ENERGY IN WOODY BIOMASS

AND THE INDUSTRIES THAT ARE USING IT

BY NELLIE ODUOR, EMILY KITHEKA AND CHURCHILL OGUTU

In Kenya, biomass energy resources are derived from forests - closed forests, community woodlands, farmlands and plantations as well as agricultural and industrial residues. This accounts for about 68 per cent of all energy consumed and for 90 per cent of rural household energy needs. The main sources of biomass for cooking and heating energy are charcoal, fuelwood and agricultural waste. Various industries use biomass energy in their processing; these include tea and edible oil processors. A study in 2013 that analysed the demand and supply of wood products in Kenya indicated that firewood and charcoal supply stood at 13,654,022m^3 and 7,358,717m^3 while demand stood at 18,702,748m^3 and 16,325,810m^3 respectively. Currently, there is unmet demand for biofuels with a 60% demand-supply gap. Forecasts for a 20-year period indicate a 20% increase in supply and 21.6% increase in demand by the year 2032 which signifies a gradually increasing deficit. However, most of the wood fuel is obtained from unsustainable sources and produced and utilized in inefficient technologies/devices. This exerts pressure on natural forests. The current moratorium by the Government of Kenya (February 2018 to date), banning logging on public and community forests has further widened the biomass fuel demand gap leading to escalating prices of charcoal.

Sustainability of the bioenergy sector is central to Kenya's aspirations to achieve middle-income status by 2030. The government has identified substantial potential for power generation using forestry and agro-industry residues, including sugarcane bagasse. Other bioenergy resources in Kenya include biogas, fuelwood, briquettes, pellets and charcoal.

Sustainable development of biomass resources for energy purposes requires not only knowledge of the biomass supply capacity but also the biomass quality which can improve the forest-based bioenergy sector and may result in its increased and more efficient use. The quality of the biomass also depends on the tree species, for not all species are suitable as a wood fuel. In this respect, sufficient details must be obtained to characterize and identify specific types of biomass because the quality of forest biomass is strongly associated with the contents of organic and inorganic components. Energy content of each species mostly depends on its chemical content (carbon, hydrogen and oxygen) and it is reduced by inorganic elements and moisture. It is therefore important that biomass is dry. Table 1 shows various energy sources and their calorific values.

A rich and abundant resource in the Aberdares, Mt Kenya and the Mau: bamboo (*Oldeania alpina*), for producing renewable electricity. Photo BGF

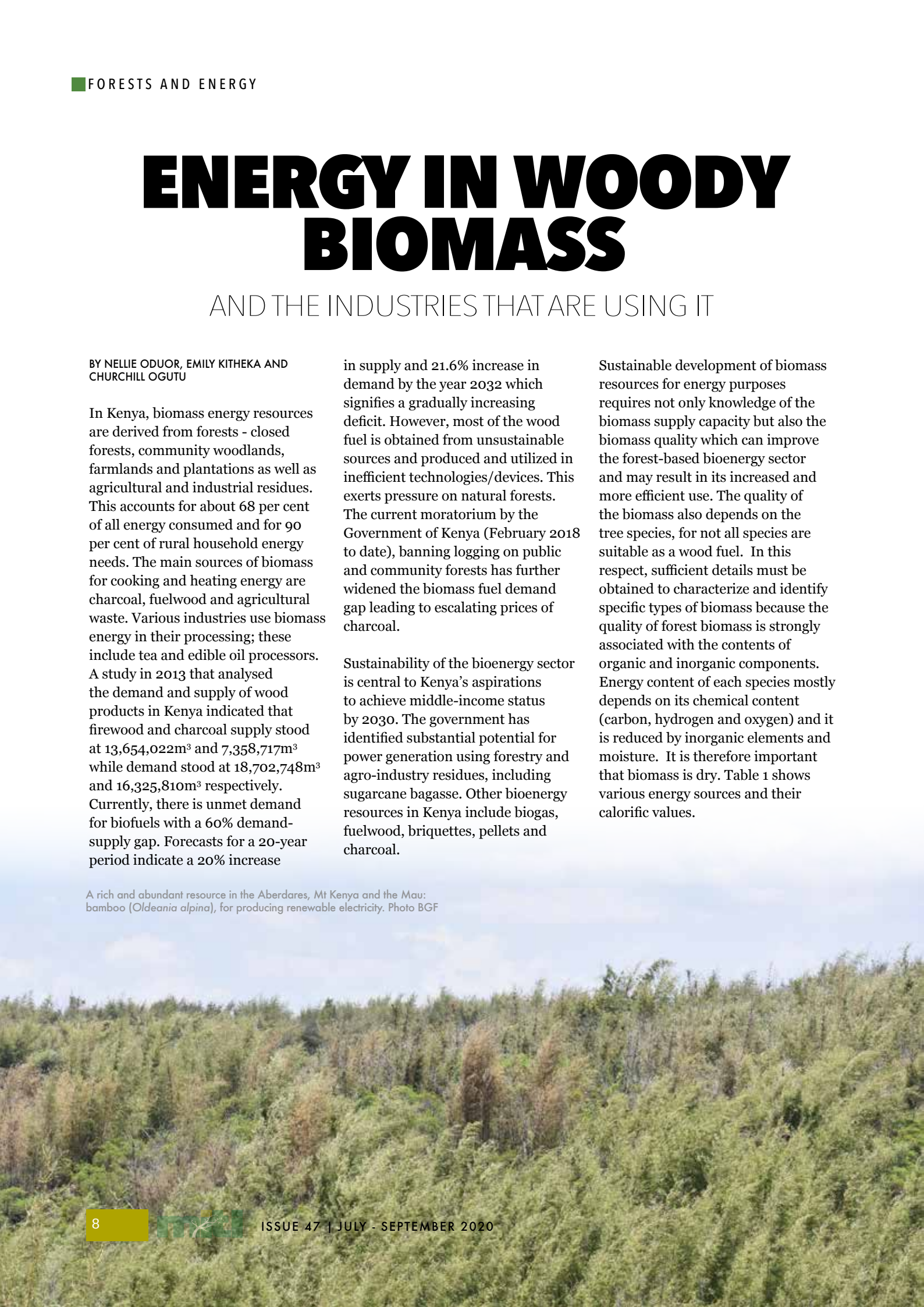

Table 1: *Energy levels of various sources of energy*

Energy source	Calorific value Kcal/g
Dry wood	General range 3.5 – 5.0
Acacia nilotica (Egyptian thorn)	4.9
Acacia polyacantha (Falcon's claw acacia)	4.0
Acacia tortilis (Umbrella thorn)	4.4
Acacia xanthophloea (Yellow fever tree)	4.4
Casuarina equisetifolia (Whistling pine tree)	5.0
Commiphora baluensis (Commiphora)	4.4
Eucalyptus camaldulensis (River red gum)	4.8
Eucalyptus grandis (Flooded gum)	4.5
Leucaena leucocephala (River tamarind)	4.6
Prosopis juliflora (Mathenge)	5.0
Terminalia brownii (Mbarao-Swahili)	4.6
Terminalia orbicularis (Spiny terminalia)	5.1
Wood chips (30% MC)	2.9
Wood pellets (10% MC)	Ranging from 3.8 – 4.3
Charcoal	General range 5.0 – 9.0
Acacia nilotica	7.3
Acacia polyacantha	6.4
Acacia tortilis	5.8
Acacia xanthophloea	7.9
Eucalyptus camadulensis	5.6
Eucalyptus grandis	7.5
Prosopis juliflora	7.9
Bambusa vulgaris (Common bamboo)	6.7
Dendrocalamus asper (Dragon bamboo)	5.3
Dendrocalamus giganteus (Giant bamboo)	5.5
Bamboo	
Bambusa vulgaris	4.4
Dendrocalamus asper	4.5
Dendrocalamus giganteus	4.5
Bamboo pellets	
Bambusa vulgaris	6.5
Dendrocalamus asper	6.2
Heating oil	10. 0

BAMBOO

Bamboo is fast becoming a source of biomass energy due to its fast regeneration if sustainably managed. Various species have been trialed in Kenya which has only one indigenous species (African alpine bamboo). Among the exotic species that have been produced in Kenya are Savanna bamboo (*Oxytenanthera abyssinica*), *Bambusa* and *Dendrocalamus* spp. Generally, if the bamboo is chipped, briquetted or pelletized, it offers a great source of biomass energy for several industries. Some tea and edible oil processors have tested bamboo chips in their boilers. The energy values for some of the species are shown in Table 1 which show great promise as a woodfuel source for industries and domestic use.

BRIQUETTES

Briquettes are biofuel substitutes to coal and charcoal and are made from agricultural and forestry residues. The huge demand for firewood by the industry calls for greater use of alternative thermal bioenergy sources such as briquettes from agricultural residues. Uncarbonized briquettes are suitable for industrial use and some tea, edible oil, cement and tobacco processors are already incorporating these biofuels in their energy mix. Carbonized briquettes are suitable for domestic use and learning institutions, hospitals and prisons.

Carbonized briquettes are made from biomass raw material that has undergone pyrolysis after which it is mixed with a binding element, moulded into various shapes then dried. Uncarbonized briquettes are processed directly from biomass sources through various casting and pressing processes also known as compaction or solidification.

Wood waste in a sawmill. How much is recovered? Photo BGF

PELLETS

These are biofuels made from compressed organic matter or biomass. They are similar to briquettes but relatively smaller in size. They can be used as fuels for power generation, heating, and cooking. They are extremely dense and can be produced with a low moisture content (below 10%) that allows them to be burned with a very high combustion efficiency. Pellets generally measure 6-10mm in diameter with a maximum length of 38mm and are formed by compressing biomass under intense pressure. The most recommended raw materials for use as feedstock include white wood chips from sawmills, round wood with huge diameters, untreated wood, and used wood without any contamination. Dies are used to obtain the required cylindrical shapes of the pellets by forcefully passing sawdust through them. Owing to the pressing involved and the corresponding friction that results when the particles are pressed against each other and against the wall, sawdust experiences a temperature increase of between 70°C to 100°C, then the lignin component acts as a natural binder.

Pellets formed from woody biomass remain the recommended feedstock for the bioenergy industries that deal with solid biomass. They are compact in nature and are regularly shaped hence, they are easier to handle, store and transport in bulk. Biomass pellets can be made from recyclable raw materials such as saw dust, rice husks, coffee husks and maize stalks. They are of high calorific value and burn with less smoke. They are dense and used in cooking meals in homes and institutions.

Pellets are not a new type of fuel in Kenya's energy market although its use at the domestic level remains limited. Studies have been carried out using locally produced gasifiers (WISDOM and SCODE gasifiers) that can burn both wood and pellets. Other ongoing initiatives include: Lean Energy Solutions who set up a pellet production facility in Naivasha; Green Steps Africa Limited who supply gasifier stoves for domestic and commercial use; Power Spot Limited that produces pellets and distributes gasifiers in Kakamega County and IKO BRIQ Limited and

Eco-bora manufactures that sells pellets to households.

A BRIEF OF THE TEA AND EDIBLE OIL INDUSTRIES IN USING BIOMASS ENERGY

Tea Industry

Kenya is the World's third largest producer and exporter of tea. The tea industries moved from using heavy fossil fuels to biomass fuel to wither and dry the green tea leaves. Out of the 113 tea factories in Kenya, almost 99 percent of their thermal energy comes from firewood and other sources of biomass and 1 percent is from oil fuel. The demand for firewood in the tea industry is around 1 million tons of firewood per year. A number of tea industries are using alternative biomass sources such as non-carbonized biomass briquettes. Sources of briquettes are from agricultural residues such as sugarcane bagasse, straws, husks, cobs or shells. According to the Sugar Directorate, around 2.4 million tons of bagasse generated by the country's 12 sugar mills is unutilized.

Other consumers of non-carbonized briquettes include schools, hospitals, the tobacco industry and the vegetable oil processing industry.

Edible oil processing factories

Edible oils are a crucial sub-sector of the manufacturing industry in Kenya. The industry currently operates at a production capacity of 850,000 tons and has an installed capacity of 1.5 million tons per year. These vegetable oil processing plants in Kenya use about 200 tons of dry biomass per day. For instance, Bidco Africa presently uses over 200 tons of macadamia and coffee husks to generate power, however, the supply of both is erratic and unsustainable. They have also trailed bamboo in chip form to meet their need for biomass to power one of its cogeneration plants in Ruiru. They estimate they would require 6,000 tons of bamboo a month to meet their energy needs.

IN CONCLUSION

With a rapidly growing population, there is need to look at sustainable provisions of biomass for domestic and industrial use. Processing of agricultural residues to solid biomass fuels is becoming an increasingly important path for moving towards circular economies and cascading use of biomass. Pellet and briquette production should be promoted together with their appropriate appliances - stoves and boilers. Promotion of commercial wood farming should essentially be on private and community land in marginal semi-arid areas to avoid competition with food production and security.

The writers are: Programme Director at KEFRI's National Forest Products Research Programme, Research Scientist and Research Scientist at KEFRI and also Biofuel4Kenya Project Manager

Extensive thickets of *Acacia zanzibarica* in Lamu County, with natural regeneration and coppicing. An opportunity for generating electricity? Photo BGF