Economic Rationale and Assessments of Solar cooker project in Sudan  
Case study Darfur state

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Abstract
The study has examined assessment and an experiences of solar cooker in Sudan focusing on Darfur state Sudan; with the scientific background of the base line information of solar energy application in Sudan.

The main objectives of this study are: to assess the application of solar energy in Sudan focusing on rural areas by examining the solar cooker project; to enable provision alternative renewable energy sources to protect and enhance women's participation in environment conservation; and benefit from development of the solar cooker project support.

Hypotheses: The use of solar cooker reduces damage to environment, use of other means of power electricity etc. enhance damage to environment.

Methodology: The study using descriptive and analytical methods to evaluate the application of solar energy in Sudan focusing on rural areas as case study by examining the solar cooker project and describe how the solar cooker support for rural women in their basic needs for power.

The result of this paper found out the project of solar cooker is efficient in the areas; for instance solar cookers provide protection for women in the refugee camps. Instead of searching the desert for wood and increasing the risk of personal attack and rape, the women can stay in the protection of the camp and cook with the sun; as well as solar cooking save the deforestation.

The study recommends that: encouragement must be made to rural people to use solar energy technologies instead of conventional energy by providing incentives from the government; government should encourage solar energy systems in view of the environmental benefit; develop a viable institutional plan for Commercialization of solar cooker systems through demonstration seminars and workshops not only to potential users but also to distributors and the public at large; promote research and demonstration of use and adaption of solar cooker using.

Keywords: Sudan Energy potential, Renewable energy, sustainable development, environment, solar cooker, and solar photovoltaic.

-1 Introduction
Energy is an essential factor in the development movement, since it stimulates and supports the economic growth and development. In recent years, Sudan has increased efforts to exploit renewable energy sources and reduce its dependence on oil (1). Application of new and renewable sources of energy available in Sudan is now a major issue in the future energy strategic planning as alternative of fossil conventional energy to provide part of the local energy demand. The Government of the Sudan, in cooperation with various international development agencies, had explored the role of traditional and renewable energy technologies in meeting the demand of energy to the rural communities. (2)

Sudan is called Sun Belt; Population 40 million, Poverty Rate 46.5% Per capita Income 1270$. Electricity reaches only about 30% of Sudan population; more than 80% of the
population; lives in rural areas. Hence, Petroleum product supplies, including diesel, kerosene and LPG are irregular and often subject to sudden price increases. Because of the inadequate supply of these fuels, Most of this is utilized for cooking and heating water in rural and semi urban areas and by the urban poor. It is of a high need to provide alternative renewable energy sources to enhance development. Household energy was the first energy sector that paid explicit attention to women and their energy needs (3). The contribution of women in the development of energy is largely ignored. Conservation, protection and rehabilitation and environmental management women have been involved in promotion of appropriate energy technologies, primarily for rural population over the past 15 years. (1) This paper highlights the experience of solar cooker project working with rural women in Darfur in seeking solutions for community energy needs through renewable environmentally friendly energy technologies using solar cooker. Sudan is in the zone known as the solar belt, where there is a direct normal radiation that is one of the world’s strongest; Sudan was well placed to use solar energy. However, domestic power consumption dominates the market, with approximately 65% of electricity consumption being attributable to the sector. Erratic power supplies stood at 19 days per year on average in (2009) (2) have contributed to a high level of private generator ownership, particularly in the commercial and industrial sectors. Approximately 41% owned and used private generators in 2009. Transmission and distribution losses in the same year stood at 22%, an average figure for the region, but still high enough to cause constraints on economic efficiency for the national utility. Sudan is looking to exploit the Saharan sun to power its underdeveloped regions and green its deserts. The expense to use the sun’s energy for regions like Darfur is great, “The costs are high compared to other conventional energy resources plan was to develop solar energy in regions not linked to the national grid like Darfur (3).

-1.2 Statement of the problem:
More than 80% of the population live in rural and isolated communities with limited economic activities, a major problem for rural people is the inadequate supply of power for lighting, heating, cooking, cooling, water pumping, radio or TV communications and security services, Darfur women trek great distances into the forest to collect fuel wood, charcoal and biomass residues from animal and agriculture, account for more than half of total energy consumption; which increasing the risk of personal attack and rape.

-1.3 Objective of the study:
The main objectives of this study is to find out the application of solar energy in Sudan focusing on rural areas by estimating to the solar cooker project, with main aims to provide alternative renewable energy sources support rural women in their basic needs from power provide protection for women in the refugee camps, also to enhance women's participation in environment conservation, and benefit from development. The incomes of rural households are often seasonal and thus issues pertaining to affordability and sustainability were also considered.

-1.4 Hypotheses: The use of solar cooker reduces damage to environment, use of other means of power electricity etc. enhance damage to environment.

-1.5 Methodology:
The study will try to adapt a descriptive and analytical approach to figure out the finding of the analysis. Using descriptive and analytical methods to find out the application of solar energy in Sudan focusing on rural areas as case study by estimating to the solar cooker project, describe how the solar cooker support rural women in their basic needs from power also making Interview with some women in refugees camp. For the purpose of this study both
Secondary and primary data were obtained. The secondary data had been obtained from general literature review and Administration of Energy and Housing and Public Utilities (Darfur State). The primary data had been collected through a visit to some selected camps locations where solar cooker applications were used. Photographs were taken at the selected locations camps for illustration of both technologies besides its documentation.

1.6 Justification of the study:
First Safety and security of women in displaced area.
Secondly Reduce use of other sources of energy which lead to environment damage.
Thirdly to reduce cost energy espetially to consumers.

2 Types of energy in Sudan:
Energy is an essential factor in the development movement, since it stimulates and supports the economic growth and development. In recent years, Sudan has increased efforts to exploit renewable energy sources and reduce its dependence on oil after the separation from the south Sudan [1].

Sudan’s main energy source is biomass, mostly in traditional uses. Electricity constitutes only 2 percent of the country's energy consumption. The national electricity grid reaches a half million households, less than 10 percent of the population; major and minor local grids serve another 5 percent. Consequently, the majority of Sudanese take care of their energy needs themselves. In addition to biomass, liquefied petroleum gas and charcoal are sources of household energy. Wealthier households often invest in diesel generators.

Energy sources are divided into two main types; conventional energy (biomass, petroleum products, and electricity); and renewable energy (solar, wind, hydro, etc.). Sudan possesses a relatively high abundance of sunshine, solar radiation and moderate wind speeds, hydro and biomass energy resources.

Table No (1). Sudan’s energy balance as of year 2016.

<table>
<thead>
<tr>
<th>Demand Sectors</th>
<th>Power</th>
<th>Oil</th>
<th>Biomass</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>ktoe</td>
<td>%</td>
<td>ktoe</td>
<td>%</td>
</tr>
<tr>
<td>Residential</td>
<td>401</td>
<td>54.3</td>
<td>298</td>
<td>7.9</td>
</tr>
<tr>
<td>Transportation</td>
<td></td>
<td></td>
<td>2994</td>
<td>79.2</td>
</tr>
<tr>
<td>Services</td>
<td>181</td>
<td>24.5</td>
<td>43</td>
<td>1.1</td>
</tr>
<tr>
<td>Industry</td>
<td>120</td>
<td>16.3</td>
<td>400</td>
<td>10.6</td>
</tr>
<tr>
<td>Agriculture</td>
<td>36</td>
<td>4.9</td>
<td>43</td>
<td>1.1</td>
</tr>
<tr>
<td>Total</td>
<td>738</td>
<td>100</td>
<td>3778</td>
<td>100</td>
</tr>
</tbody>
</table>

Looking at the table, it is rather clear that the residential sector had the highest energy demand amongst all other listed sectors with 40% share and 3911 ktoe. It is also indicative that the biomass energy.

2.1 Renewable Energy
The role of renewable energy is big in solving essential live problems especially in rural areas for people and their resource development like the availing of energy for the medical services.
for people and animal, provision of water, education, communication and rural small industries.(11)

Fig.No (1) Renewable Energy

2.1.1 Thermal Generation:
There are 13 thermal power plants with different type of generation: steam turbines, gas turbines, combined cycle and diesel. The total installed capacity (grid + off grid) is about 1,650 MW.(3)

Fig.No(2) thermal and hydrogenation.

Source ministry of Water and Electricity 2017

2.1.2 Hydro generation:
In 1962 it was a first Hydro power plant to generate electricity from Sinnar Dam with a capacity of 15 MW. Sudan has five hydro power plants with a total capacity of 1,593 MW, Sinnar Power plant: consists of two units with total capacity of 15 MW (1962); Elgria Power plant: consists of three units Turbine and two units with a total capacity of 17.8 MW (1964); Merowe Dam Power plant it is bigger dams which erected in 2009, it is consists of (9) units with total capacity of 1250 MW. Merowe Dam power evacuated via transmission of high-voltage (500 kV) for the first time in Sudan. Total Hydro generation now 1593 MW (9)

2.1.3 Wind energy:
Average Wind speeds are estimated at 3-6 m/s; higher speeds have been recorded along the Red Sea coast. Average wind density in Sudan is estimated at 400 W/m2. Wind energy in Sudan is currently used for pumping water from both deep and shallow wells to provide drinking water and irrigation through the use of wind pumps.(3)
Solar energy is the radiant energy produced by the Sun. It is both light and heat. It, along with secondary solar-powered resources such as wind and wave power, account for the majority of the renewable energy on earth; the benefits of solar energy Solar energy is not only sustainable, it is renewable and this means that we will never run out of it. It is about as natural a source of power as it is possible to generate electricity. The creation of solar energy requires little maintenance. Once the solar panels have been installed and are working at maximum efficiency there is only a small amount of maintenance required each year to ensure they are in working order. They are a silent producer of energy. There is absolutely no noise made from photovoltaic panels as they convert sunlight into usable electricity (5). There are continual advancements in solar panel technology which are increasing the efficiency and lowering the cost of production, thus making it even more cost effective.

During operation solar electricity power plants produce zero emissions the major considerations for the design of the PV mini-grid’s distribution network in addition to optimized cost are that it be safe, adequate, efficient and expandable (4). It was required to identify available conductors optimized for size to meet the mini-grid’s load requirements. The objective was to minimize the life cycle cost (LCC) of the distribution network while ensuring sustainable and adequate power delivery. The solar PV system would be centrally located for optimal interconnection with the possibility of stringing more than one conductor in different directions (4).
The above table shows Sudan’s total solar energy technology achievements by different sectors.

**Fig.No (4).Solar potential in Sudan**

Solar energy resource available in Sudan (Solar Atlas) [2].

### Applications of Solar Energy Systems in Sudan

To evaluate the potential of different solar applications, a clear understanding of the fundamental requirement [6] Energy demand should be important enough; economically speaking, to justify investment costs in a solar system for the individual user. At the same time, the macroeconomic importance should be sufficient, in order to justify the development of solar systems; Energy supply that is the chances for the successful application of a solar system are greater in a climate with greater amounts of solar radiation. Solar system efficiency: High radiation; intensity values greatly contribute to solar system efficiency. Thus the climate can have a significant influence on efficiency. (Solar system cost’) Spreading the use of a solar system over the whole year rather than over just a few months. In evaluating the solar system cost versus performance, its feasibility should be compared not only with the conventional system, but with all the other alternatives.

Socio-economic outlook: different elements can play a crucial role here, e.g. the attitude of the users towards this new technology, the size and the degree of intensity of the populations. In this same socio-economic context it is appropriate to stress the widely recognized desirable aspects of solar system from the environmental point of view.
Grothoff [7] reported that, countries in Africa with the highest PV potential include among others, Sudan. Solar PV applications in Sudan started as early as 1970 [1]. PV technologies have a number of applications relevant to rural areas use in (Sudan). These include among others, electricity generation, PV pumping, telecommunication network, vaccine refrigeration for human and animal use, traffic lighting and lighting of road sign, over-speed detection on high ways, security services, schools power supply, rural health clinics, community centers and clubs, mosques and khalwa(s) lighting.(2)

Application of new and renewable sources of energy available in Sudan is now a major issue in the future energy strategic planning as alternative of fossil conventional energy to provide part of the local energy demand (10). The Government of the Sudan, in cooperation with various international development agencies, had explored the role of traditional and renewable energy technologies in meeting the demand of energy to the rural communities.

Solar energy applications can be divided into two main categories. (2) solar thermal application and photovoltaic technologies (PV). Solar thermal is a technology where the heat from solar energy is harnessed for heating purposes, while photovoltaic is a technology where arrays of cells which contain solar photovoltaic material convert the solar radiation into direct current electricity (2). A study was conducted to understand the characteristics and contribution of PV technologies; as one of the solar energy technologies, in Northern Darfur (Sudan) provided a baseline research on the specific applications to assess the appropriateness of these technologies, and to find out the elements of sustainability within the introduced technologies.

Fig.No (5). solar energy application in Sudan

The above figures show the solar energy application in Sudan in multiple ways, solar energy pumps to be used as illustrative fields for introducing farmers to the functioning of solar energy pumps, and for training on pump’s operation and maintenance.

Fig.No(6). On and off Grid in Sudan

<table>
<thead>
<tr>
<th>Country Forecast</th>
<th>Energy Demand</th>
<th>Peak Load</th>
</tr>
</thead>
<tbody>
<tr>
<td>2016</td>
<td>3.131</td>
<td>3.265</td>
</tr>
<tr>
<td>2017</td>
<td>3.249</td>
<td>3.456</td>
</tr>
<tr>
<td>2018</td>
<td>3.264</td>
<td>3.527</td>
</tr>
<tr>
<td>2019</td>
<td>3.282</td>
<td>3.892</td>
</tr>
<tr>
<td>2020</td>
<td>3.298</td>
<td>3.986</td>
</tr>
<tr>
<td>2021</td>
<td>3.314</td>
<td>3.472</td>
</tr>
<tr>
<td>2022</td>
<td>3.331</td>
<td>3.733</td>
</tr>
<tr>
<td>2023</td>
<td>3.348</td>
<td>3.863</td>
</tr>
<tr>
<td>2024</td>
<td>3.365</td>
<td>3.972</td>
</tr>
<tr>
<td>2025</td>
<td>3.382</td>
<td>4.083</td>
</tr>
<tr>
<td>2026</td>
<td>3.399</td>
<td>4.192</td>
</tr>
<tr>
<td>2027</td>
<td>3.416</td>
<td>4.301</td>
</tr>
<tr>
<td>2028</td>
<td>3.433</td>
<td>4.411</td>
</tr>
<tr>
<td>2029</td>
<td>3.450</td>
<td>4.521</td>
</tr>
<tr>
<td>2030</td>
<td>3.465</td>
<td>4.631</td>
</tr>
<tr>
<td>2031</td>
<td>3.482</td>
<td>4.741</td>
</tr>
</tbody>
</table>

Source ministry of Water and Electricity 2016
Fig. No (7). Energy demand (GWh)

The above figures show the energy demand (GWh) with peak load (MW) with forecasting till 2031.

The Solar Home System (SHS) is intended to provide the user with a convenient means of supplying power for small electrical loads such as lights, TV and an outlet for charging a mobile phone. Each SHS consists of photovoltaic (PV) modules, charge controllers, batteries and DC/AC inverters along with luminaries, related electronic and electrical components and mounting hardware. A typical SHS operates at a rated voltage of 220 VAC and provides power for fluorescent luminaries, a colored TV or similar low-power appliance for about three to five hours a day. Additionally, a smaller 50 Wp systems intended to run about 2-3 lamps and a black and white TV. The system should be designed to have at least two days autonomy (i.e. can run for two consecutive days without charging from the panel). The SHS is packaged to provide convenient installation at a remote customer home site by a qualified technician. The system is constructed such that a user can perform routine maintenance such as adding battery water if needed, and replacing light bulbs and fuses, and a technician can easily perform system diagnostics or replace components.(9)

Study Area

Darfur is a region in western Sudan covers an area of 493,180 square kilometers (190,420 sq. mi) It is largely an arid plateau with the Marrah Mountains (Jebel Marra), a range of volcanic peaks rising up to 3,042 meters (9,980 ft.) of topographic prominence, in the center of the region. The region's main towns are Al Fashir and Nyala, population estimate 2017 9,241,369 with density 18.7/km. is covered with plains and low hills of sandy soils are the wadis feature are the Marrah Mountains and Daju Hills, The main source of energy which applicable in Sudan for rural now is solar energy, and Darfur State has been considered as one of the best parts of the Sudan for exploiting solar energy as shown in Fig. (8)
Solar Cooker
The principle of solar cooking is simple: the sun’s rays are gathered and focused by reflective surfaces on a cooking pot. A plastic bag around the pot retains heat. A solar cooker is a device which uses the energy of direct sunlight to heat, cook or pasteurize drink. Many solar cookers currently in use are relatively inexpensive, low-tech devices, although some are as powerful or as expensive as traditional stoves, and advanced, large-scale solar cookers can cook for hundreds of people. Because they use no fuel and cost nothing to operate, many nonprofit organizations are promoting their use worldwide in order to help reduce fuel costs especially where monetary reciprocity is low; and air pollution, and to slow down the deforestation and desertification caused by lessen gathering firewood for cooking. Solar cooking is a form of outdoor cooking and is often used in situations where minimal fuel consumption is important, or the danger of accidental fires is high, and the health and environmental consequences of alternatives are severe. Many types of solar cookers exist, including curved concentrator solar cookers, solar ovens, and panel cookers, among others.

Assessment of Solar Cooker Project
Established in 2007 by American fund, the aim of this project is to learn, train and teach on the principle of how to use and construct solar cookers, which provide protection for women in the refugee camps. Instead of scouring the desert for wood and increasing the risk of personal attack and rape the women can stay in the protection of the camp and cook with the sun much of the time. Deforestation is also a major issue address by solar cooking, painting pots, spreading glue, attaching aluminum foil and cutting cardboard were all part of the training Instruction and teaching on the principles of solar cooking were all a part of the two day event, Preparing food to eat and tea to drink makes solar cooking a satisfying event. But even more so when we are helping to protect the environment and the people who live in it. Many of these people living in Darfur are displaced from other regions of Sudan. Most are very poor and like others Sudanese they spend a large amount of their income on cooking fuel. Cooking with the sun utilizes a free source of energy that is readily available in Sudan. For this technology to be accepted both men and women have to choose an adjustment in their life style and cooking habits. Food has to be eaten during the daylight hours or kept in heat retention baskets fora night meal. Early morning tea has to be prepared the day ahead and kept in a hot flask.

Solar Cooker Program Implemented in Sudan Khartoum, Omdurman, El Fasher, Kutum, Malit, Um Baru, Korma localities in North Darfur Saliki camp, South Darfur. The conflict in Darfur has accelerated the destruction of the environment around camps for Internally Displaced Persons (IDPs). Shortages of fuel wood have had severe negative impact on Darfur females. Wood collection exposes women and girls to attacks, every day they must travel longer distances to find wood. In addition to safety risks, this work reduces the time and energy available for other activities of child rearing and household income generation. With over 2.6 million displaced people mainly women and children the cycle of degradation and shortages requires that effective alternatives be implemented.

Type of solar cooker is especially suitable for Darfur with hot, dry days most of the year. All types of local foods can be cooked using this cooker. While the technology does not eliminate wood-fueled cooking during rainy periods, it does deliver key benefits: Dramatically cuts the cost of and/or time spent gathering traditional fuels; diminishes exposure to assault; slows deforestation around camps; is portable and easy to set up; eliminates fire hazard and burn risk, especially for children.
4.3 Solar cooker training:

Training is key to adoption of this technology; the host facility was the house of learning the illustrated Arabic-language training manual and a compendium of recipes for common foods are significant assets to program expansion throughout the region. The cost per solar cooker, including training, is approximately $30. This includes the costs of cardboard, foil, pots and painting supplies, and plastic bags to retain heat. From 2006 through 2008, a total of 203 women in five locations Kutum, Malit, Um Baru, and Korma localities in North Darfur, while Sakali camp, South Darfur have completed Solar Cooker training.

In February 2008 the program conducted a series of trainings in collaboration with local NGOs, the Sudanese Humanitarian Aid Commission and the Sudanese Environment Protection Society. Many trainees continue with the program as local trainers. Trainee totals by location indicated women trained but not provided with complete supplies of materials.

Through 2008, Darfur Peace and Development Organization (DPDO) has subsidized training and materials procurement for this program. A goal to develop the ability of trainers to establish micro-enterprises that manufacture and sell the cookers while continuing the trainings in camps and villages available in rural areas.

The solar cooker is an important tool that can help limit and reverse the negative consequences of fuel wood collection for Darfur women. DPDO’s Solar Cooker Program is designed to bring this tool into widespread, everyday use throughout Sudan, particularly among the displaced families in Darfur. DPDO’s pilot trainings in 2006 and 2007 demonstrated that the solar cooker is not only acceptable, but has been enthusiastically embraced by many women in the target populations. In general, costs are much reduced and self-sufficiency promoted by securing all materials in Sudan rather than shipping pre-made cookers to the target population. Through 2008, a total of 381 women in five locations Kutum, Malit, Um Baru, and Korma localities in North Darfur Saliki IDP camp, South Darfur have completed Solar Cooker training.

Table (3) show the No of women training 2006-2007

<table>
<thead>
<tr>
<th>Location</th>
<th>Training</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sakali camp Nyala</td>
<td>50</td>
</tr>
<tr>
<td>Kutom</td>
<td>25</td>
</tr>
<tr>
<td>Mali</td>
<td>30</td>
</tr>
<tr>
<td>Um Baru</td>
<td>60</td>
</tr>
<tr>
<td>Korma</td>
<td>47</td>
</tr>
<tr>
<td>Total</td>
<td>203</td>
</tr>
</tbody>
</table>

Field work 2017

Table (4) show the No of women training 2008-2010

<table>
<thead>
<tr>
<th>Location</th>
<th>Training</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sakali camp Nyala</td>
<td>150</td>
</tr>
<tr>
<td>Kutom</td>
<td>50</td>
</tr>
<tr>
<td>Mali</td>
<td>60</td>
</tr>
<tr>
<td>Um Baru</td>
<td>66</td>
</tr>
<tr>
<td>Korma</td>
<td>55</td>
</tr>
<tr>
<td>Total</td>
<td>381</td>
</tr>
</tbody>
</table>

Table show the No of women training 2008-2010 indicate that the desire of women to using this technology increased; which clearly show the positive effect and impact of the solar cooker.
First generation of women and cook it style of solar cookers! This group is now starting to use the 1 generation of cook it made from plastic. The women made all their own cookers from cardboard and aluminum foil. They painted the cooking pots black and got all their supplies ready for graduation day! Pots, cookers and clear bags were given to each women who graduated from the training class. New improved plastic cooker were also given to a few of the women to test.

**Fig N0 (10) Practicing The food cooked**

The women cooked rice and tea and discussed how this would better their lives. They escapes from attack and gender violence. The conclusion was the same. We need these Solar Cookers to Protect Ourselves!

**Fig No (11) Women training using improved plastic solar cooker**
New improved plastic cooker were also given to a few of the women to test. These models we hope will last much longer than the cardboard models.

Training Teaching was done by lecture as well as hands on interaction with solar cookers and how to construct them.

Women of north and south Darfur now a day’s use solar cooker in a wide range of their daily used the solar cooker projects, have widely support in the developing settlement and sustainable development there are a large number of rural women, they need this kind of power, to improve their life and operate different activities, but unfortunately, the power of the projects lack of enough fund after the fund stopped.

Solar cooking is not the “end all” to the issue of fuel shortage but simply a part of the solution. Conservation of fossil fuel, wise usage of wood and fuel efficient stoves play a significant part as well as reforestation efforts in the community.

Fig No (12) women collection of wood

[Images of women collecting wood]

Women searching for trek great distances into the forest to collect fuel wood, charcoal and biomass residues from animal and agriculture.

5Conclusion

By using solar power, Sudan could be setting a global example across a world that is worried about climate change. As we know Sudan has a immense land contains fertilizer soil. It could be more beneficial through the use of solar energy. It would be easy to pump water into the agricultural project. We can replace the diesel energy with solar energy power, whose life span is now roughly 25 years without having operation cost like fuel and spare parts. The reduction of carbon dioxide’s emission may result from burning diesel fuel, and also would serves the environment.

Solar energy has great potential for the future. Solar energy is free, and its supplies are unlimited. It does not pollute or otherwise damage the environment. It cannot be controlled by any one nation or industry. If we can improve the technology to harness the sun’s enormous power, we may never face energy shortages again.

Solar cooking is the simplest, safest, most convenient way to cook food without consuming fuels or heating up the kitchen. Many people choose to solar cook for these reasons. But for hundreds of millions of people around the world who cook over fires fueled by wood or dung, and who walk for miles to collect wood or spend much of their meager incomes on fuel, solar cooking is more than a choice it is a blessing. There are numerous reasons to cook the natural way with the sun.

Benefits to: households health professionals businesses governments humanitarian, development and relief organizations environmental programs.
5.1 HEALTH AND NUTRITION
Moderate cooking temperatures in simple solar cookers help preserve nutrients. Smoky cooking fires irritate lungs and eyes and can cause diseases. Solar cookers are smoke-free. Cooking fires are dangerous, especially for children, and can readily get out of control causing damage to buildings, gardens, etc. Solar cookers are fire-free. Millions of women routinely walk for miles to collect fuel wood for cooking. Burdensome fuel-gathering trips can cause injuries, and expose women to danger from animals and criminals. Solar cooking reduces these risks and burdens, and frees time for other activities. With good sunlight, solar cookers can be used to cook food or pasteurize water during emergencies when other fuels and power sources may not be available.

5.2 Benefits to health professionals
Many solar cookers can be used to disinfect dry medical supplies such as medical instruments, bandages and other cloth materials, as well as to heat compresses. Indoor smoke from cooking fires leads to childhood pneumonia, responsible for over four million deaths per year. Solar cookers are smoke-free. Preventable waterborne diseases are responsible for 80% of all illnesses and deaths in the developing world. Solar cookers can be used at the household level to pasteurize water and milk, making them safe to drink. A Water Pasteurization Indicator can be used with a solar cooker to determine whether water has been sufficiently heated to be safe to drink.

5.3 ECONOMICS
Many poverty-stricken families worldwide spend 25% or more of their income on cooking fuel. Sunlight solar cooker "fuel" is free and abundant. Money saved can be used for food, education, health care, etc. Solar cooker businesses can provide extra income. Opportunities include cooker manufacturing, sales and repair, as well as solar food businesses like restaurants and bakeries.

5.4 CONVENIENCE
At moderate solar cooking temperatures food doesn't need to be stirred and won't burn. Food can simply be placed in a solar cooker and left to cook, unattended, for several hours while other activities are pursued. In the right circumstances it is possible to put a solar cooker out in the morning and return home in the late afternoon to a hot meal ready to eat. Pots used for solar cooking are easy to clean a fact especially valuable for women who must walk many kilometers to collect water. Many solar cookers are portable, allowing for solar cooking at work sites or while pursuing outdoor activities like picnics, trekking or camping.

5.5 Benefits to governments
Reduce imports of and subsidies on biomass and fossil fuels. Where forests are disappearing and many people suffer from fuel shortages, solar cookers reduce families' fuel wood needs by 30-50%. Electric companies that have trouble meeting peak hour demand because of heavy use of stoves and air conditioners can reduce that demand by promoting use of solar cookers.

5.6 Benefits to humanitarian, development and relief organizations
Address clients' fuel shortages affecting local health, nutrition and education. Budget savings for institutional cooking fuels and disaster relief situations. In some regions distribution of biomass and fossil fuels are subsidized by aid agencies. Broad use of solar cookers can decrease these costs so that more people can benefit from these humanitarian funds.

5.7 Benefits to environmental programs
5.2 Important considerations
• Solar cookers require direct sunlight to function properly. Shadows, clouds and inclement weather limit their effectiveness. Solar cookers should be used on sunny days, in locations where shadows are not a concern.
• In most regions of the world there are a few months when simple solar cookers have limited usefulness, due to low solar radiation intensity. In general, you can solar cook when the length of your shadow on the ground is shorter than your height. This is an indicator that the sun is high enough in the sky to cook. Some solar cookers, however, are efficient enough to be used year-round.

Two billion people rely on wood and charcoal for cooking fuel. Solar cooking alleviates the conflict between their basic needs and the need to preserve earth's dwindling forests. Biomass and petroleum fueled cooking fires pollute the air and contribute to global warming. Solar cookers are pollution-free, and, when used in large numbers, may help curb global warming. Kitchens remain cool while food solar cooks outdoors. This reduces the load on air conditioners.

6- Summary

Range of applications for solar PV in Sudan is not wide; all applications consist of off-grid connectivity and small application used mostly for public lighting such as street lighting, lanterns, domestic power in urban areas and small electrification systems. In recent years, it is also being used for powering water pumps for farming and drinking and being used in communication towers, as well there is an attempt to connect photovoltaic power plant to the grid. Solar energy average solar insulation in the country is roughly 6.1 kWh/m2/day, indicating a high potential for solar energy use. Total potentials over the course of a year have been estimated at 10.1 GJ/m2, utilized PV to electrify 13 rural and per-urban communities, with some 45,000 households in the country now using PV systems. Through the use of solar energy it would be easy to pump water into agricultural projects. There is a lot of underground water in all these areas of Sudan. There is a necessity to replace the diesel-powered water pumps – currently used in agricultural schemes - with solar energy-powered ones whose lifespan is now roughly 25 years without having operation costs, such as fuel and spare parts. These projects will also reduce emissions of carbon dioxide resulting from the burning of diesel fuel. Solar energy-powered pumps project for irrigation could serve the environment, development and agricultural. All renewable energy resources can be integrated easy design, installation and maintenance with standard components from grid connected market. Easy extension and connection to the public grid is possible Photovoltaic is the energy resource with the highest potential and decreasing cost.

7- Recommendations

1. Develop a viable institutional plan for Commercialization of solar energy systems through demonstration seminars and workshops not only to potential users but also to distributors and the public at large.
2. Encourage the rural people to use solar energy technologies instead of conventional energy by providing incentives from the government. Also, government should encourage solar energy systems in view of the environmental benefit.
3. Encourage training opportunities to personnel at different levels.
4. Availability of fund for maintenance of solar cooker systems and administration for maintenance responsibility.
5. Encourage the private sector to assemble, install, and repair and manufacture of solar energy devices.
6. Promote research and development, demonstration and adaption of solar energy.
8-References:


4- National Assembly, and the Energy Research Institute Sudan 2016 the renewable energy policy.


11- TECHNICAL, ECONOMIC AND SUSTAINABILITY CONSIDERATIONS OF A SOLAR PV MINI GRID AS A TOOL FOR RURAL ELECTRIFICATION IN UGANDA Geoffrey Bakkabalindi*, Al-Mas Sendegeya1, Izael Da Silva1, Eriabu Lugujjo1 Dept. of Electrical Eng., Makerere University, P. O. Box 7062, Kampala, Uganda.

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