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Can Biomass Power Development?

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Executive Summary

Biomass has been dubbed the 'Cinderella' of fuels. Few energy planners, development banks and policy makers treat biomass as a legitimate form of energy, despite it being the principal source of energy in developing countries and regardless of its importance in their economies, especially the household, industrial and service sectors. Biomass is a biological material derived from living or recently living organisms, and includes wood, vegetative waste and dung and their products, such as charcoal, alcohol fuels and biogas. It is a source of renewable energy and a versatile carbon based fuel that can be grown on even the poorest soils. It does not increase emissions of greenhouse gases when optimal energy conversion processes are used. In many countries, it is an important traded fuel and provides employment to rural people, thus assisting poverty alleviation.

However, the conventional view of biomass is that it is an unsustainable and polluting 'traditional' fuel that must be replaced by 'modern' energy, such as fossil fuel-based electricity, if rapid development is to occur. This paper explores the pros and cons of biomass and the logistics of switching to other fuels in developing countries. Calculations reveal that there is more than sufficient biomass, not only to maintain present consumption, but also to expand its use considerably. A principal cause of global warming is the increased use of fossil fuels. And the recent dramatic price rises in fossil fuels make them a volatile and insecure energy source. Therefore, rather than promoting energy policies based on fossil fuels, improving end-use efficiency, encouraging conservation and making renewable biomass more convenient are the most sensible strategies to pursue.

The author makes a number of recommendations for how biomass use and availability can be supported:

- Include biomass in energy policies as a renewable form of energy
- Base planning on accurate measures of biomass yields and demands
- Reduce deforestation through integrated rural development
- Increase support to small-scale biomass energy producers and improve use efficiencies
- Invest in biomass training, research and development.

Can Biomass Power Development?

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Introduction

Biomass energy, a term used to encompass fuelwood, crop residues and dung, plus the solid, liquid and gaseous products derived from them (Box 1), has been largely ignored both by energy planners in developing countries and by development bodies like the World Bank. This is despite the fact that about 70% of the population in the least developed countries (LDCs)—half the world's population—depend on biomass for cooking and for heating water and homes. In other words, in these countries it is the principal source of household energy (IEA 1998; Ren21, 2007).

BOX 1. CARBON BASED ENERGY SOURCES IN DEVELOPING COUNTRIES
NON RENEWABLE FOSSIL FUELS: • **Coal, peat and town gas derived from coal** • **Liquid fossil fuels from oil, such as kerosene (paraffin), diesel and petrol (gasoline)** • **LPG (liquefied petroleum gas)** • **Natural gas (and LPG) are low carbon emitting hydrocarbon fuels available in rural areas, emitting 19% less CO_2 per kilowatt hour (kWh) than oil products, 30% less than coal and more than 50% less than coal-generated electricity distributed via the grid** **RENEWABLE BIOMASS:** ***Unprocessed:*** • **Fuelwood** • **Agricultural and forestry residues** • **Dung** ***Processed:*** • **Charcoal** • **Biofuels: (methanol/ethanol, biodiesel, gelfuel, black liquor)** • **Biogas: Methane from manure can be removed in biogas digesters and used as a fuel. This biogas has about 60% of the energy of natural gas and the left-over slurry is an excellent fertiliser** • **Producer gas (CO, H_2, CH_4), made from the destructive distillation of biomass**

This paper explores why so little attention has been paid to developing and expanding biomass as a source of renewable energy. First I look at what biomass has to offer the developing world and the energy mix. I then assess why it has been generally overlooked or disregarded by development and energy planners, and outline some of the dangers in ignoring its important role. Finally I make some suggestions for how biomass can become a much bigger player in the field of renewable energy, and as a sustainable source of income, fuel and fertiliser for millions of people in the developing world.

What is the importance of biomass?

Poverty reduction

Most biomass is still used by people in developing countries in the 'traditional' way for cooking and other activities in many sectors. It is a fuel that people know how to grow and use. With help and improved management it can be used to improve agricultural productivity and stabilise the environment, add to the store of organic carbon and generate additional income; thus, expanded biomass use could be a key ingredient in the initiatives to alleviate poverty.

Woodfuel, principally fuelwood and charcoal, is the dominant 'commercial' household fuel in many sub-Saharan African (SSA), Latin American and Asian countries (Box 2). While there are no definite estimates, nearly 30 million people may be involved in the commercial production, transport and trade of biomass energy products worldwide, which could generate around US $20 billion annually.[1] And in many SSA countries, the trade in household biomass energy is much greater than the sale of fossil fuels and electricity.

Biomass is an important fuel in the service and industrial sectors, especially in rural areas of LDCs. It is used for baking (bread, confectionery etc.); beverage and alcohol preparation (beer, spirits, etc.); ceramic manufacture (brick, pottery, tile etc.); crop drying (coffee, tea, tobacco etc.); food processing (cassava, fish, sugar etc.); cooking (restaurants, cafes, canteens, hospitals, barracks, schools etc.); and in many other formal and informal enterprises.

Carbon sequestration and climate change

Atmospheric carbon is stored in biomass, particularly woody biomass, and in all types of soils. There is a greater accumulation of carbon in forest and woodland soils, and to a lesser extent in grassland soils, than in arable agricultural soils under similar conditions. Therefore, living biomass can be used to sequester atmospheric carbon from the atmosphere, while its annual production can be used as a renewable energy source or as a carbon store in wood products. There is a growing number of proposals and schemes to sequester carbon dioxide from fossil fuel burning in caves, abandoned mines, porous rocks and in the ocean to mitigate and eventually stabilise global warming. But it may be easier, less costly and safer to increase the carbon dioxide storage in biomass and soils, while at the same time increasing the supply of wood etc. for biomass energy (IEA, 1998; Mendis *et al.,* 1997).

1 This estimate assumes that there are 3 billion biomass users worldwide. It is based on figures from research in Malawi (Box 2), which estimated that the woodfuel informal sector employs 1 person for every 100 users of all biomass energy (purchased and collected). Each employed person generates about US $650 per year. Besides cooking, biomass is used for household heating and by (rural) industries and the service sector. Some wood-rich developed countries also use biomass for industrial heating and electrical generation purposes. So this employment figure and value may be underestimated.

BOX 2. THE IMPORTANCE OF BIOMASS IN MALAWI

While there are few production, transport and trade figures for traded biomass energy, a survey in Malawi in 1996/7 (Openshaw, 1997a & b) estimated that 3,800 'full-time' people (assuming a 'standard' year of 2,400 hours) were involved in tree growing; 24,560 in fuelwood and charcoal (woodfuel) production; 9,570 in transport; and 18,100 in roadside and urban trading for the four principal towns of Blantyre, Lilongwe, Mzuzu and Zomba. This included the urban plantations, especially in Blantyre. The combined total of 56,030 people employed should be compared to those employed in kerosene, LPG and electrical production, transport or transmission and trading for the household sector, an estimated 350 to 500.[a]

The estimated country total for 1996 was 93,480 full-time people involved in biomass, of which 87,070 were involved in production, transport and trade (Openshaw, 1997a & b). Of course, many people only work part time, so the actual numbers involved in commercial woodfuel enterprises is much more.

A repeat survey was done in 2008 (BEST, 2009). This found that full time employment in the growing, production transport and trade of biomass energy was an estimated 133,000, of which 122,000 served the household sector. Of course, the population of Malawi increased from around 9.2 million in 1996 to 13 million in 2008, so it is unsurprising that the traded demand for biomass energy has expanded.

a The estimated 1996 household consumption of kerosene is 476 terajoules (TJ) (1012J), LPG is 2 TJ and electricity 614 TJ: no coal is used by households. This compares to purchased woodfuel consumption of 18,225 TJ (out of 80,899 TJ), over 16 times the combined total of other fuels (Openshaw, 1997a).

Biomass can be produced indefinitely and therefore is a renewable carbon-based fuel that does not increase emissions of greenhouse gases (GHG) when using optimal energy conversion processes: this cannot be over-emphasised. As long as harvesting does not exceed the rate of biomass replenishment (e.g. annual tree growth) the amount of carbon released is balanced by the amount of carbon taken up. Burning renewable biomass in an optimal way does not add to the accumulation of atmospheric carbon dioxide because if biomass is not used it will decay and CO_2, plus some methane etc., will be returned to the atmosphere (via the carbon cycle).[2]

Each year, plants fix between 57 and 100 billion tonnes of atmospheric carbon through photosynthesis. Of this, about half is potentially available for fuel before it decays and returns to the atmosphere (Hall and Rao, 1994; Sorensen, 1979).[3] The potential available energy component in the total annual growth of biomass (between 25 and 50 billion tonnes of carbon (C)—with 40 billion t C taken as the reference figure) is many times that contained in the annual burning of fossil fuels (7.4 billion t C) (IEA, 2008). Taking into account the other uses of biomass (including food for animals and humans),[4] only

2 If burnt at the optimum temperature with adequate ventilation, most of the emissions are CO_2. If the burning is less adequate (lower temperatures and less oxygen) then you get products of incomplete combustion (PICs) which include particulate carbon (bad for respiration), carbon monoxide (bad for health) and various other gases including methane. Some of these other gases (e.g. methane) contribute much more to global warming per unit of gas than CO_2.

3 Net primary productivity (NPP) is that part of the total or gross primary productivity of photosynthetic plants that remains after some of this energy is used for growth and respiration. NPP provides the energy and material for life on earth. The world's total NPP is 172x109 dry tonnes/year, equivalent to about 80x109 t/year carbon (Richards, 2002).

4 The amount of energy used for food is about 3.25% (1.3 billion t of carbon), of which human consumption is 0.65%. Another 1.7 billion t C is used for energy purposes, giving a total use of 3 billion t C out of an estimated available 40 billion t C.

about 3 billion t out of a possible 40 billion t C are currently being used. Of the 37 billion t C that are theoretically available, at least an additional 10 billion t C in biomass could be used as fuel (27%); this could sustainably meet a considerable quantity of future energy demand. If the overall conversion efficiency to gaseous, liquid and solid fuels is 50%, then 5 billion t C would be available for motive power, electricity generation, process heat and cooking. Thus, biomass could be an important and increasing renewable input into the energy mix to sustain development whilst also reducing GHG accumulation.

Many publications assume that all carbon-based fuels increase atmospheric CO_2. The World Bank's Environmental Department (World Bank, 1990) stated that until (non-polluting) new and renewable energy resources (water, wind, solar) are adopted on a large scale, the world will have to go on burning existing (polluting) fuels, but should do so as efficiently as possible. This statement was reiterated at the 2002 World Summit on Sustainable Development in South Africa (UNDP/WB, 2002). Such thinking completely ignores the fact that half the world's population already uses biomass fuels, which are renewable and relatively non-polluting. Perhaps it would be more cost effective to expand the use of these fuels.

Energy production

According to the International Energy Agency's (IEA) official statistics (IEA, 2007), biomass supplied 10% of the world's energy in 2005 (Table 1).[5] The *Renewable 2007 Global Status Report* calculated that final renewable energy consumption worldwide accounted for 18% of total energy use in 2006, of which 13%, or nearly three-quarters, was traditional biomass (Ren21, 2007).

In most sub-Saharan African countries biomass energy accounts for over 80% of total energy demand. It is the dominant fuel in the household sector and is important in the service and industrial sectors, where it accounts for between 30% and 40% of energy demand. In Asian and Latin American countries, biomass energy use is not as dominant but still important. For example, biomass accounted for about half of energy consumption in the Philippines in 1989: 87% of energy in the household sector and one-third each in the service and industrial sectors (ESMAP, 1991).

Biomass is also used for commercial heat and power generation on a small scale in many countries throughout the world. In India in 2004 biomass energy was used in 52 power plants with a total capacity of 290 megawatts (MW) and in 57 'co-generation' plants—mainly sugar mills—with a capacity of 437 MW. In addition, 1,817 gasifier units with a capacity of 55 MW had been installed by mid-June 2003. Another 76 projects with a capacity of 807 MW were being built (MNES, 2005). India's Ministry of Non-conventional Energy Sources (MNES) estimates that biomass could be used to feed power stations with a total capacity of 19,500 MW. In Inner Mongolia (China), two combined heat and power plants are being considered. The first is a 24 MW straw-fed plant and the second is a 12 MW wood-fired plant (ESMAP, 2005).

5 Equivalent to 47.9 exajoules (an EJ is 10^{18}J), of which 39.8 EJ are in LDCs. The IEA probably under-records the number of biomass users and the quantity used. Thus, biomass could account for more than 10% of primary energy.

TABLE 1. ESTIMATED WORLD ENERGY DEMAND, 1997 & 2005 Units: exajoules (10^{18} J) except where stated						
	OECD countries[a]		Non-OECD countries[b]		Total	
	1997	2005	1997	2005	1997	2005
Population (billion)	1.09 (19%)	1.17 (18%)	4.59 (81%)	5.26 (82%)	5.68	6.43
Natural gas	43.3	50.6	36.5	48.5	79.8	99.1
Oil	88.9	94.3	53.2	73.2	142.1	167.6
Coal	43.9	47.4	50.1	73.7	94.0	121.1
Sub-total fossil fuels	*176.1*	*192.3*	*139.8*	*195.4*	*315.9*[d]	*387.8*[e]
Per-capita fossil (GJ)	161.6	164.4	30.5	37.1	55.6	60.3
Nuclear	22.4	25.5	3.8	4.7	26.2	30.2
Per-capita nuclear (GJ)	20.6	21.8	0.8	0.9	4.6	4.7
Renewable energy						
Hydro	4.6	4.7	4.5	5.8	9.1	10.5
Biomass & waste	6.8	8.1	37.33	39.83	44.1	47.9
Per-capita biomass (GJ)	*6.2*	*6.9*	*8.1*	*7.6*	*7.8*	*7.8*
Geothermal/solar/wind	1.3	1.6	0.3	0.8	1.6	2.4
Sub-total renewables	*12.7*	*14.4*	*42.1*	*46.8*	*54.8*	*62.8*
Per-capita renewables (GJ)	11.7	12.3	9.2	8.9	9.6	9.8
Total	211.2	232.2	185.7	246.5	396.9	478.8
Per-capita (GJ-109J)	193.8	198.5	40.5	46.9	69.9	74.5

a. OECD countries (29). Australia, Austria, Belgium, Canada, the Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Japan, Luxembourg, Mexico, the Netherlands, New Zealand, Norway, Poland, Portugal, South Korea, Spain, Sweden, Switzerland¸ Turkey, the United Kingdom and the USA.

b. The non-OECD countries include all developing countries except Mexico and Turkey. They also include all the former Soviet Union countries, and the Gulf States. In 1977, Albania, DPR Korea and Vietnam (populations 103 million) were excluded. In 2005 they were included (populations 109 million).

c. The biomass total for non-OECD is probably low due to under-recording. A more realistic figure for both time periods is 10 gigajoules per capita or 535 kg in wood equivalent terms. This would increase the overall biomass share by 2% in each time period. In 1997 biomass & waste energy were an estimated 45.5 exajoules (EJ) and 52.6 EJ in 2005 and the total energy consumption was 405.1 EJ in 1997 and 491.6 EJ in 2005.

d. This gives off 22.85 billion t CO_2, equal to 6.23 billion t C.

e. This gives off 27.14 billion t CO_2, equal to 7.40 billion t C. There has been a 19% increase in CO_2 emissions since 1997 – a 2% increase per year.

IEA's statistics are in million tonnes of oil equivalent (TOE). 1 TOE = 41.868 GJ.

Source: Adapted from International Energy Agency (IEA), 1999 & 2007.

Why is biomass overlooked, and what are the dangers of overlooking it?

There is reluctance in development circles to consider biomass as a legitimate energy form that can assist with poverty alleviation and sustainable development. Indeed, the 2002 World Summit on Sustainable Development held in South Africa set a 2015 target for 'renewable energy' in LDCs of 15% as part of the Millennium Development Goal (UNDP/WB, 2002). But the definition of renewable energy was mainly confined to solar, wind and water and completely ignored 'traditional' biomass fuels, which are considered to be 'unsustainable'. If biomass fuels had been included, then most LDCs would have achieved the 15% renewable energy target already.

For energy planners in LDCs, reliance on unprocessed biomass fuels is a sign of under-development. Biomass is considered a 'traditional' fuel that requires relatively more time to use and is more difficult to control than 'modern' processes such as petroleum-based energy and electricity. Biomass, especially unprocessed biomass, has a relatively low energy value per unit weight compared with fossil fuels. This means it is generally unsuited for providing large-scale motive power, heat and light—factors regarded as essential in the development process. Apart from small energy plantations, including palm oil and sugar estates, biomass energy production is very scattered, difficult to monitor and measure and in many instances it grows despite, rather than because of human intervention. On the other hand petroleum products and electricity are manufactured in discrete large-scale units that can be controlled and for which special skills and training are required for production and maintenance.

Thus, development agencies, governments and the private sector often pay scant attention to biomass energy because its production does not lend itself to large, capital intensive projects. Nor in most instances is its production recorded or its consumption metered, and the mechanics of marketing are poorly understood. A recent World Bank Group Energy Strategy Approach Paper focuses on improved energy (electricity) access for developing countries. It states that "traditional biomass" fuels are non-renewable and should be substituted as quickly as possible (World Bank, 2009). Indeed, in most publications, such as the World Bank's *Annual Development Report* (World Bank, 2003) its consumption is ignored. Only the so-called 'commercial' energy forms—petroleum, natural gas, coal, and hydro/geothermal/nuclear electricity—are recorded in energy statistics and the per-capita consumption of these 'commercial' energy forms are used as indicators of development. Thus, an energy planner can talk about petroleum products accounting for 80% of energy consumption in Tanzania, with electricity accounting for the remaining 20% (Sharma, 1979), when in fact biomass accounts for 80% of energy consumption and that of petroleum products and electricity 16% and 4% respectively (FAO, 1970).

The use of the term 'commercial' energy only to describe products of fossil fuels, electricity and, more recently, renewable energy from solar, wind and water, is very misleading and ignores the role biomass plays in the monetary economy of developing countries. Charcoal and liquid fuels such as methanol (wood alcohol), ethanol and now bio-diesel have always been commercial products and fuelwood, crop residues and dung are increasingly being traded. Biogas (60% methane), a product of biomass, is also being produced commercially.

Another part of the reluctance to regard biomass as a viable form of energy is that it is considered to impose an excessive burden on women and children who collect it and as a health hazard for the user, especially in a confined kitchen. This is true, if not properly prepared and burnt, but these are technical problems that can and should be tackled at source rather than proposing alternatives such as fuel switching, most of which are financially and logistically unattractive. Technical solutions include better ventilated kitchens; stoves with chimneys, if cooking inside; properly drying the wood, straw etc.; improved cooking stoves; training for stove manufacturers; micro loans; quality control; plus other technical support such as monitoring and evaluation.

The conventional view is that until people who cook with biomass switch to more convenient cooking fuels such as kerosene and LPG, and until energy (electricity) access is improved, poor households will not be able to escape the poverty trap. Yet in most, if not all rural areas, kerosene *is* available, but is generally used sparingly for light. Households are most reluctant to pay for fuel if they can collect it. It was proposed at the World Bank's Energy Week in March 2004 and again in March 2006 to subsidise kerosene and liquid petroleum gas (LPG)[6] (World Bank, 2004a and 2006) and to spend US$ 120 billion over the next ten years on rural electrification (World Bank, 2004b). However, experience tells us that free or subsidised kerosene will be sold, for example as a diesel substitute, and people will still cook with biomass: it will not ease the burden for women, nor reduce kitchen smoke. As for electricity access, in many instances because of inadequate tariff structures, poor maintenance and unauthorised use, electrical supply for connected users is intermittent with considerable voltage fluctuations.

Expanding the use of fossil fuels requires considerable capital investment. Nearly 12% of the World Bank's investment in the ten-year period ending 2003 was for energy development, US$ 24.8 billion out of a total spending of US$ 216.7 billion. However, only 3.2% of that energy was for renewable energy, the bulk of it non-biomass energy (World Bank, 2004b). Developed countries promote capital-intensive energy programmes because they can supply much of the equipment and technical know-how. By not treating biomass as a legitimate and renewable carbon-based fuel, an opportunity is being lost to provide employment for low-income rural and urban families.

Promoting biomass as a source of sustainable development and energy

> *"Estimating the carrying capacity of the Earth is a difficult task involving value-based decisions and assumptions. Whether the future of the Earth includes a dense population of humans with reduced biodiversity and degraded environmental qualities or a smaller human population living sustainably on a diverse resource base remains to*

6 At the 2006 WB Energy Week meeting (WB, 2006), Professor Robert Socolow of Princeton University stated that 35 kg of LPG per capita (1.65 GJ/c) should be sufficient to meet the yearly cooking requirements of the average household. This is equivalent to between 5 and 6.6 GJ/c of wood (320 to 425 kg air-dry wood) assuming a stove efficiency of 60% for LPG and 15% to 20% for biomass. This figure of fuelwood consumption is lower than survey estimates in many countries and neglects the consumption of charcoal and the other uses of wood/biomass energy in all sectors. However, assuming the above figure, the delivered cost of LPG works out at about US$ 100 for a family of six per year, excluding the cost of the container and stove; this would be a periodic cost (every 10 years) of about US$ 60. For the world, about 500 million households containing 3 billion people cook with biomass (& coal). Thus, the yearly cost of LPG would be about US$ 50 billion and the one-time cost for a cylinder and 2-burner stove would be an estimated US$ 15 billion or US$ 1.5 billion per year on average. This additional use of LPG would add between 82 and 90 million tonnes of carbon to the atmosphere each year.

be seen. However, current levels of energy consumption and the impending depletion of non-renewable energy sources point toward the necessity for a change in either population growth and/or consumption trends if the human race is to survive at anything close to its current level of subsistence." (Richards, 2002).

Clearly, the developing world must expand its (useful) energy consumption if it is to escape from the present poverty and under-development traps. But can and should it follow the conventional (Western) path and mainly plan for the expanded use of fossil fuels and electricity using traditional generating options? Or should developing nations recognise biomass as a legitimate, renewable indigenous resource and as one of several options that should be given the importance it deserves in the energy mix of individual countries? After all, about 3 billion people (500 million households) cook with biomass and it will be decades, if ever, before a significant switch to non-biomass (cooking) energy is achieved, even if this is an appropriate option to pursue either economically or environmentally.

Already, the world's population of 6.8 billion may be greater than its carrying capacity and already there are wars, fights and disputes over land and water resources. Habitats are being destroyed and species are being lost because of population and economic growth leading to the destruction and degradation of forests, grassland, farmlands, wetlands, rivers and seas etc. By 2050, if the world is not overtaken by environmental disasters, the human population may be 9.2 billion (UN median variant, UN, 2009) and people will on average be twice as wealthy as today.[7] Their total energy demand, even taking energy efficiency and conservation measures into consideration, may be in the region of 1,000 exajoules—about twice the amount used today (504 EJ in 2007; IEA, 2009). By that time, the extraction of liquid fossil fuels may be uneconomic, if they have not been banned, and of the other fossil fuels only coal will be available in quantity.

At present the top 18% of the world's population consume about 48% of the world's annual energy demand and over 80% of the fossil fuels. If the remaining 82% were to approach the energy use of the top 18%, then annual energy consumption would increase by over three times. If this increase is mainly in the form of fossil fuels it could have serious, if not disastrous, environmental consequences. Adding to this outlook is the projected growth in the world's population to 9.2 billion by 2050: it seems the world is sitting on an environmental time bomb. This is why trying to stabilise fossil fuel consumption at 1990 levels and having a vigorous policy to expand the use of renewable energy is so important (Stern, 2006). But the December 2009 Global Climate Summit in Copenhagen failed to reach an agreement on fossil fuel stabilisation.

Giga Richard has summarised estimates by various authors of the earth's carrying capacity for humans. These range from a low of 1 billion people to a high of 14 billion, with the median ranging from 2.1 billion (low) to 5 billion (high) (Richards, 2002). The high estimates are based on a much increased use of the net primary production (NPP) from biomass. This underlines that to foster truly sustainable development, all types of renewable energy and nuclear power will be needed, including biomass-based solid, liquid and

7 The World Bank Energy Strategy Approach Paper states that "The world economy is set to grow four-fold by 2050 and… energy-related carbon dioxide emissions will more than double" (WB, 2009). This translates into a per-capita increase of 2.9 times assuming the world's population will reach 9.2 billion by 2050. Obviously, the World Bank does not think there are limits to economic growth.

gaseous fuels. Electricity, and other forms of energy, can be an engine for growth. But in future, much more emphasis has to be placed on supplying the increased demand for electricity, especially in rural areas, from renewable forms of energy such as wind, solar, micro-hydro and biomass. Using biomass in stand-alone projects or as part of grid-based systems will provide jobs to rural people and help with poverty alleviation. As we have seen, biomass is universally available, can be grown simply and cheaply close to where it is required and has a sustainable supply several times that of the annual consumption of fossil fuels.

In the rest of this section I explore what needs to be done to increase the mix of biomass in the energy mix in developing countries.

Base planning on accurate measure of biomass yields and demands

One problem facing governments in general, and energy ministries in particular, in deciding on an energy strategy, is that they have little detailed knowledge either of the biomass energy supply situations or the sector demand patterns. This leads to poor planning, misallocation of resources and erroneous strategies.

For example, without measuring the growing stock and annual yield of trees and other forms of biomass in each region or district etc., it is impossible to undertake meaningful planning. Governments, development banks and companies would never finance natural gas or oil field development unless they knew the extent of the reserves, but this basic assessment is rarely, if ever, done for the dominant energy resource in many LDCs. This is extremely short-sighted for it can mean either the difference between using a resource that will last indefinitely, or mining it over a limited time period with possible adverse environmental and agricultural effects. Alternatively, it may lead to unnecessary investments in tree planting. Therefore, it is important that government, development agencies, the private sector and individuals co-operate to manage biomass resources sustainably and to target tree planting and other mitigation measures.

Estimates of biomass availability, particularly wood, can vary by a factor of four or more. One estimate in Ethiopia indicated that the country was using considerably more than its annual growth of wood (FAO, 1996). It was proposed that a massive countrywide plantation programme should be undertaken to close the demand/supply gap and that other mitigation measures be undertaken such as fuel switching. However, a more recent inventory showed that for the country as a whole, the annual growth of wood exceeds annual demand (Tecsult International, 2003). This inventory pinpointed areas of shortage and surplus. Programmes were proposed in these areas to meet the shortfall through local community and farmer driven efforts and to increase the off-take of wood in surplus areas. Similar discrepancies were found in Malawi, the Philippines and Uganda. A carbon sequestration study in 2000 undertaken for the Global Environment Facility (GEF) in Benin (PGFTR, 2000) determined that stem wood accounted for only 55% of above-ground weight. Therefore, basing the carbon store just on stem weight underestimates the above-ground carbon content of wood by over 80%. Likewise, it considerably underestimates the quantity of wood available for use (Box 3).

BOX 3. SEEING THE WOOD FOR THE TREES: MEASURING BIOMASS VOLUME CORRECTLY

Traditional inventories measure live stem wood only above a minimum diameter (7-10 cm) and sometimes just stem wood of 'commercial' timber. This underestimates the growing stock of woody biomass. Also, the designated rotation age for many commercial timber species can be excessively long (80-200 years). Usually, traditional inventories do not measure trees outside the forest. Most, if not all, types and sizes of wood are burnable, especially dead wood. Therefore, to obtain a true picture of biomass availability, an inventory of total above-ground woody biomass on all land formations is required to estimate the growing stock and annual growth. This latter is determined from the general management practices of rural people, rather than by forestry 'timber' rotations: actual tree management practices have rotations much shorter (2-30 years) than ideal timber ones. Thus, when complete above-ground inventories are undertaken, including dead wood, the results are much greater than those done when the main purpose is to determine the amount of sawlog availability.

Biomass, particularly wood, is not only a fuel or a source of industrial wood products–it has many other uses. Trees can be used to increase agricultural productivity through improved microclimate and by improving soil fertility through nitrogen fixation and leaf drop. But they are also used as a source of fodder and animal feed; they are important for honey, nut, fruit and medicinal/herbal production; and they are essential for environmental protection.

However, this versatility is both a strength and weakness. No single government ministry feels responsible for all the functions of trees and forests and so no one takes responsibility for co-ordinating these various functions and uses. Forestry departments may undertake the management/inventories of forests under their control, but rarely will they measure trees on forests and woodlands outside their control. Nor will they ever think about measuring trees on non-forest land, particularly agricultural land. Yet these trees are an important source of wood and biomass energy, particularly for rural households; they may account for up to 85% of rural energy and generate income for local people when supplying biomass to industry, the service sector and urban areas.

Reduce deforestation through integrated rural development

In most developing countries, the largest cause of deforestation is agricultural clearing. One analysis found that in sub-Saharan African countries 95% or more of deforestation was caused by clearing land for arable agriculture (Openshaw, 2004). The push factors for this include population pressure, low (subsistence) agricultural productivity and the push to produce cash crops in LDCs. The result is that more forest land is being cleared than is being replaced by newly planted or naturally regenerated trees on all land use types. Therefore, at present, more carbon dioxide is being released into the atmosphere from forest land clearing, the burning of wood *in situ* and from former forest soils, than is being sequestered.

In order to reduce deforestation, apart from a vigorous policy to slow down and eventually reverse population increase, agricultural productivity has to increase, especially in LDCs. Trees and other forms of biomass can play a role in this. Many trees and shrubs fix atmospheric nitrogen; judiciously spaced in fields such plants can maintain if not improve agricultural productivity, while at the same time providing firewood, plus browse and fodder for animals. The manure from these animals can then be used as fertiliser.[8]

There are also many areas of marginal and abandoned agricultural land that can be reclaimed for 'biomass crops' rather than clearing forests for oil crops, soy bean and pastoral agriculture. Land invaded by *Imperata cylindrica* grass—an aggressive weed species growing in many developing countries—can be reclaimed by planting nitrogen-fixing tree species such as *Gliricidia sepium* and *Leucaena leucocephala*. These trees rapidly suppress the grass (USA NAS, 1979). The reclaimed land can be used for arable agriculture, with some short-rotation trees left to provide mulch, shade and stick wood or to provide browse for farm animals. Similarly, dry areas, including deserts, can be reclaimed with *Prosopis sp*. This provides stick wood and the milled pods are protein-rich and are sold commercially as animal feed (USA NAS, 1979).

Apart from helping governments obtain good biomass supply/demand statistics, development bodies should assist them with rural development plans, especially improving agricultural productivity, promoting greater rural access, providing timely market intelligence and increasing social services. Expanding biomass use, promoting specific vegetation types and encouraging species selection to improve agricultural and silvicultural production, decreasing the incidence of pests and diseases and protecting biodiversity and watersheds should be an integral part of rural development. This could be done through training, demonstration and extension at all levels. Farmers, women's groups, villagers and local entrepreneurs can be shown how to better grow, manage, produce and market their resources on all land use types. Women can be shown better kitchen practices, and encouraged to obtain improved stoves, as part of enhanced village services. Generally, all these initiatives require outside assistance, albeit at a modest level. But usually such assistance will pay off many times over, environmentally, socially and economically.

Increase support to small-scale biomass energy producers

The World Bank has stressed the importance of assisting the private sector; in developing countries biomass energy production is principally in the hands of the private informal sector and is a fuel consumed by the poor (and rural industries). Yet very little help is given to such people (Box 4). Development banks could assist through training, market intelligence, micro loans, encouraging the removal of inappropriate bans and restrictions and improving infrastructure.

Invest in biomass training, research and development

There are petroleum engineers and electrical engineers, but few biomass production engineers. Yet these fuels are, or could be, important in LDCs. The status and sustainable use of biomass could be enhanced through systematic university/technical training in their production.

8 The methane from manure can be removed in biogas digesters and used as a fuel.

BOX 4. A NEW LOOK AT CHARCOAL

In some countries, charcoal producers are regarded as destroyers of the forests and woodlands. In fact, they are the producers of an important urban fuel and in many cases use resources that otherwise would ultimately rot or be burnt *in situ*. In some countries, such as Ethiopia and Malawi, charcoal production is illegal although the selling of it is not. This leads to surreptitious (and generally wasteful) production methods and the fear of confiscation by authorities: all this adversely affects the price of charcoal and makes charcoalers outlaws, rather than the providers of a useful product. In Ghana, night-time transport of charcoal and fuelwood is officially banned. This is a convenient excuse for 'dash' (bribes) being paid at roadblocks to allow the lorries to pass through. No such excess is imposed on petroleum vehicles; thus once again the price of a renewable fuel is adversely affected.

The charcoal production process is wasteful in the sense that up to 60% of the original energy is lost in the conversion process, but the resulting fuel has twice the energy of the parent material, is less polluting and is more convenient to use. This wastefulness is decried by some, but the same argument is hardly ever applied to electrical generation from fossil fuel, when up to 75% of the energy may be lost in production and distribution. However, charcoal production can be improved and producers should receive training in woodland management, charcoal production and in marketing. Charcoal production should be treated as a legitimate activity that is supplying a renewable and convenient energy form, while generating (rural) employment in production, transport and trading.

Similarly, energy conservation is considered to be an important way to reduce fuel costs and decrease pollution. But relatively little effort has been put into improving end-use efficiencies in the household (and other) sectors. Because biomass stoves are produced mainly by the informal sector, which can ill afford to undertake research and development, governments should assist in this effort through targeting training in stove manufacture techniques, business management and marketing; providing loans for micro-enterprise development, testing stoves and materials; and undertaking quality control. Governments should also co-ordinate the efforts of health departments and stove manufacturers to reduce indoor air pollution. Again, many rural industries using biomass energy could improve their intermediate and end-use efficiencies and, given the correct price signals, export electricity to the grid. Thus there is a need for some external help.

Conclusions

To conclude, biomass is a local resource that is environmentally benign. It is an important fuel in many developing countries, and one which can be produced indefinitely. Because it is a renewable and versatile carbon-based fuel that can be grown universally, it should be promoted as a form of energy that truly can support sustainable development. There are several recommendations that can be made to take this approach forward:

- Do not distinguish between so-called 'commercial' and 'non-commercial' energy types. Labelling biomass fuels as non-commercial immediately depreciates their value. Energy planners and development agencies should attempt to quantify the supply and demand of biomass energy alongside other forms of energy in order to highlight the importance of the different types and uses of energy and the opportunities that biomass presents in encouraging rural people to manage the resource sustainably, thus promoting rural development and poverty alleviation.

- Realise that a level playing field for all energy forms is required, especially with regard to subsidies for non-renewable energy. Indeed, if world bodies are serious about global warming, they should be promoting carbon taxes on fossil fuels (Stern, 2006).
- Build on the fact that biomass can be and is grown, managed and used by rural people with little capital inputs, and can generate income and ensure that energy is available nearby. Biomass can also provide energy for industries, thus assisting sustainable rural development.
- Take a multidisciplinary approach; biomass production impinges on forestry, agriculture, energy, environment, industry and development. It is also important to involve biomass energy specialists in energy planning and policy and to invest in biomass training, research and development.
- Slow down and eventually halt deforestation by keeping agricultural productivity on par with population increase. The agricultural policies in developed countries—subsidies and import taxes—coupled with development agency policies to prevent the subsidising of fertilisers in LDCs, penalise LDC farmers and facilitate 'cheap' imports of subsidised food. Trade and aid policies should be re-examined to promote improved agricultural productivity in LDCs. This would do more for development than current approaches.
- Modest investments, good governance and policy reform could reverse the deforestation trend.[9] Bringing the poor into partnership with government and providing more opportunities to earn money from all aspects of tropical forests, plantations, woodlands and on-farm trees could reap great environmental and economic rewards and help alleviate poverty.

9 One of the few positive outcomes of the UN Global Climate Summit in Copenhagen in December 2009 was a pledge by developed nations of US$ 30 billion over three years to help poorer countries mitigate climate change. Some of this money will go to REDD (reduction of emissions from degradation and deforestation). However, as clearing land for agriculture is a principal cause of deforestation, it is hoped that some will also go to help increasing agricultural productivity.

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