Potential of Solar Pumping in Palestine

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ABSTRACT:
The availability of Energy and water is one of the major factors affect the living standard and determine the socio-economic development in the society. Without energy and water there is no life. The energy and water resources conservation became an urgent topic and real dilemma in the world around. The potential of utilizing available abundant solar energy in Palestine using Photovoltaic (PV) system will be discussed.

This paper argues that the solar pumping technology is a meaningful issue in the solution of fresh water supply in the Palestinian remote and deprived areas. It aims to encourage minimizing the dependence on the traditional energy resources, supplying the deprived areas with water and electricity and participating in the international environmental protection actions.

1. INTRODUCTION

The problem of energy and water sources is one of the most important issues that occupy the minds of many researchers, scientists, politicians, and economists on the local, regional and international levels. Energy and water supply is considered as two stones of the main pillars in the infrastructure and the economic enhancement and development of any country in the world. In the last decades, socio-economic, political, and environmental factors were directly involved with the energy and water supply aspect, which made it complex issues to handle.

The Palestinian Territories (the Gaza Strip and the West Bank) is totally dependent on importing traditional energy such as petroleum products and electric energy from Israel. In addition, there are remote and military areas ،which are not connected to the national network. In addition, they suffer from shortage of water supply due to climatic and political reasons. These areas' distributed within all zones in the Gaza Strip and West Bank. Most of water demand in Palestine is covered through pumping of groundwater, which use up about 6 % of the total energy consumption, Baba [1]. This urges the Palestinians to minimize the dependence on importing energy from Israel and focus on assessing indigenous energy resources and developing strategies to use the available local renewable energy resources efficiently with a special emphasis on water pumping sector.

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Solar insulation in Palestine has an annual average of 5.4 kWh/m^2.day that fluctuates significantly during the day and all over the year, and approximately 2860 mean-hour sunshine throughout the year. The measured values in the different areas show that the annual average insulation values are about 5.24 kWh/m^2.day, 5.63 kWh/m^2.day, 5.38 kWh/m^2.day in the coastal area, hilly area and Jordan valley respectively, Hassan et. al. [2]. Annual monthly averages solar radiation amounts in the three climatic zones are shown in figure (1).

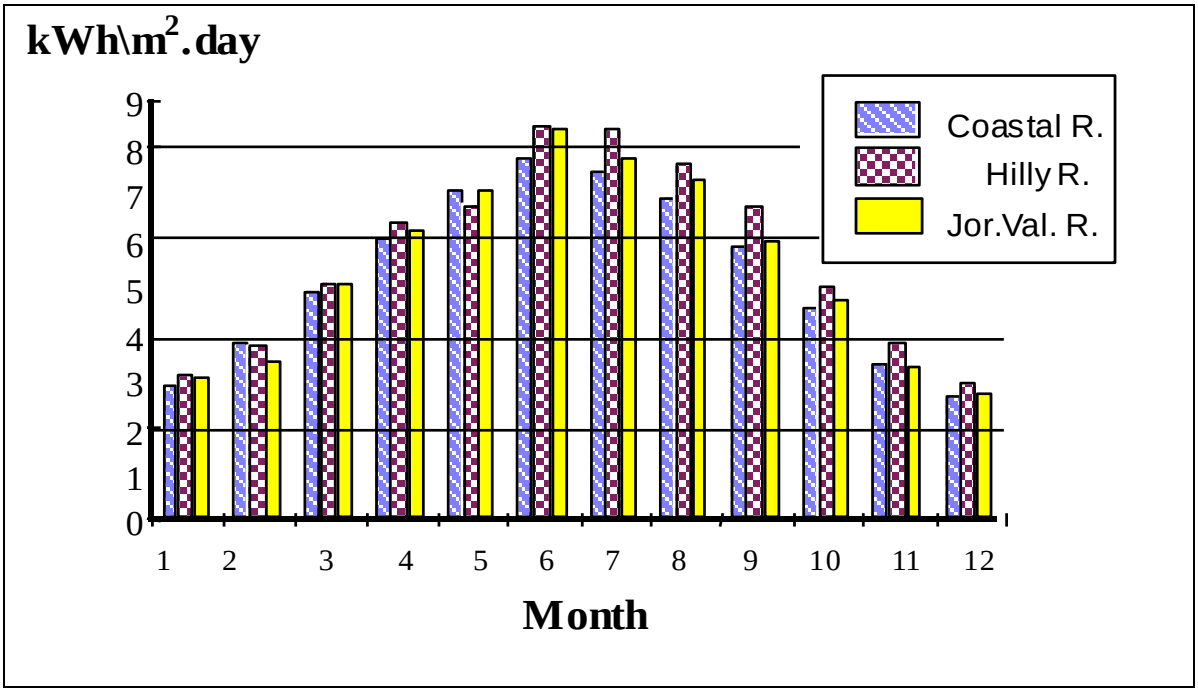


Figure (1): Annual monthly average variation in solar radiation in the three climate zones of the Palestinian Territories, Naim [3].

2. SOLAR ENERGY

Primary sources of energy are commonly grouped into renewable and non-renewable. The concept of renewablility is based on the time taken to replace the supply in relation to time-scale of human events. Non renewable energy sources are those which cannot be replenished within the space of human time. They represent the highly concentrated storage of massive amounts of material accumulated over millions of years of geographical activity, Chapman [4]. Solar energy is the major undependable source of renewable energy. It reaches the earth through the solar radiation. Its sources is the continuos nuclear fusion occurred in the center of the sun and it is the origin of all possible energy forms, such as wind, tidal, geothermal energy and hydropower. The amount of solar energy reached the earth's surface is about 1.2×10^{11} MW of solar power. This means that in less than one hour, enough energy is supplied to the earth to satisfy the entire energy demand of human over than whole year.

Figure (2) shows the relative intensity of the electromagnetic radiation received at the top of the earth's atmosphere as a function of wavelength, Markvart [5]. The amount of solar radiation reaching the top of the earth's atmosphere is called the **insolation or solar constant**, which is about 1367 w/m^2. Only about half of this radiation reaches the surface of the earth, depending on the weather conditions. Clouds, ice, and shiny surfaces reflect it. So it is composed of a direct beam from the sun, a diffuse component (radiation scattered from clouds and coming from the entire sky) and a reflected component (radiation scattered from the ground), as shown in figure (3), Ladener [6].

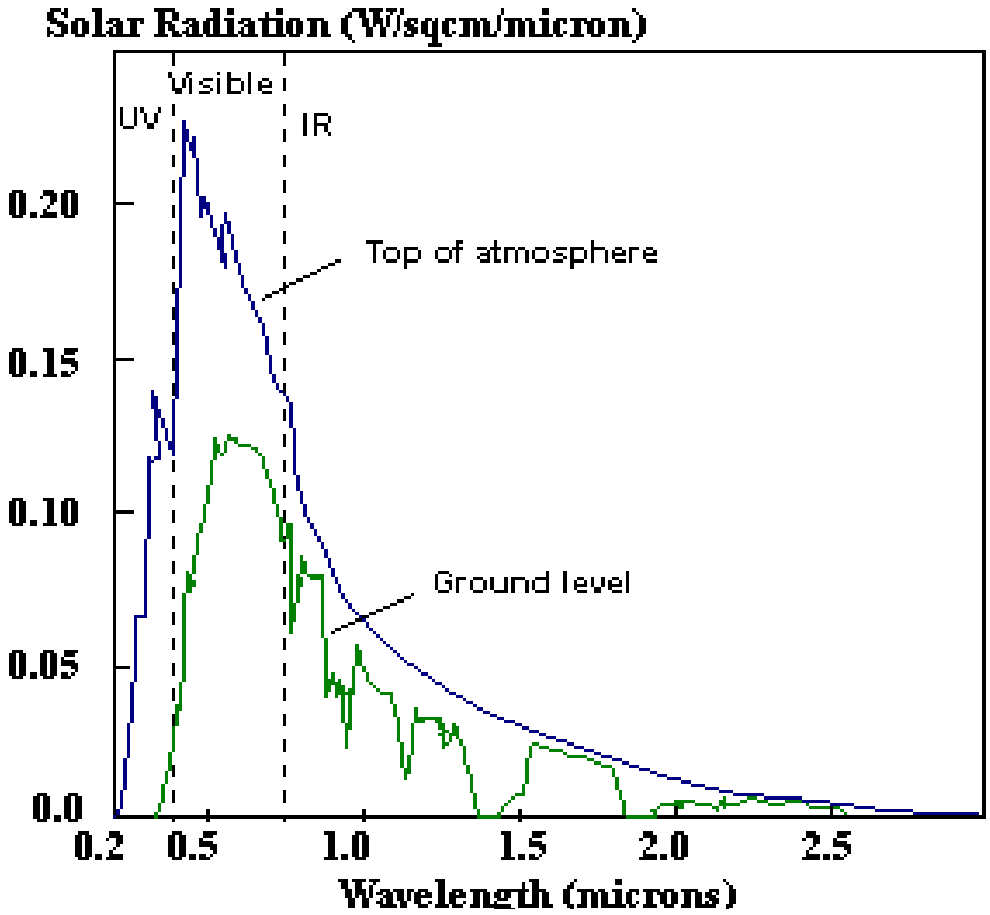


Figure (2): Spectrum of Solar radiation reaching the earth at the top of the atmosphere and at ground level, in unit of watts per square centimeter per micron of wavelength.

SOLAR WATER PUMPING SYSTEMS

There are several methods for water pumping or lifting water from its source to the point of utilization. Regarding the source of drive power, the common known water pumping methods are summarized as follows:

a) Grid electric pumping
b) Diesel pumping
c) Solar pumping
d) Wind pumping
e) Hand pumping

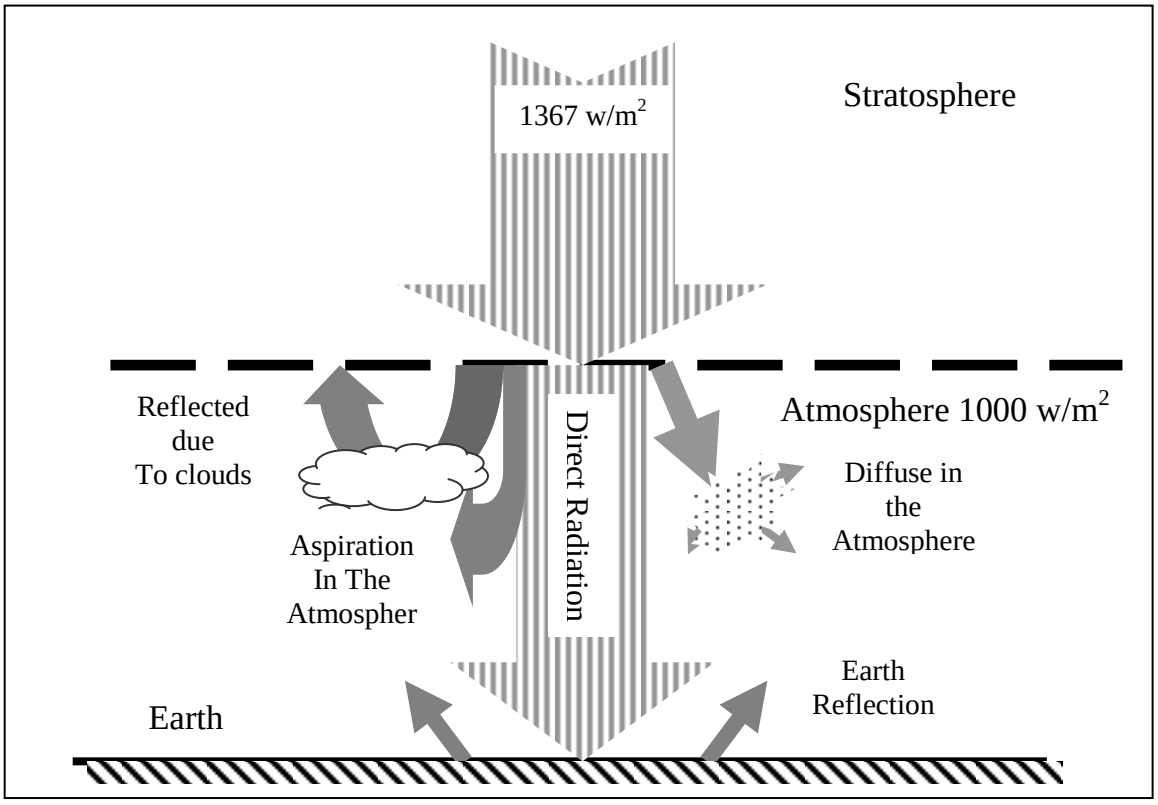


Figure (3): Components of solar radiation

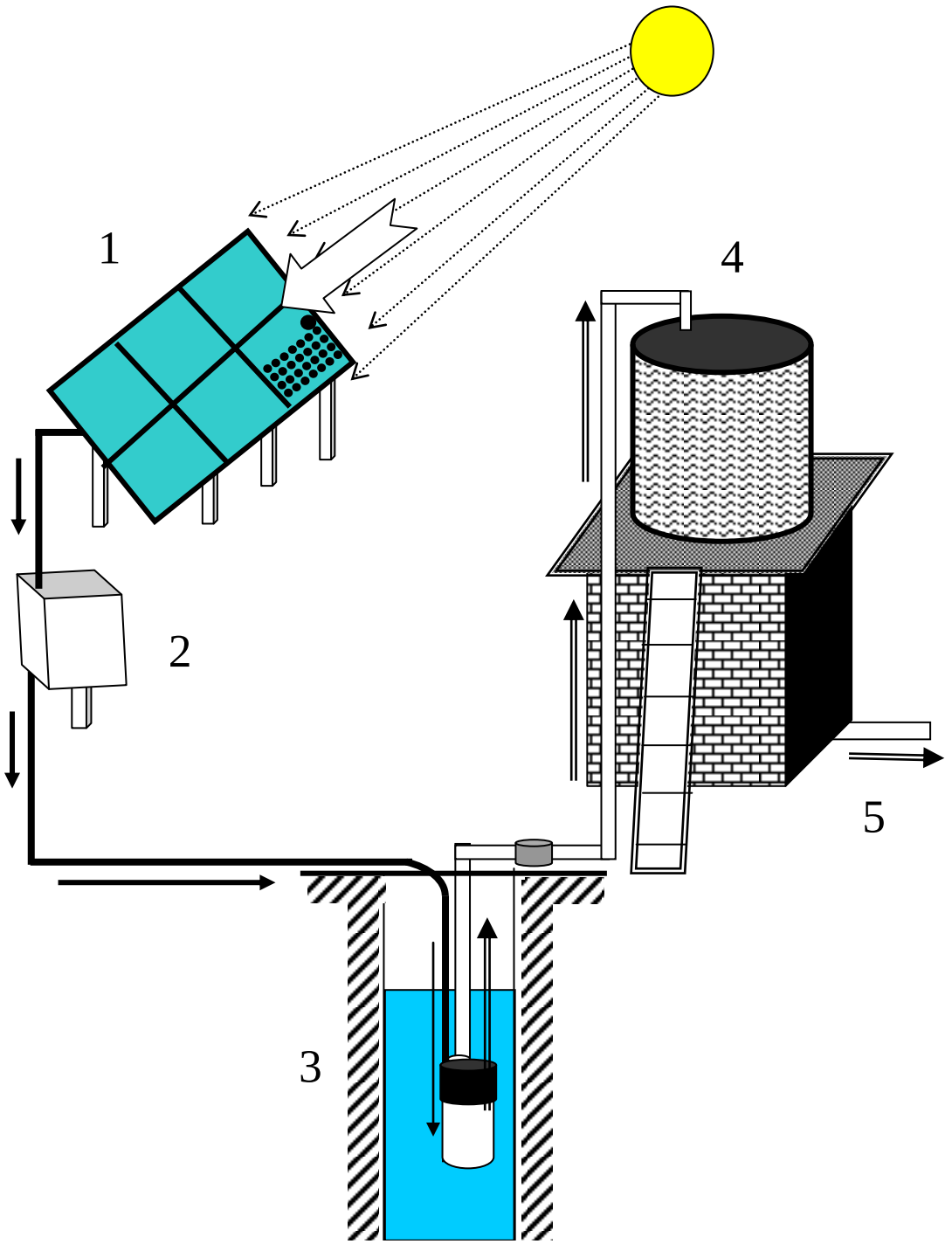
3.1 Solar Water Pumping System Components

Solar Pumping Systems are differing mainly from other systems, in that they contain the components proposed to generate electricity from the sunlight and supply the necessity to pump or lifting the water needed for the community. They are well suited to remote operation when compared to options such as diesel pumping. Solar pumps require minimal watchfulness and some types of pumps run for five or more years without requiring any maintenance. Their daily operation is also automatic, and thus daily operator attention is unnecessary. They are thus well suited to remote applications where grid electricity is unavailable and where technical skills to operate and maintain diesel systems are not guaranteed.

There are two types of solar water pumping systems: thermal pumping, using the heat engine, and electrical pumping, using Photovoltaic electric generator. The first one is not widely applicable in praxis, while there are 10,000 to 20,000 Photovoltaic solar water-pumping systems (PV-SWPS) are in use internationally, Borchers [7]. They used to pump from boreholes, open wells, rivers, canals and springs to provide water for domestic and irrigation supplies. PV-SWPS generally comprise the following main components:

- The solar Photovoltaic modules (Source of electrical energy)
- The power controller and conditioning apparatus
- The motor and pump.
- Store and distribution systems.
- Source of water.

Figure (4) shows the basic components of a Photovoltaic solar water pumping system .



Solar electric panels convert sunlight into electricity.

The electricity box conditions the electricity for the pump motor.

Electricity drives the motor and the pump.

Water is pumped from the source into the tank.

The tank supplies water to the community.

Figure (4): the basic components of a solar pumping system

3.2 The Photovoltaic System

The PV-System components differ from one type of applications to another. Generally, the System is consisting of all or some of the following components:

- PV-Generator
- Charge regulator
- Battery
- Inverter
- AC distribution Board
- DC distribution Board

Source of electrical energy or PV-Generator represents the heart of the PV-system. It consists of modules that forms the basic building blocks and they are fabricated from the in series connected fundamental units called Photocells (or Solar Cells). These cells are solid state semiconductors that convert sunlight directly into electricity via the Photovoltaic effect. They are usually made of silicon with traces of other elements. The modules are interconnected to form an array (solar panels), the DC power-producing unit. While small array output is usually 12 or 24 volts nominally, larger systems often output is over 100 volts. Individual panels are typically rated between 55 and 75 peak watts (Wp). Panels normally deliver their rated Wp at midday on a sunny day when tilted towards the sun (the radiation on the panel will be about 1000 W/m^2), Borchers [7]. The array needs to be oriented to true geographic south, and should tilted to give the optimum exposure to the sun. In Palestine typical optimum, tilt angels vary between 5° and 55° depending on the weather characteristics. The average tilt angle throughout the year is about 25°. The output may be enhanced by manual or automatic changing the tilt angle to face the sun more directly. A group of arranged solar panels may be connected in any series or parallel configuration to give required voltages or currents. The PV- Generator hierarchy are detailed in Figure (5).

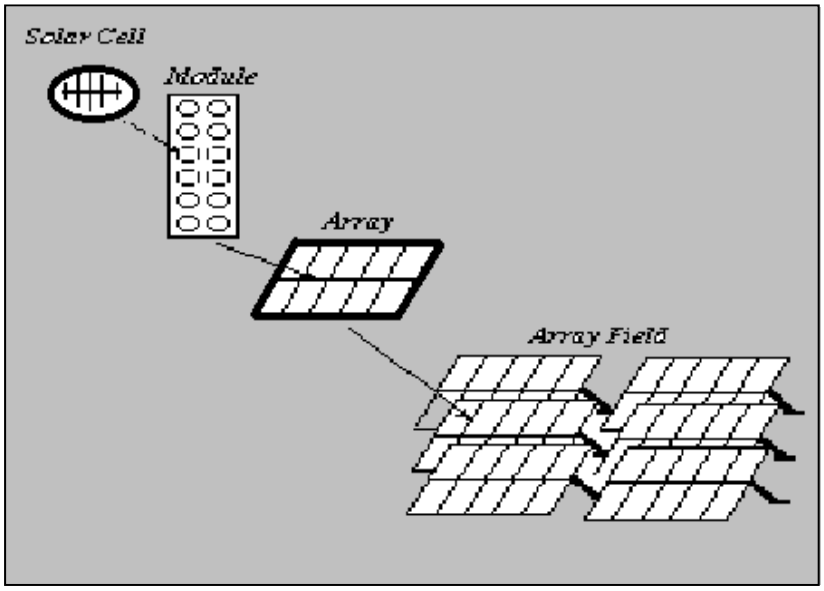


Figure (5): Photovoltaic Hierarchy, EL-Kassieh [8]

The produced electricity through protected wires will be conducted to batteries where it is stored until needed. On the way to the batteries, the electrical current passes through a controller (regulator) which shut off the flow when the batteries become full. It regulates power to and from the batteries. So it prevent batteries overcharge-amperage rating determined by array size. Depending on the application, electricity can be used directly from the batteries. This is direct current and it powers "DC" appliances. To run most appliances found in everyday life, alternating current or "AC" is used. This could be produced utilizing an inverter, which changes low voltage DC power from the batteries into high voltage AC power. The main components of a PV-system are configured in figure (6).

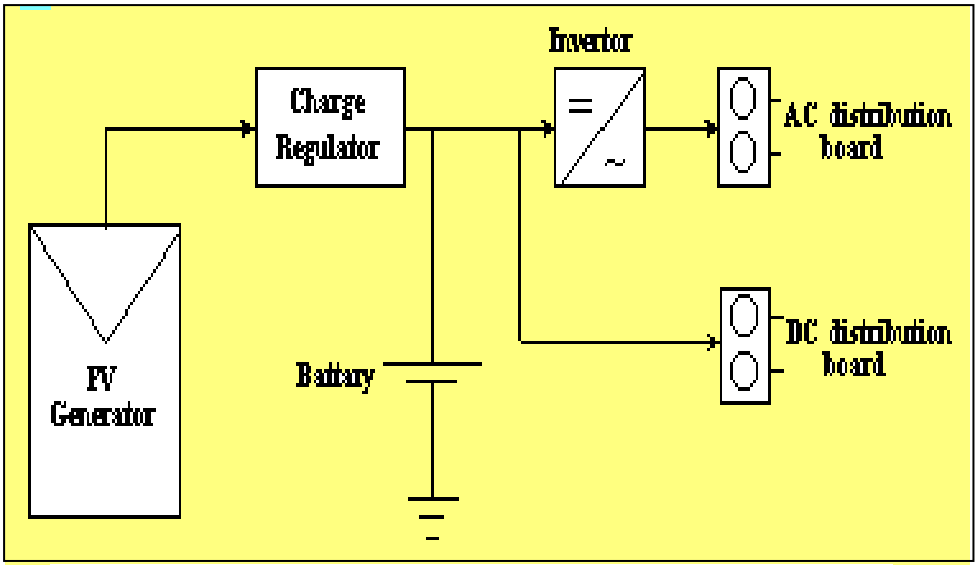


Figure (6): Structure of PV system, EL-Kassieh [8]

3.3 The Storage systems

While the average solar radiation levels could be well fixed, the short-term variation in solar radiation is not accurately predictable. One of the main problems faced the uses of the solar water pumping is the variability of solar radiation throughout the day and year. As a solution for such problem, storage systems are obligatory. There are two storage options. It is possible to apply both storage options either individual or together in the solar water pumping systems. This depends on the climatic conditions in the area.

- **Reservoirs to store the excess water:**

To overcome the community's water needs in nights and cloudy days, it is advantageous to store enough water using a higher sited reservoir during the sunshine time. Where there is not solar radiation, it will be distributed under gravity force in the time.

- **Batteries to store the excess electrical energy:**

Batteries are used to store the solar energy in form of DC electrical energy to be used in water pumping during the absence of the sun.

3.4 Source of Water

Recent solar water pumping systems are applicable in all water resources and at any pumping head. Water sources could be well, canal, spring or shallow water.

3.5 Economical and Technical Comparison between Solar, Diesel and Grid Electric Pumping System

Choosing a suitable pumping option depends on various effective factors. . Where the grid is not available, the choice of pumping option will be mostly between diesel and solar pumping. Solar pumping systems have many advantages over other types of water pumping systems, specially the diesel water pumping systems.

The main factors that enhance expansion implementation of the solar water pumping systems may be summarized in the following:

- Cost effectiveness (based on life –cycle costing).
- Environmental and social benefits.
- Flexibility
- Reliability

International studies indicate that the solar pumping systems are likely to be more cost-effective than diesel for water requirements under 2000 m^4/day. They are significantly cheaper below 1200 m^4/day, figure (7). Generally, the solar systems are cost-effective in the small and medium cases, Borchers [7].

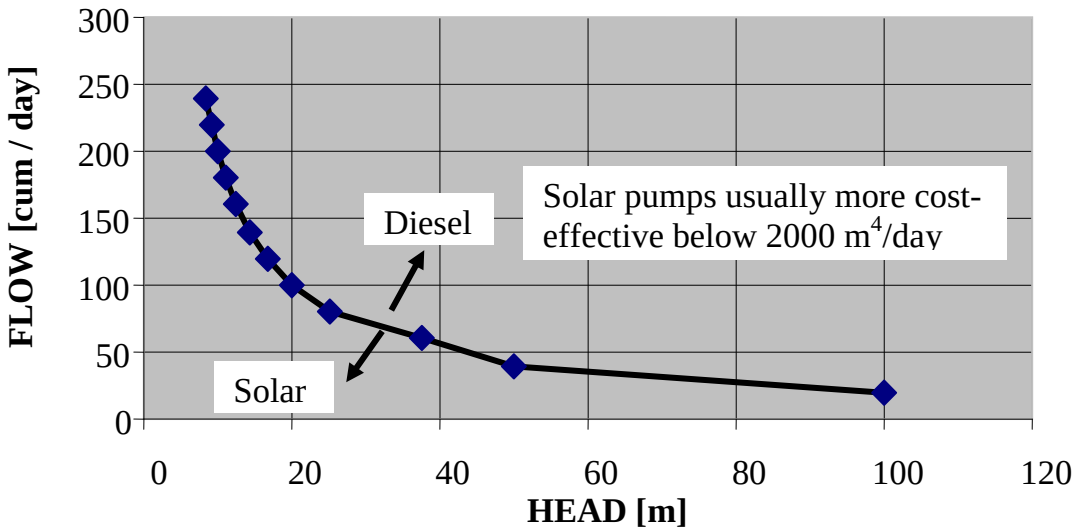


Figure (7): Guidelines for comparing the cost-effectiveness of solar vs. diesel pumping.

Solar pumping systems are considered friendly from environmental point of view. They cause lower risks or damages to the environment than the diesel systems. The environmental hazards appear only during their manufacturing and disposal stages. A brief comparison between the Solar and the Diesel water pumping systems is presented in table (1).

Table (1): comparison between Solar and Diesel Pumping Systems.

System type	Solar Water Pumping System	Diesel Water Pumping System
Advantages	• Low maintenance • No fuel needed • Easy to install • Reliable long life • Unattended operation • Low running costs • Low life cycle costs. • Modular and matched closely to need. • Can be Portable • Clean	• Moderate Capital Costs • Can be Portable • Extensive experience available • Easy to install • Easy to control the volume of the pumped water.
Disadvantages	• Relatively high capital (initial) cost • Its output depends on the weather conditions and its location. • It is not easy to change the output. • Need relatively large water storage reservoir.	• Need regular maintenance, replacement and frequent refueling. • Maintenance often inadequate, reducing life. • Running costs are relatively high. • Fuel often expensive and supply intermittent. • Noise, dirt and fume problem • Site visits necessary

4. JUSTIFICATION OF SOLAR WATER PUMPING APPLICATIONS IN PALESTINE

As shown in the previous paragraphs solar energy is comparatively clean and economical energy alternative that it is not dependent on a foreign source of fuel. So, the solar water pumping systems present distinct advantages where water supply is needed and:

A. The electrical network is not available or its extensions are costly.
B. The price of the fossil fuel is high or its transport is difficult.
C. The environmental and political affairs are special recognized.

In addition to the above mentioned, Palestine has a significant motive, that extraordinary percentage of the rural areas is deprived from traditional grid electricity due to the Israeli's military restrictions.

Diesel water pumping systems were widely known as the unique option for rural and domestic water supply in Palestine. Because of the cost effectiveness and fuel transportation difficulties, most of these systems were substituted with grid electric pumping systems throughout the last twenty years, where the electrical network is available. Despite the relatively wide expansion of the electrical network so it reached the majority of the Palestinian territories, many remote and Israeli controlled areas.

Palestine is located within the solar belt countries and considered as one of the highest solar energy potential countries. Many Studies indicate about the utilization of solar energy shows that it is applied wildly and extensively only in the field of domestic water heating. About 91% of the Palestinian houses in places with central grid are provided with solar water heating systems, Sader [9]. The Photovoltaic systems uses in Palestine are limited in few electrical applications such as for lighting public buildings, such as schools, health centers in remote areas. The electricity cost from such system is not competitive and estimated at o.41 USD/kWh, compared to 0.11 USD/kWh for the electricity from the grid, Al-Jamal [10].

About 40% of Palestinian rural residents in West Bank use insufficient, primitive and costly methods to obtain their domestic needs of water. The people in Al-Mawasi area in the southern part of the Gaza Strip use diesel pumps to secure the water for domestic and irrigation purposes. Springs and shallow water (not more than 10-m depth) in the West Bank and in El-Mawassi area respectively are not well exploited. Preliminary studies concluded that they could be feasibly utilized to overwhelm the shortage of water in remote and restricted areas using the solar water pumping systems.

Many studies and proposals for pilot project have been carried out in the field of solar pumping in the last five years. It is unavoidable national task to supply water and electricity by implementation of solar pumping system, which leads to a rational use of water sources, reduction fuel demand and protection of the environment. Such action improves the socio-economic conditions, the standard of living, health conditions and encourages staying in and building up the Palestinian political sensitive areas. According to the study carried out in august 1999 by the author, the solar pumping is more feasible than the diesel powered option.

CONCLUSION

Palestine is one of the highest solar energy potential countries. In the same time it suffers from shortage of fresh water and does not have any non-renewable energy source to cover its national demand. The average annual solar insulation is about 5.4 kWh/m^2.day and the water demand is about 320 MCM/ year.

To fulfill the current proposed water resources management plan of action in Palestine, utilization of solar pumping systems became necessary to be added to the requested measures. Water may be found at depth of few meters at the southern part of the Gaza

Strip for irrigation systems. The source of water from the springs situated in West Bank is amounted of 50 MCM/ year. In addition, large Palestinian areas are unconnected to national the electrical network. So that, it will be a great achievement and highly desired if we use the solar energy to serve these areas with needed water.

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