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Modern bioenergy from agricultural and forestry residues in Cameroon: Potential, challenges and the way forward

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HIGHLIGHTS

- Environmentally benign residues amount to 1.11×10^6 bone dry tonnes per annum.
- 0.12–0.32 billion litres of bio ethanol annually to displace 18–48% national gasoline use.
- 0.08–0.22 billion litres of biomass to BTL diesel per year to offset 17–45% of diesel use.
- 0.76–2.02 TW h of electricity, representing 15–38% of Cameroon's consumption.
- Residues could offset only 3% of national consumption of traditional biomass.

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ABSTRACT

Environmentally benign modern bioenergy is widely acknowledged as a potential substitute for fossil fuels to offset the human dependence on fossil fuels for energy. We have profiled Cameroon, a country where modern bioenergy remains largely untapped due to a lack of availability of biomass data and gaps in existing policies. This study assessed the biomass resource potential in Cameroon from sustainably extracted agricultural and forest residues. We estimated that environmentally benign residues amount to 1.11 million bone dry tons per year. This has the potential to yield 0.12–0.32 billion liters of ethanol annually to displace 18–48% of the national consumption of gasoline. Alternatively, the residues could provide 0.08–0.22 billion liters of biomass to Fischer Tropsch diesel annually to offset 17–45% of diesel fuel use. For the generation of bioelectricity, the residues could supply 0.76–2.02 TW h, which is the equivalent of 15–38% of Cameroon's current electricity consumption. This could help spread electricity throughout the country, especially in farming communities where the residues are plentiful. The residues could, however, offset only 3% of the national consumption of traditional biomass (woodfuel and charcoal). Policy recommendations that promote the wider uptake of modern bioenergy applications from residues are provided.

1. Introduction

Modern bioenergy is an important renewable energy option for reducing the societal demand for fossil fuels. Cameroon's interest in modern bioenergy is driven by several factors, including security of the energy supply, additional revenue streams for the agricultural and forestry sectors, socio-economic benefits for rural communities and cost savings from the reduced importation of refined oil. Although Cameroon is an oil rich country, it is important to recognize that the country exports crude oil only to import refined petroleum oil. For example, crude oil exports from Cameroon for the year 2009 were 3.2 million tons, while 1.4 million tons (44%) were imported into the country (IEA, 2009). This is due to a lack of adequate local refineries, thus rendering the country susceptible to price volatilities in the international market for refined oil.

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Cameroon is located in Central Africa between the 2nd–13th northern parallels and longitudes 9°–16° east, covering a surface area of 475,440 km^2. In 2012, Cameroon's population was estimated to be 20 million people, and approximately 47.9% of the population lived in rural areas (CIA, 2012) (Table 1). According to UNDP (2008), 50.6% of the Cameroonian population lived in poverty (on less than 2 dollars per day) over the period 1990–2005. Furthermore, in 2007, it is estimated that over 87% of the poor in Cameroon lived in these rural areas (World Bank, 2009). In 2011, the country's GDP per capita was estimated at $ 2300 (US) (CIA, 2012), while the Human Development Index was 0.428 in the same year (UNDP, 2011) (Table 1).

Rural poverty in Cameroon has been reported to result from a lack of modern energy access, low employment levels (30%), high illiteracy rates (44.7%), poor telecommunication infrastructure and minimal access to information (IMF, 2003; Sarantopoulos et al., 2009). Cameroon's total primary energy supply (TPES) was 7.11 Mtoe for the year 2010 (IEA 2012). A predominant component of the country's energy mix is traditional biomass, accounting for 4.55 Mtoe or 64% of the TPES (Table 2, Fig. 1). Woodfuel remains the predominant energy source for cooking in both rural and urban areas. Crude oil constitute the next largest energy supply source, providing 1.92 Mtoe or 27% of the TPES. Hydroelectricity and natural gas amount to 0.36 Mtoe and 0.26 Mtoe, respectively (Table 2).

Although the country has 105 TW h per year of economically feasible hydropower potential, only 5% of this is exploited for the generation of electricity (H & D, 2012). Currently, the generation of hydropower is 4.5 TW h per year and represents 4% of Cameroon's TPES (Fig. 1). A number of hydropower plants have been planned over the next decade. Hydroelectric power plant sites currently under consideration include Grand Eweng (1100 MW), Nachtigal (300 MW), Mbakaou (250 MW), Warak (75 MW), Vogzom (80 MW) and the Ngassona rural electrification project (2 MW). A challenge hindering the increase and sole reliance on hydropower dams in Cameroon is the growing drought conditions (H&D, 2012).

1.1. Energy access (electrification) related issues

Cameroon is endowed with several energy sources, including hydropower potential, petroleum, natural gas, biomass and other renewables. However, the bulk of the country's electrification is obtained from hydro and thermal sources (Fig. 2) and mostly

Table 2
Cameroon's national energy mix.

Energy mix[a]	Mtoe
Biomass	4.55
Oil	1.92
Natural gas	0.26
Hydroelectricity	0.36
Total primary energy supply	7.11

Authors' estimations are based on published sources (IEA 2012; CEIP, 2013).

[a] The total primary energy supply of 7.11 Mtoe was based on information from IEA (2012). The proportions of 64:27:5:4 for biomass, oil, hydroelectricity and natural gas, respectively, were sourced from CEIP (2013).

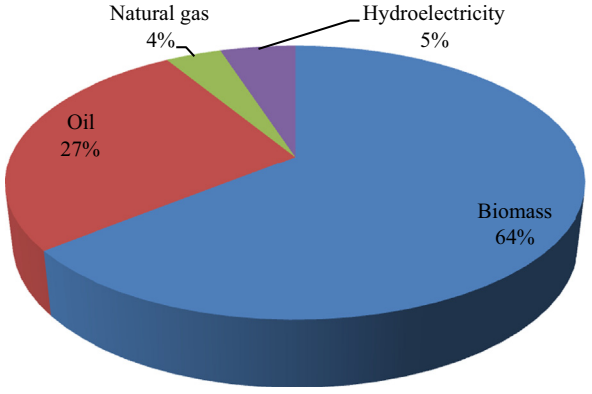

Fig. 1. Cameroon's energy mix.

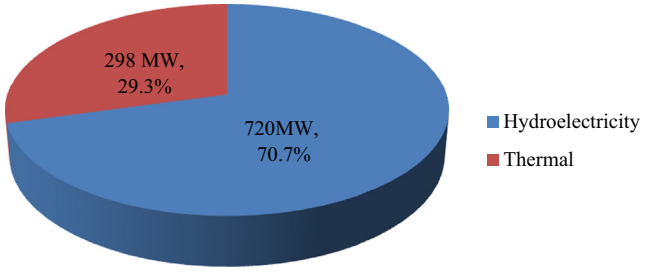

Fig. 2. Electricity generation by source in Cameroon of the national total of 1016 MW. The authors' graphical representation is based on H&D, 2012.

Table 1
Socio-economic indices, energy and related emissions in Cameroon.

Parameter	Unit	Value	Reference year(s)	Source
Population	Million	20.13	2012	CIA (2012)
Population growth rate	%	20.0	2012	CIA (2012)
GDP	Billion USD	47.12	2011	CIA (2012)
GDP real growth rate	%	3.8	2011	CIA (2012)
GDP Per capita (PPP)	USD	2300	2011	CIA (2012)
Poverty rate[a]	% of total population	50.6	1990–2005	UNDP (2008)
Human development index	–	0.482	2011	UNDP (2011)
Energy production	Mtoe	8.85	2010	IEA (2012)
Total primary energy supply (TPES)	Mtoe	7.11	2010	IEA (2012)
Total primary energy supply/population	toe/capita	0.36	2010	IEA (2012)
Net energy imports	Mtoe	−1.48	2010	IEA (2012)
Carbon dioxide emissions (emissions from fuel combustion only)	Mt of CO_2	5.03	2010	IEA (2012)
Carbon dioxide emissions/TPES	t CO_2/toe	0.71	2010	IEA (2012)
Carbon dioxide emissions/population	t CO_2/capita	0.26	2010	IEA (2012)
Population economically active in agriculture:				
Female	% of total population	51.8	2006	Ngnikam and Tolale (2009)
Male	% of total population	48.2	2006	Ngnikam and Tolale (2009)
Infant mortality (per thousand live births)		87.5	2006	Ngnikam and Tolale (2009)

[a] Poverty line: < 2 USD/day.