Design and Implementation of Non-Isolated Bidirectional DC-DC Converter in Hybrid Energy System

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Abstract- Due to exploitation of conventional energy sources reliable and innovative methods of generating electricity are required. The imperfections of conventional methods can be modified by using a system that is Hybrid with renewable energy sources. The piece of work for designing such system is done by using a bidirectional converter for energy storage. A new stand-alone wind–PV hybrid generation system is proposed for DC and AC loads. For the PV power generation branch, a converter is adopted to harness the maximum solar power by tuning the duty cycle. MPPT technique is implemented in the solar generation unit to obtain better efficiency. In the installation of power plant, MATLAB simulation studies finds applications in selecting the system and to choose particular components for the Solar PV and wind turbine applications. As a result of the SIMULINK model for the components of the Hybrid Energy System desired characteristics are obtained.

Keywords – Hybrid Energy System, Power Generation, Bidirectional DC-DC converters, PMSG, Photovoltaics

I. INTRODUCTION

Today, the generation of electricity is shifting towards renewable energy sources. As, recent developments and trends in the electric power consumption indicate an increasing use of renewable energy. Virtually all regions of the world have renewable resources of one type or another. By this point of view studies on renewable energies focuses more and more attention. Solar energy and wind energy are the two renewable energy sources most common in use. Wind energy has become the least expensive renewable energy technology in existence and has raised the interest of scientists and educators over the world. Photovoltaic cells convert the energy from sunlight into DC electricity. PVs offer added advantages over other renewable energy sources in that they give off no noise and require practically no maintenance. Many studies have been carried out on the use of renewable energy sources for power generation. The wind and solar energy systems are highly unreliable due to their unpredictable nature. Earlier, a PV panel was incorporated with a diesel electric power system to analyze the reduction in the fuel consumed. It was seen that the incorporation of an additional renewable source can further reduce the fuel consumption. When a source is unavailable or insufficient in meeting the load demands, the other energy source can compensate for the difference. Also for increasing the efficiency of system and to improve power quality of the current obtained modifications can be done in the converter used in the system. Environmentally friendly solutions are becoming more prominent than ever as a result of concern regarding the state of our deteriorating planet. Hybrid renewable energy systems (HRES) are becoming popular as stand-alone power systems for providing electricity in remote areas due to advances in renewable energy technologies and subsequent rise in prices of petroleum products. A hybrid energy system, or hybrid power, usually consists of two or more renewable energy sources used together to provide increased system efficiency as well as greater balance in energy supply. An example of a hybrid energy system is a photovoltaic array coupled with a wind turbine. Hybridizing solar and wind power sources provide a realistic form of power generation. This would create more output from the wind turbine during the winter, whereas during the summer, the solar panels would produce their peak output. Hybrid energy systems often yield greater economic and environmental returns than wind, solar, geothermal or stand-alone systems by themselves. Most of us already know how a solar/wind/biomass power generating system works, all these generating systems have some or the other drawbacks, like Solar panels are too costly and the production cost of power by using them is generally higher than the conventional process, it is not available in the night or cloudy days. Similarly Wind turbines can’t operate in high or low wind speeds and Biomass plants collapse at low temperatures. So if all the three are combined into one hybrid power generating system the drawbacks can be avoided partially/completely, depending on the control units. As the one or more drawbacks can be overcome by the other, as in northern hemisphere it is generally seen that in windy days the solar power is limited and vice versa and in summer and rainy season the biomass plant can operate in a full flagged so the power generation can be maintained in the above stated condition. The cost of solar panel can be subsided by using glass lenses, mirrors to heat up a fluid that can rotate the common turbine used by wind and other sources. Now the question arises what about the winter nights or cloudy winter days with very low wind
 speeds. Here comes the activity of the Hydrogen. As we know the process of electrolysis can produce hydrogen by breaking water into hydrogen and oxygen, it can be stored; hydrogen is also a good fuel and burns with oxygen to give water. Hydrogen can be used to maintain the temperature of the biomass reservoir in winter so that it can produce biogas in optimum amount for the power generation. As stated above biogas is a good source in summer; in this period the solar energy available is also at its peak, so if the demand and supply is properly checked and calculated the excess energy can be used in the production of hydrogen and can be stored. In sunny, windy & hot day, the turbine operates with full speed as the supply is very high, and this excess power can be consumed for the process of manufacturing hydrogen. In winter, the power consumption is also low so the supply limit is low, and obtained with lesser consumption [1]. The rest of the paper is organized as follows. Proposed System is explained in section II. Simulation and results are presented in section III. Applications and advantages are provided in section IV. Concluding remarks are given in section V.

II. PROPOSED SYSTEM

The Aim of this paper is to implement the converter and inverter for the wind and solar hybrid system and to advance hybrid energy system in field of electricity generation. For the hybrid system, extracting energy from wind and solar as possible and feeding the load with high quality electricity are the two main targets. This strategy makes hybrid system work properly when a voltage disturbance occurs in distribution system, and it stays connected to the main grid. This project presents the notion of utilizing both photovoltaic and wind energy sources simultaneously for electricity generation and the operation of the system sustains this notion. The inherent nature of DC DC converter is used to obtain DC output and additional input filters to filter out high frequency harmonics. This report presents the design and implementation of power converters for wind conversion systems. The term bidirectional means that it allows the flow of power in both directions depending upon the demand and capacity. This bidirectional behavior of power flow is achieved using a bidirectional buck boost converter which allows DC voltage flow across it to the energy storing unit when it is discharged and reverse the direction of power flow when there is no power obtained from the renewable energy sources and battery is fully charged. The harmonics arise while implementing are also rectified using filter circuit for the most part using this method.

As electricity deficiency is a major problem of world, so the system is made more flexible through using solar energy and wind energy which is a renewable form of energy. So, for power solar panels are used. In this project we use solar energy and wind energy which is used to generate electricity and also store that energy in the battery. A hybrid energy system is wherever one amongst the inputs is connected to the output of the PV array and the other input connected to the output of a generator. The wind generator and solar array are the main power sources of the system, and the battery is used for energy storage and power compensation to recover the natural irregularity of the wind power and solar irradiance. The proposed system consists of a DC/DC boost converter, a bi-directional DC/DC converter. This report presents a new bidirectional dc-dc converter for a hybrid wind or photo voltaic energy system. The configuration allows the two sources to supply the load separately or simultaneously, depending on the availability of energy sources. The features of the proposed design are separate ripple free input current, low switching loss, better input output characteristics, more efficient, individual and simultaneous operation is supported. MPPT can be realized for each source. The power converter can not only transfer the power from a wind generator, but also improve the stability and safety of the system. The inherent nature of converter, additional input filters are not necessary to filter out high frequency harmonic content is determinant for the generator life span, heating issue and efficiency. The fused multi-input rectifier stage also allows maximum power from the wind and sun. When it is available an adaptive MPPT algorithm will be used for photo voltaic (PV) system. The topology uses a bidirectional converter. This configuration allows the two sources to supply the load separately or simultaneously depending on the availability of the energy sources. Simulation is carried out in MATLAB/ SIMULINK software and the results of the bi directional converter and the output from the renewable sources are presented.

The block diagram of system consists of the controller, converter, battery and the power supply. The controller is the one which monitors the entire system.

Solar power is the alteration of energy from sunlight into electricity, either directly by means of photovoltaics (PV), or indirectly by means of intense solar power. Solar energy is most abundant source of energy in world. Photovoltaic is an effective approach for using solar energy. Photovoltaic systems have long been used in specialized applications. After hydro and wind powers, PV is the third renewable energy source in terms of global capacity. Photovoltaic systems are best known as a method for generating electric power by using solar cells to convert energy from the sun into a flow of electrons by the photovoltaic effect. Solar cells produce direct current electricity from sunlight which can be used to power equipment or to recharge a battery. Photovoltaic power capacity is measured as maximum power output under standardized test conditions (STC). But the output from these systems will be low. A tracking system must be reliable and able to follow the sun and wind with a certain degree of
accuracy MPPT methods can be implemented in order to track maximum power and thus solar and wind energy can be utilized in an efficient manner.

When sun shines the radiations are collected by the solar panels. These panels are designed with solar cells composed of semiconductor materials. The main function of Solar panels is to convert solar energy into DC electrical energy generally of 12V, which is further used for the rest of the circuit. The number of cells required and their size depends on the rating of the load. The collection of solar cells can produce maximum electricity. But, the solar panel must place exactly at right angles to the sun rays. Extracting electricity form solar energy and using that energy to dive motor and storing that energy for less insolation period plays vital role in the working of the project. For any solar based system, the capacity to drive water is a function of three variables such as power, flow and pressure. The energy collected by the panel runs water pumping process is a sensible way of solar electric power utilization throughout the sunshine hours. Solar arrays can provide specific amount of electricity under certain conditions.

In order to determine array performance, following factors to be considered:
- characterization of solar cell electrical performance
- degradation factors related to array design assembly, conversion of environmental considerations into solar cell operating temperatures
- Array power output capability.

The following performance criteria determine the amount of PV output.
- Power Output: Power output is represented in watts and it is the power available at the charge controller/regulator specified either as peak power or average power produced during one day.
- Energy Output: Energy Output indicates the amount of energy produced during a certain period of time and it is represented in Wh/m2.
- Conversion Efficiency: It is defined as energy output from array to the energy input from sun. It is also referred as power efficiency and it is equal to power output from array to the power input from sun. Power is typically given in units of watts (W), and energy is typical in units of watt-hours (Wh).

Wind power, the natural source of energy. Wind flows from high pressure to low pressure. This is due to solar radiation falling on the earth surface. The flow of wind having kinetic energy it is due to the virtue of its motion. Wind power is available more at the coastal areas during day and night, whereas solar energy is available only during the daytime. Power generation is done only in this half of the day. Next half of the day (i.e., nighttime) the unit has to be off mode. To overcome this difficulty wind generation is integrated with the solar power generation. Wind turbine will extract the kinetic energy from the wind and converts to mechanical power which helps to rotate the Electric power generator. Fig.4.2 shows the wind energy conversion principle. Energy conversion takes place from wind energy to electrical energy. Wind turbine, electric generator plays a key role in this conversion. The amount of converted energy depends on the wind energy available at that place. The classical equation of wind power can be explained below. Wind power can be computed by the kinetics which relates the objects in motion. We can extract the wind power up to its cut in speed 3m/s. Research is going on to decrease the cut in speed, so from the little bit of wind flow, it is possible to extract the power.

Solar-Wind Hybrid Energy System uses the battery for storage of energy. Storage elements improve the system reliability. The rating of the battery depends on our load. All the DC power operated devices are connected to this battery directly.

The battery installed in the system is the Li ion battery. The term “lithium-ion” refers not to a single electrochemical couple but to a wide array of different chemistries, all of which are characterized by the transfer of lithium ions between the electrodes during the charge and discharge reactions. Li-ion cells do not contain metallic lithium; rather, the ions are inserted into the structure of other materials, such as lithiated metal oxides or phosphates in the positive electrode (cathode) and carbon (typically graphite) or lithium titanate in the negative (anode). Operational analysis of the proposed system determines that renewable energy technologies offers clean, abundant energy gathered from self-renewing resources such as the sun, wind etc. As the power demand increases, power failure also increases. So, renewable energy sources can be used to provide constant loads. A new converter topology for hybrid wind/photovoltaic energy system is proposed. Hybridizing solar and wind power sources provide a realistic form of power generation.

2.1 Working Principle:
The basic working principle of the system is easy to understand. The system is divided into smaller circuitries. First one is solar circuit; it provides DC power to the components when power is needed by them. This includes a solar panel in which solar cells are connected in series and parallel to construct solar array. Temperature and irradiance
values are mentioned by the user to the PV module inside the PV cell. The outputs of the current and voltage are measured using voltage and current measuring devices. The product of these outputs is fed to the scope to obtain the power curve for the circuit. The obtained waveform is then passed through a filter circuit which is made up of inductor and capacitor. The main objective of filter circuit is to reduce the harmonics and obtain ripple free waveform. Further, output from the filter is given to the battery via charge circuitry which is controlled by controller.

Second circuit is for the power generation using wind turbine. In this case output from the wind turbine which is AC and is fluctuating with high amount of harmonics is fed to rectifier. Rectifier is a power converter that converts AC into DC quantity which is required for bidirectional dc-dc converter. But, this DC output will have harmonics and THD (total harmonic distortion) ratio will be high for such waveforms so we will pass it through filter circuit. The obtained DC from the filter circuit is now ready for its connection in Bidirectional dc-dc converter along with solar panel output.

Third circuit is for bidirectional dc-dc converter composed of both buck and boost type of converters. The constant current source is connected to the one end of the converter which denotes the incoming current from the grid. On the other side battery is connected to store the energy. The proposed model of bidirectional converter is made of two switches, two capacitors, and one inductor. Controller is connected to both the switches and the buck and boost operation will be chosen according to the switch which is open or close. The inductor at the output end of the system is utilized for the reconfiguration of the diodes. The operation of the system can be defined as the biasing of the switches takes place. When the first switch is forward biased the input source to which the diode is configured will get enhanced to the converter, then the system becomes buck converter. When the second switch is forward biased the first diode will get reversed biased thus turning off the operation of the system as boost converter and starts to operate. The relation of input- output can be witnessed using scope. If the voltage measured is higher than the reference voltage, then the bidirectional should send some current to the battery (i.e. buck converter), if voltage measured is lower than reference voltage then bidirectional should send current to boost converter. Boosting the DC voltage to enough level using the converter and obtaining pure AC voltage from the inverter are the keys to realize the above targets.

### III. SIMULATION

The basic idea of simulating a bidirectional converter is to store the maximum amount of energy harnessed from the power sources. Since, these converters have capability of bidirectional power and current flow so they can supply energy to load when demand is high and also, these can absorb energy when demand is lower than the production. Simulation of a Bidirectional dc-dc converter is done using MATLAB SIMULINK in this chapter. A three switch (MOSFET) converter along with three capacitors and two inductors is designed for DC-DC conversion. This converter is non-isolated (transformer less) in nature i.e., there is no isolation between the input and output port of the converter. This converter functions in two operating modes. Simulation and result analysis of both modes are done in following sections.

#### 3.1 Forward Operation Mode of Bidirectional DC-DC Converter

In forward operation mode (A to B operation) voltage from battery is fed into converter and then it is stepped up (Boost operation) for the DC bus. In this case the nominal voltage of battery is 85 volts. Results are obtained in form of voltage waveforms for the same using scope block in SIMULINK.

#### 3.1.1 Schematic diagram of converter in forward operation using SIMULINK

The schematic diagram of Bidirectional dc-dc converter designed in MATLAB is shown in Fig 5.1 and is composed of Lithium ion battery, inductors, capacitors. MOSFETs, scope, and current/voltage measuring devices.
3.1.2 Output Waveforms of Forward Operation Mode
In this operation two switches G2 and G3 are in conduction mode (controlled) while G1 is in OFF state. The voltage is stepped up in this case with wide conversion ratio (1:4). The duty cycle of forward operation mode is taken as 0.7. Fig.5.2 and Fig.5.3 shows the resultant voltage and current waveforms respectively. Resultant waveforms show the step up operation of the converter.

3.2 Reverse Operation Mode of Bidirectional DC-DC Converter:
In reverse operation mode (B to A operation) voltage from load is absorbed by battery and is stepped down (Buck operation). In this case the nominal voltage of battery is 85 volts. So the higher voltage level of DC link is stepped down to the nominal voltage and is stored inside the battery for later usage. Results are obtained in form of voltage waveforms for the same using scope block in SIMULINK.

3.2.1 Schematic diagram of converter in reverse operation using SIMULINK
The schematic diagram of Bidirectional dc-dc converter designed in MATLAB is shown in Fig 5.4 which is similar to that of diagram of forward operation mode. The only difference is the conducting and OFF state switches. In this case switches G2 and G3 are in OFF state while switch G1 is controlled.
3.2.2 Output Waveforms of Reverse Operation Mode

The voltage is stepped down in this case with wide conversion ratio (4:1). The duty cycle of forward operation mode is taken as 0.4. Fig. 5.5 shows the resultant voltage waveform of the reverse operation. The resultant voltage is 65 volts (approx) according to the waveform obtained.

According to the results obtained after the above simulation this bidirectional converter is then implemented in a Hybrid Energy System in next chapter. As we can see the major advantage of this converter is better efficiency and energy storage when demand is lower than production. The basic idea of developing this system is to obtain maximum power from sunlight and wind speed. The solar panel generates 12V of voltage that can be converted to higher levels by integrating them into series combinations. DC output is obtained from solar power source while AC is obtained from wind energy source. These are fed to the essential converters so that they can be converted into desired output at load terminal. Harmonic content in the power obtained from these sources can be filtered by using capacitor filter circuit.

3.3 General Architecture of Hybrid Energy System for DC Load

Hybrid energy system (Wind and Solar) is designed in SIMULINK. Fig. 6.1 shows the general architecture of the simulated hybrid energy system. It comprises of four sub-systems which are solar power generating unit, Wind power generating unit, Energy storage unit and DC Load connection.
3.4 Designing of Solar Power based generating unit
Solar power based generation unit is designed using Solar module (combination of solar cells) which is provided with irradiance and temperature. According to theoretical knowledge maximum amount of power is obtained from any solar cell when the irradiance is 1000 W/m² and temperature is 25°C. The output of this solar module is fed into MPPT controller which is using P/O algorithm for obtaining maximum power. The DC power obtained from the solar module is of low voltage level so it is passed to a unidirectional dc-dc step up converter which makes it suitable for the high voltage DC load.

3.4.1 Simulation of Photovoltaic System
Schematic diagram of Solar powered generation unit along with unidirectional dc-dc converter is designed in SIMULINK and is shown in Fig.6.2.

3.4.2 Output Waveforms of Solar power generation unit
Various output waveforms of solar power generation unit are shown below. Fig.6.3 shows the current waveform. Average current obtained is 5amps.
Similarly, voltage waveform is shown in Fig. 6.4. Average voltage obtained from solar power source is 100 volts.

Power obtained from the circuit is shown in Fig. 6.5. According to the theoretical study the power obtained in any circuit is the product of current and voltage in that circuit (5 amps * 100 volts = 500 Watts). Hence, theoretical and experimental results are verified.

3.5 Designing of Wind Power Based Generating Unit

Wind power based generation unit is designed using Wind turbine generator (Permanent Magnet Synchronous Generator) which is provided with wind speed and pitch angle. Power obtained from wind energy is very fluctuating due to the varying wind speed. The harmonics are removed using filter circuit. The power obtained from wind energy source is AC which is then converted and stepped up into DC using AC-DC converter (rectifier). The DC power obtained from the rectifier is suitable for the high voltage DC load so it is fed to DC link directly.

3.5.1 Simulation of Wind Energy power system

Schematic diagram of Wind powered generation unit along with unidirectional ac-dc converter is designed in SIMULINK and is shown in Fig. 11.
Internal circuitry of PMSG generator is shown in Fig. 12 where various scopes are employed to determine generator terminal outputs. Wind speed is taken as 12 m/s according to references for obtaining maximum power.
3.5.2 Output waveforms of Wind power generation unit

Output waveforms of wind power generation unit are shown in Fig.13. According to this 3-phase AC output is obtained by PMSG wind turbine.

![Output waveforms of Wind power generation unit](image1)

(a)

![Output waveforms of Wind power generation unit](image2)

(b)

![Output waveforms of Wind power generation unit](image3)

(c)

Figure 13. 3-Phase Voltage waveforms for wind power generation unit

Output waveforms of Line voltage, Line current and RMS voltage are shown in Fig.14.

![Output waveforms of Wind generator terminal](image4)

(a)

Figure 14. Output waveforms of Wind generator terminal (a)

Also, output waveforms of RMS current, AC power from wind turbine and Rotor speed are shown in Fig.15.
AC voltage obtained from wind turbine generator (Fig.16) is equal to the voltage level required by the DC link. This AC is fed into rectifier for AC-DC conversion and results are shown in Fig.17.

Figure 15. Output waveforms of Wind generator terminal (b)

Figure 16. Output waveforms of AC voltage from Wind turbine

Figure 17. Output waveforms after AC-DC conversion

3.6 Simulation of Energy Storage Unit
The energy storage unit is composed battery and bidirectional converter. When the demand is lower than the generated amount than to reduce the waste of energy the energy is stored in the battery. Similarly, when sources are not available for power generation then stored energy is utilized by loads.

Simulation of Energy Storage Unit with Bidirectional Converter
Simulation of Bidirectional DC-DC converter is shown in Fig.5.1 and Fig.5.4. Same block of converter are used in the simulation of hybrid energy system for storing energy.
3.7 Characteristics of Battery
Discharging characteristics of battery is shown in Fig.18 which shows that with time the amount of charge stored in the battery is increased as the power is generated in the system.

![Battery Storage](image)

**Figure 18. Charging characteristics of Battery**

3.7.1 Output waveforms of Bidirectional Convertor in Conduction Mode
High voltage DC is obtained at the output of bidirectional DC – DC converter which is shown in Fig.19.

![Voltage from Bidirectional DC-DC converter](image)

**Figure 19. Output waveform of BDC in Hybrid energy system**

3.8 Connections to DC load
DC load is connected to the output of solar power source, wind power source and energy storage unit. This is an example of stand-alone system. This system is the basic category of the hybrid energy system. Simulation of DC Load in Hybrid Energy System
All the three subsystems are collectively connected to the DC link as shown in Fig.20. In which all the connections are fed directly to the DC load.

![Simulation of DC Load in Hybrid Energy System](image)

**Figure 20. Simulation of DC Load in Hybrid Energy System**
3.8.1 Output Voltage/Current Waveforms at DC load in Hybrid Energy System
Voltage and current at the DC load are measured using voltmeter and ammeter and the output waveforms are studied using scope in SIMULINK. Output waveforms of DC voltage and DC current fed into DC load from whole system are shown in Fig. 21 and Fig. 22 respectively.

![Figure 21. Output waveform of DC voltage to DC load](image1)

![Figure 22. Output waveform of DC current to DC load](image2)

3.9 Connections to AC load
DC power obtained from the hybrid energy system is converter into AC using a 3-phase inverter. Output of inverter is suitable for AC load is connected further. This is also an example of stand-alone system. This system is the basic category of the hybrid energy system which can be used for domestic applications.

3.9.1 Simulation of AC load in Hybrid Energy System
All the three subsystems are collectively connected to the DC link which in turn is fed into inverter for DC-AC conversion. Fig. 23 depicts the simulation of AC load in hybrid energy system. The AC load is operating on 50Hz frequency and 50 kW power.

![Figure 23. Simulation of AC load in Hybrid Energy System](image3)
3.9.2 Output Voltage/Current Waveforms at AC load in Hybrid Energy System

Voltage and current at the AC load are measured using voltmeter and ammeter and the output waveforms are studied using scope in SIMULINK. Output waveform of inverter at AC load is shown in Fig.24.

3- Phase AC voltage is obtained from inverter and is fed to the load at 50 Hz frequency.

![Figure 24. Output voltage waveform at AC load](image)

All the resultant waveforms are depicted in the scope terminal attached to the AC load. Fig.6.20 shows the output waveforms of DC voltage fed into inverter, output phase voltage of inverter and Load voltage.

![Figure 25. Various Output voltage waveforms for AC load simulation](image)

All these waveforms shows that the voltage level obtained in all the cases is similar are is stepped up at the high voltage DC or AC link for efficient utilization of energy.

IV. APPLICATIONS AND ADVANTAGES

As we know that the energy consumption is growing globally. To meet the demand for electric power and controlling the depletion of conventional resources, the power obtained from renewable sources is becoming more popular. Wind and PV energies have experienced one of the tremendous growths (in percentage of 20 % each year) as compared to others. In renewable energy applications such as fuel cell systems and photovoltaics the demand of DC–DC converters with higher voltage gain is increasing gradually. Besides requirement of non-isolation and high step-up voltage gain they also demand for high power density, high efficiency, and minimized cost. The output voltage delivered by renewable energy sources is in range of around 12 to 70 VDC. So, to connect these to the grid their voltage level should be stepped up to sufficient level at which the DC/AC conversion can be performed. Higher efficiency can be attained by reducing duty cycle and reducing voltage stress on components. In non isolated dc-dc converters efficiency and voltage gain are excellent, even though two transformers are in use. Utilization of
transformer is depicted in high step up dc-dc converter for photovoltaic applications that ensures higher voltage gain but the interleaved converter topology allows the switches to work with lower duty cycle. Among the other more advanced topologies push-pull converter with additional snubbers and voltage doubler can be used as a promising solution. Inductor coupled topologies presented in and provides very compact designs for the dc-dc converters with high voltage gain. In topology, converter with higher efficiency coupled inductor and charge pump circuits for broad input photovoltaic AC module applications is implemented which is a compact and robust solution. The designers have to cope with several time related reliability issues because of utilization of renewable energy sources for many years. Also, another major issue is to minimize the maintenance and to maximize the energy yield. To produce sufficient DC bus voltage level high voltage gain is required. Additionally these should be immune to environmental conditions and operate at wide temperature range. Such necessities of systems create several designing criteria for step up DC/DC converter for efficiency of overall renewable energy systems.

The advantages of this system includes:

- **Low operating cost:** One of the important advantages is the negligible operating cost of the system. Since there is no fuel required for the pump like electricity or diesel, the operating cost is minimal.
- **Low Maintenance:** A well designed Hybrid renewable energy system requires little maintenance beyond cleaning of panels once a week. Most vendors provide the post installation service through trained technicians for every cluster, so that the farmers don’t need to worry about availability of spares or other related problems.
- **Harmonious with nature:** Another important advantage is that it gives maximum output when it is most needed i.e., both in hot and dry months.
- **Flexibility:** Panels can be placed along with the wind turbines on heights to obtain the maximum power.

**Applications:**
Solar Wind Hybrid Energy Systems are using in almost all field small electric power usage. Some of the applications of SWHES are given below.

- **Grid connected:** The large power rating of SWHES, where the access of wind and sun irradiation is more, they can be connected to Grid. In these types of generation, if the system failed to generate power the Grid will supply the load.
- **Stand alone:** Almost all SWHES applications are stand-alone not connected to the grid.
- **Street lighting:** The foremost application of SWHES is solar street lighting. Solar Street light become as SWHES lighting. Use of this reduces the load from conventional power plants.
- **Household:** Residential appliances can use power generated through hybrid solar wind energy system. SWHES are used to supply electricity to different offices or other parts of the building in reliable manner.
- **Remote Applications:** like military services where it is impossible to provide conventional power supply these SWHES systems are useful.
- **Ventilation system:** The proposed systems are also used for ventilation purposes, these helps in running Bath fans, floor fans and ceiling fans in buildings.
- **Power Pump:** SWHES can also help to pump the water to any building. DC power operated pump can circulate the water through your home.
- **Village Power:** The proposed system is very useful in villages which are in valley and on hills, where it is not possible to send electricity.
- **On shore:** The wind blows more at coastal areas, SWHES are installed near sea and on the boats for power generation
- **Commercial:** In hotels, tourist places SWHES give the required electric power.

**V. CONCLUSION AND FUTURE SCOPE**
Solar Wind Hybrid energy Systems become reliable for small power applications. To improve the solar Photovoltaic power generation efficiency, wind energy is integrated to form as hybrid energy system. The proposed systems help to reduce air pollution caused by the conventional power generation system. By installing SWHES to every house, the burden on the conventional power generating system reduces. The storage of the battery will give power for some time, even no generation takes place by this system. Almost in all field of electric power usage, the SWHES are being used. It provides the power to inaccessible convention power places. SWHES are more reliable and efficient energy generating system with less effect on the environment and almost no maintenance. In small utility
areas this SWHES is much preferred. This two energy sources are acting simultaneously to generate electric power. Load sharing takes place in this proposed system. And it can be operated on their maximum power point. Continuity of power supply also takes place in this system, if any one failed to generate power the other one will supply the load. This load monitoring was done by the respective control algorithms. Under this both power generating systems works to generate the power. By this SWHES the overall system performance is increased and will get continuous power supply. Results showed that it will be possible for users to use bidirectional converters in the hybrid energy systems to monitor directly. Further, it will help us to take advantage of the renewable energy sources to provide more efficient supplies. The output of that converter is stored in battery on one side and on another hand it is given to the AC loads after getting converted into AC using inverter circuit. Power quality improvement, efficiency increment is the field on which we can work further and compare the results.

In future if we modify it properly then this system can also use this system in designing micro grids with better efficiency. Power quality of the power obtained from the bidirectional converter can be improved further. Duty cycle comparisons can be done for the various convertors to design and select the best convertor fot the desired system. In future the advances in nano technology, improvements in smart grid and power electronics have major role in implementing solar energy policies. Our government, Research and laboratories, various solar organizations are working hard to make this energy system a better source for power supply.

VI. REFERENCES


