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# Pre-processing of sugarcane bagasse for gasification in a downdraft biomass gasifier system: A comprehensive review

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ABSTRACT

The processing of sugarcane bagasse as a potential feedstock for efficient energy production has attracted a great deal of attention in the sugarcane industry, which has traditionally inefficiently burned bagasse in boilers for steam and electricity generation. Alternative technologies for more efficient utilisation of bagasse for energy production within the industry has also been hindered by the high degree of complexity involved in bagasse handling and pre-processing before it can be utilised as an energy feedstock. This can be attributed to unfavourable characteristics of mill-run bagasse, which includes low bulk and energy densities, a wide range of particle sizes and shapes as well as high moisture content. Gasification is regarded as one of the most promising energy recovery technologies for the widespread use of biomass because of its higher efficiency when compared to the combustion technology commonly used by the sugarcane industry. There has been a strong drive to identify efficient pre-processing methods that can be applied to bagasse to make it a suitable feedstock for energy production in thermochemical conversion systems. This work provides a comprehensive review on the pre-processing of bagasse for gasification, and the gasification technology options for its conversion into energy, with a particular emphasis on the downdraft gasification technology.



**Contents**



*Abbreviations:* SCB, sugarcane bagasse; GHG, greenhouse gas; EOR, enhanced oil recovery; USDE, United States Department of Energy; USEPA, United States Environmental Protection Agency; SERI, Solar Energy Research Institute; NETL, National Energy Technology Laboratory; EBIA, European Biomass Industry Association

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## 1. Introduction

Sugarcane bagasse (SCB) is the fibrous residue obtained after the extraction of the sucrose-rich juice from sugarcane stalks. The various uses of SCB have been widely reported in the literature, and these include the manufacture of pulp and paper, animal feed, furfural, and other value added products [1,2]. However, these are limited markets which are also highly competitive. SCB has been considered as an agricultural biomass residue of great importance as a fuel for the sustainable production of electricity [1,3]. In the past, excess SCB was burned as a means of solid waste disposal, but as the cost of auxiliary fuels increased, the need to derive greater energy from all the SCB available to the factory became imperative. Currently in countries like South Africa, bagasse is used as a convenient fuel for the sugarcane industry but through inefficient combustion processes. This inefficient usage necessitates that in some instances supplementary fuels such as coal be used in significant amounts during factory operations. Consequently, for the industry to produce more energy from available SCB and offset the use of costly or non-renewable energy sources, more cost-effective and efficient technologies are required.

The application of SCB for optimal energy production requires an understanding of its composition, for which many studies have been performed. Mill-run bagasse contains approximately 50% fibre, 48% moisture and about 2% sugar [4–7]. This composition makes SCB an ideal material for energy production, however, its efficient utilisation for energy production in thermochemical conversion systems has been impeded by a number of factors, one of which is its handling and pre-processing which must be consistent with the energy conversion system that it is used in. There are various pre-processing methods that are available for biomass; however, there seem not to be a universal method or technology pathway which is most appropriate for all types of biomass including SCB. There are a number of required characteristics for a pre-processing method to be considered industrially viable. These characteristics include the requirement that the pre-processing method should result in minimum degradation with maximum component recovery; it should have a low energy demand or be conducted in a way that the energy can be re-used in other process steps as secondary heat; and, it should have low capital and operational costs [8,9]. The use of physical methods for pre-processing can be considered as meeting all of these requirements. Pre-processing of SCB is intended to overcome inherent issues related to the disperse nature of bagasse, its high moisture and inorganic contents as well as its low energy and bulk densities. These shortcomings limit the widespread deployment of the thermochemical conversion systems using bagasse as feedstock for energy production purposes, rendering these systems unattractive. However, the complexity of SCB (in chemical composition and heterogeneity) is so high that its use as an energy feedstock requires further research and development to better understand the exact pre-processing and thermal conversion system parameters with respect to the polymeric structure and mineral composition of the material. One of the thermochemical conversion pathways by which SCB can be converted into energy is through gasification, which is a thermal devolatilisation process that breaks down any carbon-based material into its basic chemical constituents [10]. The process is based on a series of complex reactions that are influenced by many factors including the composition of the feed material to be converted, the pre-processing conditions of the feed and the operating conditions of the gasifier [11]. The feedstocks required for gasification, the advantages and disadvantages of the gasification technology as an energy production process are detailed later in Section 9 of this review.