www.ijemr.net ISSN (ONLINE): 2250-0758, ISSN (PRINT): 2394-6962

Vandana Publications
IJEMR

Volume-7, Issue-2, March-April 2017
International Journal of Engineering and Management Research
Page Number: 599-604

Solar Powered Water Pumping System

Rahul Tamoli[1], Rohit Agrawal[2], Paras Arora[3], Vikalp Sharma[4], Pradeep Kumar Dubey[5]
[1,2,4,5]Student, Department of Electrical Engineering, Global college of Technology, Jaipur, INDIA
[3]Assistant professor, Department of Electrical Engineering, Global college of Technology, Jaipur, INDIA

ABSTRACT

This paper conclude that renewable energy sources (RESs) play a vital role in reducing the consumption of conventional energy sources and its environmental impacts for water pumping applications. Agricultural technology is changing rapidly. Fast machinery, farm building and production facility are constantly being improved. Agricultural application suitable for photovoltaic (PV) solutions are numerous. The recommended model takes into account the submodels of the pumping system and uses two optimization criteria, the loss of power supply probability (LPSP) concept for the reliability and the life cycle cost (LCC) for the economic evaluation. The applications are a mix of individual installation and system installed by utility companies when they have found that a PV is the best solution for remote agricultural need such as water pumping for crop irrigation or livestock. A solar powered water pumping system is made up of two basic components. These are Photovoltaic panels and water pumps. The smallest element of PV panel is the solar cell. Each solar cell has two or more specially prepared layer of semiconductor material that produces direct current (DC) electricity when exposed to sun light. This direct current is collected by the wiring in the panel. It is then supplied either to a DC pump, which in turn pumps water whenever the sun shines. The energy stored in batteries for later use by the pump. The aim of this article is to explain how solar powered water pumping system works and what the differences with the other energy sources are.

Keywords--Agriculture, solar cell, water, Pump, storage tank, control circuit

I. INTRODUCTION

Gradually decreasing energy sources and increasing demand for energy in recent years, makes more efficient and positive use of current water resources together with warming and drought. It is common to use petrol, diesel (Conventional resources) to power generators in agricultural operations. These systems can provide power where needed, But they have many disadvantages so we use non-conventional (Renewable) resources of energy to fulfill our requirements. There are some significant drawbacks of using conventional energy resources (petrol, diesel etc.), including:

- These fuels pollutes environment.
- The transportation of fuel to the generator's location, which may be quite a distance over some challenging roads and landscape.
- Their noise and fumes can disturb livestock and affects agricultural environment.
- Fuel cost increases, and spills can contaminate the land.
- Generators require a significant amount of maintenance and, like all mechanical systems, they break down and need replacement.

There are also major disadvantages of using propane and bottled gas to heat water for pen cleaning or in crop processing applications, or to heat air for crop drying, including transportation to the location where you need the heat, costs of fuel and safety issues.

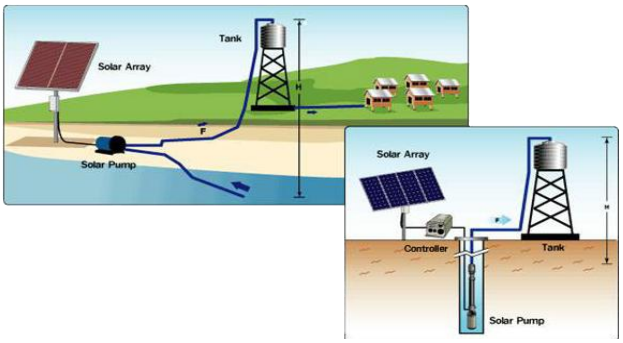

Figure 1.Basic structure of solar powered water pumping system [1]

Solar energy that is sensitive to environment, clean and requiring no maintenance is an alternative renewable energy source especially for agricultural applications. Thus for many agricultural needs, the alternative is solar energy. Modern, well-designed, simple to maintain solar systems can provide theenergy that is needed where it is needed, and when it is needed. These are systems that have been tested and proven around the world to be cost-effective and reliable, and they are already raising levels of agricultural productivity worldwide. The figure given above (Figure 1) shows the basic structure of solar powered water pumping system.

Generally there are two types of solar systems. Firstly, a system which converts solar energy in to D.C. power and

second, those system that converts solar energy in to heat energy, for the purpose in the area or building lighting, and water pumping – either for livestock watering or crop irrigation. Both the types have many applications in agricultural settings, making life easier and helpful to increasing the operation productivity.Mostly the system used for water pumping is solar generated electricity, called photovoltaic (or PV) generation and system is called solar powered water pumping system.The photovoltaic solar cells converts the sunlight to direct current electricity.

The solar cells in a photovoltaic module are made up from semiconductor materials. In which, when solar light strikes the cell, the electrons are knocked loose from the material's atoms, that produces a potential difference in the semiconductor material surfaces. Electrical conductors are attached to the positive and negative sides of the semiconductor material that allows the electrons to be captured in the form of a direct current electricity. This generated electricity can be used to power a load, such as a water pump directly for irrigation purpose, or it can be stored in a battery for further uses in night or when sunlight not available *[2]*.

It's a simple fact that photovoltaic module or panel produces electricity only when the sun is shining or sunlight is available, so it is necessary to store some form of energy to operate systems at night. You can store the energy as water form by pumping it into a water tank while the solar energy is available or sun is shining and it can be distributed or can be used by gravity when it needed after sunset or at night. For electrical applications at night, it is necessary to store the electrical energy in a battery, which is generated during the day (**Figure 2**).

Figure 2. Typical arrangement of solar panel system [3]

Photovoltaic system is a modern technology based system, well established, proven technology with a substantial international industry network. Photovoltaic system have no larger weight and it is increasingly more cost-effective compared with either extending the electrical grid or using generator in remote locations. The cost of per peak watt of today's Photovoltaic power is about $7, including local supply conditions, shipping costs and import duties, maintenance, vary and may add to the costs.

Up to 30 August, 2016 a total of 120,000 solar photovoltaic water pumping system have been installed in India. Solar water pumps may be especially useful in small scale or community based irrigation, then large scale irrigation requires so large volume of water that in turn requires a large solar PV array. The solar pumps are useful when grid electricity is unavailable because do not provide sufficient energy. A 5Hp system can deliver about 124,000 liters of water per day from a total 50 meters shutoff head and 70 meters dynamic head. Solar water pumps up to 5Hp is useful for farmers. PV systems are very economical in providing electricity at remote locations on farms, ranches, orchards and other agricultural operations. A ''remote'' location can be as little as 15 meters from an existing power source. Photovoltaic systems can be much cheaper than installing power lines and step-down transformers in application such as electric fencing, area or building lighting, and water pumping – either for livestock watering or crop irrigation. The size of PV panel system is directly depends on the size of the pumps. The solar powered water pumping system has mainly three components i.e. solar panel, the controller and the pumps.

II. WATER PUMPING SYSTEM

Water pumping is a system which delivers drinking water for livestock or irrigation purposes. Water pumping is one of the simplest and most appropriate uses for photovoltaic. From crop irrigation to stock watering to domestic uses, photovoltaic-powered pumping systems meet a broad range of water needs. Most of these systems have the added advantages of storing water for use when the sun is not shining, eliminating the need for batteries, enhancing simplicity and reducing overall system costs. In solar powered water pumping system mainly the cost about 80% is due to the solar panel required for energy generation. Solar powered electrical pumps can reduce these green-house gas emission. PV array not only provide a sustainable power source but can also provide electric source to run remote control SCADA type diagnostic with remote control and satellite communication from very remote locations to desktops. Many people considering installing a solar powered water pumping system are put off by the expense. Viewing the expense over a period of 10 years, however, gives a better idea of the actual cost. By comparing installation costs (including labour, maintenance and control etc.), fuel costs and other costs over 10 years, you may find that solar is an economical choice. A solar powered water pumping system is generally in the same price range as a new windmill but tends to be more reliable and require less maintenance. A solar-powered pumping system generally costs more initially than a gas, diesel, or propane-powered generator but again requires far less maintenance and labour *[4]*. The cost of solar pumped water per cow ranged from $0.03 to $0.15 per day. The cost per gallon of water pumped ranged from $0.002 to $0.007 per gallon.

III. SOLAR POWERED WATER PUMPING SYSTEM CONFIGURATION

Photovoltaic powered water pumping systems require only that there be adequate sunshine and a source of water. The use of photovoltaic power for water pumping is appropriate, as there is often a natural relationship between the availability of solar power and the water requirement. The water requirement increases during hot

weather periods when the solar radiation intensity is high and the output of the solar array is at its maximum. On the other hand, the water requirement decreases when the weather is cool and the sunlight is less intense. Photovoltaic water pumping systems are particularly suitable for water supply in remote areas where no electricity supply is available. Water can be pumped during the day and stored in tanks, making water available at night or when it is cloudy. Thus, there are two basic types of solar-powered water pumping systems, battery-coupled and direct-coupled. A variety of factors must be considered in determining the optimum system for a particular application *[1]*.

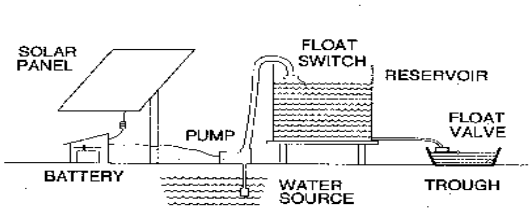

Figure 3. Battery-coupled solar water pumping system [5]

Battery-coupled water pumping systems consist of photovoltaic (PV) panels, charge control regulator, batteries, pump controller, pressure switch and tank and DC water pump (**Figure 3**). The electric current produced by PV panels during daylight hours charges the batteries, and the batteries in turn supply power to the pump anytime water is needed. The use of batteries spreads the pumping over a longer period of time by providing a steady operating voltage to the DC motor of the pump. Thus, during the night and low light periods, the system can still deliver a constant source of water for livestock.

The use of batteries has its drawbacks. First, batteries can reduce the efficiency of the overall system because the operating voltage is dictated by the batteries and not the PV panels. Depending on their temperature and how well the batteries are charged, the voltage supplied by the batteries can be one to four volts lower than the voltage produced by the panels during maximum sunlight conditions. This reduced efficiency can be minimized with the use of an appropriate pump controller that boosts the battery voltage supplied to the pump.

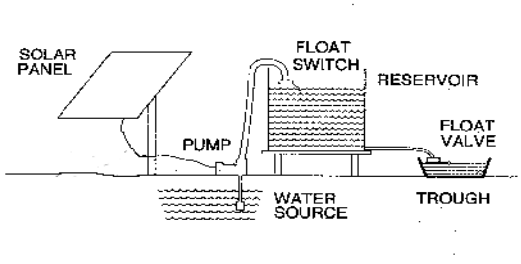

Figure 4. Direct coupled solar pumping system [5]

In direct-coupled pumping systems, electricity from the PV modules is sent directly to the pump, which in turn pumps water through a pipe to where it is needed (**Figure 4**). This system is designed to pump water only during the day. The amount of water pumped is totally dependent on the amount of sunlight attacking on the PV panels and the type of pump. Because the intensity of the sun and the angle at which itstrikes the PV panel changes throughout the day, the amount of water pumped by this system also changes throughout the day. For instance, during optimum sunlight periods (late morning to late afternoon on bright sunny days) the pump operates at or near 100 percent efficiency with maximum water flow. However, during early morning and late afternoon, pump efficiency may drop by as much as 25 percent or more under these low-light conditions. During cloudy days, pump efficiency will drop off even more. To compensate for these variable flow rates, a good match between the pump and PV module(s) is necessary to achieve efficient operation of the system.

Direct-coupled pumping systems are sized to store extra water on sunny days so it is available on cloudy days and at night. Water can be stored in a larger-than-needed watering tank or in a separate storage tank and then gravity-fed to smaller watering tanks. Water-storage capacity is important in this pumping system. Two to five days' storage may be required, depending on climate and pattern of water usage. Storing water in tanks has its drawbacks. Considerable evaporation losses can occur if the water is stored in open tanks, while closed tanks big enough to store several days water supply can be expensive. Also, water in the storage tank may cold during cold weather (winters).

IV. COMPONENTS OF SOLAR POWERED STOCKS WATER PUMPING SYSTEM

Mostly a typical solar-powered stock watering system includes a solar array, AC/DC pump, storage tank and controller [6], (**Figure 5**).

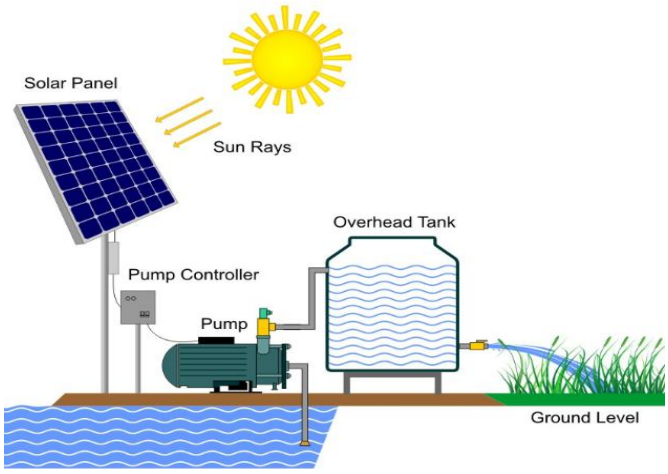

Figure 5. A typical solar-powered stock watering system [1]

SOLAR PANELS

Solar electric systems are sometimes called photovoltaic systems. The word "photovoltaic" is often

abbreviated PV. Most solar panels, or modules, generate direct current (DC) electricity. A group of modules is called an array. The solar cells in a PV module are made from semiconductor materials. When light energy strikes the cell, electrons are knocked loose from the material's atoms. Electrical conductors attached to the positive and negative sides of thematerialallow the electrons to be captured in the form of a D.C. current. This electricity can then be used to power a load, such as a water pump, or it can be stored in a battery. Solar cell is a nonlinear power source, the output current and voltage depend on the radiation level and temperature. Changing the weather condition results in a change in the operating point of the solar cell.

WATER PUMPS

Electric motors, either DC current motors or AC current motors, are currently in common use for driving PV pump systems. DC motors are used in most PV pumping systems, as they are simple and efficient for small loads. A direct current (DC) pump is used in the proposed PV pumping system. A DC pump consists of a DC motor and a pump. DC water pumps in general use one-third to one-half the energy of conventional AC (alternating current) pumps. DC pumps are classed as either displacement or centrifugal, and can be either submersible or surface types. Displacement pumps use diaphragms, vanes or pistons to seal water in a chamber and force it through a discharge outlet. Centrifugal pumps use a spinning impeller that adds energy to the water and pushes into the system, similar to a water wheel. Submersible pumps, placed down a well or sump, are highly reliable because they are not exposed to freezing temperatures, do not need special protection from the elements, and do not require priming. Surface pumps, located at or near the water surface, are used primarily for moving water through a pipeline. Some surface pumps can develop high heads and are suitable for moving water long distances or to high elevations.

ENERGY STORAGE

Batteries are usually not recommended for solar-powered livestock watering systems because they reduce the overall efficiency of the system and add to the maintenance and cost. Instead of storing electricity in batteries, it is generally simpler and more economical to install 3 to 10 days' worth of water storage.

CONTROLLER OR INVERTER

The purpose of the controller is twofold. Firstly, it matches the output power that the pump receives with the input power available from the solar panels. Secondly, a controller usually provides a low voltage protection, whereby the system is switched off, if the voltage is too low or too high for the operating voltage range of the pump. This increases the life time of the pump thus reducing the need for maintenance. The pump controller protects the pump from high- or low-voltage conditions and maximizes the amount of water pumped in less than ideal light conditions. Voltage of the solar pump motors can be AC (alternating current) or DC (direct current).direct current motor pumps are used for small to medium applications up to about 3 kW rating, and are suitable for application such as garden fountains, landscaping, drinking water for livestock, or small irrigation projects. But, an AC pump requires an inverter, an electronic component that converts DC electricity from the solar panels into AC electricity to operate the pump. The supported power ranges of inverters extends from 0.15 to 55 kW and can be used for larger irrigation systems.

FLOAT SWITCH

A float switch is a device used to detect the level of liquid within a tank. The switch may be used in a pump, an indicator, an alarm, or other devices. Float switches range from small to large and may be as simple as a mercury switch inside a hinged float or as complex as a series of optical or conductance sensors producing discrete outputs as the water reaches many different levels within the tank. Perhaps the most common type of float switch is simply a float raising a rod that actuates a micro switch. A float switch turns a pump on and off when filling the stock tank. It's similar to the float in a toilet tank but is wired to the pump controller. Low water cut-off electrodes protect the pump from low water conditions in the well.

OTHER EQUIPMENTS

A solar powered water pumping system consists of various other type of equipments i.e. storage tank, control valves, water pipes, connection wires and other required equipments.

MOUNTING STRUCTURE

There are two ways to mount solar modules: either on a fixed structure or on a tracking structure. Fixed mounts are less expensive and tolerate higher wind loading but have to be carefully oriented so they face true south (not magnetic south).

An array can easily be mounted on a trailer to make it portable. A tracking array follows the sun across the sky. A tracker will add at least $400 to $800 to the cost of a system, but can increase water volume by 25 percent or more in the summertime, compared to a fixed array.

DESIGNING AND INSTALLING SYSTEM

Every pumping and stock-watering situation is unique. The average consumer is likely to be intimidated by the prospect of sizing and designing a solar pumping system, and most people need the assistance of a qualified solar dealer. In general dealers are eager to help. Many will provide a no-cost proposal based on a few simple questions that can be asked over the phone. If the price seems too high, you can easily get bids from other dealers.

In order to size and design a system correctly, the dealer will want to know:

- How much water you need?
- When you need the water?
- Whether your water source is a stream, pond, spring, or well;
- Water available in gallons per minute (gpm);
- Well depth;
- How far the water needs to be pumped, and with what elevation gain?
- Water quality problems (e.g., silt or high mineral content) that may damage the pump;
- How much volume is available in storage tanks and how the tanks are arranged?

Installing a solar pump is a complex task, combining elements of electrical work, plumbing, and heavy construction (often including earthmoving, pouring concrete, and welding). Written instructions are not always as complete as they should be. A backhoe or tractor with a front-end loader is almost a necessity for some larger projects.

V. CONCLUSION

Since the increase in price per increase in unit power output of a photovoltaic system isgreater than that for a diesel, gasoline, orelectric system, photovoltaic power is morecost competitive when the irrigation systemwith which it operates has a low total dynamichead. For this reason, photovoltaic power ismore cost-competitive when used to power amicro irrigation system as compared to anoverhead sprinkler system. Photovoltaicpower for irrigation is cost-competitive withtraditional energy sources for small, remoteapplications, if the total system design andutilization timing is carefully considered andorganized to use the solar energy as efficientlyas possible. In the future, when the prices of fossil fuels rise and the economic advantagesof mass production reduce the peak watt costof the photovoltaic cell, photovoltaic powerwill become more cost-competitive and morecommon.

REFERENCES

[1] Anonymous, Uni-solar, *"Solar energy produces catalog and brochures"*, USA, 2001.

[2] Anonymous, *"Solar Cells EİE Department of Research on electricity applications"*, Ankara, Turkey, 1992.

[3] Anonymous, www.sandia.gov.

[4] Eker, B and A. Akdogan, *"Protection methods of corrosion on solar systems", "TMMOB Machinery Engineering Society"*, Mersin, Turkey, 2005.

[5] Anonymous, *"Solar Powered Livestock Watering Systems"*, http://www.utextension.utk.edu.

[6] Helikson, H.J and Others, *"Pumping water for irrigation using solar energy"*, University of Florida, USA, 1995.

[7] Zigler F. "Recent developments and future prospects of sorption heat pump systems". International Journal of Thermals 1999; 38:191–208.

[8] Stephan K, Krauss R. "Regulated CFCs and their alternatives". In: Meunier F, editor. Proceedings: "Solid Refrigeration Symposium". Paris: Ministere de la Rechercheet de L'Espace, 1992:32–43.

[9] Suzuki M, "Adsorption for energy transport". In: Adsorption Engineering. Japan; 1980.

[10] Srivastava NC, Eames IW. "A review of adsorbents and adsorbates in solid-vapor adsorption heat pump systems". Applied Thermal Engineering 1998; 18:707–14.

[11] Passos E, Meunier F, Gianola JC. "Thermodynamic performance improvement of an intermittent solar powered refrigeration cycle using adsorption of methanol on activated carbon". Journal of Heat Recovery Systems 1986; 6:259–64.

[12] Aceves SM. "An analytical comparison of adsorption and vapour compression air conditioners for electric vehicles applications". Transactions of the ASHRAE 1996; 118.

[13] Best R, Ortega N. "Solar refrigeration and cooling". Renewable Energy 1999; 16:685–90.

[14] Gordon JM, KimChoon NG. "High-efficiency solar cooling". Solar Energy 2000; 68(1):23–31.

[15] "Programme solaire mondial", 1996-2005, UNEP report, June.

[16] Boubakri, Guilleminot JJ, Meunier. "Adsorptive solar powered ice maker": experiments and model. Solar Energy 2000; 69(3):249–63.

[17] Tchernev DI, "Solar air conditioning and refrigeration systems utilizing zeolites 1982".

[18] Wang RZ. "An energy efficient hybrid system of solar powered water heater and adsorption icemaker". Solar Energy 2000; 68(2):189–95.

[19] Sumathy K, Li ZF. "*A solar powered ice maker with the solid adsorption pair of activated carbon and methanol"*. International Journal of Energy Research 1999; 23:517–27.

[20] LeonardovichVasiliev Letal. *"A solar and electrical solid sorption refrigerator"*. International Journal of Thermal Science 1999; 38:220–7.

[21] Speidel K, Kleinemeier HP, *"Solar cooling processes using chemical reactions"*. In: Proceeding of the Solid Sorption Refrigeration Symposium, Paris, France, 1992: 288–293.

[22] Critoph RE. "Evaluation of alternative refrigerant–adsorbent pairs for refrigeration cycles". Applied Thermal Engineering 1996; 16(11):891–900.

[23] Majumdar P. *"Heat and mass transfer in composite desiccant pore structures for dehumidification"*. Solar Energy 1998; 62(1):1–10.

[24] Davanagere BS. *"A feasibility study of a solar desiccant air conditioning system—part I": "psychrometrics and analysis of the conditioned zone"*. International Journal of Energy Research 1999; 23:7–21.

[25] Dubinin MM, Astakhov VA. "*Development of the concept of volume filling of micropores in the adsorption of gases and vapours by microporous adsorbents"*. Washington, DC: American Chemical Society, 1971.

[26] Grenier P, Guilleminot JJ, Meunier F, Pons M. *"Solar powered solid adsorption cold store"*. Journal of Solar Energy Engineering 1988; 110:192–7.

[27] Tather M, Erdem-Senatalar A. *"The effects of thermal gradients in a solar adsorption heat pump utilizing the zeolite–water pair"*. Applied Thermal Engineering 1999; 19:1157–72.

[28] Cacciola G, Restuccia G. *"Progress on adsorption heat pumps"*. Heat Recovery Systems and CHP 1994; 14(4):409–20.

[29] Guilleminot JJ, Choisier A, Chalfen JB, Nicolas S, Reymoney JL. Heat transfer intensification in fixed bed adsorbers. Heat Recovery Systems and CHP 1993; 13(4):297–300.

[30] Tather M, Tantekin-Ersolmaz B, Erdem-Senatalar A. *"A novel approach to enhance heat and masstransfer in*

adsorption heat pumps using the zeolite–water pair". Microporous and Mesoporous Materials 1999; 27:1–10.
[31] Sakoda A, Suzuki M. *"Simultaneous transport of heat and adsorbate in closed type adsorption cooling system using solar heat"*. Journal of Solar Engineering 1986; 108/239.
[32] Pons M, Grenier PH. *"Experimental data on a solar powered ice maker using activated carbon and methanol adsorption pair"*. Solar Energy Engineering 1987; 109/239.
[33] Pralon Ferreira Leite A, Daguenet M. "Performance of a new solid adsorption ice maker with solar energy regeneration". Energy Conversion and Management 2000; 41:1625–47.
[34] Rommel M, Wagner A. *"Application of transparent insulation materials in improved flat plate collectors and integrated collector storages"*. Solar Energy 1992; 49(5):371–80.
[35] Shelton SV, Wepfer WJ, Miles DJ. *"Square wave analysis of a solid-vapor adsorption heat pump"*. Heat Recovery Systems and CHP 1989; 9:233–47.
[36] Hu EJ, *"A study of thermal decomposition of methanol in solar powered adsorption refrigeration systems"*.
[37] Tchernev DI. *"Solar energy application of natural zeolites, in natural zeolite: occurrence, properties and use"*. Oxford: Pergamon Press, 1978. p. 479.
[38] Pons M, Grenier Ph. "*ASME J Solar Energy Engg 1987; 109:303–10".*
[39] Exell RHB, Bhatacharya SC, Upadyaya YR. "*Research and development of solar-powered desiccant refrigeration for cold storage applications. Thailand: Asian Institute of Technology"*, 1987.
[40] Headley AF, Mcdoom IA. *"Charcoal–methanol adsorption refrigerator powered by a compound parabolic concentrating solar"*