three phase	320	480

The process of manufacturing the pellets involves extruding the material through the holes in the mold, under the action of the presser rollers (with satellite motion) whose axle is integral with the vertical shaft of the conical gear transmission, Fig. 8.



Fig. 8. Presser chamber of the pelletizing equipment

At IHP Bucharest an original bearing system for the vertical shaft of the press has been designed to allow the use of worm gears capable of transmitting high powers and torques compared to conical gear reducers. The technical solution is the subject of a patent application.

5. Characteristics of pellets, advantages and disadvantages of their use

Diameter: 3-15 mm (the most commonly used are 6 mm diameter pellets)

Length: <60 mm

Bulk weight: ~ 650 kg / m³

Density:> 1200 kg / m³

Moisture: <8%

Ash: <1.5%

Heat power: from 3500 to 4500 kcal / kg.

Advantages of wood pellets:

- They are relatively ecological, derived from wood waste;
- They are clean, modern and cheap energy source;
- They have very high autonomy; depending on the built pellet storehouse and the automation of the thermal plant, the autonomy of a pellet boiler can be of 1 month or even 2 months;
- A pellet thermal station, being regarded as ecological, can be purchased through the GREEN HOUSE program;

- The production of pellets is done by using wood waste and thus a cleanup of the natural environment of the soil polluting materials takes place;
- They are carbon neutral because they emit as much as the same amount of CO₂ (carbon dioxide) that was absorbed by the tree during its growth;
- Smoke emission resulting from burning of pellets is very low;
- In the flue gases the dust is alkaline;
- They have a low content of metals and sulphur is almost non-existent;
- The ash resulting from the burning of pellets can be later used as a natural fertilizer because it is rich in minerals;
- The cost of using pellets is lower than in the case of fossil fuels;
- Making a comparison with firewood, it results that pellets are more efficient in terms of combustion efficiency, calorific value, comfort and safety in use;
- In comparison to a conventional gas heating plant, a pellet heating plant will consume about 20-30% less for the same thermal output produced; if a comparison is made with a condensing gas boiler, which has a better efficiency than a conventional one, a pellet boiler will have about the same consumption for the same heat output;
- It requires a relatively low storage space, for a tonne of pellets a volume of approximately 1200 - 1500 liters / 1.2 - 1.5 m³ is required.

Disadvantages of wood pellets:

- The cost of acquiring a high quality thermal plant on pellets or related equipment (bunker, sink, engine, pumps, safety valves, expansion vessels, etc.) can exceed 2 or 3 times the cost of purchasing a common wood-powered thermal power station, a gas-fired thermal power station, an electric thermal power plant on methane gas or LPG;
- High sensitivity to the pellet feed system of the boiler; the auger engine may clog or burn very quickly, the auger and the burner can be clogged by pellets if there is no periodic cleaning at 2-3 days and if the used pellets are of very poor quality;
- In the case of a pellet thermal plant, a quite large technical space is required for the installation of the boiler, the related equipment and the pellet bunker / pellet storehouse, the chamber which should meet the rules and regulations in force;
- Electric power interruption involves the introduction of safety features in the installation (which leads to an increase in the initial investment), such as a gasoline or diesel automatic generator or a UPS;
- A pellet boiler requires the installation of a chimney;
- Although the pellet boiler is considered to be ecological, however, burning pellets results in noxious matter, even if in a small quantity;
- The choice of pellets is usually done on the basis of the lowest price - the cheapest pellets; in this case there is the risk of buying poor quality pellets that will affect the correct functioning of the pellet boiler, respectively the equipment related to it.

6. Conclusions

At European level, alternative energy sources (RES) will contribute significantly to providing the necessary energy; provisions are made that in 2020 they will represent 20% of total energy used. The high potential for energy production lies with biomass (47%), followed by hydro energy (45%). The term biomass includes agricultural products, waste and residues resulting from agricultural technological processes (grain straw, residues from the production of sugar, starch, beer, tobacco, canned fruit cans, by-products of the vine and wine industry- cords, grape bunches and grape pits, branches resulting from orchard maintenance works, etc.), wastes from forestry and related industries as well as the biodegradable fraction of urban vegetal and animal wastes. Thermal treatment or torrefaction is a method by which the energy characteristics of biomass are approaching those of fossil fuels, involving changes in the structure and chemical composition, causing the carbon content to be enriched.

Biomass briquettes and pellets are superior energy products, made from compacted material without compression and without additional additives. The process of manufacturing them involves the existence of complex technological lines, which include equipment for drying, grinding, briquetting / pelletizing and storage of raw material.

Within IHP Bucharest there are concerns about finding innovative, patentable technical solutions in the development of biomass briquetting and pelletizing equipment.

Acknowledgements

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