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Potential estimation of municipal solid waste for hydrogen production in Brazil

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Abstract

The increasing volumes of non-recyclable municipal solid waste (MSW) that cause problems around the world can be reused to produce a portion of the world's clean energy resources, making them important contributors to sustainable energy systems. In 2021, Brazil generated 225,348 tons of MSW daily, 60.2% (45 million tons per year) of which was sent to landfills, and the rest - 38 million tons per year (corresponding to 39.8% of the total amount collected) - was sent to inadequate disposal facilities (controlled landfills or dumps).

In the sanitation sector, Brazil has a significant potential for biogas generation reaching 2.2 billion $Nm^3.year^{-1}$. In addition to landfills, two gasification systems are marketed in the country for the treatment of refuse derived fuel (RDF). The fixed bed system that can treat from 144 $t.day^{-1}$ (suitable for small municipalities) and the fluidized bed system that treats 56 $t.day^{-1}$ (suitable for municipalities with more than 55 thousand inhabitants).

Recently biogas and waste gasification have received considerable attention due to they offer the alternative of hydrogen production. Hydrogen has been identified as one of the sources that can facilitate decarbonization due to its ability to store and deliver large amounts of energy without generating carbon dioxide (CO_2) emissions during combustion. Hydrogen can play a decisive role in the decarbonization of energy industries, including the sectors of air and maritime transport, as well as the steel and chemical industries.

The petroleum sector accounts for about 95% of the total hydrogen production in Brazil and it is self-producing, i.e., its production is destined for its own consumption for use in

refining processes (gasoline, diesel and lubricant hydrotreatment). The remaining 5% of the national production is produced by the gases industries sector. The hydrogen consuming market in the country is found in the following sectors: steel and metallurgy (pig iron reduction), food (hydrogenation of margarine products), flat glasses (tin bath inerting process), energy production (thermoelectric plants-turbine cooling) and agriculture (fertilizers).

In the previous context, this paper presents an estimate of the potential for hydrogen production in Brazil from biomethane reforming and fluidized bed gasification of RDF processes, based on research data on waste generation per capita, number of inhabitants per municipality, and treatment capacity of the technologies available in the country. The MSW gravimetric composition for each municipality was assumed equal to the average composition of the region in which it is located in the country. In order to quantify the generation of methane (CH_4) from the waste disposal in landfills in each municipality, the methodology of the Intergovernmental Panel on Climate Change (IPCC) "Guidelines for National Greenhouse Gas Inventories" was adopted. On the other hand, in the case of gasification, the municipalities of medium size (60,000≤ inhab ≤1000,000) were evaluated.

The analysis was carried out based on two scenarios: the first scenario covers the study of the hydrogen potential according to the current MSW treatment conditions in the country, i.e., waste collection coverage of 92% and a recyclables recovery rate of 2.2%. The second scenario considers the goals of the national solid waste plan for 2040, a collection coverage of 100% and a recyclable material recovery rate of 20%. From this study it is concluded that Brazil has a potential for hydrogen generation from biomethane reforming of 2.34 million $t.year^{-1}$ and 175 thousand $t.year^{-1}$ from the RDF gasification. Aiming at sustainable economic development through massive decarbonization, increasing the participation of bioproducts, as well as valorizing MSW as a raw material for other destinations, Brazil presents an attractive market that could be an opportunity for the development of several technologies as well as the study of little explored sources for hydrogen generation. MSW recovery where industry by-products can be sent back into the economy in a circular, low-carbon manner while protecting the basic principles of waste management (waste hierarchy) will be key in the energy transition.

Keywords: Biomethane reforming; Gasification; RDF