EE3014 POWER ELECTRONICS FOR RENEWABLE ENERGY SYSTEMS

UNIT V - HYBRID RENEWABLE ENERGY SYSTEMS

5.3- Case studies of Wind

Case studies of Wind-PV system

Many remote communities around the world cannot be physically or economically connected to an electric power grid. The electricity demand in these areas is conventionally supplied by small isolated diesel generators. The operating costs associated with these diesel generators may be unacceptably high due to discounted fossil fuel costs together with difficulties in fuel delivery and maintenance of generators. In such situations, renewable energy sources, such as solar photovoltaic (PV) and wind turbine generator provide a realistic alternative to supplement engine-driven generators for electricity generation in off-grid areas. It has been demonstrated that hybrid energy systems can significantly reduce the total life cycle cost of standalone power supplies in many off-grid situations, while at the same time providing a reliable supply of electricity using a combination of energy sources. Numerous hybrid systems have been installed across the world, and the expanding renewable energy industry has now developed reliable and cost competitive systems using a variety of technologies. In a report, India‘s gross renewable energy potential (up to 2032) is estimated at 220 GW.

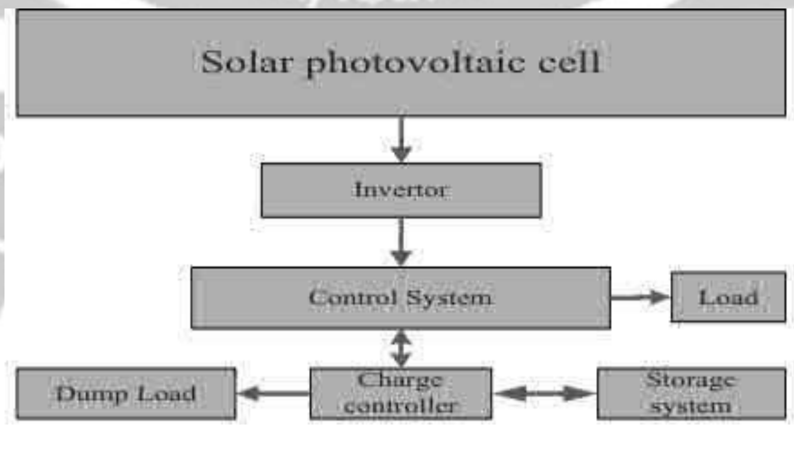
It is likewise noted in the report that, with a renewable energy capacity of 14.8 GW (i.e. 9.7% of the total installed generation capacities of 150 GW as on 30 June 2009), India has barely scratched the surface of a huge opportunity. However, in the last couple of years itself, the share of renewable energy in installed capacity has grown from 5 to 9.7%. This implies an enormous potential in energy generation, which can achieve several hundred GW with current renewable energy technologies. As the cost of building solar PV–wind capacity continues to fall over the next five to ten years; a significant scale-up of renewable generation is a very realistic possibility in the developing world. Thousands of villages across the globe are still being exiled from electricity and energizing these villages by extended grids or by diesel generators alone will be uneconomical. Moreover, with the current resource crunch with government, these villages receive low priority for grid extension because of lower economic return potential. Standalone solar PV–wind hybrid energy systems can provide economically viable and reliable electricity to such local needs.

Many countries with an average wind speed in the range of 5–10 m/s and average solar insolation level in the range of 3–6 KWh/m2 are pursuing the option of wind and PV system to minimize their dependence on fossil-based non-renewable fuels. Autonomous wind systems do not produce usable energy for a considerable portion of time during the year. This is primarily due to relatively high cut-in wind speeds which ranges from 3.5 to 4.5 m/s. In decree to overcome this downtime, the utilization of solar PV and wind hybrid system is advised. Such systems are usually equipped with diesel generators to meet the peak load during the short periods when there is a deficit of available energy to cover the load demand. Diesel generator sets, while being relatively inexpensive to purchase, are generally expensive to operate and maintain, especially at low load levels. In general, the variation of solar and wind energy does not match the time distribution of the demand.

DESCRIPTION OF HYBRID RENEWABLE ENERGY SCHEMES

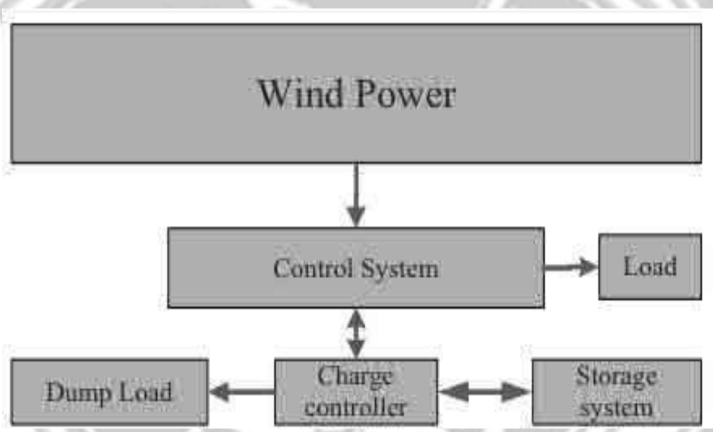
A hybrid renewable PV–wind energy system is a combination of solar PV, wind turbine, inverter, battery, and other addition components. A number of models are available for PV–wind combination as a PV hybrid system, wind hybrid system, and PV–wind hybrid system, which are employed to satisfy the load demand. Once the power resources (solar and wind flow energy) are sufficient excess generated power is fed to the battery until it is fully charged. Thus, the battery comes into play when the renewable energy sources (PV–wind) power is not able to satisfy the load demand until the storage is depleted. The operation of hybrid PV–wind system depends on the individual element. In order to evaluate the maximum output from each component, first the single component is modeled, thereafter which their combination can be evaluated to meet the require dependability. If the electric power production, though this type of individual element, is satisfactory the actual hybrid system will offer electrical power at the very least charge.

Hybrid photovoltaic system



Solar energy is one of the site-dependent, non-polluting energy sources, and is available in great quantity. It is a potential source of alternative/renewable energy and utilization of solar radiation for power generation reduces the dependence on fossil fuel. Solar PV power generation unit consists of PV generator, diesel generator, and inverter and battery system. For improved performance and better control, the role of battery storage is very important. The necessary condition for the design of the hybrid PV systems for maximum output power is hot climate. This type of system is cost effective and reliable, especially for those locations where the power supplies though the grid is not suitable and the cost of the transmission line is very high such as remote and isolated areas. Designed a system for computing production cost associated with hybrid PV battery method in which the size associated with PV method is calculated on such basis as electrical requirements not attained. For standalone hybrid PV system, analysis of reliability is determined in the term of loss of load (LOL) probability.

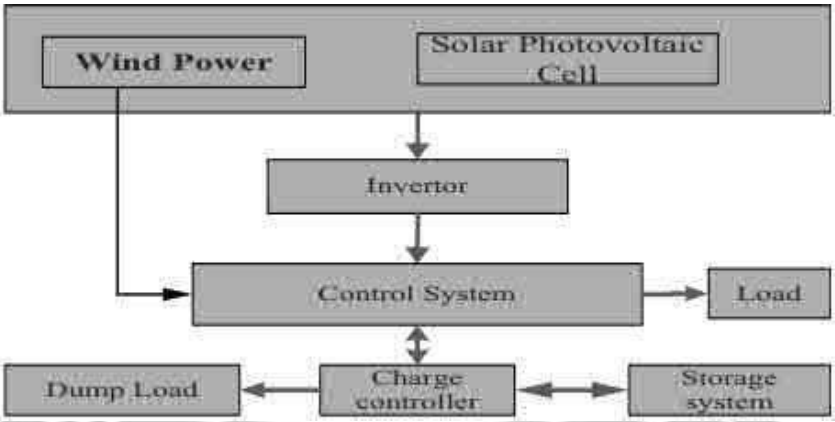
Hybrid wind energy system



For the design of a reliable and economical hybrid wind system a location with a better wind energy potential must be chosen. Optimal sizing of a hybrid wind system and forecasting of a hybrid system based on several optimization techniques are obtained based on the application. A methodology is obtained for identifying the wind turbine generator parameters as capacity factor which relates to identically rated available wind turbine and capacity factor calculated on the basis of wind speed data at different hours of the day of many years. Hybrid wind system performance, reliability, and reduction in the cost of energy (COE) can be obtained by using a battery backup system. When the hybrid system generated power is in surplus, this power is used for loading the batteries for backup security and this charge battery power is used when the load requirement is not supplied by design hybrid system. Figure shows the architecture of wind hybrid energy system.

Hybrid photovoltaic/wind energy system

PV and wind system, both depending on weather condition, individual hybrid PV and hybrid wind system does not produce usable energy throughout the year. For better performance of the standalone individual PV combination or wind combination need battery backup unit and diesel generator set results to increase the hybrid system cost.



The main objective of the design is to obtain a cost-effective solution. Different artificial techniques are available for the optimal size of the hybrid system to minimize total annual cost. A couple of renewable energy sources—PV panels and wind turbines—are viewed as, together with traditional diesel generators in order to optimally design ability as well as functioning, preparing of the hybrid system. An optimization is used to match hourly supply and demand problem had been resolved to have sparse matrices and also the linear programming algorithm.

POWER ELECTRONICS TOPOLOGIES AND CONTROL FOR HYBRIDSOLAR PV-WIND SYSTEMS

Power electronics topologies and control for Grid-connected system

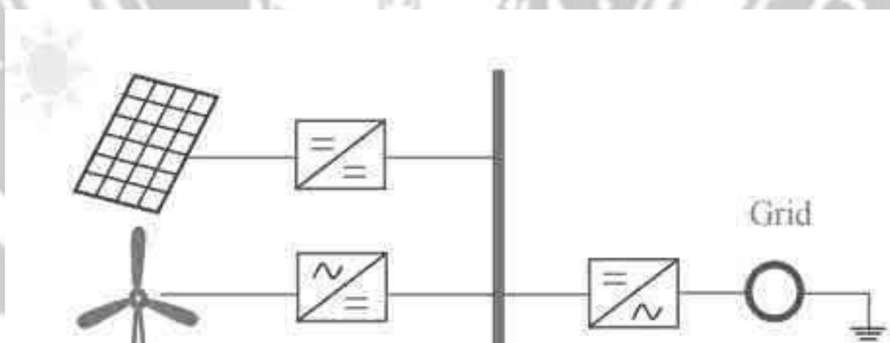


Figure 1: Grid-connected hybrid system at common DC bus

There are two topologies for grid-connected solar PV and wind hybrid system as can be seen from Figure 1 and 2. Figure 1 shows that the DC outputs' voltages from individual solar PV, wind and battery bank stream, through individual DC/DC and AC/DC units, are integrated on the DC side and go through one common DC/AC inverter which acts as an interface between the power sources and the grid to provide the desired power even with only one source available. Hence, the renewable energy sources act as current sources and can exchange power with the grid and the common DC/AC inverter controls the DC bus voltage. The individual units can be employed for maximum power point tracking (MPPT) systems to have the maximum power from the solar PV and wind systems and the common DC/AC inverter will control the DC bus voltage. The battery bank is charged when there is an extra power and discharged (by supplying power) when there is shortage of power from the renewable energy sources.

Figure 2: Grid-connected hybrid system at common AC bus

On the other hand, Figure 2 shows that renewable energy sources are injecting power directly to the grid through individual DC/AC and AC/DC-DC/AC units. Many modules have proposed and presented experimental results of PV-wind-battery hybrid systems along with power management schemes and control systems. Such systems were capable to operate in different modes of operation and able to transfer from one mode to another easily. The voltage converters play an important role in controlling the amount and the type of voltage whether AC or DC and the duty cycle of those converters can be used to improve the quality of power. The response of the duty cycle of a DC/DC converter is relatively fast in MPPT control process. Numerous intelligent techniques are used for grid-connected hybrid PV/FC/battery power system to control flow of power via DC/DC and DC/AC converters.

Power electronics topologies and control for standalone system

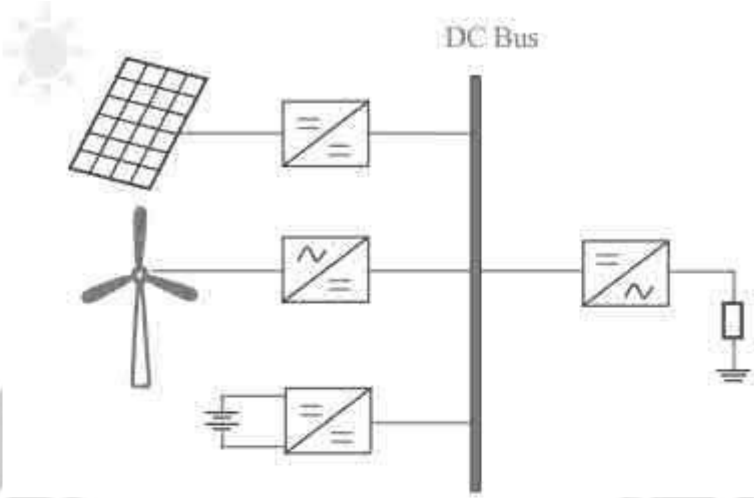


Figure 1: Stand-alone hybrid system at common DC bus

Figure 1 shows a stand-alone solar PV and wind hybrid system with DC common bus. One of its main advantages is to include DC interface bus for coupling different generation sources, which do not have to operate at a constant frequency and in synchronism. The DC bus line output voltage from all streams is set to be fixed and the output current from each source is controlled independently. The DC outputs‘ voltages from individual solar PV, wind and battery bank stream, through individual DC/DC and AC/DC units, are integrated on the DC side, combined in parallel and go through one common DC/AC inverter which acts as an interface between the power sources and the loads to provide the required power to the load by regulating the AC output voltage. The battery bank is interfaced by a DC/DC converter which regulates the DC-link bus voltage by charging (in case of extra power) or discharging the battery (in case of shortage of power). The renewable energy sources act as current sources and supply directly the loads. The interface common unit regulates the magnitude of the load‘s voltage. The individual AC/DC and DC/DC units can be employed for MPPT systems to have the maximum power from the solar PV and wind systems and the common DC/AC inverter will control magnitude of the load‘s voltage. The battery bank acts as a voltage source to control the common DC bus voltage by charging or discharging. In the conventional way for controlling the complete hybrid system, power electronics converters are used for maximum energy extract from solar and wind energy resources. In addition, advanced controlling techniques can remove the power fluctuations caused by the variability of the renewable energy sources.

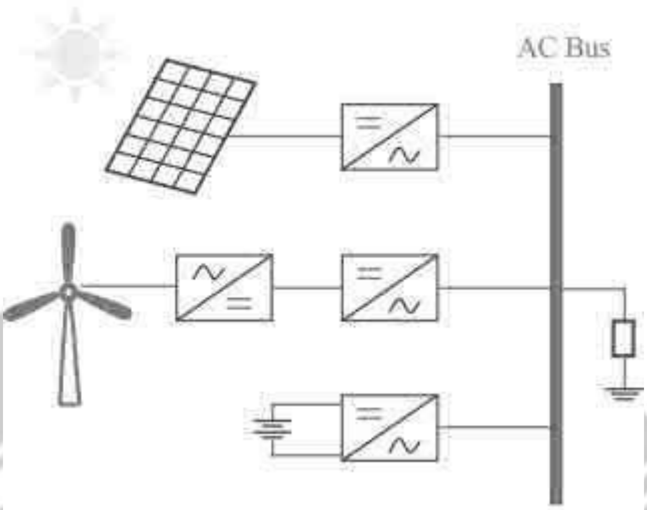


Figure 2: Stand-alone hybrid system at common AC bus

Figure 2 shows stand-alone solar PV and wind hybrid system with AC common bus. The form of pure AC bus bar system is widely used worldwide with lot of advantages, such as simple operation, plug and play scenario, low cost and easy extension according to the load‘s requirement. On the other hand, controlling AC voltage and frequency and energy management are some of the challenges for this type of topology. In this topology, the AC outputs‘ voltages from individual solar PV, wind and battery bank stream, through individual DC/AC and AC/DC-DC/AC units, are feeding the loads directly. The renewable energy sources can act as current sources provided that the battery bank exists as a voltage source to control the common AC bus voltage by charging or discharging. Hence, the individual units can be employed for MPPT systems to have the maximum power from the solar PV and wind systems provided that the battery bank exists as a voltage source to control the common AC bus voltage by charging or discharging. The battery bank is charged when there is an extra power and discharged and can supply power in case of shortage of power from the renewable energy sources. Droop control is normally applied to generators for frequency control and sometimes voltage control in order to have load sharing of parallel generators. It can also be used to perform proper current sharing ina micro-grid. With droop control, decentralized control for each interfacing converter is achieved. At the same time, no communication or only low bandwidth co-mmunication, such as power line communication, can be used in AC systems. Power flow was controlled usingfrequency and voltage drooping technique in order to ensure seamless transfer between grid connected and stand-alone parallel modes of operation.