LARGE SCALE SUPPLY AND INTERNATIONAL TRADING OF REFINED BIOMASS

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ABSTRACT: The long-term world estimated bioenergy potential is huge. It could reach 3-10.75 Billion TOE/y for the year 2050. (Source: G-8 / Bioenergy partnership). Other optimistic estimations anticipate a potential as much as 23 billion TOE/y bioenergy, enclosing residues, wastes and energy crops (Source: Report: ISSN1654-9404/UPP sala Sweden, 2009). The major role will be played by solid lignocellulosic biomass feedstocks. In particular, the large amount of agricultural residues (0.8 billion TOE/y) and of Forestry residues (0,4 Billion TOE/y) may represent the first challenging (for its lower quality) but readily available resource that needs to be refined. In this paper pelletization and torrefaction processes for biomass agricultural residues refining and trading will be analysed. Especially pelletization treatment is now reaching a real large scale spreading in international trading. Humidity, air contact storage retention time, loss of volatile organic content are the main problems related to Agro-pellets long distances transport, large volume supply and long time storage activities. Direct torrefaction of pelletized agro-residues could represent a really attractive solution to avoid many problems for large scale supply and trading of refined biomasses.
Keywords: Torrefaction, Agro-pellets, Logistic, Trading,

1 INTRODUCTION

It is common awareness that bioenergy world potential is impressive if compared to other renewable energy sources. Biomass is not only represented by wood, or energy crops plantation. A large part of still unused bio-energy potential is made of the huge amount of agricultural and forestry residues available all over the world. Agricultural residues are estimated to reach 0.8 billion TOE per year, while forestry residues 0.4 TOE/y. The problem is that both agricultural and mainly forestry biomass wastes are difficult to be collected and utilised.

This impressive amount of potential energy is well known among industries and authorities, but there are still many obstacles and problems for the practical exploitation of this resource. The challenging aspects are due to:

- The diluted and dispersed nature of residues
- The rather expensive recovery
- Lack of technology and modest experience and low economic interest for the recovery

However, in view of the general wide and diversified interest for exploiting this huge renewable energy potential, is vital to develop and in future make available on the market a: refined Solid–Biomass Commodity of universal value that, once standardized, could become attractive and of high techno-economic interest for all sectorial bioenergy markets (heat-power-transport) and bio-chemicals. One of the most attractive well-known technologies for improving biomass residues utilization and international trading is pelletization. Agro-pellets (AP) produced with this system allow biomass to be stored in smaller volume (high energy density) with only 10% moisture content, ready to be burned efficiently. Furthermore, torrefaction of AP is a new supplementary refining technology where agro-pellets are submitted to a mild-carbonisation process around a temperature of about 300°C, where volatiles are removed and a hygroscopic product with an higher energy density is produced, thus improving its use with transportations and storage savings.

2 AGRO-PELLETS

The AP technology is a basic pre-treatment technology for stabilization and compactation of humid biomasses. To understand the importance of this new technology and its impact on future modern bio-energy activities the following fundamental related issues must be considered.

2.1 AP main characteristics

Most humid biomasses for modern utilisation needs to be dried at about 14% m.c.. At harvesting in general biomasses have a moisture content of ~ 50% and are thus submitted to biological degradation with G.H.G. emissions. By processing humid biomass into AP, its specific energy content is increased from ~ 2,000 Kcal/kg to ~ 4,000 Kcal/kg (consuming ~ 600 Kcal/kg).

• Biomass for practical reasons needs to be compacted. Loose biomass has a low volumetric density (~ 150 Kg/m3). AP, having a diameter 6-10 mm, a bulk density of ~ 0,7 – 0,8 t/m3, reduce drastically the handling transport, storage, logistics costs, especially for large scale supply.

• The supply of biomass must have homogeneous chemical-physical characteristics. This is a basic condition for stable operation of a plant. Because the new technology is able to manufacture AP from any type or mixture of biomasses, the possibility to homogenising the final product coming from different biomasses supply and to arrange the elemental composition of AP (by biomass blending) makes easier the correct operation of a conversion/utilisation plant. In particular to limit the chlorine, alkali-metals content of AP, that represents a critical issue for boiler.

This AP technology seems now appearing on the market the only technology world-wide able to process directly humid* biomasses with a moisture level of 25% - 30% in one step, avoiding thermal pre-drying at 14% moisture level as requested from all other pelletization technologies. In the process the moisture is lost as steam.

• The technology is able to process also very humid biomass (moisture level 60% - 70%, like peat, entire sweet-sorghum cane) by re circulating the pellets, after

first step pelletization and grinding throughout the processing dials, but with time considerable loss (processing capacity loss) in the present existing one stage plants. In future, "Multi-stages" pelletization Units (now under scrutiny) will be available to overcome the present mechanical drying limitations. The utilization of two-three in series is a too expensive solution.
Present state of the art:

- Much lower energy consumption in comparison with other technologies: max. 100 KWhe to produce 1 t of pellets (with 10% moisture) from humid biomass (50% moisture).
- Present capacity range: 0.8 up to 10 t pellets/hr (different configurations).
- Any type of mixture can be pelletized into AP (also wood and herbaceous mixtures like bagasse foresting residues).
- Very high density of pellets: ~ 1,34 gr/cm^3
- AP (50% coal dust- 50% of biomass); peat/biomass AP (25% - 50% - 75% biomass).
- Bulk density: 750-800 kg/m^3.

Figure 1

2.2 AP storage and transportation logistics

Although its high energetic value (0.3 TOE/ m$^{3)}$ and density (1,3 gr/cm$^{3)}$, AP still presents some difficulties in large scale market and transportation. Due to its organic content, being made by only compacted biomass with 10% moisture, AP transportation is mainly performed using trucks, trains and ships, where AP are stored in closed tanks, or in bags and sacks or piles respecting well defined safety configuration to avoid air humidity increase and damage of the product. This can be translated in a considerable limitation for large scale volume and long distance transportation with consistent increase of trading costs. Furthermore, once this product is delivered, for example from harbors, an immediate transport service to deliver pellets to the utilization site is needed to avoid the high storage costs imposed by harbor for limited local spaces availability.

3 TORREFACTION

Torrefaction is a thermal pre-treatment technology, which produces a solid biofuel product that has superior handling, milling and co-firing capabilities compared to other biofuels.

Figure 2

Torrefaction involves the heating of biomass in the absence of oxygen to a temperature around 300°C. The structure of the biomass changes in such a way, that the material becomes brittle, and more hydrophobic and more energetic due to the loss of its oxygen content. Although the weight loss is in general about 15%, during the torrefaction process a combustible gas is released, which is utilized to provide steam and heat to the process. In the figure below the energy and mass yields are shown for autothermal operation as a function of the moisture content in the feedstock. With increasing moisture content more energy is required to achieve autothermal operation and as a consequence the cost of torrefaction will increase.

Here below are listed the main considerations that make this torrefied product the most promising solution for large scale supply and production of bioenergy:

- The potential amount of agro-pellets obtained from any type of biomass or mixtures (even with peat) is huge (10-20 billion TOE/y), in comparison with the estimated wood-pellets potential of only 0,4 Billion TOE/y.
- The Torrefaction (mild carbonization) process improves the quality of the treated biomass by its homogenization effect and because most of Cl and Tars are eliminated.
- Significant cost savings in transport, especially when the biomass is also pelletized after torrefaction. This results in a typical volumetric energy density of 15.0 – 18.7 MJ/m3, instead of 7.5 – 10.4 MJ/m3 for wood pellets.
- "Torrefied Pellets", using different processes, can be utilized for district-heating, cogeneration, cofiring with coal and also for advanced biofuels production and bio-chemicals (F.T., jet fuels, bio-hydrogen, synthesis gas…).
- Possibilities of fast, reasonable cost, torrefaction process for large capacity plants (0,5-3 mio t/year) have been experimentally identified and investigated.

Although Torrefaction process is an old well-known wood-treatment process since one-century, actually there is a significative revival of interest because several attractive chemical-physical characteristics of torrefied biomass like:

- Small loss of material during the process (~ 10 – 15%);
- Loss of chlorine content (up to 80%) and of Tar during the process;
- Loss of volumetric density of biomass (up to 25%);
- Increase of the energy content of biomass (up to 30%);
- Increase of the energy content (up to 5200 kcal/kg).

Intensive world-wide activity (research, development, demonstration) is under way now with more than 50 implemented programs. However no commercial technology is still available on the market, because important limitations are always present, like:

- High investment cost;
- Reliability;
- Capacity escalation difficulty (actual limit: 100000 t/y)

At present, the production of Torrefied-Pellets (or Bio-Coal-Pellets, generally identified as very attractive solid-biomass-commodity) is obtained by:

- Torrefaction of biomass (i.e. wood-chips);
- Grinding to torrefied biomass in fine powder;
- Pelletisation of torrefied powder.

EUBIA with its partners (Modern Bioenergy in Luxembourg, G-Energy Technology LLC in USA, Mezzanine Fund in Belgium, etc.) has developed a completely new full system concept based on:

- The production of AP from any type of biomass, mixtures or peat, by the new technology of mechanical drying and compactation; small (1 t/hr) mobile pelletization units (under implementation now) will facilitate thus the recovery of the huge amounts of dispersed agro-foresty residues and fo their preliminary treatment in view of final product (AP) standardization in large pelletization plant (10 – 20 t/h);
- The direct conversion of AP into "Torrefied-AP" the future most desirable anticipated solid Biomass Commodity for all Bioenergy Sectorial-Markets and Biochemical-Market. Three basic Technologies (Patent Pending) have been studied and successfully tested since five years, with anticipated processing capacity up to 3 mio t/year.
- A large supply-chain of Torrefied-AP for promoting significative international trading of Torrefied Biomass among continents.

The production and use of Torrefied-AP is also of great interest for expanding and accelerating the deployment of bio-energy world-wide. In fact, its high volumetric energy density, its hygroscopicity (outside storage) can reduce the cost of its related logistics (transport, storage..) facilitating the trading among continents. In fact the typical anticipated AP Torrefaction processing cost are reasonable (~250 €/t) with part of processing cost compensated by the transportation cost saving ~ 10 €/t.

4 COMPARISON BETWEEN CONVENTIONAL AGROPELLETS TORREFACTION COST.

Even if the torrefied AP clearly have an higher production cost than wood pellets, the torrefaction leads to a lot of savings in logistics costs, like transportation, handling and storage costs.

In fact long distance transportation (hundreds of km) of torrefied AP could be reduced drastically (patent pending). Sea-Boat transportation (i.e. between USA and EU) could be reduced around 20% because the higher energy density of the refined product and for easy handling. Storage of Torrefied-AP can be made outside (without coverage) for several moths without fuel degradation. In figure here below typical production of AP and of Torrefied-AP are presented. This should make the Torrefied-AP production market more attractive than the conventional pellets one. Intensive activity is being at present carried world-wide with the development of many technologies.

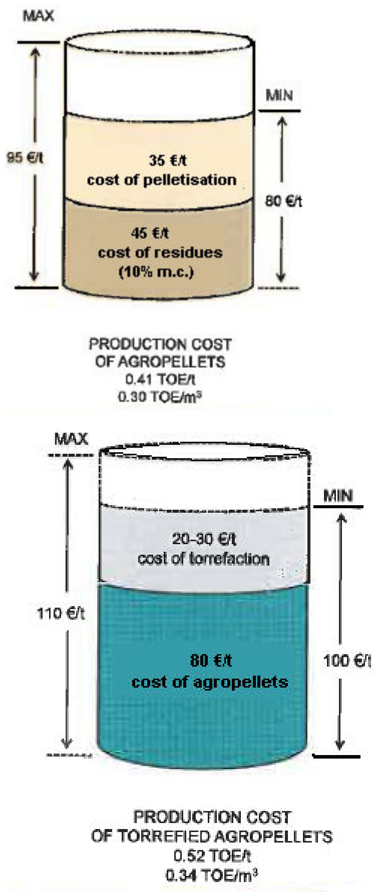

Figure 3

Two different methods are thus in competition:

- Torrefaction of biomass followed by pelletization
- Pelletization of biomass of any type followed by torrefaction

Two members of EUBIA are developing since several years and in cooperation with a USA Co. a range of specific related technologies following the above method 2.