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Renewable Energy for Rural Development – A Namibian Experience

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1. Introduction

Developing countries have 80% of the world's population but consume only 30% of global commercial energy. As energy consumption rises with increases in population and living standards, awareness is growing about the environmental costs of energy and the need to expand access to energy in new ways (Rena, 2008). As Wilson stresses that if each person currently alive would attain the US level of consumption, it would require four more Earths (Wilson, 2002:150). Increased recognition of the contribution renewable energy makes to rural development, lower health costs (linked to air pollution), energy independence, and climate change mitigation is shifting renewable energy from the fringe to the mainstream of sustainable development.

The realisation is growing that poor nations will suffer most from the effects of climate change. This vulnerability stems partly from their location in areas such as drought-prone sub- Saharan Africa or flood-prone Bangladesh. Their capacity to cope with climate change is also low because of limited financial resources, skills and technologies and high levels of poverty. And they rely heavily on climate-sensitive sectors such as agriculture and fishing. For example, Namibia is very dependent on natural resources: some estimate that up to 30 per cent of its GDP is reliant on the environment. Ironically, it is also these poor nations that have contributed least to climate change. Data covering 1950 to 2000 from the Climate Analysis Indicators Tool, developed by the World Resources Institute, indicates that African countries contributed 4.6 per cent of cumulative global carbon emissions during that period. Today their share of emissions is just 3.5 per cent of the total (IIED, 2007).

There is a growing concern on the issue of renewable energy all over the world that has been building interest among those in government, multilateral organizations, industry, and nongovernmental organizations (NGOs) pursuing energy, environment, and development agendas at local, national, and global levels. At the same time, commercial markets for renewable energy are expanding, shifting investment patterns away from traditional government and international donor sources to greater reliance on private firms and banks (Martinot, et al., 2002).

For the past 10 years, it has been frequently estimated that around 2 billion people have no access to modern energy services and about 1.5 billion people live without access to electricity (World Bank, 1996: 1; IMF and World Bank, 2006: vi). Access to modern energy services and electricity is low in many developing countries, particularly in sub-Saharan Africa and parts of Asia (see table 1 for details). If the MDGs are to be achieved in these parts of the world, then significant efforts are needed to bring rural areas out of energy poverty. This can be done in two ways: increasing access to energy for domestic use – essentially increasing access to technologies which use modern fuels or make use of traditional fuels in cleaner, safer and more environmentally sound ways – and increasing access to electricity (UNCTAD, 2010).

Country	Population		Access to electricity (% of population)		
	Total (millions)	% living in rural areas	Total	Urban	Rural
Benin	9	59.2	22	51	5.5
Cameroon	18.5	44	46	77	16.5
Ethiopia	79.1	83.3	12	86	2
Kenya	38.5	78.7	13	51.5	3.5
Malawi	13.9	81.7	7.5	34	2.5
Mali	12.2	68.4	13	41	2.5
Senegal	12.4	57.9	46.5	82	19
Uganda	30.9	87.2	47.5	8.5	2.5
Zambia	11.9	64.7	20	50	3.5

Source: World Bank, 2006 (as quoted by UNCTAD, 2010: 4)

Table 1. Levels of electricity access in selected sub-Saharan African countries

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

Renewable energy commonly refers to both traditional biomass (i.e., fuel wood, animal wastes, and crop residues burned in stoves) and modern technologies based on solar, wind, biomass, geothermal, and small hydropower. While traditional biomass provides about 7%–11% of global primary energy supply, the modern forms of renewable energy provide about 2% (Martinot, et al., 2002). For developing countries, the traditional biomass share averages 30%–45%, although some developing countries approach 90%. Besides traditional biomass, small hydropowers in China and transport ethanol in Brazil are among the largest single contributors to renewable energy supplies in developing countries (Rena, 2008). In fact, modern biomass represents 20% of Brazil's primary energy supply, aided by significant increases in the past 20 years in the use of ethanol fuels for vehicles and sugarcane waste for power generation (Byrne and Wallace, 1998).

The largest developing country and world's second largest economy —China—gets about 2% of its primary energy supply from renewable energy, mostly from small hydropower generation. Globally, contributions from wind power and solar photovoltaics (PV) are still small, but applications of these technologies are growing fast—at annual rates of 10%–30% in recent years.

Definition

> Renewable Energy Technologies (RETs) are energy-providing technologies that utilize energy sources in ways that do not deplete the Earth's natural resources and are as environmentally benign as possible. These sources are sustainable in that they can be managed to ensure they can be used indefinitely without degrading the environment (Renewable Energy Association, 2009).

By exploiting these energy sources, RETs have great potential to meet the energy needs of rural societies in a sustainable way, albeit most likely in tandem with conventional systems. The decentralized nature of some RETs allows them to be matched with the specific needs of different rural areas.

In line with this, the UN Climate Change Conference (COP15) held in Copenhagen, Denmark, from December 7-18, 2009 and with the debate around patents and climate change-related technologies, it became easy to forget that there are many low-cost and clean renewable energy technologies available in the public domain. The UN meeting highlighted how these technologies can revolutionize the way of life for rural communities.

It is surprising to note that over 90% of rural Africa and 1.6 billion people worldwide are without electricity. Kerosene, firewood, and dried dung are relied upon by rural communities for lighting and cooking fuel. These traditional energy sources pose many health hazards, especially for women (and children as well). Air quality is a major concern with kerosene and open fires, releasing carcinogens, airborne particles, and greenhouse gasses. Women are disproportionately exposed to open fires for cooking. Midwives working at night have to rely on a dim, flickering light (Barnes and Floor, 1996; Barnett, 1990). In addition, women are also the ones who scavenge for firewood or transport kerosene, often in inhospitable terrain. Thus, besides being a health risk, this is also a tremendous loss of productivity for the village; as women in these villages are forced to spend more and more time in search of diminishing fuel sources.

In the UN Conference for Trade and Development (UNCTAD), several promising solutions were described for providing electricity and cooking gas for rural communities. These solutions – solar, biomass-to-electricity, biomass digesters, geothermal, micro-hydro and micro-wind power – were each shown to be particularly affordable and technologically promising in a variety of settings.

One of the most important messages to come out of the UN meeting was that the technologies deployed must be reliable. To ensure a reliable alternative energy supply and to help empower rural women, it's important to ensure solar power takes hold in these villages. A major problem with previous efforts in using solar power in rural settings was the inability to maintain and repair the necessary equipment. Training young men as solar engineers proved futile, as they would quickly leave to more lucrative urban markets.

With the provision of clean, off-grid electricity from solar panels, the air is cleaner, the village is more productive and women are becoming empowered. What's more, it makes clear economic sense. The cost of a solar system large enough for several lanterns is roughly the cost of one year's supply of kerosene. But, solar energy can only solve some of a rural communities energy needs. Other experiences showed that there are other alternatives which can meet the need for sustainable development in rural communities (ESMAP, 2007).[1]

An attempt is made in this chapter to provide an overview of some of the issues surrounding the use of renewable energy technologies (RETs) to increase access to modern energy services in rural areas in Namibia. RETs include, inter alia, the provision of electricity generated from renewable sources such as wind, solar, water, tide/wave and geothermal, and the provision of other modern energy services that are powered by renewable sources for activities such as household heating, space conditioning and water pumping. These kinds of technologies have long been subject to international debate and action as a means of expanding access to electricity by means of offgrid or grid extension programmes. Similarly, the development of RETs such as improved cooking stoves to increase efficiency and reduce health impacts of traditional fuel use has had a long history and has shown some success (ESMAP, 2007). However, growing concern over climate change and the increasing acceptance of a need for low-carbon development trajectories have provided renewed emphasis on improving access to modern energy services using RETs (UNCTAD, 2010).

2. Conceptual framework

Three Renewable Energy Technologies (RETs) have been selected for this study; wind, hydropower and biomass. These are particularly relevant to rural areas and have both a track record and scope to develop further. There are considerable differences between these types of renewable energy technology in terms of age of technology, infrastructure requirement and scale, which are important to consider alongside their contribution to rural development of Namibia.

2.1 Wind power

Wind power is derived from the harnessing of moving air to rotate turbine blades whose motion can be converted to electricity. Wind turbines can be deployed singly or in clusters (wind farms), as with other resources, such as mineral reserves, wind can only be exploited where it occurs. In geographical and commercial terms, this points towards areas having high wind speeds. Most wind power RET development has therefore occurred in exposed western areas of the UK.

2.2 Hydropower

Hydro power has been used in industry for centuries. Like wind power, it is often located in areas of high environmental value and is subject to strict conditions at planning stage. The

[1] For details see - Renewable Energy Technologies for Rural Development (02/25/2010) available at http://ipsd.typepad.com/ipsd/2010/02/renewable-energy-technologies-for-rural-development-1.html accessed on 3 September 2011.

British Hydropower Association, which represents the sector, is critical of the obstacles to development presented by regulation through the Environment Agency.

Hydropower in the UK is mainly represented by large-scale storage or dam-based sites, built in the first part of the last century. While these continue to be most significant in terms of energy generation, environmental and planning constraints mean that most growth in hydropower is in small-scale (less than 5Mwe) schemes. These include schemes based on existing dams and lochs and run-of-river projects.

2.3 Biomass

The term biomass covers all cellulose-based feed stocks including agricultural and forestry crops and residues, animal litter wastes and by-products. Burning wood is the oldest form of energy production. It is only very recently that other fuels have supplanted wood as the world's principal fuel. Indeed, in many regions wood-burning technology has remained the sole source of energy generation with little or no technological improvements.

After decades of renewable energy programs and investments in rural areas of developing countries, relatively little is known about the ability of renewables to deliver services that will raise incomes and provide other social benefits. Certainly there are social benefits from lighting, TV, and radio powered by solar home systems, mini-grids, and biogas, and even some economic benefits from reduced kerosene and candle use. Biogas for cooking and improved biomass stoves may also reduce expenditures for fuel wood, either in time or money, as well as create jobs. A clear result of the Nepal biogas program is that women spend less time and labor for fuel wood collection and cooking. In China, however, the direct financial benefits of biogas to households, beyond the social benefits of lighting, are not as clear. On balance, the literature does not offer a strong case that large rural development benefits have occurred from renewable energy (WZhong, et al., 2006).

Most insight on the economic benefits of rural electricity comes from literature on rural electrification through extension of central power grids. Studies clearly show the consumptive benefits and improvements in quality of life through electrification (World Bank, 1996; WZhong, et al., 2006). For example, a study in Namibia indicates that electrification has improved household welfare, but almost exclusively as a consequence of electric lighting. Access to high-quality light is the major change reported, particularly the ability to study in the evenings. But where rural electrification took place without other supporting economic infrastructure and skills, as happened in many development projects, productive economic development did not follow, acknowledged both the World Bank and the German aid agency GTZ (Stuart-Hill, 2003; Republic of Namibia, 2004).

The few examples mentioned earlier of rural small industry, agriculture, and other productive uses powered by renewable energy offer some promise of economic and development benefits. However, as just noted, economic benefits depend not just on the availability of energy but also on other conditions favoring small business in rural areas, such as access to markets, finance, communications, education, and health care. That is, economic benefits from rural renewable energy are more likely in areas where economic development is already taking place. Further, those who most benefit from the availability of energy are those who can afford the electrical equipment and other infrastructure needed to convert energy into useful services and productive activity (Brew-Hammond, 2007; World Bank,2009b).

There is little question that solar home and solar community systems provide benefits that increase household welfare and quality of life, which include improved lighting for children's education, adult study, evening cottage industry, as well as television and radio. Anecdotal evidence suggests that demand for television has been a major driver of some markets (with soccer often mentioned). Distance education via television is also cited for subjects like farming, health care, and language. But little research has measured or quantified these benefits. In fact, concluded that rural households do not buy solar home systems for reduced energy costs, but rather for improved services like longer TV viewing and better lighting quality. Other anecdotal evidence supports this view of increased services rather than decreased costs: Some households continue to use kerosene for lighting so that the electricity from solar home systems can be conserved for television viewing (World Bank, 1996).

Research is emerging slowly. In Inner Mongolia, a socioeconomic assessment of small household-scale wind turbines found that households bought appliances such as refrigerators, washing machines, rice cookers, irons, and electric heaters to improve living conditions and save time, particularly for women. The study found that television and radio provide language instruction and information on commodity prices, weather, and new farming methods and practices. Electricity also increased income-generating activities, adding up to $30–$150/month to incomes (WZhong, et al.,2006; Brew-Hammond, 2007;). In Bangladesh, Grameen Shakti reports that community solar-powered cell phones, operated primarily by local women villagers in their homes, produce up to $200/month in revenue for the operators. Villagers appear willing to pay per minute connection charges for calls because of the financial benefits from learning about commodity prices, exchange rates, market trends, and from verifying cash deliveries made by relatives (Barnett, 1990; World Bank, 1996; World Bank, 2009a).

On balance, it is not clear how welfare and quality of life benefits will drive demand for renewable energy systems beyond the wealthiest rural households. "Acquisition of Solar PV(photovoltaic) Home Systems (SHS) is often a lower priority for rural households than other basic needs and commodities; only after these other needs have been met do solar home systems become an option," which limits demand for consumer applications (Martinot, et al., 2002). We hypothesize that applications of renewable energy that provide income generation and social benefits, such as clean drinking water, cottage industry, distance education, and improved agricultural productivity, will appeal to increasing segments of rural populations (Martinot, et al.,2002; UNCTAD,2010).

Lessons suggested by experience are that: (*a*) Social benefits and quality of life, rather than income and economic benefits, have driven markets for renewable energy in rural areas; (*b*) experience with productive uses of renewable energy is still in its infancy and deserves much greater attention from donors, development agencies, and governments; (*c*) economic benefits from renewables are more likely in rural areas that are already undergoing development and can incorporate the additional energy dimension into existing development activities for water, health, education, agriculture, and entrepreneurship; and (*d*) published studies of income generation and economic benefits from renewable energy are still limited and call for further research (Kaundinya, et al.,2009).

In the rural energy and development literature *(see table-2)*, much has been made of affordability of rural household systems such as solar home systems, biogas digesters, and

ECONOMIC	ENVIRONMENTAL	COMMUNITY
Short term ***increase in employment opportunities locally during plant construction but often high reliance on overseas and non-local specialist engineers***	***Negligible or no direct impact*** on the local environment. Indirect benefits include use of potential pollutant waste materials and maintaining farmers on the land	***Population increase during site / plant construction leads to a temporary increase in local cash flow***
Longer term ***increased demand opportunities for local service sector development*** to meet plant/site servicing needs	***Actual or perceived negative environmental impact of RETs often dissipates*** when plant and site up and running	***Increased self respect for individuals through employment and association with green technology***
Would reduce local household bills ***if energy generated could be procured locally***	***Reduced need for nuclear and conventional energy generation – this benefit is felt at a wider national level, rather than locally***	***Social and community support and development fund*** is often provided for use by the local population
Increased skilled and managerial job opportunities when plant is up and running – benefit not necessarily located in the same locality or region though	***Negative impact during construction phase and potentially beyond (hydro in sensitive catchments)***	***Uneven (positive) impact on rural communities generally***, in terms of geographical location
Increased opportunities for diversification of the local (largely service) economy where ownership is local	***Stimulates wider public interest in sustainable and community based solutions to energy generation and waste disposal***	Can ***help increase informal educational opportunities locally***

Source: Woodthorne, et al., (2003) *op.cit.*, p.39.

Table 2. Relationships between Renewable Energy and Rural Development.

improved biomass stoves. For example, many argue that households can afford to substitute solar home systems for candles and kerosene lighting if the monthly costs for each are comparable (World Bank, 1996; Martinot, et al., 2002; WZhong, et al., 2006). Based on affordability analyses, some donor programs for solar home systems began by offering large 100-watt sizes. Donors soon found these sizes too expensive for rural households and decreased sizes to 50 watts and even to 20 watts. This small-size approach to affordability also has occurred in the private markets in Kenya, Morocco, and China, where households often buy very small systems (i.e., 10–15 watts). In these cash markets, smaller systems may represent up to 80% of the market (World Bank, 2009a; Kaundinya, et al., 2009). Even so, most buyers are among the wealthiest households in rural areas. Some households upgrade later to larger systems when they can afford them.

A few countries such as India and China are developing policies for mandated shares of renewable energy in power generation. India has proposed that 10% of new capacity additions through 2012 come from renewable energy, which would mean an additional 10,000 MW. China's latest five-year plan calls for a fivefold increase in wind power to 1500 MW by 2005. The plan also proposes to require 5% of new power generation from renewables, which could mean an added 20,000MW by 2010 (Kaundinya, et al., 2009). However, such policies must overcome political and institutional hurdles, fit into utility-sector restructuring, and resolve who will pay for any extra costs of renewables in the shorter term until costs decline. In the longer term, renewables may integrate with "distributed generation" markets that include microturbines and fuel cells, while new technologies like biomass gasification and solar thermal power may become commercially viable (Barnett, 1990; World Bank, 1996; Mariyappan and Anderson,2002; WZhong, et al., 2006; World Bank, 2009a).

2.4 Grid-based power generation

Total world electric power capacity stood at 3,400,000 MW in 2000, with about 1,500,000MW (45%) of this in developing countries. Electricity consumption in developing countries continues to grow rapidly with economic growth, which raises concerns about how these countries will expand power generation in coming decades. According to some estimates, developing countries will need to more than double their current generation capacity by 2020 (Khennas and Barnett, 2000). Traditional options, such as coal and large hydro, have environmental and social repercussions that have increasingly taken on serious political and economic undertones.

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2.4.1 Village-scale mini-grids

Village-scale mini-grids can serve tens or hundreds of households in settings where sufficient geographical density allows economical interconnections to a central power generator. Traditionally, mini-grids in remote areas and on islands have been powered by diesel generators or small hydro. Generation from solar PV, wind, or biomass, often in hybrid combinations, can replace or supplement diesel power in these grids (Singh, 1997; Khennas and Barnett, 2000: Lew, 2001).

Most village-scale mini-grids have developed in Asia on the basis of small hydro, particularly in China where more than 60,000 mini-grids exist, as well as Nepal, India, Vietnam, and Sri Lanka, each with 100–1000 mini-grids. In China, most mini-grids have resulted from government programs. More recently, rural entrepreneurs have built and run small hydro stations by borrowing from agricultural banks; revenue from just three years of electricity sales is apparently sufficient to repay such loans (Davis, 1995; Wang, 2000; Wu and Yu, 2000; Borbely and Kreider,2001). Standardization of the industry has also facilitated interconnection of multiple stations into county-level grids. In Nepal, most mini-grids have been installed and managed by rural entrepreneurs. This Nepali entrepreneurial success story of the 1980s and 1990s has been attributed to several factors, including availability of credit from a public-sector agricultural development bank, simplified licensing procedures to reduce transaction costs, unrestricted power tariffs, private financing from commercial banks, and capital cost subsidies from the government. Also, technical assistance by bilateral donors and NGOs led to technology development and manufacturing within Nepal's industrial base (Cromwell, 1990).

Very few hybrid mini-grids employing combinations of solar PV, wind, and diesel exist, perhaps on the order of 150 systems in developing countries. Such systems are still not yet economically competitive with conventional diesel power and must be financed at least partly with government or donor funds. China's roughly 80 PV/wind/diesel mini-grids (about half of which are PV-only systems), sized 10–200kW, are installed mostly on islands along the coast and in the northern and western remote regions. In India, nine PV mini-grids (most 25 kW) and two biomass mini-grids serve 35 villages in West Bengal (Davis, 1995; Li, 2001: 89–91).

Although electricity provides improvements in the quality of life through lighting, entertainment, and increased conveniences, it is the productive uses of this electricity that increase incomes and provide development benefits to rural areas. As incomes increase, rural populations are better able to afford greater levels of energy service, which can allow even greater use of renewable energy. The major emerging productive uses of renewable energy are for agriculture, small industry, commercial services, and social services like drinking water, education, and health care (Singh,1997; Van, et.al, 2000;).

2.5 Household-scale wind power

Household-scale wind power (sized 100– 5000 watts) has been piloted in a few countries, with most installations worldwide taking place in Inner Mongolia in China. Public programs were successful in disseminating more than 140,000 small wind turbines for household energy in this region. These programs were driven by local technology promotion agencies, development of local technology manufacturing, subsidies for purchase of locally manufactured wind turbines, and a government revolving credit fund offering repayment tied to the harvest season or future sales of cattle or wool. Performance of these systems has been good, except during the summer when winds drop and system output dwindles. Many households, spurred by government programs and demonstrations, are upgrading their systems with PV to complement the wind resource and provide all-season power (Lin, 2000; Khennas and Barnett,2000; Lew, 2001).

3. Namibian experience

3.1 Country profile

The name of the country is derived from the Namib Desert, considered to be the oldest desert in the world. Before its independence in 1990, the area was known as South-West

Africa, reflecting the colonial occupation by the Germans and the South Africans. Republic of Namibia is a country with an area of 825,418 km2 (318,696 sq mi). Namibia is the world's thirty-fourth largest country (after Venezuela). Namibia's western border is the Atlantic Ocean. It shares land borders with Angola and Zambia to the north, Botswana to the east and South Africa to the south and east. It gained independence from South Africa on 21 March 1990, its capital and largest city is Windhoek. Namibia is divided into 13 regions and subdivided into 107 constituencies and a stable democracy (Wikipedia, 2011).

Agriculture, herding, tourism and the mining industry – including mining for gem diamonds, uranium, gold, silver, and base metals form the backbone of Namibia's economy. The economy is tied closely to South Africa's due to their shared history. The largest economic sectors are mining (10.4% of the gross domestic product in 2009), agriculture (5.0%), manufacturing (13.5%), and tourism. Namibia's nominal GDP (2010 estimate) - total $11.865 billion and the per capita $5,651. However, according to 2003 estimates Gini-coefficient rate 70.7 (highest in the world and the Human Development Index of Namibia is registered to be 0.606 (105th out of 174 countries) in 2010 (Ministry of Mines and Energy,2006; Rena,2010a; Wikipedia,2011).

Namibia has a population of 2.4 million people out of which little more than 50 % (51.2%) people are unemployed and the nation has suffered heavily from the effects of HIV/AIDS, with more than 15% of the adult population infected with HIV in 2007. After Mongolia it is the second least densely populated country in the world. Namibia has a high unemployment rate. "Strict unemployment" (people actively seeking a full time job) stood at 20.2% in 2000, 21.9% in 2004 and spiraled to 29.4 per cent in 2008. Indeed the unemployment rate rose from 36.7% in 2004 to 51.2% in 2008. This estimate considers people in the informal economy as employed (Rena, 2010a; Wikipedia, 2011).

According to the recent World Bank statistics, Namibia (based on per capita income) has moved from Lower Middle Income (LMC) country to the list of Upper Middle Income countries(UMC) by June 2011. Paradoxically, half of the population lives below the international poverty line of U.S. $1.25 a day. With this background, Namibia therefore receives foreign aid. There are a number of legislative measures in place to alleviate poverty and unemployment. In 2004 a labour act was passed to protect people from job discrimination stemming from pregnancy and HIV/AIDS status. In early 2010 the Government announced that "henceforth 100 per cent of all unskilled and semi-skilled labour must be sourced, without exception, from within Namibia" (Rena, 2010b; Wikipedia, 2011).

3.2 Sustainable development in Namibia

Sustainable development marks a commitment by the Namibian people to meet their own needs without compromising the ability of future generations to meet their own needs. Sustainable development depends on our knowledge of ecosystems, how well we understand and account for the human, social, cultural and economic forces in them, and how we use this knowledge and understanding to guide human behaviour.

The Directorate of Environmental Affairs (DEA) of Namibia's Ministry of Environment and Tourism, with support from the Government of Finland, has undertaken a national programme entitled "Information and Communication Service for Sustainable Development in Namibia". The programme was initiated in 1998 through its first phase. The first phase of the programme was mandated "To promote environmentally sustainable development practices in Namibia by providing pertinent and appropriate environmental information to policy, planning and decision-making processes and to all relevant stakeholders through the State of Environmental Reporting system".

Namibia is the most arid country south of the Sahara. This means that solar energy is one of the most abundant resources available. Grid electricity is becoming more expensive and power blackouts in the Southern African region are now a common occurrence and bound to continue in the future. It is therefore necessary to reduce energy consumption and to find additional renewable energy sources (Republic of Namibia, 2008). There are numerous ways of utilising this energy, from active interventions to passive benefits. Energy efficient buildings are more comfortable to work and to live in and have lower running and maintenance costs (Wienecke and Mawisa, 2008).

Namibia has seen a steady increase in power consumption over the last ten years. Currently, electricity supply is based on 240MW from hydro, 120MW from coal and 24MW from diesel power and this must be understood against our electricity demand which is roughly 500MW. Given the vastness of the country and low population density, it is extremely difficult and costly to extend the grid to un-electrified areas, hence the need to strongly consider renewable sources energy (Tjivikua, 2010).

For the purposes of this chapter, it is useful to separate RETs into two categories: those used to provide *energy for domestic use* (predominantly cooking and heating) and those used to supply *electricity*. RETs used to produce energy for domestic use tend to do so by exploiting modern fuels or by utilizing traditional fuels in new and improved ways in Namibia. RETs that generate electricity can do so either as part of a stand-alone (or off-grid) system or as a grid-based system, by way of connection to a mini-grid or the national grid. Table 3 lists renewable energy sources, as defined by the United Kingdom Renewable Energy Association (2009), and corresponding RETs that provide modern energy services and electricity.

	RETs	
Energy source	**Energy for domestic use**	**Electricity**
Elemental renewables		
Solar	Solar pump, solar cooker	Solar PV
Water (including wave/tidal)		Micro- and pico-hydroelectric generating plant
Wind	Wind-powered pump	Wind turbine generator
Geothermal		Geothermal generating plant
Biological renewables		
Energy crops		Biomass generating plant
Standard crops (and by-products)		Biomass generating plant
Forestry and forestry by-products	Improved cookstoves	Biomass generating plant
Animal by-products	Biogas digester, improved cookstoves	Biogas digester

Source: Renewable Energy Association 2009 (as quoted by UNCTAD, 2010: 5).

Table 3. Renewable energy sources and corresponding RETs

Renewable energy is shifting from the fringe to the mainstream of sustainable development. Markets for rural household lighting with solar home systems, biogas, and small hydro power have expanded through rural entrepreneurship, government programs, and donor assistance, serving millions of households. Applications in agriculture, small industry, and social services are emerging. Public programs resulted in 220 million improved biomass cook stoves. Three percent of power generation capacity is largely small hydro and biomass power, with rapid growth of wind power. Experience suggests the need for technical know-how transfer, new replicable business models, credit for rural households and entrepreneurs, regulatory frameworks and financing for private power developers, market facilitation organizations, donor assistance aimed at expanding sustainable markets, smarter subsidies, and greater attention to social benefits and income generation.

3.3 Potential for solar energy in Namibia

Namibia is a country with high values of solar radiation. About 300 sunny days per annum are experienced. It is therefore ideal to utilise solar radiation, which can be done by selecting solar hot water geysers, PV panels, and passive solar design.

Namibia enjoys sunny days throughout the year. Sunshine determines the amount of radiation that reaches the earth's surface. The map below illustrates the number of hours of sunshine per day. Sunshine hours are lowest along the coast – up to 5 hours - due to fog and cloud cover. The number of hours increases as one proceeds eastwards inland with a zone stretching from the central Namib Desert south-eastwards enjoying between 10 and 11 hours of sunshine per day. The central and northern parts of the country enjoy less sunshine hours (between 8 and 10 hours) due to cloud-cover during the summer months. The aridity is the result of many cloudless days; therefore Namibia has high solar radiation levels (Ministry of Mines and Energy, 2006).

The easiest way to achieve the objective of energy efficiency in Namibia is when a new building is planned. If existing structures are to be refurbished, the costs of such an exercise are usually higher than planning correctly from the start. However, there are opportunities to improve such buildings. This requires careful planning and an awareness of possible solutions (Wienecke and Mawisa, 2008).

3.3.1 Solar energy - Cooking

Cooking always requires energy. According to the 2001 census, energy sources for cooking were dominated by wood in 64% of all Namibian households. About 25% used electricity, ten percent used paraffin or gas, and less than 0.2 percent undertook solar cooking (Wienecke and Mawisa, 2008:15).

There are two types of solar cookers that are developed in Namibia by the local NGOs: the box cooker and the parabolic mirror. In the first case, food can be baked or cooked without any fear of burning. The second concentrates the sun's light at one point, which results in very high temperatures (see figure-1). However one must be careful enough (not to cook for too long as food can easily burn). Looking into the centre of the mirror must be avoided as the concentrated light can injure the eyes.

Fig. 1. Solar cookers (parabolic and box cooker) Source: Wienecke and Mawisa, (2008). p.15.

3.3.2 Water heating

Various types of hot water geysers are available in Namibia for domestic and industrial use, whether on flat or sloping roofs. The majority at present are flat plate systems that collect the sun's radiant heat. They consist of an insulated tank and solar thermal collectors. Fluid is circulated through in the tubes of the collector. This exchanges the heat from the absorber and transports it to the water tank (Wienecke and Mawisa, 2008:15).

Another system has been developed in Namibia that consisting of a series of modular transparent tubes, or rows of parallel transparent glass tubes. Inside the tubes are absorber tubes, where a fluid or gas is heated. This heat is then transferred to the water tank. These evacuated tube systems are lighter than the flat plate systems (see figure-2). However, the tubes are much more fragile than the flat plate. All systems should be installed by qualified companies.

Electricity generation from the sun Photo Voltaic (PV) panels generate electricity from the sun by converting direct sunlight into energy. These systems do not have moving parts and as a result require minimal maintenance. The electricity is generated with no emissions and no noise (see Figure-3). Multiple cells make up a PV panel. They consist of two or more thin layers of semi-conducting material, such as silicon. When the cell is receiving sunlight, an electrical charge is generated. There are four types of these cells namely: 1. mono crystalline, 2. polycristalline, 3. thin film, and 4. Armophous (Wieneck and Mawisa, 2008:16).

Fig. 2. Indirect Solar Water Heater Systems with heat collector. Source: Wienecke and Mawisa ,(2008).p.15.

Fig. 3. Direct Heat Exchange via Vacuum Pipes. Source: Wienecke and Mawisa, (2008).p.15.

3.4 Construction methods

Construction methods and building materials can influence long-term energy usage and the interior climate of a building. The durability, life cycle costs and energy consumption needed for maintenance, possible transportation of components or materials, the recycling potential at the end of a life cycle, and the environmental impact, determine the energy used. The cheapest materials, from an energy point of view, are those which are locally sourced and available, as they do not require long distances to transport. In other words these have low embodied energy and therefore their impact on the environment is minimal (Wienecke and Mawisa, 2008:10). One way to reduce several of the problems is to use what is locally available. This requires an investigation into local resources. The latter refers to building materials and human resources, such as builders, artisans or artists.

Natural building materials often only use the energy from the sun, for example thatch requires sunlight to grow, or clay blocks use the sun's warmth for curing. Stone does not require any energy, except if transport is required or cement mortar is used during the construction. Sometimes different types of materials can be combined, for example in the case of soil cement blocks, where soil and cement are mixed (Wienecke and Mawisa, 2008:11-12).

Walls can be built with non-conventional building materials for example sand bags, rammed earth, gabions filled with building rubble or stone, or natural stone. It is necessary that the bottom of the trench is compact and level. The sides have to be plumb to provide for a solid foundation (Wienecke and Mawisa, 2008:11-12).

Once the foundations have been completed, the construction of foundation walls and walls can proceed, similar to conventional building methods. The difference is the materials, for example adobe (sun dried clay blocks) and clay mortar.

Suitable material consists of about 65% sand, 20% clay, and 15% silt. The suitability of material can be tested as follows:

- Take some moistened soil and compress it in the hand.
- drop the lump on the floor from a height of about one meter.

If the lump breaks up into a few pieces, then the material can be used for construction. If the lump breaks up and scatters into many small pieces, more clay needs to be added. Good quality clay does not require any additions. However, if the material needs reinforcement straw or grass can be used. Reinforced clay balls formed by hand are then used to build the walls by twisting them to form a solid mass (Wienecke and Mawisa, 2008:11-12).

Soil-cement blocks can also be produced using the so-called hydraform machine to produce the blocks. Around 75% of Namibian soils can be utilised. Cement or lime can be added to ensure the required strength of the blocks. At the HRDC, blocks with cement content of 4-8% were manufactured; thereby savings on cement usage were achieved. These blocks do not require mortar in between, except for the first layer to obtain a level surface. This constitutes another saving. However, they have to be cured for a week to ensure that these stabilised blocks are of good quality before they are used in construction (Wienecke and Mawisa, 2008:13).

3.5 Industrial materials

Industrial materials usually require heavy investment in energy. The route from mining to processing to the finished product is energy intensive. Various machines and equipment are used in the mines, the ore is then transported for further processing, after which it is again shipped to factories, and then to warehouses and to retailers. Transport costs add to the price consumers have to pay. Examples include steel imported from South Africa, burned clay brick manufactured in Kombat and Mariental, or ready mixed concrete in Windhoek. Industrial products contribute significantly to the problem of pollution and global warming (Wienecke and Mawisa, 2008:10).

Another possibility is wind energy, which can be converted into electricity. The higher the mast on which a turbine is mounted, the higher the effectiveness of the system, as more energy is generated due to the higher wind speeds at a higher altitude. This energy is stored in batteries to ensure that electricity is available whenever needed.

3.5.1 Saving energy

The cheapest and easiest way of saving energy is not to use it or using reducing consumption. Passive solar design is one option. Another includes skylights or clerestory windows to maximise the use of daylight and distribute the light in a room. One possibility of saving energy, is replacing energy intensive appliances and light bulbs. Fluorescent bulbs save up to 85% of energy consumed by an equivalent incandescent bulb for the same amount of light. Although they are slightly more expensive than the "regular" bulbs, the money saved on electricity consumption is more than the extra costs paid over the life time of a compact fluorescent bulb (Wienecke and Mawisa,2008:16).

Electrical appliances and equipment should be compared to determine the amount of energy they consume. Below is a list of the most commonly used appliances in the home with their electricity consumption loads, average hours used per day and the approximate electricity consumption costs per month at current Windhoek prepaid meter electricity prices. The last column is a projection of monthly costs at a constant electricity price increment at 10% per annum over 5 years (Wienecke and Mawisa, 2008:17).

Appliance	Electricity Demand (w)	Hours used per day	Monthly Cost (N$)	10% price increase over 5 years(N$)
Geyser	2 500	5	285.00	427.50
Heater	1 600	4	145.92	218.88
Two plate cooker	2 000	2	91.20	136.80
Oven	2 500	1	57.00	85.80
Fridge	300	3	20.52	30.78
Kettle	2 200	0.5	25.08	37.62
Incadecent bulb (x3)	60	6	24.62	36.94
Iron	1 000	0.5	11.40	17.10
T. V. (colour)	80	4	7.30	10.94
Radio	6	4	0.55	0.82
Fluorecent bulb (x3)	15	6	6.16	9.23
sewing machine	100	3	6.84	10.26

Source: Wienecke and Mawisa,(2008).*Op.cit.*, p. 17

Table 4. Use of appliances in the home with their electricity consumption loads

Over the five year period, the running cost of the appliances would on average increase by about 33%. Electrical appliances and equipment should be compared to determine the amount of energy they consume. Below is a list of the most commonly used appliances in the home with their electricity consumption loads, average hours used per day and the approximate electricity consumption costs per month at current Windhoek prepaid meter electricity prices. The last column is a projection of monthly costs at a constant electricity price increment at 10% per annum over 5 years (Wienecke and Mawisa, 2008:17).

However, the costing of appliances used in the home does not consist only of purchase and operation costs. An appliance cost has to be considered for its operational life - what is termed life cycle costing. Life Cycle Costing is a process to determine the sum of all the costs associated with an asset or part thereof, including acquisition, installation, operation, maintenance, refurbishment and disposal costs. Table 5 shows the estimated lifecycle costs of common appliances used in the home. The costs include the cost of electricity connection, appliance costs, appliance replacement costs, and energy costs at current prices. The lifecycle cost is calculated for a period of five years (Wienecke and Mawisa, 2008:17).

Appliance	Electricity Demand (w)	Hours used per day	Monthly Cost (N$)	Estimated Lifecycle cost over 5 years(N$)
Geyser	2 500	5	285.00	22 608.73
Heater	1 600	4	145.92	12 274.20
Two plate cooker	2 000	2	91.20	8 941.95
Fridge	300	3	20.52	7 330.20
Kettle	2 200	0.5	25.08	5 019.75
Iron	1 000	0.5	11.40	4263.90
T. V. (colour)	80	4	7.30	6 617.00
Fluorecent bulb	15	6	6.16	3 711.16

Source: Wienecke and Mawisa,(2008).p. 17.

Table 5. Lifecycle costs of common appliances used in the home

4. The role of HRDC in Namibia

The establishment of the Habitat Research and Development Centre (HRDC) was initially based on the fact that about 80% of building and construction materials were imported. It is a well-known fact that there are many resources in Namibia, which are not utilised. In 2002 the then Ministry of Regional and Local Government and Housing (MRLGH) supported the proposal to build a Centre, which will investigate and test alternative technologies, building materials and approaches. The latter included design and architecture with a focus on various types of energy inputs. This resulted in expanding the options to be considered, from available resources, e.g. clay and lime, to additional natural resources such as prosopis and local stone, to what is called waste. The latter included old tyres, building rubble, and metal drums (Wienecke, 2010:17-18).

The operations of the HRDC had to consider a wide range of activities. The HRDC is an institution in which the public and private sector can participate, as well as NGOs active in housing and associated fields. This requires a trans-disciplinary and trans-institutional knowledge generation approach to achieve the numerous objectives in the field of housing and its related issues (Wienecke, 2010:17-18).

Most of the HRDC design is in accordance with concepts such as alternative technology and Green Architecture, by utilising locally available materials, recycling materials, environmental benefits are derived, and taking environmental aspects into consideration in the design and during the construction process.

The HRDC is a government funded project and experienced bureaucratic delays. The reason is simple: the team involved constantly looked for resources, which could be used. For example, its interesting to note that when the Windhoek Municipality demolished a flat building, HRDC contacted the municipality and made an enquire about the fate of the materials, e.g. building rubble, window and doorframes. The latter two were to be kept in store for a community project, whereas the rubble was to be dumped at a landfill site, as it was regarded as useless waste. Cooperating with the municipal department and the contractor the rubble was transported to the HRDC site, where it was reused in gabions and cement bricks were reused in walls. Similarly when a service station was built close to the site the natural stone (mica) left from the excavations for the petrol tanks were brought to the HRDC site – all free of charge (Wienecke, 2010).

When the construction of the HRDC started, the municipality issued a directive that all old tyres had to be transported to the main landfill site, where a fee of R7.50 per tyre was charged. This resulted in many tyres were disposed in the field around Windhoek. When the HRDC offered to take the tyres free of charge, hundreds were delivered to the site. They were incorporated in the construction of retaining walls, and buildings such as walls for storerooms and the double garage. Farmers in the southern parts of Namibia provided sheep wool, Grade 3, which was regarded as useless due its poor quality, but it was utilised in the construction as an insulating material between the roof sheets and the ceiling.

The question could be asked: what is the value of alternatives? Alternatives provide choices, they can support efforts of employment creation, they can utilise locally available materials. Most governments are interested in creating employment opportunities. Government has, for example, provided funding to train young school leavers in various skills. A group was trained as masons in 2010 at the HRDC. A private contractor provided them with the chance to gain practical experiences at one of his building sites what they have learned as interns. This cooperation of public and private institutions shows that there is an untapped potential of advancing local opportunities.

5. Conclusion

In conclusion, this chapter mainly discussed the RETs that provide energy for domestic use (predominantly cooking and heating) and those used to supply electricity. RETs used to produce energy for domestic use tend to do so by exploiting modern fuels or by utilizing traditional fuels in new and improved ways in Namibia. The chapter further discussed the RETs used in the rural development of countries like India, China, Nepal, Mozambique, and Kenya and so on. Namibia can fairly draw some lessons from the experiences of these countries.

Namibia has huge potential in the development of RETs for rural economic development. It is therefore the community based conservation has been regarded as one-way of protecting the environment and subsequently provide employment in rural Namibia. The efforts are exerted in this direction and the emphasis has been made on making money from the conservation, not to keep the environment in its pristine state. However, in general, the knowledge about nature and the intricate relationships between the many parts is still limited in Namibia, although people claim to have vast knowledge. Little knowledge can be dangerous. Earth is a highly complex ecosystem, which is hardly understood by humans. To continue with unsustainable practices is endangering the basis of life on earth. However, in many developing countries including Africa, the non-sustainable model of the North is promoted as the solution to the many problems. High population growth rates on a continent where a substantial percentage of the land consists of deserts and arid regions, the question of conserving and preserving natural resources has become critical.

With the provision of clean, off-grid electricity from solar panels, the air is cleaner, the village is more productive and women are becoming empowered. The cost of a solar system large enough for several lanterns is roughly the cost of one year's supply of kerosene. But, solar energy can only serve some of the Namibian rural communities energy needs.

Climate change is clearly a key influence on economic growth in Namibia. Therefore Namibia should no longer ignore the contribution of the environment to, and the importance of environmental sustainability for, national wealth in the face of the climatic shifts. It is imperative that Namibia needs to recognize and assess the likely impact of climate change on their desired development pathways of RETs, and to ensure all policies and activities are 'climate proof. While climate change clearly must be mainstreamed into policies and planning and this has to be done from the gross root level.

Sustainable development is important because all the choices we pursue and all the actions that we make today in Namibia will affect everything in the future. Government of Namibia needs to make sound decisions on renewable energy technologies at present in order to achieve the sustainable development and avoid limiting the resource availability for future generations.

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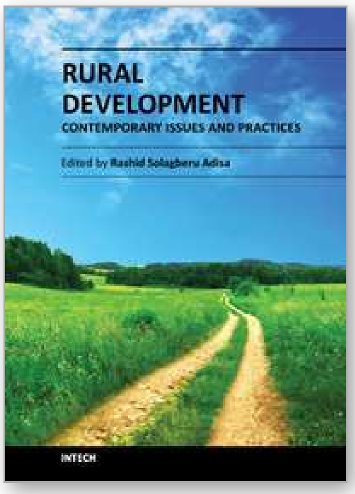

Rural Development - Contemporary Issues and Practices

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Development of rural areas has witnessed increasing attention globally, especially over the past three to four decades. The highpoint in the renewed global interest in the development of rural people and their environment was reached with the setting of the Millennium Development Goals (MDGs) in the year 2000. All of the set goals are basically rural development goals. With less than four years to the deadline for the achievement of the MDGs, it is almost certain that the goals are far from being achieved in, especially, most developing countries for whom the MDGs were essentially set. The struggle thus continues for rural development. As long as problems of poverty, disease, illiteracy, unemployment, poor infrastructure, environmental degradation and others persist (or increase) in rural communities, better and more result-oriented solutions to perennial and emerging problems of rural communities would be required. But rural development, in spite of the variations in thresholds of rurality among nations, is not exclusively a Third World or ‘developing countries’ process, owing to its multi-dimensionality. It is a global phenomenon that obviously requires global strategies. This book not only looks at rural development from its multi-dimensional perspectives, it is also a product of the experiences and expertise of distinguished scholars across the continents. Aiming to provide a comprehensive single volume that addresses salient issues and practices in rural development, the book covers themes ranging from sustainable agriculture, biodiversity conservation, strategic environmental assessment, renewable energy, rural financial resources, assessment of protected areas to statistics for rural development policy. Other subject matters covered by the book include social marginality, land use conflict, gender, cooperatives, animal health, rural marketing, information and communication technology, micro-business, and rural economic crisis. The book is thus an invaluable source of useful information on contemporary issues in rural development for researchers, policy makers, and students of rural development and other related fields.

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