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Sudan Government
“RENEWABLE ENERGY TECHNOLOGIES
For
SUSTAINABLE RURAL DEVELOPMENT”
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CONTENTS

• Introduction.
1. The Energy Situation in Sudan Rural Areas.
3. Forests Are the Primary Energy source Consumption.
4. Environmentally Appropriate Technologies for Sustainable Rural Development.
5. Recommendations.
6. References.
INTRODUCTION

More than 70% of the total 37 million Sudanese population lives in rural and isolated communities; characterized by extreme poverty and poor social and economical activities. The current electricity distribution reflects that the Sudan rural communities are completely out of the reach of the NEG and also being by-passed from the petroleum products supply pipe lines. The unavailability and the acute shortages of the conventional energy supply {petroleum & electricity} to rural people forced them to use alternatives available energy sources like biomass. That situation causes serious environmental degradation. Also due to shortages of energy supply, the rural people receive poor services in the followings:

- Food Security
- Water Supply
- Health Care
Poverty, and iniquity in the basic services are the major components that hindered rural development. Unless being addressed now, none of the great goals of the international & nation community peace, human rights, environment, and sustainable development will be achieved or even be progressed. Energy is a vital prime mover to the development whether in Urban or Rural Areas. The rural energy needs are modest compared to urban once and for proper rural development the following objectives must be considered;

- Analyze the key potentials and constraints for rural energy development.
- Assess the socio-technical information needed for decision makers and planners in rural development.
- Design, implement, and interpret different types of surveys to collect relevant information to be input to planners.
- Utilize a number of techniques and models supporting rural energy planning.
The previous sections indicate clearly the poor situation of convention energy supply to Sudanese rural people who are characterized by high dependence on biomass woody fuels, {fire wood & charcoal}. In order to raise rural living standards, the per capita energy availability must be increased; - Through better utilization of the local available energy resources. The rural energy requirements can be summarized in Table{1}, including the energy cost of the materials such as cement, fertilizer, etc.

The suitable energy source, needed for the above rural energy requirements must be of diffuse low cost types rather than high cost & large central installation once. Also they must be appropriate, environmentally, socially and economically acceptable. Some of these technologies are given in Table{2}. 
Table (1), Energy requirement in Sudan rural areas.

<table>
<thead>
<tr>
<th>Rural sector</th>
<th>Activity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Domestic</td>
<td>lighting, cooking, heating, cooling.</td>
</tr>
<tr>
<td>agriculture process</td>
<td>land preparation, harvesting, sowing, weaving</td>
</tr>
<tr>
<td>crop process &amp; storage</td>
<td>Drying, girding, and refrigeration.</td>
</tr>
<tr>
<td>Small &amp; medium industries</td>
<td>power machinery</td>
</tr>
<tr>
<td>Wind pumping</td>
<td>Domestic use.</td>
</tr>
<tr>
<td>Transport</td>
<td>Schools, clinics, communication, radio, television, etc.</td>
</tr>
</tbody>
</table>
Tab. (2): Energy Sources For Rural Areas.

<table>
<thead>
<tr>
<th>source</th>
<th>Form</th>
</tr>
</thead>
<tbody>
<tr>
<td>Solar energy</td>
<td>solar thermal + solar PV</td>
</tr>
<tr>
<td>biomass</td>
<td>woody fuel + non woody fuels</td>
</tr>
<tr>
<td>Wind energy</td>
<td>mechanical types + electric types</td>
</tr>
<tr>
<td>mini &amp; micro hydro</td>
<td>amass Water fall + current flow of water</td>
</tr>
<tr>
<td>geothermal</td>
<td>hot water</td>
</tr>
</tbody>
</table>
The present position for most people in rural areas for obtaining the needed energy forms (heat, light etc.), is that the sun in association with traditional building practices, provides environmental comfort conditions supplemented when necessary by fire wood. Cooking is largely by wood from forests or its derivative, charcoal. Cattle dung / agricultural waste being used to a lesser extent. Mechanical power is provided by human, animals, and diesel or gasoline engines. Some cooking & lighting is by kerosene. It should be recognized that this situation is unlikely to be changed for the next one or two decades. However because of the need to increase energy availability and also to find alternatives to the rapidly decreasing wood supplies in many rural areas. Its necessary that a vigorous program researching into alternative renewable energies should be setup immediately.
There should be much more realism in the formulation of such program, e.g. it's no use providing a solar powered pump at a price competitive with a diesel for someone who can not even afford a diesel engine. The urgent problem for rural development is to increase the energy available per capita and also for raising up the present level of extreme poverty and better basic needs services. Another area in which rural energy availability could be secured where woody fuels have become scarce, is the improvements of traditional cookers and ovens to improve their efficiency in fuel saving and by planting fast growing trees for constant future fuel supply.
2 - RENEWABLE ENERGY POTENTIAL & APPLICATIONS:

2.1 - biomass:

Biomass represents quite significant percentage of the Sudan Energy Balance. In 1995 contributed by 78% in the form of woody fuels i.e. charcoal and firewood. The non woody fuels (animal and agriculture waste) share was about 8%. Study carried out by Ministry of Energy & Mining in 1990/1989, indicated that:

- 96 million metric tons available from agriculture waste mainly cotton stalks, and peanut shells.
- 34.9 million metric tons available from animal waste.
- 3.49 million metric tons bagasse.

Table (3) and Table (4) give the estimated available amount of Agriculture.
Tab. (3): AGRICULTURE WASTE, Ref [6].

<table>
<thead>
<tr>
<th>Wastes types</th>
<th>Amount Thousands ton</th>
<th>% for energy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cotton stalks</td>
<td>292</td>
<td>8 %</td>
</tr>
<tr>
<td>Dura</td>
<td>6838</td>
<td>3 %</td>
</tr>
<tr>
<td>Millet</td>
<td>2381</td>
<td>2.5 %</td>
</tr>
<tr>
<td>Peanut shells</td>
<td>2230</td>
<td>6 %</td>
</tr>
</tbody>
</table>
### Tab. (4): Animal Waste.

<table>
<thead>
<tr>
<th>Animal Waste Type</th>
<th>Amount million ton</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cows</td>
<td>224.5</td>
<td>22.5%</td>
</tr>
<tr>
<td>Sheep &amp; goats</td>
<td>60.4</td>
<td>6%</td>
</tr>
<tr>
<td>Camels</td>
<td>16.4</td>
<td>1.6%</td>
</tr>
</tbody>
</table>
Utilization of both agriculture and animal waste started long time ago for animal feedings. The technology has been improved and used in dried pressed blocks or cakes with an additional of a binding material to give the stiffness. These blocks or briquettes are currently being used in commercial industries like, bread making, brick kilns etc. It is proved that these briquettes have almost the same firewood characteristics; with regard to sizes, strength and calorific values. Another use is carbonizing the waste and then pressed with a binding material and used in form of briquettes e.g. in shape of woody charcoal. Commercial effort also being tried and medium demonstration factories were being build in Rahad mechanized & Khashm Al Griba Schemes. Another use of the non woody fuel is the animal waste and being used in biogas digestors. The biogas technology is introduced worldwide and used for cooking at family and community or group sizes. The technology is known and the construction is based on the local available skills and materials. Currently there are more than 100 units built all over the Sudan. Essential requirement is the availability of animal waste from at least 3 cows or 10-15 goats/sheep.
2.2 - SOLAR ENERGY:

Sudan is rich in solar energy, with daily solar radiation and sunshine availability for more than 10 hrs, through the whole year. Fig {1} shows the solar radiation distribution in Sudan. This radiation can be utilized into two ways; Thermal solar application in the form of heat and the conversion to electricity by using solar photovoltaic cells. Research and development on solar energy began in Sudan forty years back at the level of the universities. Then in the 1970’s ERI was initiated. It started with manpower development and building the infrastructure. After mid 1980’s and wards results of R&D had been demonstrated in small scale through foreign and local support.. The Projects; - SREP, SEP, SWE and RSED were being implemented by ERI, MEM,FC and others related institutes, see Ref.[7] for more details.
These projects demonstrated the following solar energy technologies:
- Solar lighting system
- Solar P.V. pumps systems
- Solar cooling for health care
- Solar T.V. for education
- Telecommunication
- Solar water heater
- Solar cookers
- Solar evaporators
- Solar distills
The above solar system has been demonstrated in actual application. Monitoring and evaluation of the above applications have been carried out. The results indicated that they have remarkable socio-economic and environment impacts. Some of this application will be discussed in more depth in section 4.

Up to the end of the year 2002, Sudan used to import solar panels from abroad and mainly through NGOs, UN organs and individual private sectors through their involvement with the Government in the bilateral agreements. In the beginning of the year 2003 and through an agreement with R of China an assembly line of P.V. production was commissioned and started production of P.V. modules. The capacity of the assemble line is equivalent to one MGW [About 20,000 PV Module of 50wp]. The total PV system cost is reduced by 35% compared to the imported one.
2.3. Wind Energy:

SUDAN is considered within the low-medium range of wind regime. The coastal site (Red Sea) is the most promising, with annual average wind speed of 6.5 m/s. Also the North States (Karema & Dongola areas) are also good sites. They have an average annual wind speeds of 5 - 5.5 m/s. Khartoum and central states have annual average wind speeds of 4 - 4.5 m/s. West States have an annual average wind speeds of 3 - 3.5 m/s. The Southern States are really not suitable for wind energy application Fig{2}.

Wind energy in Sudan is currently used for pumping water from both deep & shallow wells to provide water for drinking and irrigation through the use of windpumps. This application is presently applied in the North, Khartoum, Central Butana and Nile States. The attractiveness of windpumps is that they can be manufactured completely from local available materials.
2.4- MINI & MICRO-HYDRO POTENTIAL & APPLICATION:

Mini & micro hydro can be utilized or being utilized in Sudan into two ways;

- The water falls from 1m to 10m.
- The current flow of Nile water

There are more than 200 suitable sites river turbines applications along the Blue & the main Niles. River turbines are currently being demonstrated on the main Nile, by Atbata university and ERI. The results so far indicated a promising future use.
2.5 - GEOTHERMAL Energy:

No detailed studies of the potential of the geothermal as a source of energy is being carried out in Sudan, but the following sites are expected to have a significant potential:

- Jabel Mara Area
- Volcanic territories
- Suwakin, red sea

Scientific field studies are needed on the above sites to determine the possibility of geothermal utilization.
3. Forests are the primary Energy, Sources:

Sudan is like other developing countries, biomes is a major primary energy supply. It contributes by a share of 87% of the total energy supply. About 70.8% of that % is in the form of wood fuels produced by forest. Agricultural waste and animal residues contribute by 7.7 % in form of non-woody fuel.
The woody fuel is produced by forest in form of charcoal and firewood. The non-woody fuels are produced form agricultural residues and animal waste in form of charcoal briquettes.
4- APPROPRIATE TECHNOLOGIES FOR SUSTAINABLE RURAL DEVELOPMENT:

The rural Areas development is essential and economically important since it will eventually lead to better standards of living, people's settlement and self- sufficiency in the following needs:

Food and water supplies
Better services in education and health care
Good communication modes

Due to the present limitations and sharp shortages/ or unavailability of both electricity and petroleum products to rural people, some renewable energy technologies (RET) are recommended as alternative options. The RET’s are based on utilizing local available energy sources, material and skills. These technologies are not for complete rural electrification (although they can), but they are applied as energy stand alone systems, providing energy sources to some rural basic needs. The RET’s are summarized in the tables{ 7} and Table(8 ) which provide information about capacity, total cost and components of the RETs.
4.1- Solar Home System (SHS):

Are used for providing electricity to School, Khallawa, Mosque, Churches and social clubs, Table (5) gives more details of SHS:
About 75% of the total system cost is in local currency
About 25% of the total cost is in USD$.
Life time 25 years or more.

4.2- Solar Water Pump System:

Used for pumping / lifting water - to supply water for drinking or irrigation.
About 60% of the total cost is in local currency.
About 40% of the total cost in USD$
Life time more than 20 years

4.3- Wind Pump Systems:

Are used for pumping/lifting water for drinking or irrigation purposes
100% cost in local currency
Life time more than 15 years.
4.4 - Small & Medium Wind Generators:
Used for providing electricity in the range of up to 50 kW.
About 80% of the total cost in local currency
About 20% of the total cost in USD$
Life time more than 15 years.

4.5 - Solar Fridges for Medical & Food Storage:
The solar fridges are used for both medical and food storage purposes.
Total costs depend on the capacity of the fringe.
About 70% of the total cost in local currency
About 30% of the total cost in USD$
Life time more than 20 years.

4.6 - Telecommunication:
Solar energy is used to power radio, faxes and telephones, etc.
About 85% of the total cost is in local currency.
About 15% of the total cost in USD$
Life time more than 20 years
4.7 - Energy Saving Cooking Stoves:

Cooking stoves for the use of both charcoal and firewood’s.

100% cost in local currency.

4.8 - Solar Cookers:

Solar cookers are used in rural and urban areas. 100% cost in local currency.

4.9 - Alternative Fuels From Agriculture & Animal Waste:

- Biogas diagestor- animal waste.
- Charcoal and briquettes- agricultural residues.
Both technologies are simple and completely from local available material. Main use for cooking and small industries like, brick making, bakeries ... etc. The RET’s mentioned above are being under testing and demonstration for the last twenty years (some of them more than 30 years). The results indicated that they are clean energy, reliable and sustainable technologies. Socio-economic and environmental studies were carried out by specialist on their applications. The output of the studies pointed out that, they are acceptable to the rural people and have measured remarkable impacts on the social life, economical activities and rural environment.
RECOMMENDATIONS:

1. Special energy conservation program in the household energy consumption is required.
2. Allocate officially certain lands for a forestation programs.
   
   2.1. Encourage agroforestry, trees planting and nurseries building programs with concentration on fuelwood types.
   2.2. Utilize and encourage the use of available potential of non woody fuels, such as agriculture and animal wastes.
   2.3. Encourage the use of improved cooking stoves with high efficiency in energy saving.
   2.4. Improve the efficiency of supplies and transportation modes of woody fuels from the production sites to consumption areas
3. Enhance and encourage R & D work in renewable energies applications, particularly for rural and isolated communities energy supplies.

   3.1. Implement the RET’s that prove their socio-economic and environmental acceptability.
   3.2. Prepare field studies on the potential availability of the mini and micro hydro potential.
   3.3. Prepare field studies on the possibility of utilizing the geothermal energy in the expected potential areas.
   3.4. Establish a financial systems or institutes to support the promotion of RET’s.
   3.5. Encourage and attract the interest of private and semi private organizations to invest in RET”s
4. Implement rural electrification program or secure adequate energy supplies to rural people.
4.1. Encourage social and economical rural activities and generate sustainable small and medium industries in rural areas, to alleviate poverty and raise the standard of living.
5. The revenues of oil export and the local availability of petroleum products must be invested and used to increase and develop the agricultural sector, for self-sufficiency in agricultural products and for exportation purpose.
5.1. Establish and encourage agro-industry activities.
5.2. Reduce the government support & direct management on Agricultural schemes
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