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Title: **LOW COST SOLAR ENERGY APPLICATIONS IN RURAL SETTINGS**

Abstract

This paper presents an overview of some proven solar energy applications that can be easily disseminated in rural areas of the Arab world. All of the presented technologies have one thing in common; that is, they are of low cost and low maintenance. They can be managed and even produced by locally available material and skills. More specifically, this overview covers the applications of: large scale *solar crop drying*, box type *solar oven* for food cooking, and *disinfecting of drinking water* with solar energy. Other potential applications of solar energy, such as: *solar water heating*, *greenhouses*, *passive solar architecture*, and *composting latrines*, are treated briefly. Photographs and illustrations are integrated in the paper. This paper does not treat the photovoltaic technology as well as high temperature applications of solar energy.

Besides energy savings, applications of solar technologies bring various benefits to rural households. **Solar crop drying** brings economic benefits to farmers and cooperatives. It produces high quality storable products.

Solar cooking in box-type solar ovens is one of the most efficient uses of the solar power. In the Arab region families can cook in it their main daily meals for more than 300 days per year. It is easier, cleaner, safer, convenient and cheaper to cook with solar oven.

Solar disinfection of drinking water is a simple technology, which provides safe drinking water, free from bacterial contamination. This improves the health conditions of people in general and it saves the lives of small children in particular. It saves the money that is spent on bottled water or on measures for sterilization of available water.

INTRODUCTION

Global warming phenomena, pollution of the atmosphere, acid rains, and irrational management of natural resources are some of the major environmental issues that humanity is facing for its survival on the planet Earth. The major cause of these problems is the use of fossil fuels by man. Since early 1970s the international community is exerting consistent efforts, to reverse the trends that lead into the deterioration of the environment. The major decisions that are being taken nowadays emphasize the preventive measures, which are proved to be much effective than remedial approaches. It is a well-established fact that, man should avoid the deterioration of the environment by implementing alternative practices and processes to their activities.

The applications of renewable energy technologies, particularly the ones related to solar energy applications are the ideal alternative practices in the energy sector. These provide us with the cleaner energy production options. By mass scale application of these alternative measures, it is foreseen that man will be able to minimize the trend of environmental deterioration.

The use of solar energy applications and other renewable energy devices offset pollution, which would be produced by using fossil fuels. For instance, for a four-member family, using solar water heaters means offsetting about 1-2 tons of carbon dioxide per year from the atmosphere, which is a greenhouse gas. It would also accrue a return on investment of around 10-20 %. (Talbot 2000).

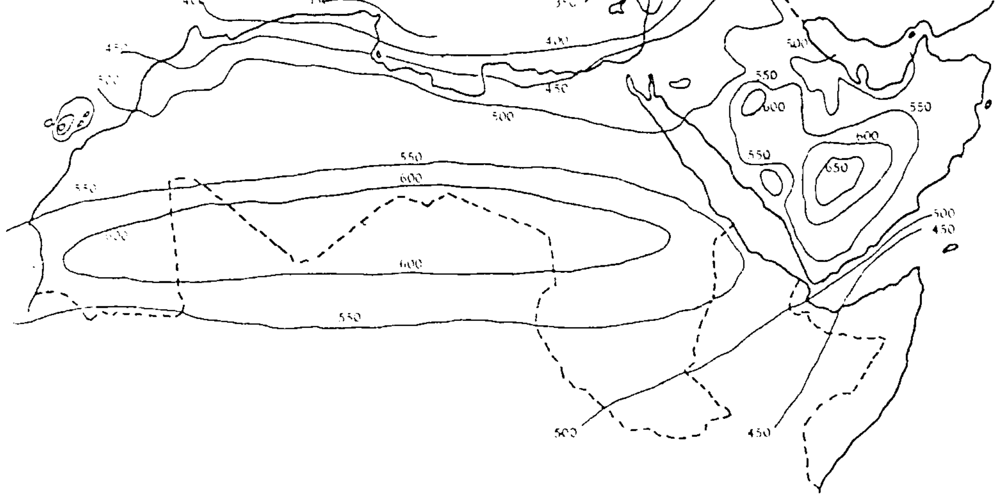
Since 1970s and 1980s some discrete efforts are being exerted in the ESCWA region for the dissemination of the applications of renewable energy technologies. So far these efforts have not lead into the stimulation of wide scale application of renewable energy related technologies by the general public, particularly in the rural areas. Usually the efforts in each country have been confined to pilot studies or limited activities carried out by university circles and research centres. It is urgently needed to diffuse the renewable energy applications in the rural areas.

POTENTIAL SOLAR ENERGY APPLICATIONS IN THE ARAB COUNTRIES

Sun is the ultimate source of many types of renewable energy. Wind, biomass, waves and other forms of renewable energy have their origin in the solar power that is radiated from the sun.

The Arab world, including the ESCWA region, falls in an area of very high insolation, which ranges from 300-700 cal/cm^2 per day, as indicated in the following map. The average insolation of the Arab world is estimated at more than 520 cal/cm^2/day or about 250 w/m^2. (Figure-1 presents the insolation map of the Arab countries). This is the most abundant clean energy resource that all Arab countries possess. The solar energy reaching the entire Arab territories in one year is estimated at 30 x 10^{15} kWh, or 100Q units, which is more than five times than the estimated reserves of petroleum on Earth. (ESCWA 1981).

Figure-1: Yearly average isopleths in the Arab world; equal insolation received at the surface of the ground. Values in cal/cm^2 day.(ESCWA 1981)



However, solar energy reaches on the Earth's surface discretely and its collection and use is not always competitive with the non-renewable energy sources.

But there are various matured solar technologies, which can be readily applied in the rural areas, and which are economically feasible in most Arab countries. The largest share is for domestic level solar **water heating**, which is economically attractive to most Arab countries, but only in some countries it is being applied in a wide scale. Jordan is the most advanced country in this respect, while in Tunisia, Lebanon, Syria and Egypt its application is at a lesser extent. **Solar crop drying** and **solar water desalination** (distillation) are applied at limited scale in some Arab countries, while solar **greenhouses** are widely practiced in Lebanon, Jordan and in other countries. **Solar indoor space heating** and **cooling, disinfection of drinking water** and other applications of solar technologies are limited to very small scale use. A recent practice, **solarization**, is being evolved for the disinfection of the soil of greenhouses. In here the direct solar energy is utilized, to kill harmful fungi prior to seeding. This technique is being promoted in all Arab countries, through the global programme related to Montreal Protocol for the protection of ozone layer. Solarization is considered as an alternative to methyl bromide, which is ozone depleting agent and which is being phased out globally.

Solar energy applications need to be integrated to various other rural activities, such as: solar architecture, improvement of composting process of organic wastes, speeding up biologic activity in waterless/odorless latrines.

Due to the limitations of this paper, we have presented here below the details of three types of solar energy applications, which have the potential of bringing economic and environmental benefits to rural areas. In addition, brief descriptions of other types of potential applications are also presented. Those solar energy applications are the following:

1- Large scale solar crop drying

Open drying of agricultural products and meats is the oldest means for food preservation in the world, but it is not an effective measure for obtaining quality products, which are free from insects, dust and mold. In the last decades attempts have been made in various countries for research and development and for dissemination of the concept of solar crop drying. Solar dryers of various sizes and design are developed in many countries of the world. But most of these new devices have found limited applications, because of technical and operational inconveniences during their use. However, the breakthrough in this field came by the development of large size **solar tunnel dryers**. This device enables attainment of high quality dried food products, which commend high price in the local and international markets.

Large-scale solar crop drying is adequate in rural areas, particularly when large quantities of products, such as fruits and vegetables get spoiled because of lack of markets. The use of large-scale solar dryers enables the rural householders to start commercial enterprises for food drying, packaging and marketing. This creates job opportunities for rural women and helps farmers to have better income.

Morocco is the most advanced Arab country, where commercial scale solar drying of apricots, grapes and herbs is being carried out. In Lebanon, during the last couple of years large scale solar crop drying is being introduced in rural development programmes.

Large-scale solar crop drying with Solar Tunnel Dryers is a proven technology. Solar drying protects the products from the enemies of stored food, namely: insects, dust and mold. Large-scale solar dryers are the most practical tools for commercial scale production of dried food products. Through solar drying, harvest turns into storable and high quality tradable good. The stored goods become a regular source of income for farmers and diminish their dependence on seasonal harvest and low farm-gate prices of products.

The Solar Tunnel Dryer is suitable for commercial scale drying of fruits, vegetables, medicinal plants, spices and meats. It can also be used in industries where drying of products is involved. Even under the adverse weather conditions the operation of tunnel dryers are reliable.

Specific advantages of good quality solar tunnel dryers include:

- Many types of products can be dried in a solar tunnel dryer including: ***dates, apple, apricot, grapes, figs, citrus slices, banana, tomato, potato, onion, garlic, spices, pepper, medicinal plants, fish, meat, and other products.***
- They have large loading capacity: 600 to 1000 kg of fruits and vegetables or 150 to 300 kg of herbs. They dry 4 times faster than open drying.
- Each batch of food products can be dried within 1-4 days, depending on the thickness of the crops and the intensity of solar insolation.
- They are built with durable material and have long lifetime, which exceeds 30 years.
- The capital cost of a dryer can be returned within one year.
- They provide superior hygienic conditions by protecting the crops from insect infestations, dust and rain.
- They operate without energy costs. They get their power supply from the sun, free of charge.
- They can attain temperatures in the range of 30-80°C or more. This allows preparing jams and pastes in the dryer.
- Their ventilation system is based on the electricity that is generated by photovoltaic solar panels, assembled on the dryers. Ventilators are the only moving parts of the system. They stop when there is no sunrays. (Hauser 1997, $MECTAT_b$ 1998).

The following photograph and illustration give an idea on the size and practicality of the solar tunnel dryer.

Figure-2: Drying apricots with solar tunnel dryer

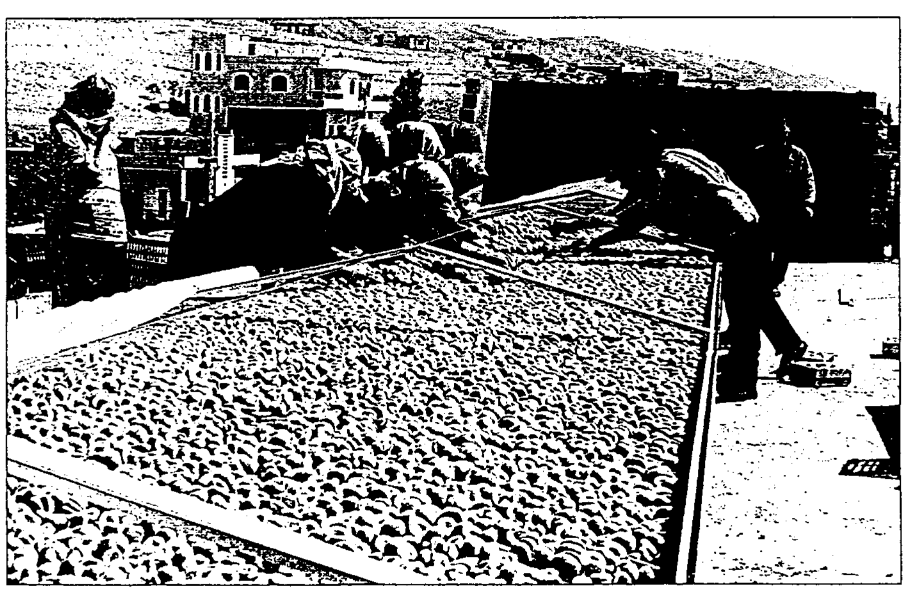
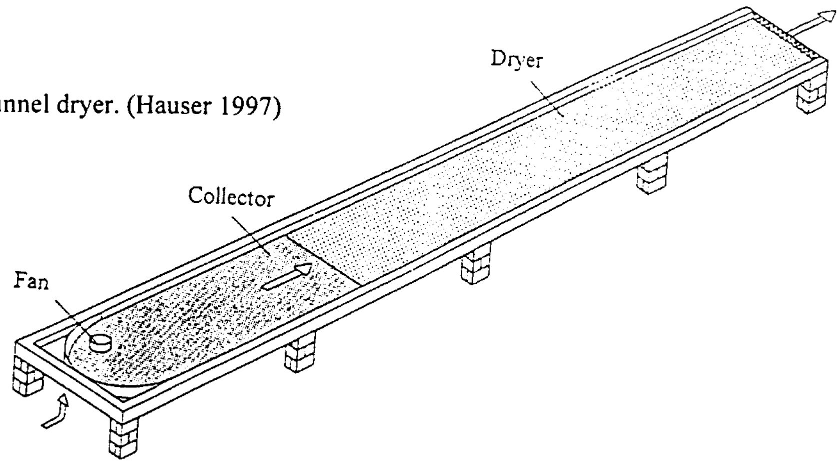


Figure-3: The layout of a typical solar tunnel dryer. (Hauser 1997)



Household scale solar dryers have also been developed in various research centres of the world, including the Arab region. Even low cost foldable models of crop dryers are available, which can be mass produced and distributed to rural households. This device enables proper preservation of foodstuffs for domestic use. It contributes for family food security. At a price of less than $5, a foldable dryer of 0.25 m^2 area can enable rural women to preserve their food products, which need drying. (MECTAT$_b$ 1998).

Large-scale solar crop drying is a tool for attaining sustainable development in rural areas of many Arab countries.

2- Box-type solar oven for food cooking

Cooking with solar energy is one of the most efficient uses of the solar power. Its use is cheaper compared with other forms of cooking and beneficial for areas with abundant sunshine.

The need for solar cooking is greater than it is for solar water heating in most of the rural areas of the developing countries. Unfortunately, scientific community has not given enough attention to solar cooking. Most of their work has been concentrated on developing the solar water heater, which is the need of affluent societies.

There exist three types of solar cookers, namely: concentrating mirrors; steam cookers; and, box-type solar cookers or solar ovens. Solar ovens are the simplest and most practical solar cookers due to their ease for use at domestic level, which can be easily built with locally available low cost materials and skills.
The solar oven is a proven technology, beneficial in areas with much sunlight, which is the case of Arab countries.

It is easier to cook with solar oven than cooking with gas oven or electric stove. The cooking process does not need tending and there is no fear of burning or overcooking. On an average, the cooking take about 30 to 45 minutes longer when compared with cooking on gas or conventional stoves. But the taste of food cooked in solar ovens is superior than that cooked with other types of stoves.

In the Arab World, where the sunny days are numerous, people with box-type solar ovens can at least cook their main dish for more than 300 days per year, thus, relieving the firewood demand in rural regions, where often forest resources are scarce. Therefore, solar cooking is an efficient way to fight deforestation in regions where firewood is widely used for cooking. E.g. Yemen and Sudan.

Solar ovens absorb the incoming solar rays and store the trapped heat energy. The temperature in the solar oven rises easily to above 100°C, which is sufficient for cooking. The temperature can even reach to 200°C and above. The oven can be used to cook all types of foods that need baking or boiling. It can easily cook meats, vegetables and cereals. Even bottling of cooked food can be done in the solar oven.

Solar cooking with solar ovens can also become a popular exercise for students, in their school projects.

MECTAT's experience in cooking with solar ovens

Since 1983, MECTAT (The Middle East Centre for the Transfer of Appropriate Technology) has carried out intensive research work on solar ovens. So far ten models of solar ovens are designed, constructed and field tested at MECTAT, and many other ovens are constructed during training sessions.

A solar oven is just a box within a box, between them containing a layer of insulation of about 5cms in thickness. Various sorts of low cost building materials are utilized in the construction of these solar ovens, such as plywood, pressed wood, cardboard, metal sheets, glass, aluminum foil, insulation (various types) and other materials.

The outer and the inner boxes are either constructed with mild steel sheets or plywood or pressed wood or even carton. The inner boxes are either covered with aluminum foil or painted with dull black paint, which can resist heat. Sawdust, shredded newspapers, fiberglass, and other locally available materials are utilized as insulation. The thickness of insulation varies from 3 to 5cms.

Figures 4 and 5 present a photo and an illustration of a solar oven. And **Table-1** provides specifications of the ten solar ovens that MECTAT has developed.

Figure-4: A typical solar oven with 4 reflectors

Figure-5: Sectional view of a solar oven

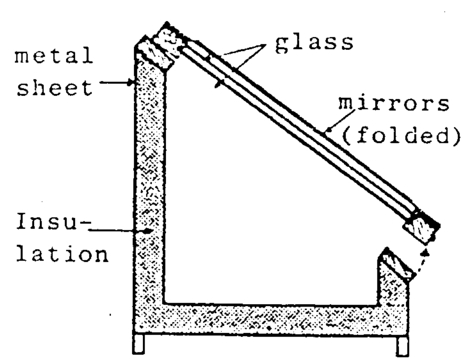


Table-1: Specifications on MECTAT's Ten Solar Ovens

Solar Ovens (Ref. No.)	Date of construction and place	Dimensions (cm)	Aperture (m^2)	Angle of tilt	No. of* reflectors	Material of outer box	Material of inner box	Insulation used	Cost** in US $
SO-01	Sept. 83 Beirut	63x32x43	.084	30°	4	Wood and carton	Carton	Shredded newspaper	5.00
SO-02	Nov. 83 Beirut	32x50x60	.126	25°	4	Pressed wood	Plywood	Fiberglass	30.00
SO-03	March 84 Beirut	63x32x43	.084	30°	4	Steel sheet	Steel sheet	Polyurethane	70.00
SO-04	March 84 Jeddah	35x50x60	.125	20°	4	Wood	Plywood	Fiberglass	35.00
SO-05	July 84 Beirut	45x48x55	.220	40°	4	Steel sheet	Steel sheet	Fiberglass	60.00
SO-06	July 85 Beirut	55x55x65	.325	35°	4	Wood	Steel sheet	Fiberglass & Polystyrene	80.00
SO-07	Oct. 85 Beirut	60x50x50	.260	40°	1	Steel sheet	Plywood	Fiberglass	95.00
SO-08	June 86 Beirut	60x55x40	.247	0° (horizontal)	1	Cardboard	Cardboard	Sawdust	5.00
SO-09	Sept.86 Beirut	52x45x25	.140	0° (horizontal)	1	Thin plywood	Thin plywood	Sawdust	5.00
SO-10	August 93 Beirut	60x40x35	.150	0° (horizontal)	1	Wood	Thin plywood	Sawdust and paper	30.00

* The reflectors of SO-01, SO-08, and SO-09 are made of aluminum foil pasted on cardboard. Reflectors of other ovens are made of stainless steel.

** The ovens are usually constructed on self-help basis. The high cost of some models is due to the use of stainless steel reflectors and metal sheets, which are done in metal workshops. The low cost of other models is due to the utilization of recycled materials.

The upper cover of the solar ovens have two plane glass sheets (3 mm in thickness) in parallel, separated by one cm, which allows the short-wave solar rays to enter the oven and do not permit the infrared (long-wave) re-radiated waves to escape from the oven. When the solar oven is placed under the sun, a dull black painted metal tray kept inside the oven absorbs the penetrated solar rays, upon which the pot is placed.

The angle of inclination of the top of MECTAT's solar ovens varies from 0^o(for the flat top type) to 40^o. Their apertures vary from 0.084 m^2 to 0.26 m^2.

Reflectors of the size of the aperture are fixed at the rims of the aperture windows. They are made of either stainless steel sheets or aluminum foil pasted on plywood. 1 to 4 reflectors are fixed on each oven.

- **How does the solar oven function?**

When the solar oven is placed in the sun, the blackened tray starts absorbing the sunrays coming through the glass cover. The temperature inside begins rising rapidly, because the intake of energy is greater than the loss of heat. However, after a short while equilibrium temperature is reached within the box, in which cooking pots (also blackened) are placed with food material. The amount of the incident energy can be increased by reflectors, which can focus additional amount of solar energy inside the box. It is found that the use of a single reflector is the most practical alternative, which also acts as protecting cover for the glass sheets, while the oven is not in use.

- **Cooking experience**

The solar oven is best suited for boiling and baking type cooking. We have successfully cooked many sorts of Middle Eastern food; even bread was baked in the ovens. A temperature of just over 100^0C is enough to cook boiling type foods. A temperature of above 150^0C bakes bread. All cooking is done in pots. Even during the shortest and coldest days of the year, i.e. mid-December, we have been able to cook. In large models we were able to cook three dishes at the same time, i.e. 3-5 kg of food per batch.

If cooking is started at 09:00 a.m. the food becomes ready at noon. It can be kept hot inside the oven for several hours, without the fear of overcooking. On an average, the cooking take about 30-45 minutes longer when compared with cooking on gas or electric stoves. In some cases it has turned out that cooking in solar ovens is faster than on conventional stoves. For example, unsoaked broad-beans ("ful") and peas were cooked within one hour in a preheated solar oven: placed in glass jars with sealed screw caps. The same type of beans, even after overnight soaking, takes longer when cooked in a pressure cooker on gas stove. Figure-6 presents a typical performance/graph of MECTAT's solar oven SO-06.

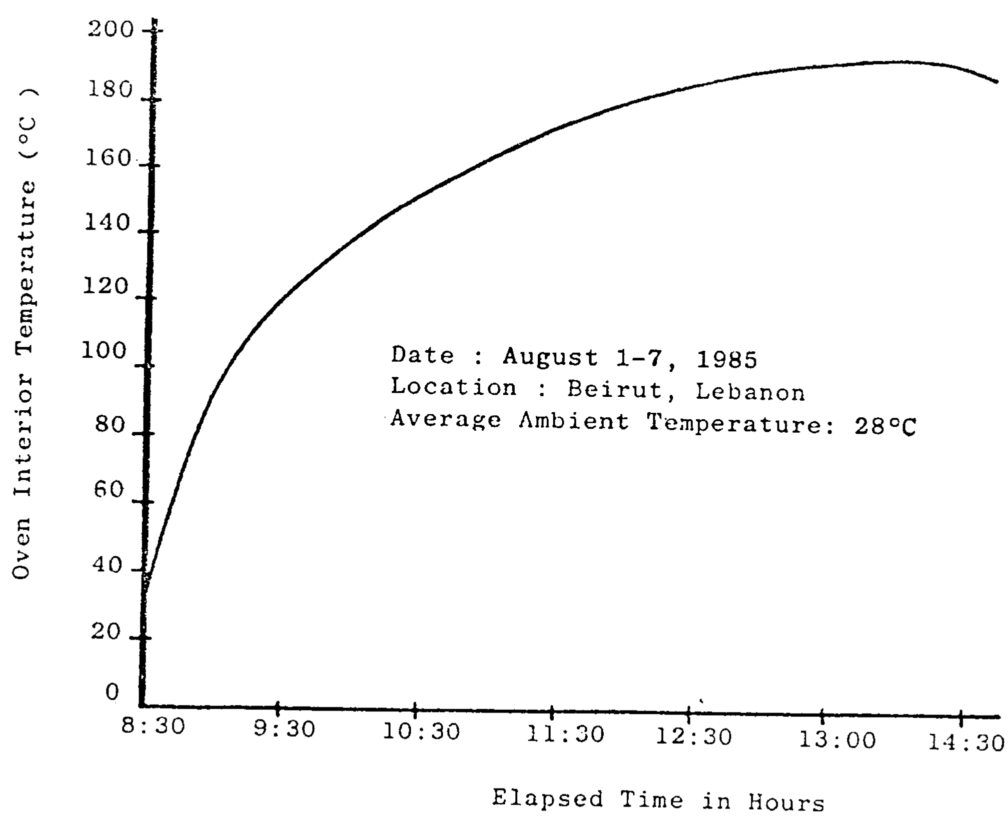
- **Advantages and Disadvantages of Cooking with Solar Ovens**

It is easier, cleaner, safer and more convenient to cook with solar oven than cooking with conventional stoves. A lot of firewood and other sorts of energy can be saved when cooking with solar ovens. The cooking process does not need tending (stirring and refocusing of the oven). Therefore, housewives can perform other chores while the food is being cooked in the oven. There is no fear of burning or overcooking if the pot is left in the oven for several extra hours. Because no water is added to fresh vegetables and meats they have wonderful flavor; the usual amount of water is added to cereals. The solar ovens are reasonably priced, and they are easy to build and repair.

However, the main **disadvantage** of the solar oven is that cooking can not be done when the sun does not shine. People always point out this defect. But it should be kept in mind that a cooked meal can stay hot inside the oven, even after the sunset. Also various types of foods can be canned, by using the solar oven and consumed whenever needed. It is worthwhile to mention that, even in the poor rural areas of the Arab World, householders utilize several types of stoves simultaneously. For instance, they use the bread oven ("tannour"), open fire stove, gas stove, kerosene stoves, and sometimes electric stoves. All of these devices are supplementary to each other. It naturally follows that, solar ovens can be considered as supplementary cookers, until the heat storage type solar cookers are perfected.

When the conventional fuels become expensive, cooking with solar ovens would turn to be more attractive.

Figure-6: Performance chart of MECTAT's solar oven SO-06 (Ghougassian, 1988)



3- ***Disinfecting of Drinking Water with Solar Radiation***

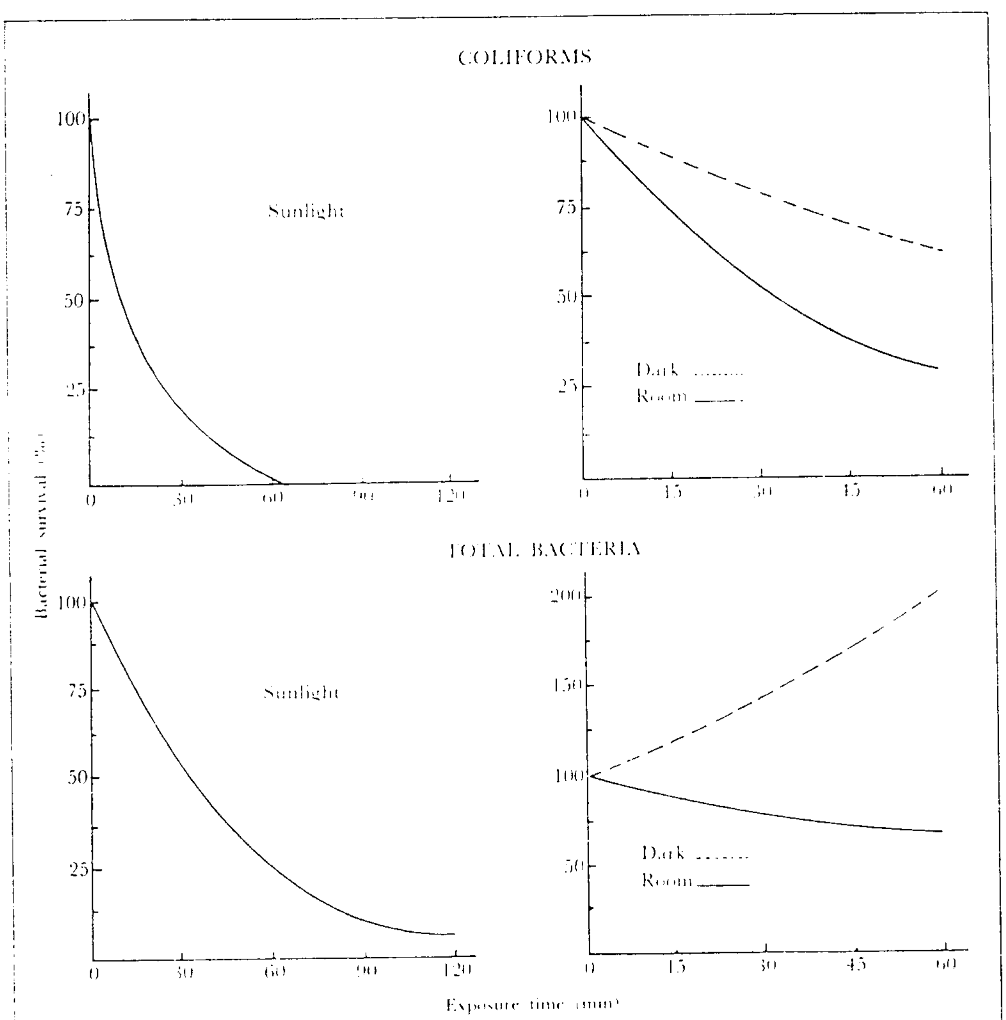
Introduction

Securing safe drinking water is a constant challenge in many countries. Often the available water is contaminated with disease-causing bacteria, and must be disinfected to make it safe. There are a few methods for the disinfection of drinking water at the household level. These include boiling and adding chlorine compounds, but both methods are time-consuming and expensive. In some regions, it is difficult to ensure a reliable supply of chlorine, which can also give the water an unpleasant taste. In many areas, there is little fuel available for boiling water. Besides that, the disagreeable taste of boiled water often discourages its consumption.

In early 1980s, researchers at the American University of Beirut in Lebanon developed a low-cost, practical means to provide safe drinking water in both rural and urban settings. Solar energy was used for the disinfection of available water. The initial research has focused on small quantities of drinking water, sufficient to satisfy the daily requirements of a family. Next the continuous-flow system was developed, to provide safe water for institutions.

The key to this method lies in the ability of direct sunlight to destroy pathogenic and non-pathogenic organisms. Even cholera bacteria are subject to the lethal effect of sunlight. For instance, the time required to kill 99.9% of coliform bacteria by sunlight is about 1.5 hours (Acra 1984). Viruses, molds and yeast are also susceptible to sunlight, but they need longer exposure time. Graphs of Figure-7 show the germicidal effect of solar radiation on bacteria.

Figure-7: Germicidal effect of solar energy on bacteria. (Acra 1984)



The rate of bacteria destruction by solar rays depends upon a number of factors, such as: the intensity of sunlight; the type of bacteria being exposed; the characteristics of containers in which contaminated water is exposed to sunrays, and, degree of turbidity of the water.

The **near-ultraviolet** region (A) of the light spectrum with wavelengths ranging from 315nm to 400nm (nanometers)* is the most effective at destroying bacteria. It accounts for about 70% of the bacterial destruction potential. On the other hand, visible light characterized by wavelengths ranging from 400nm to 750nm account for the remaining 30% of bacterial destruction capacity (Acra 1984). Therefore, colorless glass or plastic containers are the best choice to be used for solar disinfection of water. This is because they transmit light in the 315nm to 750nm, which is the most lethal range for bacteria. Violet, blue, and very light green tinted glass follow colorless glass or plastic in order of suitability.

More recent research carried out at Montreal's Brace Research Institute, in collaboration with international colleagues, indicates that transparent plastic bags are the best and inexpensive material for solar water disinfection.

Various shapes of transparent containers can be used for water disinfection. But the best ones are the cylindrical and spherical shaped containers. When using large sized transparent containers for water decontamination, the exposure period should be prolonged. The bottles should be clean and labels removed. To ensure proper disinfection of water, the water filled bottles should be placed in a convenient place that receives direct sunlight for at least two hours. During cloudy days, the scattered rays of sunlight would still exhibit germicidal action, but at about ten times slower rates (Acra 1984). To be on the safe side, the exposure period should be one complete day. In the Arab world there are more than 300 sunny days with clear sky, which are best suited for the disinfection of drinking water within a couple of hours. For the remaining days with cloud coverage, exposure from morning hours till evening would be adequate to get safe drinking water.

The temperature of water will rise while exposed to sun. In the event that the solarized water becomes unpleasant for drinking, it would be necessary to put the containers in a cool place or in the refrigerator. After use, the empty containers can be refilled with the available water, without the need for rewashing unless they have become dirty.

The treated water stays pure and bacteria fail to regrow at ordinary room temperature. This suggests that large quantities of water can be sterilized at one time and stored for future use. It is also possible to install institutional size solar water disinfecting systems with continuous-flow. These systems purify the water continuously during the day time and stop functioning during the night. Such systems contain automatic regulators, in order to make sure that during the daytime flow water is sufficiently exposed to solar rays. In such continuous systems, adequate storage for the purified water is provided, which is protected from recontamination (Acra 1989). Figure-8 gives a general idea on the set up of the apparatus for continuous-flow.

The treated water is suitable for drinking, and can also be used to prepare Oral Re-hydration Solutions (ORS), to treat dehydration suffered by children, caused by gastro-intestinal diseases, such as diarrhea.

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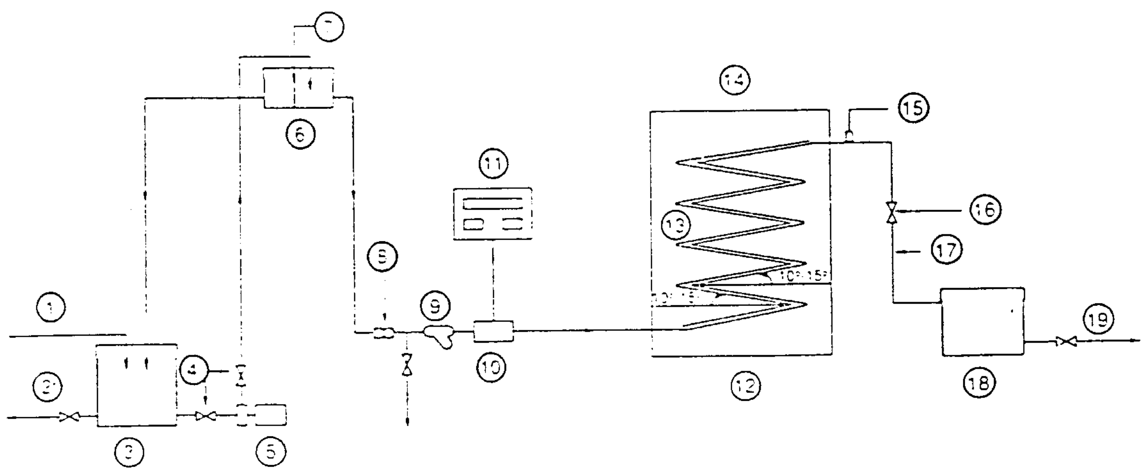
* $1nm = 10^{-9}m$

Figure-8: Layout of a typical continuous-flow solar reactor facility.(Acra 1989)

1-water feed, 2- drain, 3-storage of available water,
4-gate valve, 5-pump, 6-constant head tank,
7-overflow, 8- flow regulator, 9-strainer,
10-flow meter, 11- digital flow meter & control, 12-solar reactor,
13-transparent tube, 14-frame support, 15-air valve,
16-globe-valve, 17-effluent 18-storage tank of purified water,
19-distribution



Potential users

All rural and urban families can apply this technology and save money along with the protection of the health of their family members.

Other users include primary health care workers and technical people working in the areas of solar energy and water disinfection. The system can also be used in small communities, refugee camps, institutions, and in disaster situations where water supply is interrupted.

During the war years of Lebanon, 1975-1990, UNICEF and other collaborators promoted this technology in fighting zones of Beirut and other parts of the country. Many people benefited from its application. Now in Lebanon there are families who practice the solar disinfection of drinking water for more than 20 years. By doing this they avoid contracting diarrheal diseases.

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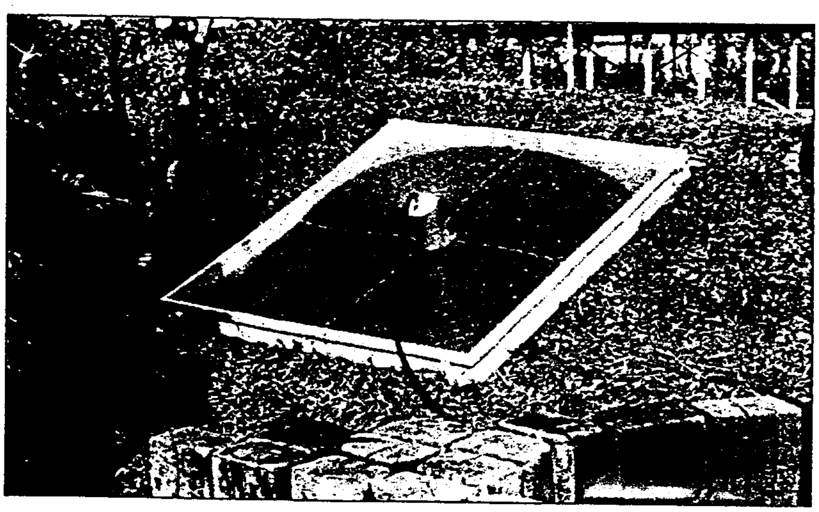
Solar energy applications such as: solar water heating, solar distillation of saline water; waterless/odorless latrines; greenhouses, passive solar architecture and other applications are feasible in the rural areas of Arab countries, some of which are briefly discussed here below.

4- Solar water heating

Solar water heating technology is in a mature stage and solar water heaters are the most widely disseminated solar devices in the world. They have become commercially available in the Arab region since 1970's. Both imported and locally produced types are available in most countries. However, very little has been achieved during the last 25 years, in terms of wide scale application of solar water heaters. In rural areas only few households have installed solar water heaters. In the Arab world, Jordan takes the first place in terms of wide scale use of solar water heaters. In the case of Lebanon and Syria, although they are located suitably, the dissemination of this technology is not well done as in other neighboring countries, e.g. Cyprus.

We are not going to elaborate on this technology and would not describe the causes and difficulties faced for its wide scale dissemination. We just want to point out that there is an urgent need to promote simple type and low cost solar water heaters in rural areas of the region. Figure-9 presents a low cost solar water heater that can be produced locally and promoted in rural areas.

Figure-9: Coil type simple solar water heater.
(MECTAT$_a$ 1998)



5- *Solar distillation*

Solar distillation is the process of desalinization of seawater through the use of solar energy. Every $1m^2$ of solar still can produce 3-5 litres of drinking water daily, which is badly needed in all parts of the Arab region.

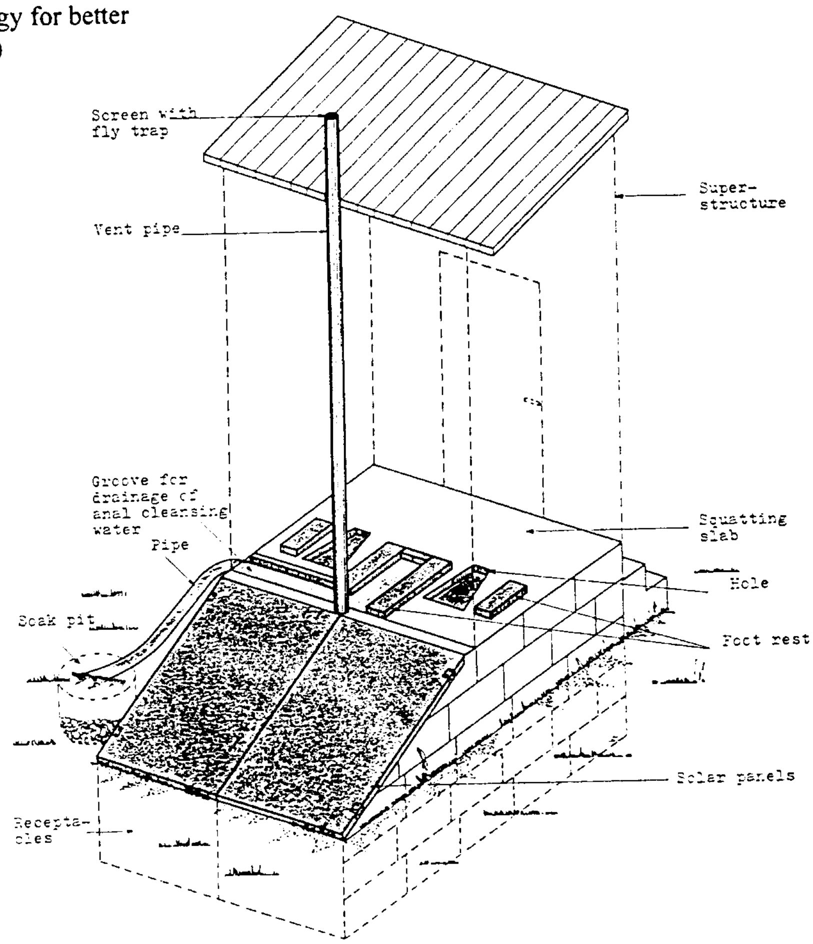
The overall costs for distilled water production in some Arab countries range from $0.75 to $3/m³ of fresh water. This cost is highly compatible in isolated areas, but by far costly than the water supplied by municipalities in urban centres.

The cost of solar still depends on its size. On an average 4 liters of water are produced per square meter area of solar still. Solar stills are compatible with any other means of desalination for all applications necessitating less than $200m^3$/day of fresh water.

6- *Sanitary latrines*

Solar energy is utilized in **Waterless/Odorless sanitary latrines** for their effective functioning. This latrine is a double vaulted composting latrine. A black colored vent pipe, which catches solar energy, makes the latrine odorless. Its solar absorber accelerates the composting process by increasing the temperature of waste pile, and therefore, eliminating the pathogens more effectively. The latrine is a cost effective tool for the disposal of human excreta, particularly in rural and semi-urban settings. Figure-10 presents an illustration of a typical sanitary latrine that utilizes solar energy.

Figure-10: Diagram of a waterless/odorless latrine which utilizes solar energy for better performance. (MECTAT 1985)



The sanitary latrine has no negative environmental impacts. As water is not poured in the latrine, no wastewater is generated in its receptacles. It also remains fly proof.

The sanitary latrine, which is odorless, waterless, solar heated, double vaulted, composting, fly proof, low cost and maintenance free, is the ideal sanitary tool for rural areas, recreational sites, municipal parks, camping sites and other public locations (MECTAT 1985).

7- *Greenhouses and soil sterilization*

Greenhouses and solarization of soil are other solar energy applications, which are suitable for rural areas.

Growing of crops in greenhouses are widely used in all countries of the Arab region. Jordan and Lebanon are well advanced in this practice. However, in many rural areas this application is not diffused yet.

In the greenhouse cultures, a new non-chemical technique for soil sterilization, known as **soil-solarization,** is being introduced in the region as an alternative to methyl bromide, which is an ozone depleting agent. This programme is initiated and being promoted by the Secretariat of the Montreal Protocol. Soil solarization is found to be less expensive than methyl bromide. Results obtained with solarization and other safe measures are exceeding the results of methyl bromide itself, in terms of better production and higher yields.

Therefore, this technique is environmentally safe method for soil sterilization and it is more economical and non-toxic, which is being introduced to vegetable producing farmers.

8- *Passive solar measures in architectural designs*

Passive solar provision for buildings is another solar energy application which need to be introduced in rural areas. Architectural designs should incorporate passive solar measures in order to save energy and maximize indoor comfort.

The main aim is to reduce energy consumption and thus limitation of CO_2 emission, which is a greenhouse gas and has become a major concern to the world community. The goal is then to save on fossil fuel consumption and rather rely more on renewable, non-polluting energy sources such as solar and wind energy.

Energy can be saved and indoor micro-climate can be improved significantly by good building design: for instance using adequate insulation, practicing night ventilation, installing cooling towers, using heat storing materials, taking advantage of solar radiation during the cold season, and other techniques of passive climatization (MEEA 1996). Space heating in winter by using solar energy presents a high potential in the Arab world. But so far this potential is not used properly. On the contrary, traditional buildings, which inherently have passive solar measures, are being demolished or abandoned and concrete blocks are being constructed, which require huge quantities of energy for cooling and heating.

BENEFITS OF SOLAR ENERGY APPLICATIONS

Some of the benefits of solar energy applications are listed here below:

- Energy needs are satisfied in a manner that both saves money and protects the environment. Global environmental problems, such as climate change, acid rains and pollution of the environment are minimized.
- Applications of small-scale solar technologies in rural areas have the potential of bringing socio-economical and environmental benefits to rural folks.
- Production of devices for solar energy applications provides employment to rural technicians and handicraftsmen.
- Health standards of the families and communities become better.
- Forests are saved and lands are protected from erosion.
- Women are freed from the task of wood gathering and smoky fuel wood burning practices.
- Some rural communities can attain energy independence.

RECOMMENDATIONS

Due to their favorable geographic location, all Arab countries are rich in solar energy. However, this potential source of energy is still under-utilized. Policy makers should take decisions for the proper dissemination of renewable energy related technologies in their countries, particularly in rural areas.

- Solar energy applications promotion should encompass an integrated programme based on the capabilities and development of local expertise in the fields of research, design, manufacturing, marketing and training.
- Governments to implement economic instruments, such as tax deduction, to give incentives for mass scale application of solar energy.
- Governments to have clear goals and plans for wide scale diffusion of renewable energy technologies. For instance, they should have plans for installing X number of square meters of solar panels per year. They should set targets for renewable energy use. For example, to set the goal of 5% of total energy use that will be contributed by renewable energy sources.
- Intensive solar energy promotional campaigns to be launched.
- Encourage the establishment of demonstration zones for the integrated application of renewable energy.
- Implement electrification projects using solar photoelectric energy and wind power.
- Promote training programmes, directed towards specific groups, in close collaboration with regional experts and institutions.

- Create a regional network of agents involved in the matters of solar and renewable energy so as to promote cooperation in the field of energy planning and in the development of joint projects.

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