Optimal Utilisation of available Solar Energy

By

Balachandra M Hegde, Sunny Arokia Swamy B and Pavan R Manvi

M.S.Ramaiah Institute of Technology

Shoiab and Salim

M.S.Ramaiah School

Abstract:

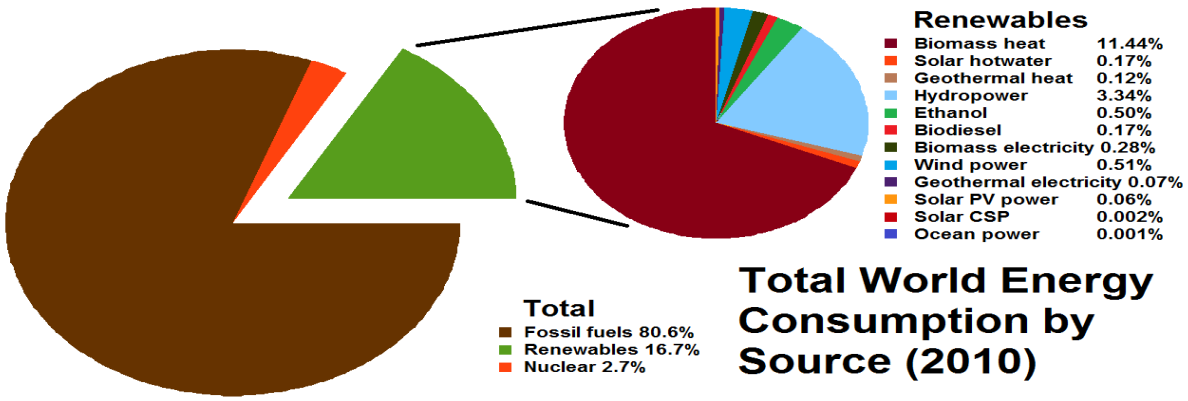
Technology is increasingly weaving its way into our daily lives. Due to this there is a large demand for Energy consumption. The power which is being generated is not sufficient to meet the required demand and finally this causes a deficiency in power in some economically backward sectors. Hence, saving the power has become one of the major objectives of many people. This Project mainly focuses on these economically backward sector areas by developing a standalone photo voltaic system which is of affordable cost and secondly it uses total solar energy which is available on earth by converting solar energy into thermal as well as electric energy efficiently. The thermal energy is used to make water hot and electric energy is used very efficiently by varying the intensity of light as per the human requirement. Hence, this proposed model with light intensity variation can be also used in huge buildings, hospitals etc for saving of power.

Introduction:

Energy is basically defined as the capacity to do work. Energy is available in different forms like Kinetic Energy, Mechanical Energy, Chemical Energy, Heat Energy, and Electrical Energy etc… Energy resources are mainly classified into two forms on the basis of their availability i.e., Renewable (Non-Conventional) Energy resources and Non-Renewable (Conventional) Energy resources.

Non-Renewable Energy resources also known as finite resources are the resources that will not sustain for a long period of time for economic extraction. Some of the examples are Coal, petroleum, oil, gas and metal ores etc… The main disadvantage is these processes generally take from tens of thousands to millions of years and they leave behind harmful by-products upon combustion, thereby causing a lot of environmental pollution which has become a major concern in global warming.

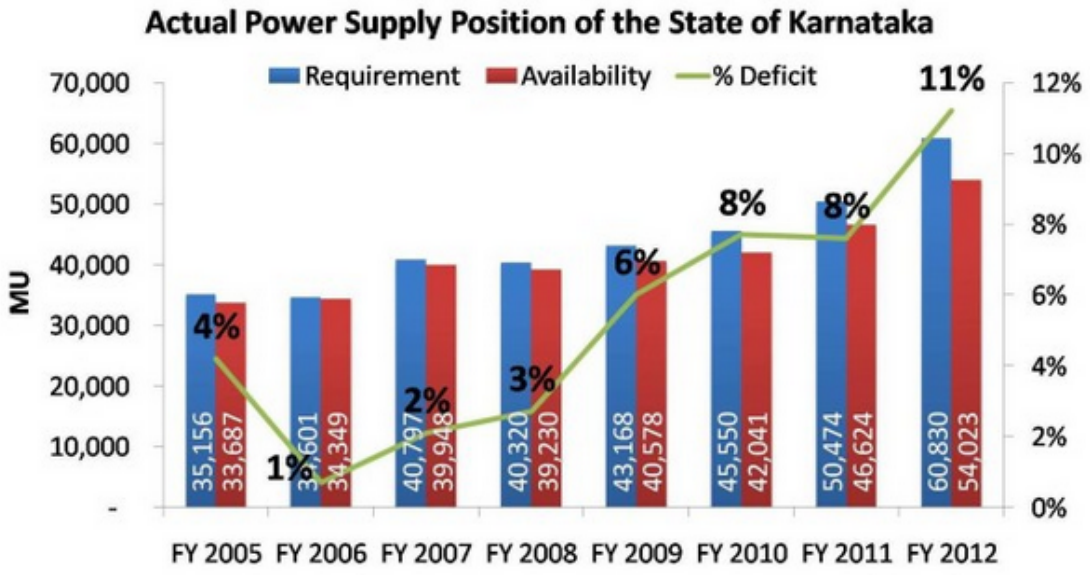
Renewable Energy is generally defined as energy that comes from resources which are naturally replenished on a human timescale such as sunlight, wind, rain, tides, waves and geothermal heat. Renewable energy replaces conventional fuels in four distinct areas: electricity generation, hot water/space heating, motor fuels, and rural (off-grid) energy services. About 16% of global final energy consumption presently comes from renewable resources, with 10% of all energy from traditional biomass, mainly used for heating, and 3.4% from hydroelectricity. New renewable (small hydro, modern biomass, wind, solar, geothermal, and bio fuels) accounts for another 3% and are growing rapidly. The pie chart given below clearly depicts the total world energy consumption by source in the year 2010.



Present scenario

With growing urbanisation, industrialisation and modern lifestyle there has been an increasing demand towards energy. The modern technology is definitely aiding the energy demand but it is not fulfilling the demands. This leads to an unequal distribution of power among the different consumer sectors. Due to economical benefits power distributors, tend to divert the power from rural areas towards urban areas which lead to acute power shortage in the rural areas.

Based on the study on the Indian state of Karnataka we can substantiate the above statements.



From the above bar graph it is pretty evident that the demand and generation of power is increasing over the years, but there is an increasing mismatch in the same. As we see in the financial year 2005, the deficit was just 4% but it has increased around three times in the next 7 years. In rural areas, the deficit is met mainly by Bio-gas whose disadvantages over shadow their advantages, as those are expensive, harmful to environment, has a very low efficiency and requires more land. It also needs a regular supply of raw materials. Most of these can be overcome by solar energy which is economical over a long run and has abundant raw material in the form of sunlight.

Why renewable energy has great importance?

- Minimal impact on environment
- Less maintenance than traditional generators
- Economic Benefits
- Power available to the areas near the Grid
- Reliable and Resilient energy system
- Stable energy prices
- Contribute to increasing energy independence and security of energy supply at National level

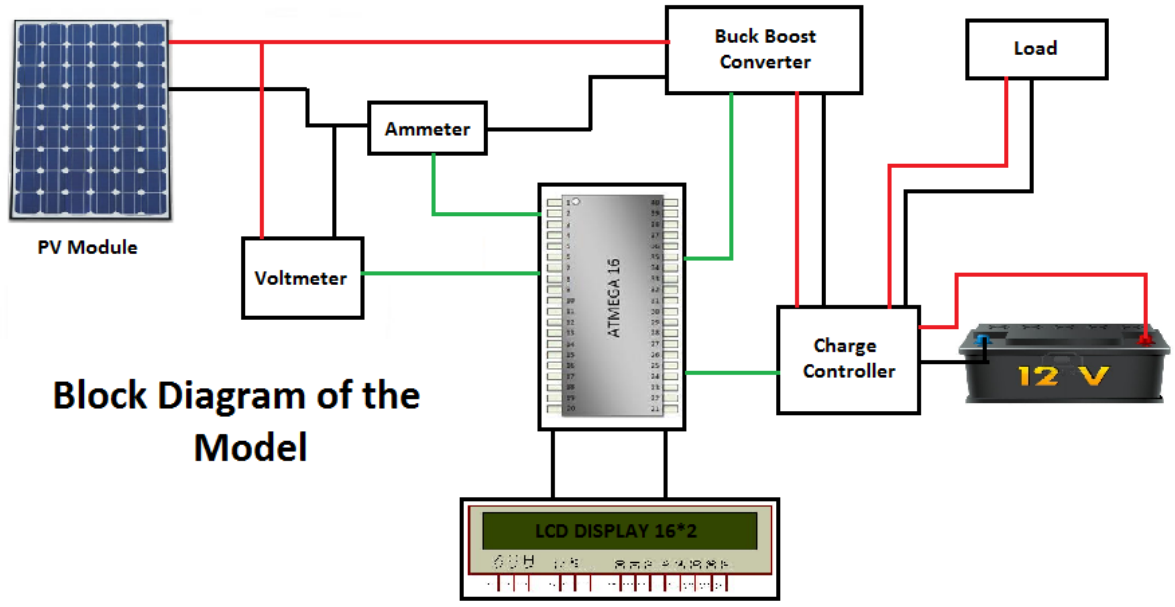
Proposed Model

After a literature survey on Energy utilisation and resources available mainly in the state of Karnataka, We have come to a conclusion that solar energy is a better solution than other renewable energy resources. Hence, this project mainly focuses on Optimal Utilisation of available Solar Energy. The model has been proposed as a

standalone PV system which can be kept in each and every individual's house. This model automatically varies the intensity of light when it (light) is not required. While converting solar energy into electrical energy there is a lot of thermal energy getting wasted in the form of heat. Hence this model uses this thermal energy which is getting wasted to heat the water by placing water in pipes behind the PV panel. This also helps the PV panel to keep the panel cool and increase its durability and efficiency.

How the model works?

The block diagram of the proposed model is shown in the figure below. It clearly depicts the working of the stand alone PV power system. When the Sunlight falls on the PV panel there is a electron hole pair generation which creates a potential difference, across the cell. As each cell has very low voltage and current ratings hence, they are connected in series and parallel combination to meet the required power requirement. The output voltage and current of the PV panel is sensed by Voltmeter and Ammeter and their converted analog signals are sent to the microcontroller. The microcontroller (ATMEGA16) is programmed on the basis of P&O algorithm which ensures the maximum power point at various solar intensities. The generated control signal is sent to DC-DC converter (Buck Boost converter) which matches the load and source impedance to satisfy the maximum power transfer theorem. The Charge controller monitors the battery condition and also indicates the level of the battery. As it is completely DC system, loads are connected directly from the charge controller. LCD display is used to display the voltage, current and the battery level.

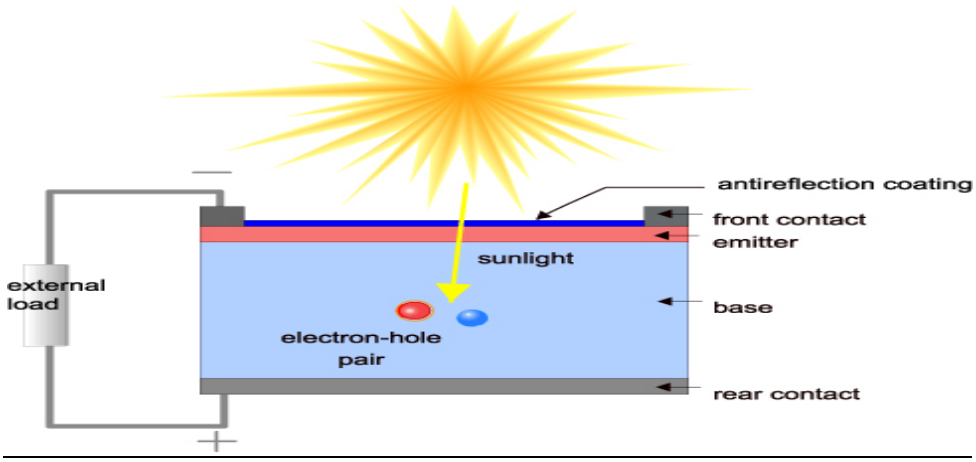


Block Diagram of the Model

For lighting purpose LEDs are connected at the load point. A LED driver is designed to vary the intensity of light in order to achieve maximum utilisation efficiency. In the further sections we will see the different parts of the model.

Stand Alone Photovoltaic System Components

Photovoltaic Cell: A photovoltaic cell is a semi conductor device that converts light to electrical energy by photovoltaic effect. If the energy of the photon of light is greater than the band gap then the electron is emitted and the flow of electrons creates current.



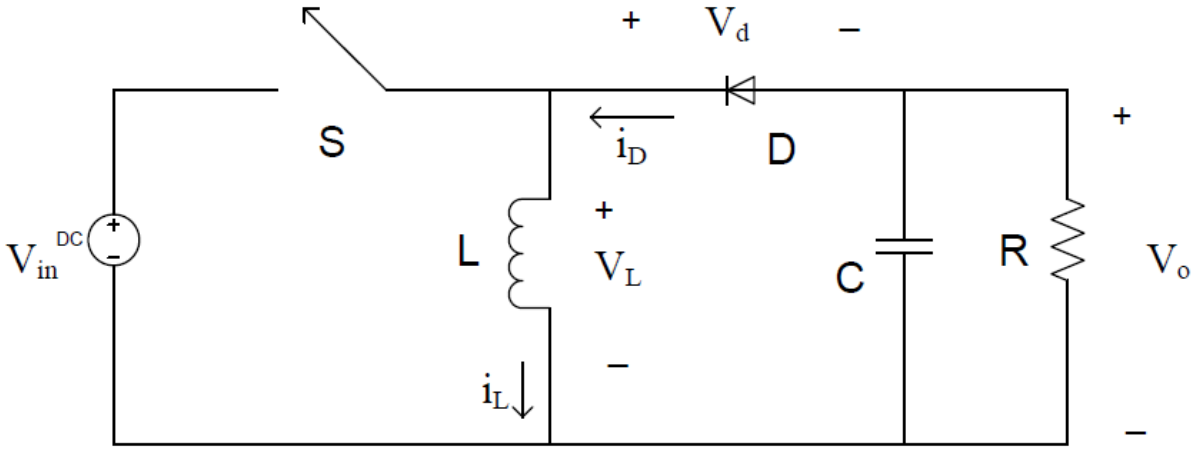
PV Module: Usually, a number of PV modules are arranged in series and parallel to meet the energy requirements. Series connections are responsible for increasing the voltage of the model where as the parallel connection is responsible for increasing the current in the array.

Sensors: The implementation of sensors is essential in order to achieve the desired functionality of the system. The sensors are the devices that are going to be in charge of monitoring and communicating everything that was happening in the system to the microcontroller. Two of the sensors that were going to be needed in the design were a voltage and current sensor. Both of these sensors played a significant role in one of the main goals of the project which was achieving maximum power point tracking. As its name implies, these sensors keep the microcontroller updated with the voltage and current values being provided by the panel so that it can react to it accordingly.

Microcontroller: ATmega16 is a low power AVR 8 bit microcontroller. Some of the main features of this microcontroller are Two 8-bit Timer/Counters with Separate Prescalers and Compare Modes, One 16-bit Timer/Counter with Separate Prescaler, Compare Mode, and Capture Mode, Real Time Counter with Separate Oscillator, Four PWM Channels, 8-channel, 10-bit ADC, 2 Differential Channels with Programmable Gain at 1x, 10x, or 200x, Programmable Serial USART, On-chip Analog Comparator. The ADC and PWM of the microcontroller plays an important role in which ADC is used to take analog input i.e., from current and voltage sensor. PWM is used to generate a varying voltage level signals which is used to disturb the MPP point.

Buck Booster Converter: The maximum PowerPoint tracking is basically a load matching problem. In order to change the input resistance of the panel to match the load resistance (by varying the duty cycle), a DC to DC converter is required. To obtain a stable voltage from an input supply (PV cells) that is higher and lower than the output, a high efficiency and minimum ripple DC-DC converter required in the

system for residential power production. Buck-boost converters make it possible to efficiently convert a DC voltage to either a lower or higher voltage. Buck-boost converters are especially useful for PV maximum power tracking purposes.



Charge Controller: There are four possible states that the battery can be in that will determine what charging mechanism is going to be used. The quantitative value of each of the thresholds was determined by the battery and solar array that was ultimately implemented, but the software was able to check and react to the following conditions:

Off State: When there is little or no power coming from the solar panel, the device should go into an off state to protect the battery from leaking back into the solar panel.

On State: When there is minimal power coming from the solar panel, enough to power the system but not enough to move to the next state, the system turns on and attempts to deliver all of the power.

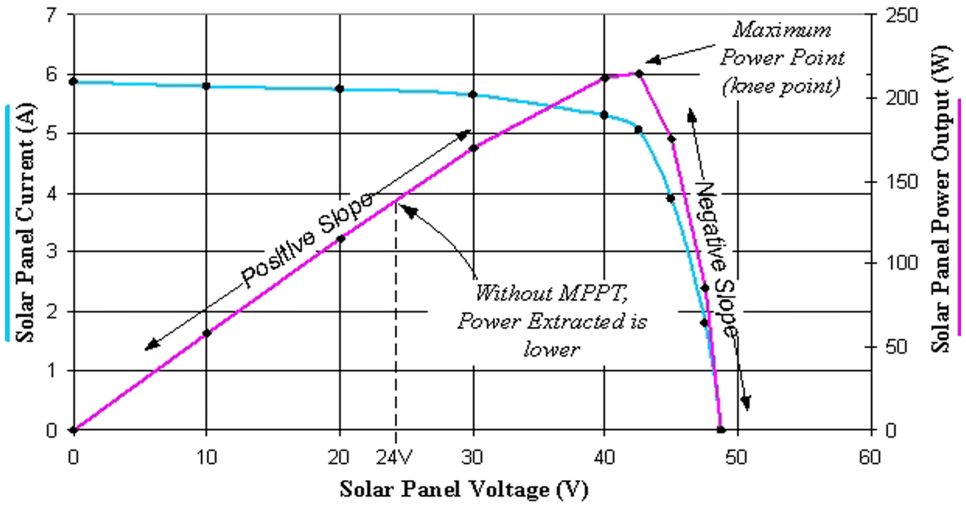
Bulk State: This is the main charging state where the MPPT algorithms were most relevant. Here the maximum power point was determined and the battery was charged accordingly.

Float State: Once the battery reached a high enough voltage and was close to fully charged, the controller then moved into the float state. In this state, the goal was to maintain the voltage level and compensate for self discharge.

Battery: Battery is a small storage device which is used to store electrical energy. Technically, it is defined as a device that converts chemical energy contained in its active materials directly into electric energy by means of an electrochemical oxidation-reduction (redox) reaction. There are different types of batteries like Lithium ion, Lead acid, Nickel Cadmium etc. Lead acid battery is used for this project because of its features like

- Nominal Voltage: 2.1V
- Specific Energy: 33-42 W-h/kg
- Moderate energy density of 60-110 W-h/L
- Specific Power: 180 W/kg
- Charging and discharging: 50-95% (Higher discharge rates result in considerable loss of capacity)
- Moderate rate of self-discharge of 3-20%
- Cycle durability: 500-800 cycles
- Moderately expensive.

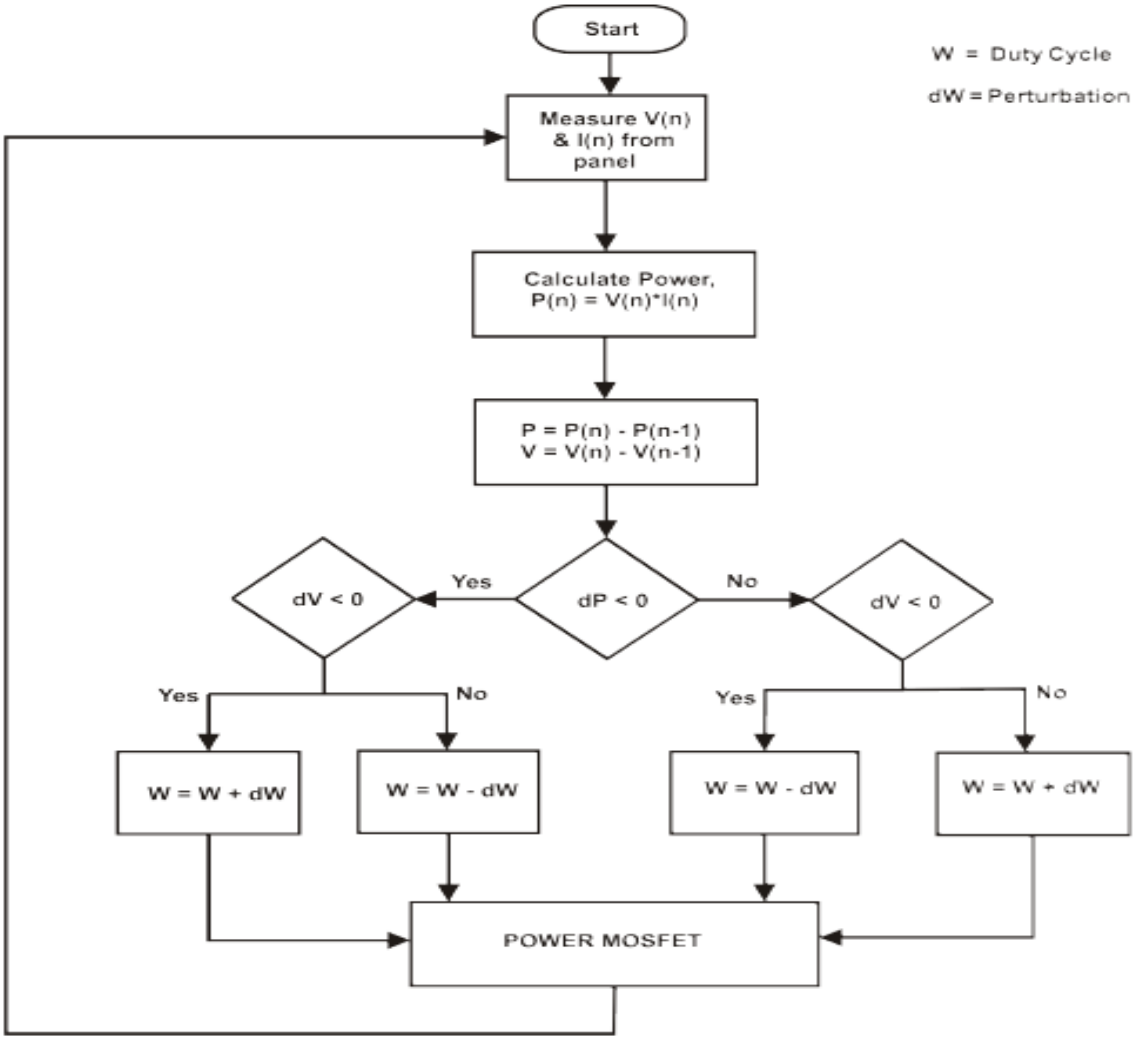
An Overview of MPPT(Maximum power point tracking): A typical solar panel converts only 30-40% of incident solar radiation into electrical energy. MPPT technique is used to improve the efficiency of the solar panel. According to maximum power transfer theorem, the power output of a circuit is maximum when the source impedance matches with load impedance. Hence our problem of tracking MPPT reduces to an impedance matching problem.



Different MPPT Techniques: There are different techniques used to track the maximum power point. Few of the most popular techniques are

- Constant voltage method
- Incremental Conductance method
- P & O (Perturb and observe) algorithm

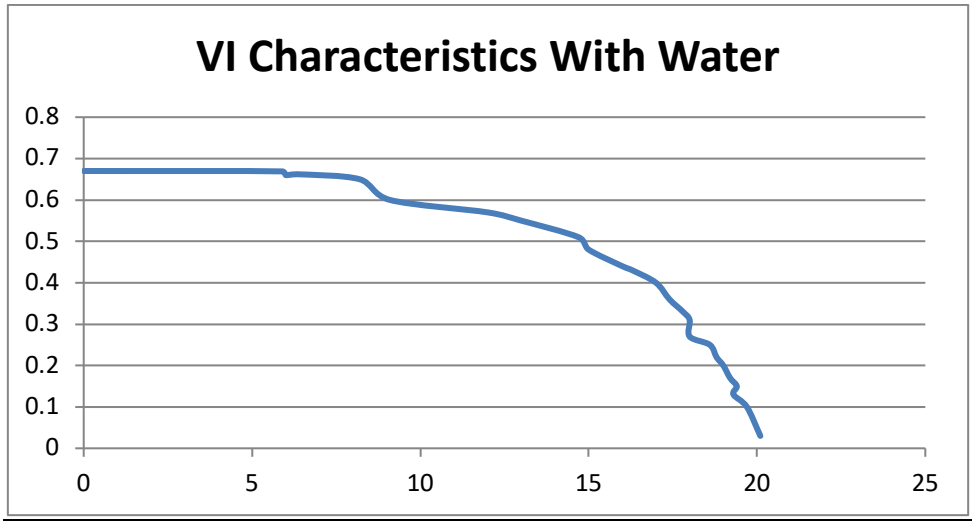
We have used P & O (Perturb and observe) algorithm, it states that when the operating voltage of the PV panel is perturbed(disturbed) by a small increment, if the resulting change in power ΔP is positive, then we are going in the direction of MPP and we keep on Perturbing in the same direction. If ΔP is negative we are going away from the direction of MPP and the sign of Perturbation supplied has to be changed. The flowchart for the P&O algorithm is as shown in the figure,

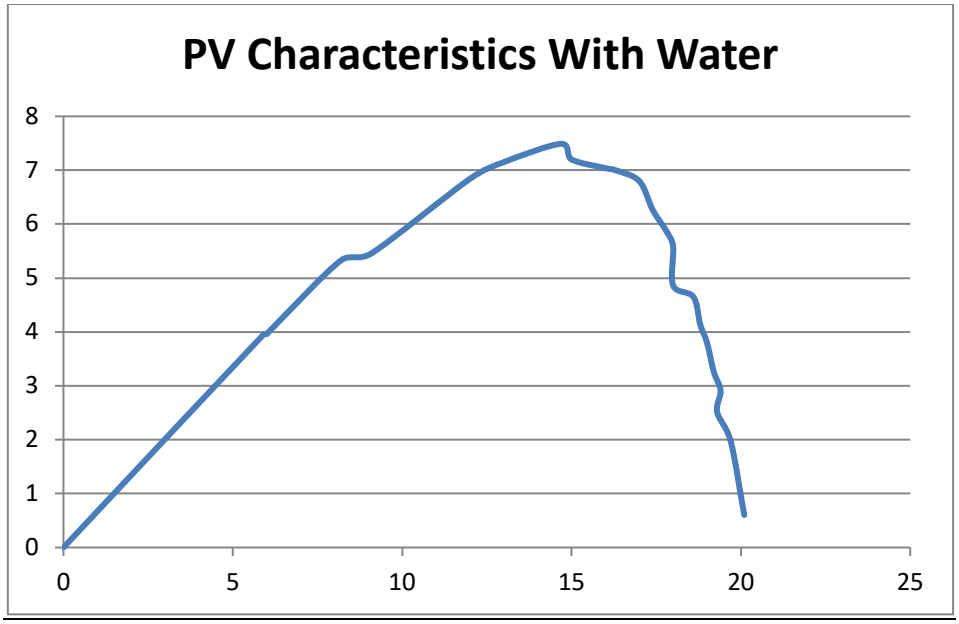


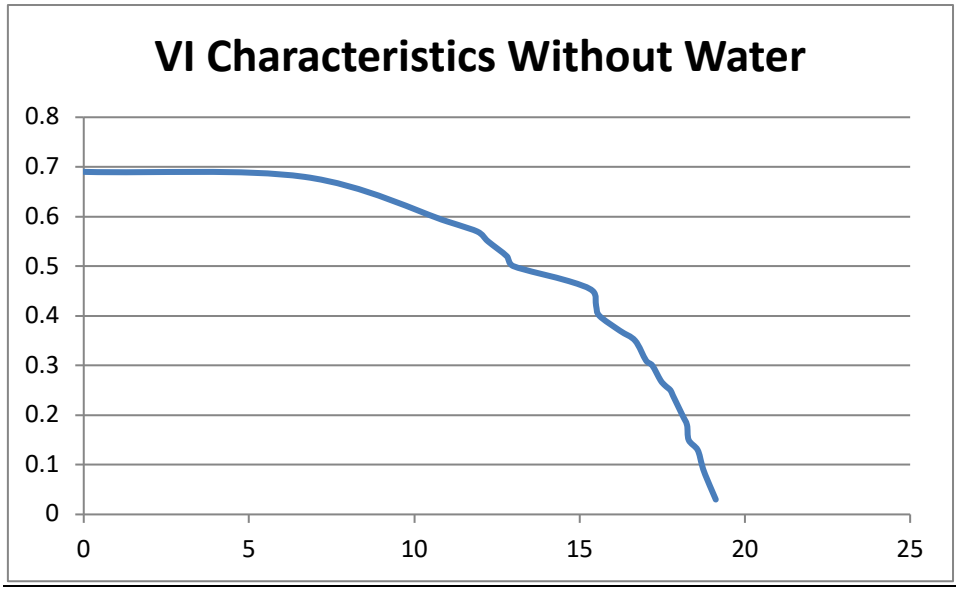
Results

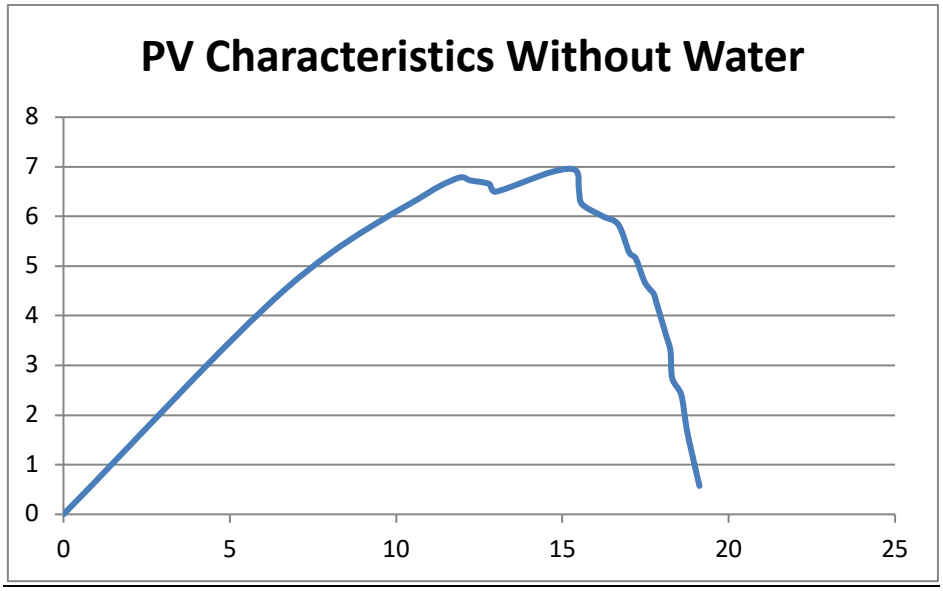
Tests on the model were conducted in both states i.e.., by flowing water under the panel and without water.

The following graphs clearly depicts that the efficiency of the solar panel is increased by flowing water under the panel. It is shown by plotting VI curves.


VI Characteristics With Water
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0
5
10
15
20
25


PV Characteristics With Water
8
7
6
5
4
3
2
1
0
0
5
10
15
20
25


VI Characteristics Without Water
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0
5
10
15
20
25



The PWM outputs were observed on the CRO and has been taken

Conclusion and Future work

The scope of this project was to create a working model of efficient standalone Photovoltaic system. Both Conversion and utilisation efficiency was improved. At conversion side MPPT technique was used. This system successfully uses the simple P&O algorithm to reach the Maximum power point (MPP). Reaching a stable, true MPP at steady state instead of oscillating around this point would improve the system's efficiency and increase reliability. Another extension of this project would be to directly power the microcontroller and other circuits from the solar panel instead from an external power supply.

To improve utilisation efficiency light intensity variation concept was used.