# Factors Contributing to Use of Biomass as Domestic Fuel and Options for Efficient and Sustainable Usage in Nigeria

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**Abstract**

Biomass energy dominates household cooking energy in developing countries and Nigeria is not exceptional. However, a number of implications such as indoor air pollution, environmental degradation and social burden have been associated with the use of biomass energy. The paper discusses factors that determine the use of biomass as domestic energy and implications of biomass as household energy. The use of biomass energy in Nigeria is still on a high level and this poses great challenges to the environment and welfare of households. It has been envisaged that with improved household economic situation, this will translate to shifting to less polluting and cleaner energy. It is therefore pertinent that people, especially at the rural level, are empowered so as to be able to afford cleaner cook fuels. Also, alternative cook energy to biomass should be made available to people at affordable prices. Projects for the distribution of efficient biomass energy technologies such as cooking stoves should be embarked upon by concerned government agencies and non-government organisations to improve efficient use of biomass in places where other alternative energy are not easily accessible.

**Keywords**: Biomass energy, clean energy, household, indoor air pollution, cooking stoves

**Introduction**

Biomass is the oldest source of energy used by people around the world for cooking, heating and other purposes. The International Energy Agency (IEA, 2008) reported that biomass energy accounts for approximately 13% of the world‘s final energy consumption in 2006. About 75% of the world’s consumption of biomass fuels takes place in developing countries (Parikka, 2004) with majority of the usage in Africa. According to Heruela and Wickramasinghe (2008), the prospect for poor households finding alternatives fuels to traditional biomass fuels is uncertain. This is due to a continuous increase in the price of alternative cooking energy like kerosene, liquefied cooking gas (LPG), diesel and coal (table 1). In Nigeria, there has been a steady rise in the prices of all the petroleum products within the last two decades with extreme negative impacts on the people (Adelekan and Jerome, 2006; Babalola, 2011). Each time the price is increased, all the sectors of the economy are affected ranging from prices of food stuffs and other household commodities in the markets, to increase in transportation fares, cost of energy, among others (Adelekan and Jerome, 2006; Babalola, 2011). The rising inflation is even making the matter worse. All these issues keep creating more demand for biomass energy and further increase in energy consumption.

Over the last decades, economic development and modernisation have allowed households in wealthier parts of the world to switch over to cleaner sources of energy. According to Dutt and Ravindranath (1993), consumer references for cooking fuels are known to shift from dung to crop residues, fuelwood, coal, charcoal, kerosene, liquified petroleum gas, natural gas, and electricity, in increasing order, as incomes rise. However, more than 2 billion people of the world, mostly in poor, developing countries still rely on solid and unprocessed biomass fuels as the primary source of domestic energy. According to Johnson (2007), biomass such as woodfuel, agricultural residues, and animal dung accounts for about 11% of total primary energy consumed globally. In addition, International Energy Agency (IEA, 2006) reported that fossil fuels continue to account for the overwhelming share of global primary energy consumption, together accounting for nearly 80% of the total. In Nigeria, Babalola (2011) found that biofuels such as firewood, charcoal and agricultural waste, constituted a major portion of total household energy consumption in rural areas unlike the urban areas where kerosene, electricity and LPG were the major energy carriers. Due to the economic situation, this situation is fast changing with majority of the people in the urban areas gradually shifting their cooking energy from clean energy to solid and unrefined energy, especially charcoal and firewood with implications for household health. Modern energy sources such as electricity and petroleum-based fuels generally provide a small part of the energy consumed by rural people, mainly because of supply and affordability constraints (Johnson and Lambe, 2009). Despite the reduction in the proportion of global energy derived from biomass fuel, biomass use is still increasing among the poor (WHO 2007).

**Table 1: Price of petroleum products in Nigeria (1973–2007)**

| Year | Petrol | | Kerosene | | LPG (Cooking gas) | |
|---|---|---|---|---|---|---|
| | Naira/litre | % change | Naira/litre | % change | Naira/litre | % change |
| 1973-78 | 0.10 | - | 0.08 | - | 31.2 | - |
| 1979-85 | 0.15 | 61.1 | 0.11 | 30.0 | 32.3 | 3.5 |
| 1986-89 | 0.40 | 158.0 | 0.11 | 0.0 | 40.0 | 24.0 |
| 1990 | 0.51 | 29.01. | 0.15 | 42.9 | 40.0 | 0.0 |
| 1991-92 | 0.60 | 17.6 | 0.40 | 166.7 | 80.0 | 100.0 |
| 1993 | 3.25 | 442.0 | 2.75 | 587.5 | 200.0 | 150.0 |
| 1994-97 | 11.00 | 238.5 | 6.00 | 118.2 | 200.0 | 0.0 |
| 1998-99 | 20.00 | 81.8 | 17.00 | 183.3 | 450.0 | 125.0 |
| 2000-01 | 22.00 | 10.0 | 17.00 | 0.0 | 1000.0 | 122.2 |
| 2002 | 26.00 | 18.2 | 24.00 | 41.2 | 1200.0 | 20.0 |
| 2003 | 40.00 | 53.0 | 38.00 | 58.3 | 1500.0 | 25.0 |
| 2004 | 43.00 | 7.5 | 51.00 | 34.2 | 1700.0 | 13.3 |
| 2005-2009 | 65.00 | 33.9 | 50.00 | -2.0 | - | - |

*Sources:* Nigerian National Petroleum Corporation, Lagos; Central Bank of Nigeria: Annual Reports and Statements of Accounts, various issues; Petroleum Products Pricing Regulatory Agency (PPPRA, http://www.pppra-nigeria.org/)

The United Nations Development Programme (UNDP, 2008) has discovered a number of implications of rise in fossil fuels on the achievement of Millennium Development Goals (MDG). As presented in Table 2, high oil prices will further aggravate poverty from increase in cost of living, affect food security from the production of biofuel, increase time spent on fuel collection for women with reduction in productivity, increase in-door air pollution and health hazard for children and nursing mothers. It was reported by the World Health Organisation (WHO, 2006) that women exposed to indoor smoke are three times more likely to suffer from chronic obstructive pulmonary disease (COPD) than women who cook with electricity or gas. Furthermore, it was estimated that indoor air smoke is responsible for 1.6 million deaths and 2.7% of the global burden of disease in the year 2000 (WHO, 2007). It is therefore pertinent that action be taken to either create alternative sources of cooking energy or improve the way biomass energy is utilised at the household level.

**Table 2: Implications of high oil prices on achievement of Millennium Development Goals**

| | |
|---|---|
| *MDG 1: Eradicate extreme poverty and hunger* | At the local level, drastic reduction in or the complete removal of fuel subsidies will result in high prices for agricultural inputs, transport services to workplaces and market, lower incomes and elimination of savings. This can be mitigated through new employment opportunities emerging from the introduction of renewable energy supplies to remote rural areas and commercial cultivation for biofuel production. The later can, however, have negative implications for food security and may worsen problems of malnutrition. |
| *MDG 3: Promote gender equity and empower women* | The time that women and children spent on fuel collection and cooking will increase as a result of increase in demand for biomass fuels. This will eat into the time they will have for other more productive activities. Families' pressure to curtail household expenses may opt to withdraw girls rather than boys from schools, thus worsening gender disparity. |
| *MDG 4: Reduce child mortality* | Smoke from inefficient wood burning and charcoal stoves will raise pollution within homes to the detriment of all. Infants will be particularly susceptible. |
| *MDG 5: Improve maternal health* | The health of nursing mothers will also be infected due to indoor pollution. |

Source: UNDP, 2008

## Factors Determining Domestic Energy Consumption

Large proportions of the energy consumed in households have been discovered to be required for cooking, lighting and space conditioning (both space heating and space cooling) (UN-DESA, 2004). In most African households, energy consumption while cooking has been discovered to account for between 90 and 100%. Despite this, a number of factors still determine the household energy consumption levels and the types of energy used; these mainly include the costs of energy sources and availability (World Energy Council, 1999; Karekezi and Kithyoma, 2002). As presented in Table 3, the general observations of energy consumption in developing countries, especially in Africa, is that the low-income rural households rely mainly on biomass fuels for cooking, whereas the high-income households use modern fuels such as kerosene, LPG and electricity. This situation is also typical of Nigeria. The major challenge facing energy consumption among the poor are access to information, financial resources and technology (Kammen *et al.*, 2001). From the forgoing, it can be deduced that household income actually plays a major role in determining the type of energy used in African households. It has been discovered that as incomes increase, the use of modern energy becomes more prevalent even in rural households (UN-DESA, 2004).

**Table 3: Household energy use based on household income category**

| Energy end use | Household income category | | |
|---|---|---|---|
| | Low | Medium | High |
| Cooking | Wood, residues, dung | Wood, residues, dung, kerosene, biogas and LPG | Wood, kerosene, biogas, LPG, coal and electricity |
| Lighting | Candles, kerosene, wood | Candles, kerosene, LPG and electricity | Kerosene, electricity |
| Space Conditioning | Wood, residues and dung | Wood, residues, dung and LPG | Wood, residues, dung, coal, LPG and electricity |
| Other appliances | Often none | Grid or genset- based electricity and batteries | Grid or genset - based electricity and batteries |

*Source: AFREPREN, 1999*

**Implications of Current Patterns of Domestic Energy Consumption**

As earlier stated, biomass energy dominates household cooking energy in developing countries with Africa accounting for the highest usage. A number of implications have been associated with the use of biomass energy and with resultant challenges at the household level. Among these challenges include the following:

***Indoor air pollution***: Incomplete biomass combustion leads to high concentrations of indoor air pollution. This leads to high number of cases of respiratory diseases such as acute respiratory infections, tuberculosis, and chronic obstructive lung disease in households. (Kammen *et al*, 2001; ESMAP, 2003; Ekouevi, 2001; Ward, 2002). At the household level, women and children are adversely affected by particulate emissions from biofuels smoke because they spend much of their time near biomass-based cooking fires. A study undertaken in rural Kenya found that women, who do most of the cooking, were exposed to twice as much particulate emission as their male counterparts, and were on the average, twice as likely to suffer from respiratory infections (Karekezi and Kithyoma, 2002; Karekezi and Ranja, 1997; Akarakiri, 2002).

***Environmental Degradation:*** Biomass harvesting leads to decreased vegetation cover and ultimately carbon accumulation in the atmosphere. In addition, biomass harvesting results in soil erosion, decrease in soil fertility, loss of soil moisture, and loss of biodiversity. Furthermore, production of charcoal leads to deforestation and land degradation. In some African countries, animal manure is used as domestic fuel and this has been discovered to take away valuable fertilizer decreasing soil fertility and leading to lower yields; this may force households to rely on more expensive inorganic fertilisers (Kammen *et al*, 2001).

***Social Burden:*** Firewood use in rural and urban households in various African countries is either collected or purchased (Misana, 2001). Firewood collection in most cases is the responsibility of women and children (Semere, 2001). It was reported that 90% of the population in rural Africa use firewood collected by household members in comparison to only 20% in urban areas (UN-DESA, 2004). Due to pressure on forests as a source of firewood, the average distance travelled to collect fuelwood is gradually on the increase (Zhou, 2001). As a result of travelling long distances to collect firewood, women and children in rural Africa are often left with limited time for other activities resulting in low agricultural productivity and inadequate time to pursue educational opportunities (UN-DESA, 2004).

**Biomass energy and carbon sequestration**

Interest in biomass as a mechanism for coping with greenhouse warming is gaining global recognition and adoption in mitigation strategy. This has focussed on the growing of trees to sequester carbon. It has been suggested that the growing of biomass as a fossil fuel substitute for use in modern biomass energy systems would provide substantially greater $CO_2$ mitigation benefits than the alternative strategy of sequestering carbon in planted forests (Hall et al., 1991a; 1991b; Marland and Marland, 1992). According to Larson *et al.* (1995), per tonne of biomass substituted for coal can be as effective as carbon sequestration, in reducing $CO_2$ emissions;

however, fuel substitution can be carried out indefinitely, while carbon sequestration can be effective only until the planted trees reach maturity.

In addition, far greater biomass resources can be committed to fossil fuel substitution at any given time than to carbon sequestration, because (i) producers will tend to seek for energy applications biomass species with higher annual yields, and (ii) biomass for energy can be obtained from sources other than planted forests (e.g., biomass from plantations of perennial grasses and from waste residues of existing agricultural and forest product industries). Moreover, biomass energy is potentially no more costly and in some instances even less costly than the displaced fossil fuel energy under a range of circumstances, so that the net cost of displacing $CO_2$ emissions would often be near zero or even negative. In regions where biomass yields are too low to be economically interesting for bioenergy production or in remote areas where the costs of transporting the biomass to markets are too high, sequestration strategies will be preferred to fossil fuel substitution strategies (Larson *et al.*, 1995).

**Options for sustainable use of biomass energy use in Africa**

Larson *et al.* (1995) informed that if the biomass is produced sustainably and the energy systems are modernized, "biomass can make major contributions to the global commercial energy economy in ways that help promote rural development, reduce local environmental problems, and reduce greenhouse gas emissions through fossil fuel substitution".

Various studies have proposed options for sustainable use of biomass energy in Africa so as to reduce (if not totally remove) the adverse effects. Although some regions of Africa, such as the North and the South of Africa, have promoted the use of cleaner energy such as the use of more efficient electrical, LPG, kerosene stoves, CFLs, solar water heaters and wind. However, this move is not across the whole continent. The sub-Saharan Africa household sector is yet to make appreciative efforts in promoting the use of cleaner and efficient energy most especially targeted at the rural or the poor. This section is therefore focused on the promising options for promoting sustainable use of biomass energy at the household level in sub-Saharan Africa.

***Efficient energy use***: a household can save the quantity of energy used in domestic cooking by adopting some efficient cooking strategies.

Some of these include: using thin dry pieces of wood which burn better producing more energy than large pieces; pre-soaking of hard and dry food stuff (maize, beans, etc) to reduce time of cooking thus consuming less fuelwood; cutting food into small pieces; having the fire burn only when you need it; using lids on cooking utensils; and simmering.

In addition to these, Muguti *et al*, (1999) gave the following ways by which households can reduce or save energy:

a. The use of thick walled containers when cooking, boiling, heating water or brewing beer; this retains the heat for longer cooking.
b. Shield of open fires to concentrate the fire on the cooking utensils.
c. Transfer of cooking pot to an insulated container when it has reached a cooking point, this will reduce the consumption of firewood or charcoal.

***Sustainable tree harvesting for fuelwood or charcoal production***

As a result of the harmful environmental impacts of charcoal production in sub-Saharan Africa (Plate 1), the need to regulate the production of charcoal has been proposed (Scully, 2002). Among the proposed strategies for the regulation of charcoal production include afforestation and reforestation projects. In addition, the use of improved and efficient charcoal kilns in the production process has also been encouraged (Karekezi and Ranja, 1997). Efforts toward replanting lost forests and other woodlands as a result of over-exploitation for fuelwood should be extended to planting of trees within the household compound as well as on farmlands in the form of agroforestry systems.

**Plate 1: Methods of charcoal production considered unsustainable for forests**

### *Factors contributing to fuel switching*

Fuel switching simply means moving from the use of one fuel to another fuel; this is considered an improvement when one moves from less cleaner to more cleaner fuel such as switching from biomass to kerosene, natural gas, LPG, biofuel and biogas. However, there is tension between the desire to move away from traditional biomass fuel and the desire to avoid reliance on fossil fuels. Some factors that determine household energy consumption include access to information, financial resources and technology. These are also major factors that contribute to switching between fuels. In addition, other factors that could contribute to fuel switching include availability of cleaner fuel and their affordable. It is one thing is for cleaner fuel to be easily available, it is another if household income will be enough to afford the cleaner energy. In urban areas where alternative fuels are available, fuel switching away from biomass can be realized unlike in the rural areas where options are limited to biomass energy in most cases.

The roles of government in facilitating fuel switching from less to cleaner fuel cannot be underestimated. A good example of this is the case of energy switching in Botswana. A survey conducted between 1986 and 2000 discovered that there was increase in the use of Liquefied Petroleum Gas (LPG) from 45% to 76%. This switch was discovered to be due to the provision of an appropriate enabling environment for marketing LPG throughout the urban areas of Botswana. Elements of the enabling environment included the abundance of gas dealers which has improved the distribution of gas; the free home delivery of gas by dealers; and, housing developments incorporating gas outlets in housing designs (Afrane-Okese, 2001). Another government intervention that facilitated fuel switch was observed in Senegal through the "butanization program" which was targeted at addressing the deforestation, environmental degradation, and increasing scarcity of traditional fuels. Basically, the aim is to replace 50% of fuelwood (charcoal) consumption with LPG in major urban areas. The butanization process recorded remarkable success initially due to tax breaks (exemption from customs duties on equipment connected to butane) and later subsidies awarded for this fuel in 1987. LPG grew from 15,000 tonnes in 1987 and nearly 100,000 tonnes in 2000, resulting in diversification of cooking fuels. Initially, LPG use was more prevalent in the upper income areas of Dakar. However, over the years, it has come into general use all over Dakar and other regions. In the major western towns of Senegal, the price of LPG is at its lowest because of low transport costs and has thus become the main cooking fuel (Sokona, 2000).

*Efficient biomass energy technologies*

Mainly, this option involves the use of improved biomass technologies (IBTs). The main technology in this regard is the introduction of cooking stoves. These are special stoves designed to reduce heat loss, increase combustion efficiency and attain a higher heat transfer (Plate 2a to 2d).

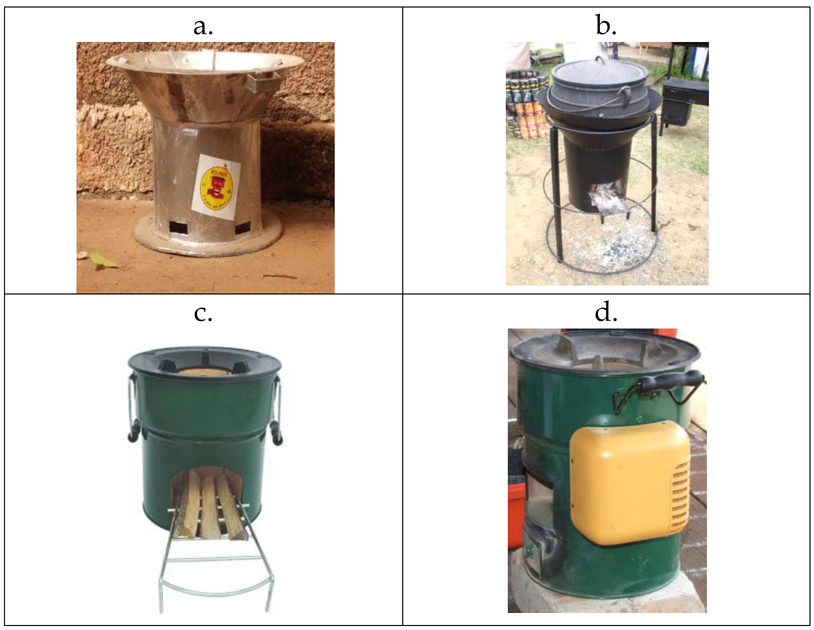


Plate 2: Images of improved cooking stoves (a) First generation cook stove (Photo GTZ Burkina Faso) (b) Rocket stove (c) New cook stove designs (www.envirofitcookstoves.org/) (d) Advance cook stove with a ceramic combustion chamber (StoveTec™ stove)

These stoves could ensure efficient utilisation of fuelwood and could significantly reduce indoor air pollution thus mitigating respiratory health problems associated with smoke emissions from stoves (ITDG-EA, 1999; Desanker and Zulu, 2001; Kammen *et al*, 2001; Zhou, 2001; Akarakiri, 2002; Karekezi and Kithyoma, 2002). It has been recommended that improved biomass energy technologies with focus on alleviating the burden and negative health effects of traditional biomass energy on the rural poor (primarily women and children) should be promoted and given prominence in government policies (Energia, 2002). Women are always at the centre of household energy use in rural areas, they should therefore be the target of improved biomass initiatives, and should be involved in design, planning and the actual implementation of these projects.

Despite its potentials in provision of clean and efficient energy at household level, the introduction of improved cook stoves has faced lots of challenges in Africa. Presented in Box 1 are the main challenges that faced introduction of improved cook stoves in Africa.

**Challenges of introducing improved cooking stoves**

At the beginning of the 1980s, as a result of ongoing desertification in western Africa, some African governments took various measures to fight this problem. A number of international donors have invested a large amount of funds in the introduction of improved cooking stoves in Africa. It is worrisome to discover that none of the strategies introducing improved cooking stoves was really sustainable in some parts of Africa. The production and distribution process of improved cooking stoves nearly stopped when there was no longer financing from the state or by international donors. There are a number of explanations for these. In the first instance, in the 1980s and to some extent in the 1990s, it can be assumed that there was no real need for improved cooking stoves as fuel prices (wood and charcoal) were not high enough to encourage people to pay for an "expensive" improved stove compared to a traditional and cheaper one. This issue is even more obvious in the rural areas than in the cities. In the urban areas, the failure of improved cooking stoves could be probably assumed to the relatively high price of improved stoves. When compared to the low quality of metal stoves for charcoal, an improved stove cost easily about 3 to 5 times more. This is a huge difference for majority of the middle and low income households. People therefore argue that by spending less money on buying biomass energy, they save more money on the long run than buying expensive improved cooking stoves.

Another explanation concerning the non-sustainability of improved cook stove initiatives is that, in most cases, assumptions of the implementation agencies on the adoption rate of the people are not right. The plan of the international project is to use mass production of the cooking stoves with introduction of subventions to reduce the market price thereby boosting the adoption process. After a while, the subvention would slowly be removed with the hope that people will still buy the same product at price that is a little higher. Subventions always complicate issues rather than serve as an encouragement. People rather wait for the re-introduction of the subvention again instead of buying at a higher price. Other indirect subventions were designed and introduced, but such an indirect intervention eventually led to the shortage of the product available for sale. This proves that it is not only a question of the price of a stove but that we deal with complex circumstances.

**Alternative strategies to improved cooking stove programmes**

Due to the challenges faced in introducing the cook stoves, other alternative policy interventions have been proposed to resolve the very problems that improved cook stove programs aim to tackle. Some of the interventions are listed in Table 4. For instance, projects targeted at reducing indoor air pollution may through shifting from polluting to less polluting fuels, or by installation of outlet that facilitates removal of smokes in homes. Better still, there is a need for rural electrification projects and encouraging the use of electricity as domestic cooking energy. In the same vein, projects that target at reduction of pressure on natural forests (such as afforestation projects) may be embarked upon close to rural areas in order to meet their demand for firewood and reduce pressure on remaining natural forests. In addition, projects that intend to save time and money spent by households on acquiring cooking fuel may be embarked upon. Due to the level of poverty among people in the rural areas, incentives such as subsidy on domestic cooking fuels could be introduced and supported with adequate monitoring strategies. Most importantly, the people could be empowered through provision of income generating activities especially micro-enterprises to be able to afford cleaner and less polluting cook fuels, as well as improved cooking stoves.

**Table 4: Alternatives to improved cooking stove programmes**

| Problems aim by project | Alternative intervention |
|---|---|
| Reducing indoor air pollution | • Transition to less polluting fuels for cooking, such as LPG, Ethanol, or solar energy.<br>• Improving indoor environments with the addition of chimneys, flues, hoods, and ventilation.<br>• Changing household behaviour, i.e. modifying cooking practices,<br>• Keeping children away from the fire places.<br>• Rural electrification. |
| • Less pressure on forest and energy resources.<br>• Reduced biomass use.<br>• Reduce greenhouse gases. | • Reforestation programmes<br>• Transition to less polluting fuels for cooking<br>• Rural electrification |
| Money and time saved in acquiring fuel | • Income and/or fuel price subsidies |
| Skill development and job creation | • Programmes concentrating on income generating activities<br>• Micro-finance projects |

*Source: Anhalt and Holanda, 2009 cited in UN-DESA, 2004*

## Conclusion

The use of biomass energy in Nigeria is still high and this poses great challenges to the environment and welfare of households. It has been envisaged that with improved household economic situations, this will translate to shifting to less polluting and cleaner energy. It is therefore pertinent that people, especially at the rural level, are empowered so as to be able to afford cleaner cook fuels. Also, alternative cook energy to biomass should be made available to people at affordable prices. Projects for the distribution of efficient biomass energy technologies such as cooking stoves should be embarked upon by concerned government agencies and non-government organisations to improve efficient use of biomass in places where other alternative energy sources are not easily accessible.

**References**

Adelekan, I. O. and A.T. Jerome (2006). Dynamics of household energy consumption in a traditional African city, Ibadan. *Environmentalist*, 26:99-110.

Afrane-Okese Y., (2001). Fuelwood use Patterns and Future strategies in Urban Botswana. Gaborone, Botswana: Ministry of Minerals, Energy and Water Affairs

Akarakiri J.B., (2002). 'Rural Energy in Nigeria: The Electricity Alternative', Proceedings: domestic use of energy, international conference towards sustainable energy solutions for the developing world. 2nd-3rd April, 202, Cape Technikon, Cape Town, South Africa.

Babalola, F.D., (2011). Domestic energy carriers and consumption pattern: implications of biomass energy on household welfare in rural and urban households. *Mediterranean Journal of Biofuels and Bioenergy*, Vol. 1(1):5-13.

Desanker, P.V. and L. Zulu (2001). Gender, Energy, Development and Environmental Change in Southern Africa. South Africa: Southern Africa Gender and Energy Network.

Duntt, O.S. and N.H. Ravindranath (1993). Bioenergy: Direct Applications in Cooking. In: Kelly, Reddy, Williams (eds.) Renewable Energy: Sources of Fuels and Electricity, Johansson. Island Press, Washington. DC, 1993, pp. 653-697.

Ekouevi, (2001). 'An Overview of Biomass Energy Issues in sub-Saharan Africa', Proceedings of the African High-Level Regional Meeting on Energy and Sustainable Development for the Ninth Session on the Commission on Sustainable Development. Denmark: UNEP Collaborating Centre on Energy and Development.

ESMAP, (2003). Energy and Poverty: How Can Modern Energy Services Contribute to Poverty Reduction? Proceedings of a Multi-Sector Workshop, Addis Ababa, Ethiopia. 23rd-25th October 2002. Washington DC, USA: Joint UNDP/World Bank Energy Sector Management Assistance Programme (ESMAP).

Hall, D.O., H.E. Mynick and R.H. Williams (1991b). Alternative Roles for Biomass in Coping with Greenhouse Warming. Science and Global Security 2:1-39.

Hall, D.O., H.E. Mynick and R.H. Williams (1991a). Cooling the Greenhouse with Bioenergy. Nature, Vol. 353.

Heruela, C.S. and A. Wickramasinghe (2008). Energy Options for Cooking and Other Domestic Energy Needs of the Poor and Women in the

Era of High Fossil Fuel Prices. A Discussion Paper. ENERGIA – UNESCAP Asia Regional Policy Consultation on "Networking towards Gender and Poverty Sensitive Energy Policies". 30pp.

IEA (2008): Key World statistics 2008, International Energy Agency , 9, rue de la Fédération 75739 Paris Cedex 15, www.iea.org.

International Energy Agency (IEA), (2006). World Energy Outlook 2006, Paris: OECD/IEA.

ITDG-EA, (1999). 'Fighting the Hazards of Smoke', KIT, December 1999. Nairobi, Kenya: Intermediate Technology Development Group, East Africa (ITDG-EA).

Johnson, F.X. and F. Lambe (2009). Energy Access, Climate and Development. Commission on climate change and Development. 9pp

Johnson, F.X. (2007). Bioenergy and the Sustainability Transition: from Local Resource to Global Commodity. World Energy Congress (WEC), Stockholm Environment Institute. Rome. 4pp

Kammen, D.M., R. Bailis and A.V. Herzog (2001). Clean Energy for Development and Economic Growth: Biomass and Other Renewable Energy Options to Meet Energy and Development Needs in Poor Nations. California, USA: University of California.

Karekezi, S. and W. Kithyoma (2002). Renewable Energy Strategies for Rural Africa: Is PV Led Renewable Energy Strategy the Right Approach for Providing Modern Energy to the Rural Poor of Sub-Saharan Africa? *Energy Policy* 30:11-12.

Karekezi S. and T. Ranja (1997). Renewable Energy Technologies in Africa. London, United Kingdom: Zed Books Ltd.

Larson, E.D., C.I. Marrison and R.H. Williams (1995). $CO_2$ Mitigation Potential of Biomass Energy Plantations in Developing Regions. PU/CEES Working Paper No. 13. 71pp.

Marland, G. and S. Marland (1992). Should We Store Carbon in Trees. Water, Air, and Soil Pollution 64:181-195.

Misana, S.B. (2001). 'Gender Concerns in Accessing Energy for Sustainable Development', Proceedings of the African High- Level Regional Meeting on Energy and Sustainable Development for the Ninth Session on the Commission on Sustainable Development. Denmark: UNEP Collaborating Centre on Energy and Development

Muguti, E., S. Everts, B. Schulte and L. Smallgange (1999). Energy Efficiency for Small and Medium Scale Enterprises. London, United Kingdom: Intermediate Technology Publications Ltd.

Parikka (2004). Matti Parikka , Global biomass fuel resources, *Biomass and Bioenergy* 27: 613–620

Scully, J., (2002). (Ed). Ecoforum, Vol.25 No. 4. Nairobi, Kenya: The Environment Liaison Centre International

Semere, H. (2001). Current Energy Utilization and Future Options in Rural Areas in Eritrea. 3rd Draft Report. Nairobi, Kenya: African Energy Policy Research Network

Sokona, Y. (2000). LPG Introduction in Senegal. Paper Presented at the first of the Forum on Sustainable Energy Rural Energy: Priority for Action. www.enda.sn/energie. Dakar, Senegal: Enda Tiers Monde

UN-DESA (2004). Sustainable Energy Consumption in Africa. UN-DESA Final Report. 54pp

UNDP (2008). Overcoming Vulnerability to Oil Price Increases. United Nations Development Programme, Regional Energy Programme for Poverty Reduction (REPPoR), UNDP Regional Centre in Bangkok, Thailand.

Ward, S. (2002). The Energy Book for Urban Development in South Africa. Noordhoek, South Africa: Sustainable Energy Africa

World Health Organisation (India) (2007). Health effects of chronic exposure to smoke from biomass fuel burning in rural areas – final report 2007, Sticker No. SE/07/11828.

World Energy Council (1999). The Challenge of Rural Energy Poverty in Developing Countries. London, United Kingdom: World Energy Council

Zhou, P.P. (2001). Rural Energy Needs and Requirements in Botswana: Final Report. Gaborone, Botswana: EECG Consultants Pty Ltd and Rural Industries Innovation Centre (RIIC).