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Traditional Biomass Energy

Improving its Use and Moving to Modern Energy Use[1]

Thematic Background Paper

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Each TBP focusses on a different aspect of renewable energy and presents policy implications and recommendations. The purpose of the TBP is twofold, first to provide a substantive basis for discussions on the Conference Issue Paper (CIP) and, second, to provide some empirical facts and background information for the interested public. In building on the existing wealth of political debate and academic discourse, they point to different options and open questions on how to solve the most important problems in the field of renewable energies.

All TBP are published in the conference documents as inputs to the preparation process. They can also be found on the conference website at www.renewables2004.de.

Executive Summary

Biomass energy is an important source of energy for majority of the world's population. The use of biomass energy is expected to increase in the near future, with growth in population. In many developing countries (particularly sub-Saharan Africa), traditional biomass energy dominates national energy statistics, leading to significant negative impacts on human health and the environment. There are, however, opportunities for developing improved and modern biomass energy technologies, which offer substantial benefits in terms of enhanced quality of energy services and reduction in negative health and environmental impacts. In addition, the sustainable harvesting of biomass resources is essential for ensuring the continued availability of this important energy source particularly for the world's poor. This paper presents the global status of biomass energy use, as well as a range of plausible future biomass energy scenarios. It categorizes biomass energy use into three clusters, namely: traditional, improved and modern biomass. With special emphasis on developing regions (which rely on biomass to meet a substantial proportion of their energy needs), the paper proposes policy options targeted at increasing the further development and wider dissemination of improved and modern biomass energy.

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1. Introduction

1.1 Why is biomass energy important?

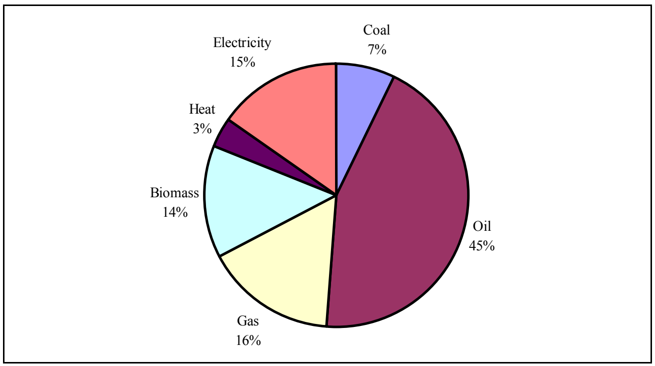
Biomass energy plays a vital role in meeting local energy demand in many regions of the developing world. Biomass is a primary source of energy for close to 2.4 billion people in developing countries (IEA, 1998). It is easily available to many of the world's poor and provides vital and affordable energy for cooking and space heating. Biomass-based industries are a significant source of enterprise development, job creation and income generation in rural areas (Karekezi et al, 2002; Goldemberg, 2003; Reddy et al, 1997). Modern biomass energy is widely used in many developing countries as well as in parts of the industrialized world. With proper management backed by adherence to appropriate ecological practices, modern biomass can be a sustainable source of electricity as well as liquid and gaseous fuels. Biomass, therefore, is not only a vital source of energy for many today but is likely to remain an important source of energy in the future subject to its sustainable exploitation (Yamamoto et al, 2001; Hall, 1998).

Growing interest in biomass energy is driven by the following facts among others:

- It contributes to poverty reduction in developing countries;
- It meets energy needs at all times, without expensive conversion devices;
- It can deliver energy in all forms that people need (liquid and gaseous fuels, heat and electricity)
- It is carbon dioxide-neutral and can even act as carbon sinks; and
- It helps to restore unproductive and degraded lands, increasing biodiversity, soil fertility and water retention (Best and Christensen, 2003)

Available statistics indicate that the share of biomass in the global energy consumption has remained roughly the same over the last 30 years[2]. Biomass energy[3] accounted for an estimated 14% and 11% of the world's final energy consumption in 2000 and 2001 respectively (IEA, 1998 and IEA, 2003). As shown in figure 1, the International Energy Agency (IEA, 2003c) estimates that at global level, the share of biomass in total final energy consumption is comparable to that of electricity (15%) and gas (16%).

Figure 1: World Final Energy consumption 2001



Source: IEA, 2003

At a regional level, however, the share of biomass energy in total energy consumption varies significantly (table 1). Developing regions (Africa, Asia and Latin America) record high levels of biomass energy consumption (IEA, 2002, World Bank, 2003c) in comparison to developed regions.

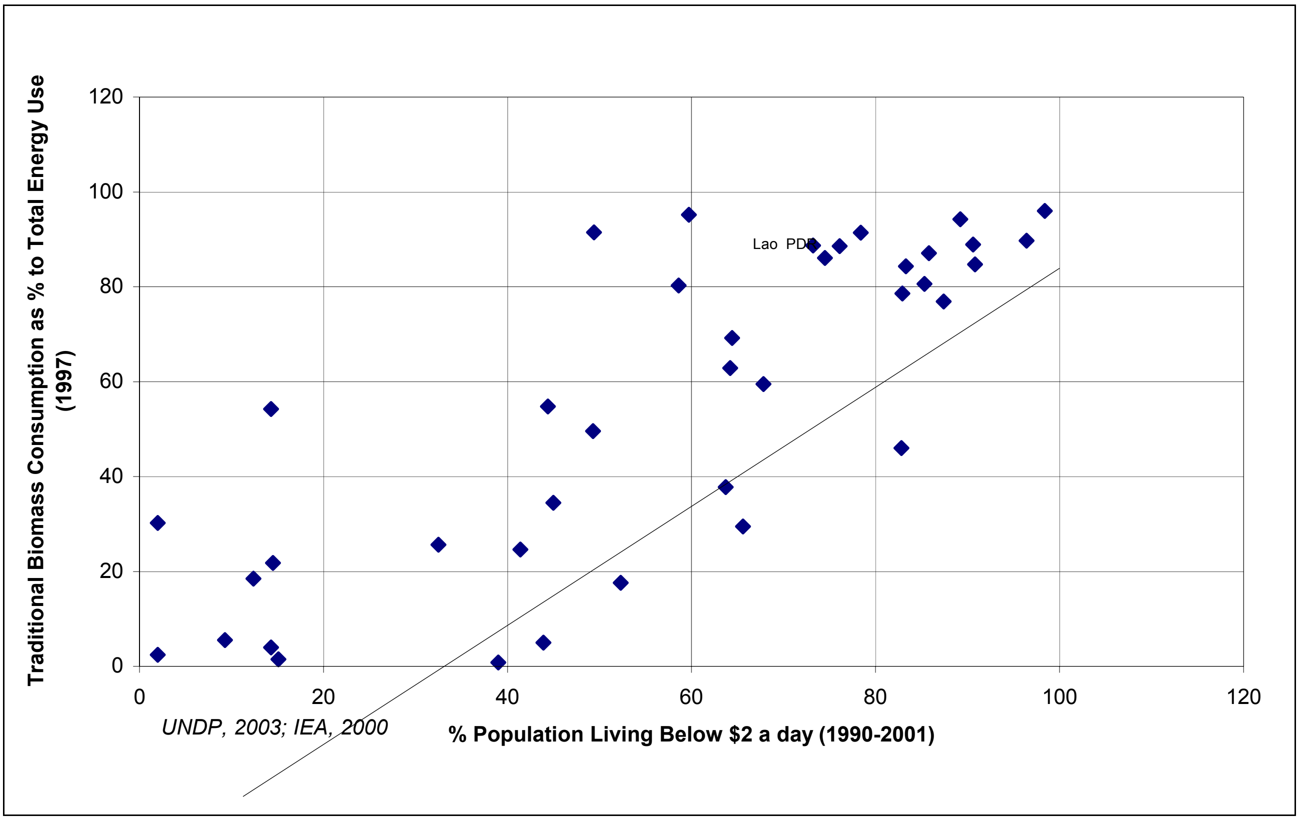
Table 1: Biomass supply as a percentage to total primary energy supply, 1971 and 2001

Region	1971 (%)	2001 (%)
OECD	2	3
Non-OECD Europe	4	5
Latin America	31	18
Asia	48	25
Africa	62	49

Source:IEA,2003

According to the International Energy Agency (IEA, 2002a), approximately 50% of the population in developing countries relies on biomass energy, with some regions recording higher proportions (73% in Africa). Biomass is the energy source for the poor. This is especially true for traditional biomass energy, which is often collected as a 'free'[4] fuel (Reddy et al, 1997; Karekezi and Kithyoma, 2002; Kgathi et al, 1997; Hall and Mao, 1994; Karekezi and Ranja, 1997). There appears to be a correlation between poverty levels and traditional biomass use in many developing countries (Figure 2). As a rule, the poorer the country, the greater the reliance on traditional biomass resources (IEA, 1998).

Figure 2: The Link Between Poverty and Traditional Energy Use



1.2 Why simultaneously address traditional, improved and modern use of biomass energy?

The phrase *"traditional biomass energy use"* as used in this paper refers to the direct combustion (often in very inefficient devices) of wood, charcoal, leaves, agricultural residue, animal/human waste and urban waste, for cooking, drying and charcoal production. "*Improved traditional biomass energy technologies (IBTs)"* refers to improved and efficient technologies for direct combustion of biomass e.g. improved cookstoves, improved kilns, etc. "*Modern biomass energy use"* refers to the conversion of biomass energy to advanced fuels namely liquid fuels, gas and electricity (AFREPREN, 2002). Although primarily focussing on *traditional biomass energy* as well as improved use of traditional biomass (which from now on will simply be referred to as *improved biomass*), this paper also examines the question of modern biomass energy for several reasons. First, all the three biomass energy forms largely rely on the same natural resource base.

Second, many of the options aimed at addressing problems associated with *traditional biomass energy* use, entail the deployment of *improved biomass energy technologies (IBTs)*. While biomass energy, particularly traditional biomass energy use, is often perceived in a negative light, there are attractive opportunities for using biomass energy in a more modern, efficient and environmentally friendly ways (Karekezi and Ranja, 1997; Hall and Rosillo-Calle, 1998).

Improved biomass energy technologies (IBTs) have the potential to reduce the negative impacts of current traditional biomass energy use.

Many policy makers and researchers in the developing world (as well as interested analysts and decision makers in the more developed parts of the world) are keen to see a progressive shift from traditional biomass use to improved use, and eventually to modern biomass energy use (Karekezi, et al 2002 and Leach, 1992). Of priority interest in developing countries is the need to first, improve the current use of traditional biomass and secondly to transform biomass into high-quality low-emission electricity, fuels and gases (Goldemberg and Coelho, 2003). In many industrialized countries, (i.e. Austria, Germany, Sweden, Norway), modern bioenergy is increasingly entering energy balances. Thirdly, existing data sets do not differentiate between traditional, improved and modern uses of biomass energy[5]. In many cases, residues available for energy must be derived directly from agricultural data. This is particularly true of aggregated global and regional data sets. Most statistical sources combine biomass energy used in sustainable and unsustainable methods. One of the key challenges facing biomass energy analysts is the compilation of reliable trend data that distinguishes traditional biomass energy use from improved as well as modern biomass energy consumption (Goldemberg and Coelho, 2003).

1.3 Global scenarios

Biomass energy dominates current renewable energy statistics (Table 2). About 80% of current global renewable energy supply comprises of biomass energy (IEA, 2003a).

Table 2: Global Renewable Energy Supply for 2000

Country/Region	Total Primary Energy Supply (Mtoe)	Of which Total Renewables (Mtoe)	Share of Total Renewables in TPES (%)	Share of the Main Fuel Categories in Total Renewables		
				Hydro (%)	Geothermal, Solar, Wind, etc (%)	Combustible Renewables and Waste[6] (%)
Africa	508	259	50.9	2.3	0.2	97.5
Latin America & Caribbean	456	127	27.9	37.3	1.3	61.3
Asia (excluding China)	1,123	382	34.0	4.0	3.3	92.7
China*	1,158	234	20.2	8.2	0.0	91.8
Non-OECD Europe	95	9	9.9	46.1	0.9	53.0
Former USSR	921	30	3.3	65.5	0.2	34.3
Middle East	380	3	0.8	41.3	22.7	35.9
OECD	5,317	329	6.2	34.4	10.8	54.8
World	9,958	1,373	13.8	16.5	3.7	79.8

* China includes People's Republic of China and Hong Kong, China

Source: IEA, 2002b

Various global studies on the potential of biomass indicate that its use is expected to increase in the future. The IEA estimates that final consumption of biomass energy will increase in most regions (table 3), although at a slower rate than conventional energy consumption. The share of biomass energy in total global energy supply will, however, not increase and is expected to remain at about 11% (IEA, 1998). In Africa, available estimates indicate that by 2020, biomass energy use is expected to increase roughly at the same rate as population growth rates (IEA, 1998), resulting in insignificant changes in the share of biomass in total final energy supply. In contrast, the share of biomass in total final energy supply in developing countries as a whole (Africa, Asia and Latin America) is expected to decrease in the same period particularly for Asia and Latin America which are expected to register a substantial reduction (table 3).

Table 3: Projected Final Biomass Consumption in Relation to Total Energy Use, 2000 and 2020

Country/ Region	2000				2020			
	Biomass (Mtoe)	Conven-tional Energy (Mtoe)	Total (Mtoe)	Share of Biomass (%)	Biomass (Mtoe)	Conven -tional Energy (Mtoe)	Total (Mtoe)	Share of Biomass (%)
China	214.48	943.4	1,157.9	18.50	224	1,524	1,748	13.00
Asia	343.20	467.74	810.94	42.30	394	1336	1730	22.80
Latin America	69.34	284.96	354.30	19.570	81	706	787	10.00
Africa	221.10	1,57.37	378.47	58.40	371	260	631	59.00
Total non OECD	859.65	2,417.86	3,277.51	26.23	1,097	5,494	6,591	17.00
OECD countries	126.17	3,551.32	3,677.49	3.40	96	3,872	3,968	2.00
World	985.2	5,969.18	6,955	14.20	1,193	9,365	10,558	11.00

Source: IEA, 1998; IEA, 2003a

The IEA estimates on biomass energy present the business-as-usual case, based on current biomass energy use and supply (both sustainable and unsustainably). For example, IEA estimates for charcoal consumption in developing countries consider the highly efficient production methods in Latin America, and the traditional low-efficiency methods prevalent in Africa and Asia (IEA, 1998). IEA's future projections can therefore be considered as the conservative scenario for future biomass energy use.

A study conducted jointly by the International Institute for Applied Systems Analysis (IIASA), and the World Energy Council (WEC) also projects an increase in global biomass energy use. The IIASA-WEC estimates indicate that the global biomass consumption in 1990 was 5.4Gtoe. In the year 2020 the IIASA-WEC estimates biomass energy consumption to be between 6.7 – 7.5Gtoe (table 4). By the year 2050, the biomass energy potential will have increased to between 8.8 - 10.8Gtoe (Fischer and Schrattenholzer, 2001). The IIASA-WEC scenario takes into account competition for land between bio energy and food production, and the sustainable production of biomass energy. The estimates in the IIASA-WEC scenario can therefore be considered as a more optimistic scenario. Other studies[7] also indicate growth of biomass energy in global energy supply, albeit at different rates.

Table 4: World Biomass Energy Potential – IIASA-WEC (Mtoe)

Biomass energy resource	2020 (Mtoe)
Crop Residue	480-499
Wood	1,791-2,025
Energy crops	2,971-3,535
Animal waste	994
Municipal waste	516
Total	6752-7569

Source: Fischer and Schrattenholzer, 2001

Approximately 40% of the world's population depended on biomass energy in the year 2000 (IEA, 2002). The proportion of the population in developing countries relying on biomass energy is expected to increase. In some regions (e.g. Africa), biomass energy use will increase at the same rate as the population (IEA, 1998). Table 5 shows the projected increase in the number of people dependant on biomass energy. South Asia and Africa are expected to register the highest increase.

Table 5: Number of People Relying on Biomass for Cooking and Heating in Developing Countries (million)

Country/Region	2000	2030[8]	2000-2030 (%)
China	706	645	-9
Indonesia	155	124	-25
Rest of Asia	137	145	6
India	585	632	7
Rest of South Asia	128	187	32
Latin America	96	72	-33
Africa	583	823	27
Developing Countries (Total)	2,390	2,628	10

Source: IEA, 2002a

1.4 Case for differentiated regional assessment of biomass energy issue

As demonstrated by the preceding discussion, the use of biomass energy varies significantly across the globe. Biomass energy is an important source of energy in many developing countries especially Africa. The role of biomass energy in industrialized countries is more modest. Even in developing parts of the world, there are variations in the type of biomass energy that is dominant. For example, in Africa, traditional biomass dominates national statistics while in Asia one sees greater use of improved biomass technologies. Use of modern biomass technologies is more prevalent in Latin America (IEA, 1998; Hall and Rosillo-Calle, 1998).

Biomass energy resources vary geographically, and are not uniformly distributed (IEA, 2002a; Reddy et al, 1997). Biomass energy use is dependent on various factors, such as geographical location, land use patterns, preferences, cultural and social issues. Income distribution patterns also contribute to variations in biomass energy use, with poorer regions relying on traditional forms of biomass, and industrialized regions using more modern biomass energy technologies (Leach, 1992; Hall, 1991). Biomass energy issues also vary in urban and rural areas (Sathaye and Meyers, 1985). For example, while biomass can be collected for free in any rural areas of developing countries, it is a largely purchased commodity in urban areas.

These variations point to the need for a regional assessment of biomass energy issues. The next section, therefore, discusses biomass energy use from a regional perspective, with greater emphasis on developing countries of Africa, Asia and Latin America.

2. Regional Perspectives

2.1 Africa

Biomass energy forms the bulk of Africa's total final energy supply. It is, however, important to note that data on biomass in Africa is particularly problematic. Most countries do not have reliable and up-to-date databases on energy, and especially biomass energy[9]. Available data estimates indicate that biomass constituted 60% of total final energy consumption in Africa in 1995 (IEA, 1998). According to the same source, in 2001, biomass accounted for 49% of total primary energy supply (IEA, 2003). Although there was a decrease from the share of biomass in total primary energy supply over a 30-year period (from 62% to 49%, IEA, 2003), biomass still plays a dominant role in Africa's energy sector (IEA, 2003a).

The heavy reliance on biomass is notably prominent in sub-Saharan Africa, where biomass accounts for 70-90% of primary energy supply in some countries (UNDP, 2003; Karekezi, et al, 2002), and 86% of energy consumption (IPCC, 2003). The bulk of biomass energy used in sub-Saharan Africa is traditional biomass (UNDP, 2003). Variations within Africa exist, with biomass accounting for only 5% of energy consumption in North Africa and 15% in South Africa (IPCC, 2003).

The heavy reliance on biomass energy in Africa is unlikely to change in the near future, given the stagnant (or sometimes declining) per capita modern energy use as well as slow economic growth. Estimates indicate that by 2020, biomass energy use is expected to increase roughly at the same rate as population growth rates (IEA, 1998; Barnes, 1990), resulting in insignificant changes in the share of biomass in total final energy supply (Table 6). In contrast, the share of biomass in total final energy supply in developing countries is expected to decrease in the same period. The absolute number of people relying on biomass energy in Africa is also expected to increase between the year 2000 and 2030 - from 583 million to 823 million, an increase of about 27% (IEA, 2002a).

Table 6: Total final energy supply including biomass energy in Africa

	2020		Annual growth Rate (%) 1995-2020
	Biomass (Mtoe)	**Share of Biomass in total supply (%)**	**Biomass**
Africa	371	59	2.4
Total developing countries	1,071	22	1.0
World	1,193	11	1.0

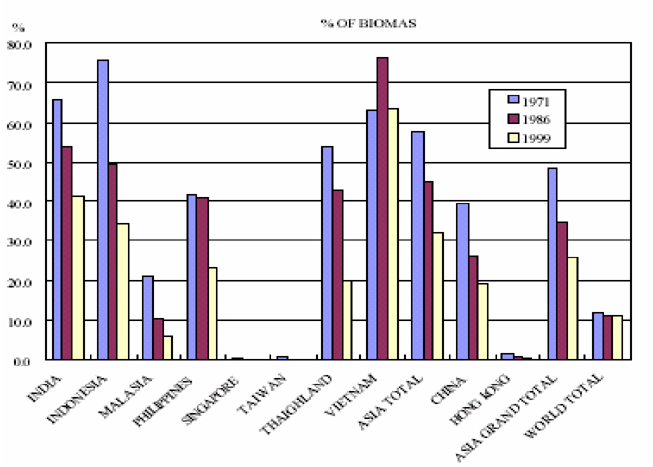
Source: IEA, 1998

2.2 Asia

Biomass energy plays a significant role in Asia's energy sector. The share of biomass energy in total primary energy supply for Asia in 2001 was 25% (IEA, 2003a). Asia also records significant variations in biomass energy consumption at regional and national levels. Biomass energy use accounted for 24% of the total energy consumption in China, 25% in East Asia and 56% in South Asia (IEA, 1998). The types of biomass energy used in Asia are a mixture of traditional, improved and modern biomass energy.

Over 80% of the total rural population and 20% of total urban population of Asia depend on biomass to satisfy their cooking energy needs. Fuel wood, dung cakes and crop residues still remain the primary household fuels with their share in household energy consumption well above 50% in most Asian countries (Lefevre et. al 1997). Non-commercial activities consume the highest proportion of solid biomass (10.4% of total primary energy supply) in Asia. Figure 3 presents the contribution of biomass to primary energy in selected Asian countries. Annex 1 (Asia) provides estimates of projected fuel wood consumption in Asia (FAO, 1998).

Figure 3: Share of biomass in total energy supply of few Asian countries



A survey carried out in India showed that the share of biomass fuels in rural household energy consumption had declined from 97% to 94%, but that of fuelwood had increased from 42% to 47% (Ershad, 2002). It was also found out that the proportion of households using firewood logs increased to about 56% from 35%, while those using firewood twigs slightly declined to 63% from 68%. Although the share of wood in total energy consumption is decreasing, (India - 49% in 1983 to 24% in 1999; Bangladesh - 83% in 1981 to 67% in 2000), it is increasing in absolute terms, mainly due to population growth and growth in per capita energy consumption (Ershad, 2002).

China accounts for one fourth of the global population and is second to the United States in total primary energy consumption. With an estimated energy consumption total of 1,139.4 Mtoe, China derives the bulk of its energy from coal and oil. Crop residues and wood fuel are important rural energy resources inspite of rapid increases in the use of coal, oil and electricity in rural areas. From 1993 to 1999, total biomass share decreased from 69% to 30% (IEA, 2003a; Zhenhong, 2001). However, in 1999, the total rural energy consumption was 464 Mtoe of which about 30% came from biomass, mainly crop residues and firewood.

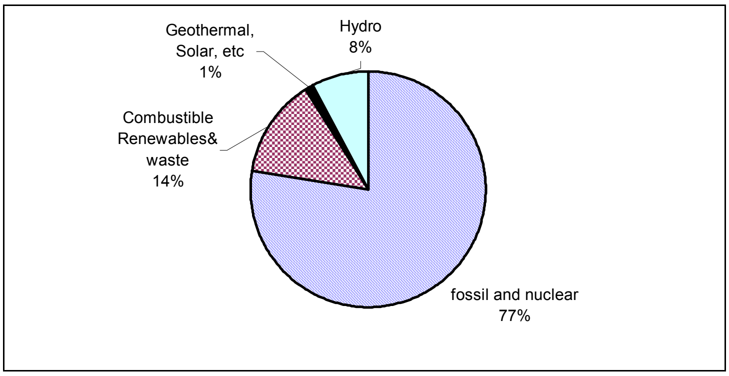
2.3 Latin America and the Caribbean

The share of biomass in the total primary energy supply of Latin America and the Caribbean (LAC) was estimated at 18% in 2001 (IEA, 2003), making it the developing region with the lowest share of biomass in energy consumption. More recent estimates (IEA, 2002b), indicate that the proportion of primary energy derived from biomass (Combustibles and Renewable Wastes, CRW[10]) has decreased to 13.5% but the statistics vary significantly within the countries. Annex 2 (Latin America) presents the estimated consumption of biomass energy in each LAC country. It is, however, difficult to establish how much of this share is produced in a sustainable way.

Biomass energy use in Latin America is more modernized – for example, alcohol production from “sustainable”[11] biomass is an important source of fuel for the transport sector in a number of countries (Coelho et al, 2003). A large proportion (46%) of biomass energy use in Latin America is used in the industrial sector (IEA, 1998).

Existing data shows huge disparities among LAC countries, as discussed in Annex 2 (ECLAC, 2003). Even in the countries where there are experiences with modern biomass – like Brazil, for example, there are still several parts of the country where reliance on inefficient traditional biomass energy is still prevalent (Coelho, 2003).

Figure 4: Primary Energy Supply Latin America - 2000



Source: IEA, 2002a

2.4 Industrialized Countries

Industrialized countries record significantly lower levels of biomass energy supply, most of which is modern biomass energy use (IEA, 2003b). The OECD[12] estimated the share of biomass in total primary energy supply in industrialized countries at 3% in 2001. This was an increase of 1% since 1971 (IEA, 2003). The bulk of biomass energy use in industrialized countries comprises of modern biomass energy technologies (IEA, 2001; IEA, 2002). Biomass contributed about 2% of fuels used for electricity generation in industrialized countries in 2001 (IEA, 2003b). Table 8 presents the contribution of biomass energy to electricity generation in industrialized countries.

Table 8: Biomass Electricity Production in Industrialized Countries - 1999

Country	Biomass Electricity (TWh)	% of Total Electricity
US	63.5	1.6
Japan	16.2	1.5
Germany	9.4	1.7
Finland	8.7	12.5
Brazil	8.5	2.6
UK	7.7	2.1
Canada	7.1	1.2
Netherlands	4.0	4.6
Australia	3.7	1.8
Sweden	3.4	2.2

Source: IEA, 2001.

Biomass energy use in industrialized countries is expected to increase in the future, although its contribution to final energy consumption will not substantially grow (IEA, 1998). According to the IEA, the share of biomass energy in electricity generation in industrialized countries is expected to increase from 1.6% in 1997 to 2.1% in 2020 (IEA, 2001).

2.5 Categorization of biomass energy: Traditional, Improved and Modern

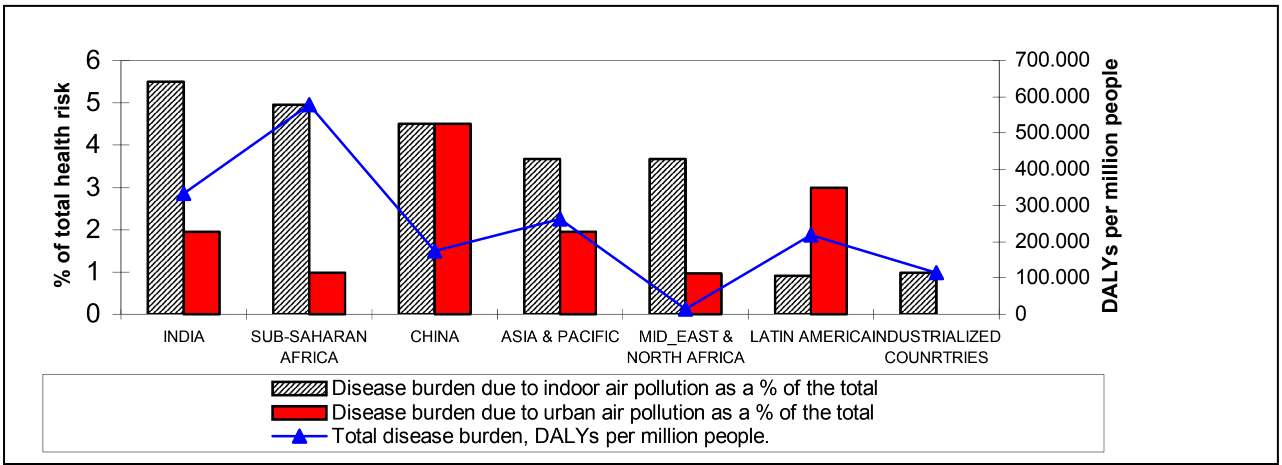
As mentioned earlier, biomass energy use can be broadly categorized into the following three(3) clusters: Traditional biomass energy, Improved Biomass Energy; and Modern Biomass Energy. The goal is to move from traditional biomass energy to improved biomass energy and eventually to modern biomass energy. The following section discusses the benefits and challenges of each of these categories of biomass energy, and the potential role in the energy sector of developing countries.

3. Traditional Biomass Energy Technologies

Traditional biomass energy is a local energy source, which is readily available to meet the energy needs of a significant proportion of the population – particularly the poor in rural areas of the developing world. Traditional biomass energy is low cost and it does not require processing before use (Hall and Mao, 1994).

Traditional biomass use, however, has significant drawbacks. The indoor air pollution from unvented bio-fuel cooking stoves (figure 5) is linked to respiratory diseases in many highland areas of developing countries[13] (Karekezi and Ranja, 1997; Karekezi and Kithyoma, 2002; Kammen and Ezatti, 2002; Smith 1991; Smith, 1994). Rural and poor women and children in many developing countries spend a significant portion of their time gathering and collecting woodfuel, crop residues and animal dung for use as cooking and space heating fuels (Energia, 2001; Energia 2002; ITDG, 2003). Traditional biomass energy use has direct negative impacts on women and children, who are the most vulnerable group in terms of biomass energy scarcity and adverse indoor air pollution impacts (Ezatti, 2001)[14].

Figure 5: Comparison of Total Disease Burden and Disease Burden arising from indoor and urban air pollution



DALY – Death and Disability Adjusted Life-Years

Source: Schirnding, 2001

Reliance on traditional biomass (especially in the form of charcoal) contributes to land degradation (Scully, 2002) and deforestation in countries where charcoal (sourced from natural forests and not planted forests) is widely used (see table 9). The unreliability of biomass energy data complicates attempts to link deforestation to biomass use but the consensus among leading biomass energy experts is that inefficient charcoal production from natural forests and woodlands contributes to deforestation[15] (FAO/ADB, 1995).

Table 9: Losses in charcoal production in Developing Countries

	1995	2010	2020
East Asia			
Share of charcoal in final biomass use	5%	7%	8%
Charcoal production/use (Mtoe)	5.6	7.8	9.2
Wood input in charcoal production (Mtoe)	16.5	21.7	25.1
Energy losses in charcoal transformation (Mtoe)	**10.8**	**14.0**	**15.9**
South Asia			
Share of charcoal in final biomass use	2%	3%	4%
Charcoal production/use (Mtoe)	3.5	7.9	11.1
Wood input in charcoal production (Mtoe)	12.6	28.2	39.5
Energy losses in charcoal transformation (Mtoe)	**9.1**	**20.3**	**28.4**
Latin America			
Share of charcoal in final biomass use	9%	9%	9%
Charcoal production/use (Mtoe)	6.4	7.0	7.2
Wood input in charcoal production (Mtoe)	13.2	14.5	14.9
Energy losses in charcoal transformation (Mtoe)	**6.8**	**7.5**	**7.7**
Africa			
Share of charcoal in final biomass use	3%	6%	8%
Charcoal production/use (Mtoe)	6.8	19.1	30.8
Wood input in charcoal production (Mtoe)	27.0	72.1	112.1
Energy losses in charcoal transformation (Mtoe)	**20.3**	**53.0**	**81.3**
Total developing countries			
Share of charcoal in final biomass use	3%	4%	5%
Charcoal production/use (Mtoe)	22.3	41.8	58.3
Wood input in charcoal production (Mtoe)	69.3	136.5	191.6
Energy losses in charcoal transformation (Mtoe)	**47.0**	**94.7**	**133.3**

Source: IEA, 1998

In some areas (for example around major cities such as Lusaka, Zambia; Nairobi, Kenya; and, Dar-es-salaam, Tanzania) charcoal demand appears to contribute to degradation of the surrounding woodlands and forests (Scully, 2002). Traditional charcoal production relies In addition, charcoal production often leads to uncontrolled fires, which destroy biodiversity and contribute to regional air pollution. on the traditional and rudimentary earth kiln, which is considered to be a major contributor to deforestation and land degradation in many peri-urban and rural regions of developing world.[16]

Traditional charcoal production is a particularly inefficient process, resulting in significant loss of energy in the conversion of woodfuel to charcoal (Karekezi and Ranja, 1997; IEA, 1998; Rosillo-Calle et al., 1995).

The ownership of traditional biomass resources presents an additional problem. Forests are often public property (communal) and the entire community harvests products from the forest (e.g. wood and timber). However, few people are willing to pay for the resource recovery through protection and reforestation (Scully, 2002). Often termed the "crisis of the commons", the question of ownership of traditional biomass resources bedevils both researchers and policy makers and has yet to be satisfactorily resolved. This is often compounded by the intricate relationship between control over biomass energy resources and prevailing land tenure practices, policies and regulatory frameworks (FAO/ADB, 1995; Scully, 2002).

Some of the key challenges facing many countries that rely heavily on traditional use of biomass include: firstly, ensuring the biomass used is sourced from sustainable biomass resources (e.g. wood plantation, sustainable management of native forests); secondly, how to widely disseminate improved biomass energy technologies (IBTs); and finally, how to promote modern biomass energy technologies (MBTs) that use a wide range of biomass resources (woodfuel, agro industrial residues, rural and urban residues) to generate high quality fuels, gases and electricity (Hall and Rosillo-Calle, 1998; Masera et al, 2000).

4. Improved Biomass Energy Technologies

4.1 Benefits and Challenges

Improved biomass technologies (IBTs) contribute to more efficient and environmentally sound use of biomass energy. Improved cookstoves, for instance, are designed to reduce heat loss, decrease indoor air pollution, increase combustion efficiency and attain a higher heat transfer (Karekezi and Ranja, 1997; Masera et al, 2000). This results in savings in the amount of fuel used, which translates to direct cash savings (table 10).

Table 10: Savings from improved stoves in Africa

Average daily charcoal consumption (kg per person per day)			**Yearly savings per family** (kg)	**Value of savings** ($)	**GNP Per Capita (US$)**
	Traditional Stove	**Improved Stove**			
Kenya	0.67	0.39	64.70	613	350
Rwanda	0.51	0.33	84.10	394	220

Source: Karekezi and Ranja, 1997; World Bank, 2003

There are several advantages of using improved biomass technologies such as more efficient cookstoves, charcoal kilns and dryers. These advantages are not only limited to the reduction of local (mainly indoor) pollution[17], but also because more efficient biomass conversion technologies can reduce the negative deforestation impact of, for example, traditional charcoal production. Improved use of biomass in households, institutions and industries leads to reduced fuel consumption, faster processing, improved product quality and products with better shelf life (Schirnding, 2001; Karekezi and Ranja, 1997; Karekezi et al, 2002).

Other benefits that accrue from increased use of improved biomass technologies (IBTs) include the alleviation of the burden placed on women and children in fuel collection, freeing up more time for women to engage in other activities, especially income generating activities. Reduced fuel collection times can also translate to increased time for education of rural children especially the girl-child (Karekezi et al, 2002b). The production and dissemination of improved biomass energy technologies provides employment and job opportunities for a significant proportion of the population, particularly women (Energia, 2002). The provision of more efficient stoves can reduce respiratory health problems associated with smoke emission from biofuel stoves (Barnes and Floor, 1996; Khennas et al, 1999; Karekezi and Kithyoma, 2002).

Improved biomass energy technologies (IBTs) provide an attractive option for small and medium enterprises. IBTs improve the efficiency of biomass use in traditional energy-intensive rural productive activities such as charcoal production, crop drying, fish drying and beer brewing (Reddy et al, 1997; Karekezi and Kithyoma, 2002).

Initiatives to disseminate IBTs have delivered significant benefits to both the urban and rural poor in developing parts of the the world. Urban improved stove initiatives deliver several benefits to the urban and rural poor, respectively. First, in terms of jobs created in improved stoves programs and second, in terms of reduced charcoal consumption through the use of improved charcoal stoves (Khennas et al, 1999; Karekezi and Kithyoma, 2002). The informal sector, which provides employment to the urban poor, is the principal source of improved stoves (see following case studies)[18].

Case Study 1.The Kenya Ceramic Jiko (Improved Charcoal Cookstove)

The Kenya Ceramic Jiko (KCJ) is one of the most successful stove projects in the Africa. The KCJ is made up of a metal cladding with a wide base and a ceramic liner. At least 25per cent of the liner base is perforated with holes of 1.5 cm diameter to form the grate. The stove has three pot rests, two handles, three legs and a door. The door is used to control the airflow. The standard model weighs about 6kg, which means it can be carried around easily (KENGO, 1991; Karekezi and Kithyoma, 2002).

The stove is suitable for cooking and space heating The KCJ helps to direct 25-40 per cent of the heat from the fire to the cooking pot. The traditional metal stove that the ceramic Jiko replaces delivers only 10-20per cent of the heat to the pot, whereas an open cooking fire yields efficiencies as low as 10per cent (Kammen, 1995). The cost of the stove is about US$2, which makes it accessible to the majority of the urban population in Kenya, although this cost does not include fuel costs (charcoal).

The manufacture of the KCJ is now a relatively mature cottage industry. As expected, the level of specialization in the manufacture of the stove has increased, as has the level of mechanisation. There is now a discernible labour division. Shauri Moyo is the principal artisanal production centre in Nairobi, where there are artisans whose occupation is to purchase clay liners and metal claddings and to assemble and retail complete stoves to customers. There are two types of stove producers in Nairobi: mechanised manufacturers and semi mechanised producers. It is estimated that mechanised producers are manufacturing close to 3,200 liners a month. Semi –mechanised producers are now producing an estimated 10,600 liners per month.

Based on achievements to date, the KCJ can be declared a success story. The future of this stove is not completely secure, however, because of several constraints. The overall penetration rate for Nairobi, for example, was found to be around 50 per cent, indicating that the dissemination of the KCJ is far from complete. Another source of concern is the lack of quality control, a question that has not been adequately tackled so far. Quality control will require the intervention of concerned NGOs and government agencies. (Karekezi and Ranja, 1997; Karekezi et al, 2002)

Case Study 2: Maendeleo/Upesi Improved Woodfuel Stove

The Women and Energy project of the Ministry of Energy in Kenya initially spearheaded the production and dissemination of the Upesi stove (a one-pot improved ceramic stove that is cleaner than the traditional fire place). The German Technical Cooperation (GTZ) funded the project. The project had the overall objective of improving the living conditions of Kenya's rural population by reducing fuel wood requirements and improving fuel wood availability (Muriithi, 1995).

Given the difficulty faced in disseminating the Maendeleo Stove in rural areas, the Intermediate Technology Development Group (ITDG) which actively participated in the second phase of this programme renamed the stove 'Upesi', and promoted its commercial production in west Kenya. ITDG focussed on benefits to the producers and the development of a commercial market for the stoves.

Women were the main implementers of the project by ITDG, and 19 women's groups were trained in the manufacture of the stove. To date, a total of 10 women's groups are recognised as producers of the stove. This has had a positive impact on the recognition of women's status in the society, as well as control over household budgets. The project developed a participatory approach to ensure that the producer groups controlled the extent of their training.

The aim is to ensure that only the most motivated and best-organised groups continue with the training and production. This competitive aspect has impacted positively on the quantity as well as the quality of stoves produced.

Overall, the project has achieved significant results because of working with the beneficiaries of the technology thus ensuring that end-user needs are incorporated in technology development. The annual production is over 12,000 Upesi Stoves and 2,500 liners for the Kenya Ceramic Jiko. The total profit generated by the production of stoves is estimated to be between 217,500 Kenya Shillings (US$2,788) and 397,500 Kenya Shillings (US$5,096) (Khennas et al., 1995). The project provided the opportunity for women to engage in income generating activities, and has undoubtedly improved their livelihood and welfare (Khennas et al, 1999).

4.2 Prospects

Given the relatively low levels of dissemination of improved biomass energy technologies (IBTs) in developing countries (especially Africa), and the projected increase in the number of people relying on biomass, the potential for IBTs is vast. For example, almost every country in developing regions has put in place a programme for the dissemination of improved cookstoves, and this provides a good basis for significant increases in the dissemination of other IBTs. Greater dissemination of improved cookstoves is likely to result in significant energy savings and efficiency improvements (table 11). There is also significant potential for increased use of other improved biomass technologies (IBTs) in the developing countries.

Table 11: Potential Energy Savings in Developing Countries from Improved Cookstoves

	Rural household bioenergy use (Mtoe)	**Efficiency improvements** (%)	**Energy savings** (Mtoe)	**Maximum fuelwood savings*** (million tonnes)
China	198	20-30	40-59	180
India	168	20-35	34-59	178
Latin America	28	10-40	3-12	36
Africa	116	30-40	35-46	141

*Using the conversion factor: 1 tonne of firewood = 0.33 toe.

Source: IEA, 2001

5. Modern Biomass Energy Technologies

5.1 Benefits and Challenges

Modern biomass technologies have the potential to provide improved energy services based on available biomass resources and agricultural residues[19]. Widespread use of combined heat and power generation biomass options in rural areas can address multiple social, economic and environmental issues that now constrain local development. The availability of low cost biomass power in rural areas could help provide cleaner, more efficient energy services to support local development, promote environmental protection, provide improved domestic fuels and improve rural livelihoods. Bioenergy technologies based on sustainable biomass supply are carbon neutral and lead to net CO_2 emission reduction if used to substitute fossil fuels (IPCC, 2003; Coelho and Walter, 2003; Fischer and Schrattenholzer, 2001).

In addition, modern biomass energy technologies can contribute to better bio-waste management. For example, land-fill gas can assist urban waste management, while bagasse-based co-generation reduces the problem of safe disposal of bagasse at sugar plantations (Veragoo, 2003; Deepchand, 2002).

Another advantage of modern biomass energy is its job generation potential – a very important attraction for many developing countries faced with chronic levels of unemployment or under-employment. Existing studies (Goldemberg, 2003; FAO, 2000) indicate that, in comparison to other primary energy sources, the job generation potential of modern biomass is among the highest (Table 12). For example, in Brazil, the annual production of 14 billion litres of ethanol from sugarcane is responsible for the creation of 462,000 direct and 1,386,000 indirect jobs in the country, corresponding to a rate of 263,000 annual jobs per MTOE generated (Goldemberg, 2003).

Table 12: Comparison of job creation – Biomass and Conventional Energy Options

Sector	Jobs (person-years) Terawatt-hour
Petroleum	260
Offshore oil	265
Natural gas	250
Coal	370
Nuclear	75
Wood energy	1,000
Ethanol (from sugarcane)	4,000

Source: Goldemberg, 2003

One of the main challenges facing modern biomass use is the extent to which it can compete on cost and reliability with conventional fossil fuel options - both for transportation and for electricity supply. There is, however, a growing body of assessments of national implementation programs demonstrating in an unequivocal fashion, that modern large-scale biomass energy systems are fully proven on both economic and technical grounds. Examples include biofuels in Brazil, co-generation using a wide range of agro-residues (using wood residues, sugarcane bagasse, rice husks, etc.) in many agro-industries (IEI, 2001; Winrock, 2002; Deepchand, 2002; Veragoo, 2003).

On the other hand, smaller-scale applications of modern biomass energy technologies still face numerous challenges particularly at the level of cost-competitiveness (although many argue that this is due to an absence of a level playing field) (IEI, 2002; Coelho and Walter, 2003). Small scale biomass based modern biomass systems have registered encouraging levels of success in India, South East Asia and parts of Latin America (Shrestha, 2003; Pandey, 2002).

Case Study 3: Modern Biofuel Use in the Latin American Transportation Sector

Examples of the use of biofuels for transportation sector in LAC can be found in Brazil (with the alcohol program) and in Argentina (with the biodiesel program). The Brazil programme has recorded notable success.

The Brazil program was established in 1975 with the purpose of reducing oil imports by producing ethanol from sugarcane. It now delivers significant environmental, economic and social benefits. It has become the most important biomass energy program in the world. Ethanol is used in cars as an octane enhancer and oxygenated additive to gasoline (blended in a proportion of 20 to 26% anhydrated ethanol in a mixture called gasohol) or in dedicated hydrated ethanol engines. Since 1999, the Brazilian government eliminated controls on prices and hydrated ethanol is sold for 60 to 70 percent of the price of gasohol at the pump station, due to significant reductions in production costs. These results show the long-term economic competitiveness of ethanol fuel when compared to gasoline (Goldemberg et al. 2002).

The world leader on alcohol production continues to be Brazil, where alcohol prices are competitive and the development of the new flexible fuel cars (FF) promotes greater ethanol use by providing flexibility to consumers. Ethanol has made a valuable contribution to the development of the country's agro-industry. Moreover, the increased use of alcohol as a transport fuel appears to have contributed to the reduction of air pollution in mega-cities such as São Paulo (Coelho, 2003). According to the Bariloche Foundation, there are four biodiesel plants in Argentina using sunflower, cotton and soybean as feedstock (www.bariloche.com.ar/fb).

A Federal Law in Colombia requires the addition of 10% of ethanol in gasoline. By 2006, the seven largest cities in Colombia are expected to switch to gasohol. The gasohol fuel will be introduced in other cities of the country in tandem with the development of sugar-alcohol agro-industry. About 700 million litres of ethanol will be required per year, corresponding to 150 thousand hectares of sugarcane crops (Campuzano, H., 2003).

The development of modern biomass energy often requires significant capital investments and technical expertise, which may not be readily available in many developing countries[20]. In addition, there are cases where the legal and regulatory framework in place does not support the development of modern biomass energy technologies (AFREPREN, 2001). This has been a major barrier, for example, in the co-generation of electricity for sale to the national grid by sugar companies in many countries of sub-Saharan Africa (AFREPREN, 2003).

The growing of the biomass energy resource can also presents several challenges. Firstly, inappropriate high-input mono cropping can result in the loss of biodiversity, soil fertility and land degradation, and can be accompanied by the use of fertilizers and pesticides, which could lead to pollution of underground and surface water sources. Secondly, it could lead to competition for land between food production and biomass resources (Masera et al, 2000). Although useful long-term scenarios of potential conflict between food and biomass energy plantations have been undertaken (see following box) available data is still not fully conclusive. Additional research is required to provide a more nuanced and disaggregated understanding of the challenge.

> **Land Availability for Food and Fuel**
>
> The availability of land for the production of biomass in developing countries is determined by the demand on land for food production. With increasing population, food production and consumption in developing regions is expected to increase (FAO, 1995). Estimates by the Response Strategies Working Group of the IPCC indicate that the use of land for food production in developing regions (Asia, Africa and Latin America) will increase by 50% by the year 2025 (IPCC, 1996). In addition, the demand for biomass energy is also expected to increase with population increase. Estimates by the WEC indicate that by 2100, about 1,700 million hectares of additional land will be needed for agriculture, while about 690-1,350 million hectares of additional land would be needed to support biomass energy requirements (UNDP, 2000). The challenge, therefore, is ensuring sustainable biomass supply to meet growing energy demand, without taking up land for food production. Some of the options for avoiding the competition for land between food and fuel are: increasing food production on current agricultural lands; the establishment of large tree plantations; and, the use of modern forestry practices (IPCC, 1996).
>
> Source: Sudha and Ravindranath, 1999

The impact of modern biomass energy technologies on the poor is not well understood. It can complicate and compound existing competition over available biomass resources and land (Masera et al, 2003). Without appropriate, sensitive and equitable management, large-scale modern biomass energy development can lead to further marginalization of the rural poor. It is, however, possible that the growth and development of these technologies could lead to increased incomes for the poor (e.g. smallholder sugar farmers) if a well-designed revenue sharing scheme is established. Mauritius provides a model case example of where a share of the benefits from large-scale co-generation plants that flow to low-income farmers have increased over time through direct policy interventions and an innovative revenue sharing mechanism (Deepchand, 2002; Karekezi et al, 2002).

5.2 Prospects

Although modern biomass energy technologies have not been widely disseminated in many parts of the developing world, the IEA has attempted to assess the prospects of biomass-based power generation in different developing regions of the world (table 13). More comprehensive assessment that examine a wide range of modern biomass energy options (electricity, gas and fuels) are hampered by the poor quality of biomass energy data that is available.

Table 13: Biomass-based power generation in Developing Countries

	1995	2010	2020
China			
Biomass-based power generation (Twh)	. .	0.4	0.7
% of total electricity generation	. .	1.7%	1.8%
Biomass used in power generation (Mtoe)	. .	0.1	0.2
East Asia			
Biomass-based power generation (Twh)	0.3	0.6	1.5
% of total electricity generation	0.0%	0.0%	0.1%
Biomass used in power generation (Mtoe)	0.3	0.7	1.7
South Asia			
Biomass-based power generation (Twh)	. .	4.6	7.3
% of total electricity generation	. .	0.4%	0.4%
Biomass used in power generation (Mtoe)	. .	2.0	3.1
Latin America			
Biomass-based power generation (Twh)	9.6	13.1	17.1
% of total electricity generation	1.2%	0.9%	0.8%
Biomass used in power generation (Mtoe)	3.3	4.5	5.8
Africa			
Biomass-based power generation (Twh)	0.3	0.6	0.6
% of total electricity generation	0.1%	0.1%	0.1%
Biomass used in power generation (Mtoe)	0.4	0.8	0.8
Total developing countries			
Biomass-based power generation (Twh)	10.2	19.3	27.1
% of total electricity generation	0.3%	0.3%	0.3%
Biomass used in power generation (Mtoe)	4.0	8.1	11.7

Source: IEA, 1998

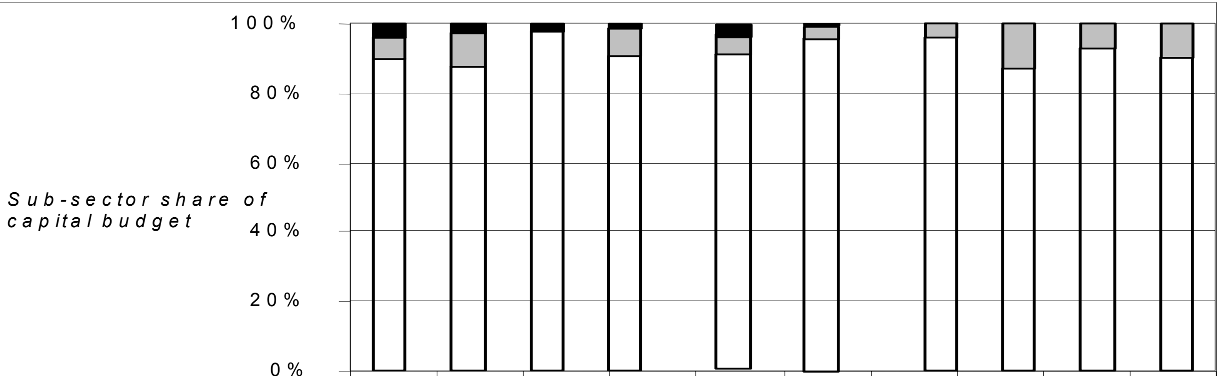
6. Implications for Energy Policy and Recommendations

As this paper is largely aimed at developing countries, the policy implications and recommendations will be restricted to developing countries and associated development partners. The desired shift from traditional biomass energy to improved and modern biomass energy has not materialised in many developing countries. This can be attributed to a number of policy challenges.

In spite of the importance of biomass energy in developing regions, biomass energy policy planning in most developing countries is often undertaken in an ad-hoc fashion. This is in part due to the absence of a single focal institution responsible for biomass energy. In many countries, a wide range of institutions have some jurisdiction on biomass energy issues ranging from the ministries of energy, environment, agriculture and forestry, to a plethora of national and sub-national agencies responsible for land tenure policy and rural development.

Budgetary allocation to biomass energy is very limited in most developing countries, despite the reliance on biomass by the majority of the population. The bulk of national energy budgets are allocated to the conventional energy sector, which serves a smaller proportion of the population. For example investment trends in Ethiopia's energy sector reveal heavy investments in the electricity and petroleum sub-sectors. As shown in figure 6, investments in petroleum quadrupled from 1990-2000, while investments in electricity almost tripled in the same period. In contrast, expenditure on traditional and alternative energy (which includes biomass and other renewables) has steadily decreased from about 1% of total expenditure in 1990, to 0.1% of total expenditure in the year 2000 (Wolde-Ghiorgis, 2002). About 93.4% of the population in Ethiopia relies on traditional energy (World Bank, 2003). This investment pattern holds true for many developing countries.

Figure 6: Energy sector capital budget shares % and total budget shares in million Birr for Ethiopia, 1990-2000



	1990	1991	1992	1993	1994	1996	1997	1998	1999	2000
Traditional and alternative	14.2	5.9	4.0	4.1	10.5	0.7	0.5	0.5	0.4	0.5
Petroleum	21.8	19.8		20.1	16.9	5.5	36.1	81.0	93.2	94.3
Electricity	314.0	182.0	187.0	240.0	267.0	145.0	861.0	539.0	1,209.	886.0

Source: Wolde-Ghiorgis, 2002

Designing and establishing an appropriate and effective institutional and associated legal and regulatory framework for biomass energy is a key challenge that decision makers and analysts need to urgently address (Karekezi et al 2002; Karekezi and Ranja, 1997). In particular, policy measures (with matching budgetary allocations) that support the increased contribution of sustainable biomass energy to total energy supply are required. These measures could include modern forestry approaches, improved and modern biomass energy technologies.

Data and information on biomass energy use in many developing countries is outdated and often unreliable, which makes it difficult to plan. In comparison to the conventional energy sector, which has comprehensive 5-10 year plans, planning for biomass energy is often incoherent, sporadic, and starved of the necessary budgetary allocation. The mobilization of additional financial and technical resources to support data collection and associated biomass energy planning is of priority importance (IEA, 2003a).

One of the key challenges facing many developing countries as well as respective development partners is the level of effort and resources that should be expended on the previously mentioned three (3) clusters of biomass options, namely: Traditional biomass energy; improved biomass energy options; and, modern biomass energy options.

Traditional Biomass Energy:

Initiatives pertaining to inefficient and environmentally unsound traditional energy options should primarily be aimed at research and analysis as well as data collection to provide the basis for developing effective strategies for reducing reliance on traditional energy options. As mentioned earlier, many poor developing countries do not have reliable databases on traditional biomass energy use. This makes it difficult to formulate appropriate policy and field-oriented interventions. Mechanisms for collection and documentation of data on traditional biomass supply and consumption, which is regularly updated and validated, need to be instituted (IEA, 2003).

Such data would be instrumental in setting and monitoring targets aimed at reducing reliance on traditional biomass energy.

Above all, planning for biomass energy development should have a decentralized component and should involve end-users. Special attention should be devoted to involving women, because they bear the burden of traditional energy systems and are likely to be the greatest beneficiaries of improved biomass energy systems. Decentralization of rural energy planning is wise because these systems are primarily based on traditional biomass. Consequently, an assessment of the demand and supply flows and of desirable interventions must also occur on the same geographic scale. Through their superior knowledge of the local situation, local people—women in particular—can be integral part of the solution (World Bank, 2003; Karekezi and Kithyoma, 2002). In particular, widespread dissemination of information on the negative impacts of traditional biomass energy use to end-users (Indoor Air Pollution), as well as available options would be instrumental.

Improved Biomass Energy:

While there is no full consensus among policy analysts and researchers, there is a growing body of evidence indicating that for low-income developing countries with large and very poor rural populations, the accent should be on the promotion and disseminating of improved biomass energy options (Karekezi et al, 2002; Hosier et al, 1993; ESMAP, 2002). This approach is likely to yield large near-term developmental benefits in terms of job generation, increased incomes and assist in reversing the negative environmental impacts of traditional biomass energy use (Masera et al, 2003).

Many policy analysts stress the need for aggressive dissemination of improved biomass technologies (IBTs) in developing regions, to mitigate the negative effects of traditional biomass energy use particularly indoor air pollution that is linked to respiratory diseases, one the main causes of death for children under the age of five (ESMAP, 2002; Hosier et al, 1993; Barnes and Floor, 1996; Karekezi et al, 2002). Governments should put in place policies that support the development and dissemination of IBTs (ESMAP, 2002; Karekezi et al, 2002). Private sector, NGOs, CBOs and donor organisations should implement projects aimed at ensuring the rapid dissemination of IBTs. Efforts to reduce the cost of widely used IBTs such as improved cookstoves should be accelerated, so that they are within the reach of even the poorest of the poor in Africa (Smith, 1991; Smith 1994; Kammen and Ezatti, 2002). Barriers to the uptake of improved biomass technologies should be addressed, and lessons from successful programmes documented for widespread dissemination and replication.

Given the harmful environmental impacts of charcoal production in the region, there is need to regulate the production of charcoal (Scully, 2002). Afforestation and reforestation projects should be established as part of all charcoal production programes. The widespread use of improved and efficient charcoal kilns should be promoted (Karekezi and Ranja, 1997).

It is important for improved biomass energy system development and dissemination programmes to recognize the gender- and income-differentiated impacts of biomass energy use. In particular, improved biomass energy technologies that alleviate the burden and negative health effects of traditional biomass energy on the rural poor (comprising primarily of women and children) should be promoted and given prominence in government policies (Energia, 2002).

Although consensus on the most effective policy measures for accelerating access to

IBTs has yet to be attained, there are a number of options that have been analysed by leading biomass energy experts and that could provide an embryonic base for broad national, regional and global IBTs initiatives (Best and Christensen, 2003; Battacharya and Salam, 2002). Notable options that could be considered for implementation by policy makers in developing countries and respective partners, include:

- Setting targets, which include identifying and setting goals for the incremental contribution of improved biomass energy to total energy supply. The targets should preferably include financial commitments by governments and development partners.
- Introduction of new and innovative financing mechanisms, e.g. allocating a proportion of available energy subsidies (for example levies on electricity and petroleum) to the adaptation and wide scale dissemination of improved biomass energy technologies.
- Further research on the reasons for the relatively low dissemination of improved biomass technologies, with the aim of overcoming these barriers and speeding up uptake.

Modern biomass:

For developing countries with lower levels of poverty and higher levels of industrialization, the emphasis should probably be best placed on the encouragement of modern biomass energy technologies that can be used as levers for further development of agro-industries and as a basis for leap-frogging to cleaner biomass-based advanced fuels, electricity and gases. In fact, modern biomass energy production and use opens opportunities for the agricultural sector to diversify to act as a significant energy producer and to become an important actor in terms of rural sustainability and local and environmental benefits. The synergies between agriculture's role in both food and energy production can lead to benefits such as increased rural productivity, economic feasibility, rural infrastructure and employment.

The development of modern biomass energy technologies will require supportive legal and regulatory frameworks that attract investment in modern biomass energy systems. Due to the substantial amount of resources required to develop these technologies, it is important that a clear legal and regulatory framework is put in place. The potential for conflict between food production and large-scale biomass energy plantations needs to be examined in greater depth and detail. In addition, new and innovative ways of financing modern biomass energy projects should be pursued (Goldenmberg et al. 2002; Karekezi and Ranja, 1997). In Brazil, the PROINFA program (Annex 4) is one example of such policies.

In the case of ethanol production, collaboration within the sugar industry would facilitate rapid improvement of agricultural practice (to increase productivity and reduce adverse environmental impacts) and allow the capture of substantial scale benefits associated with larger and more efficient plant. Ethanol producers can fully utilise economies of scale if some form of collaboration at an international level was initiated. Currently, international trade in ethanol is constrained by various trade and non-trade related constrains. Increased trade in ethanol could provide an important impetus to the further development of the biofuel industry (Berg, 2001).

Long-term energy training programmes designed to develop a critical mass of locally trained manpower with the requisite technical, economic and social-cultural skills are needed. Many of the engineering and technical courses that are currently taught at universities and colleges in developing countries provide little exposure to biomass energy technologies. Capacity building of local analytical expertise to provide comprehensive evaluations of available biomass energy resources and options for utilizing them are needed. Non-partisan groups, such as academic institutions, NGOs and independent research institutes and networks are well placed to assist in the requisite capacity building (IEI, 2001; Karekezi and Ranja, 1997).

As in the case of IBTs, there is no general consensus on what policy options would accelerate the use of modern biomass technologies but the following options could provide an initial menu for action:

- Ensuring the level playing field for modern biomass and conventional energy forms, e.g. setting prices that are attractive to investors in the modern biomass energy sector.
- Enacting a legal and regulatory framework that allows for the development of modern biomass energy, and provides, among other incentives, access to the grid and transport fuel market.
- Setting targets, which include identifying and setting goals for the incremental contribution of modern biomass energy to total energy supply. The use of tradable renewable energy certificates could assist in further promotion of modern biomass energy technologies.
- Setting up regional and international funds for financing large-scale biomass energy technologies.
- Further research and dissemination of information on the barriers to modern biomass energy development.

In conclusion, the future prospects for biomass energy development will in part be driven by the following factors (Best and Christensen, 2003):

- Security of energy supply, which can be increased using domestic resources;
- Employment and land-use aspects (both for and against the increased use of biofuels);
- Local concerns about health issues related to burning biofuels indoors.

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8. Annexes - Africa

Annex 1. Traditional fuel consumption in African Countries

Country	Traditional fuel consumption* (as % to total energy use)-1997
Algeria	1.5
Angola	69.7
Benin	89.2
Burkina Faso	87.1
Burundi	94.2
Cameroon	69.2
Central African Republic	87.5
Chad	67.9
Congo	72.6
Cote d'voire	91.5
Democratic Republic of Congo	86.5
Egypt	5.0
Eritrea	72.9
Ethiopia	96.0
Gabon	52.2
Gambia	78.6
Ghana	67.7
Guinea	74.2
Guinea Bissau	57.1

Kenya	**80.3**
Madagascar	**84.3**
Malawi	**88.6**
Mali	**88.9**
Mauritius	**36.1**
Morocco	**4.0**
Mozambique	**91.4**
Niger	**80.6**
Nigeria	**84.7**
Senegal	**59.5**
Sierra Leone	**86.1**
South Africa	**21.8**
Sudan	**79.5**
Tanzania	**95.2**
Togo	**37.7**
Tunisia	**18.5**
Uganda	**89.7**
Zambia	**76.9**
Zimbabwe	**62.9**

* Traditional fuel consumption=estimated consumption of fuel wood, charcoal, bagasse, animal and vegetable waste

Sources: UNDP, 2003; IEA, 2000.

Annex 2. Fuel wood consumption in Africa ('000 cubic meters), 1996

Country	Consumption
Burkina Faso	11,014
Cape Verde	113
Chad	2,229
Gambia	895
Guinea -Bissau	375
Mali	7,150
Mauritania	292
Niger	3,756
Senegal	2,611
West African Region	28,435
Djibouti	56
Eritrea	3,446
Ethiopia	61,199
Kenya	19,382
Somalia	3,617
Sudan	8,036
East Sahelian Region	95,736
Benin	3,390
Cote d'voire	8,485
Ghana	9,008
Guinea	7,572
Liberia	1,872
Nigeria	121,909
Sierra Leone	3,079
Togo	3,013
West Moist Africa	158,328
Burundi	5,403
Cameroon	13,557
Central African Republic	3,105
Congo Demo. Rep.	46,055
Congo Rep.	2,527
Equatorial Guinea	334
Gabon	865
Rwanda	5,056
Sao Tome Principe	164
Uganda	24,352
Central Africa	101,418
Angola	5,971
Botswana	1,934
Malawi	11,183
Mozambique	19,988

Namibia	**1,933**
Saint Helena	**0**
Tanzania United Rep.	**43,629**
Zambia	**9,831**
Zimbabwe	**13,462**
Tropical Southern Africa	**107,931**
Comoros	**291**
Madagascar	**9,760**
Mauritius	**34**
Reunion	**9**
Seychelles	**1**
Insular East Africa	**10,095**
Total Tropical Africa	**501,943**
Algeria	**2,086**
Egypt	**2,451**
Libya	**544**
Morocco	**10,661**
Tunisia	**2,535**
North Africa	**18,277**
Lesotho	**1,517**
South Africa	**19,118**
Swaziland	**861**
Non Tropical Southern Africa	**21,496**
Total Non Tropical Africa	**39,773**
Total Africa	**541,716**

Source: FAO,2003.

Annex 3: Charcoal Consumption in Africa ('000 Toe), 1996

Country	Consumption
Burkina Faso	34.8
Cape Verde	0.2
Chad	125.4
Gambia	0.0
Guinea -Bissau	84.8
Mali	93.0
Mauritania	176.2
Niger	0.0
Senegal	353.8
West African Region	868
Djibouti	2.1
Eritrea	14.8
Ethiopia	261.9
Kenya	1,369.0
Somalia	160.8
Sudan	2,362.0
East Saherian Region	4,171
Benin	12.1
Cote d'voire	1,271.1
Ghana	399.8
Guinea	146.8
Liberia	139.4
Nigeria	782.0
Sierrra Leone	77.6
Togo	114.6
West Moist Africa	2,943
Burundi	57.5
Comeroon	87.0
Central African Republic	0.0
Congo Demo. Rep.	256.6
Congo Rep.	15.0
Equatorial Guinea	0.0
Gabon	0.0
Rwanda	33.6
Sao Tome Principe	0.0
Uganda	469.0
Central Africa	919

Angola	**909.2**
Botswana	**36.9**
Malawi	**326.1**
Mozambique	**334.0**
Namibia	**8.1**
Saint Helena	**0.0**
Tanzania United Rep.	**509.5**
Zambia	**586.1**
Zimbabwe	**10.1**
Tropical Southern Africa	**2,720**
Comoros	**70.4**
Madagascar	**619.9**
Mauritius	**1.4**
Reunion	**0.0**
Seychelles	**13.1**
Insular East Africa	**705**
Total Tropical Africa	**12,226**
Algeria	**0.0**
Egypt	**0.0**
Libya	**0.0**
Morocco	**384.9**
Tunisia	**148.2**
North Africa	**533**
Lesotho	**0.0**
South Africa	**917.6**
Swaziland	**21.8**
Non Tropical Southern Africa	**939**
Total Non Tropical Africa	**1,472**
Total Africa	**13,799**

Source: FAO,2003.

Annex 4: Case Studies

Co-generation in Mauritius.

The Mauritian experience in co-generation is one of the success stories in Africa. As a result of extensive use of co-generation in Mauritius, the country's sugar industry is self-sufficient in electricity and sells excess power to the national grid. In 1998, close to 25% of the country's electricity was generated from sugar industry, largely using bagasse, a by-product of the sugar industry (Deepchand, 2001). By 2002, electricity generation from sugar estates stood at 40% (half of it from bagasse) of the total electricity demand in country (Veragoo, 2003).

Government support and involvement has been instrumental in the development of a cogeneration programme in Mauritius. First, in 1985, the Sugar Sector Package Deal Act (1985), was enacted to encourage the production of bagasse for the generation of electricity. The Sugar Industry Efficiency Act (1988) provided tax incentives for investments in the generation of electricity and encouraged small planters to provide bagasse for electricity generation. Three years later, the Bagasse Energy Development Programme (BEDP) for the sugar industry was initiated. In 1994, the Mauritian Government abolished the sugar export duty, which served as an additional incentive to the industry. A year later, foreign exchange controls were removed and the centralization of the sugar industry was accelerated. These measures have resulted in the steady growth of bagasse-based electricity in the country's electricity sector.

Bagasse-based co-generation development in Mauritius has delivered a number of benefits including reduced dependence on imported oil, diversification in electricity generation and improved efficiency in the power sector in general. Using a wide variety of innovative revenue sharing measures, the co-generation industry has worked closely with the Government of Mauritius to ensure that substantial benefits flow to all key stakeholders of the sugar economy, including the poor smallholder sugar farmer. The equitable revenue sharing policies that are in place in Mauritius provide a model for emulation in ongoing and planned modern biomass energy projects in Africa.

Sources: Veragoo, 2003; Deepchand, 2001.

Ethanol Production in Zimbabwe, Malawi and Kenya

In Africa, large scale ethanol production has been implemented in Zimbabwe, Malawi and Kenya, countries that do not have indigenous oil reserves and rely on oil imports. Ethanol production in Zimbabwe started in 1980 at Triangle Ltd, a sugar company located in the north eastern Zimbabwe with an annual production capacity of 40 million litres per annum. On commissioning, the blending target of ethanol/gasoline for the country was 15:85. But by 1993, the blending ratio stood at 12:88. Ethanol production programme has contributed significantly to the Zimbabwean economy. Benefits include reduced gasoline imports by about 40 million litres, increased incomes of about 150 cane farmers and availability of a market for molasses, which was formerly a waste product (Scurlock et al, 1991b; Hall, et al, 1993)

In Malawi, the Ethanol Company Limited (ETHCO) is the sole producer and distributor of ethanol. Commissioned in 1982, ETHCO has a distillery capacity of 17 million litres annually but production averages 13 million litres a year. At one time, it was mandatory for all the gasoline used in the country to be blended with ethanol. In 1993, the blending ratio was 15:85. Unfortunately, this ratio was not maintained due to tussles between ETHCO and the oil industry concerning acceptable market shares and pricing of ethanol in relation to imported gasoline. Available evidence demonstrates that the plant has helped to reduce use of scarce convertible currency revenues on oil imports and assisted in solving the sugar company problem of safe disposal of molasses, which was previously a hazard to the environment (Kafumba, 1994; Gielink, 1991).

Kenya's interest in ethanol was sparked off by the oil crisis in the early 1970s. Like other countries, Kenya was keen to exploit locally available energy sources. Consequently, the Agro-Chemical and Food Corporation (ACFC) was established in 1978, with the objective to utilize the surplus molasses produced. Located in Muhoroni near three sugar factories, ACFC had an installed capacity of 60,000 litres a day with a daily average output of 45,000 litres a day. The blending target ratio for the country was 10:90. The plant created both direct and indirect employment for about 1,200 people. In addition, it partially reduced dependence on imported fuel supplies. Major challenges that have faced the programme include drought and poor infrastructure affecting yield and transportation of the cane to processing points. Above all, lack of government commitment and absence of clear-cut production, blending and marketing policies eventually led to the cessation of ethanol use for transportation purposes (Omondi, 1991; Kyalo, 1992; Okwatch, 1994; Baraka, 1991).

Sources: Karekezi and Ranja, 1997; Karekezi, 2002

Tanzania Wood Project

Tanzania's forest resources cover about 33.6 million ha, most of which are miombo type woodland. Tanganyika Wattle Company (TANWAT), a private company has the largest forest plantations in the country of about 15,000 ha. The forest estate comprises of 8,000ha of wattle trees, 4,000ha pine trees and 1,000ha eucalyptus trees. Founded in 1949, TANWAT operates a 2,500kWh biomass fired power station at its factory site situated near Njombe town in the Southern Highlands Tanzania. The station generates 13.147 GWh; with 41,687tons of biomass burned. The station was commissioned in 1995 (Ariss, 2003; Ngeleja, 2003).

TANWAT power station provides sufficient power to meet various needs of the company i.e. the wattle factory, sawmill and timber treatment plant, including associated offices and housing. In addition, the surplus power produced is made available to a neighbouring tea estate and the rest sold to TANESCO. Currently, the maximum power demand supplied from TANWAT to TANESCO varies between 1,400 and 2,100 kVA. In the year 2002, the station supplied 4.349 GWh of electricity to TANESCO (Ariss, 2003)

Sources: Ngeleja, 2003; Ariss, 2003

9. Annexes - Asia

Annex 1. Projections of wood fuel supply and consumption in Asia (PJ)

	Projected Fuelwood Supply 2010	Projected Fuelwood Consumption 2010
Asia Total	11,408	11,605
South Asia	4,942	4, 953
Bangladesh	409	416
Bhutan	14	16
India	3,631	3,649
Nepal	287	290
Pakistan	500	473
Sri Lanka	101	109
South East Asia	3,756	3,921
Cambodia	103	87
Indonesia	1,934	1,919
Laos	74	54
Malaysia	124	141
Myanmar	250	281
Philippines	390	499
Thailand	411	541
Vietnam	470	399
China	2,710	2,731

Annex 2: Energy Fuels in rural areas of Asia

	China		India	Nepal
Fuel (%)	Household energy (1993)	Rural industry energy (1993)	House hold energy (1996-1997)	House hold energy (2001)
Crop resides	43	----	13.1	17
Fire wood	26	7	Logs-33.8; twigs-27.8	71
Coal	26	54	0.3	----
Electric	4	20	----	----
Diesel	1	9	----	----
Coke	---	4	----	----
Gasoline	---	6	----	----
Dung cake	----	----	16.9	9
Biogas	----	----	1.8	----
Kerosene	----	----	4.4	----
Others	----	----	2.0	----

Source: Zhenhong, 2001, Natrajan et al., 1998 and Shrestha, 2002

Annex 3: Case studies

Larger hope for Large Cardamon

Processing of large-Cardamon, one of the much sought after spices from India's north-east, is never going to be the same. And neither would its quality. Researchers at The Energy and Resources Institute (TERI), New Delhi, have now perfected an entirely new way of drying and curing this spicy cash-crop. Presently over 250 systems could be found in the field of Sikkim. Used widely in India as a main spice ingredient in Mughal cuisine and other non-vegetarian dishes throughout the country, large-cardamom is currently priced around Rs. 70,000 a ton. Pakistan, Afghanistan and the middle-east are the main export markets.

The traditionally popular large cardamom curing technique results in large amounts of wastes of both raw material and fuelwood. An estimated 20,000 metric tonnes of fuelwood is wasted every year for drying large cardamom in Sikkim alone, owing to the primitive curing technique, which involves burning of big logs of wet wood in traditional `*bhatti'* (oven made of blocks of stones and bricks) and passing the resulting smoke through a thick bed of cardamom placed on a mesh structure made of bamboo wiremesh. Apart from using up large amounts of fuel wood, the traditional technique results in non-uniform drying of the product, ending up with poor quality cardamom that has a charred and smoky appearance, low oil content, and burnt smell. Besides, in the primitive smoking method, the risk of raw material catching fire is high as flame control is very poor. The method has also been found responsible for the low oil yield of the product.

The results of this new technique are astounding. Rich natural colour (reddish) to the fruit, 35% more oil content, absolutely no burnt smell common to the traditional product, ability to dry large quantities at one go, and an incredible 50-60 % saving of the fuelwood using similar low cost gasifier based systems for thermal applications in rural agro-based industries like ginger, tobacco, cashew, etc., can go a long way in alleviating the problem of rapid deforestation due to present inefficient use of fuelwood and also can open new doors for additional income generation in these sectors.

Palm sugar stove development, East Java, Indonesia

Sarongan Village is located in the buffer zone near Meru Betiri National Park in East Java. The 5,981 villagers live in a flat area of approximately 27,000 hectares, located 6 meters above sea level. This area collects as much as 2,000 mm of rainfall per year. The village is rurally located, 261 kilometers from Surabaya, the provincial capital of East Java.

The residents of Sarongan Village make their living as farmers, palm sugar producers, civil servants, merchants among others. Life is very dependent on the close proximity to forests in Meru Betiri National Park, it allows collection of wood in the park. One community of residents that uses the national park's forests are tree tappers, and palm sugar producers. The process of making palm sugar requires a large amount of wood-fuel for the evaporation process.

After a technical training on stove production, the Hamim foundation took the initiative to modify the existing palm sugar stove used by the Sarangon village. Stove development was needed to reduce wood-fuel consumption and time used to make palm sugar. The stove development process was not easy, as community members were attached to their traditional stove. As of November, 2002, 72 palm sugar producers were using the modified stove in Sarongan Village. Community members who first went through the stove modification process have become training facilitators for several other communities.

Energy from sugarcane trash

The prestigious Ahedan Award winner project for conversion of sugarcane trash to charcoal briquettes was initiated by Appropriate Rural Technology Institute (ARTI) with the financial support from Ministry of Non-conventional Energy Sources (MNES) in 1997. The project aims to manage the 4.5 million tonnes of sugarcane dry leaves waste generated in Maharashtra, India. The leaves are about a meter long and form a thick layer of 20-30 cm in the field. In order to get rid of these waste materials, the leaves are burnt in an open field without extraction of any form of energy. ARTI developed an oven and retort type of kiln for charring the biomass wastes. The unit is very small. Three persons can generate100 kg char/day, which can be turned into briquettes using an extruder. In a period of 25 weeks during sugarcane harvesting season, a family can generate about 15 tonnes of briquettes, which would earn an income of about Rs. 75,000. Ten sugarcane demonstration-cum-training units will be set up in sugarcane growing districts of Maharashtra, using the award money. The villages are now on the path of income generation using biomass wastes.

10. Annexes - Latin America

Annex 1 - POLITICAL COMMITMENTS

The Latin American and Caribbean region agreed in May 2002 on the following proposal for targets and timeframes on renewables, stated as:

"Increase in the region the use of renewable energy to 10% as a share of total by 2010" (Draft of the Final Report of the 7th Meeting of the Intersectional Committee of the Forum of Ministers of Environment of Latin America and the Caribbean, São Paulo, May 2002)

Paragraph 19 of the World Summit on Sustainable Development (WSSD) Plan of implementation adopted in Johannesburg reads as:

19. Call upon Governments, as well as relevant regional and international organisations and other relevant stakeholders, to implement, taking into account national and regional specificities and circumstances, the recommendations and conclusions of the Commission on Sustainable Development concerning energy for sustainable development adopted at its ninth session, including the issues and options set out below, bearing in mind that in view of the different contributions to global environmental degradation, States have common but differentiated responsibilities. This would include actions at all levels to:

(...)

(c) Develop and disseminate alternative energy technologies with the aim of giving a greater share of the energy mix to renewable energies, improving energy efficiency and greater reliance on advanced energy technologies, including cleaner fossil fuel technologies;

(d) Combine, as appropriate, the increased use of renewable energy resources, more efficient use of energy, greater reliance on advanced energy technologies, including advanced and cleaner fossil fuel technologies, and the sustainable use of traditional energy resources, which could meet the growing need for energy services in the longer term to achieve sustainable development;

(e) Diversify energy supply by developing advanced, cleaner, more efficient, affordable and cost-effective energy technologies, including fossil fuel technologies and renewable energy technologies, hydro included, and their transfer to developing countries on concessional terms as mutually agreed. With a sense of urgency, substantially increase the global share of renewable energy sources with the objective of increasing its contribution to total energy supply, recognising the role of national and voluntary regional targets as well as initiatives, where they exist, and ensuring that energy policies are supportive to developing countries' efforts to eradicate poverty, and regularly evaluate available data to review progress to this end.

Annex 2 – TRADITIONAL BIOMASS (FAO, 2003, ECLAC, 2003) / Modern Biomass

In El Salvador, Guatemala, Haiti, Honduras and Nicaragua, wood energy plays a crucial role in their respective national energy sectors. While this indicates that the use of fossil fuels is limited, it has a negative impact on national forest resources and on the quality of life of the users.

Conversely, in countries where the use of biomass as an energy source is almost negligible, such as Argentina, Ecuador, Mexico and Venezuela, sustainability problems may arise owing to the heavy use of fossil fuels for final industrial and household consumption and for intermediate consumption in electric power generation. In these countries, hydrocarbons account for 80% to 90% of the total primary energy supply.

Lastly, there is a category of countries that have a combination of problems. For example, Cuba uses many renewable energy sources, but relies on inefficient combustion processes. The Dominican Republic and Panama show inefficiencies in the thermal transformation of imported fossil fuels; and Chile and Uruguay are almost wholly dependent on petroleum and hydroelectric power.

There are two countries that do not fall into any of the above categories, since their primary energy supply consists of over 90% renewable sources not related to wood fuels and less than 2% petroleum: these are Paraguay, on the basis of its hydroelectric resources, and Costa Rica, which has the most complete and balanced renewable energy mix in the entire region. Much of Costa Rica's primary energy supply comes from geothermal and hydroelectric power, sugar cane products and wood and wind energy.

Table 1 - Woodfuel Consumption by country - Latin America

Country	Total Consumption (PJ, 1997)		
	Fuelwood	Charcoal	Black liquor
Antigua and Barbuda	n.a.	-	n.a.
Argentina	47.72	10.40	14.09
Aruba	-	0.00	n.a.
Bahamas	-	-	n.a.
Barbados	-	-	n.a.
Belize	1.26	0.00	n.a.
Benin	33.95	0.37	-
Bolivia	18.75	0.29	n.a.
Brazil	964.77	216.02	117.18
British Virgin Islands	-	0.00	n.a.
Chile	149.12	1.63	42.45
Colombia	92.46	6.16	300.45
Costa Rica	33.16	0.65	n.a.

Cuba	21.46	2.46	n.a.
Dominica	n.a.	-	n.a.
Dominican Republic	43.72	2.16	n.a.
Ecuador	40.67	2.17	n.a.
El Salvador	66.50	0.83	n.a.
French Guyana	0.60	0.06	n.a.
Guatemala	128.00	1.05	n.a.
Guyana	8.72	0.05	n.a.
Haiti	62.90	11.14	n.a.
Honduras	60.41	0.62	-
Jamaica	10.31	2.43	n.a.
Mexico	233.39	3.74	7.01
Netherlands Antilles	-	0.01	n.a.
Nicaragua	37.88	0.84	n.a.
Panama	14.92	0.00	n.a.
Paraguay	71.07	11.64	n.a.
Peru	72.95	4.58	-
Trinidad and Tobago	0.10	0.06	n.a.
Uruguay	22.77	2.98	0.80
Venezuela	8.58	0.33	3.14

Source: FAO, 2003

As other tropical countries, Brazil has a high potential for the use of biomass and it is the largest producer of ethanol in LAC (Table 2) and in the world.

Table 2: Ethanol production in LAC

Ethanol Production (1000 hl)					
Country	2001	2000	1999	1998	1997
Argentina	1 530	1 710	1 735	1 766	1 610
Brazil	119 000	114 000	129 821	141 221	154 934
Canada	2 380	2 380	2 000	1 500	1 500
Cuba	850	840	800	795	1 100
Ecuador	627	375	321	313	263
Guatemala	600	600	450	450	500
Mexico	701	671	562	531	532
World	313 915	299 361	310 713	319 630	329 611

Source: Berg, 2001

Annex 3 - Case Studies

Electricity production from biomass

Bagasse is the by-product from sugarcane crushing; it corresponds to around 30% (in weight, 50% wet, LHV=.1,800 kcal/kg) of sugarcane. It is used for cogeneration (thermal/electric energy) in the sugar/alcohol mill. Because bagasse production is high (for an average Brazilian production of 300 million tones of sugarcane, 90 million tones of bagasse are produced), its use has always been inefficient. Low pressure (20 bar) boilers and low efficiency steam turbines are common in most Brazilian mills. Also, both thermal and electric energy consumption in the sugar/alcohol process are high: around 500kg of steam (at 2.5 bar) and 15-20 kWh of electricity per tone of crushed cane.

Until the end of the 90's there was no interest from the owners of sugar mills in selling surplus electricity generation to the grid. Local utilities also did not consider seriously this option. Despite the commercial availability of more efficient cogeneration systems, cultural aspects and the lack of an institutional framework did not allow its implementation in the sector. Nowadays, the situation has changed in Brazil. The Brazilian Development Bank (BNDES) launched a program, allowing special credits for biomass power plants that will generate electricity and sell the electricity surplus to utilities or engage in its direct commercialisation, encouraging the introduction of more efficient technologies.

In the interlinked system, the energy sector's reformulation process, conceived at Federal level, has accorded special status to renewable energy sources, through the recently approved Law 10438/02 that created the Incentive Program for Alternative Electric Generation Sources (PROINFA – Programa de Incentivo a Fontes Alternativas).

The PROINFA plan is divided into two phases. In the first phase within the first 24 months after the Law dismissal, long-term contracts (of 15 years) are supposed to be made over 3,300 MW by the Eletrobrás (Holding of the Brazilian Power System). The fixed amount is supposed to be achieved equally by the following energy sources: wind power, small hydropower projects and biomass. The acquisition of this energy will be defined by the economical value for each specific technology. This value is calculated by the execution force, in this case the Ministry of Mines and Energy but has to represent at least 80% of the average national tariff to the end user.

After erection of the first 3,300 MW, the second phase will begin. The program is designed so that wind energy, small hydropower and biomass will achieve 10% of the Brazilian power production. This goal is supposed to be reached within the next 20 years, as in the first phase with contracts over 15 years. The price of the purchased energy is determined by the economic value of the referential competing energy source, defined by the average costs of power production by new hydropower projects with an installed capacity over 30 MW and new gas power stations. The Ministry of Mines and Energy again determines the price. The regulation of the PROINFA has been established in December, 2003 and presents some inconsistent points, such as the definition of the economical value and environmental issues. (Coelho et al, 2003)

In Argentina there is a similar program which aims a target of 8% renewable energy in the national matrix by 2013. It is included in the program wind, solar, geothermal, tidal, small-hydro (up to 15 MW) and biomass. (Salvatori, P. 2003)

Innovations on Brazilian charcoal production (Coelho and Walter, 2003)

Brazil has one of the best technology for implementation of dedicated forests of eucalyptus in the world. Large-scale industrial use of eucalyptus includes pulp and charcoal production and technologies were developed to reduce pulp and steel production costs. Due to adequate weather conditions, genetic developments, and the planting technology, average yields of about 22 t/ha.year (dry basis) are usual for eucalyptus.

The forest division of steel industry Mannesmann – MAFLA – has developed in Brazil a rectangular kiln of high capacity. This kiln has a tar condenser that allows its recovery and its further distillation for the production of high-value by-products. Gases can also be recycled and used as fuel in the carbonisation process. In comparison with traditional kilns, the technology presents higher productivity, higher yields, improvements on charcoal quality and partial mechanisation. Most of the rectangular kilns developed in Brazil are large enough to allow trucks to come inside the kiln, reducing time for loading and unloading.

A conceptually similar kiln was developed by the steel industry Belgo Mineira between 1991 and 1998. In comparison with traditional kilns, results of the R&D program show that the new technology is advantageous regarding the initial capital costs and the requirements of working force, and equivalent regarding charcoal quality.

On the other hand, the steel industry ACESITA developed a program aimed at modernisation of charcoal production and consumption. This program included the development of a continuous carbonisation retort, i.e., a kiln in which heating is promoted by circulating gas. During tests the measured yield was 35 per cent, while the maximum yield for charcoal production – that depends on the wood composition – is estimated between 44 and 55 per cent (dry basis). The same company developed a rectangular kiln with a charcoal production cost 15 per cent lower than traditional kilns. As part of the same R&D program, until mid 1990s a continuous process of pyrolysis for charcoal production and liquids recovery was developed. Theoretically continuous kilns allow better control of the process and, as a consequence, production of better quality charcoal. Gases produced by pyrolysis are recovered and burned, supplying energy for the process, while liquids are also recovered – tar between them – and can be used in the production of chemicals. According to test results, the yield of charcoal production was estimated as 33 per cent (dry basis). It is important to mention that this R&D program was conducted while ACESITA was a state-owned company; the pyrolysis plant, for instance, was dismantled after the company's privatisation.

Endnotes

[1] Views expressed in this paper are entirely those of the principal authors and should not be attributed to the reviewers, contributors and sponsoring institution.

[2] Data and statistics on biomass energy are derived from national sources, which are not very reliable due to the variations in methods of collecting the data as well as weak institutional capacities for data collection. Data on biomass energy should, therefore, be treated with caution and considered indicative (IEA, 1998; IEA, 2003).

[3] "Biomass energy" as used in this paper refers to firewood, agricultural residue, animal wastes, charcoal and other derived fuels (IEA, 1998). Bioenergy is energy of biological and renewable origin, such as fuelwood, charcoal, energy crops, agricultural waste and by-products, livestock manure, biogas, biohydrogen, bioalchohol, microbial biomass and others (FAO, 2003)

4 The real price of traditional biomass has always been underestimated in the energy markets because of its perceived low economic value (RWEDP, 2001)

[5] Most developing countries do not have reliable databases on traditional energy consumption and use. Data on traditional biomass energy in these regions should, therefore, be treated with caution (IEA, 2002b)

[6] Combustible Renewables and Waste (CWR) refers to:

Solid biomass and animal products: Biomass refers to any plant matter used directly as fuel or converted into other forms before combustion. Included are wood, vegetal waste (including wood waste and crops used for energy production), animal materials/wastes, sulphite lyes, also known "black liquor", and other solid biomass also includes charcoal.

Gas/Liquids from Biomass: Biogas is derived principally from anaerobic fermentation of biomass and solid wastes and combusted to produce heat and /or power.

Municipal Waste: Municipal waste consists of products that are combusted directly to produce heat and /or power and comprises wastes produced by residential, commercial and public services sectors that are collected by local authorities for disposal in a central location. Hospital waste is included in this category.

Industrial Waste: Industrial waste consists of solid and liquid products (e.g. tyres) combusted directly, usually in specialized plants, to produce heat and/or power and that are not reported in the category solid biomass (IEA, 2002)

[7] Fischer and Schrattenholzer (2001) compare the IIASA-WEC bioenergy potential to various bioenergy potentials reported in other studies (Dessus, 1992; Greenpeace, 1993; Woods and Hall, 1994; Kusumikawa and Mori, 1998; Johannson et al., 1993; Leemans et al., 1996; Lashof and Tirpak, 1990; Shell, 1996; Yamamoto et al., 1998). Although comparability of the various potentials is not strictly possible, the general trend indicates an increase in future bioenergy potential (Fischer and Schrattenholzer, 2001).

[8] Assuming that biomass use per capita is constant, at 0.3toe per capita over the projected period. This figure is an average across all regions and countries. Analysis indicates that average per capita biomass use varies between 0.24toe in South Asia to nearly 0.40toe in many countreis in East Asia (IEA, 2002)

[9] The IEA rates the quality of data on Africa's biomass energy sector as low quality (IEA, 2003). There is need for urgent capacity building in order to improve biomass energy databases in this region.

[10] Combustible Renewables and Waste (CWR) refers to:

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Industrial Waste consists of solid and liquid products (e.g. tyres) combusted directly, usually in specialized plants, to produce heat and/or power and that are not reported in the category solid biomass (IEA, 2002)

[11] Sustainable from a supply-demand balance perspective. There are still some legitimate questions on the extent to which mono-crop large scale biomass plantations that use pesticides and fertilizers can be considered fully sustainable.

[12] Organisation for Economic Co-operation and Development

[13] In many rural highland areas of the developing countries, biomass is used for both cooking and space heating in poorly ventilated homes that aggravate indoor air pollutions. The need for space heating is less acute in low-lying areas thus reducing exposure to indoor air pollution from biomass-fuelled cookstoves.

[14] Studies in some regions e.g. India (Schirnding, 2001), however, indicate that men are also exposed to negative effects of biomass energy use, with young boys and men registering higher prevalence of respiratory infections compared to young girls and women. These findings indicate the need for further research on the impacts of biomass energy on men and women, and suitable response options (Schirnding, 2001; Cecelski, 2003).

[15] Deforestation in countries where charcoal is not widely used (or is sourced from planted forests) is often linked to clearing for agriculture.

16 For instance, in Central Zambia charcoal production usually destroys about 50% of total woody biomass of miombo woodland which takes 10-15 years of growth to re- establish. (Hibajane, et al, 1993; Hosier,1993). In Senegal, forest cover is depleted at a rate of approximately 1.2% per annum through charcoal production. This translates to about 165, 000 ha/year (Ribot,1993).

[17] Studies have shown that women and children are most likely to be adversely affected by particle emissions from biofuels smoke because they spend a significant proportion of their time near biomass based cooking fires (Schirnding, 2001; Karekezi et al, 1995; Energia, 2001; Kammen et al, 2001).

[18] There have been significant successful cases of disseminating improved bio-fuel cookstoves in developing countries. There are, however, numerous stove programmes that have not registered similar success. Detailed analysis of the success and failure of biofuel stove programmes would be instrumental in ensuring the success of current and future stove programmes (Barnes and Floor, 1996; ESMAP, 2002).

19 Another way of modernizing biomass energy use is through the use of ethanol gel, although its use is not widespread. This is a liquid fuel that is composed of ethanol, water, thickening agent, colouring and flavouring agent. It has heat value of 22.3MJ/kg. Ethanol gel is packed in bottles and sachets for easy transportation. The fuel can suitably substitute wood, charcoal, gas and kerosene for domestic cooking in developing countries with ethanol production potential. In Zimbabwe, ethanol gel is used for camping, starting barbeque fires and in the army (BTG, 2003).

[20] Modern biomass energy sources are, in some cases, more expensive than traditional biomass energy forms when only monetary costs are considered. It is important that efforts to promote improved and modern energy technologies consider the cost implications to ensure access to the poor in developing countries.

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