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Design and Analysis of a Solar-Wind Hybrid System

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Abstract

The renewable energy sources like wind and solar energies can be combined to increase the total power generation and thereby increase the efficiency of the system. The combination also provides a means to overcome the intermittent nature of the solar and wind renewable energy sources, since one source can be used for power generation when other is not available. AC-DC converters are used convert the alternating voltage of the wind generator to a constant DC value which can be used to charge the batteries or later converted to AC voltage to drive AC loads. A Maximum Power Point Tracking (MPPT) system using boost converter is designed to extract maximum possible power from the sun when it is available. This method provides better harmonic reduction since Harmonic content is detrimental for the generator lifespan, heating issues, and efficiency. Simulations are carried out in PSIM software and MATLAB.

Keywords: *Renewable energy, MPPT, Boost converter*

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INTRODUCTION

While mindful of the dwindling stock of fossil fuels and their detrimental impact on the environment, countries around the world are now moving toward renewable energies such as solar, wind, bioenergy , hydro, geothermal and ocean energy in their efforts to ensure energy security.
In recent times, both in developed and developing countries, the use of renewable energy has increase d significantly.
REN21's Global Status Report on Renewables 2014 suggests that, in 2012, renewable energy account ed for an estimated 19% of global energy consumption compared to 16.7% in 2010 [1-2].

Bangladesh also attached due importance to the production of renewable energy, keeping pace with th e global trend. Public proposals — Five Year Plan, Master Plan for Power System — and policy papers like National Energy Policy, Industrial Policy 2010 stressed renewable energy.
Renewable energy development has been identified as one of the Strategy and Action Plan for Climat e Change in Bangladesh. The Bangladesh National Building Code also provides renewable energy ch oices.

A dedicated strategy, Bangladesh's Renewable Energy Strategy, has been in place since 2009, aiming to have 5% renewable energy capacity by 2015 and 10% by 2020.
In order to promote sustainable energy and energy efficiency, the government has formed the Sustaina ble and Renewable Energy Development Authority (SREDA).
Bangladesh became one of the first members of the International Renewable Energy Agency (IRENA), the only intergovernmental agency working exclusively on renewable energy, in order to strengthen international cooperation. Such actions reflect the dedication of Bangladesh [3-5].
Bangladesh receives 4-
5 kWh / m2 of average daily solar radiation. Power Division has initiated a plan to produce 500 MW

of solar-based energy, enabled by the availability of solar radiation.
Under this program, projects to electrify rural health centers, educational institutions, union-level e-centers, religious establishments and remote railway stations are required by the authorities concerned to be implemented.
Commercial projects such as Solar Irrigation, Solar Mini Grid, Solar Park and Solar Rooftop applications are planned to be introduced by the private sector [6].

By installing solar panels, the government gradually meets part of the lighting and cooling load of public offices. The national solar energy development capacity currently exceeds 150 MW.
Most of the additional capacity comes from Solar Home Systems (SHS) introduced by a government-owned financial institution, Infrastructure Development Company Limited (IDCOL).
Bangladesh's SHSs are known by the international community as the world's fastest-growing solar power dissemination program[7].

The use of solar wind hybrid renewable energy system is growing day by day and has shown tremendous growth for the worldwide production of electricity in the last few decades.
A new problem emerges with the development of new technologies in the area of the sustainable solar-wind hybrid energy system, which is becoming much more interesting to solve [8-].

Hybrid solar-wind powered systems are only becoming a cost-competitive option in areas where wind and solar patterns greatly complement each other; otherwise they will be too costly. Prices of hybrid systems for the same electrical output are higher than simple solar (or wind) systems[9].
In some countries, the wind also blows stronger at night, so solar technology can only produce energy during the day.
By using this basic concept in a related way more sophisticatedly and integrating it with more advanced forms of energy storage. For a much broader use of solar-wind hybrid system, the door could be opened [10].

The main advantage of the solar-wind hybrid system is that the reliability of the system is enhanced when solar and wind power productions are used together.
In addition, the battery storage size can be slightly reduced as there is less reliance on one power generation method. Still, there's plenty of wind when there's no sun[11].

The burning issue in Bangladesh now is the energy crisis. Our primary source of electricity is the lack of natural gas that will run out. Most power plants are operated by the furnace and some are dependent on oil.
These power stations are more costly and are not accommodating to the environment. They produce greenhouse gas that kills the layer of ozone and causes global warming[12].

Severe power crisis forced the government to enter into contractual agreements for a high-cost temporary solution on an emergency basis, such as rental power and limited IPPs, most of which were based on diesel or liquid fuel. This has put tremendous fiscal strain on you.
The country faces a simultaneous shortage of natural gas and electricity with an electricity sector that is almost dependent on natural-gas fired generation (89.22 percent). Other fuels for generating low-cost, base-load electricity, such as coal, or renewable sources such as hydropower, are not readily available and the government has no choice but to go for the option of generating fuel diversity [13].

In order to achieve this pledge, the government has taken multiple steps to produce 6,000 MW by 2011, 10,000 MW by 2013 and 15,000 MW by 2016, given the main deterrents energy crisis and gas supp

ly shortage, far beyond the promise in the election manifesto.
In three years, 2944 MW of electricity (as of January 2012) has already been added to the grid.
Power system Master Plan 2010 has already been implemented by the government. The estimated de mand would be 19,000 MW in 2021 and 34,000 MW in 2030, according to the Master Plan.

In 2030 the generation capacity should be 39,000 MW in order to meet this requirement. The proposal proposed a fuel-
mixed alternative of 30% domestic coal, 20% imported coal, 25% natural gas (including LNG), 5% li quid fuel, 5% nuclear power, renewable energy, and 20% electricity import[14].

Bangladesh has a long legacy in the field of renewable energy, which started with the development of the country's first hydroelectric project at Kaptai, Chittagong, in 1957.
The fourth and fifth generating units were installed in October 1988, both 50 MW Kaplan-
type turbines, which raised the total generating capacity to 230 MW.
In the mid-
1980s private sector initiative played an instrumental role in developing Sylhet's 1st Solar Home Syste m (SHS) with a single home system installation.
Since the implementation of SHS in 1996, it has now become Bangladesh's largest renewable energy s ystem, so far 4.5 million units have been built and its number is increasing because of an integrated pr ogram pursued by the government through its financial institution IDCOL [15].
A hybrid wind-
solar electric system requires greater initial investment than single larger systems: large wind and sola r photovoltaic systems are proportionally cheaper than smaller systems.
But the hybrid solution is the best option whenever there is a significant output and performance impr ovement
which occurs when the sun and wind resources have opposite cycles and intensities on the same day o r in some seasons [16].

METHODOLOGY

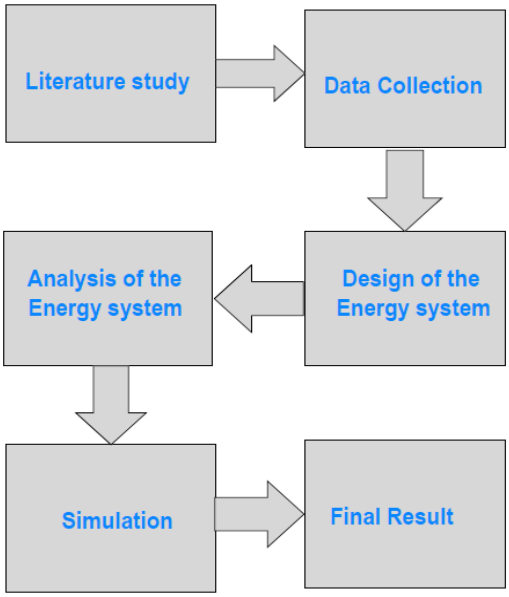

Fig. 1: *Methodology for achieving goal*

At first, different resources on power sector of Bangladesh, renewable energy and hybrid energy systems has been studied. Then, the necessary data to design the system and selected the suitable renewable energy sources for our system has been collected. After that, the design and analyzation of

the system has been developed using PSIM and MATLAB. The final versions show the results in the form of graphs to highlight the merits of the system under consideration.

DESIGN PROTOTYPE

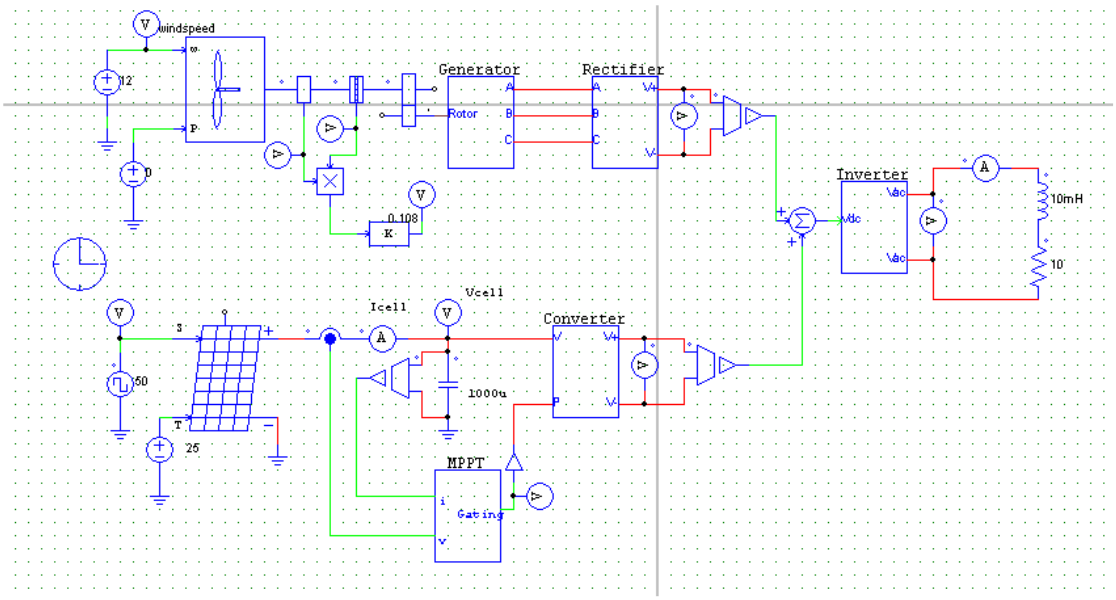

Fig. 1: *Schematic Diagram of Wind-Solar Hybrid System using PSIM.*

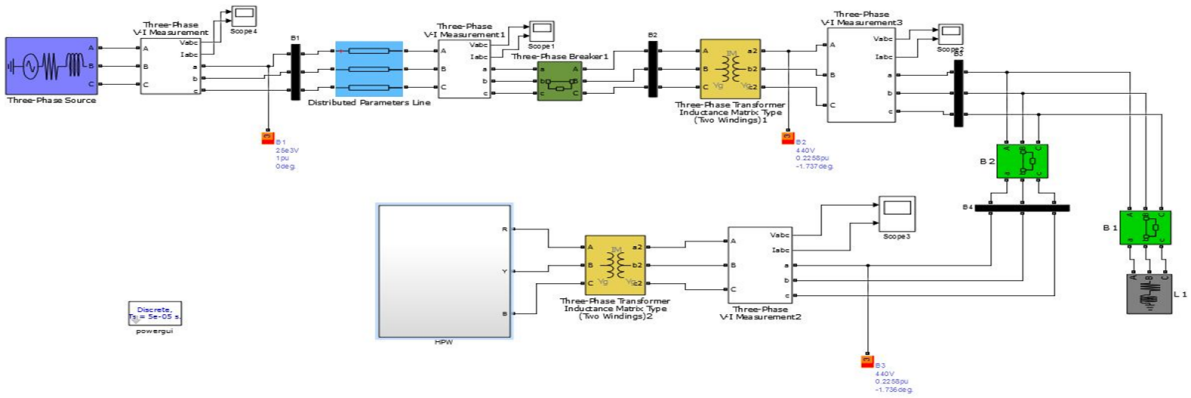

Fig. 2: *Schematic Diagram of Wind-Solar Hybrid System using MATLAB*

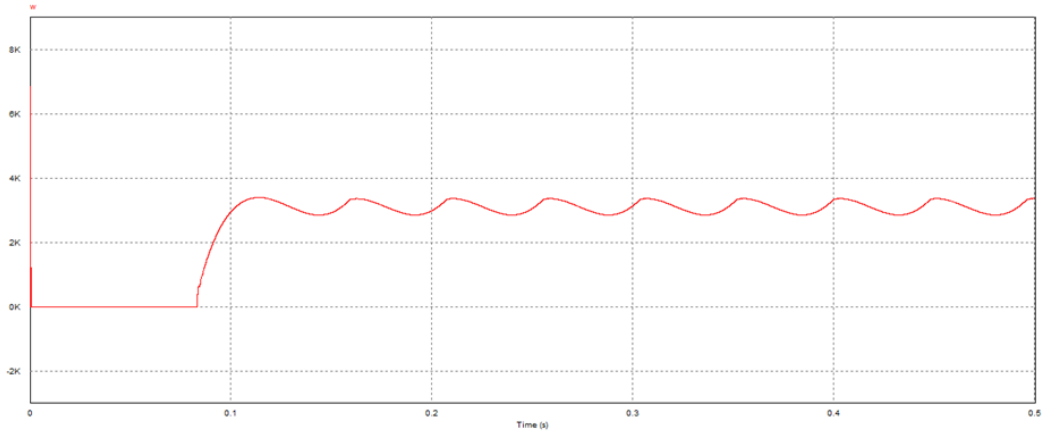

Fig. 3: *Output Power of Wind Turbine*

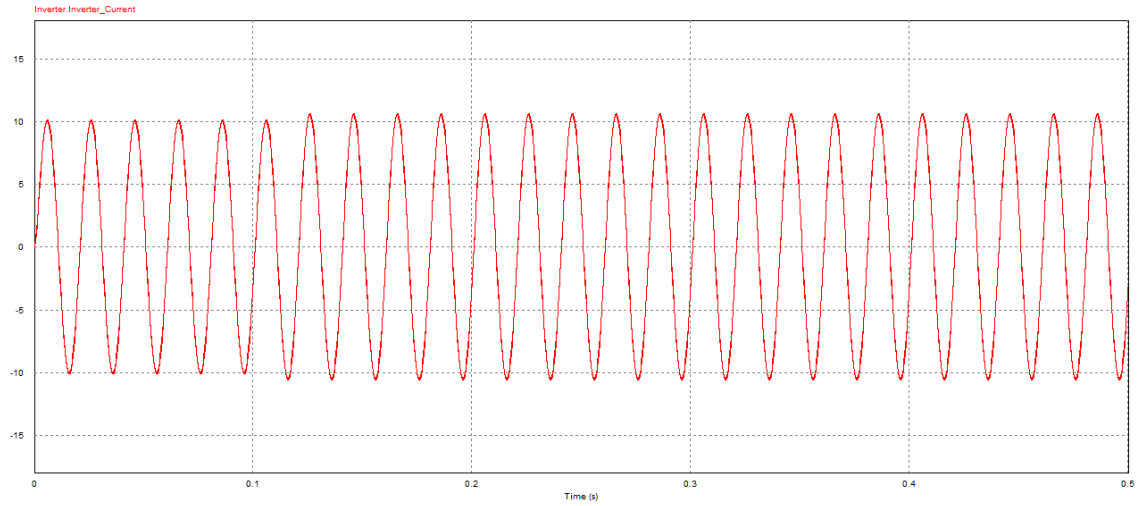

Fig. 4: *Output current of Inverter*

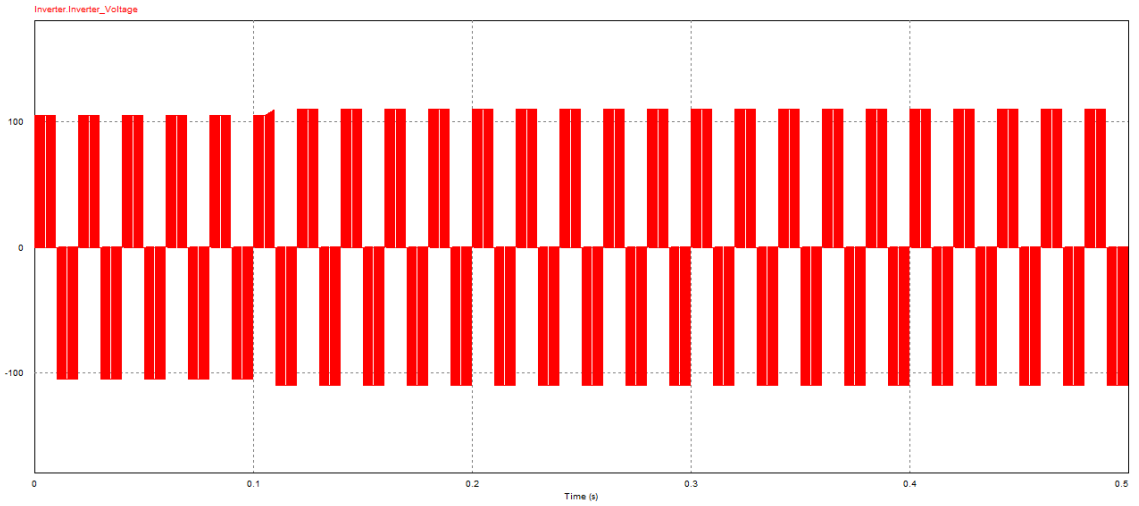

Fig. 5: Output Voltage of Inverter

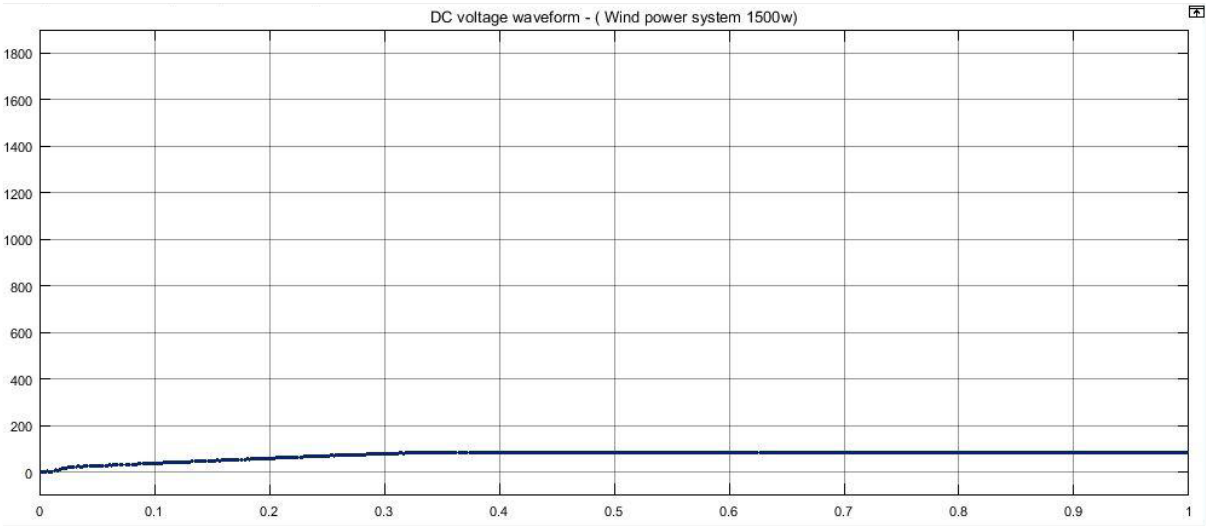

Fig.6: Output Voltage of the Rectifier

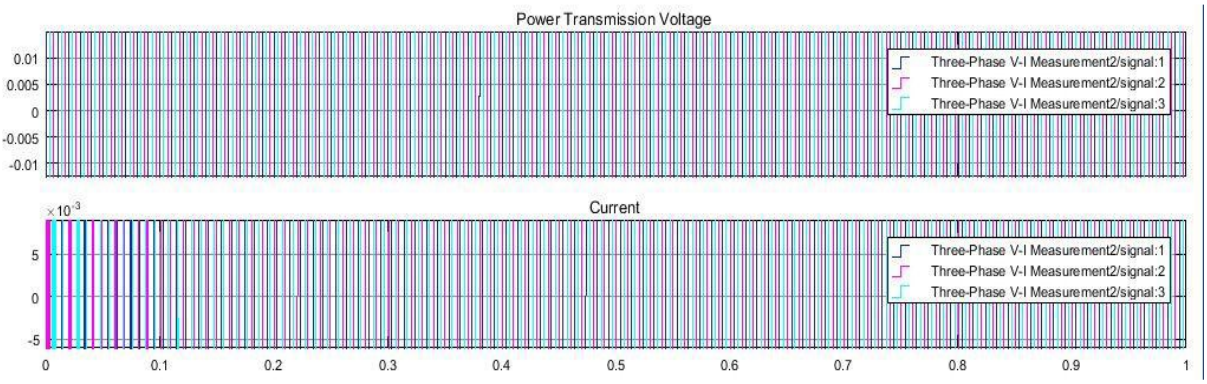

Fig. 7: Output Voltage of the Hybrid System

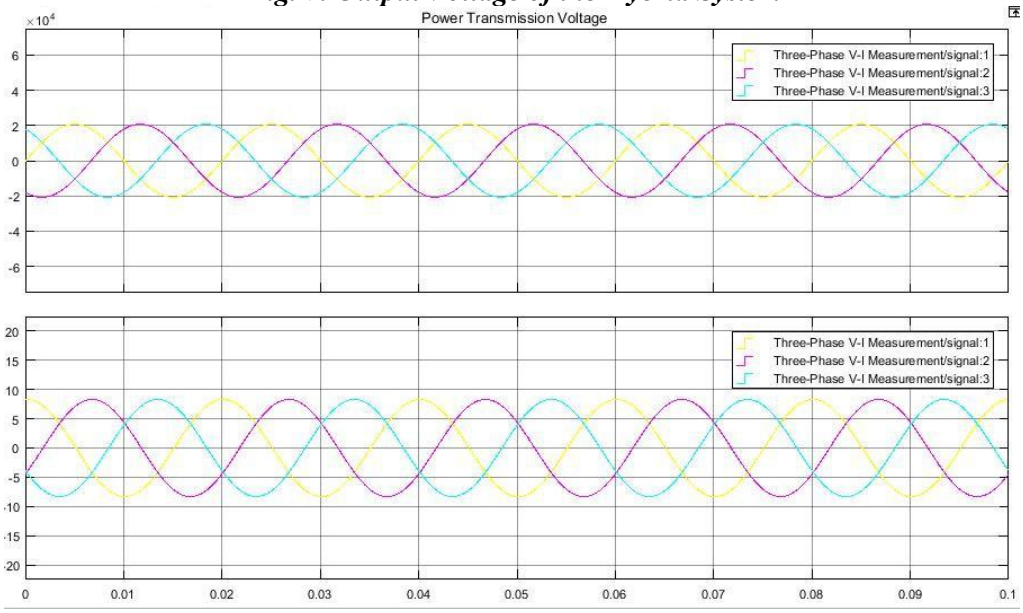

Fig.8: Output of the Grid-connected Three-Phase Generator

CONCLUSIONS

In this paper, a hybrid renewable energy system has been designed, which consist of one wind turbine and one solar module. We have designed the system in PSIM and MATLAB. We have varied the wind speed during simulation and observed the output of different devices.

In future, an energy storage system can be included in the model, which will help us to store the excess energy for later use. Different renewable energy sources like hydro and tidal energy can be used. Different types of converter can be used such as SEPIC and CUK. New MPPT algorithms can be implemented for the hybrid energy system.

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