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Hybrid Water Pumping Control System for Irrigation using Arduino

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Abstract- **There are many water pumping system such as diesel powered,solar photovoltaic, mechanical windmill exists. Few combine solar and wind energy sources to provide better performance and reliability to the existing system. In this paper wind turbine and solar photovoltaic (pv) water pumping array are analysed separately and are combined as a hybrid system. Large amount of water pumped from the water resources are not effectively used. So a suitable control methodology was also proposed to operate the pump automatically depending on the water availability and the water requirement for crops .The main objective is to provides 1.Advantage of hybrid system over WT or solar PV array separately.2.suitable methodology to prevent water loss. Additionally MPPT system can be used to improve the efficiency of PV array.**

Keywords— Solarpanel, windturbine, dc-dc converter, rectifier, waterlevel sensor and soil moisture level sensor interfaced with arduino, water pump, driver circuit.

I. INTRODUCTION

The production of electricity in India from utilities has increased from 9,22,451 GWh during 2011-12 to 9,63,722 GWh during 2012-13.All the generated power are not effectively utilized, transmission losses may occur in the power system and reduce the efficiency of the power transmitted. The estimated electricity consumption increased from 4, 11,887 GWh during 2005-06 to 8, 52,900 GWh during 2012-2013 and further increases during 2014 due to the utilization of heavy rated machines. Vast power are consumed by agriculture and industries ,since Agriculture plays a significant role in the socio economic development of a country.The subsidies paid for the power consumption by the agriculturist is less.This may affect the economic status of our country.So, inorder to reduce the consumption of power from the main grid, Hybrid system is implemented in the agricultural land. But, Agriculture faces a problem such as soil consolidation, dryness, flood may occur by supplying excessive water to the field. Irrigation acts as a key tool for solving these problems.It assists the effective growth of crops,Maintains landscapes,revegetation of soil in dry areas due to inadequate rainfall.Thus,this paper proposes the method to utilize the electric power produced from the hybrid solar and wind system to pump the water for irrigation.The pumping of water depends on the availability of water resources.The effective utilization of water when it is available in surplus amount or in the demand condition is provided by a suitable control sensor

II. A.WIND ENERGY WATER PUMPING SYSTEM:

Wind energy is one of the renewable energy sources which can be used for water pumping applications. In India, wind power generation has gained a high level of attention and acceptability compared to other renewable energy sources. India has highest wind energy potential after the USA, Germany, Spain and China .In 1983,Pandaetal estimated the water pumping cost of systems under Indian meteorological conditions. The cost per m^3 of irrigation water supplied by the most economic wind turbine irrigation system was varied between 38paise and 71paise in Delhi, India during the month of October, 1983.

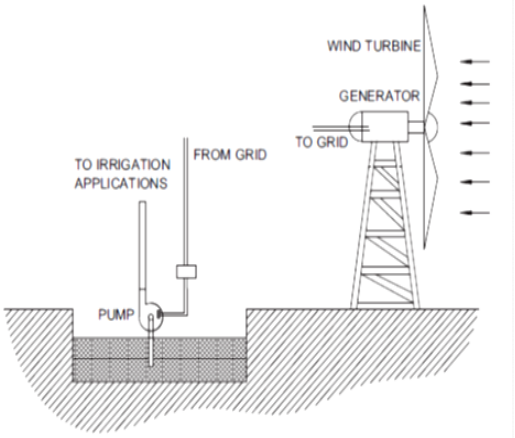
Pumping of water by means of small wind powered system had became popular due to its flexibility over other mechanical system and its advantage to spare electricity for other applications.

Working principle:

The storage of an adequate quantity of groundwater is essential for irrigating crops during low-wind conditions. Excess power from the wind turbine was used to drive booster pumps to circulate the stored water in low wind velocity conditions. Depending on the requirements, water can be pumped to an overhead storage facility and can then be provided by gravity. In this system, a wind powered rotor is coupled to a synchronous generator with permanent magnets, which convert the wind energy into electrical power energy. Synchronous generators are most commonly designed for the charging of storage batteries. The asynchronous generators are found in large wind turbines. The generator is then coupled to a common induction motor ,which drives the centrifugal pump for pumping water.

Limitations:

- Turbines may lead to noise pollution both mechanically and aerodynamically.
- The velocity of wind is not consistent, it may affect the performance.
- In case of using wind energy ,the losses are more than those in Solar. Thus, maintenance is required for mechanical components.
- The speed of the turbine reduces the wind velocity if they are located near the farms, which may affect the output of the wind turbine.



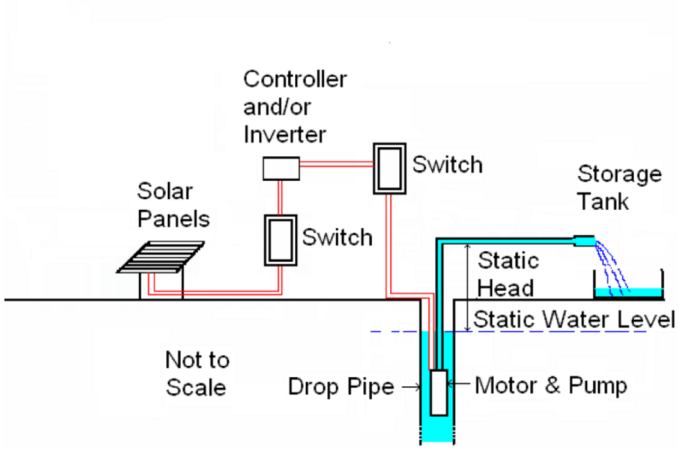
Layout of wind energy water pumping system

II.B.Solar water pumping system:

Now a days, Solar energy is commonly used in almost all the fields to generate power. Solar water pumping system is one of the reliable and the renewable solution for pumping water to the agriculture lands. The cost of the water pumped by photovoltaic systems is also much less than that of water pumped using conventional grid connected and diesel

Working principle:

The solar water pumping system uses a photovoltaic panel, inverter, dc-dc converter and a pump. Battery and the charge regulators are used depending on the system design. Battery less system is of low costs,but requires regular maintainence.However, battery operated system provides continuous power during the lean and off shine hours. Depending on the type of pump ac or dc pump,inverter can be used.900W and 800W photovoltaic panels were tested and it is observed that solar based water pumping system can pump upto 3.4-3.8 li/h in different hours of a day.The maximum performance of the pump is achieved in the middle of the day.However,the performance of the system is reduced due to different meteorological conditions such as solar intensity,Wind velocity,relative humidity and solar intensity.It is observed that simulation output is closer to the practical output. The tilt angle of the Panel is optimized by linear search inorder to improve the efficiency of the panel. In some cases MPPT is used to improve the efficiency of the panel. The advanced solar water pumping system uses controller, control valves,PV panel,converters,backup batteries and sensors. This developed system will irrigate the land at a pre specified time or duration. It will automatically irrigate if the soil is dried below certain moisture level and it will also optimize the quantity of water for particular crops and specified area. This method operates as follow,PV panel will generate a dc output. The DC output power ranges between 100 to 320 watts, which depends upon the rating of the solar panels. The solar array is conneted to the converter,which inturn is connected to a battery.A DC-DC converter is used to convert the variable DC power to fixed power and inverter ,which converts AC to DC should be used in case of Ac pumping system.The power output is given to the battery to store the energy that can be used in needed conditions.16% efficient module consists half of the area of 8% on 230 watt module.



The solar PV panels are heated due to the energy conversions. This excessive heat generation may affect the performance of the panel. Hence a suitable water cooling system must be provided to improve the efficiency. This can be done by spraying water over the front panel of the photovoltaic panels. In the recent days, carbon nanotubes coated with heat conducting material is used to provide better cooling.

Environmental impacts:

PVsystems consume a large amount of energy and also emit green house gases like co2 during manufacturing,assembly,balance of system (BOS), transportation, installation and recycling.The global warming potential of photovoltaic systems is approximately 10 times lower than that of a coal-fired plant,but it is 4-times higher compared to a nuclear powerplant and windturbine power plant. A life cycle assessment of five different types of panels were investigated they are mono-crystalline,multi-crystalline, amorphous silicon, cadmiumtelluride thin film and copperindium selenide thin film. Among the five photovoltaic modules,cadmium telluride thin film photovoltaic system has the best environmental benefits, whereas the silicon based photovoltaic module has the worst performance.Thus ,the cadmium telluride thin film system can be preferred.

Limitations:

1.The performance of the solar water pumping system is affected due to improper solar intensity.

2. Heat generated in the photovoltaic cells during energy conversion affects the output of the photovoltaic cells.

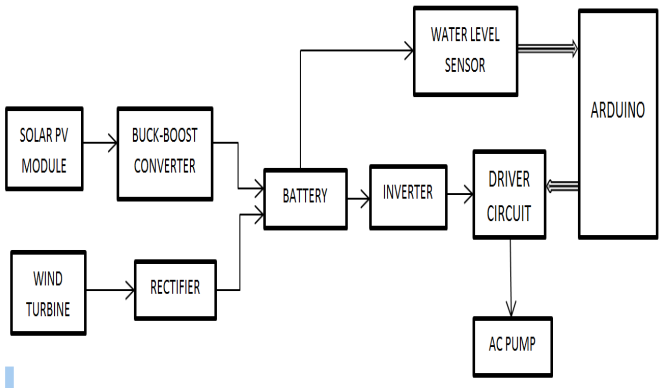
3. Dust accumulation over the solar PV panels can reduce 30% of the energy output within a few weeks of installation.

4. The ambient relative humidity and wind velocity will affect the performance of the SPWPS .

5. Solar photo voltaic panels produce global warming during their lifecycle but comparatively less when compared to other sources.

III. HYBRID WIND/SOLAR PV WATER PUMPING SYSTEM:

This paper proposes the system which uses both solar power and wind energy to pump the water. It provides better reliability and increases the daily water volume. While pumping the water to the agricultural land ,crops may be destroyed due to the ineffective utilization of the water resourses.This paper proposes the methodology which examines the water level in the tank and soil moisture content and gives the command signal to the arduino based microcontroller to control the opening and the closing of the pump depending on the requirement.



III.A.Components used:

The solar photovoltaic panel is more efficient than thermoelectric type. Generally, Cadmium telluride type or carbon nanotube material used solar panels are used because of its high efficiency. The Buck-boost converter module is used to step up the dc voltages obtained from the solar panel. The wind turbine operated with the permanent magnet synchronous is used for effective utilization of wind energy. Since the wind turbine generates the three phase ac current. The three phase bridge rectifier is used to convert ac current to dc. The pump used can be AC pump or the DC pump. DC pump is used only for small scale irrigation and whenever irrigation is to be done on the large scale AC pump is used. Single phase pwm inverter is the used in the case of AC pump.Arduino type microcontroller is chosen ,since it is an open source electronic platform based easy to use hardware. It uses ATmega 316 ,that takes any number of inputs. The output of the water level sensor and soil moisture content sensor is given to the controller. The reliability of solar photovoltaic powered helical pump systems is better than that of solar photo- voltaic powered diaphragm pump systems for pumping depths greater than 30 m.

III.B.Analysis of data:

It is inferred that about 20 to 3000W of power may be required for pumping water from the ground. So various parameters should be analysed in order to get the desired output power for pumping. These parameters depends upon the availability of water resources, wind and the sunlight, which varies with climatic conditions. Hence it is important to have an analysis of these parameters.

Determination of water resources:

The configuration of the watering system will be defined by the type of water source and its location relative to the places you want to provide water. The water source will either be subsurface such as well or surface such as pond, stream, or spring. Wells are preferable because of the improved water quality and consistency. However, wells are expensive to drill, particularly where water tables are deep. Surface water sources may vary seasonably, such that the amount and quality of the water is low during the summer when it is needed most.

Suitability of the Site for Solar :

The site of the water source must then be evaluated for the installation of the solar-powered water pumping system. The following are specific issues that must be considered:

- The solar panels require a south facing location with no significant shading
- Locations must be found for the water pump (surface), controllers, storage tank and wind system
- The solar array should be as close to the pump as possible to minimize wire size and installation cost
- If batteries are to be used, they must be in a reasonably dry/temperature controlled location with proper venting.

Determine Total Dynamic Head:

Total dynamic head (TDH) is the sum of the static lift of the water, the static height of the storage tank, and the losses from friction. The static lift is measured from the solar array to the low water level in the well, pond, or stream. The static height of the storage tank is measured from the array to the top of the tank

GPM = (gallons per day *hr) / (peak sun hours per day * 60 mins)

Maximum efficiency of solar panel=

$$\frac{\text{Max.output power}(P_{MAX})}{\text{Incident Radiation flux } E_{sv} * \text{Area of the collector}(A_c)}$$

Efficiency of Wind Turbine:

In addition to solar power, wind energy is also used here.Hence, the Power per unit area of the wind turbine is calculated using the formula:

$P_{p.u}$=Kinetic energy of wind * velocity

Max.power extracted from wind turbine,

$$P_{MAX}=16*P_{OUT}/27$$

Where,

P_{out} is power contained in wind and is given by

P_{out} = (Air mass per unit time *wind velocity ^{2})*0.5

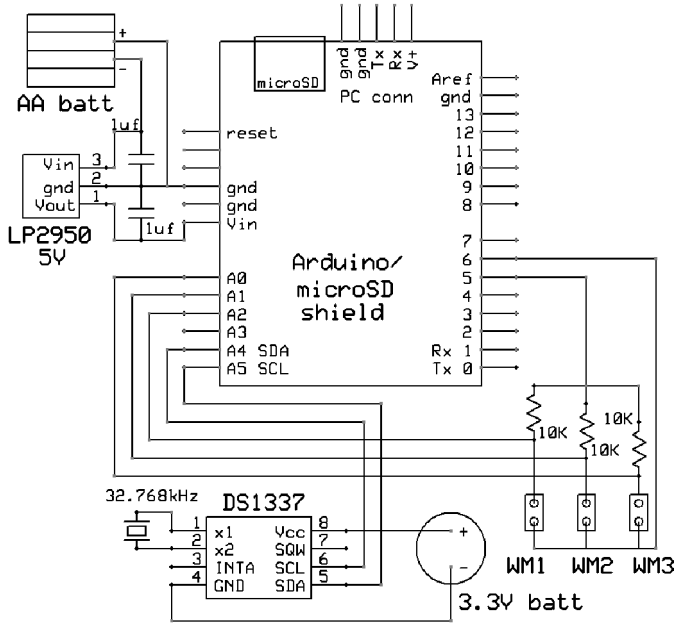
III.C.Description:

In this hybrid system, the power from the solar and wind energy is used to pump water from the ground and a controller which automatically turns on/off the pump by detecting the water level with the help of a sensor.When the solar radiation is incident on the solar panel,current will be produced by the principle of 'photovoltaic emission'. Since , solar energy is not available all time,it cannot provide a continuous power supply for water pumping.Hence,wind turbine is used to improve the efficiency of the pumping process.In wind turbine, the kinetic energy of the wind is converted into mechanical energy by means of rotating action of the turbine blades.in order to improve efficiency, two-blade horizontal turbine system is used. A permanent magnet synchronous motor is used to convert the mechanical energy into electrical energy.

Due to some internal resistance , there will be some loss in the output power of solar panel.Hence,a converter is used which acts as a step-up transformer. Different types of convereters are available such as follows:buck, boost, buck-boost and cuk converter. Buck converter steps down the voltage whereas Boost converter steps up the voltage.Buck-boost converter performs the above two operations depending upon the impedence level.Cuk converters are used in power system applications as it has low current ripples when compared with the other types of converters. MOSFET is used in these converters because of its high switching frequencies and response time.

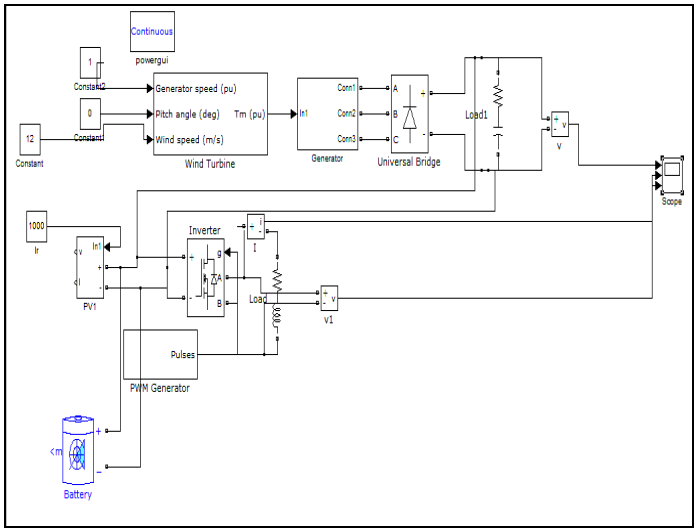
The power produced from the wind is alternating in nature which is to be converted into direct current. Hence, a rectifier is used for AC to DC conversion. There are different types of rectifiers such as half-wave, full-wave and bridge rectifiers ,which are applied in different fields depending upon their needs. The wind turbine produces a 3 phase output power, hence a 3 phase bridge rectifier is used in this system, because of its high Transformer Utilization Factor(TUF) and low ripple voltage. The solar and wind output power is stored in a Lithium battery, which energizes the AC pump ,the sensor and the controller. The DC output power from the battery is converted into AC by means of a single-phase PWM inverter, which in turn provides supply to the pump.

Soil-moisture level sensor is installed at several depths below the soil level. It will sense the moisture content of the soil periodically and gives an electrical signal to the arduino controller. Similarly, water level sensor is placed inside the tank which gives command signal to the controller when the water level in the tank exceeds the desired level. Depending upon the command signal produced by the two sensors, the arduino controller will automatically turn on/off the AC pump by the relay action. This overall circuit will provide the automated water supply for irrigating agricultural land. Moisture level sensor can be placed at various locations below the soil level that depends upon the crops cultivated.

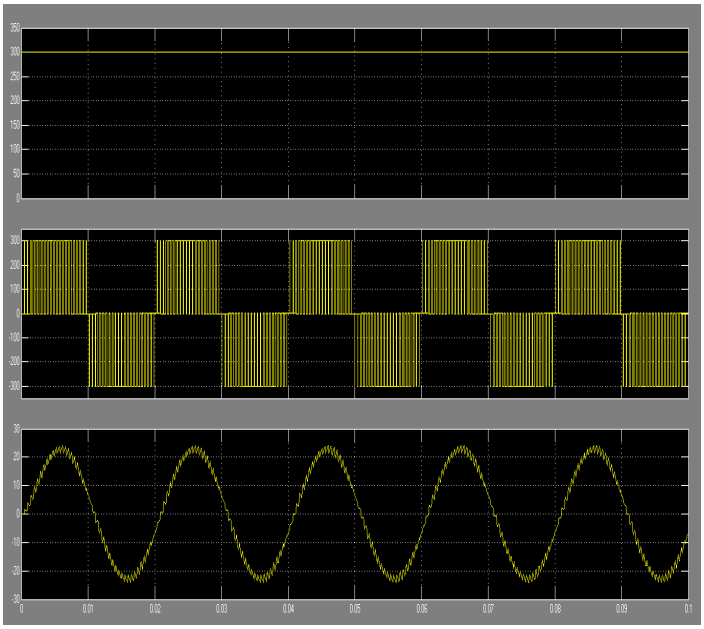


IV.SIMULATION:

The simulation is performed for the analysis of the power required for the pumping action to be performed, obtained from the specified rating of the solar panel and the wind velocity. The overall simulated circuit is shown as below:



The software used for simulation is MATLAB R2010 and the output is the analysis of current and voltage waveforms, of the two different sources of power production.This waveform varies depending upon the input power sources and it is shown in the figure below:



V.CONCLUSION:

The wind turbine generates variable output power and hence, it cannot be matched with the pv module,in normal cases.But in this hybrid system this problem is overcome by connecting the solar module and the wind turbine to the utility pumping system through the inverter. It only uses the renewable sources of energy, thus forming a standalone hybrid system. Even after installation of this system, if required , additional sensors can also be interfaced with the arduino controller, leading to efficient irrigation.

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