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# Review of sugarcane trash recovery systems for energy cogeneration in South Africa

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ABSTRACT

Biomass is a potential sustainable source of energy. Approximately one-third of the energy available from sugarcane is contained in the tops and leaves (trash), which are generally either burnt prior to harvesting or are not recovered from the field. Based on results reported in the literature and assuming a 50% trash recovery efficiency, it is estimated that 1.353 million tons of trash is available annually for cogeneration in South Africa, which could potentially produce 180.1 MW over a 200 day milling season. Studies in Brazil and Australia have shown that the most efficient way of recovering the tops and leaves for cogeneration of power at sugar mills is to use a chopper harvester with the separation of cane stalks and trash on the harvester either fully or partially turned off. In South Africa more than 90% of the sugarcane crop is burnt and manually harvested and hence new systems are proposed to recover the trash and to transport the material to the mill.



**Contents**



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## 1. Introduction

As a consequence of the rising global demands for energy, the cost volatility, the dwindling reserves of fossil fuels and the impacts of the use of fossil fuels on greenhouse gas emissions have all resulted in biomass to be considered as an important, alternative source of energy [6,14,41]. The environmental impacts of the growing demand for petroleum derived fuels can be mitigated by the use of lignocellulosic biofuels [15]. Not only is it being realised that biomass presents a potential renewable source of energy opportunity that could provide an alternative to the use of fossil resources and reduce human dependence on fossil fuels, but also that it will impact positively on many environmental issues, including the minimisation of the production of greenhouse gases [6]. The high production of biomass reported by Muchow et al. [39], combined with the efficient use of water by sugarcane in terms of biomass produced per unit of water, makes sugarcane an ideal energy crop [6].

The sugarcane industry has been moving from sugar production to sugar and energy production with the development of cogeneration and ethanol plants and this will result in the cane energy content and energy yield per hectare and per ton of cane becoming important parameters which will be used for variety selections in the future, and being a part of future payment systems [7]. The agronomic benefits and the potential energy resource of sugarcane tops and leaves, commonly referred to as trash, have been recognised and the development of new harvesters has promoted the utilisation of these benefits [44]. In a study to investigate diversification options for the sugar industry in Australia, whole crop harvesting to maximise electricity cogeneration was identified as the venture with the highest priority [61]. The potential for the sugar industry in South Africa to mitigate against climate change by producing renewable cogenerated electricity and fuel ethanol was highlighted by Govender [19].

Sugarcane bagasse (fibrous fraction of cane) is the most abundant crop residue produced globally and this resource can be increased by harvesting the sugarcane leaves and tops [5]. With the improvements in sugarcane harvesting and cogeneration technology, bagasse and sugarcane trash have become important sources of bio-energy [1]. The use of sugarcane trash has the added benefit of not competing as a food source and has a similar energy content as bagasse per unit weight, but is frequently burnt off to facilitate harvesting of the stalks [1]. The sugarcane trash, which is currently mainly burnt prior to harvest, is a significant source of energy [55,56] and sugarcane has the highest rate of energy production per hectare (0.5–2 GJ $ha^{-1}$) [5]. Despite the potential to generate heat and power from bagasse, the potential for the cogeneration of electricity remains largely unexploited [5].

Over 9 GW of worldwide generation capacity is currently provided by biomass based electricity schemes. Sugarcane bagasse and sugarcane trash have the potential to provide a significant amount of biomass for electricity production, and the potential becomes much higher with the use of advanced cogeneration technologies [38]. Sugarcane leaf biomass has a high calorific value which has a low production of micro-pollutants when processed with improved technology and thus represents a significant source of energy which can reduce environmental issues associated with energy generation [53]. It has been estimated in Brazil that energy from residual biomass can supply energy to 7.0 million people and that 5.5 million people can be supplied with energy from bagasse [53] and sugarcane biomass is seen as one of the most readily available energy sources in Brazil [37]. However, high recovery costs will be incurred in gathering, baling, transportation, chopping and technology to utilise the trash on a large scale [37]. The sugarcane transport infrastructure currently used to transport the sugarcane stalks to mills can be utilised to make the trash an economically viable energy source for boilers, irrigation power and to export to the local area [41].

Not burning sugarcane prior to harvest has environmental benefits and the residual biomass can help reduce the global energy deficit, but the feasibility of extracting the energy from the currently unutilised biomass has not been proven [53]. Many countries are considering the use of sugarcane as a potential source of renewable energy. For example, in El Salvado it is projected that 55 MW of power can be generated during the four month cane crushing season from 346,503 t of sugarcane [69]. In Mauritius, 10 out of 11 sugarcane processing mills export electricity to the grid during the milling season. This generation of electricity was promoted by government incentives which focussed on the optimum use of bagasse to generate electricity and by the use of sugarcane trash for electricity generation [11]. Efficient energy production from biomass has the potential to offer new development paths, sustain rural livelihoods, reduce dependence on imported energy sources and reduce green house gas emissions in sub-Saharan Africa, particularly in Malawi, Mozambique, Tanzania and Zambia, which have the greatest potential to achieve this after accounting for food production and resources constraints [24]. An analysis by Johnson et al. [24] showed that in South Africa 1.2% of the energy provided by petrol could be supplied by ethanol in 2005 and this could rise to 7.4% by 2030.

The escalating real cost of energy and advances in technology to produce bio-energy is starting to make the bio-energy cost competitive and this presents opportunity to the sugar industry in South Africa to generate income from co-generation and fuel alcohol [68]. Government commitment to develop renewable sources of energy, protection of jobs, reducing green house gas emissions from fossil fuels and the need for energy security will aid the sugar industry to produce bio-energy [68].

With the exception of Brazil, sugarcane is produced primarily as a food crop although many countries are investigating energy options as well [26]. Thorburn et al. [62] discuss the impact of changing the production of sugarcane from a purely sugar focus to a sugar and energy focus which may require changes to farming systems and the use of feedstock from other biomass to ensure year round cogeneration potential. Integrated supply chain models are necessary to enable the assessment of the impacts and to benefit from participation by stakeholders [62]. Harvesting, loading and transport are approximately one third of the cost of cane at mills in Brazil [21].

Given the above, it is evident that the recovery of some of the sugarcane trash for energy production, while retaining a trash blanket, has much potential. However, the recovery of the trash and the low bulk density of the trash will have cost impacts on harvesting, transport and processing of the biomass.