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Evaluation of Potential and Technological Challenges in Producing Hydrogen from Biomass in India.

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I. Introduction

Hydrogen has been an important intermediate in the chemical industry and refineries. It has reported the annual production of around 60 million metric tonnes in 2018 (Statista, 2021). However, fossil fuels account for 95 percent of the global hydrogen supply today, resulting in significant carbon dioxide emissions. Furthermore, water electrolysis with electricity produces a small amount of hydrogen but since it uses fossil fuels for electricity, it does not sustainably address the greenhouse gas issues. As a result, hydrogen generated from renewable energy is a viable option for addressing the problem of greenhouse gases, especially carbon dioxide. Hence, hydrogen production through gasification could be a promising choice for future decarbonization applications based on renewable and carbon dioxide-free hydrogen.

Biomass is a renewable source if it is derived from sustainable sources including forest residues, tree, energy crops, farm waste, and other wood residues. Nevertheless, the availability of biomass can be a major barrier to producing H_2. So, selecting a country that has enormous resources of biomass is strongly considered. An example of that India has a high potential of producing biomass. Currently, it has about 500 metric tons per year availability (Mnre, 2021). The figure below illustrates the different resources for biomass feedstocks in India**.**

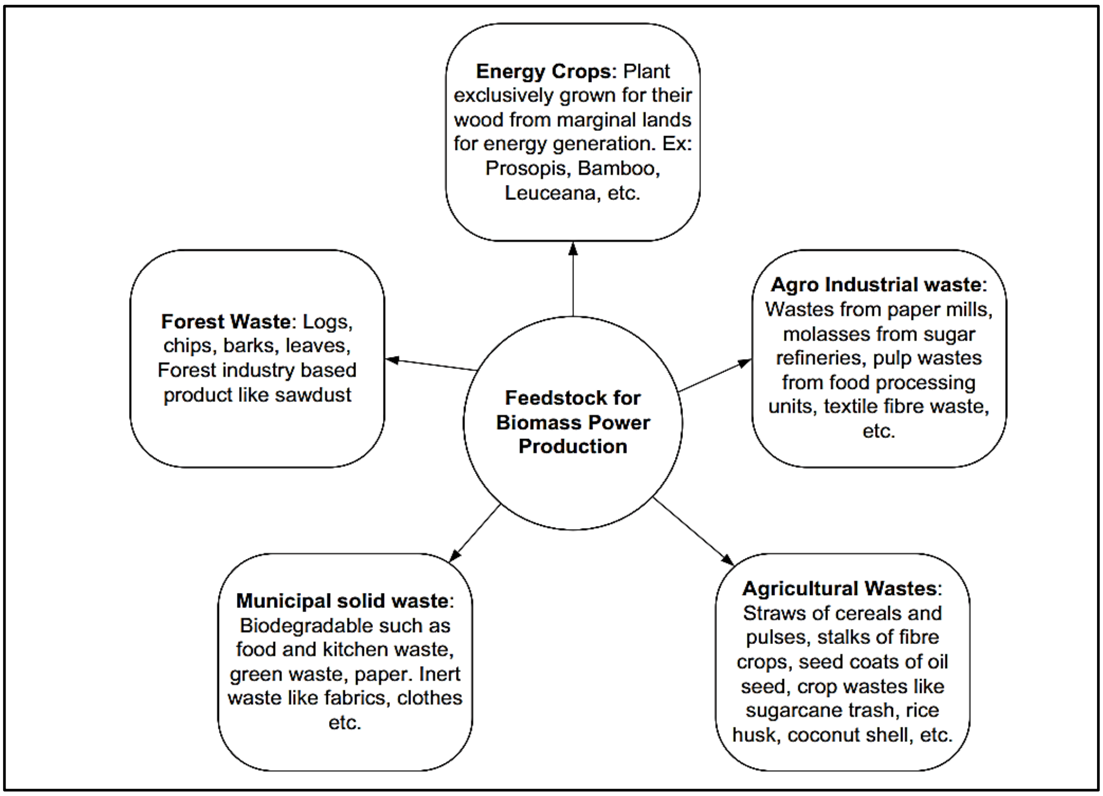

Figure 1: Shows the different resources of biomass feedstocks in India (Kumar et al., 2015).

Biomass gasification is a mature technology for hydrogen production and has been applied in the chemical and refinery industry between 1960 and 1980 (Breault, 2010). The process is a thermochemical process that covert organic matter by partial oxidation into gaseous products called syngas. These products contain hydrogen, carbon monoxide, carbon dioxide, ash, and tar. Therefore, the aim of this report is to evaluate the potential and challenges of biomass gasification for hydrogen production in India.

Biomass availability in India

Since India has such a large agricultural land area, it produces a lot of residues. The table below has shown crop residue production in million tonnes in India. These agricultural residues refer to all organic materials produced as a by-product of the processing harvesting of crops. Moreover, there are two types of agricultural residues: primary and secondary residues. The primary one is that which is collected in the field at the time of yield, while the second residue is that which is gathered during processing. In addition, main residues include sugar cane tops, rice straw, and bagasse, while secondary residues include bagasse and rice husk. All residues can be used as a sustainable feedstock for chemical and energy products.

	Crop residue production (million tonnes)
2010	556
2020	708
2030	868

Table 1: Shows crops production increases in million tonnes in different years (Pavlenko et al., 2019).

Biomass gasification

Biomass gasification is mainly composed of four stages. Firstly, it is drying at about 40 to 200 Celsius (Jewiarz et al., 2020). This is a necessary stage to remove all moisture or water of biomass feedstock before pyrolysis takes place. Secondly, it is devolatilization or pyrolysis which involves the production of biochar and other synthesis gases in absence of air and temperature between 300 and 650 ℃ (Basu, 2018). additionally, tar gases or char from pyrolysis could be used as fuel for combustion since most heat drives drying, pyrolysis and reduction occurs directly from oxidisation reaction or is recovered indirectly from combustion via a heat exchange process. Gasification is where the decomposition of hydrocarbon into a synthesis gas takes place at a controlled amount of oxygen. This is carried out at a temperature between 800 and 1000 ℃ (Basu, 2018). The resulting gases are hydrogen and carbon monoxide with by-products including liquids and tars, charcoal, and mineral matter. The below reaction shows the partial reaction that can be found in biomass gasification.

$$carbohydrate\ matter\ (C_6\, C_{10} O_5) + O_2 \rightarrow C_X H_Y + C_L H_M O_N + CO + H_2 + Heat$$

A biomass gasifier can run at ambient pressure or at a higher pressure than that. The gasifying agent may be air, oxygen, or oxygen-enriched air in general. Air is usually used as an oxidant in biomass gasification.

Types of Gasifiers

Gasifiers are categorized according to how air or oxygen is added. So, gasifiers are broadly divided into fixed bed, fluidized bed, and entrained flow. Downdraft and updraft gasifiers are the two forms of fixed bed gasifiers as they are shown in the figure below which are sometimes referred to as concurrent and counter current. For the classification of updraft gasifier, the air is passing through the biomass from the bottom and the combustible gases come out from the top of the gasifier. This is similar to the downdraft gasifier; the air is passing from the tuyeres in the downdraft direction. However, each gasifier has different limited sizes of particles, amount of carbon, and investment. This has been summarised and shown in table 2.

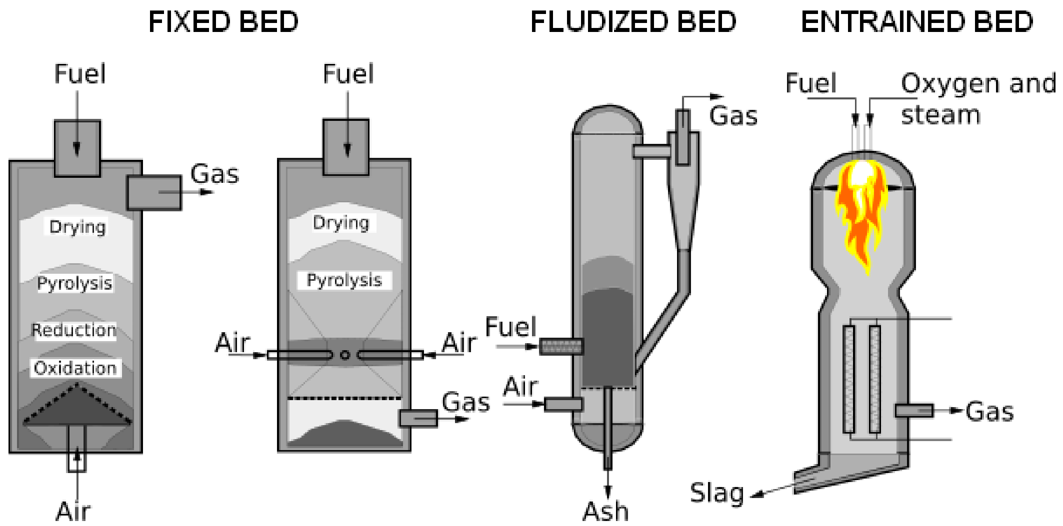

Figure 2: Shows the main types of fluidised bed and fixed bed gasifier (Gasification - FLEDGED, 2021).

Table 1: Shown main difference between fluidised bed and fixed bed.

Fluidized bed	Fixed bed	Ref.
• Limited size particle size (up to 50 mm)	• Very great particle size possible (up to 100mm)	[8]
• Tar (1 g/m3n); high tar content in the gas	• Nearly tar free gas	[8]
• Low carbon formation	• High carbon formation	[9]
• There is no plant operating continuously at design parameter for more than 500 h/a	• There is no plant operating continuously at design parameter for more than 500 h/a	[8]
• Lower investment	• Higher investment	[8]
• No problems with feedstock fines	• Feedstock fines must be agglomerated	[8]
• Broad particle size distribution	• Particle size as uniform as possible	[8]
Where red dot represents negative and the orange one represents positive.		

The table above has shown some of the technological challenges with the most common gasifier used for biomass gasification. In addition, it has been concluded that tar formation can be led to poor efficiency and other mechanical issues of the process. So, the successful removal of tar is a technological challenge for biomass gasification technology.

Tar removal

Tar is considered a major issue in biomass gasification since it can produce a variety of problems, including, lower system productivity, equipment blockages as well as poor gas quality. Tar is made up of such different materials and is made up of a group of extremely complex mixtures. Toluene benzene, naphthalene single-ring aromatic hydrocarbons, and other components. The main reason of formation tar is because the lower temperature of gasification. So, the study shows that increasing the temperature of gasification can reduce the amount of the tar in the outflow as well as increasing the temperature could promote tar cracking. Research shows that by rising the heating rate from 70 percent at 100 Celsius per second to 48 percent at 10,000 Celsius per second, the maximum tar yield decreases (Nik-Azar et al., 1996). However, the size of particles can lead to the high formation of tar as well. According to previous studies, particle size and the surface area to volume ratio of the loading feedstock have an important impact on tar yields. It was discovered that for beech wood, the overall tar yield decreases from 53 percent to around 38 percent as particle size increases from 53 – 63 micrometres to 270 to 500 micrometres (Nik-Azar et al., 1996). However, in terms of thermal kinetics, gasification of larger particles requires more time to overcome greater thermal conductivity resistance and it would take also longer to complete heat transfer and devolatilization of biomass materials. Although tiny particle size can also aid the rapid diffusion of gasification agent and reducing the overall process time, the small size of feedstock particles requires a much higher energy input during the biomass preparation process.

II. Conclusion

To sum up, this report has evaluated the biomass gasification process for hydrogen production. It has selected India as a country for biomass. It has been found that tar formation can be a major problem and can lead to high-cost maintenance and low gas quality. In addition, hydrogen production by biomass is still in small scale and it has been found that no plant can operate at design parameters for more than 500 h/a. Therefore, gasification technology is still struggling with these challenges including tar and other trace impurities.

Reference

[1]. Statista. 2021. *Hydrogen production worldwide 2030 | Statista*. [online] Available at: <https://www.statista.com/statistics/1121207/global-hydrogen-production/> [Accessed 11 March 2021].

[2]. Mnre.gov.in. 2021. *Current Status | Ministry of New and Renewable Energy, Government of India*. [online] Available at: <https://mnre.gov.in/bio-energy/current-status> [Accessed 11 March 2021].

[3]. Kumar, A., Kumar, N., Baredar, P. and Shukla, A., 2015. A review on biomass energy resources, potential, conversion and policy in India. Renewable and Sustainable Energy Reviews, 45, pp.530-539.

[4]. Breault, R., 2010. Gasification Processes Old and New: A Basic Review of the Major Technologies. Energies, 3(2), pp.216-240.

[5]. Pavlenko, N. and Searle, S., 2019. The potential for advanced biofuels in India: Assessing the availability of feedstocks and deployable technologies.

[6]. Basu, P., 2018. Biomass Gasification, Pyrolysis and Torrefaction - Practical Design and Theory. 3rd ed. Elsevier. Retrieved from https://app.knovel.com/hotlink/toc/id:kpBGPTPDT1/biomass-gasification/biomass-gasification

[7]. Jewiarz, M., Wróbel, M., Mudryk, K. and Szufa, S., 2020. Impact of the Drying Temperature and Grinding Technique on Biomass Grindability. Energies, 13(13), p.3392.

[8]. Warnecke, R., 2000. Gasification of biomass: comparison of fixed bed and fluidized bed gasifier. Biomass and Bioenergy, 18(6), pp.489-497.

[9]. Zhang, S., Xiao, R. and Zheng, W., 2014. Comparative study between fluidized-bed and fixed-bed operation modes in pressurized chemical looping combustion of coal. Applied Energy, 130, pp.181-189.

[10]. Nik-Azar, M., Hajaligol, M., Sohrabi, M. and Dabir, B., 1996. EFFECTS OF HEATING RATE AND PARTICLE SIZE ON THE PRODUCTS YIELDS FROM RAPID PYROLYSIS OF BEECH-WOOD. Fuel Science and Technology International, 14(4), pp.479-502.

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