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**The Role of Renewable Energy in Sustainable Development and some considerations for Governments and Civil Society.**

**Third Draft**

**For Circulation**

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## Executive Summary

Energy is a vital component that underpins human society and supports economic and social development. However, the exploration and utilization of energy resources, especially with the pollution due to large scale consumption of fossil energy, has become a prominent global environmental issue, threatening the survival and development of mankind. With economic development and social evolution, global energy consumption will continue to increase and energy resources and the environment have become issues of key importance. The 2002 World Summit on Sustainable Development in Johannesburg and the 2004 International Conference for Renewable Energies in Bonn sent out the same voice to the world, that is, the exploration and utilization of renewable energy is an important approach to poverty alleviation and sustainable development.

In view of the current fuel crisis facing the world, global warming, alarming rate of environmental degradation, the need to diversify the supply of energy, sustainability of renewable energy sources, interest is shifting to renewable sources of energy which in developing countries emerging as a source of revenue and job creation. The four main sources of renewable energy discussed in this paper are biomass, hydropower, wind and solar energy with a perspective from developing countries where development priorities are controlled to the ruling

government, project and development commitments are short-term and often geared at securing political interests. Potentials of these energies are known and models which can be replicated in other countries where they don't exist are in black and white. Many countries in Africa find themselves in this predicament. The civil society therefore should take an active role in education and mobilizing the world to take the challenge to improve technology in renewable energy.

Energy projects must be valued in terms of their total costs and benefits to the society and the environment. Hydropower which is major source of renewable energy can also be a significant source of environmental and social degradation. Future development of large-scale hydropower need to take into consideration the major environmental impacts associated with it so that mitigation measures are taken to create harmony between development and sustainability. On this regard therefore small hydropower plants are recommended. It is thus imperative that each hydro scheme be carefully evaluated on a case by case basis.

Clean energy has been recognized as an essential element for development and the attainment of basic human needs. The role of clean fossil fuel in a secure energy future cannot be overemphasized. Discussions on clean energy carriers with emphasis on hydrogen and Carbon Capture and Storage (CCS) are abound. CCS is a mitigation technology that aims to produce a concentrated stream of CO2 which can be transported to a storage site. The development and subsequent utilization of these energy carriers remains a task that developing economies and their governments need to explore in details if part of the MDGs are to be fulfilled and sustainability in the renewable energy sector is to be upheld.

Investment into renewable energies should be shifted towards technologies and systems that cause minimal impact to the environment. Politics, policy issues, technological challenges, international cooperation and investment should all create synergies for the speedy development of RETs in the developing countries. Viable sustainable energy source requires donors and governments to rethink in traditional development assistance patterns and investment formulas in renewable energy.

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**List if Acronyms**

| | |
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| CCS | Carbon Capture and Storage |
| $CO_2$ | Carbon dioxide |
| MDGs | Millennium Development Goals |
| RETs | Renewable Energy Technologies |
| UNEP | United Nations Environmental Program |
| NGO | Non Governmental Organizations |
| SHS | Solar Homes Systems |
| PV | Photovoltaic |
| BOS | Balance of Systems |
| IBT | Improved Biomass Technologies |
| MBTs | Modern Biomass Technologies |
| CBOs | Community Based Organizations |
| MW | Mega Watts |
| IUCN | The World Conservation Union |
| WCD | World Commission on Dams |
| TERNA | Technical Expertise for Renewable Energy Application |
| LPG | Liquid Propane Gas |
| MFO | Market Facilitation Organization |

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## 1 Background: Energy, Environment and Development

### 1.1 Energy and The Millennium Development Goals

It has been said that none of the eight MDGs addresses energy directly. This is just as well because energy underpins all the MDGs, most of which are interrelated, more so in Africa. For example, child mortality and maternal health will rest on our ability to empower women with resources that will also reduce poverty and hunger. Anybody with some knowledge of Africa will immediately see how this will affect the fight against HIV/Aids and other diseases, including Malaria, and the impact of all of this on primary education.

The driving force for all of this will be energy, which in most of Africa today, will be largely fuelwood (traditional) and petroleum (modern) with a small mix of electricity although other forms of energy will also play a significant part. Statistics indicate that 80% of the world's population is concentrated in developing countries yet they consume only 30% of global commercial energy. As energy consumption rises with increases in population and living standards, awareness is growing about the environmental costs of energy and the need to expand access to energy in new ways. Increased recognition of the contribution renewable energy makes to rural development, lower health costs (linked to air pollution), energy independence, and climate change mitigation is shifting renewable energy from the fringe to the mainstream of sustainable development. Support for renewable energy has been building among those in government, multilateral organizations, industry, and nongovernmental organizations (NGOs) pursuing energy, environment, and development agendas at local, national, and global levels. At the same time, commercial markets for renewable energy are expanding, shifting investment patterns away from traditional government and international donor sources to greater reliance on private firms and banks.

Changing investment patterns make it more important to think about markets for renewable energy, rather than simply about the technologies themselves and their economic characteristics. Changing investment patterns also elicit increased decision-making and participation from a wider variety of stakeholders—not just traditional donor agencies and governments, but also manufacturers, rural entrepreneurs, individual households, local technicians, NGOs, community groups, utility companies, and commercial banks.

Renewable energy is in fact a multi billion dollar industry and the most dynamic sector of the global energy market yet in developing world the renewable energy sector remains far the smallest segment of the world's energy industry. Various finance related risks and barriers are hindering faster growth. Most renewable energy projects have high upfront capital costs relative to competing technologies and low rates of return. Many investors therefore are not willing to invest in these high risk-low returns. This is particularly the case in developing countries where access to affordable finance is extremely difficult and relies on targeted subsidies. Investments in these regions are impeded by poorly developed financial markets, products and institutions as well as high political, credit currency and economic risks, the lack of local capacity to adopt technology and lack of infrastructure to deliver services.

### 1.2 Petroleum: The End of an Era

The fuel price crisis hitting the world in the recent past is a manifestation of a bigger issue: the oil age is coming to a close. Evidence of this is found in the increase frequency and steepness of price hikes over the past twelve months crude oil prices have risen by more than 40% and steeper rises appear almost daily. This is taking place in the backdrop of increased consumption and dwindling stocks of new finds. Current stocks are getting used up new finds are less frequent with less spectacular yields. Current world stands at some 80 million barrels a day expected to rise to 112m barrels by 2020. New findings on the other hand are becoming smaller in capacity and more expensive to extract. While estimates of the remaining available oil resource vary according to the optimism of those making the assessment, the one thing which is clear is that oil production will peak during the lifetime of many of today's young people.

The world is slow in coming to terms with this reality. It is as if we are in a state of denial, despite the wake up call from global warming and the environmental degradation which is evident. For, while it took millions of years for the present oil stocks to form, our attempts to burn most of it in the stretch of one century has resulted in considerable warming of the environment, with long term damage we are yet to come to terms with.

However petroleum oil is not the only fuel on which our economies can run. Many countries have successfully implemented trials in alternative locally produced fuels. Natural gas is an easy substitute, but it is subject to the same capacity limitations as petroleum, besides requiring a substantial change in infrastructure to accommodate distribution. Hydrogen powered cars are running on an experimental basis now and will offer real options for the future once the infrastructure issues are resolved. Indeed hydrogen can be made by electrolysis from solar cells, which would put sun-drenched Africa in the energy frontline if we could get the necessary investment to install the necessary plant.
This scenario is compounded for developing economies without oil resources as impacts consume even larger proportion of their export earnings. Petroleum imports constitute more than 16% of import bill for Kenya, consuming more than 31% of all her export earnings, a situation which generally replicated through the continent, and is only getting worse. However this need not be a totally lost cause. There is a silver lining at the edge of the cloud and an even brighter picture if we can lift ourselves to look at the clouds from above. As prices continue to rise, economic sectors dependent on oil will be forced to look for alternatives. Renewable energy sources, currently considered uneconomic, will become more affordable as oil prices continue to rise. With a little foresight and good planning we should leverage ourselves from the increasing debt of fuel import, and generate economic activities in areas that will create wealth for ordinary citizens. Indeed the amounts paid out today will exceed the investments required to lift us out of this situation.

### 1.3 Role of Governments

It is widely accepted that the responsibility for sustainable energy policies rests with governments. This is principally because governments are best placed to address issues of policy conflicts where a careful balance must be sought to achieve an optimal outcome in terms of economic and social development in the face of potential negative externalities, such as the environmental consequences arising from energy production and use. However, governments also have specific and vested interests of their own, with long term strategies sometimes compromised by the need to attract political support.
It is also accepted that national governments and parliaments are responsible for the formulation of policies that support effective and efficient markets in general, the requirement of regular elections has often led to the compromise of long term, slow yield programs as against vote winning short terms options. A combined effort of business, governments and the NGO community is required to define and articulate a long term vision for the environment and sustainable exploitation of our global energy resources. A clear political determination can realize such a vision and allow the world to benefit from the advantages of both a wide use of renewable energies and significant energy efficiency improvements. Powerful national commitments create the enabling environment necessary to mobilize the dynamics for a rational and effective use of existing renewable energy potentials.

A participatory approach involving all stakeholders is needed to facilitate progress. The civil society in particular, must play its part in sharing experiences on the development of renewable energy, to exchange views on development policies, financing mechanisms and technologies in the renewable energy sector, to promote the international cooperation of renewable through technical assistance and technology transfer, and to further promote global renewable energy development. energy, to assist developing countries to explore and utilize renewable energy

## 2. Biomass, Bio-energy and Biodiversity

### 2.1 Biomass Energy

Biomass is material originally produced by photosynthesis - such as wood or plants - or related municipal and agricultural wastes. Bio-energy technologies use these resources to produce heat, electricity or fuels that substitute for petroleum, petrochemicals, or other energy-intensive products. Bio-energy resources such as woody crops, biomass residues and wastes already provide about 14% of the world’s primary energy supplies. In particular, biomass energy plays a vital role in meeting local energy demand in many regions of the developing world providing in excess of 70% of energy needs of many African countries. Modern biomass energy is widely used in many developing countries as well as in parts of the industrialized world. Biomass is a primary source of energy for close to 2.4 billion people in developing countries. 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.

Traditional biomass use, however, has significant drawbacks. The indoor air pollution from unvented biofuel cooking stoves is linked to respiratory diseases in many highland areas of developing countries. Rural and poor women and children in many developing countries spend a significant portion of their time gathering and collecting wood fuel, crop residues and animal dung for use as cooking and space heating. 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. Reliance on traditional biomass (especially in the form of charcoal) contributes to land degradation and deforestation in countries where charcoal (sourced from natural forests and not planted forests) is widely used. 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.

## 2.2 Challenges of Biomass Use

Key challenges facing many countries that rely heavily on traditional use of biomass include first how to ensure the biomass used is sourced from sustainable biomass resources such as 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. The use of improved biomass technologies such as more efficient cookstoves, charcoal kilns and dryers can reduce respiratory health problems associated with smoke emission from biofuel stoves and reduce the negative deforestation impact of, for example, traditional charcoal production, to yield reduced fuel consumption, faster processing, improved product quality and products. Other benefits 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.

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. Small-scale applications of modern biomass energy technologies still faces numerous challenges particularly at the level of cost-competitiveness, although many argue that this is due to an absence of a level playing field. The growing of the biomass energy resource can also presents several challenges. In particular, high-input mono cropping results in the loss of biodiversity, soil fertility and land degradation, and is often 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. For example, pulpwood plantations in many developing countries have led to the displacement of farmers and a decline in production of agriculture and other forest products.

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. The development of modern biomass energy often requires significant capital investments and technical expertise, which may not be readily available in many developing countries. In addition, there are cases where the legal and regulatory framework in place does not support the development of modern biomass energy technologies.

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 has some jurisdiction on biomass energy issues ranging from the ministries of energy, environment, and forestry to a plethora of national and sub-national agencies responsible for land tenure policy and rural development. 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.

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. Mechanisms for collection and documentation of data on traditional biomass supply and consumption, which is regularly updated and validated, need to be instituted. 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 systems. For low-income developing countries with large and very poor rural population, the accent should be on the promotion and disseminating of improved biomass energy options. 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 energy use.

## 2.3 Policy Issues in Biomass

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. Governments should put in place policies that support the development and dissemination of IBTs. The private sector, NGOs, CBOs and donor organisations should implement projects aimed at ensuring the rapid dissemination of IBTs. In particular, 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. It is important for improved biomass energy system development and dissemination programmes to recognize the gender- and income-differentiated impacts of biomass energy use.

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 advanced biomass energy technologies. Both capacity and demand for local analytical expertise to provide comprehensive evaluations of available biomass energy resources and options for utilizing them are needed. Non-partisan groups, such as NGOs and independent research institutes and networks are well placed to perform such studies.

There is no general consensus on what policy options would accelerate the use of modern biomass technologies but some suggestions have been put forward for consideration. Among them: ensuring a level playing field for modern biomass and conventional energy forms; 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 options to total energy supply. The use of tradeable renewable energy certificates could assist in further promotion of modern biomass energy technologies. A further option involves the setting up regional and international funds for financing large-scale biomass energy technologies.

## 3. Hydropower and sustainable development

### 3.1 Extent of Hydropower

It is estimated that one-third of the countries in the world currently rely on hydropower for more than half of their electricity supply. Largely considered a clean renewable energy source, hydropower has provided many economic and social benefits. Many countries have chosen to develop their hydroelectric resources as a means of improving domestic energy security, providing more energy services, stimulating regional economic development and increasing economic growth. Hydropower has played an important role as backup power and electricity storage for years. Together with other renewables such as biomass and geothermal it also has the potential to serve as backup power as shares of renewables in electricity supply increase.

### 3.2 General impacts due to hydropower development

Damming a river and creating a lacustrine environment has profound impacts on hydrology and limnology of the river system. Dramatic changes occur in the timing of flow, quality, quantity, and use of water, aquatic biota, and sedimentation dynamics in the river basin which may change the physical, chemical, and biological quality of the water flowing in it. The significance of this change depends largely on water quality requirements for downstream uses such as protection of aquatic ecology, domestic water supply, irrigation, specific industrial applications (e.g. cooling, food processing, etc.) and recreational use. In addition to the impact on wildlife and fisheries due to land take, social impacts arise from displacement due to land take for the project, increased population and competition for resources, danger of increased health problems due to spread of communicable diseases. These are however countered by increased income from employment and increased business opportunities and better living standards.

As a result of the increasing global campaign against construction of large-scale hydropower dams, probably focus should shift to promoting medium-sized dams. Development of these resources, due to the financial commitment involved, needs great and sustained support from politicians, governments, and multilateral agencies. This should be done in the light of the increasing global environmental threat to the climate and other factors as a result of emissions of greenhouse gases from the burning of fossil fuels.

### 3.3 Small vs. large hydro

Every hydro plant is unique in its design, location and impacts. While there is no directly proportional relationship between the installed capacity of a hydro plant and its impacts, in general one can expect higher impacts as the size of the project increases. Small hydro can, if responsibly implemented, be environmentally and socially low-impact and provide many of the benefits of new renewables, in particular providing power and related development benefits to dispersed rural communities. The cumulative impacts of multiple small hydro schemes on small watersheds are of particular concern.

It is thus imperative that each hydro scheme be carefully evaluated on a case-by-case basis. The site-specific nature of hydros means that it has been difficult to reach international agreement on a size limit for small hydros. According to the International Association for Small Hydro, however, a limit of up to 10MW capacity “is becoming generally accepted.” To ensure that the hydro projects have low impacts and meet community priorities, it is imperative that every hydro scheme be planned, built and operated in line with the recommendations of the World Bank/IUCN-sponsored World Commission on Dams.

Proponents argue that large hydropower is a key tool in sustainable development. The poor social, economic and environmental performance of large hydropower, however, shows that the technology can only play a role in sustainable energy development if its planning and management are subject to strict guidelines and criteria, alternatives are fully considered, and projects are implemented through transparent and accountable processes. Hydropower planning and management must be reformed along the lines recommended by the WCD if large hydro is to play a role in the cost-effective, environmentally sustainable and socially equitable development of the world’s energy resources.

The nature of large hydropower – capital-intensive, slow to build, centralized, dependent on large centers of demand and long, expensive and often inefficient transmission lines, means it is particularly inappropriate for meeting the needs of the unserved and rural areas. In many low-income countries, especially in Africa, power ministries, supported by foreign donors, have devoted large proportions of government budgets, aid funds and institutional resources and attention to building and managing large hydropower projects. Meanwhile, distribution networks have been starved of investment.

## 4. Wind generator technology

### 4.1 Development of Wind Resource

This section discusses wind energy technology for electricity generation, and in particular, the experience gained from Europe and elsewhere in developing and operating this modern form of renewable energy. Experiences of several wind generator projects show that the key factors influencing the dissemination of wind generation are not technological, but are more focused on policy issues such as institutional development and on financing and economic considerations. Human resource development and retention is of particular importance in the African context. The experiences of wind energy developments in Germany, the UK, Morocco and India provide a useful guide. Compared with many other renewable energy technologies, establishing suitable frameworks that are intended to encourage expansion in the wind sector has an important role to play. In addition, the more often unstable socio-economic and political conditions in African countries have a bearing on whether these frameworks can be developed successfully.

To stand any chance of being economic, electricity generation from wind energy requires an annual average wind speed greater than five metres per second. Data from Civil Aviation authorities and measurements taken at various locations worldwide indicates that these conditions can be met in many locations in Africa, close to load centres. However, wind energy is one of the most intermittent renewable energy sources. Large-scale generation of electricity from wind power has been developed during the last 20-25 years. This has actively been encouraged, particularly in Europe, North America and Asia, through the intervention of government programmes aimed at stimulating renewable energy technologies. Many countries have established targets for wind energy capacity, and there has been a buoyant market for equipment sales by indigenous manufacturers together with considerable export potential. However, the market for wind energy is mostly politically driven. Security and diversity of supply considerations were the initial drivers during the 1970s and 1980s. On the other hand, recently these concerns have been supplemented by environmental factors, most notably the threat of global warming and the need to substitute for fossil fuels. The fundamentals of the technology have shown there is little doubt about its technical feasibility.

### 4.2 Economic and Technical Considerations

Wind turbines for power generation have been developed over a range of electrical power outputs from kilowatts to multi-megawatt units. They are available commercially up to around one MW, while larger units of around 1.5 MW up to 2 MW are under development or in pilot testing. Large-scale generation of electricity requires a number of these machines, typically around 20, to be grouped together for economy and ease of operation in a wind farm. The machines are usually spaced between five and ten rotor diameters apart, in order to reduce interaction effects, which might impair their performance to an unacceptable level.

During their 20-year design lives, the wind farms are not permanently staffed. Remote control capabilities are commonly designed into the project. Consequently, the operation of each turbine can be constantly logged and remotely monitored using a computer programme from a local office, with site visits limited to scheduled servicing and maintenance of the machines. Wind offers substantial benefits as a renewable and widely distributed energy resource. The wind is an intermittent energy resource, but this does not reduce its value as a source of power. The variable output from wind energy poses no special difficulty for power system operation. Electricity demand is constantly fluctuating, hence, supply and demand have to be matched on a minute to minute basis, 24 hours of the day and every day of the year. The fluctuation caused by the introduction of wind to the electrical system will be compensated by a corresponding action from the other generators in the system. The use of wind-diesel or other hybrids will ensure continuity of supply while minimising generation costs associated with fuel.

Wind projects may help to attract new capital and foster a new approach to independent power production, since the turbines are modular and can be added into a supply network in relatively small increments. Wind farms contribute no gaseous or liquid emissions to the environment. They, thus, help reduce the environmental impact of producing electricity. One potential source of environmental disturbance is the noise generated by the mechanical power train components. Modifications and more sophisticated design methods now ensure that wind turbines are extremely quiet. Wind is seen therefore, as a clean and efficient renewable energy source.

Africa has seen little development of modern wind turbines. This is partly due to low wind speeds compared with many parts of Europe, Asia and the Americas, resulting in poor economics of wind energy. Moreover, this has also been combined with a low level of technical skills and awareness of the potential of the technology. One result is that few projects have been undertaken in Africa, and there is only limited experience of wind energy for grid-connected or mini-grid electricity generation. However, wind pumping and small-scale electricity generation have been developed in many parts of Africa.

There have been, though, several wind energy pilot projects aimed at larger scale electricity generation in some countries in the region during the last ten to twelve years. These have included studies or initial projects in Namibia, South Africa and Kenya. More recently, large-scale developments of wind farms have commenced, including projects in Morocco and Egypt. There appears to be good opportunities for wind energy development in Somalia, provided the establishment of a stable government. Expansion will also depend on the establishment of sound regulatory and fiscal frameworks to attract investment. It is likely that joint ventures, successful pilot projects and demonstrations will be critical factors.

### 4.3 Human Resource Development and Retention

An additional key factor in the African context is human resource development and retention. It is apparent from the factors considered above that building and retaining local capability will be essential. The design, planning, construction and continued operation of installations depend on a wide range of specialist inputs from government agencies, electricity utilities, manufacturers and project developers. These organisations must have sufficiently trained and experienced staff in the field to support the development of wind energy technology. In particular, operational or component failures result in low technical availability of a wind plant and adversely affect its economic viability whereas badly screened projects and poor site selection results in operational and economic difficulties.

Considerable resources in training, skill enhancement and professional engineering development are required. This lack of human resources has been recognised, and as an example, in order to disseminate such experience, the German Government is funding a wind-energy programme called TERNA. The programme is supposed to provide technical expertise and assistance with wind energy projects in developing countries. The TERNA programme has assisted the Government of Namibia to conduct a wind energy study, in order to examine the technical and economic feasibility of wind farms near the Atlantic coast. The development of a 20 MW wind park is now being pursued. A crucial barrier that inhibits the wider use of wind energy in Africa is the lack of expertise and experience in planning wind farms. There is a clear need for building capacity for resource estimation, planning, site selection and organising suitable contractual arrangements for construction and operation.

## 5 Solar Energy and Sustainable Development

### 5.1 Solar Photovoltaics

Perhaps the most ‘visible’ form of renewable energy in Africa today is the ‘Solar Home System’ or SHS as it is generally known. In many parts of Africa, solar home systems consisting of a photovoltaic (pv) solar collector, a storage battery and some basic wiring, has brought the benefits of modern electricity to many homes, schools, health institutions and other commercial centres which would otherwise not enjoy the benefits of modern energy. Indeed, the level of awareness and local technical competence is quite high even in some of the more isolated parts of the continent. Where it has been available, it has enabled local populations to listen to radios, watch television, (sometimes with the help of satellite communications) and enabled school children to extend their study hours and generally improve quality of life.

The major drawback of SHS has been the issue of affordability. The capital costs of the equipment is often quite high many rural households opt to buy solar electric lighting systems equipment piecemeal, one component at the time—e.g., first a battery and a television; later, a first small solar module to avoid frequent recharging of the battery; and so on. This requires good skills on the part of the users, as the systems are technically imperfect. Duties and taxes on imported PV equipment, high dealer margins, and high costs of doing business contribute to relatively high prices for PV electricity system installations.
Often PV is seen as an inferior technology, not because of its functionality but because of a lack of enforced installation and design standards, mixed quality of balance of system (BOS) components available locally, and a lack of full awareness among end-users on operation and maintenance of solar electric systems. About one-third of the existing systems in Kenyan rural areas are not fully operational because of poor installation, customer misuse, and poor design practices.

### 5.2 Options for Increasing Access to Solar PV

Lack of access to finance often prevents end-users from investing in suitably sized and installed systems. Financed solar electric systems are an attractive option for rural households and small businesses because financing allows end-users to buy properly designed, high-quality systems— larger systems than would be possible to purchase with cash. Regular monthly payments for PV systems (which are not much larger than current energy expenditures) should suffice, over time, for loan repayments. Furthermore, the cost of financing systems can be offset by bulk purchases, which allow higher economies of scale.
Some suggested Solutions:

- provide an integrated package that links rural finance mechanisms with the provision of properly designed, installed, inspected, and serviced high quality solar electric systems at the local level. Technical specifications insure that the systems last longer than the length of the loan repayment period;
- establish credit procedures for lending to rural households through local savings or credit groups with specified maximum payback periods. Interest could be fixed by the financing institution as per normal prevailing rural rates, possibly slightly reduced through external financial assistance;
- establish credit procedures for rural-based enterprises with potential to increase productivity with access to electricity. Such enterprises can sell equipment (PV systems, components, etc.)

# 6 The role of clean fossil fuel in a secure energy future

## 6.1 Petroleum is still here for a while!

There has been increased recognition that clean energy is essential for development and the attainment of basic human needs especially in urban and for security both in terms of reliability of energy supply and protection against price volatility. After the Kyoto protocol was put in place countries continue to consider short term responses but there is little disagreement about the dramatic nature of the long term transition that may be needed. Because of the long lived nature of carbon dioxide and most greenhouse gases, global emissions reduction in the range of 60-70% relative to current levels may be necessary in the coming decades. This will need to be accomplished even as the global population multiplies and the level of economic activities expands. Improved energy efficiency and new technology for energy sequestration will play important roles.

## 6.2 Increased Use of Renewable Energy

Especially in rural areas, there have been significant improvements in access to commercial energy over the past decade, including access to LPG, modern biogas, and village-scale electricity grids. Use of renewable energy, including solar, wind, and small hydropower, also has increased dramatically.

For example, solar home systems using photovoltaic (PV) technology, which was virtually unknown in 1992, now provide lighting, television, and radio to more than 1 million rural households. Thousands of rural communities now receive drinking water from solar PV-powered purifiers and pumps. Small hydropower and biomass generation capacity worldwide increased 20-30 percent over the past decade, to 25,000 megawatts and 16,000 megawatts, respectively. More than 50 million households are served by small-hydro village-scale mini-grids, mostly in China. Wind power generation capacity has increased from virtually zero to over 1.700 megawatts, mostly in India. In addition, the number of households served by solar hot water heaters has tripled, to roughly 10 million households, mostly in China. Programs for improved biomass cooking stoves in China, India, and several African countries have benefited some 220 million households through reduced fuel costs or fuel wood collection burdens.

## 6.3 Increased Private Investment in Renewable Energy and Energy Efficiency

With the encouragement of the World Business Council for Sustainable Development and other business councils in industrial and developing countries, a large number of leading industries have become increasingly engaged in renewable energy and energy efficiency investments. It is estimated that between $500 million and $1.5 billion of renewable energy projects in developing countries are being financed each year, a market that is growing 5-10 percent annually.

At least 30 major firms have made commitments to invest billions of dollars in renewable energy over the next two to five years. Shell International Renewables was one of the first to make a large scale commitment with $500 million pledged in 1998. Others have since followed with similar commitments, some for over $1 billion. Total commitments now amount to at least $10-$15 billion.

## 6.4 Greater Reliance on Markets and the Private Sector

During the past decade, commercial markets for renewable energy have expanded, shifting investment patterns away from traditional government and international donor sources to greater reliance on private firms and banks. These changing investment patterns have made it more important to think about markets for renewable energy, along with the policy and social conditions that underlie markets, rather than simply about the technologies themselves and their economic characteristics. The policy and social conditions vary widely from country to country, resulting in a diverse range of market conditions that require a similarly diverse range of market-oriented approaches. Changing investment patterns also elicit increased decision-making and participation from a wider variety of stakeholders-not just traditional donor agencies and governments, but also manufacturers, rural entrepreneurs, individual households, local technicians, NGOs, community groups, utility companies, and commercial banks.

## 6.5 Carbon Capture and Storage CCS)

Carbon capture and storage (CCS) is a mitigation technology that aims to produce a concentrated stream of $CO_2$ which can be transported to a storage site. While in some cases the reason for injecting $CO_2$ may be commercial (notably in enhanced oil recovery), CCS typically aims to mitigate greenhouse gas (GHG) emissions from fossil fuel combustion. It is mostly applicable in large centralised sources, e.g. power plants, other energy industries (oil refineries, synthetic fuel plants) and fossil-fuel-intensive industries (iron & steel, cement, chemicals). After initial capture of the gas, the $CO_2$ needs to be transported to a suitable storage site for injection. Monitoring $CO_2$ after injecting it into a storage area (geological formations) is important to ensure permanent storage and safety for human health and the environment.

Once captured, $CO_2$ can be kept in storage areas, such as geological formations. The $CO_2$ can be trapped physically below impermeable rock, dissolved or ionised in groundwater, retained in pore spaces, or adsorbed onto organic matter in coal and oil shale. All these forms of storage have long residence time (thousands to millions of years). Possible types of storage sites include depleted oil and gas fields and deep underground formations filled with saline water. Existing technology required to inject carbon in deep geologic formations, has been developed by the oil and gas exploration industry. Projects specifically designed to store $CO_2$ have started to develop experience with storage for CCS specifically, although the scale is still small relative to the future requirements. Costs are variable and are location-specific. Environmental concerns relate to the permanence of the storage and the health and safety implications of possible concentrated releases in the future. Criteria for site selection include the storage capacity (related to its porosity), permeability, any physical or hydrological barriers to $CO_2$ storage and the stability of the geological formation. To reduce transport costs, it is important that sources and sinks are matched.

## 7 Hydrogen

### 7.1 Hydrogen as an Energy Carrier

Hydrogen is the simplest, naturally occurring element that can be found in numerous materials—natural gas, methanol, coal, biomass, and water. Hydrogen, an energy carrier, is anticipated to join electricity as the foundation for a globally sustainable energy system using renewable energy. Hydrogen can be made safely, is environmentally friendly, and versatile, and has many potential energy uses, including powering non-polluting vehicles, heating homes and offices, and fueling aircraft. An energy carrier, not a source, hydrogen must be manufactured, principally by either splitting water or by extracting it from natural gas through steam reforming. Interest has been spurred by a growing awareness of growing environmental threats to which hydrogen produced by solar-generated electricity seems the near perfect solution. The theoretical combination of the two is appealing: electricity generated from the limitless supply of solar energy, then used to produce a flexible, transportable, and easily stored fuel which is virtually non-polluting. Cost remains the largest single obstacle, although there are formidable engineering challenges as well.

### 7.2 Future Options for Hydrogen

There are advantages and opportunities to using hydrogen as an Alternative fuel. The production of hydrogen from renewable electricity and from biomass could reduce our dependence on imported petroleum. Hydrogen can be combined with gasoline, ethanol, methanol, or natural gas; just adding 5% hydrogen to the gasoline/air mixture in an internal combustion engine could reduce nitrogen oxide emissions by 30% - 40%. An engine converted to burn pure hydrogen produces only water and minor amounts of nitrogen oxides as exhaust. Hydrogen can be produced from a variety of renewable sources and has many uses in our economy. Because of the versatility of production methods and end use, wide-spread hydrogen energy use will create significant benefits to the agricultural, manufacturing, transportation, and service sectors of the U.S. economy.

Hydrogen can also supplement other sources of energy to produce electricity. Gaseous hydrogen can be stored like an industrial gas. And, on paper at least, hydrogen could be shipped in modified natural gas pipelines, thus carrying energy over long distances more economically than high-voltage transmission lines. Some researchers have estimated that it is about one-fourth as expensive to pipe hydrogen across long distances as it is to transmit electricity the same distance.

There is an emerging consensus that as global warming manifests itself, the benefits of a hydrogen economy based on clean electricity might well exceed its incremental costs.

## 8. Shifting Investments in Renewable Technologies to Developing Countries.

### 8.1 Renewables is still 'Too New'

Financiers are generally averse to things that are new, the difference between renewable energy and conventional energy systems and the risk perceptions they imply can become the most significant barrier to investment. Even for renewable energy technologies that are cost competitive with conventional energy supply options. Considering investing in the renewable energy sector for the first time is considered too risky. To become more effective at lending capital in renewable energy markets, financiers must travel up a learning curve. Market failures impede this learning process and create barriers to entry into the market. The information that enables correct assessment of a project's viability is generally lacking and there is limited economic justification for any single participant to produce such information. As a result of insufficient information, underlying project risk tends to be overrated and transaction costs can increase.

### 8.2 Price Support

A key issue for financing on grid renewable investments is how to create a price support mechanism that provides stability and portability over medium and long term. Achieving this will reduce the risk premium in the cost of capital which will increase the amount investment in renewables and lower the price that consumers have to pay for renewable energy. The renewable energy sources for developing countries should be priced reasonably to make the affordable. Investors or donors can subsidise the prices at source of origin. This is necessary because people in developing countries have less disposable incomes.

### 8.3 Developing New Portfolios

To enter a new sector, financial institutions need o focus on creating the right policies or strategies and even train personnel. The financial institutions need to develop specialized funds or loan portfolios that target specifically renewable energy the same way the do for other sectors like agriculture. Money or loans that target renewable energy can be lent out at fairly subsidized rates; the banks' interest should be fully aligned with those of the donors, both interims of minimizing defaults and continuing lending activity after donor support has been phased out. Extending the credit periods to improve cash flows and decreasing security requirements are some measure to than banks can use to promote renewable energy. With such measures, donors can channel fund for renewable energy through the existing banking institutions as they have the necessary capacity and experience to reach out to the local borrowers for renewable energy investments.

### 8.4 Consumer Credit

Consumer credit is another approach to affordability. Credit may be provided either by vendors themselves, by rural development banks, or by micro credit organizations. In Kenya for example the cooperative movement is quite developed and members of these cooperatives who in most cases are small savers get credit facilities. One of the best examples is the giant Teachers Savings and Credit Cooperative Society (SACCO) with almost all secondary and primary teachers (about 200,000) as members thought the country. The cooperative has a credit facility for solar energy systems; however the money there is never sufficient because it is the same resource base that is lent out for emergency loans and other loans. So donors can best use this means as a door way to availed renewable energy to greater majority of the developing world population like Kenya. The money can be lent directly to the cooperative society at a much lower rate and the same rate; it can be lent out to members specifically for investing in a renewable energy source. this facility can easily reach out to women who are members of the cooperative or whose spouses are, equally it will ease the pressure put on the existing commercial banks since these cooperative societies also borrow substantially form the commercial banks.

### 8.5 Other Risk Mitigation Tools

This involves the process of using financial instruments to transfer specific risks away from project sponsors and lenders to insurers and other better able to underwrite or manage the risk exposure. There are currently constraints on the availability of such risk management instruments which relate to factors parties such as the willingness and capacity of insurance and capital markets to respond. Many risks associated with renewable energy projects are non traditional and hence uninsurable. It can be difficult to diversify risks in an area where actuarial data is not available to properly asses the risks. Underwriters have difficulty understanding of renewable energy projects and associated risks and have difficulty aligning strategies for dealing with them. The insurance firms therefore need to develop appropriate underwriting rating methodologies, aggregate projects to create portfolios of scale and risk diversification, develop new risk management instrumental to bundle heterogeneous risks. Donors can also channel funds through the existing insurance companies to mitigate risks associated with renewable energy.

### 8.6 Bundling

Costs may be lower if vendors of existing products and services add renewable energy to their activities, and use their existing networks of sales outlets, dealers, and service personnel. Dealers of farm machinery, fertilizers, pumps, generators, batteries, kerosene, liquid propane gas (LPG), water, electronics, telecommunications, and other rural services can bundle renewable energy with these services. Of course, dealers must still develop new technical expertise and train their staff. Kenya is an example where market growth was rapid because existing electronics and other retail businesses added solar home systems to their offerings. An investor can therefore use these existing retailers to promote, and distribute renewable energy as they are wide spread throughout the country. Incentives such as commissions, discounts and price cuts can be offered to them and these will translate into lower prices for the rural folks.

There is need also to develop the capital market in developing countries to include companies that deal in renewable energy to help in pooling of resources. Policies should be built to promote sustainable rural energy goals. Such approaches could include supporting rural entrepreneurs with training, marketing, feasibility studies, business planning, management and linkage to banks and community organization.

## 9. Conclusion

Viable, sustainable energy source requires donors and governments to rethink on traditional development assistance patterns and investment formulas in renewable energy. Governments need to foster the appropriate conditions for viable rural entrepreneurship and grid-based power investments that incorporate renewable energy. Commercial banks, multilateral organizations, and other public lenders need to provide business finance to entrepreneurs, credit to consumers, and project finance to grid-based power developers. National governments and international donors should support the creation and strengthening of innovative market facilitation organizations (MFOs). Finally, further research is needed on successful experiences and business models, social benefits and income generation, technology applications that meet user needs, and sectoral policy lessons from emerging policy successes and failures—grounded in the specific culture, politics, institutions, and history of each country.

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