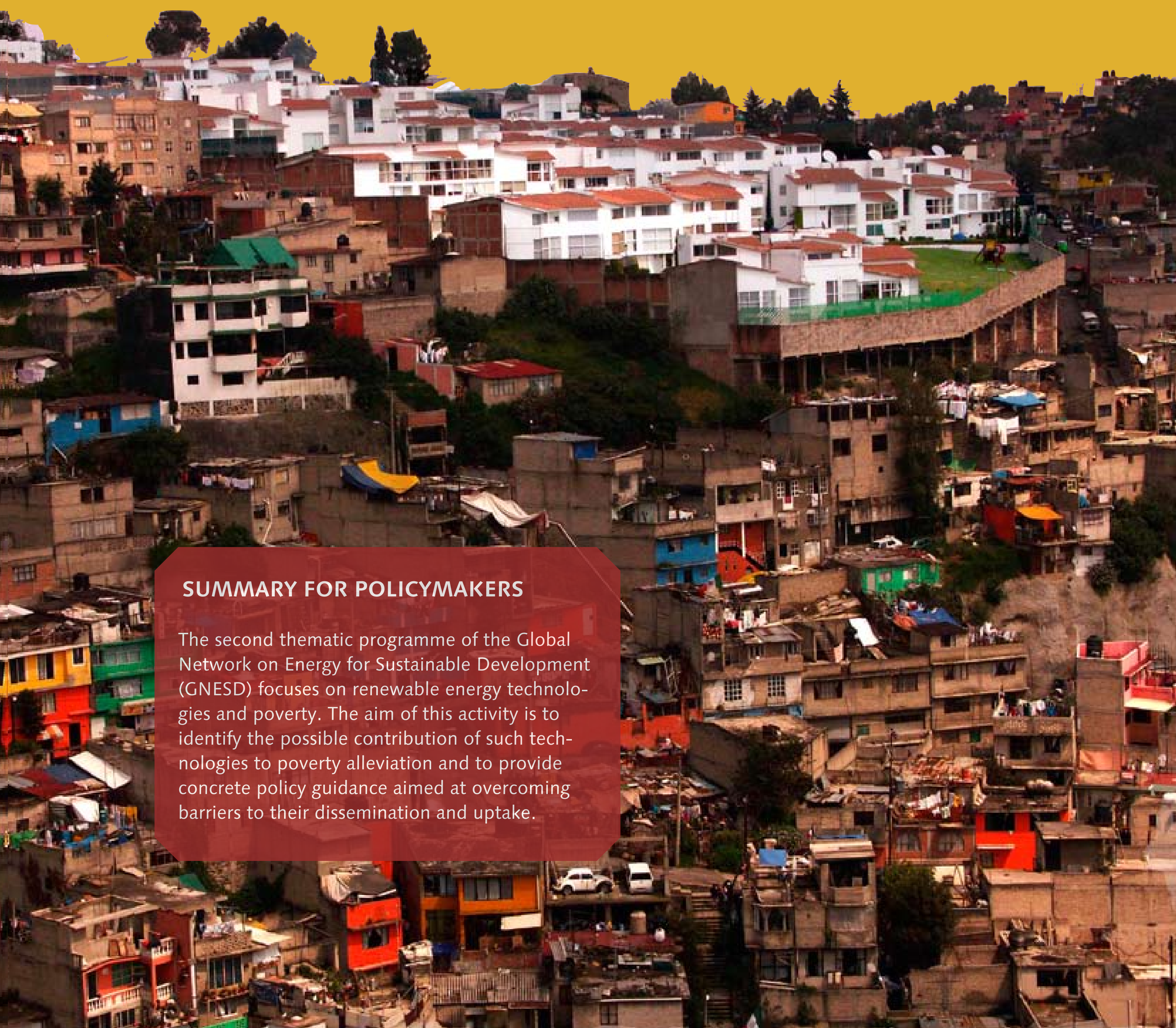
GNESD

GLOBAL NETWORK ON ENERGY FOR SUSTAINABLE DEVELOPMENT

Poverty Reduction

Can Renewable Energy make a real contribution?



SUMMARY FOR POLICYMAKERS

The second thematic programme of the Global Network on Energy for Sustainable Development (GNESD) focuses on renewable energy technologies and poverty. The aim of this activity is to identify the possible contribution of such technologies to poverty alleviation and to provide concrete policy guidance aimed at overcoming barriers to their dissemination and uptake.

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The Global Network on Energy for Sustainable Development (GNESD) is UNEP facilitated knowledge network of Centres of Excellence and Network Partners, renowned for their work on energy, development, and environment issues. The main objective of GNESD is to work for reaching the Millennium Development Goals (MDG) by:

- Strengthening the Members Centres' ability to acquire, assimilate, and apply existing knowledge and experiences.
- Working for a better understanding of the links between sustainable energy and other development and environment priorities, and technology and policy options, leading to better articulation of practical policies that can be adopted so as to promote and highlight the crucial role of energy for sustainable development.
- Working to provide research findings to the Governments to be considered in formulating their policies and programmes, and the private sector to attract investments in the energy sector, so that these favour energy sector growth for sustainable development, especially for the poor in the developing countries.
- Promoting a communication infrastructure that provides a means for Members to share experiences and draw on each other's strengths, expertise, and skills, and
- Strengthened South-South and North-South exchange of knowledge and collaboration on energy issues of common interest.

GNESD is one of several Type II partnerships in the field of Energy that were launched at the World Summit on Sustainable Development (WSSD) in Johannesburg, September, 2002

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Summary

The first phase of the GNESD study on Renewable Energy and Poverty is now completed and results focus on:

- Country specific and sub-regional assessments of current RE applications and impacts, plus an identification and prioritization of major barriers for RETs expansion
- Policy guidance to overcome the identified barriers
- Recommendations for future actions and strategies to increase the integration of RE in the national policy.

Results are being presented in detailed sub-regional reports; a comparative analysis and this summary for policy makers (see www.gnesd.org). Based on the results of this first phase the GNESD members are currently analyzing the major policy options identified for each sub-region with the aim of providing specific guidance on how to enhance implementation of RE technologies in areas where it is most appropriate at present.

The results show that in countries where there has been stable and long-term policy frameworks like for example in Brazil, China and South Africa significant progress has been achieved in selected areas like biofuels, mini hydro, domestic solar hot water and drying systems, small scale wind etc. While electricity producing technologies dominate, the importance on non-electrical RE technologies must not be underestimated in relation to affordable energy services to the poor. With biomass providing the cooking fuel for most poor households more efficient and clean stoves can have a major impact on fuel consumption and indoor air pollution.

In order to address the poverty issues it is important not only to focus on improving domestic energy services but also to focus on contributions to improving the productive uses of energy as a way of contributing to income generation. In order to improve agricultural productivity the use of wind or even treadle pumps for irrigation and solar devices for crop drying show significant potential esp. in the African studies and for South Asia.

In summary some of the general findings are:

- The role of RETs for poverty alleviation is generally found to be important in all countries studied, and contrasts with the low level of development and priority assigned to the area
- The role of RETs for poverty alleviation varies among countries, depending on resources, capacities, existing energy infrastructure and population distribution (urban/rural)
- Relevance of non-electrical technologies for satisfying priority household and productive energy requirements (cooking, water heating, heating, water pumping) is high in many countries
- In some of the countries (e.g. Brazil), large scale RE projects are an option for poverty alleviation through increased economic activity in rural areas and through adequate access to energy
- High potential for local job generation through system manufacture, O&M and renewable resource extraction and processing

In order to strengthen the application of RETs action should focus on:

- Need to develop political will, commitment and application of adequate policies and strategies supported by both the public and private sectors
- Policies should be formulated to fit each country and playing rules be sustained in time
- Overcoming the widespread high investment cost barrier relative to household income level by innovative and adapted financing schemes
- Using RETs as a tool for developing income generation activities as a key element for project sustainability
- RETs should become an integral part of development programmes (opposite to isolated and technology driven projects)
- Availability of adequate databases matching population distribution, energy requirements, income level and energy resources is generally lacking and would be very useful for planning.
- Coordination of activities and stakeholders is required to avoid wasting resources and efforts (adequate institutional cross-sector framework)
- Equipment manufacturing and O&M infrastructure are generally weak, though some capacity exists (variable among countries) and should be strengthened through cooperation
- R&D should be coordinated and focus on technologies that correspond to priority energy requirements and local capacities

The current second phase of the GNESD study is focusing on providing detailed analysis of key regional priority action options and developing concrete policy advise on how implementation can be successful. The results of this work will be available in second half of 2006 and will be presented and discussed at regional workshops in Africa, Asia and Latin America.

Background to the GNESD Study

Current patterns of energy production are polluting and unsustainable, and are characterised by inequity in consumption and access. Finding appropriate energy solutions that will fuel economic growth and increase social equity while protecting the environment is one of the major challenges facing humanity in this early part of the 21st century.

Energy is one of today's most serious issues. It is also one of the most complex. Satisfying the needs of hundreds of millions of people living in subsistence conditions has implications for international policy and economic relations as well as for the organisation of countries' economic structures, the problems of availability and depletion of non-renewable resources, better use of renewable sources, the development and large-scale application of new technologies, management of the environment, and many other factors.

The issue is particularly pressing for developing countries, since economic development—vital if millions are to be helped out of poverty—requires greater use of energy, while the equally vital sustainability of that development imposes a requirement for better use of energy.

Reconciling these demands will require creativity and innovation and will mean addressing the very nature of the development patterns of most developing countries. Unfortunately, where energy is concerned, most developing countries have 'inherited' the prevailing model in industrialised countries, based on centralised generating systems, distribution grids and conventional energy sources. That such models will often rapidly reach their limits in providing the poor with sustainable energy becomes evident when the problem is viewed 'bottom up' that is taking account of realities in the field. Many of the world's poor live in isolated, rural areas and have incomes that are not only low but are also unstable (e.g. farmers whose incomes fluctuate seasonally). For utility companies (especially those operating in privatised power sectors), the prospect of installing and maintaining costly transmission lines to serve such a market is not an attractive one and the plight of the poor is often overlooked in central energy planning. For many of the urban poor, connection to modern style energy grids can be prohibitively expensive, leaving them to fend for themselves without even the support of traditional rural resources, or to resort to theft.

It is here that renewable energy technologies (RETs) could play a significant role. RETs are, broadly speaking, energy sources that are site-specific and that satisfy energy demand directly. They also, generally, avoid the need for the long distribution chains that so rarely reach the most deprived. In many cases, RETs can rely on renewable sources that are locally available and use simple technologies, opening up a potential for manufacture of equipment and appliances by developing country industries.

GNESD and RETs

It is in this context that the GNESD has undertaken its second thematic programme in which nine participating Centres of Excellence have focused on RETs and the contribution they can make to alleviating poverty and improving living conditions.

Focusing on the potential of RETs to contribute to poverty alleviation widened the scope of study beyond a simple examination of access of the poor to household energy services. The resulting reports stress the importance of energy for income generating activities, and extend to the use of even the simplest technologies to spark a process of development. For instance, the East Africa study features non-electric technologies and considers the use of a simple, human-powered pump to provide water for irrigation. The resulting additional crop yields can generate sufficient income to cover the costs of an electric pump, leading to even greater efficiency, further income and a way out of the poverty trap.

The first serious efforts to introduce RETs began decades ago but, for a variety of reasons, most initiatives failed to provide the hoped for sustainable energy supply, particularly for those who need it most. In spite of large amounts of money, time and human resources devoted to the subject, and the many studies that clearly identify barriers and opportunities, advancement has been slow and the pattern one of repeated failure. This observation underlies a second major objective of the GNESD study: to provide concrete policy guidance to identify and profit from opportunities to overcome previously identified barriers to RETs and other subtle obstacles underlying those barriers.

In summary, the Centres adopted a common framework to address the following key issues:

- What is the role of RETs in poverty alleviation?
- What have been the main mistakes and successes in past approaches to renewable energy projects and disseminating strategies?
- What and where are the missing links and main barriers for dissemination and sustainable use of RETs?

Although the common approach assumes the identification of energy needs and services as a starting point, the potential role of RETs is strongly conditioned by factors which vary from region to region and country to country. There is, therefore, no *a priori* definition of that role in the process of sustainable development. Whether RETs are considered as a 'transition source' to facilitate access to energy or as a long-term sustainable solution depends on the reality and objectives identified in each case. In the light of this, each of the participating Centres of Excellence chose its own list of sources and technologies to be addressed.

The regional reports summaries presented below give a flavour of the diversity of situations encountered in the developing world and also demonstrate that there is an equally diverse set of possible responses, set against a background of a wealth of untapped potential renewable resources. Case studies are presented that show where RETs have been successfully employed. In the reports, further 'niches' are identified in which certain aspects of case studies can be extrapolated to regional or national level.

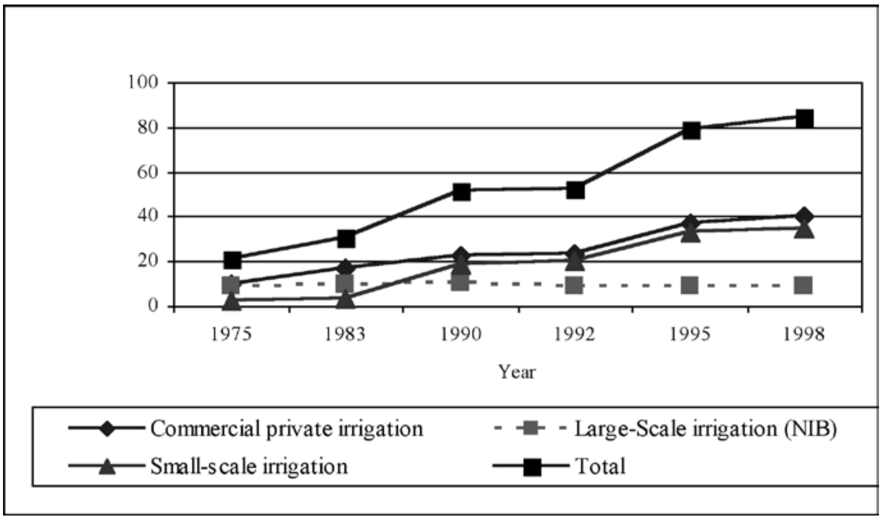
East Africa – a Study of Selected Non-Electrical RETs

The focus of this study is on the potential of selected non-electrical RETs to reduce poverty in the eastern African countries of Kenya and Tanzania. The technologies examined are wind pumps, treadle pumps and ram pumps used for irrigation and, to a lesser extent, for water supply.

These non-electric technologies are particularly relevant to the contribution of RETs to poverty reduction because the majority of the populations (around 70 per cent) of both countries are rural, poor and are severely lacking in modern forms of energy such as electricity. This is illustrated by Table 1, which provides a comparison with South Africa.

Agriculture is the dominant activity in the rural areas of Kenya and Tanzania and is a significant source of national income (25 per cent of gross domestic product [GDP] in Kenya, 50 per cent in Tanzania). However, in spite of the importance of the sector, the majority of the rural populations of both countries gain only low and intermittent incomes from their agricultural activities. Furthermore, the pressure of increasing population is forcing people to give up traditional, rain-fed, subsistence farming methods and to turn to irrigation technologies that supply water all the year round (as illustrated, for Kenya, by Figure 1). The trends shown in figure 1 are up to 1998 as reliable up-to-date data was not available, however, it is understood that the trends have continued in the same pattern with the commercial private and small scale irrigation continuing to grow at the same rate..

Figure 1: Trends in irrigation development in Kenya



Source: Balla, 2004

The high growth rate of small-scale irrigation development indicated by Figure 1 is partially attributable to a number of promising, small-scale irrigation technologies being promoted in rural areas, including, but not limited to, the treadle and wind pumps that are the subject of the case studies described below.

Status of energy and of RETs in rural areas in East Africa

The limited access of low-income households to modern energy means that the rural energy sector in East Africa is dominated by traditional (and inefficient) biomass, representing 65 per cent and 82 per cent of primary energy supply in Kenya and Tanzania respectively. Some modern biomass (in the form of bagasse and wood waste) is used in the sugar industry and in saw mills as fuel for cogeneration.

Both Kenya and Tanzania have considerable renewable energy potential (e.g. solar, wind and small-scale hydropower) but only a small proportion of this has been harnessed. Table 2 presents the status of dissemination of selected renewables in the two countries.

Table 1: *modern energy consumption per capita (kgoe) in East Africa/South Africa*

	1992	1993	1994	1995	1997	1998
South Africa	1 110.0	1 071.0	1 068.0	1 138.0	1 165.0	1 166.0
Kenya	88.4	86.7	88.9	88.8	86.5	84.0
Tanzania	24.0	22.0	21.0	21.0	20.0	20.0

Source: Karekezi et al (eds) 2002

Energy for irrigation

The use of small-scale, non-electrical RETs for irrigation could have considerable impact on the region's agricultural sector and therefore on the plight of the rural poor. For example, end-user experience shows that the treadle pump a simple technology operated by animate (human) energy—can transform the living conditions of some users. The economic life of a treadle pump is, on average, five crop seasons and, depending on the area irrigated, during that time a pump can generate sufficient additional income for a poor farmer to procure a more advanced motorised or electric pump which will, in turn, generate income.

Table 2: dissemination of renewable energy technologies in Kenya and Tanzania

	Tanzania	Kenya
Improved household stoves	54 000	3 136 739
Biogas units	1 000	1 100
Estimated PV units	n.a	200 000
Estimated PV installed capacity (kWp)	300	3 600
Wind pumps disseminated	58	360
Treadle pumps disseminated	>200	36 000

n.a - data not available
Sources: AFREPREN, 2004; Republic of Kenya, 2004; Balla, 2004; TaTEDO, 2004

The potential for wider use of wind pumping is also significant in Kenya and Tanzania, as both have average wind speeds in many regions above the minimum 3 metres per second required. This potential has not been fully exploited, mainly due to the high initial cost of pumps. The situation is similar for solar photovoltaic (PV) water pumps.

Case studies

Case studies are presented here for wind pumps in Kenya and Tanzania, for treadle pumps in Kenya and hydraulic rams in Tanzania.

Wind pumps in Kenya

Kenya currently has a total of 360 wind pumps in operation. They are, however, too costly for the majority of poor rural Kenyans and most of the pumps have been bought and installed under projects led by donors, churches and other institutions.

In areas where they have been installed, wind powered water pumps have helped to increase agricultural activity and improve water supply for remote rural populations. They have also contributed to industrial development by giving rise to a new manufacturing industry. In fact, manufacturing of wind pumps is a well-established industry in Kenya and most of the pumps on the market are made locally, with the bulk of the components sourced from local stores and workshops.

One of the most successful self-help groups in the utilisation of wind pumps has been the Gatongora Development Group (GDG) located in Ruiru which, in 1999, installed a wind pump bought with a loan from a micro-financing institution. Under the completed project, water is sold to the community with the proceeds being used to repay the loan.

Livelihood benefits have arisen from the installation of a wind pump in Mwiyoyo, in the western division of the Nyeri District. The water serves 200 homes and is used mainly for domestic purposes and watering livestock. Farmers have started kitchen gardens to enhance food security and a tree nursery has been developed. Also, importantly, some 200 women each now save an average of two hours a day that were previously used in the collection of water. The pump was installed with the financial support of the UNDP GEF Small Grants Programme

Wind pumps in Tanzania

Wind pumping is a mature technology in Tanzania where it is used for

community, livestock and irrigation purposes. According to the Ministry of Energy, there were around 200 pumps installed in 2004.
Working wind pumps in the Dodoma and Singida regions have contributed to increasing livestock numbers, availability of clean water for domestic purposes and hence healthier and more productive rural communities. The distance covered by women and children in Dodoma to fetch water has been reduced from an average of 3–8 km to less than one kilometre.

Local manufacturing capacity for wind pumps is low, however, and most of the pumps are imported and installed by expatriates or volunteers. Data show that local manufacturing capacity once existed and reports of successful installation and operation in the field in the 1970s indicate that a sustainable local industry could produce such technology in Tanzania.

Treadle pumps in Kenya
The simple principle behind the treadle pump has been used for centuries to lift small amounts of water from streams and wells. The concept has now been adapted for use in irrigation, with the most important innovation being to change the driving force from arms and hands to feet and legs, allowing much greater quantities of water to be lifted

Such small-scale irrigation systems using human power have been gaining popularity in Kenya since the 1990s. The country's potential for the use of treadle pumps is estimated at 360 000 units.

Box 1: impact of treadle pumps on the rural poor, an example
Not long ago Mr Moses Chumo and his family were living on his father-in law's farm trying to grow maize and using a bucket to irrigate less than 1/8th of an acre of kales from a local stream. The family was barely getting by until Mr Chuo saw the 'Super Moneymaker' pump being demonstrated at a local store. He saved US$75 to buy a pump which allowed him to grow almost 1 acre of kales and enough good quality grass to feed his cows. The increased milk production and income allowed him to buy more and better cows, a chaff cutter (for better feed) and an additional 7 acres of land. Mr Chumo now plants tomatoes, French beans, kales & fruits and will have space left to grow Napier grass for his 5 cows. He and his wife are now planning to send the first of their five children to a good secondary school.

As illustrated by Box 1, the impacts on farming practices can be substantial. They include:

- Increased land area under irrigation.
- Reduced work time compared with bucket irrigation.
- Full irrigation of fields resulting in improved crop quality.
- Reduced frequency of irrigation to two or three times a week.
- Less strenuous irrigation work compared to bucket irrigation.
- Additional crops grown each season.
- Increased numbers of growing cycles as crops are able to grow faster with full irrigation.
- Improved farm incomes.

Hydraulic rams in Tanzania
Hydraulic rams (also referred to as ram pumps or hydrams) are water-pumping devices that are powered by falling water. When such a head of water can be obtained, they can be used as a comparatively cheap, simple and reliable means of raising water to considerable heights.

In the Njombe and Mbeya rural districts rams are supplying water, to 1 300 and 1 500 inhabitants respectively. Most of the pumps are manufactured locally and have been in operation for more than 10 years. Rams can be used for irrigation, although they were not originally designed for this purpose and require significant investment in drive and delivery pipes to ensure the necessary high flows required.

Hydraulic rams in Tanzania are reported to have helped increase crop yields; improve animal husbandry; and supply water to villages, thus reducing walking distance for women and children collecting water. However, despite these potential benefits, the cost of hydraulic rams is well beyond the reach of most Tanzanians.

Barriers
Barriers have been identified to the uptake of the technologies described above with some, such as cost and inadequate local capacity for maintenance and spares, being common. The discussion below focuses on water pumping technologies, but the same issues are likely to apply to most non-electrical RETs.

Barriers to dissemination of wind pumps
The cost of investing in water pumping technology has been identified as a major limitation of wind pumps and thus a barrier to its scaling up. Pumps are currently too expensive for use by ordinary citizens for water supply and irrigation.

Lack of funds to develop wind-pumping technology has also been a major barrier, and the process of research, design and development of wind pumps often suffers from budget constraints. As a result, the pace of research and development of wind pumps has been too slow.

Where pump installation and maintenance are concerned, lack of qualified personnel and logistical problems have led to difficulties in many instances. In addition technicians and buyers are often unfamiliar with wind pump technology, and pumps in remote locations frequently break down because of a lack of servicing, spare parts, or trained manpower.

In areas of Kenya and Tanzania where wind regimes are reliable and where there is no feasible future of introducing grid electricity, lack of understanding of the possible role of wind pumps in supporting water supply and irrigation initiatives has led to them being considered as old and inappropriate technology by government and other developers. This has led to neglect of the sector and no motivation and support to help develop infrastructure for local manufacturing.

In some instances, short sighted projects that introduced inappropriate technology or did not allow for long-term maintenance and repair infrastructure have given the technology a bad reputation, resulting in policy makers forming a misguided opinion

Local adaptive research, development, and production of wind pumps once existed in Tanzania but lack of government support and failure to translate political will and interest into budgetary expenditure adversely affected sustainability of the initiative. The capacity to produce wind pumps in Tanzania is still available in some institutions. This could be rejuvenated to provide employment, increase economic activities and agriculture and improve health.

Participatory approaches are central to the success of community projects. When there is no sense of responsibility and ownership among the community sustainability of schemes is threatened and the likelihood of vandalism increased.

Barriers to wide scale dissemination of treadle pumps
Although treadle pumps cost less than other irrigation technologies, many people in rural areas still cannot afford them.

The potential for wider use of treadle pumps is still unexploited because of many factors, including:

- rampant poverty;
- limited policy attention to small scale irrigation systems;
- slow research and adaptation of technologies;
- lack of information and inadequate dissemination strategies;
- mechanical operational problems;
- lack of access to adequate and good quality water to run the pumps;
- limited knowledge of irrigation methodologies;
- inadequate land for potential users.

Barriers for uptake of ram pumps in Tanzania
There are two major barriers to the development of ram pumps, namely:

- their price—well above what most Tanzanians can afford;
- lack of availability of spare parts.

Policy outline for dissemination of wind and hydraulic pumps

Using wind and hydraulic pumps has proven effective in improving the living standards of communities. Availability of clean water and reductions in the distances covered and time spent by women fetching water have also had positive economic impacts. However, poor communities cannot install such systems unless support and credit incentives are facilitated. It is therefore recommended that affordability should be improved by efforts to facilitate friendly credit schemes and tax incentives. State efforts are also required on funding of R&D for wind pump designs to enable scaling up the use of wind energy resources.

Proper planning, feasibility studies, design, availability of spare parts, local maintenance capabilities and participation are central to sustainable operation of the pumps for their intended applications. It is therefore recommended that the government and other development players make efforts to develop relevant databases related to wind-powered water pumping and hydro rams.

Local capacity building and partnerships, and community involvement in project development, planning and implementation have proven to be effective for project sustainability.
It is therefore recommended that governments and other development stakeholders adopt participatory approaches when planning and implementing projects at local levels.

Policy outline for dissemination of treadle pumps

The treadle pump is a technology whose target end users are poor people. There is therefore a need for subsidies that will help roll out the technology while ensuring affordability. For example, incentives such as tax relief on raw materials should be provided to investors to manufacture and trade in the pumps as a way of making them affordable.
Uptake of treadle pumps has been encouraging in areas where there is public awareness of the technology and of the beneficial effects it can have on farming. This calls for action on the part of government and other interested stakeholders to reach those not yet aware and to provide mechanisms through which people will adopt treadle pumps. Mass marketing of the technology to the rural poor will also help create demand for the pumps.

Division of land resulting from population increase means that the future of irrigation lies with poor, small-scale (i.e. less than 2 acres) farmers striving to meet their needs from small plots. Governments and other stakeholders should realise this and encourage design of affordable and pro-poor technologies that are appropriate to the scale of farmers' operations and needs.

Cross cutting policy considerations

Lack of a coordination model poses a barrier to dissemination of treadle, wind and hydraulic ram pumps. These are technologies that straddle several sectors (e.g. water, agriculture, etc.), creating a gap in coordination. There is a need for a coordination model.

Past project failures pose a challenge to development and adoption. Identifying and documenting the reasons why the technologies have failed to meet poor people's needs in the past will help to overcome barriers.

Lack of capacity development in terms of training remains a barrier to sustainability of mechanical RETs. Development of university and college curricula has not addressed the need for personnel and artisans for such technologies at local level. There is a need to review training curricula to suit the needs of low-income groups and technologies. The role of informal technicians and artisans who have been innovative in the fabrication and maintenance of such technologies has also not been recognised.

Conclusions for East Africa

Non-electrical energy technologies have shown significant potential for water pumping and irrigation in East Africa. Recognising this potential and devising mechanisms to address the barriers mentioned above would assist in rejuvenating and developing these technologies and thus help to meet needs of the poor in rural areas of Kenya, Tanzania, and elsewhere. There is an urgent need to create an enabling environment for the uptake of these small-scale technologies. Combined political will and commitment towards local technological initiatives for productive uses, good policies and strategies backed by well-targeted public and private investment will ensure that poor people in rural areas have the right technology to meet their needs for water.

Renewable Energy Technologies for Poverty Alleviation, Initial Assessment: South Africa

South Africa is a developing country with a population of 44 million people. It is also a country in which first world and a third world economies exist side by side, reflected in a highly unequal income distribution. Poverty is one of the greatest burdens on the country, shaped by the apartheid system and the unequal business and industrial development which accompanied it.

Energy policy—previously characterised by energy security priorities, excessive secrecy and racially skewed provision of services—underwent a major shift after 1994 when the Reconstruction and Development Programme (RDP) placed a strong focus on energy for development. Policy now requires the country's energy resources to be used to meet needs of all South Africans and requires production and distribution to be sustainable and to lead to an improved standard of living. Ambitious RDP programmes saw electrification of 2.5 million additional households by 2000, bringing the country's level of electrification to 70 per cent. Renewable energy naturally became one of the areas that the government wished to consider in managing energy-related environmental impacts and diversifying energy supplies from the present coal-dominated system. In May 2004, a White Paper on Renewable Energy Policy announced a government commitment to provision by 2013 of 10 000 GWh of electricity from renewable resources (mainly biomass, wind, solar and small-scale hydro projects)—approximately 4 per cent of the country's estimated electricity demand.

Renewable energy resources

It would be technically feasible for South Africa to produce around 87 000 GWh from renewable sources, corresponding to about 49 per cent of its electricity consumption in 2001.

Hydro: There is some potential for the development of hydropower in South Africa. Small-hydro schemes (from 1 to 50 MW) are considered as renewable energy sources and eight such facilities are currently operating, with a combined capacity of 68 MW. There are also an estimated 3 500–5 000 potential sites for mini-hydro

Solar Photovoltaic (PV) systems: South Africa has very high levels of solar radiation, ranging from 4.5 to 6 kWh/m^2.

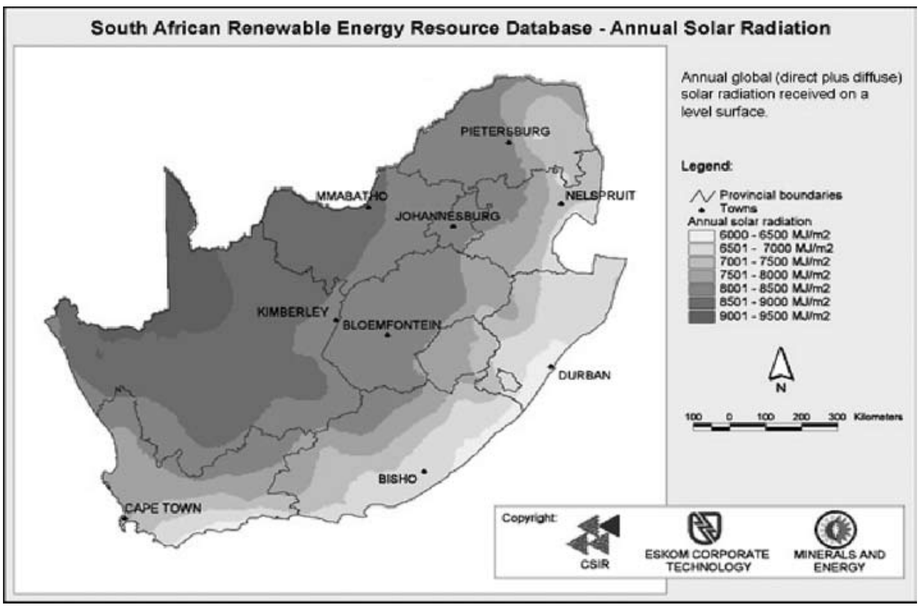
PV systems are already used in telecommunications networks, small-scale remote stand alone power supplies for domestic use, game farms and household and community water pumping schemes. PV is also used for off-grid rural electrification, with around 20, 400 solar home systems (SHS) installed to date on a concession (fee-for-service) basis.

Solar water heating: currently covers around 1.3 per cent of the solar energy market.

Wind: It is estimated that wind power could supply at least 1 per cent of South Africa's projected electricity requirements. Eskom, the national utility, is currently generating electricity from a wind farm to the north of Cape Town, with generating capacity of just over 3 MW. A national demonstration project is also underway which will eventually allow an independent power producer (IPP) to sell electricity to the city of Cape Town.

Biomass: South Africa's main sources of biomass are fuelwood (in the rural domestic sector), bagasse (in the sugar industry), and pulp and paper waste (used for industrial in-house

Figure 2: annual direct and diffuse solar radiation in South Africa



Source CSIR, 2002

Map 1: wind power potential in South Africa

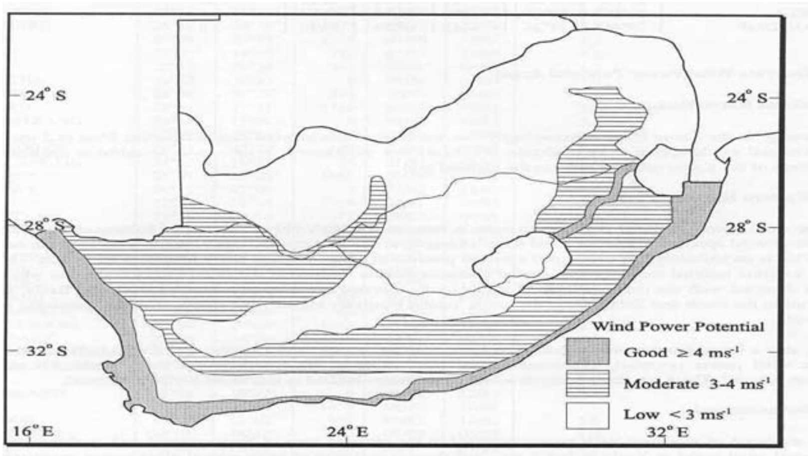


Table 3: Annual fuelwood and pulp energy potential

Type	Tonnage (T/Year)	Energy potential (GWh/ year)
Sawmills	1.57	7 639
Pulp mills	1 million	4 528

Source: Renewable Energy Technologies for Poverty Alleviation, Initial Assessment: South Africa

heat and electricity generation). Biomass accounts for close to 10 per cent of the country's net energy use.

Wood can be considered as a viable source for energy for generation of electricity if used within the wood, pulp and paper industries. Table 3 below gives the result of modelling of the wood and pulp industries energy potential based on availability and energy content of fuels.

There is also a considerable potential for raising energy from livestock manure and litter and from the combustion of other wastes.

Wave energy: the potential for wave energy along the Cape coastline is estimated as significant.

Case studies: biodiesel, solar water heating and fuelwood

Case studies were made of three renewable energy sources—biodiesel, solar water heaters (SWH) and fuelwood—selected on the basis of their contribution to poverty alleviation, their feasibility and level of government policy priority.

Biodiesel

At present, there are no fuel crops grown specifically for biodiesel production in South Africa, but oil crops such as soya and sunflower are already grown for animal and human consumption. It is estimated that South Africa could produce 1.4 billion litres of biodiesel without impacting negatively on food production, amounting to 20 per cent of the country's diesel production. However, considerable new capacity would have to be built to process, blend and market the fuel.

Biodiesel costs two to three times as much to produce as petroleum diesel and appropriate polices and regulations would be necessary for it to compete in the marketplace. Approaches adopted in other countries include:

- Taxation-based policies: typically policies that reduce fuel excise tax (already reduced by 30 per cent for biodiesel in South Africa in 2002).
- Agriculture-based policies: e.g. farming credits for using biomass on set-aside lands that are unavailable for food production.
- Fuel mandates: i.e. determining a minimum percentage of biofuels that motor fuels must contain.

The major contribution to poverty alleviation of a biodiesel programme would be job creation and economic development in disadvantaged rural areas, where it could energise remote communities and raise productivity. For the best case scenario, it is estimated that up to 300 000 jobs could be created, mainly in disadvantaged rural areas.

Solar water heaters

South Africa has a well established SWH industry but one which suffered a collapse from which it has never totally recovered. Ten times more SWH were sold in the 1970s and 1980s than at present. Collapse was partly due to the ending of an active nationwide marketing programme, the activities of 'fly-by-night' companies (leading to dissatisfied customers) and unsuitable design. To prevent this happening again the industry is forming an umbrella organisation. Manufacturing standards are set but they are not mandatory. It is also necessary to change the way solar water heating is viewed and raise the profile of the industry.

It is estimated that manufacturing, installing and servicing SWH could create around 6 000 jobs, adding over R175 million (around US$26.5 million) to the incomes of low-income households. However, as SWH will in some cases replace electric water heaters, some jobs may be lost in the electric-water-heater industry.

Different groups of people could benefit from expansion of the SWH industry. If all RDP houses were fitted with SWH, 6.5 million people would enjoy the comfort of running hot water at lower cost, helping to improve hygiene and health. High income households and commercial and institutional sectors are the principal targets for installation of SWH, because they are most likely to afford them.

Fuelwood
Even after extensive electrification, fuelwood is still the energy source most commonly used by the rural poor in South Africa, who often cannot afford appliances and monthly electricity bills.

Nationally, fuelwood is a very valuable resource with annual demand estimated to be worth R3 to 4 billion (US$450–600 million). Individual households using fuelwood as a major energy source consume about 1 to 4 tonnes per year.

If harvested sustainable, fuelwood is a renewable resource that will meet the energy needs of the rural poor for many decades, even though declining forest and woodland resources in some areas are making it harder for the poor women who gather the wood to meet their needs. Growing trees for sustainable fuelwood harvesting also has environmental and socio-cultural value and could create many jobs. The potential for carbon sequestration and international trading of carbon credits are additional potential benefits.

Analysis of barriers and problems

South Africa's 2004 White Paper on Renewable Energy is a major step towards promoting RETs. Identifying barriers to implementation is another important step to future progress. The following general barriers to the further implementation of renewable energy in South Africa have been identified:

- The capital cost of many RETs is considerably higher than that of conventional energy supplies.
- Implementation of RETs requires significant initial investment, and they may need long-term support before becoming profitable.
- Lack of consumer awareness of the benefits and opportunities of renewable energy.
- The economic and social system of energy services is based on centralised development around conventional sources of energy.
- There is a lack of non-discriminatory access for RETs to key energy infrastructure such as the national electricity grid.
- Market power of utilities.

Particular barriers are discussed below.

Barriers: biodiesel
Producing biodiesel is technically feasible. The major barrier is price competition with mineral diesel. Biodiesel needs substantial initial capital and support for at least ten years before reaching profitability. At present, the projected cost of biodiesel cannot compete with petroleum diesel at the pump. However with increasing crude oil prices and reducing production cost biodiesel will be able to compete in the future.

There is a potential for conflict with food crops for land and water resources. National food security and limited water resources have to be carefully assessed before large-scale oil crop plantations are started. If poverty alleviation is to be achieved emergent farmers and farmers in disadvantaged areas will have to be included in the programme as a priority, and the lack of infrastructure in disadvantaged areas addressed.

If biodiesel is to help the disadvantaged, starting capital will be needed to assist small-scale and community producers to set up biodiesel plants. If only commercial farmers are able to participate poor subsistence and emergent farmers will not benefit.

Barriers: solar water heaters
The initial installation cost of a SWH is high and affordable financing schemes are not available. Given that electricity tariffs are low, installation of a SWH is not perceived as being a worthwhile investment. Affordable financial and service loans could be developed for buying a SWH.

Information on and awareness of SWHs are lacking and their benefits and limitations are not therefore appreciated. Potential customers are also not sure about the reliability of SWH. Accreditation of manufacturers and installers to a professional association and the mark of approval by the Bureau of Standards would be a solution to this problem.

However, most poor people live in areas without piped water and could not therefore benefit from normal SWH systems even if installation were subsidised.

Barriers: fuelwood
One of the greatest barriers to sustainable fuelwood supply for the poor is an incorrect understanding of the problem. It is now understood that agricultural practices, land clearing and commercial fuelwood harvesting and not fuelwood collection for individual household needs are the major causes of deforestation.

It is not widely recognized that fuelwood resources are a major national asset. The role of trees in the rural economy and environment is not fully understood and insufficient recognition is given to the value of woodland and woodland products to rural communities. The emphasis on industrial forestry, which creates large-scale employment and export earnings, has marginalised the role of community forestry.

Building on indigenous knowledge systems in sustainable woodland management may be one of the useful strategies. A community approach and social forestry (SF) have been successful in rural communities. Facilities for training in SF need to be better developed.

Policy outlines

The main problems, opportunities, objectives and policy outlines for the three technologies discussed are summarised below. These are followed by a list of key recommendations for RETs in general.

Problems, opportunities, objectives and policy outlines for biodiesel

Problem: globally, there are political threats to the security of continuous oil supplies and, in the long-term, the problem of exhaustion.
Objectives: sustainably produced biodiesel that is competitive with petroleum diesel, gradually replacing it; greater security of supply.
Policy outlines: national production of biodiesel, increased security of supply and substitution.

Problem: development of new technologies is a long and capital-intensive process.
Objectives: capital investment fostering development of expertise in growing of appropriate crops and in processes allowing an industry to develop and biodiesel to compete with conventional diesel without the need for supporting incentives.
Policy outlines: facilitate the attraction of capital to biodiesel development; provide agricultural extension services to farmers growing oil crops; and provide support to oil plant research and technology transfer.

Problem: very high unemployment undermines policies aiming at greater equality, poverty reduction and development of disadvantaged rural areas.
Objectives: jobs created in rural areas and biodiesel plants become growth centres for economic empowerment of the poor leading to rural development.
Policy outlines: encourage training of farmers and other rural people to grow and process oil plants; encourage the establishment of feedlots for cattle raising; promote economic empowerment of the poor.

In addition to the above objectives intended to improve livelihoods, policies to encourage biodiesel could also help South Africa to reduce its greenhouse gas emissions— among the highest in the world on a per capita basis—and thus meet its commitments to the UN Framework Convention on Climate Change. This argument is also true for SWH, discussed below.

Problems, opportunities, objectives and policy outlines for solar water heaters

Problem: high upfront capital cost and the absence of affordable financing schemes discourage the installation of SWH.
Objectives: companies offer attractive financing schemes leading many households and the commercial sector to install SWH.
Policy outlines: facilitate attractive financing schemes; expand markets.

Problem: lack of awareness or negative image of SWH.
Objectives: convince people of benefits of SWH by information, education and quality assurance.
Policy outlines: support information programmes; foster research into benefits and limitations of SWH; implement quality assurance.

Problem: high unemployment rates limit socio-economic development.
Objective: creation of employment in manufacturing and installing SWH.
Policy outlines: encourage and support manufacture of SWH and training in manufacture, installation and maintenance.

Problem: the poor live in shacks and houses with insufficient service provision. Even if they have an electricity connection they cannot afford to use it for water heating.
Objective: installation of SWH in all housing projects for the poor.
Policy outlines: subsidise capital on SWH for the poor; facilitate access to SWH for people in social housing.

Problem: economic empowerment is still lacking in the country.
Objective: a high percentage of SWH companies owned by potential black entrepreneurs.
Policy outlines: facilitate training of black entrepreneurs in the social sector; support access of this group to financing.

Problems, opportunities, objectives and policy outlines for fuelwood

Problem: Increasing scarcity of fuelwood means poor women and children have to walk greater distances for collection.
Objective: implementation of a strategy to give the poor easy access to fuelwood.
Policy outlines: development of a fuelwood strategy; provision of affordable access to fuelwood for the poor.

Problem: the value of woodlands for the poor is not fully recognised. Fuelwood production is not economically viable.
Objectives: recognition of fuelwood as a major national resource and its marketing with other wood products; creation of jobs by involvement of communities in harvesting and marketing.
Policy outlines: recognise fuelwood as a major national resource; facilitate marketing of fuelwood with other products; involve and support communities in harvesting and marketing.

Problem: unsustainable harvesting and management of the resource has negative environmental impacts.
Objectives: communal management of the resource creates a sustainable supply of fuelwood; respect of rules on harvesting and access by the community and others; creation of employment.
Policy outlines: facilitate community management of the resource; generate a sustainable fuelwood supply; create employment in the sector;

Problem: women and children are exposed to indoor pollution when cooking leading to a number of diseases.
Objective: dissemination and acceptance of efficient, smokeless stoves that use less wood.
Policy outline: recognise that indoor pollution is a major health problem; promote dissemination of better stoves.

Problem: the poor do not have access to 87 per cent of the land, which is owned privately or by the state.
Objective: implementation of strategies giving the poor access to state-owned land to collect fuelwood.
Policy outlines: facilitate access to state-owned land for fuelwood collection; develop rules for access and collection.

Key recommendations

In the light of the barriers identified to implementation of a renewable energy strategy in South Africa, the following key recommendations are proposed:

- A reduction in the initial cost (or form of subsidy) of RETs is critical in order to make them more competitive with conventional technologies.
- The cost of conventional energy services should better reflect actual cost.
- Training and skills development in RETs for nationals should be promoted as a private-public initiative.
- R&D in RETs should be promoted in order to develop the local industrial market.
- RET projects should have a pro-poor focus.
- Legal and regulatory frameworks should be put in place to give equal access to independent power producers operating with RETs.
- More needs to be done to promote communication and awareness of renewable energy and RETs.
- Quality standards should be developed and implemented for RETs.

The Role of Renewable Energy in the Development of Productive Activities in Rural West Africa: the Case of Senegal

The countries of the West African Economic and Monetary Union (WAEMU)[1] are characterised by wide spread poverty and extremely low levels of access to modern energy services. West Africa remains the region with the lowest electricity consumption in the world.

Poverty is most widespread in rural areas and tends to affect women in particular, because it is they who fetch the water, grind cereal and collect wood with the aid of only crude implements. These are physically wearing and time consuming tasks that trap women in absolute poverty.

Wood, charcoal and agricultural waste account for 52–90 per cent of final energy consumption and 90–98 per cent of energy demand in the residential sector in countries such as Burkina Faso, Mali and Niger. Populations in big urban areas (primarily the capitals) find themselves in the same energy predicament as rural-dwellers. According to forecasts by the International Energy Agency in 2002, biomass energy will still account for 34 per cent of total energy demand and 75 per cent of energy demand from West Africa's residential sector in 2030

1 WAEMU countries are: Benin, Burkina Faso, Ivory Coast, Mali, Niger, Senegal and Togo

Renewable energy in West Africa

The situation described above persists in spite of the fact that, as illustrated by Table 4, WAEMU countries are relatively well endowed with natural resources and renewable energy potential.

Although efforts to date have not significantly increased energy supply to those in need, experiences with RETs in West Africa have highlighted the fact that suitable mature technologies are available; that their costs are gradually falling; and that such technologies could boost creation of employment and add value to national economies, thus helping to eradicate poverty.

Senegal's experience with wind pumps and solar PV, presented below illustrates practices that could be shared.

Table 4: renewable energy potential in WAEMU countries

Country	Solar (kWh/m²/d)	Wind (m/s)	Hydroelectricity (MW)
Benin	Na	na	238
Burkina	5.5	2-4	200
Ivory Coast	4–5	Na	1 650
Guinea Bissau	Na	Na	60
Mali	6	Na	1 050
Niger	6	2.5–5	273
Senegal	5.4	2.5–5	1 000
Togo	4.5	2–3	224

Source: The Role of Renewable Energy in the Development of Productive Activities in Rural West Africa: the Case of Senegal, ENDA Energie, 2005

Senegal: background

Around 48 % of Senegal's households can be classed as poor[2], with poverty being particularly severe in rural areas (around 65 % of individuals, 57.5 % of households, 2001-2002).

Agriculture is still the major economic activity of rural populations and the source or their income. Two types

2 Poverty here being defined as not having sufficient resources to consume 2 400 kcal per person per day or living on less than US$1 per day, according to the Poverty Reduction Strategy Paper, 2002.

of agriculture prevail: rain-based and flood agriculture.

In terms of productive use, RETs could be valuable in the following instances:

- Pre-harvest: water, PV solar and wind power could be useful for irrigation and drainage.
- Post-harvest: PV or wind based electricity generation systems offer opportunities for processing and preservation. Solar driers and mills have particular promise for wealth creation and for lightening the workload of women.

Other rural sectors that need small-scale mechanised units or systems (such as clothes-making, welding and poultry-rearing) could also benefit from access to more energy services.

Alongside wood gathering and cereal grinding, collecting water is one of the most important and hardest of chores for Africa's rural populations. It is usually performed by women and girls of school age who spend much of their time meeting this fundamental need, with the all too familiar consequences of inadequate school attendance (around 65 per cent of girls attend school against 74 per cent for boys) and the result that women are particularly hard hit by poverty. Other consequences include increased risk of water borne diseases and individual levels of water consumption that are below the amount recommended by the World Health Organisation (WHO).

Potential and penetration of renewable technologies in Senegal

Senegal has significant potential for biomass, solar and wind energy. To date, biomass resources have only been used by traditional methods. Solar potential is high with more than 3 000 hours of sunshine per year and average radiation (5.4 kWh/m2/day) that is more than adequate for the production of thermal and PV power. Wind patterns along the 700 kilometres of coastline are suitable for generation of electricity. Lower wind speeds in other parts of the country could be harnessed for water pumping.

Wind power and solar PV are considered in the Case Studies below because they are technologies that have reached maturity and offer significant scope for nurturing wealth-creating activities in rural areas.

Wind power

The first attempts to introduce wind power in Senegal, in the early 1980s, met with very mixed results. Of more than 200 wind pumping systems installed in 1983 and 1984 only 40 per cent were operating three years later and even these fell fairly quickly into disrepair. This served as an important lesson: future projects included maintenance. Successful projects are the subject of the Case Study presented below.

Case study—wind pumping and the 'VEV' programme

The deployment of RETs, especially wind pumps, could pave the way for wealth-creating activities for marginalised populations. Proving that this is so is the goal of the 'Vent Eau pour la Vie' (wind/water for life) programme which aims to serve as a best practice example of north-south technology transfer.

VEV is the extension of a wind pumping project launched in the 1980s by the Lay Volunteers International Association (LVIA). This sought, from the outset, to ensure that the technologies were owned and managed by the local population, by inculcating the knowledge and skills to handle maintenance and installation work. After 12 years, the association withdrew and Senegalese workers took over the project, forming VEV, an economic interest group. The windmills are now produced locally in VEV workshops using 95 per cent of Senegalese manufactured parts.

The prices charged for the water provided by the pumps are based on need—domestic users pay for the volumes they use while market gardeners or cattle farmers, for example, pay a lump sum. This allows advantageous rates for productive activities—in one village the cost of water for a 5m² plot land is now 60 times less than the rate charged by the Société Des Eaux water company.

Village committees are set up to oversee operation of the systems, with women responsible for selling water at the drinking fountains. One-third of the sums collected remunerate the manager, the other two-thirds being put into a repair fund.

Positive impacts observed from the project include development of off-season crops (market gardening) and development of a village woodlot generating income from sales of poles and firewood.

Solar PV

PV technology has been making inroads into Senegal since the 1980s, through the efforts of regional programmes and national programmes driven by bilateral co-operation.

Achievements include family photovoltaic systems, pump systems and photovoltaic power stations (mini-grid) aimed at providing services including lighting, communication (radio, TV, telephones, etc.), drainage, irrigation, refrigeration, etc.

Table 5 indicates the types of systems installed in Senegal. Further breakdown shows that the main use of SHS is for domestic lighting, followed by water pumping. Lighting improves the quality of life while pumping provides opportunities to develop income-generating activities such as market gardening.

When current projects—such as 'Isophoton', aiming to set up another 5 solar power stations, 5 desalination and 662 community systems, and the ATERSA project for 2 648 PV street lights—are concluded, Senegal will have 2.3 MW of installed PV power (by the end of 2005).

The PV market is expected to grow with the Rural Electrification Agency ASER programmes. The Decentralized Electrification option is offered a good framework to prosper especially with the adoption of the Local Initia-

Table 5: types of systems and installed power

Type of equipment	Power (kW_p)
S. Hybrid PV/aerogenerator	5
PV power station	265
PV pumping systems	328
Desalination systems	65
Research centres, health centres, tourist facilities, cold storage, school infrastructure, batter rechargers	77.26
Telecommunications	315
Solar home systems (SHS)	600
Total	1 655.26

Source: DAHOUENON, Mansour Assani. et al 2004

tives for Rural Electrification "ERIL" adopted by ASER.

Case study—PSAES: the German Senegalese Photovoltaic Project
After 10 years, the PSAES, launched in 1987, resulted in:

- The installation of two solar power stations providing benefit to 3 000 people—one in Diaoulé with a capacity of 28 kW the other in Ndiébel, with a capacity of 19 kW.
- Installation of six solar pumping systems (0.1–1.3 kW).
- Four mini solar power stations with capacities of 150–1 230 W, for health centres and village tourist camps.
- More than three thousand 50 W PV SHS.

Two major aspects of this project were: a socially-oriented pricing system, and operation and management by the community.

Pricing
Studies of villages that had had access to electricity supply for a number of years showed that too high subscription costs were barring many households from effectively gaining access. In Diaoulé and Ndiébel this barrier was addressed by adapting tariffs to the ability of different groups to pay. As illustrated by Table 6, three groups were identified.

Community organisation and management
The power stations are managed by village committees that deal with protection of the facilities, billing, requests for connection, system extension, elimination of fraud and payment collection. As a result, the access level is now 93 per cent in Diaoulé and 98 per cent in Ndiébel. All of the households connected use electricity for lighting and around 2.5 per cent also use it for productive purposes (e.g. selling ice and fresh drinks, engaging in crafts, etc.).

The project provided technical training in each of the participant villages in order to build capacities on a decentralised basis and embed a system of maintenance. A total of 30 technicians were trained. Over time, the training modules were transferred to the relevant training centres, thereby ensuring that the system is perpetuated.

Summary of impacts
Access to electricity in Diaoulé and Ndiébel helped to combat poverty by making possible:

- development of rural micro-enterprises (around 10);
- dissemination of 3 000 SHS for lighting and communications;
- development of local expertise and creation of jobs as well as transfer of expertise to training

Table 6: subscription costs

Group	Income source	Cost of access (euros)
Poor	Agriculture only	4.5
Middle	Agriculture & cash transfers/ payments in kind	9
Well-off	Trades and employees (teachers, nurses, etc.)	22

Source: The Role of Renewable Energy in the Development of Productive Activities in Rural West Africa: the Case of Senegal, ENDA Energie, 2005 centres to ensure continued transmission.

Barriers to RETS in Senegal

In spite of the maturity of some proven technologies, obstacles still impede the propagation of RETs in Senegal. These can be classified in two categories: market constraints, and political, institutional and regulatory constraints

A genuine market for RETs does not prosper yet in Senegal, for the following reasons:

- Funding mechanisms (RET promotion funds, credit lines, etc.) and measures for encouraging use of RETs are lacking.
- Low demand has prevented the emergence of a well-structured national supply to underpin development of the sector. Many operators have become disillusioned and have abandoned their activities because of the lack of an adequate market.
- Lack of communication between stakeholders hinders development of mutually-beneficial relationships and prevents synergies. There are, as already mentioned, a number of players involved with RETs each of whom has information relevant to a specific area. There is little evidence of a pressing information deficit, but the fact that data are highly compartmentalised, and that there are relatively few spontaneous exchanges, is a major institutional hurdle.
- Renewable energy is not competitive compared to conventional energy: initial investment costs far exceed most people's means.
- The banking sector and the micro-finance institutions in particular, are absent from discussions and seems almost entirely oblivious to RETs, restricting itself to providing financing for conventional consumption items, which are rarely available in rural areas. The banking system presents a number of barriers including: shortage of expertise for assessing RET projects, poor understanding of investment opportunities in the rural energy sector, and an exaggerated notion of the risk of renewable energy projects.

Therefore, this environment has not been suitable for the development of energy services delivery enterprises to meet the energy needs of the population at the local level.

Policy aspects

Where energy policy is concerned, African countries have tended to focus on supplying modern energy services and have restricted renewable energy initiatives to disparate, isolated or scattered projects. For the future, it would be fruitful to apply well-thought out policies rather than just implementing series of projects. Senegal's experience with RETs development has exposed some obstacles to penetration which in turn suggest possible policy, institutional and fiscal/financial measures.

In institutional terms, there is a real need for information pooling and a coherent institutional arrangement to facilitate this, in order to overcome the barrier of compartmentalisation of information already mentioned.

Senegal introduced fiscal and regulatory measures to stimulate use of RETs but these were rescinded when the WAEMU imposed a common external tariff as part of a sub-regional harmonisation of fiscal and regulatory measures. There is still a long way to go for regional market integration and for fiscal measures to encourage the establishment of RET infrastructure.

In terms of financing, studies indicate a very high elasticity of demand for RETs depending on payment methods of energy services and access to credit. There is a need for consumer credit schemes to fund the purchase of domestic RETs, meaning that opportunities are ripe for the banking sector to broaden the scope of its business activities.

Conclusion and recommendations

The wealth of experience with RETs in West Africa indicates that suitable technologies are available, that there is local management capacity, and that the socio-economic conditions for the dissemination of these technologies are relatively well understood. Over the past two decades, a number of projects have been executed in West Africa, demonstrating that it is possible to adapt RETs to the local environment. In this context, the following recommendations seem paramount for the future development and dissemination of RETs:

- **A coherent operational framework** must be provided. This means the creation of a mechanism with expertise in energy in charge of renewable energy and energy efficiency, to help focus more on non-electric solutions which, in spite of their importance, are not at the forefront of policy concerns at present.
- **Implementation of technical standards** and labelling of RETS for the West African subregion via the work of research institutes.
- **Creation of financing** opportunities and mechanisms (promotion funds, credit lines, etc.) for development of RETs. The AREED experience is to be capitalized as a successful initiavie.
- **Improved information and communication,** by organising exchanges at the national, subregional and local levels. Stakeholders in the development arena as well as consumers at all levels should be sensitised to the advantages of RETs in their various contexts.
- **Implementation of a multisectoral approach** to cultivate synergies between involved sectors and to mainstream renewable energy to the local development process.
- **Consolidation of the concept of Fee for Service** initiated through the PV experiences carried out in Senegal (Isopho-

ton project, Japanese project).

- **Definition of the technology option on a demand basis** instead of a supply approach, taking into consideration the poverty constraints (adopt a technology neutrality approach).

Renewable Energy Options in Improving the Life of Western Rural Population in China

Although China's economy is growing rapidly, it is still a developing country with a huge population of which a significant portion is still in poverty. Most of China's poor people live in the country's western provinces, in widely dispersed rural communities that have little infrastructure and low levels of access to modern energy services. At present, around 4.6 million households, mostly in remote areas that are far away from power grids do not have access to electricity. For the majority of them, it is estimated that access to electricity via extension of the grid will not be possible within the next 20 years.

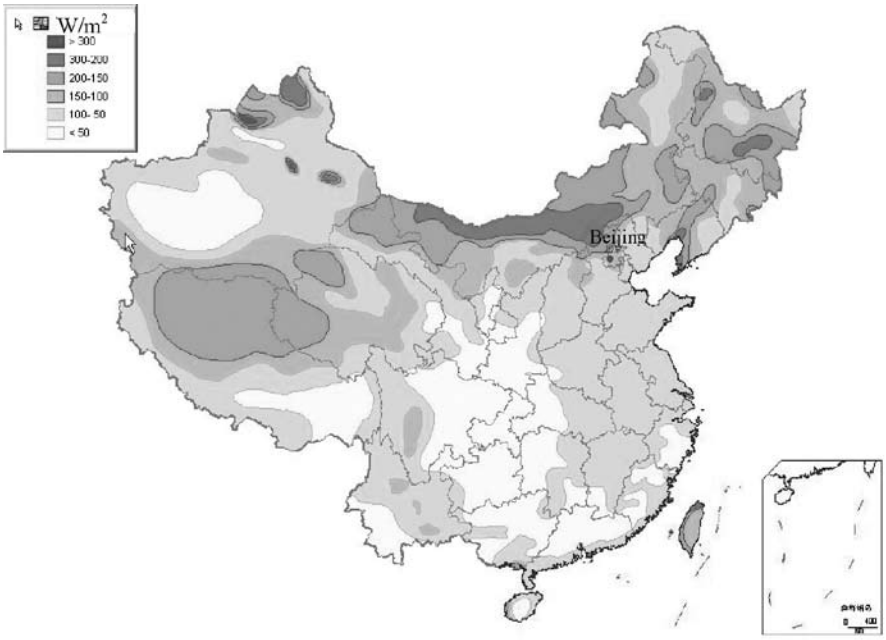
Energy deficiency limits these people's development and their heavy dependence on traditional biomass is accompanied by problems of ill health and environmental degradation. Finding a feasible way to address the energy problems of the poor in the western provinces is a crucial precondition for their development and for protection of the environment.

Renewable energy in China: previous activity and potential

China has considerable potential for development of renewable energy resources, especially wind, hydro, solar and biomass. Moreover, although the western provinces comprise China's poorest areas, they are also endowed with the country's richest renewable energy resources. Renewable energy has been the subject of considerable development activity in China since the 1980s, especially in the western provinces.

Initial efforts focused on small-scale hydropower then, in 2000, the government initiated the 'Brightness Programme' to promote micro-hydropower, small-scale wind power, small PV, and hybrids of these technologies to the 30 million members of the population who still had no access to electricity. This was followed by the National Township Electrification Programme (NTEP), started in year 2002. In 2003, the Chinese government set a new target of making all of society 'well-off' by 2020. Making better use of these renewable resources is seen as a way to reduce poverty to help to achieve this goal.

Figure 3: wind energy potential in China



Small hydropower

Latest estimates put China's exploitable small-scale hydropower resources at 120 GW, of which just over 30 GW were exploited by the end of 2003. As shown in Table 7, the greatest proportion of exploitable potential is in western China (although exploitation at present is low).

In addition to the abundant potential resources, overall, small-scale hydropower has a 50 year history of devel-

Table 7: China's small hydro resources

	Exploitable potential (GW)	Output potential (TWh/y)	Percentage
Western part	81.79	269.9	65.6
Middle part	22.34	73.72	17.9
Eastern part	20.49	67.61	16.5
Total	124.62	411.24	100

Source: Ministry of Water Resources.

Table 8: Solar energy resource distribution in China

Category	Area	Annual sunshine (Hours)	Annual radiation (kcal/cm2·y)
1	West Tibet, Southeast Xinjiang, West Qinghai, West Gansu	2800~3300	160~220
2	Southeast Tibet, South Xinjiang, East Qinhai, South Ningxia, Mid Gansu, Inner Mongolia, North Shanxi, Northwest hebei	3000~3200	140~160
3	North Xinjiang, Southeast Gansu, South Shanxi, North Shaanxi, Southeast Hebei, Henan, Jilin, Liaon-ing, Yuanan, South Guangdong, South Fujian, North Jiangsu, North Anhui	2200~3000	120~140
4	Hunan, Guangxi, Jiangxi, Zhejiang, Hubei, North Fu-jian, North Guangdong, South Jiangsu, South Anhui, Heilongjiang	1400~2200	100~120
5	Sichuan, Guizhou	1000~1400	80~100

Source: White Book of China New and Renewable Energy. 1999

opment in China and there is now a complete and mature industry.

Wind
China has total theoretical wind resources of 1000 GW: 250 GW onshore, 750 GW offshore. As can be seen from Figure 3, the richest wind resources are located along the eastern coast, the offshore islands and in the northern, north-eastern and north-western regions.

Many areas have abundant wind resources but little solar radiation in winter and experience the reverse situation in summer, suggesting the suitability of hybrid wind/PV systems. The 'Brightness Programme' includes the installation of around 4 000 such hybrid systems. However, despite the low operating costs for these systems, they remain too expensive for rural residents.

Solar energy
China also has a very large potential for solar energy, equivalent to around 170 billion tonnes of coal, with the highest levels in the western provinces and north-western regions. Table 8 shows the breakdown for such resources over the country.

For many people in remote areas solar PV is the only solution for access to electricity. In China, three types of PV systems are used for electrification of rural populations: small-scale, stand-alone generating units, PV household systems and PV water pump systems. Small-scale generating units can provide electricity for work, medical and educational activities and PV water pumps have great potential for irrigation and drinking water for people and livestock. However, cost is a major barrier to extension of PV systems and, at present, most home PV users depend on government subsidies.

Biomass
Biomass is satisfying most of rural China's energy demands, mainly in the traditional forms of agricultural wastes (including crop residues and animal wastes) and forestry residues.

High levels of consumption of fuelwood can pose a serious environmental problem when overfelling western provinces burned almost 230 million m^3 of fuelwood in 2001, far more than the 64 million m^3 quota set by China's State Council. To try to address this problem, a western rural energy plan has been formulated to encourage the use of small-scale hydropower, biogas, biomass gasification, etc.

Modern biomass technologies
China is carrying out research and organising demonstration projects into modern uses of biomass, such as production of biofuels from crops to replace petroleum based products

and bagasse and rice husk cogeneration. Such processes do not, however, extend to the poorer regions at present.

Crop stalks (and other agricultural wastes) can be used to produce combustible gas for cooking or for small-scale productive applications. Domestic gasification stoves used for cooking and even for some productive purposes (tobacco, tea) achieve levels of efficiency that are 5–7 times those of traditional stoves. There is a great potential for dissemination of such units in western rural areas. However, the relatively high unit cost is a major barrier.

Case studies

The following case studies serve to illustrate different aspects of China's efforts to develop RETs.

Biogas

The government has paid great attention to research and development of biogas since the late 1970s and the technology has advanced continuously. Biogas was chosen because it is possible to build digesters wherever conditions of temperature and humidity are suitable and because it is an environmentally comprehensive approach with the gas having multiple uses, digester sludge providing a fertiliser and the effluent providing a safe pesticide. Fisheries and livestock and rice farmers have all benefited from biogas which also helps farmers to develop business opportunities other than farming.

'Three-in-one' units (combining fruit plantation, biogas digester and pig farming) and 'Four-in-one' units (plantation, digester, livestock and solar energy greenhouse) have been widely distributed in southern and northern China respectively. Improvements will extend the scope of the technology to other areas.

By the end of 2002, more than 11 million households were using biogas to improve their income. It is expected that there will be 18 million home biogas digesters in rural areas by 2010.

Electrification: the National Township Electrification Programme

In 2001, there were still 1,061 townships in China without access to electricity, mostly in the western provinces. It was clear that grid extension would not be economically viable to provide electricity to these people. RETs therefore became an important technical option to generate electricity and provide services to the population.

In 2002, the National Development and Reform Commission (NDRC) initiated the National Township Electrification Programme to supply reliable and continuous power to these unelectrified townships. By the end of 2003, 601 PV power stations were operative and able to provide electricity; 26 small-scale hydropower stations were completed and another 135 under construction.

The NTEP is a 'leap frog' process, allowing poor people who cannot be connected to a grid to obtain power from the most advanced technologies in the world. In addition to brightening the lives of around 1 million people and stimulating local economies, the programme has helped to create a robust and sustainable RE infrastructure in rural China, particularly for PV.

However, some long-term problems remain. The most important of these is to establish ownership of the power stations, to allow collection of funds for maintenance. Service companies only cover the first three years of maintenance and system integrators are concerned only with design and installation. This is an urgent problem which reflects an omission in the programme design process.

Barriers

In spite of significant decreases in prices of RE equipment in recent decades, high cost and low affordability coupled with inadequate funds to help the poor, constitute the largest obstacles for wide use of RETS in the rural poor regions in China. Critical poverty and traditional lifestyle make this particularly relevant to people in western China. The poor have to depend on subsidies or obtain loans from credit companies if they are to buy systems

Institutional and policy aspects

Although China's central government has clearly paid attention to the development and use of renewable energy and poverty reduction in western China, as well as to the underlying relationship between the two issues, the existing polices favourable to RETs are too general, and lack concrete measures. Fortunately this situation was changed since China Renewable Energy Law had been approved and took effect from January 1st 2006. Concrete matching measures in favour of RETs and its application for poverty reduction, such as Special Renewable Energy Fund supporting RE application in rural area and R&D activities, are expected to be issued in line with the law soon.

Underdevelopment of industry and technology

As a result of its experience with RETs, China has capable personnel in the fields of SHP, solar water heater, biogas, and small wind turbines. Capabilities are still weak, however, with respect to more advanced technologies such as PV stations, PV pumps and biomass generation. Generally, the industries are not strong and market-support infrastructures for RE products are still underdeveloped. There are, nonetheless, encouraging signs with a few companies involved in the Brightness and NTEP programmes having developed basic competence and skills, and representing a good starting point for rapid development of industry in the future.

Isolation of the poor

China's poor generally live in closed and isolated regions where there are few opportunities for them to profit from productive activities and thus increase income. The great majority of un-electrified townships in China are located in very remote areas where road conditions are very poor. This is a significant practical difficulty for the provision of after-sales service.

In addition, consumers have often had few educational opportunities and therefore lack the knowledge and skills required to operate and maintain systems. System problems arising from users' lack of knowledge and experience are frequent.

Programme organisation
Although the designers and administrators of most national programmes pay enough attention to the construction process, follow up management, operation, daily maintenance and repair work are not well designed and carried out, resulting in inadequate technical services and support. This can result in the paradoxical situation of progress with RETs apparently being made but households being unable to actually benefit once projects are completed.

Conclusion and policy outlines

Experience in China has confirmed that the poverty which retards social and economic development and places a burden on the local environment is usually related to lack of access to basic modern and clean energy. Modern RETs have proved their ability to play an active role in addressing these issues and are expected to continue to do so. China's experience, borne out by that of other countries, has also shown that relevant support, especially from government, is essential to achieving this goal. To ensure that the outcomes of future actions foster the development and use of RETs, great efforts should be made to:

- **Decrease the cost, especially initial cost of RE system**
  There is a urgent need to strengthen the R&D on RE system, specifically tailored to diversified local conditions, and increase the capacity of domestic RE industry and research institutions, so as to lower the cost of RE system.

- **Promote sufficient as well as diversified financial support**
  In addition to the special RE Fund in line with the law, private and foreign involvement through mechanism innovation, e.g. CDM, could and should be encouraged to ensure sufficient and diversified financing sources.

- **Push forward formulating well designed implementation regulations for RE law**
  As a comprehensive law, the China's renewable law is quite general and its smooth implementation has to rely on detailed regulations. Currently, it is urgent to formulate these implementation regulations, setting out clear favourable policies, such as feed-in tariff. By doing this, it is possible to achieve the law's targets as soon and effective as possible.

- **Promote the RE industry, especially in poor rural area and increase local capacity.**
  Take advantage of the law, create RE market via mandated market share for RE, as well as offer favourable tax, credit instruments for industry fostering. Moreover, there is a need to strengthen the awareness and pattern of RE technology transfer to poor rural area

- **Create opportunities for productive and particularly business use of RET** to increase income of rural residents. This task involves providing direct support of business and enterprise development, raising awareness of the desirability of modern RE technologies among the poor.

Renewable Energy in South Asia for Improving Access to Energy (with Focus on India and Nepal)

At present, 80 per cent of the people lacking access to electricity in South Asia live in rural areas. However, the absence of employment in these areas is driving migrations towards urban areas, thus perpetuating and increasing urban poverty.

India

India faces such a predicament, with the lack of access to electricity in rural areas being a major factor in urban migration. Some 140 000 Indian villages (out of a total of 586 000) remain to be electrified and in many others that are officially electrified the quality of service is such that they have lost all semblance of true electrification.

Unelectrified communities continue to rely on fuelwood and crop residues for cooking and home heating—accounting for more than 80 per cent of supply.

Although electricity is not the only energy requirement of rural populations, it is very often the starting point for development. Electricity seeds the process of development by facilitating education and connection to the outside world and is also the most versatile form of energy for a variety of requirements.

Energy needs and requirements The energy demand assessment for rural poor of India was assessed categorising the country in various zones based on climatic conditions and further selecting two extreme conditions for energy demand assessments. One of the criterions for selection was also the economic development of the region. The energy requirements for normative energy, drinking water and agriculture were assessed for the regions. The typical energy requirement for rural unelectrified remote village of 100 households, as worked out by India's Ministry of Non-conventional Energy Sources (MNES) under Village Energy Security Programme, is summarised in Table 9. The estimate targets to meet entire need of cooking, lighting and productive energy.

The renewable energy based technological options to meet the demand are solar PV, biomass gasifiers and mini-micro hydro for which the technology is indigenously developed for medium to high levels.

Renewable energy potential

India has abundant renewable energy resources which have not yet been fully assessed or adequately tapped. A policy framework is in place to assess resources and develop the relevant technologies. Resources are summarised below.

Solar

It is estimated that if only 1 per cent of India's land area were to be used to harness solar energy and if this

Table 9: minimum energy requirements for villages in India

Category	Type of requirements	Energy requirements	Group	Impact	Priority
Residential	Electricity for lighting and other domestic requirements, particularly for entertainment	150 W/h	All	Improved living standard, educational status, fostering lighting-based income generating activities, etc.	High for lighting Medium for entertainment
Productive	Water pumping for crop irrigation	7.00 kW/village	Rural	Increased food production with increased income	High
	Small-scale industry	5.0 kW/village	All	Increased income	Very high
Social/Community services	Water for drinking	3.75 kW/village	All	Meeting the minimum requirement of livelihood, safety, social gathering	Very high
	Street lighting	0.5 kW/village	All		Medium
	Primary health centre	250 W	All		Very high

Source: Renewable Energy in South East Asia for Improving Access to Energy (with Focus on India and Nepal) were to be converted to electricity with an efficiency of just 2 per cent, 600,000 MW of power could be produced. This represents a solar PV generation potential of 20 MW/km².

Wind
Observations of wind resources indicate that India has a gross wind potential of around 45 200 MW if one per cent of the land were to be used to exploit the potential resource.

Biomass
By March 2004, 613 MW of power from biomass had been commissioned in India, from an overall potential of 19 500 MW, of which 3 500 MW would be from cogeneration plants fuelled by bagasse and 16 000 MW of grid quality power from surplus biomass. At present, there is no biomass 'atlas' for the country, but some states have taken the lead in surveying their biomass potential.

Hydropower
Around 4 200 sites with small hydro potential have been identified, with around 10 300 MW out of an overall potential of 15 000 MW being exploited.

Case studies The two case studies presented below are extracted from seven studies contained in the full *Renewable energy in South East Asia for Improving Access to Energy (with focus on India and Nepal)* report. The case studies in full covered various technological and financial schemes which succeeded for promotion for renewable technology for wide range of applications. The two case studies selected are because of their relevance to productive use of energy and, in the second case, discussion of the financing mechanism.

Case study 1—biomass gasifier for cardamom drying in North Eastern States
Over 150 cardamom growers in Sikkim have increased the value of their produce by using biomass gasifier technology for drying. Cardamom dried in this way conserves its natural colour, contains 35 per cent more oil and does not have the burned smell characteristic of the traditional method. It is therefore fetching higher prices (10–20 per cent) in the local trading centres. The technology also provides a healthier working atmosphere for the farmers and more efficient combustion of fuelwood, resulting in savings of 50–60 per cent. Low cost gasifiers like the one used here have potential for use in other niches, i.e. for other rural produce such as tobacco, ginger, cashew nuts, etc. The project is summarised in Table 10.

Table 11: data for Case Study 2

Category	Requirement	Energy requirement	Technology	% covered with RETs	Target population	Case study context
Productive	Irrigation	2 Hp	Solar PV	6 414 pumps installed by March 2004	Rural farmers with 2–4 ha land holding	Dry and arid zone

Source: Renewable energy in South East Asia for improving access to energy (with focus on India and Nepal)

Table 10: data for Case Study 1

Category	Requirement	Energy requirement	Technology	% covered with RETs	Target population	Case study context
Productive	Use of biomass for large cardamom drying	2–2.5 kg/kg of fresh cardamom (traditional) 0.8 kg/kg of fresh cardamom (with gasifier)	Biomass gasifier	58 MW installed under govt. funding schemes as of March 2004	Rural	Thermal applications for rural industries in humid zone

Source: Renewable Energy in South East Asia for Improving Access to Energy (with Focus on India and Nepal)

Case study 2—solar PV water pumping for agriculture in Punjab
A scheme for financing solar PV pumping systems was introduced by the MNES in Punjab (north-western India), a dry and arid zone with abundant solar resources and very poor irrigation.

The Punjab Energy Development Agency (PEDA) financed pumps able to deliver sufficient water to irrigate 1.5 to 2.3 hectares of land for most crops. The PEDA also helped to secure soft loans from the Indian Renewable Energy Development Agency (IREDA) and offered pumps under a lease-finance scheme. This scheme has been very successful and around 1 400 pumps have been installed. It is estimated that farmers save around US$800–1 000 per year in diesel costs.

Nepal

Nepal is a small country with over 85 per cent of its population living in rural areas, involved mainly in agriculture and meeting their energy requirements from traditional uses of biomass. About 38 per cent of the country's population live below the US$1/day poverty line. The country has around 625 000 low income households that are electrified and some 960 000 unelectrified poor households (of around 4 200 000 households nationally).

Energy needs and requirements
The main energy requirement of Nepal's residential sector is for cooking and lighting, met largely at present through traditional use of biomass.

In the productive sectors, water pumping for crop irrigation and small-scale income generating activities has been identified as critical requirements. Social and community service requirements identified include drinking water, street lighting and energy for public health purposes.

Renewable energy potential

Nepal's villages are mostly inaccessible and scattered and the country's diverse and rugged terrain impedes full grid extension to every household. However, Nepal does have significant renewable energy resources.

Hydropower
Nepal's hydroelectric potential is estimated at 83 GW, with 43 GW considered economically feasible. Sixty-three of the country's 75 districts have hydropower potential.

Solar
On average, Nepal has nearly 7 hours of sunshine per day with solar radiation levels that give the country a very large potential solar resource.

Wind
Although wind mapping has not yet been carried out, some places have been identified where wind power could be harnessed, making solar PV/ wind hybrid systems a good option.

Biomass
There is a high potential for penetration of biomass gasifier technology, as crop and forest residues are readily available in most parts of the country.

Barriers
The barriers discussed below are assumed to be relevant to market penetration of the entire range of RETs, from off-grid domestic to grid connected power generation. It is also assumed that their removal would enhance market penetration of RETs.

Policy and regulatory aspects
Lack of clear, long-term and consistent policy for introduction of RETs is the major barrier across all of South Asia. Until there is a strong renewable energy policy based on proper resource assessment and planning, initiatives will remain *ad-hoc* and will fail to become part of national mainstream energy planning.

Financing
The high initial cost of RETs is a barrier when incomes are low. Correctly targeted subsidies to address this are essential if RETs are to become affordable to potential users. The absence of innovative financing options such as micro-credit is a critical issue in the region in spite of some successful initiatives. Knowledge of other funding avenues (e.g. CDM and Prototype Carbon Fund) which could be accessed for RETs is also low.

Technology and related aspects
Lack of accurate information on availability of resources is a common barrier in most South Asian countries, as an absence of accurate resource data limits the possibilities for inclusion of RETs in planning processes and design of specific programmes.

Failure to develop products that are appropriate to local needs is limiting the use of renewable energy resources. R&D efforts to develop or adapt specific RETs in terms of local market requirements are therefore essential for successful renewable energy programmes. In most South Asian countries, there is also a shortage of trained people able to introduce innovations into product and system design.

Policy outlines

An overall assessment of RETs in India has led to identification of four major problems which are discussed below, together with some objectives and policy options to help alleviate them.

First, policies and programmes addressing individual RETs often lead to competition between RETs and limit harnessing of their potential. A national policy for assessment, exploration and use of renewable energy can facilitate selection of the most appropriate technology for a given project. Outlines of relevant policies to achieve this include:

- Assessment of long-term goals of relevant ministries and departments, and their integration into development of an overall vision for development of RETs.
- Similar investments and R&D efforts for all RETs, to bring them to maturity.
- Assessment and capacity building of all stakeholders.

Second, subsidies and incentives for promotion of RETs are unable to increase the competitiveness of RET markets. Public-private partnerships have found renewable energy to be a technically and financially attractive area of business, and work effectively. Policy outlines include:

- Reflection in markets of the actual price of fossil fuels, to make RETs more economically attractive.
- Introduction of performance based subsidies.
- Introduction of generation linked tax credits.
- Indigenisation of RETs, retaining social acceptance as a critical instrument.

A third problem is that current mechanisms for RET implementation are not helping to reduce poverty because they do not incorporate livelihood and income generating activities at the local level. Where successful, energisation of villages based on RETs projects has created job opportunities and improved the living standards of rural populations. Policy outlines to foster this include:

- Creating links between RE services and poverty alleviation and between rural development schemes and RET implementation programmes.
- Building of capacity of local people and NGOs.
- Participation of local populations in implementation of RE projects.
- Availability of upgraded technologies to local crafts people and industries.
- Creation of market supply network for local crafts/industry.
- Raising of awareness of the opportunities that electricity can provide to improve livelihoods.

The final problem identified is the lack of technically trained manpower and of relevant institutions and governance to prove that RET projects are sustainable. Capacity building at all levels can result in a viable and competitive environment for success of RETs. Relevant policy outlines here are:

- Empowerment of decision makers, from local villager users to national planners, who understand the wide range of issues that relate to efficient use of RETs.
- Training of trainers and other key people.
- Creation of a renewable energy resources database and atlas, to allow stakeholders to plan, prepare and implement renewable energy projects.
- Creation of organisations to facilitate market entry and enterprise development for RETs.
- Promotion of joint R&D by industry and research institutions and technology ventures.

Key findings and recommendations for the South Asia region

The countries of South East Asia have common requirements for the promotion of RETs, relating to energy security issues and to the provision of service to their large rural populations. Many local governments have made commitments to development of RETs and have implemented them with varying degrees of success. Consideration of the following key points could help to enhance the process of development in the future.

- There is a need for national renewable energy policies that integrate targets and the visions of various departments and institutions, as well as for an effective institutional mechanism based on public-partnerships to implement policy at all levels.
- There must be a focus on technology and product R&D that is in tune with local energy requirements and is compatible with the socio-economic characteristics of the target communities.
- There is a need to enhance national manpower for resource assessment, technology and product customising, planning as well as project development and implementation, etc.
- Efforts should be made to improve understanding of the technical and commercial aspects of RETs beyond the RET ‘community’, to foster an enabling environment for growth of the sector.

At present Thailand is heavily dependent on energy imports (55% of the net energy supply in 2003),, in spite of numerous government led actions and programmes to encourage energy savings and use of alternative energy sources. This dependence will increase if the alternatives are not further developed.

Energy in rural Thailand

In rural Thailand, where over 85 per cent of the country's poorer people live, traditional biomass is still the most commonly used fuel for cooking and other needs requiring heat, including productive uses[3].

The productive sector can be broken down into business and industry, with 'business' meaning restaurants or shops and 'industry' referring to production units for foodstuffs, handicrafts, workshops, etc.[4] As can be seen from Table 12, the activities consuming the most energy in the productive sector are cooking (almost 40 per cent in the business sector) and industry/handicrafts (around 52 per cent). The most commonly used fuels are charcoal, LPG and fuelwood, with greater use of wood and charcoal than LPG for industrial purposes.

In rural Thailand, energy related costs can be an important part of the total expenditure of a household or small-scale business or industry. The proportion of energy costs to total running costs for production units depends, of course, on the type of activity. It can be as high as 70 per cent for certain

Table 12: average yearly consumption of the productive sector in Thailand

Type of energy service	Residential + Business			Residential + Industry		
	Consumption (kgoe/hh)	Share (%)	Main fuels used	Consumption (kgoe/hh)	Share (%)	Main fuels used
Cooking	340.75	39.56	Charcoal LPG	409.05	25.49	Wood, Charcoal
Agriculture	236.22	27.43	Diesel Electricity	187.33	11.66	Diesel, Gasoline
Industry & handicraft	145.74	16.92	Electricity LPG	830.97	51.73	Wood, Electricity
Lighting, entertainment and convenience	129.30	15.01	Electricity Diesel	127.61	7.94	Electricity, Diesel
Others	9.32	1.08	NA	51.39	3.20	NA
Total	861.32	100		1 606.35	100	

Source: DEDE (2003c)

Table 13: prioritisation of energy use in the productive sector in rural Thailand

Type of energy service	Energy Consumption (kgoe/hh/yr)	Main fuel used	Cost (US$/hh/yr)	Group	Impact
Heat for thermal processes	796.58	Wood	191.4	Rural Small industry	Increases production, Increases quality, Increases income
Cooking	404.05	Wood	112	Rural	Increases production, Increases income
Field ploughing	145.7	Diesel	67.2	Rural	Increases production, Increases income
Water pumping for crop irrigation	33.1	Diesel	16.4	Rural	Increases production, Increases income
Cold Storage for production conservation	7.82	Electricity	6.9	Rural small industry	Preserves production, Increases income

Source: DEDE (2003a, 2003b, and 2003c)

3 The term 'productive use' refers broadly to uses that enhance opportunities to generate income and increase productivity

4 A particular feature of rural Thailand is that it is often difficult to distinguish between productive and residential uses, the same energy-using devices being employed for both professional and personal activities. Thus 'Residential and Business' and 'Residential and Industry' are defined.

agricultural activities that require large amounts of water or foodstuff production that require cold storage. More traditional small-scale activities, such as fruit drying, small pig farms or rainwater paddy cultivation use less energy. Any reduction of these costs can provide an additional income or create employment opportunities. On the other hand, traditional activities, such as fruit drying, small pig farms or rainwater paddy cultivation have limited energy expenses but their production is usually limited as well (both in terms of quantity and quality).

Table 13 summarises and prioritises the energy needs of Thailand's rural productive sector. It also indicates the 'impact' of energy on the activity, thereby indicating the potential for improvement from better energy services.

RETs: current status and potential in Thailand

By the end of 2002, the total RETs installed base in Thailand was around 560 MW, comprising 550 MW of biomass-based generation (mainly inefficient cogeneration systems) and 6 MW from solar energy. The remaining 4 MW were from wind, micro hydro and geothermal based technologies These RET installations covered 0.5 per cent of Thailand's total energy consumption in 2002.

However, despite the fairly high installed capacity,utilisation rate of RETs has not been alaways high in Thailand .In particular, large numbers of installed PV systems (water pumps, battery charging stations and solar home systems) failed because of general lack of involvement of the users in the government led programmes. Similarly, of the 59 micro-hydro projects with a total capacity of 2 MW implemented in 1979, only 23 remained in operation by 2003, with an installed capacity of around 600 kW. Furthermore, most of the biomass based power plants are low efficiency cogeneration systems in rice mills.

The potential for solar and biomass based energy in Thailand is presented below.

Solar

The annual average daily solar radiation in Thailand is about 5.0 to 5.3 kWh/m2-day corresponding to 18 to19 MJ/m2-day. The highest solar radiations are recorded in April and May with 20-24 MJ/m2-day. The overall potential for PV power generation has been estimated at more than 5,000 MW.

Biomass

Thailand's biomass resources can be classified in four main categories: agricultural wastes, wood and plantation waste, animal dung, garbage and wastewater. The recoverable energy potential for each of these in Thailand is shown in Table 14.

Table 14: energy potential from biomass in Thailand in 2000

Types	Biomass (kton)	Exploitable Biogas (Mm^3/year)	Recoverable Energy Potential (REP) (TJ/year)
Agricultural residue	42 494	-	604 821
Animal Dung	-	560	11 751
Municipal solid waste	7 324	1 184	112 047
Waste water	-	435	10 448
Feasible wood production from plantation	22 500	-	337 500
Total	72 318	2 179	1 076 567

Source: Limjeerajarus et al (2004)

More than 2.8 millions of litres per day of bio-ethanol could be produced from cassava and molasses. The total potential for biodiesel production in Thailand has not been reported. Promising sources of biodiesel include used vegetable oil, palm oil, coconut oil and physic nut oil.

Wind and small hydro

Wind resources in Thailand are promising along the coast but their potential is very low in the inland, with only 0.2 per cent of the land experiencing good wind conditions. The overall potential for power generation is estimated at 1,600 MW. There are also opportunities for village scale wind turbines pumps.
There is an estimated potential for small-hydro power generation of

700 MW, mainly in the north of the country.

Case studies

Solar Drying

Improved solar dryers can be used to dry different agricultural products: rubber, rice, chillies, bananas etc. Experience exists in Thailand in solar drying of rubber and bananas. Solar dryers improve the quality of the dried products, protect drying goods from dust and insects and reduce the drying period. The investment required for a solar dryer is high for farmers. For example, a 100 kg/batch banana dryer costs about US$ 4,900. This is high average monthly income per household in rural Thailand (US$ 222). However, due to the improved quality and higher quantity of the production, higher income can be earned by the producers. For example, solar dried bananas have a market price 75% higher than traditionally dried ones. The payback period of a solar banana dryer is between 2 and 5 years for banana dryers. In the Philippines, similar solar dryer are reported to have a payback period of between 1 and 2.5 years.

Charcoal from agricultural residue

Charcoal is a very important fuel in rural Thailand where it is, by far, the most used fuel for cooking. Traditionally, it is made from mangrove and rubber trees, with fresh wood often being used for the purpose. However, a demonstration project is now under way showing that good quality charcoal can be produced from burning of coconut shells under controlled conditions. The project is located next to a coconut factory, producing 1,080 tons of coconut shell per year. The payback period of the installation recycling coconut shells into charcoal, fertilizer, boxes and other by-products is of about 3 years. Thailand is a major producer of coconut and use of the waste shells could have the double advantage of reducing cutting of fresh wood and providing an alternative to disposal of the waste shells. So far, the project has achieved yields of around 20 per cent but other projects, in India and Sri Lanka, are indicating that yields of 30–40 per cent could be possible.

Biogas

This technology has considerable potential in Thailand given the large number of pig farms, cassava plants, palm oil factories and slaughter houses. The technology has been in use in the country since the 1980s and there is now a total volume of around 142,530 m^3 of digesters installed. There are about 7.8 million head of pigs in Thailand's pig farms, generating some 880 million kg of dry dung per year, from which around 2,800 terrajoules of energy could be recovered. One farm, in the north of the country, is mixing the biogas from its digester with diesel oil to fuel five motors that power the farm's fans and generate electrical power. Use of the biogas has reduced diesel consumption by 62 per cent. The installation cost US$ 30,900 and the pay back period, considering a government subsidy of 23%, is of less than 4 years. This period is decreasing with the increase of the diesel price in Thailand.

There are also two large-scale, pilot plants in Thailand transforming solid biomass into producer gas (a mixture of carbon monoxide, hydrogen and methane) that can be used either for heat or mechanical power. The fuel at one plant, completed in 2003, is rice husks; the other, still under construction, will be powered by parawood wastes and oil shells.

Biofuels

Thailand already has the technology to produce both biodiesel and bioethanol. It is currently producing 30,000 litres/day of biodiesel and 640,000 litres/day of bioethanol. There are currently six licensed ethanol operators. Fourteen others are in the process of being licensed. These twenty producers could cumulate a total production of 4.19 million litres/day by 2011.

However, if biofuels are to be accepted economically they will have to be cheaper than conventional fossil fuels. In the case of biodiesel, competition with the food manufacturing industry for the limited supply of raw materials (used vegetable oil, palm oil and coconut oil), and high production costs mean that the biofuel cannot be sold below conventional diesel prices if it is not heavily subsidised. Biodiesel is currently more expensive than diesel and cannot, therefore, compete with the conventional energy source

Other renewables

Wind resources in Thailand are promising along the coast but are very low inland, with only 0.2 per cent of the land experiencing good wind conditions. There are opportunities for smaller wind turbines and pumps able to operate at lower wind speeds. These technologies are delivering around 0.4 MW of power in Thailand at present.

There is an estimated potential for small-hydro power generation of 700 MW, mainly in the north of the country. Of 59 projects with a total capacity of 2 MW implemented in 1979 only 23 remained in operation by 2003, with an installed capacity of around 600 kW.

Programmes to promote RETs

To reduce its dependence on imported fossil fuels and promote sustainable development, Thailand's government has undertaken various initiatives to promote energy savings and RETs. Some of the key initiatives are summarised below:

- From the beginning of the 1980s, the government launched specific programmes to promote RETs. For example, dissemination programmes were introduced for PV and PV pumping stations, resulting in more than 3,000 units installed free of charge. The same approach was adopted in 2004 to electrify the remaining off-grid households (about 300,000) with solar home systems.In the late 1980s, the Energy Policy and Panning Office (EPPO) started a programme to subsidise biogas digesters for pig farms.
- In 1992, the government passed the Energy Conservation and Promotion (ENCON) Act and two years later launched the ENCON Programme to promote energy

saving and develop use of renewable energy source.

- In 1996, the National Energy Policy Office (NEPO) initiated a 'Divided by 2' campaign to raise awareness of efficient and effective use of energy.
- In 2002, the Department of Alternative Energy Development and Efficiency (DEDE) was created, a body dedicated to RETs within the Ministry of Energy. 2002 also saw adoption of a policy allowing small RETs power producers(up to 1 MW) to sell their excess electricity to the grid.

The government has set a target of raising the RET's share in the country's energy mix from 0.5 per cent in 2002 to 8 per cent in 2011. As part of this strategic plan, a policy called Renewable Portfolio Standard (RPS) obliging each retail seller of electricity to include 5 per cent of electricity from renewable energy resources in its resource portfolio is under discussion. A policy defining feed in tariffs for RETs is also currently being discussed.

Table 15: energy use in rural Thailand and potential RETs

Category	Type of energy service	Renewable technologies	Competing non-renewable
Residential	Cooking	Biomass and Biogas Solar cooker	LPG, Grid
	Lighting, Entertainment and Convenience	Solar PV Micro hydro Wind Geothermal Biodiesel Bioethanol	Grid, diesel, kerosene
	Transportation	Biodiesel Bioethanol	Diesel, gasoline, CNG
Industrial	Heat for drying units, bakeries, etc.	Solar dryer Biomass Biogas Geothermal	Grid, LPG, Kerosene
	Water pumping for crop irrigation	Solar PV Biodiesel Biogas Biomass gasification Wind	Grid, diesel, gasoline
	Field ploughing	Biofuel	Diesel, gasoline
Social/Community Services	Refrigeration for vaccine conservation	Solar PV	Grid, Kerosene, LPG

Source: The Role of Renewable Energy for Productive Uses in Rural Thailand

Matching Thailand's energy needs with RETs

Renewable energy technologies are a viable alternative to satisfy Thailand's energy needs for both domestic and productive uses, providing viable alternatives to conventional sources of energy and playing a major role in alleviating poverty in a sustainable manner. New income generating activities are more likely to develop if modern and reliable sources of energy are available. RETs can bring modern forms of energy (e.g. electricity) to remote areas that are unlikely to be linked to national grids in the near future.

Table 15 shows the main current energy uses in rural Thailand and matches them with renewable technologies that could be used to provide the energy.

Barriers to RETs

Despite government efforts to promote RETs over the past 20 years, barriers still remain. These can be categorised as follows:

- **Financial barriers:** in Thailand, as elsewhere, the capital cost of RETs is high compared with fossil fuel technologies. In addition, pricing policies are not favourable to RETs and access to credit for small entrepreneurs in rural areas is considered difficult
- **Information barriers:** there is a serious lack of awareness of RETs which hinders their development. In particular, there is a lack of success stories with RETs, no information campaign about RETs exist for the general public and agricultural residue producers are unaware of the energy potential of their production
- **Technical barriers:**. many RETs

suffer from a lack of research and development activities and technology transfer that could lead to development of products suited to local needs. For example, many components of PV systems are imported and spare parts are not readily available. Locally developed technology, such as biogas digesters are not mature yet
- **Institutional barriers:** in particular, a lack of coordination between the different organisations involved with RETs, especially biomass based. In addition, non-specialists of RETs are still in charge of PV projects within the government

Other barriers include: the government's focus over the past two decades on diffusion of PV systems even though other promising options are available and more urgently needed (for heat production in particular). Finally, the top-down approach used to promote PV technologies acted as a barrier for proper utilisation and maintenance of RETs.

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Policy outlines

Barriers to RETs promotion could be overcome by appropriate policies. The main policy outlines identified can be summarised as follows:

- Reflecting the real costs of conventional sources in retail price.
- Promoting RETs for creation of income generating activities and reducing energy expenditures in the long run.
- Making RETs imports financially more attractive.
- Facilitating access to credit for RETs in rural areas
- Providing financial incentives for:
    - RETs users,
    - RETs electricity producers,
    - RETs manufacturers,
    - RETs spare parts producers and suppliers.
    - Using existing information structures to further inform general public, politicians and financial institutions about RETs
- Promoting national and international networks of experts for knowledge sharing and technology transfer.
- Increasing R&D activities to make RETs (including low cost) appropriate to the local conditions (in terms of size, capacity and type of application)

Encourage implementing agencies to:

- assess local resources and needs before implementation;
- include users in the design process;
- train users and local maintenance and repair staff in a language they can understand.
- Linking the residue producers to the potential users (for biomass based RETs)

Argentina: Initial Assessment and Policy Outlines

Some decades ago Argentina's situation was unique in Latin America in terms of income distribution and basic development indicators, but this situation has changed in recent years. The country, which used to have a relatively even income distribution, has seen increasing social inequality and a growing income gap between higher and lower socioeconomic classes.

After the crisis and currency deflation of 2001, the numbers of both poor and indigent people and of unemployed or underemployed rose abruptly. Currently, more than 90 per cent of the population live in urban areas (settlements of more than 2 000 inhabitants) and more than 40 per cent are considered poor. It is also a particular feature of Argentina that, unlike most other Latin American countries, poverty is largely an urban issue.

Where energy is concerned, Argentina has one of the highest electrification rates in Latin America, but it is currently experiencing a slowdown due to saturation and the privatisation of formerly public power enterprises. Use of large scale hydropower has declined in recent years and both large-scale hydro and nuclear developments are at a standstill. At present the country is moving away from a diversified energy mix towards higher dependency on natural gas and fossil fuels supplied by private enterprises, with a resulting vulnerability and risk of shortages.

As a result of these processes, a large portion of the population, both in urban and rural areas, suffers from a deficit in energy supply for basic household requirements, essential services, and productive activities. It is estimated that, in 2001, around 20 million poor people in Argentina were not consuming the energy needed to cover their minimum requirements.

Renewable energy technologies in Argentina: background and assessment of resources

Argentina has a history of activities related to RETs and a number of public and private stakeholders are involved in R&D, manufacture, distribution, etc. However, a survey of past actions indicates that they were initiated several decades ago under an energy self-sufficiency and diversification strategy and that the actual impact of RETs on national primary energy supply has been low.

Argentina has diverse renewable energy sources (hydro, geothermal, biomass, wind, solar, etc.). Information on their potential and use has, however, been scattered, unsystematic and partially lacking. The analyses presented below—resulting from a comprehensive data gathering exercise—are intended to contribute to making such data more systematic.

Table 16: wind energy potential in Patagonia

Power density 0.09 MW/km² f_c > 20	Power (MW)	Energy (GWh/yr)	Capacity factor
Chubut	85	238	32
Neuquén	15	34	25
Río Negro	26	63	27
Santa Cruz	40	109	31
Tierra del Fuego	0	0	
Patagonia	167	445	

Power density 4 MW/km² f_c > 20	Power (MW)	Energy (GWh/yr)	Capacity factor
Chubut	3,786	10,589	32
Neuquén	685	1,523	25
Río Negro	1,177	2,793	27
Santa Cruz	1,781	4,864	31
Tierra del Fuego	0	0	
Patagonia	7,429	19,769	

Source: Argentina: Initial Assessment and Policy Outlines

Wind
There is good information on wind resources in Patagonia, allowing identification of high-potential areas suitable for wind farm installation. Overall, the resource is significant from the points of view of both coverage and quality. Table 16 shows a gross estimate of wind energy potential for generation in the provinces of Patagonia, based on data aggregated at county level. Two extreme values for the power density are presented because of the large uncertainty in determining this parameter.

Potential from wind energy in Patagonia represented between 0.6 per cent and 25 per cent of national electricity demand in year 2000. In order to tap this potential it would be necessary to link the Patagonian grid with the national grid. Civil engineering works for this purpose began in 2004. Furthermore, local large turbine technology development is undergoing, and official announcements include 380MW of new wind power capacity before year 2010.

However, high investment cost still places wind energy at a disadvantage in meeting a large proportion of the energy needs of low-income households.

Solar
Estimates from available information indicate that Argentina's potential generation of electricity from solar energy is lower than that of wind. On the other hand, the available resources for caloric uses are quite significant, and the appropriate technologies are more accessible, meaning that there is an interesting potential here.

Solar water heaters represent an interesting niche, due to the applicability to urban and periurban areas where most of the poor population inhabits, and to the accumulated experience in the development and adaptation of this technology.

Hydro
Hydro resources in Argentina have been estimated, approximately, for large and medium volume rivers but local information is lacking and the potential for small-scale hydro energy is ignored in this estimation. Small hydro stations may nevertheless represent an attractive solution to cities or settlements located close to them. A more thorough market analysis would give some indication of the magnitude of energy needs that could be met using small-scale hydro options.

There exists local manufacturing capacity and wide experience with this technology.

Biomass
Annual availability of renewable energy from biomass is estimated at 6.6 million toe, equivalent to 10 per cent of the country's national primary energy supply in 2002.

Seventy-five per cent of the available biomass energy is from livestock manure. If this were used to produce biogas it could meet around 10 per cent of the non-electric energy demand of the residential sector (based on demand for year 2000). There is also an estimated annual sustainable extractable potential of wood from native forests of around 27 million tonnes, equivalent to 5.4 million toe/year. This is eight times the current rate of extraction.

Analyses to date indicate that firewood (if extracted in a sustainable manner) and livestock manure converted into biogas are the renewable biomass resources with the highest potential to meet the energy needs of the poor.

Table 17: renewable energies resources, annual production and potential in Argentina (2002)

Province	Wood ton	Other wood ton	Bagasse ton	Agricultural Residues ton	Agroindustrial Residues ton	Animal Manure ton	Solar kWh/m2.day inc.=latitude	Wind m/sec annual average	Small Hydro MW (projects) Small, mini and micro	Geothermal Number of geothermal zones by province
Buenos Aires	162,844	47,930		9,706,286	395,343	4,512,014	4.0 - 5.0	3-5		3
Catamarca	44,237	55		93,197	1,278	80,561	4.5 - 5.5	1-3	6.13	1
Córdoba	31,650	9,316		10,040,348	256,714	1,801,969	4.5 - 5.0	2-4	7.95	1
Corrientes	386,544	113,562	514	138,989	67,586	981,611	4.5 - 5.5	2-4		2
Chaco	1,319,177	57,507		1,689,703	180,473	589,534	4.5 - 5.5	2-4		
Chubut	46,285	6,713				229,603	3.5 - 4.5	6-9	15.99	
Entre Ríos	214,564	60,942		2,692,159	116,610	1,020,436	4.5 - 5.0	2-4		7
Formosa	26,420	11,417		83,369	8,826	406,430	5.0 - 5.5	2-4		
Jujuy	32,126	3,238	1,002,694	131,306	380	56,414	4.5 - 5.5	2-3		2
La Pampa	44,954	7,939		707,046	121,160	986,071	4.5 - 5.5	2-5	2.25	1
La Rioja	15,556	5		3,996	599	87,616	4.5 - 5.5	2-3	30.17	
Mendoza	21,193	3,817				135,854	4.5 - 5.5	1-3	41.52	1
Misiones	450,753	159,518	15,120	6,081	98	152,360	4.0 - 5.0	1-2	0.04	1
Neuquen	21,164	2,602				85,859	4.5 - 5.0	3-8	35.25	2
Río Negro	22,892	5,453				226,803	4.5 - 5.0	3-8	22.59	
Salta	44,303	29,954	328,479	571,286	10,750	166,572	4.0 - 5.0	1-3		2
San Juan	473	0				18,309	5.0 - 6.0	2-3	24.10	1
San Luis	104,690	975		245,060	10,050	415,082	4.5 - 5.5	3-4		
Santa Cruz	3,346	13				119,250	3.0 - 4.0	4->10	10.58	
Santa Fe	33,936	7,722	73,908	7,899,576	156,057	1,740,759	4.5 - 5.5	2-4		
Santiago del Estero	413,994	2,115		1,332,817	65,159	372,564	4.5 - 5.0	2-4	1.06	1
Tierra del Fuego	814	4,136				31,989	4.0 - 5.0	1-3	53.60	1
Tucumán	24,688	1,439	3,034,285	759,018	5,840	35,368	2.5 - 3.5	4-5	9.44	
Total Country	**3,466,603**	**536,367**	**4,455,000**	**36,100,236**	**1,396,922**	**14,253,026**			**260.66**	**26**

Source: Argentina: Initial Assessment and Policy Outlines

Table 18: case studies

Case Study	Population	Zone	Uses	Renewable technologies
1	Urban with EE	Temperate and warm	Residential, workshop and other productive activities	Solar water heater, biomass stove
2	Rural dispersed	Warm and temperate	Residential, cattle raising, agriculture	biomass stove, biogas, PV, solar drier
3	Rural dispersed	Temperate	Residential, cattle raising, agriculture, workshop	Biogas, wind pump, wind turbine, biomass stove
4	Rural dispersed	Arid	Residential, cattle raising, agriculture, workshop	Wind turbine, solar water heater, solar stove, wind pump, biomass stove
5	Rural community	Warm	Residential, community services, workshop	Biogas, minihydro, solar drier, biomass stove
6	Rural community	Temperate	Residential, community services, workshop	Biogas, wind turbine, wind pump
7	Rural community	Cold/Arid	Residential, cattle raising, workshop	Wind turbine, biomass stove, wind pump

Source: Argentina: Initial Assessment and Policy Outlines

Biodiesel
Although development of biodiesel is in its early stages in Argentina, the technology associated with its production has been much promoted as it is linked to an important economic group in Argentina, the agricultural latifundium sector, and on account of its potential to replace diesel. The potentially attractive market has driven development in a relatively-short period and the fuel is now in the process of standardisation for use in diesel engines. There is also local development of prototype plants.

Summarising RETs in Argentina

Renewable energies have a significant potential to meet key needs of settlements in Argentina that will probably lack access to conventional energy supply in the short and medium terms. In this context, it is worth noting that an assessment of energy requirements for the different climatic zones[5] indicates that caloric uses of energy (cooking, water heating, heating) make up 69 per cent of the country's minimum poor household requirements. This indicates the importance of orienting policies towards energisation and not only electrification of households.

5 For this analysis, Argentina was divided into four bioclimatic zones: warm, temperate; arid and cold.

The study of energy requirements indicates that the supply of electricity from the public service to meet the basic and minimum power and electricity requirements of the poor and indigenous population would demand a significant effort, although it would not be unachievable since in terms of electricity demand it represents only 10% of the national consumption and 26% of the installed power in 2001. Overall, net energy consumption from these sectors would represent less than 8% of the total for Argentina in year 2001.

It is clear that renewable energies can contribute significantly to the satisfaction of the energy needs of poor population sectors and bring down the impact on the Public Electricity Service, but conventional energies still seem to have an important role to play in the short and mid term, particularly in urban and peri-urban areas where access to conventional grids would be the most rational solution.

This study also confirmed the lack of detailed and reliable information on renewable energies resources that could be used for planning at local level. A related problem is the lack of detailed information describing the spatial distribution of the poor population and their energy needs. A local level mapping of this distribution jointly with energy resources would constitute an extremely useful planning tool.

The estimated potentials for the different renewable energy sources are summarised in Table 17.

Ultimately, analysis of RETs and of their respective capacities has identified mini hydro, wind chargers, wind pumps, efficient biomass cookers, solar water heaters, solar cookers and ovens, solar driers, photovoltaic systems, and biogas digesters as the most appropriate to meet the energy requirements of the poor and indigent sectors of Argentina's population in the short term.

Case Studies

Seven case studies, classified in Table 18, were prepared from analysis of: energy requirements within the different socioeconomic sectors; renewable resources available in each region of the country; capacities; and renewable technologies with a degree of commercial development.

The case studies are presented in full in the *Argentina: Initial Assessment and Policy Outlines* report.

For the purposes of this summary, the following considerations, emerging from the case studies, are of particular interest:

- Use of firewood in efficient cookers to yield caloric energy in most of the country has a key and hard to replace role. Adequate management of the resource is a significant issue.
- Many renewable energy generating systems (with the exception of mini hydro stations) have difficulty in meeting 100 per cent of electricity requirements and are very costly, especially for isolated rural dwellers and for production purposes.
- Biogas shows wide versatility as an energy carrier able to satisfy multiple requirements.
- Mini hydro stations play a significant part in satisfying productive uses in isolated areas.
- Complementary use of several technologies is necessary to meet multiple uses.
- Grouped rural consumers have a comparative advantage over scattered rural consumers in terms of system cost per household and quality and range of services
- In urban areas, some RETs (solar water heaters and efficient firewood cookers) form an important complement to conventional fuels allowing fuel expenditure to be reduced.
- Research, development, and fine tuning needs are significant for small and medium power electricity generation and motive power systems that are based on biomass (firewood, waste, biogas) and are at adequate cost (in areas with abundant biomass but lacking adequate wind or hydro resources).

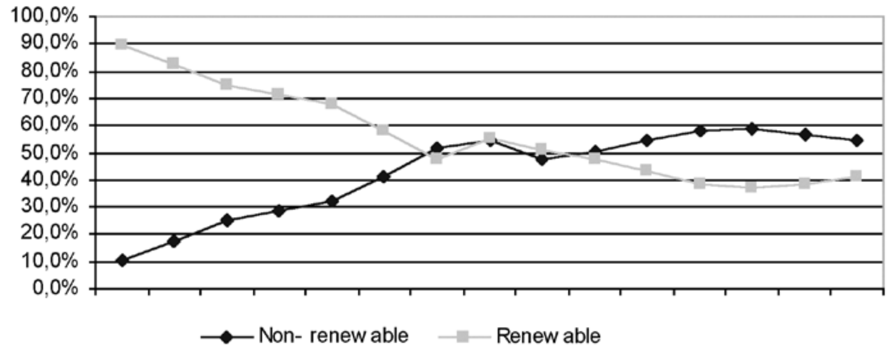
Identification of problems and key findings

In the past, Argentina has demonstrated great potential for the development of highly complex technologies. The development of its nuclear industry is an example, where a clear political decision sustained and coordinated the necessary resources for development at national level. Lack of such a clear national policy, planning and strategy for renewable energies is one of the principal causes of their slow development and dissemination, and the root of many of the problems defining the current situation of RETs in Argentina. The following recommendations focus on the most important issues:

- An adequate institutional framework should be developed to help coordinate the activities of stakeholders and design of policies to integrate renewable energies into the national development strategy.
- Coherence and stability should be brought to the legal and regulatory framework, making it supportive of RETs and eliminating bias against them.
- Alternative financing mechanisms and incentives should be established, recognising the non-economic benefits of RETs. Rules should be stable over time, to guarantee the effectiveness of instruments.
- Instruments for risk and uncertainty management in renewable energies projects should be developed.
- Knowledge of renewable energy resources should be improved to identify areas with highest potential.
- R&D should be supported for RETS, aimed at local industrial production and equipment cost reduction.
- Quality standards should be developed to ensure compliance.
- Support should be given to projects oriented towards income generation for poor and middle-income populations.
- An adequate operation and maintenance structure should be developed.
- Stakeholder capacity should be developed relating to the diverse issues connected with renewable energies (policies, incentives, financing, project design and management, installation, use, etc.).

Renewable Energy Technologies to Improve Energy Access in Brazil

Figure 4: domestic energy supply in Brazil, 1945–2003 (renewable and non-renewable sources)



Source: MME, 2004.

Twenty million people in Brazil still lack access to electricity, one-third of the rural population. In Brazil, as in other countries, grid expansion into remote areas with low population densities has come up against the limits of long transmission lines, lower average purchasing power (and hence a lower density of connections together with smaller loads), meaning that conventional energy utilities must operate such grid-based supply at a loss. Without obligations to implement rural electrification, private distribution companies lack incentives to improve supply to low-income consumers and to sustain existing off-grid projects.

Table 19: Brazilian Energy Matrix, 2003 (based on domestic energy supply)

Non-renewable Energies	**56.2%**
Oil and derivates	40.2%
Mineral coal and derivates	6.5%
Natural gas	7.7%
Uranium and Others	1.6 %
Renewable Energies	**43.8%**
Hydro and Electricity	14.6%
Firewood and Charcoal	12.9%
Sugar cane products	13.4%
Others (basically, solar and wind)	2.9%

Source: MME, 2004

Brazil's current energy situation is the result of a move that began in the 1940s away from traditional biomass sources to use of hydropower and oil, keeping pace with a growing and increasingly urban population. This is illustrated by Figure 4. The 1970s saw a drive for energy independence that included increased domestic oil production and an Alcohol Programme (launched in 1975 and guaranteeing that all gasoline sold in Brazil would be blended with ethanol).

Today, Brazil's power sector is characterised by its division into two large systems: the interlinked system (grid) and the isolated system. Ninety per cent of the electricity carried by the interlinked system, covering most of the country's states, is generated in hydropower plants. The isolated system includes small local grids, mainly in the Northern Amazon region. Many poor communities in these isolated regions are far from the distribution grid and rely on diesel to produce electricity. Renewable firewood and forest wastes are estimated to provide for up to 80 % of domestic firewood consumption. Residential (52,3%) and industrial (34,2%) sectors are the most important consumers of primary wood. In Industry this high proportion of usage is mainly because of the important role of charcoal as a fuel and feedstock for pig iron manufacturing. Up to 20 % of the wood used in industry is estimated to be renewably produced.

Inspite of significant progress, renewable energy can improve energy access in remote/rural areas by, for instance, providing energy from locally available biomass resources (at low or zero cost) or from PV and similar systems that do not consume fuel.

Renewable energy resources in Brazil

As shown in Table 19, renewable energy sources are still contributing significantly to Brazil's approximate 99 500 MW of installed capacity.

Large-scale hydropower (which may or may not be considered as renewable) is the country's dominant energy source. Newer renewable energies such as wind and solar are still making only a small contribution to electricity generation. However, expanding the use of new RETs, that is, diversifying the energy matrix is one of the best policy options to reduce greenhouse gases emissions and provide local resources to remote communities, guaranteeing the necessary energy supply with much lower environmental impacts than transporting energy produced in distant places.

Biomass

Biomass, in the form of wood products, is one of the oldest and most widely used (and unsustainable) sources of energy in Brazil. Although traditional, informal uses of biomass, such as firewood for heating and cooking had become less significant, being replaced by LPG, wood consumption for residential uses is tending to rise again in poorer areas.

In industry, large-scale applications could greatly increase the importance of biomass with use, for example, in the sugar and alcohol sector. The most common technologies used for biomass conversion in Brazil are steam-based cogeneration systems in operation in sugar cane (bagasse) and pulp and paper mills (wood residues and black liquor).

Brazil's intense solar radiation and plentiful rainfall favour biomass cultivation. Furthermore, large tracts of sparsely populated territory and high unemployment create good conditions for the development of an ambitious programme.

Agricultural and wood residues

Use of bagasse has already been mentioned, but Brazil also produces high volumes of other agricultural residues. Although only a small proportion of this is used at present, there is a potential for around 13 600 MW of power from agricultural and wood residues in Brazil.

Vegetable oils

Vegetable oils could replace some of the diesel currently powering around 1 000 power plants supplying electricity to isolated cities and villages in the Amazon. More than 670 of these units have less than 500 kW capacity. They are, generally, old and inefficient, and emit high levels of pollutants

The main types of vegetable oils extracted in Brazil are palm oil (*Elaeis guineensis*), macauba (*Acronomia aculeata*) and buriti (*Mauritia flexuosa*), with corresponding annual production of 71 000 tonnes, 25 000 tonnes and 35 million tonnes, respectively. There is widespread potential for small communities to extract oil from locally available nuts or other vegetable sources like mamona and soy.

Although selling of oils to the food industry is often more profitable than their use for fuels, use for generating of electricity is sometimes an option. For example, in isolated communities without access to grid energy and where the sale of the oil is not an option because it is difficult to bring to market.

Gasification

A 20 kW gasification system has been installed in a village in the Amazon State with the aim of testing and adapting gasification technology to provide sustainable electricity to isolated communities (see Case Studies).

Biogas

Brazil generates over 20 million tonnes of municipal solid waste (MSW) annually, which could produce 50 million MWh of energy per year. The two principal means of extracting useable energy from MSW are anaerobic decomposition for the generation of combustible gases, and the direct combustion of the waste material. Box 2 gives an example of use of biogas to produce energy.

These processes, however, require large investments and can only be carried out in the context of integrated waste management programmes. In many municipalities, the challenge of adequate treatment of MSW stalls at the first step, collection

Brazil also has large pork, poultry and dairy industries generating considerable amounts of concentrated animal waste with a potential for methane generation through anaerobic digestion. There is, however, a general lack of information in the country regarding energy generation from animal waste and such technology has not been introduced into the industry in any significant way.

Small hydro plants

Several estimates have been made of Brazil's remaining hydropower potential according to type of power plant: micro (below 100 kW), mini (between 100 and 999 kW) and small (between 1 and 30 MW). Estimates put the potential for small hydro plants at between 7 and 14 GW.

Incentives for building small hydroplants (SHP) have been in place for some years resulting in an additional capacity of around 1 000 MW between 1995 and 2002. Twenty-two of Brazil's states (out of 27) have plants in operation, under construction or authorised. The primary role of SHPs built in past decades has been the electrification of isolated areas.

Given Brazil's high hydroelectric potential, the SHP market is attractive to foreign entrepreneurs and it is also important to note that the BNDES (national bank for social development) has adopted a new and more favourable position regarding support for implementation of SHPs in the country.

Solar PV

Although solar PV technology has been under development in Brazil for almost two decades, it has only recently been recognised as a potential option to improve the quality of life of those living far from urban centres. Used originally in the telecommunications sector and by the military, PV is now being used to generate electricity for basic needs such as lighting, water

Box 2: energy from landfilled waste in São Paulo, Brazil

In 2003, a thermoelectric power plant was inaugurated in the Bandeirantes landfill, in the city of São Paulo. The Bandeirantes landfill is one of the largest in the world in its category and has the largest plant fueled with biogas in Brazil. The gas, generated from the solid waste, is collected from the landfill via a 50 km pipe network before being pumped to the motors of 24 generators. The surplus gas is flared.

Bandeirantes produces 12 000 m3/h of biogas with a minimum methane content of 50 per cent, 24h/day, 365 days/year. This is enough for an installed capacity of 20 MW, which will produce up to 170 000 MWh of electricity—enough energy to supply a city of 400 000 inhabitants for 10 years.

pumping, refrigerators, etc. in remote areas.

Government programmes, electricity utilities, private enterprises and some NGOs are paving the road, and dissemination of PV technology is taking off in Brazil. Major initiatives are in progress and around 15 MW are already installed.

Dissemination is being backed by the PRODEEM programme, developed by the Ministry of Mining Mines and Energy (MME), which is becoming the core of the country's PV dissemination effort. Designed to address residential, commercial and productive uses of electricity, the programme's focus is now on productive applications. 4 MW have already been installed under PRODEEM, and the bidding process for a further 2 MW is now closed.

Decentralised connection of PV systems to the grid has also developed in the past few years. However, the main practical applications of the technology have been in remote systems supplying off-grid power.

Wind

Current data indicate that Brazil's wind energy potential is around 143 000 MW, of which some 7 695 MW have already been authorised. Figures from the MME (for 2003) indicate that the plants in operation at present have a generating capacity of 22 MW, of which more than 20 MW from medium to high capacity wind turbines feed into the grid. This technology is currently made available in Brazil by international manufacturers.

Almost 65 per cent of the installed wind capacity is located in the state of Ceará. The best wind potentials are concentrated on the coastline of the north-eastern region and, to a lesser extent, along Brazil's south and south-eastern coastlines. Some very good sites located far from the coast have been reported in the states of Minas Gerais and Paraná.

Selected case studies, Brazil

Two case studies with a focus on the benefits of using locally available resources are summarised below.

Biomass gasification in Amazon region

A 20 kW gasification system was installed in Aquidabam Village in the Amazon State. The aim of the project was to test and adapt small-scale, biomass fixed bed gasification technology, imported from the Indian Institute of Science, to provide sustainable electrical energy to isolated communities in the Amazon region, and thus offer an alternative to the current fossil fuel (diesel).

Aquidabam was chosen because it presented the basic conditions for implementing the system: available biomass, experience with diesel engines, easy access and, most of all, great interest and involvement of the 700 members of the community. One of the agricultural products produced by the community is Cupuaçu (an Amazonian fruit), which is sold *in natura*, with a very low added value, due to the lack of electricity that would allow the frozen pulp to be kept.

Tests of the gasification system with eucalyptus chips, cupuaçu and babaçu were satisfactory and the aim is now for the gasifier to work eight hours per day to replace 75 per cent of the diesel. The electricity will be used to improve the process at the cupuaçu pulp factory.

Use of in natura vegetable oils in modified engines in the Amazon region

In the isolated community of Vila Soledade, Pará State, a conventional diesel engine has been modified to operate with *in natura* vegetable oil to generate electricity, in order to test the use of vegetable oil for energy production in field conditions. The demonstration unit, a new generator set manufactured in Brazil and adapted with a conversion kit, operates 6 hours/day on the distribution grid, providing 3.3 MWh a month.
A major social benefit brought about by the project was the beginning of night classes, attended by the whole community. The replacement of the old generator has brought other

benefits, such as the elimination of technical failures of the system and increase in the energy supply.

Barriers

Despite their advantages, dissemination of RETs has not yet reached the desired momentum in Brazil and projects to spread renewable energy still meet obstacles.

Although there are no significant technological barriers to PV, wind and small hydro, small-scale electricity generation using biomass, which is important for isolated communities, still encounters technical obstacles.

- No small-scale steam cycles (minimum 200 kW) are commercially available in Brazil and the few existing ones have high generation costs. However, there are positive perspectives with small-scale projects started in 2003.
- Small-scale gasification systems have low conversion efficiency and high levels of tar emissions. However, projects to adapt Indian systems to Brazilian conditions are under development (see above—Case studies).
- Biogas and vegetable oil engines are not yet available in Brazil, but projects to adapt existing conventional engines to biogas are under development (see above—Case studies).

Lack of means for long-term energy policies constitutes the major political and institutional barrier. Energy policy, planning and regulation are still almost completely separate from one another. For example, the MME and ANEEL (the national regulating body for electricity) have developed and implemented their own programmes without coordinating their actions or identifying synergies. Perhaps as a result of the predominant hydroelectric culture and of sector interests that remain strong in the country, regulation of renewable energies is considered a duty, without there being a real intention to implement them.

Policy outlines

Overall, Brazil still needs a clearly defined comprehensive national strategy for universal energy access, including definition of the volume of available resources, deadlines for universal access, estimate of the maximum impact that would be acceptable on tariffs and examination of how the available funds could minimise such impact. Efforts to coordinate the actions of the various institutions and programmes addressing income generation, poverty alleviation, infrastructure provision and rural electrification programmes complete the list of most pressing requirements.

However, the specific conditions prevailing in Brazil's two electricity supply systems ('isolated' and 'interlinked') mean that different policy measures are appropriate. For example, expanding coverage of the fund that currently covers 'biodiesel' to 'biofuels' would help to finance use of *in natura* vegetable oils for energy production. Relaxation of standards that require systems installed to generate 24 hours/day would also be favourable for some RETs (e.g. solar).

The installation of systems providing energy at specific periods of the day is already a remarkable improvement. For the interlinked system, the main difficulty is the lack of policies to make RETs attractive to the private sector. The government has attempted to improve this situation, but more favourable agreements on tariffs for electricity purchase are required between government and entrepreneurs.

And finally, Brazil is a large market for both grid extension and distributed electricity production using RETs but existing market information is very inaccurate. If uncertainties are to be reduced to make the market attractive to investors, a definitive quantifying survey to define precisely how the market could be split between these alternatives is vital.

Renewable Energies Technologies Contribution and Barriers to Poverty Alleviation in Jordan, Syria and Lebanon

Table 20: electrical energy demand and forecast (GWh) in Jordan, Syria, and Lebanon

Country	1995	2000	2005	2010	2015
Jordan	4 778	5 810	7 596	8 849	10 159
Lebanon	5 484	8 630	10 284	12 512	14 087
Syria	14 661	2 0580	32 843	44 366	59 372

Source: Renewable Energies Technologies Contribution and Barriers to Poverty Alleviation in Jordan, Syria and Lebanon

The forecast for total energy consumption in Jordan, Syria, and Lebanon (Table 20) indicates a continuous increase in energy demand in the three countries, bringing with it the challenge of finding sustainable ways to manage this increase.

The development and use of renewable energies would help to meet this challenge, would, at least partially, relieve the countries from the present economic burden of oil imports, and could create new job opportunities.

In the past two decades Jordan and Syria, have researched the possibility of developing and exploiting renewable resources and polices and strategies for promotion have been introduced. They have also taken steps to design and install special networks to measure solar and wind energy using advanced resource assessment methods.

However, despite this significant interest in development of alternative energy sources, their actual contribution to energy consumption in Jordan, Syria and Lebanon is limited. Figures for Jordan[6], for example, give the proportion of water heating provided by solar water heaters (by far the greatest use of solar energy) as 1.7–1.8 per cent, PV systems contributing 0.0016 per cent of power and hydropower and wind providing 0.06 and 0.007 per cent respectively. In Syria, renewable energy use is limited to pilot projects with government and international financing. The challenge for the three countries is to ensure sustainable energy development in a situation in which the need for economic development is driving increasing energy demands.

6 Figures for 1993.

Energy status in the three countries

Electricity production in Jordan, Lebanon and Syria is still predominantly based on thermal power plants, primarily using fuel and gas oil. Syria has a fair proportion of hydroelectric resources on the Euphrates and Lebanon has several small hydroelectric facilities, mostly on the Litani River in the Bekaa valley. The tendency to move towards use of natural gas is increasing because of its economic and environmental benefits. Gas networks are becoming increasingly available in Syria and Jordan. Jordan also has oil shale reserves estimated at more than 50 billion tonnes, equivalent to 50 billion barrels of crude of oil. The Jordanian government gives great importance to the exploitation of this energy resource.

Poverty and energy status in rural areas

The level of poverty in Jordan, Syria and Lebanon ranges from 25 to 30 per cent of the population (based on an income of US$10–12 per day). Lebanon has a higher percentage of population living in urban areas but all three countries have densely populated poor neighbourhoods. In addition, the countries are host to thousands of Palestinian refugees living in poorly managed camps often located in the outskirts of cities. Table

Table 21: poverty and social indicators, Jordan, Syria, Lebanon

Country	Lebanon	Syria	Jordan
Average annual growth, 1996-02			
Population (%)	1.4	2.5	3
Labour force (%)	2.6	4	4
Most recent estimate (latest year available, 1996-02)			
Poverty (% of population below national poverty line)	28	25	30
Urban population (% of total population)	90	52	79
Life expectancy at birth (years)	71	70	72
Infant mortality (per 1,000 live births)	26	23	25
Child malnutrition (% of children under 5)	3	N/A	5
Access to an improved water source (% of population)	100	80	96
Illiteracy (% of population age 15+)	13	24	9
Gross primary enrolment (% of school-age population)	99	109	101
Male	101	113	101
Female	97	105	N/A

Sources: World Bank (www.worldbank.org) and USDS (www.usds.gov)

21 summarises poverty and gives some social indicators for the three countries.

In Jordan, 99.8 per cent of the rural population had access to electricity at the end of 2002. The government is working on providing the rest of the residential areas in the Jordanian countryside with electricity through a Rural Electrification Programme financed via taxation of electricity bills.

In Syria, there is a general orientation towards social and economic development of the countryside and towards a decrease in migration to urban areas. An Energy Planning and Conservation Project, has collected statistics to help develop rural areas and increase use of sustainable energy systems.

In Lebanon, most rural areas are supplied with energy and have access to commercial energy resources. Some Palestinian refugee camps are not paying for their electricity and are thus placing a burden on the already difficult financial situation of Electricity De Liban (EDL – national utility) which the government is seeking to privatise. The relatively high cost of energy in the country is pushing low-income families to rely on electricity theft to supply their needs; system losses have reached severe proportions in the past.

Renewable energy resources

Most member countries of the UN Economic and Social Commission for Western Asia (ESCWA) are not only rich in fossil fuel resources, which make the major contribution to energy production, but also have extensive renewable resources, especially solar, wind and biomass. Details for Jordan, Syria and Lebanon are given below.

Jordan

Jordan is one of the 'sunbelt' countries (i.e. within 30° north of south of the equator), and has average annual levels of direct solar radiation that are highly favourable for projects that use solar energy to generate electricity.

At present, the main use of solar energy in Jordan is for domestic solar water heating (about 30 per cent of the country's houses). There are more than 25 manufacturers producing locally designed systems.

Demonstration projects have been implemented for solar PV for uses such as emergency telephones or to cover minimum energy requirements and water pumping in remote areas. There are PV village electrification systems for remote areas with system capacities varying from 1 kW to 4.5 kW, and water pumps have been installed for Bedouins, with capacities varying between 1.4 and 6.3 kW per system.

Jordan has considerable wind energy resources and wind technology is mature in the country. Wind potential has been assessed and a 'Wind Atlas' prepared, showing that there is a potential of several hundreds of megawatts for wind power installations.

Hydro resources in Jordan are very limited and there is only one hydro plant for electric power generation—at King Talal Dam, with an annual capacity of 25 GWh.

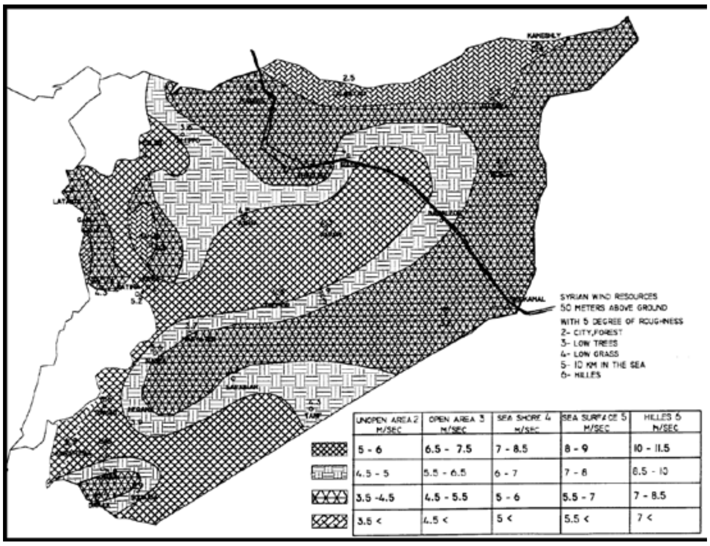
Jordan has adopted a programme for bio-energy under which pre-feasibility studies for the generation of electricity from municipal solid wastes have been prepared, in cooperation with GEF. The outcome of these studies was the first biogas project in Jordan and in the region, with a capacity of about 1 MW of electricity. The project generated 5.4 GWh in 2002, it is due to be expanded to 5 MW shortly.

Studies have indicated that animal waste and MSW in Jordan have an annual energy potential of about 100 000 tonnes of oil equivalent (toe).

Syria

Syria has abundant solar resources. At present, the country has some 15 000 to 20 000 installed solar water heaters, manufactured by 50 small private businesses and has demonstration PV systems. There is a 3.25 kW PV pumping system used to lift 120 m^3/day of water in Dummar, near Damascus, and a 5 kW PV-pumping and desalination station. PV village electrification was demonstrated in 1994 in two villages and a PV home electrification system is used to supply

Map 2: wind resources in Syria



Source Renewable Energies Technologies Contribution and Barriers to Poverty Alleviation in Jordan, Syria and Lebanon

44 houses in the village of Zarzita. Individual stand-alone PV systems have also been used successfully to supply electricity to 65 houses in some villages in Aleppo.

As can be seen from Map 2, wind energy is also abundant in Syria, with wind speeds of between 3.5 and 11 m/s.

Most of the available large and medium scale hydro power potential in Syria has been harnessed, but studies have been made of 32 potential sites for micro-hydro units which could be stand-alone units or linked into mini-grids.

Biomass estimates for the country (made in 1999) indicate that, annually, there are around 577,000 tonnes of dry animal dung, 360,000 tonnes of dry chicken droppings, 230,000 tonnes of human waste and 34,000 tonnes of dry kitchen residues.

Lebanon

Lebanon has solar, wind, hydro and biomass energy sources but these are not widely used. Data have been collected on the potential of these renewable sources and some plans have been made. For instance, the country is intending to maximise the benefits from its water resources by considering construction of dams on rivers throughout the country. There is also a potential to produce electricity from gasification using agricultural waste and for extraction of methane from MSW.

Summary of renewable resources in the three countries

Jordan, Syria and Lebanon have many similarities in terms of energy requirements. Energy demand is increasing in all three countries and the main sources used to meet demand are fossil fuels, with a minimum contribution from renewables. Jordan and Syria are attempting to exploit their renewable resources, Lebanon, in contrast, has still not taken any steps to study the potential impact of renewable energy on its social and economic development. Table 22 summarises the renewable energy potential of the three countries.

Case Study—wind energy, Jordan

Jordan has implemented policies to encourage development of renewable energy and RETs that are relevant to the country's needs have been adopted, particularly in rural and remote areas. These include the Hofa wind farm, where the Central Electric Generation Co. is generating electricity from five 225 kW turbines and the

Table 22: renewable energy resources in Jordan, Syria, and Lebanon

Country	Global solar radiation kWh/m2/day	Direct normal solar radiation kWh/m2/day	Wind energy Average wind speed (m/s)	Biomass and fuel wood (mtoe/year)
Jordan	5–8	5–7	5.5–10	0.74
Lebanon	4–6	4–6	3.5–6	0.59
Syrian Arab Republic	5–6	-	4.5–11	1.24

Source Renewable Energies Technologies Contribution and Barriers to Poverty Alleviation in Jordan, Syria and Lebanon

Al-Ibrahimiyyah farm with four 80 kW turbines.

The successful operation of these two stations has led the Ministry of Electricity and Mineral Resources to issue an international call for tenders for a wind generating project with a capacity of 75–90 MW at three sites

Case study—providing energy to rural and Bedouin areas, Syria

In Syria, a mixture of solar PV, wind and hybrid solar/wind sources is being used to supply electrical energy to the three Bedouin areas of Homs, Hama, and AL-Hassakek (1100, 1418, and 2510 households respectively). Energy is supplied for residential use, for commercial and community services and for pumping of water from wells for agricultural use.

Household supply provides 200 kWh/month for applications such as lighting, TV, refrigerators and kitchen appliances. The project also covers supply of 150 kWh/month to 34 schools, 7 shops and 3 veterinary practices. To help improve agricultural activities, power is supplied to pump water from 37 wells in Homs, 20 wells in Hama and 33 wells in AL-Hassakek. Depending on the depth of the wells, 100 per cent of power or 50 per cent can be supplied by RETs.

Barriers and some recommendations for future actions

Despite the efforts made to develop RETs in Jordan, Syria and Lebanon, their promotion has encountered barriers some of which are outlined below:

- Policies for renewable energy development have not been sufficiently integrated into overall energy planning.
- Limited investments have been made available to make RETs affordable to end-users; most investment has gone to conventional systems.
- Limited cooperation between different parties.
- Limited industrial capabilities and services for promotion of renewable energy and energy efficiency programmes.
- Lack of awareness of the benefits of RETs and of ways of improving their use.
- Problem of communication between renewable energy development bodies such as manufacturers, institutions, dealers and end-users.
- Limited regional cooperation and financing, obliging countries to seek foreign financing agencies and technologies.
- Proximity to countries that are mainly dependant on oil and gas revenues. There is an apparent but false conflict of interest between the region's oil and gas community and the promotion of renewable energy.

Based on the constraints described above, the following actions are recommended to foster renewable energy development in the three countries:

- Development of national strategies and action programmes with specific targeted contributions of clean and non-polluting RETs to total energy consumption.
- Raising of awareness and provision of adequate information to promote RETs systems and sustainable use of energy resources.
- Promotion of innovative financing arrangements to reduce up-front costs, with a focus on the needs of rural and poor areas.
- Strengthening of national and regional institutions that develop, implement and operate programmes for renewable energy development and energy for sustainable development.
- Strengthening of human resources in the area of RETs, including educational programmes; promotion of training programmes for decision makers, engineers and technicians; and development of hands-on experience for specialists and technicians.

Policy issues for all three countries

In the final analysis, the energy sectors in Lebanon, Syria, and Jordan are facing two common policy challenges:

- The need to move to more sustainable production and use of energy.
- The need to strengthen links and promote regional and international coordination in the field.

To meet these challenges, the countries need to further develop their policies and plans, taking account of national circumstances. Efforts should continue to be directed towards:

- Establishment of national and regional agreements to promote energy accessibility within the countries, and provision of basic needs, especially in rural areas.
- Development of cost effective mixed systems that combine fossil fuels with RETs.
- Promotion of energy conservation by reduced consumption and sustainable development of both cleaner fuels and more advanced fossil fuel technologies.
- Consideration of the impact of the energy sector on the environment, water distribution/use, and on health.
- Enhancement of regional coordination for energy transfer and investments to achieve an acceptable level of sustainable development.

Concluding remarks

A sentence borrowed from *Renewable Energy Options in Improving the Life of Western Rural Population in China* sums up the situation in the developing countries that have been the focus of this second GNESD thematic programme: *'Energy deficiency limits […] people's development and their heavy dependence on traditional biomass is accompanied by problems of ill health and environmental degradation. Finding a feasible way to address the energy problems of the poor […] is a crucial precondition for their development and for protection of the environment*.'

In many countries, the energy deficit is wide and levels of access to modern forms of energy are extremely low. Yet even a cursory glance at the country reports shows a wealth of untapped resources with a huge potential for development of RETs that are suited to local conditions. A second observation is that many developing countries already have considerable experience with RETs, but that expected results have not been forthcoming. Some common causes for this failure can be identified.

In almost every case attempts have been made to import sophisticated electricity-producing technologies in an *ad hoc* manner, with heavily subsidised or donor sponsored projects working well while support lasts but failing once it is withdrawn.

Two lessons can be drawn here: first, the initial costs of the sophisticated RETs on offer have been far beyond the ability of poor individuals and communities to purchase and maintain them; second, if communities are not consulted as to their real needs and capacities, there will be a mismatch between what is provided and what is actually required. Inappropriate technologies which local skills are not adequate to operate or maintain do not, generally, drive development.

The pattern emerging from the reports is one of a focus that has been firmly on the provision of modern energy supplies using the centralised grid-based systems common in the industrialised world. RETs projects have typically been only fragmented R&D efforts, most often carried out in isolation from other development challenges such as health, poverty, education and regional development and, above all, without the guidance of integrated programmes and policies.

This lack of coherent policies has led to a lack of coordination between stakeholders that has not been conducive to efficient development. Furthermore, a concentration on RETs for residential supply to low income households, rather than for productive uses, has made financial institutions shy of RETs, considering them as risky and of low profitability.

In contrast to this, the Case Studies presented show that when RETs that are really appropriate to local conditions and needs are selected they quickly begin to increase income and thus empower users to begin to take charge of their own development. The barriers to this process are not technological but rather the need for an enabling environment that focuses clearly on the development of appropriate technologies as part of a holistic approach to development.