

## Comparative Analysis of Wind-Electric and Solar Based Water Pumping System

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**Abstract:** Many under developed countries are facing the issues of water shortage that directly influenced on drinking water, agricultural growth rate, electric power shortage, livestock etc. To cope up with these issues, many systems have been developed to store water and generate electricity. Among all these systems, Wind-Electric Water Pumping System and Solar based Water Pumping System are two efficient systems in terms of performance, efficiency, cost and maintenance.

Wind and Solar Energies played vital role to get energy for different purposes efficiently. Both energies can be used for water pumping system. Design and realization of these two energy efficient water pumping systems give high performances and are able to resolve the issues of water shortage.

This paper reveals the efficiency of both wind-electric and solar based water pumping system by their comparison and critical study that provides the efficient way of saving and storing water that can be utilized in different ways in order to overcome the hurdle of water storage and electrical power shortage for betterment of country's economy.

**Keywords:** Wind Turbine, Solar Panel, Permanent Magnet Synchronous Generator, AC Induction motor, Centrifugal Pump, Transformer.

### I. INTRODUCTION

In many under develop countries the issues to improve the social economy is of great demand and the main thing that can improve the social economy is the Energy resources [1-2]. Many of these countries are suffering the critical energy problems. The electricity generation process is still inefficiently maintained and the increasing demand of electricity leads us towards this research, in which two different water pumping systems are discussed; "Windmill Water Pumping System" and "Solar Power Pumping System". The comparison of both systems gives the best way to solve the water and electricity issue and to raise the economy. This paper consists of three more sections; section-II presents the detailed of Wind-Electric Water Pumping System whereas section-III provides the detailed of Solar based Water Pumping System. In the last section which is section-IV, comparison of both the system is discussed.

### II. WIND-ELECTRIC WATER PUMPING SYSTEM

#### A. Design:

The *windmill system* and the *water pumping system* are two parts of the system. The wind turbine system and permanent magnet synchronous generator are used in windmill system, whereas, the AC induction motor and centrifugal pump are used in pumping system. These four parts are discussed below:

- a) **Wind Turbine:** The horizontal axis wind turbine is selected to generate electrical power

from the conversion of kinetic energy from the wind [3]. Wind Turbine having the tip speed ratio of 3.68 and the radius is 0.35m is used.

- b) **Wind Turbine Generator:** Wind turbine consist of a rotor and a generator to convert kinetic energy into mechanical power first and then mechanical power into electrical power. 9-pole pair Permanent magnet synchronous generator is used due to its stability, no external excitation and no need of slip ring [4].
- c) **Centrifugal Pump:** The kinetic energy is obtained from the conversion of input power through the centrifugal pump. The liquid is pumped through this centrifugal pump with suspended solids from the surface etc. To pump the fluid at rated speed, Impeller is used which is a revolving device. The liquid or fluid that is trapped in the channel of the vanes needs a motion which is given to it by impeller vanes which rotates by an Impeller. Mostly an electric motor drives the Impeller. Fluid therefore passes outwards in high pressure pipeline (delivery). The continuous evacuation of fluid from impeller makes it to repeatedly draw fluid from the low pressure (suction) pipeline into the casing [5]. 90m dynamic head centrifugal pump is used.
- d) **Centrifugal Pump Motor:** The electric motor that drives the impeller is selected as 3 phase one pole induction motor [5].

**B. Operation:**

The wind mill system operates as follows:

- Wind turbine drives the PMSG.
- The generated electrical power will go to AC induction motor.
- Transformer connects the motor to PMSG.
- AC induction motor drives the impeller which fetch the water

The block diagram for the system is shown in Fig 1

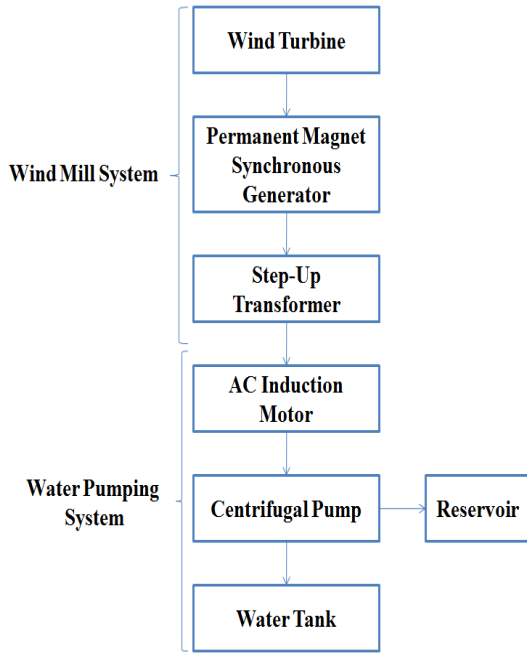


Fig 1: Block diagram of Wind-Electric Water Pumping System

**III. SOLAR BASED WATER PUMPING SYSTEM**

**A. Design:**

Solar power pumping system comprises of following parts:

- a) Solar Panel:* A Light is converted into electricity through solar cell. When the light source is unspecified, it is termed as Photovoltaic (PV) cell. Assemblies of cells are used to make solar panels, solar modules, or photovoltaic arrays which converts energy in to electricity [6].
- b) Battery:* An electric battery is a device consisting of one or more electrochemical cells that convert stored chemical energy into electrical energy.
- c) DC to AC Inverter:* DC power is converted into AC power through DC-AC Inverter.

- d) AC to 3-Phase AC Inverter:* Single phase AC source is converted into 3-Phase AC source to give supply to the transformer [7].
- e) Step up Transformer:* Step up Transformer has been used to step up the voltage source to run the AC induction motor of water pumping system.
- f) Centrifugal Pump and Centrifugal Pump Motor:* Same pump and motor has been used as it is in Wind-Electric water pumping system.

**B. Operation:**

The Solar based water pumping system operates as follows:

- Solar panel converts light source into electricity which goes to the battery bank to store the energy.
- The generated electrical power will converted from DC to AC power and then from AC to 3-Phase AC power.
- Step up transformer connects the AC induction motor and the AC to 3-Phase AC Inverter to step up the voltage to the required power to the water pumping system.
- AC induction motor drives the impeller which fetch the water.

The block diagram for the system is shown in Figure 2.

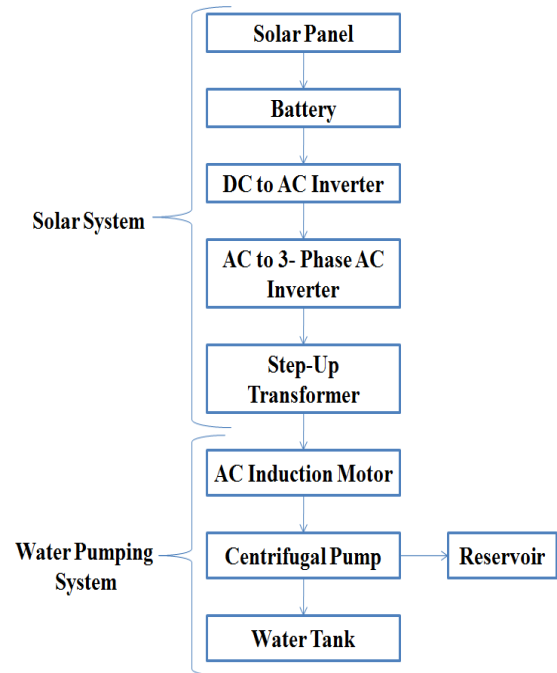


Fig 2: Block diagram of Solar Based Water Pumping System

## IV. COMPARISON OF BOTH SYSTEMS

### COMPARATIVE ANALYSIS OF BOTH SYSTEMS:

Both the systems were operated and examined. Wind-Electric Water pumping system was operated and the flow rate and pressure was examined in different frequencies through flow meter and pressure gauge which was implanted on the centrifugal pump. The performance of Wind-Electric Water pumping system is shown in Table 1.

Table: 1 Flow Rate and Pressure of Wind-Electric Water Pumping System

Freq (Hz)	Flow Rate (lt/hr)	Pressure (bar)
50	640	0.13
45	570	0.10
37.5	430	0.050
30	300	0.025
22.5	105	0.010

Solar based Water pumping system was operated and the flow rate and pressure was examined in morning time between 8:00 AM to 12:00 PM, during peak time 12:00 PM to 4:00 PM and in evening time 4:00 PM to 6:00 PM through flow meter and pressure gauge which was implanted on the centrifugal pump. The performance of Solar based Water pumping system is shown in Table 2.

Table: 2 Flow Rate and Pressure of Solar Based Water Pumping System

	On Load	Off Load	Flow Rate (lt/hr)	Pressure (bar)
Morning	1.5 Amp	0.9 Amp	600	0.11
Peak	1.8 Amp	0.9 Amp	1200	0.35
Evening	1.5 Amp	0.9 Amp	700	0.17

From the both system results, it can be analyzed that Solar based water pumping system is more efficient than Wind-Electric water pumping system as the flow of water and pressure is high. Also if we compare the hydraulic power, electromechanical efficiency and mechanical power then solar based water pumping system is more efficient than Wind-Electric water pumping system. Table 3 and Table 4 show the hydraulic power, electromechanical efficiency and mechanical power of both the systems.

Table 3: Wind-Electric Water Pumping System Mechanical Characteristics

Speed of Motor (rpm)	Hydraulic Power (W)	Electromechanical Efficiency (%)	Mechanical Power (W)
2974.2	2.1368	7.7	106.65
2677.8	1.425	6.1	96
2239.2	0.482	2.9	80
1786.68	0.1261	1.1	64
1329	0.00057	0.009	48

Table 3: Solar Based Water Pumping System Mechanical Characteristics

Speed of Motor (rpm)	Hydraulic Power (W)	Electromechanical Efficiency (%)	Mechanical Power (W)
2974.2	2.523	8.2	112
2677.8	1.857	6.6	101
2239.2	0.752	3.3	87
1786.68	0.2547	1.5	70
1329	0.0085	0.05	52

## V. CONCLUSION

This paper investigates the design and operation of Wind-Electric Water Pumping System and Solar Based Water Pumping System and comparative analysis of both systems performance in terms of efficient use. From the results of both the system, it can be concluded that solar based water pumping system is more efficient than wind-electric water pumping system as the pressure and flow rate is high and also the mechanical characteristics of solar based water pumping system is far better than wind-electric water pumping system. The purpose of this experiment was to analyze the best performance system to operate the water pumping system efficiently in order to generate electricity efficiently; store water for livestock, agriculture and drinking water and also less maintenance, low cost is required for solar based water pumping system.

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