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# Comprehensive Review and Analysis on Applications and Advantages of Soft Computing Based Maximum Power Point Tracking in Solar PV Energy System

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**Abstract**
For both production and daily living, electricity is essential. Power generation, power transmission, power conversion, and power consumption make up the four components of the power system. It is difficult to set up transmission and transmission systems for minimal power demands on isolated farms, forest farms, and islands. The past ten years have seen the discovery and publication of several methods for finding MPP. These technologies differ in many ways, including the types of sensors used, their complexity, price, speed of detection, accuracy in tracking changes in light and temperature, the materials required for the application or user data, etc. There are several methods, including P&O, ear networks, open or short-circle volumes, current probe, and fuzzy logic controllers. The majority of these techniques provide at least locally, however others, such open or short circular circuits, only provide an average MPP. This is not an issue because the V-P curve often has just one meaningful value. However, there will be more than one maximum in these curves if the PV curve is somewhat obscured. This research article provides a thorough analysis of the various renewable energy sources, as well as their maximum point tracking methodologies and comparison outcomes.

**Keywords:** MPPT, P & O, I & C, Solar and Wind Hybrid Power System.

## I. INTRODUCTION

Global energy demand is constantly growing, and fossil fuel exploration is a priority. These oils are not durable but pollute the environment. The expansion in worldwide energy request and increment consideration regarding natural issues has prompted the investigation of renewable energy sources, for example, solar and wind [17]. The use of renewable energy (RES) is affected by the scarcity of fossil fuels and the unfavorable climate because renewable energy is a large part of the energy obtained from solar and wind. Energy from the sun and wind is a natural source that its use will not damage and is becoming increasingly popularIn order to reduce the demand for electricity in the traditional power generation sector, the optimal use of these natural resources is essential for power generation [20]. The electricity grid connects power plants, transmission lines, or allotment lines to provide power to users. In power plants, electricity comes from renewable or non-renewable energy sources. The current is then transmitted from one place to another through the transmission line. Finally, the power is distributed among the users using distribution feeders [24].

The current trend in the developing economy has led to the expansion of renewable power. Over the past three years, Figure 1 shows that renewable energy and biomass energy account for a significant part of current renewable energy consumption. The recent development of solar photovoltaic knowledge or reliable introductions of projects in countries/regions such as Germany and Spain have also brought significant growth in the solar photovoltaic market [30]. It is expected that there will be more than other renewable energy sources in the solar photovoltaic market. In 2019, more than 115 countries set political goals to achieve their predetermined role through renewable energy compared to 45 countries in 2005. Most of the objective is ambitious, reaching 30-90% of national production through renewable energy [7].

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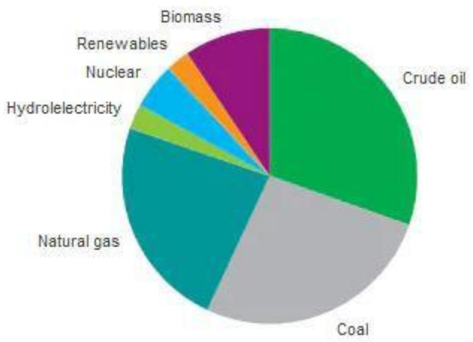


Figure 1.: Global energy consumption in the year 2020

## II. LITERATURE SURVEY

In this section a detailed literature review on maximum power point techniques is illustrated as per various researchers

**H. Zhou et al. (2011)** proposed the Perturb and Observed method to use the maximum power in a photovoltaic solar system. It is a simple algorithm and requires no prior knowledge of the PV system. It can be easily applied with analog circuits.. The disadvantage of this method is that it rotated when the MPP arrived, and it cannot be adequately followed when conditions change [10].

**D. Wang et al. (2012)** The photovoltaic solar system is connected to the load through two bridge converters currently operating with multiple inverters. In this embodiment, the small capacitors in the film replace the high-voltage capacitors that are common in the system. Even under rapidly changing conditions, this program can provide high efficiency. The 5kW PV converter was developed to test the efficiency of the algorithm. The control of both active bridges and multilevel inverters is the disadvantage of this approach [13].

**S. Lee al. (2013)** proposed MPPT monitoring technology for solar photovoltaic systems. This technique considers the thermal stress exerted by the semiconductor switch on the converter. As a result, losses are reduced, and overall efficiency is improved. The algorithm works better with climate change changing the environment [15].

**Chun Wei et al. (2014)** MPPT algorithm developed for energy conversion systems. Combine the artificial neural network and the Q learning algorithm to obtain the maximum energy point. Follow the maximum power of the corresponding rotor speed. The small chemical WECS Artificial neural networks require more training time [16].

**M. Hamzeh et al. (2015),**DC Microgrid with photovoltaics. Controlled energy storage systems include batteries, supercapacitors, DC loads, electric motors, and energy management systems (EMS). The main goal is to manage the demand for goods effectively. Simple adaptive energy management control is achieved. In MATLAB / Simulink, the system is configured with different input conditions and loads, and the results are obtained. It is found from the obtained results that the DC Microgrid using the energy control system meets the requirements of all the conditions [3].

**U. Manandhar et al. (2018**), with renewable energy development such as hydrogen energy, renewable energy supply has become an integral part of the DC Microgrid. Related monitoring and power management have become the focus of current research. The Microgrid DC photovoltaic / fuel / DC energy storage in this article includes photovoltaic (PV), fuel cells, lithium-ion batteries, and supercapacitors, as well as DC / DC and DC / AC converters. To ensure the stability of the photovoltaic / fuel cell / hybrid DC microgrid energy storage. This paper presents a control and energy management system. The proposed power control and management system effectively controls the cost of the bus and balances the power by automatically controlling the power of each model. Under the power control and management system, when the load changes suddenly, the bus load stays stable, and the power supply remains balanced [7].

**A. A. Radwan et al. (2019)** Adherence to the maximum power point (MPP) of a photovoltaic (PV) model is critical to improving utilization. In the partial shade condition, the P-V curve shows multiple peaks. Therefore, the function of state-of-the-art technology (MPPT) is to monitor the location of the global power supply and prevent running over the top of the city. Especially in partial shadow situations, one of the most effective methods is logic control flooring (FLC) technology [12].

## III. GRID CONNECTED POWER SYSTEM

Renewable energy is power derived from natural possessions, such as solar, wind, waves, or geothermal energy. These resources are renewable and can be recycled naturally. Therefore, compared to the depletion of traditional fossil fuels [1], these sources of information are considered inexhaustible. The global power crunch provides

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a new impetus for the development or maturity of clean or renewable energy. [2]. In addition to the decline in fossil fuel transportation worldwide, another major reason fossil fuels do not work is the pollution associated with burning fossil fuels. In contrast, it is well known that compared to traditional energy sources, renewable energy sources are cleaner, or energy produced has no adverse effects on pollution.

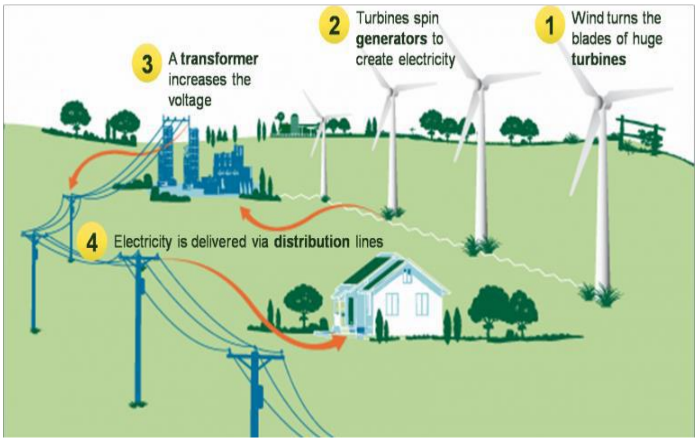

Figure 2.: Solar and Wind Power Hybrid Energy Plant

**Different Sources of Renewable Energy Wind Power**

Wind turbines can be used to harness the power generated by the airflow [3]. The power of turbines used per day is around 600 kW to 5 MW [4]. Because power output is a function of wind speed, it amplifies hastily as wind speed increases. Recent advances have become wind turbines, which are more resourceful than better aerodynamic construction.

**Solar Power**

The evolution of solar energy came from the British astronomer John Herschel [5], who used solar collectors for cooking food during his travels to Africa. Solar power can be used in two main ways. First, the extracted heat can be used as energy from the sun and heat the atmosphere. Another option is to convert solar radiation into electrical energy, which is the most needed form of power. This can be accomplished with solar photovoltaic cells [6] or solar-powered power stations.

**Small Hydropower**

Power plants running with up to 10 MW are considered high-power generators and are regarded as renewable energy sources [7]. It uses hydraulic turbines to convert potential energy for water stored in dams into usable electricity. The purpose of flood power is to use the kinetic energy in the water without the need to build dams or dams.

**Biomass**

Plants capture energy from the sun through photosynthesis. These plants release energy when they burn. In this way, biomass can be used as a natural battery to store solar energy to produce it if needed.

**Geothermal**

Geothermal energy is the thermal energy generated by storage in different layers of the earth [9]. The gradient prepared in this way results in a continuous heat transfer from the base to the ground's surface. This media can be used to heat water to produce very hot steam and use it to run a gas turbine to produce electricity. Significant losses in geothermal energy are often associated with areas near the tectonic plate boundary, although recent developments in technology have become popular [10].

## IV. MPPT TECHNIQUES

In this section various types of maximum power point techniques are explained. As are given below.

**1. Perturb and Observe**

The P&O algorithm is also called "climbing," but both names refer to the same algorithm depending on its application. The correction includes disruption of the power cycle of the power converter and P&O and disruption of the working power of the DC link between the photovoltaic array and the power converter.On the upside, interrupting the power converter's circuit breaker means changing the DC link between the PV array and the power converter so that one technology refers to the same technology. In this method, the final turbulence and the increase in the final

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turbulence signal are used.To determine the expected subsequent turbulence. Figure 3.1 shows that an increase in power increases the power, while on the right side of the MPP, a decrease in power increases the power.

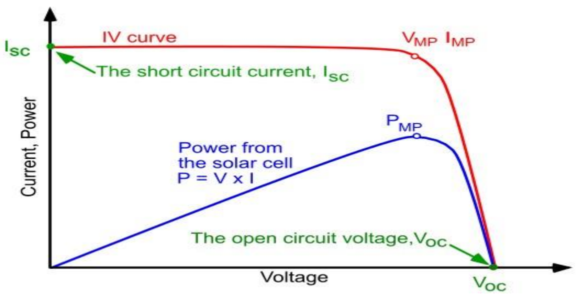


Figure 3.: PV Panel Characteristic Curves[11]

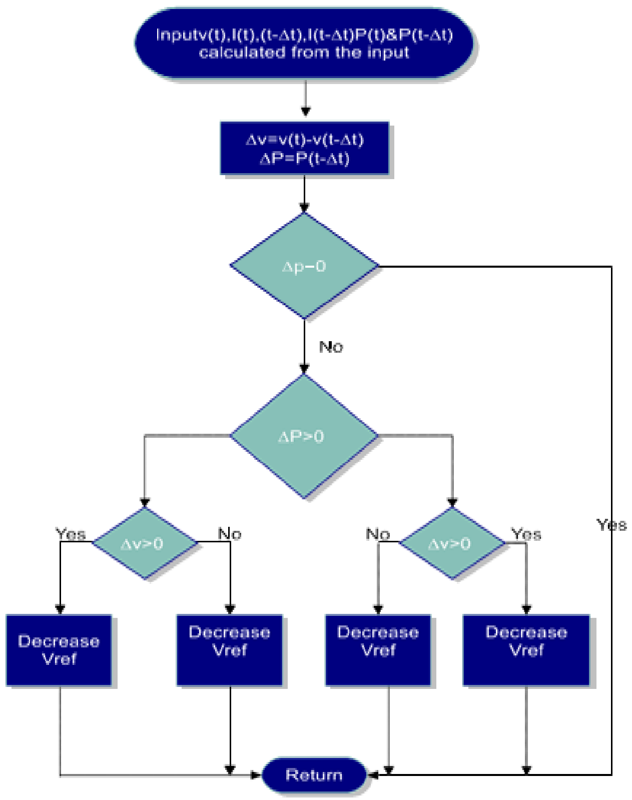


Figure 4.: The Flowchart of the P&O Algorithm

Perturb and Observe method is a most commonly used method for solar and wind energy conversion system. In case of solar PV system the PV output voltage and current are measured two consecutive intervals. The power is calculated for two successive intervals. The change of power to change voltage is calculated dP/dV. Based on the positive and negative values of the slope dP/dV the duty cycle is incremented or decremented. Accordingly the voltage and power are adjusted to the maximum power point. If the slope dP/dV=0, then the maximum power point is reached for the present environmental conditions. This is a continuous process. The measurements are to be continuously taken and change power and change of voltage are calculated to take control actions. Basically the MPP is achieved by making the impedance of the solar PV with the impedance of the load side. The duty cycle is adjusted to match the impedance. The algorithmic steps are given below.

**Algorithmic steps:**

**Step 1:** Measure the two consecutive values of voltages and

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currents of solace PV.
**Step 2:** Calculate the powers P(n) and P(n-1).
**Step 3:** If the powers are increasing, then decrease the duty cycle. **Step 4:** If the powers are decreasing, then increase the duty cycle. **Step 5:** Go to step1.

## 2. Incremental Conductance

The incremental conductance approach is to decide the terminal voltage of the PV module with the aid of using measuring and evaluating the incremental conductance with the immediate conductance. The most strength is reached while the incremental conductance is identical to the immediate conductance. The terminal voltage of the PV module is constantly perturbed at normal durations till the incremental conductance is identical to the immediate conductance. This is represented in the following equation (Ting-Chung & Yu-Cheng 2012).

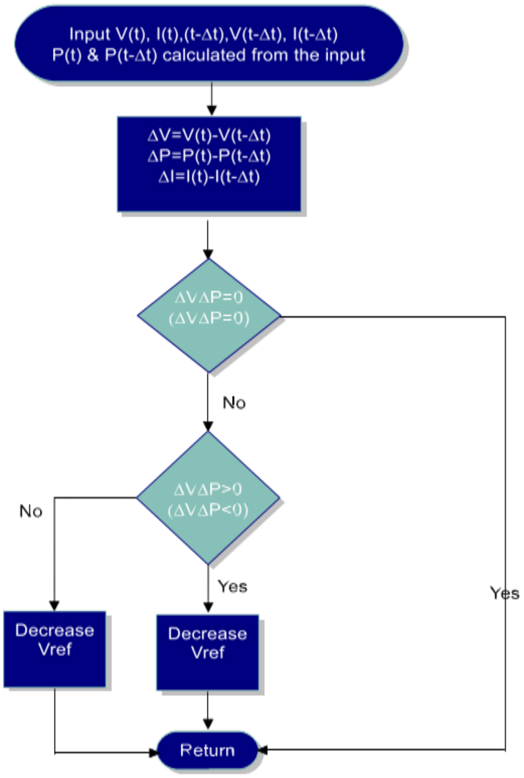


Figure 5.: Incremental Conductance Algorithm

In voltage source region $\frac{\partial I_{pv}}{\partial V_{pv}} > -\frac{I_{pv}}{V_{pv}}$ →D=D+ΔD (increment D)

In the current source region, $\frac{\partial I_{pv}}{\partial V_{PV}} < -\frac{\partial_{pv}}{v_{pv}}$ ,→D=D+ΔD (Decrement D)

At MPP, $\frac{\partial I_{pv}}{\partial V_{pv}} = -\frac{I_{pv}}{V_{pv}}$ $\rightarrow D = D$ (reatain D)

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The incremental conductance method is explained in detail in chapter 4 for the maximum power
point tracking for solar PV energy conversion system. The algorithmic steps are given below:

**Algorithmic steps:**
**Step 1:** Sense the two consecutive voltages and current of solar PV
**Step 2:** Calculate the dI/dV.
**Step 3:** If dI/dV >0, the operating point is in the left of MPP. Increment thevoltage. **Step 4:** If dI/dV <0, the operating point is in the right of MPP. Decrement thevoltage. **Step 5:** Go to step 1.

## 3. Fuzzy Logic Control

Over the past decade, fuzzy logic controls have become more popular because they can handle inaccurate inputs, do not require accurate mathematical models, and tolerate inequalities. A single microcomputer contributes to the information of fuzzy logic controls .Fuzzy logic consists of 3 stages: development, system thinking, and destruction. Fuzzification involves the procedure of transforming a digital entry into a language change depending on the level of membership in a particular group. The member function (as in Figure 3.5) is used to associate a priority with each word. The number of member jobs depends on the precision of the monitor but often varies between 5 and 7 .In Figure 3.5, seven odd levels are used: NB (significant negative), NM (negative medium), NS (small negative), ZE (zero), PS (small positive), PM (moderately positive), and PB (great bad). The values a, b, and c are based on the mean of numerical values. In some cases, the function of members is not very symmetric and has even been validated for application to obtain accurate accuracy.

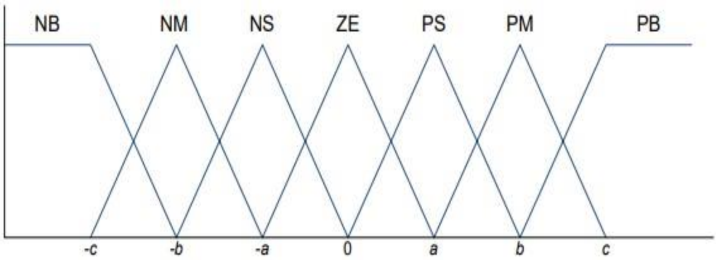


Figure 6.: Membership Functions. (reconsider)

## 4. Neural Networks

Another MPPT method that is very suitable for microcontrollers is the headset network [8]. They have fuzzy logic and are in the so-called "soft computing." The simplest example of a neural network (NN) includes three layers: an input layer, a hidden layer, and an output layer, as shown in Figure 7. More complex NN constructions add more hidden layers. The number of layers and nodes in each layer and the operations used by each layer will be different and depend on the user's knowledge.

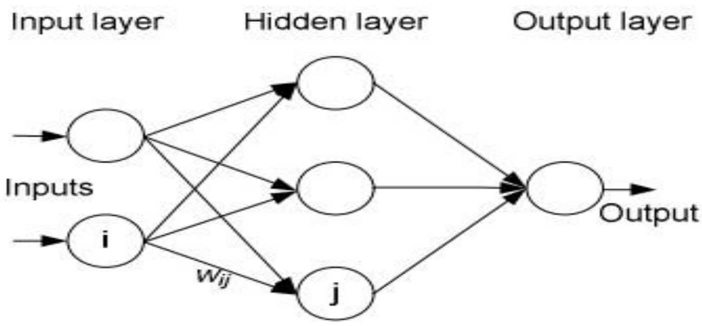


Figure 7.: Neural Network

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## V. RESULTS & DISCUSSION

Most of the MPPT algorithms residential in recent years have been discussed in the preceding sections. Some of them are related, using the same rules, but in different ways, like the last three algorithms listed in Hill Climbing Technique. According to the number of releases, the most popular MPPT algorithms are P&O, InCond, and Fuzzy Logic. However, they have a few disadvantages, as mentioned earlier. In the case of P&O and InCond, a few suggestions are offered, which overcome the limitations of the original method of tracking MPP below the water's edge. The FLC was designed according to reference, and its active efficacy was tested and compared with the MPPT scaling method. Bythis study we have concluded that MPP tracking methods can be used to track MPP for solar and wind hybrid power system.

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