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Assessment of dry residual biomass potential for use as alternative energy source in the party of General Pueyrredón, Argentina

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ABSTRACT

The present article assesses the residual biomass availability and its energy potential in the Party of General Pueyrredón, a region located southeast of the province of Buenos Aires, Argentina. These were considered herbaceous and vegetable residues derived from the agricultural activity developed in the region, and forest residues resulting from the pruning of urban trees and garden maintenance. The estimates were based on statistical information of the 2011–2012 harvest and a series of parameters obtained from an extensive literature review. The calculations resulted in an availability of residual biomass of 204,536 t/year, implying an energy potential of 2605 TJ/year. If this biomass is used to generate electricity, it could supply 76,000 users from Mar del Plata city, the largest consumer center in the region. If the same available biomass is used for heat generation, 25,160 users could be supplied by the available residual biomass. The authors concluded that the residual biomass energy potential is significant in the studied region, but a more detailed study must be conducted to assess the techno-economic feasibility of using the available residual biomass as alternative energy source.

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1. Biomass, world overview

The global energy market depends heavily on fossil fuel energy sources such as coal, oil, and natural gas [1,2]. Since it takes millions of years for these fuels to be formed in the earth, their reserves are considered finite, thereby subjected to depletion as they are consumed. The only natural and renewable resource based on carbon that is vast enough to be used as a substitute for fossil fuels is biomass [3,4]. Unlike fossil fuels, biomass is renewable in the sense that only a short period of time is needed to replace what is used as an energy resource [5,6].

The use of biomass for energy generation has gradually declined throughout the humankind history, due to the massive utilization of fossil fuels. Nevertheless, in the nineteenth century biomass still continued to be the main source of primary energy. Currently, it provides 10% of worldwide primary energy (53.3 EJ), and this proportion has not significantly changed in the last decades, as shown in Fig. 1.

Considering the countries' level of development, it can be observed an uneven use of biomass as a primary energy source. While in developed countries[1] it constitutes the most utilized renewable energy source (corresponding to 5% of the primary energy supply, above hydroelectricity with a 2% of contribution), in developing countries' contribution of biomass in the primary energy supply exceeds 8% (see Fig. 2). This three percentage point difference may seem insignificant, but when disaggregating the non-OECD data, as shown in Fig. 3, it can be observed that in African countries biomass represents the main source of primary energy. Similarly, the contribution of this energy source in Asia is substantial, reaching 14.5%, and in non-OECD countries in the Americas, the percentage is almost 20%. In developing countries biomass is mainly used by the residential sector, which consumes 66% of the supplied primary energy, being the main end use for home heating and cooking [7–9].

In recent years the world energy context has changed considerably. The increasing cost of fossil fuels and the technology advances have empowered the development of biomass-based energy systems that are more efficient, reliable, and environmentally friendly [10]. In this context, the concern of many countries to use this renewable energy source as a total or partial alternative to fossil fuels is increasing [11,12].

It is of common knowledge that the development capacity of the biomass sector is still significant, nevertheless the estimates of which will be the contribution of biomass in the future global energy market vary significantly depending upon the literature consulted. According to the study presented by Berndes et al. [13], the contribution of biomass in the global energy supply in 2050 ranges from 100 EJ/year to over 400 EJ/year. For these authors [13], the reason for such significant divergence in the forecasts relay on the uncertainty over two key factors: the availability of land and the energy crops productivity levels.

A more recent study published by the World Energy Council [14], based on an extensive literature review, shows that the worldwide technically available biomass potential may reach 1500 EJ/year in 2050. However, most predictions that take into account sustainability constraints point out a more conservative potential between 200 and 500 EJ/year (see Fig. 4). As seen in Fig. 4, the projection of the primary energy demand for 2050 ranges between 600 and 1000 EJ/year, expecting a bioenergy demand of 250 EJ/year. According to Gadonneix et al. [14], biomass can sustainably supply between one quarter and one third of the estimated primary energy demand for 2050.

According to Long et al. [15] the discrepancy in the results among different projection models is due to the complexity of the factors that influence the bioenergy potential, which has hindered reaching an understanding about the participation of biomass in the future global energy scenario. Furthermore, these authors [15] identify the most controversial factors in the biomass scenarios assessment: climate exchange, technical and economic development, and land availability.

It is important to consider that biomass use may impact, in a competitive way, on some other uses, as food and fodder. Dodić et al. [16] discussed the policy, market conditions and food security of biomass energy sources for supplying the future needs of Vojvodina, Serbia, concluding, in a general way, that international cooperation, regulations and certification mechanisms must be established regarding the use of land, the mitigation of environmental and social impacts caused by biofuel production. Pedroli et al. [17] expressed their worry about how to reach, in a sustainable way, the renewable energy targets of European Union adequately identifying land resources to be used for biomass production and/or harvesting without causing losses in biodiversity. Vávrová et al. [18] present a model for biomass potential assessment under different scenarios of agricultural land utilization, concluding that current biomass potential can be significantly increased with allocation of energy crops on less fertile land according to food security scenarios.

2. Biomass: general aspects

Biomass comprises all biological material derived from living, or recently living organisms. In the context of biomass for energy this is often used to mean plant based material, but biomass can equally apply to both animal and vegetable derived material [19–21]. Within this definition, biomass for energy can include a wide range of materials, such as: virgin wood, derived from forestry, arboricultural activities or from wood processing; agricultural residues, from agriculture harvesting or processing; industrial waste and co-products, from manufacturing and industrial processes; food waste, from food and drink manufacture, preparation and processing, and post-consumer waste; domestic and municipal waste; and animal manure. These materials contain chemical energy from the solar radiation energy transformation. This chemical energy can be directly released by combustion, or alternatively converted to other energy sources, according to the end used [22].

The reaction between CO_2 in the air, water, and sunlight via photosynthesis produces the carbohydrates that constitute the building blocks of biomass. This process typically converts about 1% of the available solar energy into chemical energy [5,23]. This energy derived from the sun is stored in the chemical bonds of the

[1] In this work it is consider developed countries those members of the OECD organization.