Biowaste energy potential in Kenya

@ 2010 Charles Nzila [a], Jo Dewulf [a], Henri Spanjers [b], Henry Kiriamiti [c], Herman van Langenhove

Abstract

Energy affects all aspects of national development. Hence the current global energy crisis demands greater attention to new initiatives on alternative energy sources that are renewable, economically feasible and sustainable. The agriculture-dependent developing countries in Africa can mitigate the energy crisis through innovative use of the available but underutilised biowaste such as organic residues from maize, barley, cotton, tea and sugarcane. Biogas technology is assumed to have the capacity to economically and sustainably convert these vast amounts of biowaste into renewable energy, thereby replacing the unsustainable fossil energy sources, and reducing dependency on fossil fuels. However, the total energy potential of biogas production from crop residues available in Kenya has never been evaluated and quantified. To this end, we selected five different types of residues (maize, barley, cotton, tea and sugarcane) from Kenya and evaluated their energy potential through biomethane potential analysis at 30 °C and a test time of 30 days.

The specific methane yields for maize, barley, cotton, tea and sugarcane residues obtained under batch conditions were respectively 363, 271, 365, 67 and 177 m^3 per tonne volatile solids. In terms of energy potential, maize, cotton and barley residues were found to be better substrates for methane production than tea and sugarcane residues and could be considered as potential substrates or supplements for methane production without compromising food security in the country. The evaluated residues have a combined national annual maximum potential of about 1313 million cubic meters of methane which represent about 3916 Gigawatt hour (GWh) of electricity and 5887 GWh of thermal energy. The combined electrical potential is equivalent to 73% of the country's annual power production of 5307 GWh. Utilization of the residues that are readily available on a 'free on site' basis for energy production could substitute the fossil fuels that account for a third of the country's total electricity generation. Besides, exploitation of the potential presented by the biowaste residues can spur an energy revolution in the country resulting in a major economic impact in the region.

Introduction

To date there is a global energy crisis as a consequence of declining quantity of fossil fuels coupled with the unprecedented rising crude oil prices. The crisis demands greater attention to alternative energy sources and revision of existing technologies. Hence it is critical now not only to focus on sustained economic use of the existing limited resources but to identify new technologies and renewable resources that have the potential to cater for the increasing energy demand in addition to possessing other positive attributes such as being sustainable, globally available, easy to exploit as well as having the capacity to positively contribute towards actualization of the United Nations millennium development goals, MDG [1], [2].

Biomass could play a phenomenal role for future energy supply mainly through thermochemical, physicochemical, and biochemical transformations as well as conventional combustion. Suffice to say that biogas, biodiesel and bioethanol are some of the candidate alternative fuels from biochemical transformations that have continued to receive wide attention owing to their inherent 'green' potential. However, in terms of technological and social economic considerations, biogas technology is more

preferred due to its economical feasibility [3] and sustainability potential [4] as well as its ability to meet all the MDGs [1]. Besides, biogas technology is mature and offers a very attractive route to utilize diverse categories of biomass [5] and the inherent biowaste for meeting energy needs as well as contributing to resource and environmental conservation. Biogas is particularly suited for meeting small scale energy needs, can contribute to environmental sanitation [6] and biogas technology is simple enough to avoid production limitations. Overall, the energy balance is particularly favourable for biogas when considering the ratio of energy yield (output) versus all the energy invested (input), excluding the energy content of the biomass but including all process efficiencies as shown in Table 1.

Section snippets

The potential of biogas technology

Biogas technology has not been successfully adopted for both energy and economic strategies within the African continent [1]. A case point is East Africa where the technology has continued to lag behind since 1950 when the first biogas plant was introduced in the region. It is still at its infancy due to economical factors as well as inadequate knowledge and hence over-reliance on animal dung as the principal digester feedstock. Indeed recent initiatives to revamp the biogas technology in the

Substrates

All substrates used in the analysis were residues obtained from western Kenya. The maize residue was collected from a farm whereas the barley, cotton, tea and sugarcane residues were collected from waste stockpiles of a brewery plant, ginnery, tea factory and sugar factory, respectively. About 6 kg of each sample were collected from the respective stockpiles by means of the grab technique. Thereafter, the samples were air-dried at ambient conditions in a laboratory at Moi University to average

General properties of the substrates

The proximate analysis demonstrated the similarities and differences among the substrates in terms of their chemical properties (Table 3). A key characteristic feature of the substrates was their high volatile solids content that was quite comparable and ranged from 84% in barley residues to 96% in maize residues. On the contrary, the crude protein, fat and carbohydrates content in the residues varied a lot.

The crude protein content varied from around 1% in sugarcane residues to 24% in barley

Conclusions

The results presented here demonstrate the potential of energy production from selected biowaste in Kenya. It is clear that in addition to VS content, other chemical properties of biowaste influence the BMP. Substrate characterisation is thus deemed to be paramount in the interpretation of biowaste BMP studies as evidenced by our results which show that the BMP of barley residues is only second to that of cotton residues, whereas the VS amount suggested a very low BMP. Besides, it is clear from