# Study Of Solar PV Sizing Of Water Pumping System For Irrigation Of Asparagus

Mya Su Kyi, Lu Maw, Hla Myo Tun

**Abstract**: The motivation for this system come from the countries where economy is depended on agriculture and the climatic conditions lead to lack of rains. The farmers working in the farm lands are dependent on the rains and bore wells. Even if the farm land has a water-pump, manual involvement by farmers is required to turn the pump on/off when on earth needed. This paper presents design and calculation analysis of efficient Solar PV water pumping system for irrigation of Asparagus. The study area falls 21º-58'-30" N Latitude and 96º-5'-0" E Longitude of Mandalay. The PV system sizing was made in such a way that it was capable of irrigation one acre of Asparagus plot with a daily water requirement of 25m³/day.

**Keywords**: Irrigation, pump, solar, latitude, longitude, asparagus

## I. INTRODUCTION

In our country the economy is mainly based on agriculture and climatic conditions are isotropic. The continuous increasing demand of food requires the rapid improvement in food production technology. Irrigation is the artificial application of water to the land or soil. It is used to assist in growing of agricultural crops, maintenance of landscapes and revegetation of disturbed soils in dry areas and during periods of inadequate rainfall. The main reason is the lack of rains and scarcity of land reservoir water. Another very important reason of this is due to unplanned used of water due to which a significant amount of water goes to waste [1]. Asparagus (Asparagus Officinalis) is a member of the lily family and perennial vegetable. It has been grown for more than 2,000 years and is quite popular in the home garden today. Asparagus is an excellent source of vitamin A and contains 2significant levels of calcium, phosphorus, riboflavin, thiamine and vitamin C. Asparagus plants grow mostly tropical, sub-tropical and temperate regions. The plants are suitable in fertile soil and not suitable to flood condition. When watering Asparagus, avoid watering the tops of the plants and to reach the water at the base of the plants. Agriculture has, throughout the history, played a major role in human societies endeavors to be self- sufficient in food. Irrigation is an essential component of crop production in many areas of the world. In Asparagus for example, recent studies have shown that proper timing of irrigation is an important production factor and that delaying irrigation can result in losses. Automation of irrigation system has the potential to provide maximum water use efficiency by monitoring soil moisture at optimum level [2]. Maintaining an optimum moisture level in the soil at all times results in less water loss to the sun and the wind. No water is wasted on non-growth areas, and the root zone is maintained at its ideal moisture level, combining the proper balance of water for a very efficient irrigation system [3]. There are many systems to achieve water savings in various crops, from basic ones to more technologically advanced ones. In an automated irrigation system, the most significant advantage is that water is supplied only when the moisture in soil goes below a determined threshold value [4]. In current times, the farmers have been using irrigation system through the labor intensive control in which the farmers irrigate the land at regular intervals by turning the water pump on/off when essential. These procedures sometimes consume more water and sometimes the water supply to the land is delayed due to crops dry off. This problem can be rectified if we used automated irrigation system in which the irrigation will take place only when there will be acute requirement of water. In crop manufacture it is mostly used in waterless areas and in periods of rainfalls shortfalls, but also to protect plants against hoar frost [5].

## II. DESIGN METHODOLOGY OF THE PROPOSED SYSTEM

### System Description

Proposed system objective is to supply water for the fields in alternative way by generating electricity through solar panels. The system mainly consists of two modules, solar pumping module and automatic irrigation module. In solar pumping module solar panel of required specification is mounted near the pump set.Then using a control circuit that it is used to charge a battery. From the battery using a converter circuit it gives power to the water pump which is submerged inside the stream. Then the water is pumped into the field for watering the crops

**In the current work we have designed following hardware systems:**

In automatic irrigation module the water outlet of the pump is electronically controlled by a soil moisture sensing circuit. The sensor is placed inside the field. The sensor converts the moisture content in the soil into equivalent voltage. This is given to a sensing circuit which has a reference voltage that can be adjusted by the farmers for setting different moisture level for different crops. The amount of water needed for soil is proportional to the difference of these two voltages. Therefore, the amount of water flowing is proportional to the moisture difference [6].

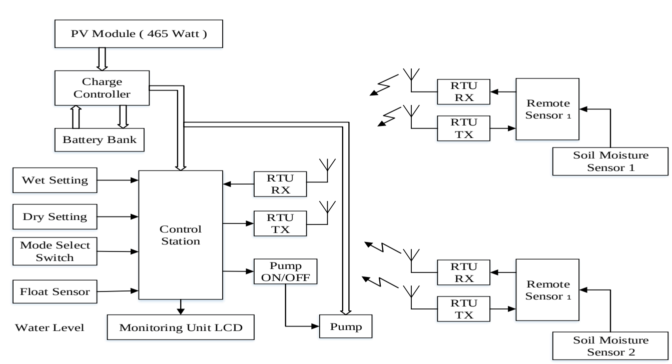



***Figure.1.*** *Overall system configuration*

## III. SOLAR POWER UTILIZATION FOR WATER PUMPING

### A. Water Requirement of the Plant

The water requirement of the plants varies with time and depends on the season and growth of the plants. It is essential to irrigate optimally during the stage of flowering to fruits maturity. The type of soil and the climatic parameters are other factors that need to be considered.

***Figure.2.*** *Insufficient soil condition of Asparagus Field*

Water is the primary source of life for mankind and one of the basic necessaries for rural development. The rural demand for water for crop irrigation and domestic water supplies is increasing. At the same time, rainfall is decreasing in many arid countries, so surface water is becoming scare. As these trends continue, mechanized water pumping will become the only reliable alternative for lifting water from the ground. Diesel, gasoline, and kerosene pumps have traditionally been used to pump water. However, reliable solar (Photo Voltaic [PV]) are now emerging on the market and are rapidly becoming more attractive than traditional power sources. These technologies powered by renewable energy sources (Solar), are especially useful in remote locations where a steady fuel supply is problematic and skilled maintenance personal are scare [7].

***Figure.3.*** *Sufficient soil condition of Asparagus Field*

### B. Calculation of Solar PV System for Water Pumping

**PV Sizing:**

Different size of PV modules will produce different amount of power. To find out the sizing of PV module, the total peak watt produced needs. The peak watt (WP) produced depends on the size of the PV module and climate of site location. To determine the sizing of the PV modules, calculate as follows:

**First Step:**

Load requirements = 25000 liters of water everyday from a depth of 5m

Amount of water to be pumped/day = 25000 liter/day
= $25m^3$

To determine Total Dynamic Head (TDH)

Possible max elevation of piping unit inlet = 3m

Possible max head of running stream fluctuates = 2m

Total vertical lift = 3m + 2m
= 5m

Possible frictional losses = 5% of total vertical lift
= $5 \times 0.05$
= 0.25

TDH= 5m + 0.25m =5.25m

To determine estimate load requirement with selected DC pump[Experimental]

Selected DC pump max head = 7m

Selected DC pump max flow = $5m^3$/hour

Supplied voltage = 12V

No load current = 3A

Loading current = 14A

Power consumption, P = VI = $12 \times 14$
= 168 Watt

$$\text{Required running hour/day} = \frac{\text{Amount of running hour /day}}{\text{DC pump max flow}}$$

$$= \frac{25\text{m}^3/\text{day}}{5\text{m}^3/\text{hour}}$$

= 5 hour/day

Required electrical energy/day = Power consumption × Running hour/day
= 168Watt × 5hour/day
= 840 Watt hour/day

To determine Ampere hour requirement of DC load

System voltage = 12V

Load Current = 14A

Required running hour/day = 5 hour/day

Required Ampere hour/day = Load current × Running hour /day
= 14A × 5 hour/day
= 70A-hour/day

**Second Step:**
Battery Sizing: 12V, 14A load for 5hour day time

Typical battery terminal voltage = 12V

Number of days of Autonomy = 0 [day to run no sunlight]

DOD for Lead Acid Battery = 20%

Required capacity of battery bank $= \frac{\text{Required total Ah/day}}{\text{DOD}}$

$$= \frac{[\frac{\text{Ah}}{\text{day}} + (\text{Autonomy} \times \frac{\text{Ah}}{\text{day}})]}{20\%}$$

$$= \frac{[70 + (0 \times 70)]}{20\%}$$

$$= 70 \times \frac{100}{20}$$

$$= 350 \text{ Ah}$$

Selected battery capacity = 100 Ah
Numbers of parallel batteries in the bank =

$$\frac{\text{Required capacity of battery bank}}{\text{Selected battery capacity}}$$

$$= \frac{350\text{Ah}}{100\text{Ah}}$$

= 3.5 ≈ 4 Numbers

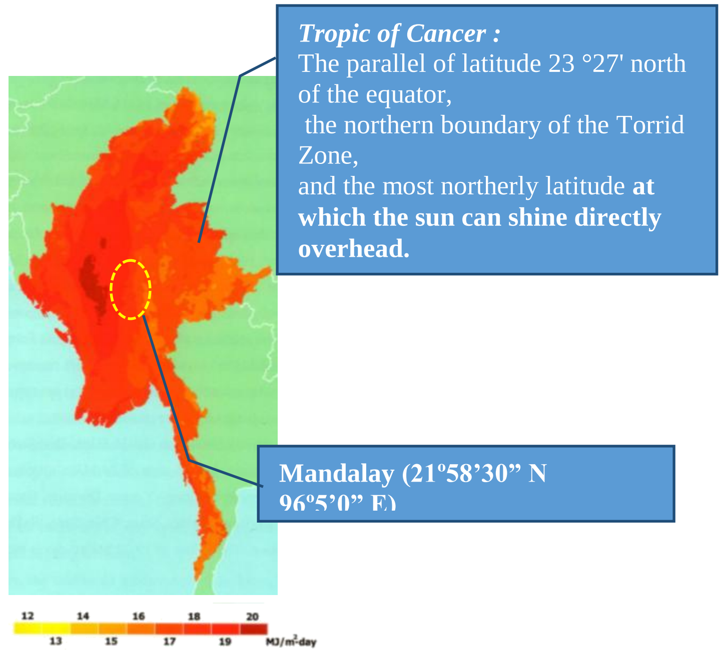
**Third Step:**
PV module sizing: charging for battery bank 100Ah, 4 Nos, 12V, 400Ah/day

**Solar Radiation Data:**

| | |
|---|---|
| **Purpose:** | **Irrigation** |
| **Site Location:** | **Mandalay** |
| **Coordinates:** | **21º58'30" N 96º5'0" E** |
| **Climate:** | **Tropical wet anddry** |

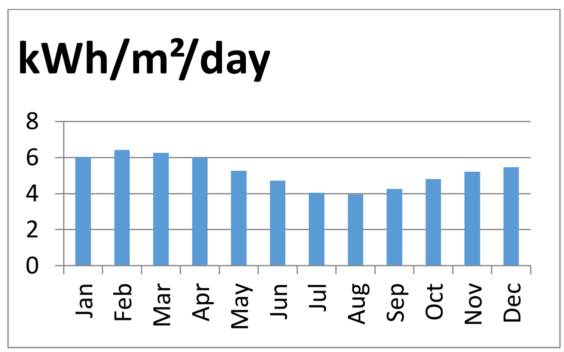
**Climate Data For Mandalay**

| Month | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Year |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Average high °C (°F) | 28.6 (83.5) | 32.1 (89.8) | 35.8 (96.4) | 38.4 (101.1) | 36.8 (98.2) | 34.2 (93.6) | 34.3 (93.7) | 32.3 (90.1) | 33.1 (91.6) | 32.2 (90) | 30.2 (86.4) | 28.2 (82.8) | 33.0 (91.4) |
| Daily mean °C (°F) | 21.0 (69.8) | 23.5 (74.3) | 27.8 (82) | 31.4 (88.5) | 31.3 (88.3) | 30.0 (86) | 30.1 (86.2) | 28.8 (83.8) | 29.0 (84.2) | 27.9 (82.2) | 24.8 (76.6) | 21.5 (70.7) | 27.26 (81.05) |
| Average low °C (°F) | 13.3 (55.9) | 14.9 (58.8) | 19.7 (67.5) | 24.4 (75.9) | 25.8 (78.4) | 25.8 (78.4) | 25.8 (78.4) | 25.2 (77.4) | 24.9 (76.8) | 23.5 (74.3) | 19.4 (66.9) | 14.8 (58.6) | 21.5 (70.6) |
| Average rainfall mm (inches) | 4 (0.16) | 2 (0.08) | 1 (0.04) | 40 (1.57) | 138 (5.43) | 116 (4.57) | 83 (3.27) | 136 (5.35) | 150 (5.91) | 125 (4.92) | 38 (1.5) | 6 (0.24) | 839 (33.03) |
| Average rainy days | 0.4 | 0.4 | 0.4 | 3.3 | 8.3 | 7.2 | 5.9 | 8.7 | 8.1 | 6.8 | 2.8 | 0.7 | 53.0 |
| Average relative humidity (%) | 68 | 58 | 49 | 50 | 66 | 73 | 71 | 76 | 76 | 77 | 74 | 72 | 67.5 |
| Mean monthly sunshine hours | 309 | 280 | 301 | 291 | 267 | 208 | 182 | 168 | 215 | 223 | 269 | 278 | 2,991 |



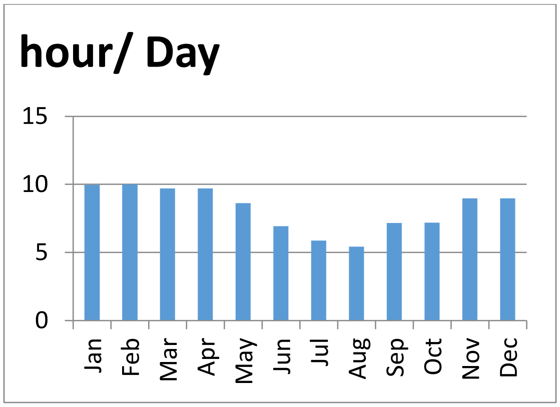

***Source:*** *World Meteorological Organization Weather Base Record : The Solar Electricity Handbook website*

Monthly Solar Energy Potential at Selected Region




| Month | kWh/m²/day |
|---|---|
| Jan | 6.03 |
| Feb | 6.41 |
| Mar | 6.26 |
| Apr | 5.99 |
| May | 5.26 |
| Jun | 4.72 |
| Jul | 4.05 |
| Aug | 3.96 |
| Sep | 4.26 |
| Oct | 4.81 |
| Nov | 5.22 |
| Dec | 5.47 |

Mean Monthly Sunshine Hour at Selected Region




Possible min Solar radiation [August] = 3.96 kWh/m²/day
Possible min Sunshine hour [August] = 5.4193545 h/day
Possible max load = 70Ah/day
Battery efficiency for charging and discharging = 90%
PV module efficiency due to temperature = 30%
Possible total loss factor $= \frac{1}{\text{battery efficiency}} \times \frac{1}{\text{temperature efficiency}} \times \frac{1}{\text{other loss efficiency}}$

$$= \frac{1}{90\% \times 30\%}$$

$$= \frac{1}{0.9 \times 0.3} = 3.7037037 \approx 3$$

Estimated Ah requirements from PV module = Possible max Load × Loss factor
= 70 Ah/day × 3
= 210 Ah/day

Solar Isolation[August] $= \frac{\text{Solar Radiation[August]}}{\text{Sunshine hour[August]}}$

$$= \frac{\frac{3.96\text{kWh}}{\text{m}^2}/\text{day}}{5.4193548\text{h/day}}$$

= 38.75A

Total Ampere requirement from PV module = $\frac{\text{Ah requirement from PV}}{\text{Sunshine hour}}$

$$= \frac{210\text{Ah/day}}{5.4193548\text{h/day}}$$

= 38.75A

PV module system voltage = 12V
PV module system current = 38.75A
Required PV module Power capacity, P = VI
= 12V × 38.75A
= 465 Watt
Selected PV module unit = 55 Watt
Required numbers of PV modules = $\frac{\text{Required PV module power}}{\text{Selected PV module unit}}$

$$= \frac{465\text{ Watt}}{55\text{ Watt}}$$

= 8.4545455

≈ 9 Numbers

| Month | Hours | hour/ Day |
|---|---|---|
| Jan | 309 | 9.967742 |
| Feb | 280 | 10 |
| Mar | 301 | 9.709677 |
| Apr | 291 | 9.7 |
| May | 267 | 8.612903 |
| Jun | 208 | 6.933333 |
| Jul | 182 | 5.870968 |
| Aug | 168 | 5.419355 |
| Sep | 215 | 7.166667 |
| Oct | 223 | 7.193548 |
| Nov | 269 | 8.966667 |
| Dec | 278 | 8.967742 |

## V. DISCUSSION AND CONCLUSION

In this study, automatic irrigation of Asparagus planted to one acre of area is realized with solar energy powered and RF units. An installed capacity of 55W with 9 pieces of solar panels was designed to satisfy water requirement by growing of trees. Water demands of trees were defined with soil moisture sensors and were satisfied with output pressure and flow rate is achieved by pump. As the proposed model is automatically controlled it will help the farmers to properly irrigate their fields. The model always ensured the sufficient level of water in the Asparagus field avoiding the under irrigation and over irrigation, they can provide irrigation to larger areas of plants with less water spending and inferior pressure. We designed and implemented this model considering low cost, reliability, alternate source of electric power and automatic control. Using this system, one can serve manpower, water to get better manufacture and eventually income.

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