SUPPLY AND DEMAND OF BIOMASS-BASED ENERGY IN BRAZIL: ESTIMATES USING TIME SERIES ANALYSIS AND GENERATION POTENTIAL

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Overview

In this work, we developed estimates of the supply and demand of biomass-based energy in Brazil. This type of energy is receiving increasing attention due to its benefits in terms of sustainability and trade balance. We applied time series analysis to forecast demand based on historical data. The energy potential was estimated based on agricultural, livestock, urban solid waste and forestry production. The projections indicate that the demand in 2032 will reach 78 million tons of oil equivalent, which is around 17% of the 457 million tons of national energy potential based on the production of 2022, or 22% of the upper bound considering a 95% confidence interval. The results show a significant gap between the projected use and the potential supply of this type of energy in the country. A national energy planning aimed at exploring this gap, while considering its effects with respect to inputs, costs and other uses, may lead to a higher share of alternative energy sources, better diversification and improved efficiency.

Methods

First, we developed a method to project biomass energy consumption in Brazil over the next ten years, from 2023 to 2032, applying historical data in an ARIMA (Autoregressive integrated moving average) model. The data were obtained from a periodic report released by the Brazilian Ministry of Mines and Energy (2022). The series corresponds to energy consumption from total biomass, comprising sugarcane bagasse, firewood, black liquor, biogas and other recoveries, in tons of oil equivalent (toe), between 1970 and 2022.

We analyzed the historical series in order to identify trends or changes in the variance. We then verified whether the stationarity requirements are met using the augmented Dickey-Fuller test. We found that the series is stationary in level. After testing, we applied the Box and Jenkins (1976) time series technique, concluding that the autoregressive model of order 1 is the most appropriate for the series.

The second part of our analysis comprised the estimation of the potential for production of biomass-based energy in Brazil. Firstly, we estimated the potential for energy generation based on biomass from crops in Brazil. We extracted data of the Municipal Agricultural Production (PAM) in 2022, released by IBGE (Brazilian Institute of Geography and Statistics). We considered all products with national production above one million tons in 2022, both permanent and temporary crops. We estimated the energy in toe based on the formula presented by Gonzalez-Salazar et al. (2014), which is basically the production of the agricultural product multiplied by waste to product ratio, adjusted by the moisture content, and finally multiplied by the lower calorific value. These parameters for each product were obtained from several academic studies and are presented among the references in the full paper. Among the 27 products (that total 1.1 billion tons in Brazil in 2022), we did not find the parameters only for papaya (1.1 million tons) and watermelon (1.9 million tons).

Regarding livestock biomass, we obtained data from the Municipal Agricultural Production (PPM) in 2022, also from IBGE. We considered cattle, swine, poultry and equine. We estimated the energy potential of the waste based on the formula also presented by Gonzalez-Salazar et al. (2014), which considered as reference the amount of biogas produced from each animal's manure through a biodigestion process. The formula relates the number of animals to the production of manure per animal, the yield of biogas per manure and the lower calorific value. The values of those parameters were presented by Gonzalez-Salazar et al. (2014), based on a literature review.

We estimated the energy potential from forest biomass using the survey carried out by IBGE on the production of plant extraction and forestry in Brazil. The production volume of charcoal, firewood, round wood and cellulose (for bleach production) was multiplied by the by-product to product ratio, the average density and the lower calorific value. The values of those parameters were also obtained and presented by Gonzalez-Salazar et al. (2014), based on a literature review.

Finally, with respect to the urban solid waste, we considered the estimate made by IPEA (Brazilian Institute of Applied Economic Research) that approximately 160 thousand tons of waste of this type are generated per day in Brazil, discounted by an ideal recycling rate of 60%. We converted it into landfill volume and then into energy potential using the lower calorific values cited by Gonzalez-Salazar et al. (2014). Whenever we found more than one parameter value in the literature, we chose the lower one to have conservative estimations.

Results

According to the historical data, total biomass consumption showed a sharp increase in its share of the energy matrix, equivalent to 86.5%, between 2000 and 2022 (2.9% per year), going from 34 to 64 million toe. This energy comes mainly from the use of sugarcane bagasse in cogeneration systems. In line with this growth rate, our results for total biomass projections pointed to an increase of 22.9% between 2022 and 2032 (2.1% per year), reaching 78 million toe in 2032.

With respect to the annual energy potential, our estimate totaled 457 million toe, 14 million based on biomass from permanent crops, especially orange, 412 million based on biomass from temporary crops, particularly sugar cane, soybeans and corn, 11 million from livestock farming, 19 million from plant extraction and forestry, and 579 thousand toe from the use of urban solid waste. Actual biomass energy consumption in Brazil in 2022 represents 14% of this consolidated estimate of potential generation.

Conclusions

Our analysis shows that there is still a considerable gap between Brazil's biomass-based energy consumption and its production capacity based on the generation of waste and co-products in agriculture, livestock, forestry and urban activities. Considering the advantages of this type of energy in terms of carbon neutrality, energy security with local production chains, and socioeconomic development, this scenario favors the adoption of public policies to stimulate an increase in the production, through tax incentives and special lines of financing for the acquisition of machinery and the development of both waste and co-product supply chain and the flow of the produced energy.

Moreover, the promotion of research and innovation initiatives to improve the efficiency of waste-to-energy conversion processes contributes to this goal, as well as the modernization of the legal and regulatory framework related to the use of waste and to energy trade. Such policies should include an evaluation of the effects of any stimulus in terms of the inputs needed to intensify the production, as well as its impact on other supply chains.

It is important to highlight that our consumption projection method is based mainly on the historical growth, and that actual demand could be even greater due to the contribution of structural shocks, such as new public policies to encourage the production and use of this type of energy, or to reduce the use of fossil fuels. Furthermore, our potential production estimate is based on data about waste generation of 2022, which means that it may also present a growth projection that can be addressed in future work. The determinants of consumption and production potential of this type of energy can also be investigated to contribute to this analysis.

References

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