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Review

Scaling-up renewable energy technologies in Africa

Etiosa Uyigue[1] and Ediang Okuku Archibong[2]*

[1]Community Research and Development Centre, Benin City, Edo State, Nigeria.
[2]Nigerian Meteorological Agency, P. M. B. 1215, Oshodi, Lagos State, Nigeria.

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Energy is very vital for socio-economic, human and technological development, yet there is not MDG on increasing access to energy. Africa's electricity consumption remains low, about 8% of global electricity consumption. There is significant variation in energy consumption among the different regions and countries in Africa. The over-reliance and unsustainable use of traditional biomass fuel in Africa leads to a low levels of energy efficiency and ability to mitigate climate change and high levels of deforestation, biodiversity loss, and health hazards due to indoor air pollution. The development of the various renewable energies (wind, solar, geothermal, bioenergy, fuel cells and tidal energy) is panacea to the energy crisis in Africa. Africa has a very attractive solar radiation and the continent has one of the highest levels of average annual solar radiation; 95% of the daily global sunshine above 6.5 kWh/m^2 falls on Africa during winter. This paper discusses the potential for renewable energy in the African continent, the obstacles to the development of renewable energy and energy efficiency and enumerates the strategies to scale up the renewable energy market in Africa.

Key words: Renewable energy, energy efficiency, Africa, climate change, electricity.

INTRODUCTION

We need energy to drive socio-economic, human and technological development. There is no MDG on energy, yet access to energy is needed to achieve the MDGs. Access to clean modern energy services is an enormous challenge facing the African continent, despite the fact that the continent is the home of enormous potentials for renewable energy resources. Africa accounts for about 3% of world energy consumption, the lowest per capita modern energy consumption in the world. On the other hand, in terms of biomass energy consumption, the African continent has the highest share in the world, 59% of total energy consumed is biomass (Ejigu, 2005). The energy-deprived people are the world's most impoverished, living on less than $2 per day with majority living in sub-Saharan Africa.

It has been reported that Africa's electricity consumption remains low, about 8% of global electricity consumption. The majority of the African population does not have access to electricity. In the year 2000, only 22.6% of the population in Sub-Saharan Africa had access to electricity, compared with Asia – 40.8%, Latin America – 86.6% and Middle East – 91.1%[1]. Lack of access to electricity inflate production cost and make competition in the global market difficult for developing countries. On the supply side, Africa's energy profile shows low production and huge untapped potential. The African energy situation is characterized by a high rate of demand driven mainly by demographic factors, while supply lags significantly behind. About 11.3% of the electricity generated in Africa is wasted compared with world's average of 9.2% (Ejigu, 2005).

There is significant variation in energy consumption among the different regions and countries in Africa. For example, electricity consumption in sub-Saharan Africa amounts to only 2.9% of total energy consumption, while in North Africa is 15.1% and in South Africa is 25.9%. The reliance on biomass is highest in sub-Saharan Africa (81.2%). North Africa and South Africa consume 4.1% and 16.5% of biomass respectively of their total energy budget (Karkezi et al., 2004). Thus sub-Saharan Africa continues to rely heavily on biomass. More worrisome is the use of biomass in an unsustainable and in an inefficient way. This over-reliance and unsustainable use of traditional biomass fuel leads to a low levels of energy efficiency and ability to mitigate climate change and high

*Corresponding author. E-mail: ediang2000@yahoo.com. Tel: 2347033466011, +2348033437731.

levels of deforestation, biodiversity loss, and health hazards due to indoor air pollution (NGO Position Paper for the Senegal Conference, 2008).

This paper will look at the potentials for the different renewable energies available in West Africa, highlight the obstacles to the development of renewables and strategies to scale-up renewable energy in West Africa.

RENEWABLE ENERGY TECHNOLOGIES

Wind energy

The energy contained in the force of the winds blowing across the earth's surface can be harnessed. Such energy can be converted into mechanical energy for performing various works such as generating electricity, pumping water, grinding grain, etc. Modern wind turbines are being used to generate electricity in countries such as Germany, Denmark, India, China, and the United States to supplement more traditional sources of electric power. Design improvements such as more efficient rotor blades combined with an increase in the numbers of wind turbines installed, have helped increase the world's wind energy generating capacity by nearly 150% since 1990 (Encarta Encyclopedia, 1999). Modern wind energy systems are made up of three basic components - tower, rotor and generator.

The tower

This is the structure on which the wind turbine is mounted. Advancements in structural design and construction materials have led to the construction of taller towers, allowing rotors to be mounted farther off the ground, where winds are typically stronger. Wind turbine towers can be constructed from metal, reinforced plastics, and concrete. The towers also house the cables that conduct electricity from the generator.

The rotor

The rotor is the component that is turned by the wind. It spins when driven by the wind and supports blades that are designed to capture kinetic energy in the wind. Most modern wind turbines have rotors that spin about an axis parallel to the ground. The spinning rotor turns a shaft which converts the wind energy into mechanical power. In turn, the shaft drives the generator, which converts mechanical energy into electricity.

The generator

The generator converts the mechanical energy of the spinning rotor into electricity. Many of these wind turbines use two generators, a small generator for light winds and a large generator for strong winds. Other wind turbines use a single generator that contains dual electric windings. These dual electric windings accomplish the same task as the combination of a small and large generator. Some wind turbines use another type of specially designed generator that is driven directly by the rotor without a transmission.

Wind turbine size

Wind turbines can be arbitrarily divided into three classes: small, medium, and large. Small wind turbines are capable of generating between 50 W and 60 kW of power, and use rotors ranging in diameter from less than 1 to 15 m (3 to 50 ft). Small wind turbines are installed primarily in remote areas where access to conventional sources of electricity is either too expensive or too unreliable. Some small turbines, known as micro-turbines, are so compact they can be carried to remote locations. Medium-size turbines use rotors spanning diameters between 15 and 60 m (50 and 200 ft), and have a generating capacity ranging from 50 - 1500 kW. Most commercial wind machines are medium-size turbines and have a generating capacity in the range of 500 - 750 kW. Large wind turbines have rotors spanning in diameters between 60 and 100 m (200 - 330 ft), and are capable of generating 2 - 3 mW of power.

Wind turbines installation

A vital factor to consider when installing wind turbines is location, that is, finding suitable terrain and wind conditions. Location is critical for maximizing the electricity wind turbines can generate. The amount of kinetic energy available in the wind is a cubic function of wind speed. When wind speed increase doubles, there is a corresponding eight-fold increase in available energy. This exponential relationship between wind speed and wind energy makes location extremely important.

Advantages of wind energy

Wind turbines are suitable for power generation in remote places where energy is needed but costly to connect to a central source. They are particularly suitable for development of energy in rural communities in developing countries. Wind turbines can be installed in single units, in clusters (of two to ten turbines), and in large arrays, called wind power plants or wind farms. Wind farms are an assemblage of multiple independent wind turbines, and may number up to several thousands. Wind power plants in the Altamont Pass, California contain a total of

6000 wind turbines. Although each wind turbine in a wind power plant operates independently, the turbines are typically connected to a central monitoring system, where the power they generate is aggregated and delivered to an electric utility network.

Wind energy is a clean and renewable. However, wind energy is an intermittent resource. At windy sites, wind turbines operate 60% of the year. Sometime, the wind may be insufficiently strong for wind turbines to generate at full capacity. The intermittent nature of wind energy does not affect consumers when wind turbines are tied to an electrical network, or power grid. People located in remote sites that rely on electricity from wind turbines often use batteries or a backup generator to provide auxiliary power during extended periods without sufficient wind. In the mode of operation, modern wind turbines are as reliable as conventional power plants. Most commercial wind turbines are down for maintenance or repair less than 3% of the time. Wind turbines are also known for their longevity. Many American farm windmills have been in continuous use for generations, while some traditional European windmills have been working for almost 300 years.

Wind energy and the environment

With the rising concern about global warming, the use of wind energy will continue to increase. Wind power is a cost-effective source of electricity, thus the market for wind power will continue to expand. Some environmental and political factors, however, will also influence the growth of wind energy. Although wind energy is a relatively clean means of generating electricity, there are associated impacts. One of these is the potential for a wind farm to alter the visual quality of the landscape, especially when located in a scenic area. Noise associated with spinning wind turbine rotors has generated complaints from the public. Another environmental concern associated with wind energy is the impact on wildlife. Wind turbines in some areas are responsible for killing birds that are accidentally caught in the rotor blades. However, some of these environmental concerns are being addressed.

Wind energy and other conventional energy sources

Wind power is the fastest growing of the renewable energy options and is competitive with other conventional options when a back-up generation source is available and when government support is provided as an incentive. Global annual growth in installed capacity of wind turbines averaged 40% between 1994 and1998. In 2000, installed capacity stood at more than 13 000 MW in 50 countries. Europe has 70% of the grid-connected wind capacity, North America about 19% and Asia about 10%. About 45% of the European wind capacity is installed in Germany (Encarta Encyclopedia, 1999).

Solar energy

Solar energy can be collected using artificial devices called solar collectors. The energy collected is used either in a thermal process or a photoelectric (photovoltaic) process. When used in a thermal process, solar energy is used to heat a gas or liquid. In the photovoltaic process, solar energy is converted directly to electrical energy without intermediate mechanical devices. There are two types of solar collectors:

Flat plate collectors

Flat plate collectors are used in thermal processes. They intercept solar radiation on an absorber plate in tubes carrying fluid. The carrier fluid (liquid or air) passing through these flow channels has its temperature increased by heat transfer from the absorber plate. Flat plate collectors are capable of heating carrier fluids up to 82°C (180°F) with efficiencies between 40 and 80%. They have been used efficiently for water and comfort heating in residential houses. Typical residential applications employ roof-mounted fixed collectors. The optimum angle at which to mount collectors relative to the horizontal plane depends on the latitude of the installation.

Concentrating collectors

To run applications such as air conditioning, central power generation, and industrial heating, flat plate collectors cannot provide sufficient energy for these. More complex and expensive concentrating collectors can be used. Concentrating collectors are devices that optically reflect and focus incident solar energy onto a small receiving area resulting in the concentration of the intensity of the solar energy, which is magnified, and the temperatures that can be achieved can approach several hundred or even several thousand degrees celsius. The concentrators must move to track the sun if they are to perform effectively, and the devices used to achieve this are called heliostats. To use solar energy for cooling, concentrating collectors are more suitable than flat plate collectors.

Photovoltaic process

Solar cells have been developed which convert solar radiation directly into electricity. Cells with conversion efficiencies in excess of 30% are now available. Large

numbers of these cells can be connected into modules. Due to the intermittent nature of solar radiation as an energy source, excess solar energy during periods of small demand are stored in order to meet demands when solar energy availability is insufficient. Batteries are used as storage devices for excess electric energy produced from photovoltaic devices.

Solar energy development

Africa is well endowed with sunshine all year round. Solar resources are by far the most abundant and readily accessible in the African continent. In recent years, the numbers of households in developing countries using solar cookers and heaters tripled to more than 10 million, and in mainly rural areas, the number of households serviced with “solar home systems” grew from zero in the early 90s to one million today. Thousands of communities receive clean drinking water by using solar-powered pumps and purifiers. The cost of solar photovoltaics (PV) has dropped by 80% in the past two decades and will need to fall by a further 50 - 75% in order to be fully competitive with conventional energy sources. Photo-voltaic technologies have reached a global production level of 120 mW (Encarta Encyclopedia, 1999).

Geothermal energy

The earth is hotter the deeper one drills below the surface. Water and steam circulating through deep hot rocks, if brought to the surface, can be used to drive a turbine to produce electricity or can be piped through buildings as heat. Some geothermal energy systems use naturally occurring supplies of geothermal water and steam, whereas other systems pump water down to the deep hot rocks. The cheapest and best form of geothermal energy comes from the ground in the form of dry steam. In most habitable areas of the world, this subsurface energy source lies so deep that drilling holes to tap it is very expensive. Presently, many nations of the world have begun tapping these subterranean resources to generate electricity, such as Iceland, France, Hungary, and New Zealand. A fundamental advantage of geo-thermal energy is that it is relatively clean, free energy source, and the reserves are thought to be long lasting. On the contrary, the capital investment for developing geothermal energy is high, and prospecting is somewhat limited

Bioenergy

Biomass is the short form for biological mass, which is the amount of living materials provided by a given area of the earth's surface. Biomass energy is the fuel energy that can be derived directly or indirectly from biological sources. Biofuel is any solid, liquid, or gaseous fuel produced from organic matter. Biofuel is produced either directly from plants or indirectly from industrial, commercial, domestic, or agricultural wastes. Biomass energy from wood, crop residues and dung remains the primary source of energy in many developing regions. In a few instances, it is also a major source of power, as in Brazil, where sugarcane is converted to ethanol fuel, and in China, where fuel gas is obtained from dung. Biodiesel has been developed in some parts of the world and may compete with fossil fuel in the near future.

Fuel cells

Fuel cells are electrochemical devices that convert hydrogen and oxygen directly into electricity and heat. A number of companies are currently investing significant amounts in fuel cell research and development and expect the commercialization of the technology for use in vehicles and in grid and off-grid electricity supply. While natural gas is expected to be the main source of hydrogen initially, in the future hydrogen could be produced at remote hydropower sites, wind farms, solar stations and ocean power plants.

Tidal energy

The energy of tides has been harnessed to produce electricity. In the summer of 1966, a tidal power plant with a capacity of 240,000 kW went into operation on the Rance River, an estuary of the English Channel in northwestern France. The incoming tide of the river flows through a dam, driving turbines, and then is trapped behind the dam. When the tide ebbs, the trapped water is released and flows back through the dam, again driving the turbines. Such tidal power plants are most efficient if the difference between high and low tide is great. The highest tides in the world occur in the Bay of Fundy in Canada, where the difference between high and low tide is about 18 m (about 60 ft).

POTENTIAL FOR RENEWABLE ENERGY IN AFRICA

In this paper, potential for renewable energy in the African continent in general is discussed because of the similarity in climate all over the continent. The climate of Africa is predominantly tropical having hot and dry seasons. There are small regions of temperate (cool) climates in the extreme south and north and at high altitudes in between. Parts of West Africa, as well as the western part of central Africa, are humid throughout the year.

Solar energy is the best known renewable energy in Africa. Africa has a very attractive solar radiation and

Table 1. Average solar insolation for selected countries in Africa.

Country	Average solar insolation (kWh/m^2)
North Africa	
Egypt	5.5 - 60
Algeria	5.0 - 6.0
Morocco	5.0 - 6.0
Sub-Sahara Africa	
Eritrea	4.0 - 7.0
Ethiopia	5.0 - 6.0
Kenya	4.0 - 6.0
Uganda	4.0 - 5.0
Sudan	6.1
Botswana	6.1
Swaziland	5.0
South Africa	4.5 - 6.5
Zambia	5.6
Mozambique	5.0
Zimbabwe	5.7
Tanzania	8.0

Source: Karekezi and Kithyoma (2005); El-Khayat (2008).

has been used for a long time for dying animal skin, preserving food, drying crops and extracting salt. The continent has one of the highest levels of average annual solar radiation; 95% of the daily global sunshine above 6.5 kWh/m^2 falls on Africa during winter (Table 1).

Today solar power is being used at the household level for lighting, cooking, heating water and cooling. Solar water heaters have been disseminated in North and South Africa. Not much data of solar water heaters has been gathered in Sub-Saharan Africa (Karekezi and Ranji, 1997). Solar thermal energy for electricity production has been tested in North Africa, where two solar thermal power stations are under construction in Egypt and Morocco with a total capacity of 380 mW (El-Khayat, 2008).

OBSTACLES TO RENEWABLE ENERGY AND ENERGY EFFICIENCY DEVELOPMENT IN AFRICA

1) Inadequate policy and lack of implementation of existing policy. In African countries, policy formulation is usually left in the hands of government officials and consultants without consultation with the civil society. In other instances, policies are not given adequate publicity and thus rot away in the shelves of government officials. Such policies do not adequately reflect the needs of civil society.

2) Inadequate funding of government agencies responsible for generation and supply of electricity. Funds are often allocated to procurement of military facilities and equipment by many governments in Africa, so there is less to spend on the energy sector.

3) Inadequate access by installers and end-users to funds or financial services necessary to buy, install and operate renewable energy and energy efficiency systems.

4) Misappropriation of funds allocated to the energy sector.

5) Poor market for renewable energy products in Africa. Some parts of Africa lack the right policies to develop an efficient market for renewable energy technologies.

6) Lack of skilled man-power and skilled local labour to develop the energy sector in Africa. Agencies responsible for the generation and supply of electricity often do not have the necessary qualified staff and in many cases rely on expatriates from the developed countries to run some of their operations. This will usually mean higher operational costs than if local man-power was used.

7) Lack of exchange of information and experience on what works and what does not within and between countries, given differences in cultural and marketing contexts.

8) Minimal supporting infrastructure for these energy systems including businesses that manufacture components and whole equipment, others that stock and sell the supplies and materials, others that maintain systems in operation and businesses that provide appropriate financing.

9) There are no adequate and efficient policies and legislatures that will regulate the activities of the private sector in providing energy services; private companies

could capitalize on social, political and environmental circumstances for exploitation.
10) Lack of awareness of renewable energy technology's advances. Renewable energy technologies have not been given adequate publicity in the continent especially among policy makers, business community and the civil society.
11) The reluctance of policy makers to change from old ways of thinking and to embrace new ways of doing things.
12) Very little understanding of or emphasis on promoting energy efficiency from within government or industry.
13) Insufficient international cooperation (e.g., signing of technological protocols) on technological transfer from developed to African economies.
14) Insufficient financial resources and expertise knowledge with regard to the implementation of modern renewable energy technologies on the African continent that would be not only efficient, but also cost effective (from an emissions perspective) and equitable (from a social perspective).
15) Renewable energy technologies are not affordable by many people in Africa. This has been seen as a key barrier to the development of renewable energy in Africa. This can be overcome by developing economic empower programmes.
16) Existing energy policies are gender neutral and do not consider the genderized nature of energy uses and energy access. As a consequence they refuse to address the most urgent energy needs affecting the most vulnerable, especially women and children.
17) Vested interest of governments, development banks and large (foreign) utilities to develop large scale centralised power plants rather than consider small scale renewable based decentralised power production.
18) In many countries in Africa, there are no agencies responsible to promote energy efficiency. Even in places where such agencies are present, they often have little funding and are scarcely known.
19) No linkage between renewable energy potentialities (including biomass) and sectoral policies (health, agriculture, etc.); it is very important to mainstream energy needs in sectoral policies.
20) Lack of enforceable property rights. This comes from a lack of the rule of law, corrupt practices and poor governance.

STRATEGIES TO SCALE-UP RENEWABLE ENERGY MARKET

Use of informal market instrument

By informal markets, we mean a system whereby end consumers of a product can pay for a product in several installments. Because of the low-income status of the African society, many people are unable to fully pay for a solar water heater, photovoltaic or other renewable energy facilities in a single installment. Allowing them to spread the payment over a period of time (6 months to 1 year or even longer) will help to broaden access to renewable energy systems. The government, NGOs, the private sector and financial institutions can use the informal market instrument to scale-up renewable energy markets, which will consequently help to increase access to these facilities and consequently more modern energy services. For large scale electricity generation using renewable technology, a hire-purchase type of agreement, underwritten by development bank(s) or similar institutions, but with interest of no more than 3% per annum may help.

Priority investment on renewable energy

Since access to energy is fundamental for development and achieving the MDGs, African governments should increase investment in sustainable energy. Yet few countries in Africa have given priority attention to investment in renewable energy technology for the majority of people now without access to modern energy services. There is need for African government to invest more on sustainable renewable energies such as solar, wind, geothermal instead of large hydro and thermal stations which have taken much of the investment on energy in the continent. Moreover, large dams have been found to contribute to the emission of greenhouse gases (WCD, 2000).

Removal of import tariffs and other trade barriers

On short-term bases, the reduction or appropriate elimination of tariffs and non-tariff barriers on renewable energy facilities may help to stimulate the nascent renewable energy industry in Africa. This should be done in a way to protect local industries. More importantly, emphasis should be laid on strengthening the production capacity of renewable energy facilities, putting in place measures to reduce the burden of high cost of energy and promoting investments on renewable energies.

Policy formulation

In African countries, there is need to develop a comprehensive strategy, policy and investment program for a transition to the use of sustainable energy. Considering the most urgent energy needs and existing capacities of the majority of their population, countries in Africa should develop targets for improving access to modern energy services and develop national renewable energy goals. Such a system should be anchored on the use of renewable energy and energy efficiency. Such policies should be driven by the state in partnership with private sector and active civil society participation. Although many African countries have formulated energy polices, the policies are too often consultant driven and

lack inputs from the wider civil society and many policies in the past have passed their implementation life in the shelves of senior government officials. New policies should address all issues such as trade, production, distribution, consumption, investment in renewable energy and end-use and demand-side energy efficiency. There is need for a paradigm shift in energy development.

Policy consideration should involve:

i) Putting in place market and fiscal policies that promote renewable energy
ii) Promote open energy markets to remove legislative and commercial barriers to entry and promote transparent competition in supply
iii) Promote non-electricity producing renewables. Cooking is the main energy need of the poor and this will not change even when electricity becomes available. Promotion of improved cook stoves, small scale biogas for cooking, solar thermal technologies for sterilisation in health centres, etc. should be considered alongside electricity producing technologies, if not in priority.
iv) Focus on energy end-uses. Energy policy and programmes in developing countries focus only on the provision of energy (usually electricity) to a certain number of households. One has to go beyond this paradigm and look at who uses energy and for what purpose. Linking energy access to productive and social uses of energy is a prerequisite to ensure that energy has a true impact on the socio-economic development of developing countries and really contributes to the achievement of the MDGs. For decentralised energy systems, a minimum load has to be ensured in order to guaranty proper use and maintenance of the system. Residential use alone is usually not enough to ensure this minimum load is achieved.
v) Before involving the private sector to provide energy services, strong polices, legislation and institutions should be put in place to regulate their activities.

Improve governance in the energy sector

There is need for improved governance of the energy sector. Since electricity generation and supply require huge investments in the development and maintenance of infrastructure (e.g., transmission technologies), it is important to build upon the existing experience of government agencies in supplying electricity. African government should provide better funding for state owned utilities. Countries could establish a government-run utility that is compelled to implement energy efficiency. Policy that encouraged a public-private partnership could be developed. However, the involvement of the private sector should be preceded by policies and legislations that will regulate their activities; private companies could capitalize on social, political and environmental circumstances for exploitation.

Training of African personnel

Training of African personnel on renewable energy technologies is an important factor that will help to scale-up renewable energy market in the continent. This will help to minimize the over reliance on foreign experts in the installations and maintenance of renewable energy technologies, consequently helping to reduce the cost of renewable energy services.

Awareness creation

Lack of awareness of renewable energy technologies has caused major setbacks to development in Africa. Until recently, most of our policy makers and government officials were not knowledgeable on the technology, thus policy could not be formulated in favour of the technology. On the side of the potential end users, creating awareness of the technology will go a long way to help Africans start to integrate the technology into their thinking and acting. The media personnel if adequately trained on these issues can help to create awareness. The government should commit adequate funds to train media personnel as well as to run jingles and advertorials in national dailies to project the importance and benefits of renewable energy. This will facilitate market growth for renewable energy in Africa. Awareness generation about energy efficiency practices, technologies and techniques will go a long way to help reduce unnecessary waste of energy.

Elaborate regional perspective in renewable energy development

There are sub-regional organizations in Africa that command the political support of their members. Such organizations include the Economic Community of West African State (ECOWAS), the Southern Africa Development Community (SADC) and others. These organizations have the means to promote renewable energy and integrate energy policies in development policies and expand the market for renewable energy.

Creation of special agency responsible for renewable energy and energy efficiency

It may be necessary for governments in Africa to create special ministries responsible for the promotion of the use of renewable energy technologies and energy efficiency. This can help to scale up the market for renewable energy if the agencies are well structured and mandated. Such agencies will be instruments to implement government policies on renewable energy and energy efficiency. Ideally, these agencies will work closely with

the private sector, NGOs and other stakeholders to advance national use of renewable energy and energy efficiency technologies in a coordinated manner.

International cooperation and negotiation on raising funds for technological transfer and channeling investments in renewable technologies operating on the African continent

The failure of the CDM mechanism to channel more significant sums of investments into low-carbon technologies on African soil is increasingly acknowledged. Such failure needs to be understood and addressed. The international community needs to be made more systematically aware of the immense potential for renewables available on the African continent. This may be achieved through international cooperation, discussions and negotiations (particularly within the UNFCCC and IPCC framework and their side events), so that international agreements and technological protocols are agreed upon and adopted inducing the diffusion and widespread adoption of low-carbon technologies on the African continent (particularly in sub-Saharan Africa). For instance, we advocate for the establishment of an international fund that African economies may tap from in order to promote/subsidize such investments (and research).

Gender mainstreaming in the energy sector

Gender mainstreaming is fundamental if we must develop an energy policy that promotes even development of men and women. A gender sensitive energy programme can ease the double burden of lack of energy and poverty on women and provide opportunity for education, income generation and improve the social and economic status of families in Africa. There is need to have a gender analysis framework aimed at understanding gender issues. The capacity of decision makers, policy makers, women, planners, implementers and researchers should be built to integrate gender issues in sustainable development especially in the energy policy, and that there should be a shift from the government-only approach to an approach that embraces partnership amongst government, private and the civil society.

Financing

International finance institutions such as the World Bank should give priority investment to renewable energy instead of investing in fossil fuel. The developed countries of the world are responsible for most of the emissions leading to climate change and should sincerely invest in renewable energy. Organs of the United Nations such as UNEP, UNICEP and others commit huge amount of money to health care, education etc. The fact is that all these are essential, but some of these will not be achieved even if money is spent without adequate energy, and one way of ensuring adequate energy is by encouraging renewable energy. Just like African governments will need to reconsider their budget allocation to energy, so also will these international organisations. The new climate investment funds proposed by the World Bank need to ensure support for renewable energies and technologies that do not impact the environment or the livelihoods of the people negatively and whose impact on poverty eradication can be measured.

Promote energy sovereignty and energy security

Renewable energy technologies have the ability to give self reliance to local communities, where they can utilise the excellent renewable energy resources available for their own good. It will allow local people to have control over their energy resources and determine the type of energy to use for their daily needs. In Africa, this issue of energy sovereignty needs to be scaled up and this can only be possible by the use of renewable energy. Renewable energy can also help to limit the insecurity in terms of supply of energy and promote access to more vulnerable populations. We therefore advocate that renewable energy should be integrated into local development plan while focusing action on the development of rural enterprise (including local production).

Develop and enforce sustainability criteria for bioenergy

We advocate for the urgent development and application of sustainability criteria for biofuels, at regional and global level, that includes the entire life-cycle. While sustainable and efficient use of biomass energy holds great potential for local development, commercially driven biofuels production could devastate the natural resources base in huge areas of Africa if there are no stringent regulations, as well as great caution regarding promises of foreign exchange earnings. Wood and charcoal are renewable energy sources as long as they are produced sustainably (which normally is not the case). Therefore one of the major challenges should also be to upgrade the unsustainable (traditional) supply of biomass (mainly wood) energy to a sustainable provision of wood energy. For example, in Madagascar the three largest cities are provided with sustainably produced charcoal for cooking which is the major household energy need.

Financial viability

The sustainable introduction of renewable energy into

Africa must be founded on commercial viability. This means that the users of renewable energy technologies, and the suppliers of these systems, must all see some form of financial benefits. This will enable the optimum growth of renewable energy market otherwise the use of renewable energy will always be dependent upon external finance, grants and short-term policy obligations.

Conclusion

The World Summit on Sustainable Development (WSSD) in Johannesburg in 2002 took an important step in recognizing the important role of energy for reaching the Millennium Development Goals (MDGs). Access to affordable, reliable and sustainable energy is essential to sustainable development. An adequate attention to energy problems will contribute to achieving progress across all pillars of sustainable development: economic, social and environmental and in meeting the UN Millennium Goals. Although there is no specific MDG on energy access, the WSSD recognized that adequate access to energy is vital for poverty alleviation.

The United Nations Declaration on the Rights to Development of 1986 recognizes that the human person is the central subject of the development process and that development policy should therefore make the human being the main participant and beneficiary of development. So the human rights approach to development promotes participatory development in policy making, project conception and implementation. The domestic energy crisis in Africa cannot truly be attributed to the expansion of domestic consumption. The problem at this time may be attributed to Government policy conflicts in the energy sector and the overall macro economy. And also, the energy crisis could be attributed to obstacles in the nation's energy planning, management and conservation strategies. As identified during the WSSD, it is imperative for African countries to:

"Take joint actions and improve efforts to work together at all levels to improve access to reliable and affordable energy services for sustainable development sufficient to facilitate the achievement of the Millennium Development Goals, including the goal of halving the proportion of people in poverty by 2015, and as a means to generate other important services that mitigate poverty, bearing in mind that access to energy facilitates the eradication of poverty".

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