Integration Schemes for Hybrid Generation Systems

Ashish Grover, Anita Khosla, Dheeraj Joshi

Abstract: ***The progress in renewable sources,the wind energy has given rise to augmented attention on more trustworthy and useful electrical generator systems. Because of the reason that sunlight and wind energy is alternatingin nature and has great success in power generation over conventional sources.However due to irregular in nature andhigher dissemination of renewable sources, in present day Power generation plants many technical problemsparticularly when used independentlyconnected to grids or standalone systems without appropriate energy storage devices. To make the system more reliable the integration the two renewable resources into an optimum combination, cansolve the impact of the inconsistent nature of solar and wind resources andalsomake the system efficient to run. The paper gives you an idea aboutproblems and its related best solutions for integrating hybrid solar, wind and conventional Power generation systems both a grid connected and standalone system.Voltage and frequency fluctuations generate harmonics which are significant reasons of power quality and have very high impact on power generation. By proper design and advances fast response controllers and goodOptimization techniques resolve the problem to large extent. The paper also provides review on optimal sizing design, power switching devices and its control. The paper presents types of integrated schemes available in Hybrid systems for both grid-connected and standalone Solar PV and Wind Systems.***

KeyWords: ***Solar PV; Wind; Fuel Cell; Hybrid Renewable Energy Sources (HRES);Grid Connected; Standalone.***

I. INTRODUCTION

The fuel generated from fossils and economically high cost of such sources have increased the interest innon conventional energy sources. Due to non pollution, east accessibility renewable sources are getting popular. The main reason of using renewable sources is due to less emission of harmful gases. In remote areas, such as islands standalone systems are required and to meet energy needs only renewable sources can give the better results. Now a day'swind, solar is employed for most the applications like Electric Vehicle, water Pumping, telecommunications and remote area electrification. Hybrid Power generation is preferred for remote area telecommunication, satellite systems and electrification. Independently solar and wind generation systems are more popular to employ on large scale as compared to self governed systems to avoid interrupted power supply. To fulfill the demand of energy required some storage systems are therefore required tostore the generated output.The storage system are usually very expensive so hybrid generation system are combined in a such a way that minimum cost of installation shall be engaged and requirement of storage system shall be reduced.Most of the villages in India are connected to countrywide grid due to the isolation and conservation constraints.For such a isolated villages or remote areas Hybrid renewable energy sources are the only solution to meet the energy demands. Therefore, Micro grids must be taken into operation using renewable energy sources.

II. TECHNOLOGY SELECTION AND UNIT SIZING OF HRES

Due to varying weather conditions and depletion of conventional sources, to meet the energy demand required the different renewable sources must be integrated. Hence, the work on dynamic modeling of various mechanism involved in isolated systemsmust be done .Also steady state and transient modeling of the system is required to carry out. Besides, that overall controller must be designed to control multisource power generation. For each generation sub systems the controller designed must be operated in online mode and switching control circuit is also been designed for power conversion. For a particular location, Power system reliabilityand effective cost investigationare also very substantial in the scheduling of hybrid energy system. To utilize renewable sources effectively and at optimum cost, proper unit sizing must be implemented. The "optimal sizing method" can help to design the system using Solar, wind and other resources with low investment and better output.Different constraints and components are required for different load criteria. Mostly considered criteria and constraints to design a hybrid energy system are:

- Hybrid energy systems may be examined by constancy of the system using probability based on loss of power, increased demand and loss of load. [12].
- System Cost: These criterionsinclude total energy generation cost, load and demand costs and community costs.
- Less fuel with minimum emissions and increased reverse capacity along with the optimum power generation is the part of operational requirements of Power system. [7]. Hybrid system design proposal uses different artificial intelligent methods to optimize the size, cost with iterative methods and probabilistic approach.

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The researchers are focusing the problems and issues occurring in the designing of integratedsystem .The learning includes small scale grid based on one or more sources, their modelling parameters, controllers and simulation results.The paper also emphasis on optimum,reliable,cost-effectivedesign of renewable based generation system.

A. Integration Schemes of Hybrid Renewable Energy Systems:

The hybrid systems are classified on the basis of source it uses,e:g. PV-Wind system,PV-Diesels system and PV-Fuel cell system. On the other hand hybrid systems are also classified a series hybrid system, parallel hybrid system or switched hybrid system.

i. PV-diesel hybrid system:In this configuration DC Power is generated by diesel generator and converted back into AC Power with the help of Inverter. TheConversion of AC into DC is done with maximum rated inverter to handle peak load.The PV source is also connected to the DC bus via DC-DC to converter at which battery is connected.The DC-DC converter ensures the function of MPPT to optimally use PV array. Theshortage of power is compensated by battery.It also helps to start the diesel generator [4]. The configuration is called series as diesel generator is not connected in parallel with the inverter. The limitation of the configuration is that it should be rated for maximum load requirement, had low efficiency as the diesel generator supplies power through the series rectifiers.

Parallel Configuration:Both diesel generator and inverter are connected in parallel to the AC load.As theresult rating of the inverter is less and efficiency of the system is higher. In other in parallel configuration power supplied is more than series configuration for the same rating of inverter.Switched Configuration: this system also have several limitations as series and parallel hybrid configurationsonly one source can be connected to the load at a given instance. And moreover while switching the power get interrupted. The advantage of the system is that the diesel generator can be directly connected to loads which leads to increase in efficiency and also no synchronization is required.

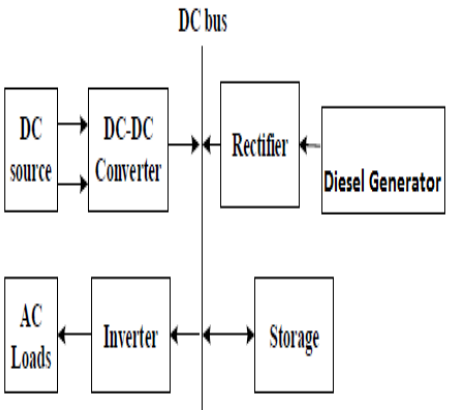

Fig. 1(a)DC-Series (PV-Diesel Hybrid systems)

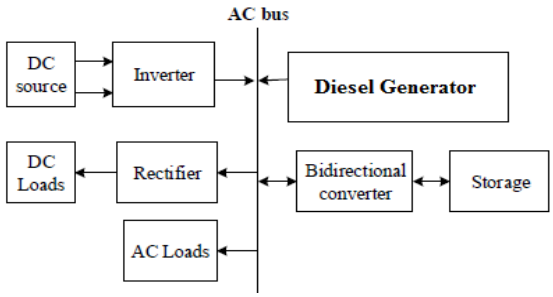

Fig.1(b) AC-Series(PV-Diesel Hybrid systems)

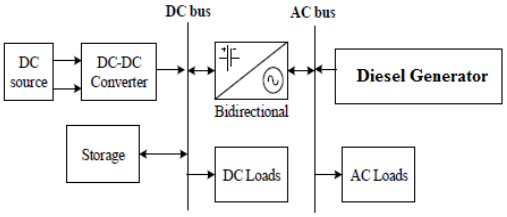

Fig.1©Parallel Configuration(PV-Diesel Hybrid systems)

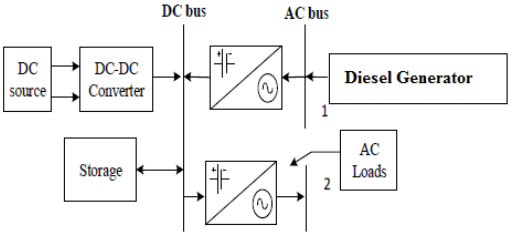

Fig.1(d)Switched configuration(PV-Diesel Hybrid systems)

ii.**Solar-Wind hybrid Systems**: In this configuration the deviation in the wind speed results into large alteration in the frequency and output power of the Generator.So AC output is converted first in DC and then back into AC with the help of inverter [16].The PV and wind generated output is connected parallel forming DC Link.Solar and wind both are unreliable source, hence to store the power and to meet the load demand large storage system is required.

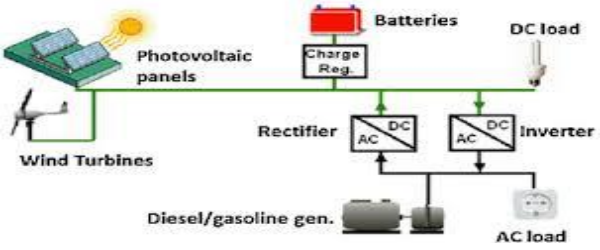

Fig2: Solar-Wind Hybrid Systems

iii.Solar-fuelCell hybrid systems:The solar-wind hybrid system is weather dependent and unreliable so to overcome the problem fuel cell is best integrated system [17]. In this configuration parallel connection of two DC-DC converters will be examined. Primary is fed from solar, while other is fed from fuel cell.

The other advantage of the system is easy synchronization as compared o the synchronization of the two AC sources. Even if the isolation varies, the output power supplied to the load can be maintained by drawing the deficit power from the fuel cell. The maximum power from solar arrays are generated through DC-DC converters.

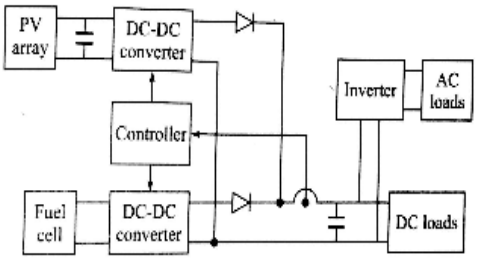

Fig 3: Solar-Fuel Cell Hybrid systems

B. Grid connected systems:

The types of grid tied arrangements are shown in fig. 2. The layout of the design depends upon geological, climateand scientificfactors. Integrated dc-bus structural design shown in Fig. 2(a). The Wind & Diesel are ac energy sources which first deliver power to rectifier and then convert it into DC before being fed to DC Bus Bar [24]. The major function of inverter is to integrate DC bus with ac grid. Centralized ac-bus architecture shown in Fig.2 (b), before connected to the grid,the conventional resources using thestorage device such as power banks all are installed in one place and are fed to ac bus barfirst, through suitableswitching device. In the centralized system ,the battery and all the energy conversion systems delivering power are fed to grid at one point. In Distributed ac-bus planning shown in Fig 2(c), the power sources are not required to be installed at one place and also not connected to grid. The sources are dispersed in diversepositionaccording to weather conditions available and connected to the grid independently. The power conditioning by each source is doneindividuallyas required by the grid.

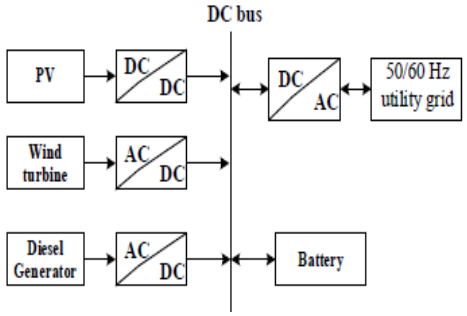

Fig 4(a): Varoius Standlone Grid connrcted Hybrid Systems-Centralized DC Bus

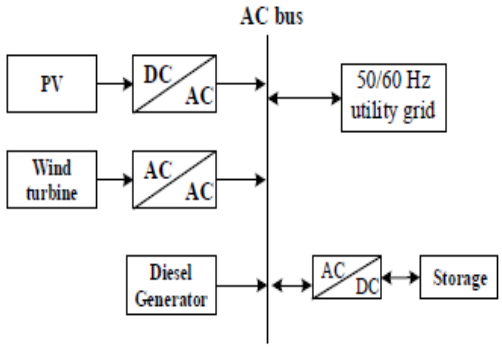

Fig 4(b): Varoius Standlone Grid connrcted Hybrid Systems- Centralized AC Bus

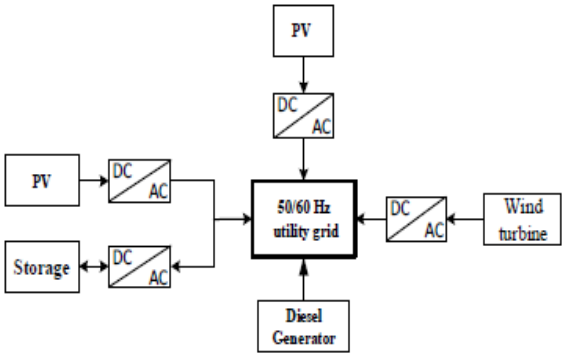

Fig 4©: Varoius Standlone Grid connrcted Hybrid Systems- Distributed AC Bus

III . RESULTS AND FINDINGS

HRES has developed a lot in resent power generation systems and there use is increased day by day. However, problems and power quality issues are also significant due to integration of conventional and non-conventional sources. The findings are revealed after the study of hybrid systems.Table I shows the solutions to problems occurred in standalone configurations and Table II explains the solutions to the problems generated under Grid tied plants.

Table I. Solutions for challenges in standalone system

Sr no.	Challenges	Solutions
1.	High storage cost	Integration of Solar and wind systems with common storage device will reduce the overall cost of the system.
2.	Less usable energy during the year.	Back-up systems such as battery storage and diesel generator in integration to renewable energy sources.
3.	Power quality	Harmonic filters with proper controller will improve the voltage and current fluctuations
4.	Protection	Upgradation of protection devices must be done when distribution generators are introduced
5.	Environmental and safety	Use of super capacitors enhanced instead of Lead-acid batteries to avoid pollution.

TABLE II. Solutions for challenges in grid-tied system

Sr no.	Challenges	Solutions
1.	Voltage fluctuations	Series and shunt active power filters. Power Conditioning devices must be incorporated such as static & Switched Compensators to avoid the fluctuations due to wind speed and irregular solar radiations
2.	Frequency fluctuations & Harmonics	PWM schemes of inverter controller for regulating three-phase frequency in a microgrid and help in improvement of frequency fluctuations
3	Intermittent energy	Appropriate regression analysis for forecasting of weather to get maximum solar radiations and high wind speed. Automatic Generation control & advanced optimization techniques for optimal power flow.
4	Synchronization	Phase-locked loop technique is mainly used for synchronization. Using combination of filters coupled with non-linear transformations other techniques should also be included by detecting the zero crossing of the grid voltages.

Further after classification, optimizationtechniques suggested for performance of the system with actual component sizing will be given in tableIII

Table III: Optimization methods for different type Hybrid system

Type of Hybrid System	Optimization Technique	Outcomes
Wind Pumped storage standalone system	Linear programming	Defines optimal number of turbines for wind energy generation and its size .Also control charge and discharge of water Pumps.
Wind and solar Grid connected system	Linear Programming and sparse matrices	Optimum scheduling determine the generation rate on hourly or yearly basis.
Diesel and hybrid system	Analytical hierarchy Process	Depends on Multi Criteria decision making, complex to achieve required output.
PV and fuel cell based system with battery storage	Genetic algorithm with Mathematical equations	Optimal performance of the PV system along the actual environmental conditions.

IV. CONCLUSION:

This paper has given edge on a review of problems and its solutions to integrate solar PV,wind energy sources and fuel cell technologies for electricity generation. The irregular and changing weather conditions are most significant problem to integrate standalone and grid connected system. To make the system more reliable the two resources are integrated with fuel cell into an optimum Grid DC Bus -AC Bus combination. The system can be made more consistent and cost effective by using renewable sources such solar and wind along with conventional sources. The standalone systems had major advantage of using hybrid systems with storage banks and diesel generators. The wind-diesel,battery-diesel and solar-dieselrenewable tied system can congregate the system load during peak hours. ProficientPower management systems should be designed to ensure high system competencewith betterconstancy and least cost. Forecasting of weather helps in reducing discontinuous energy by proper utilization of solar radiation and wind speed. Power Quality problems such as transients in Voltage and frequency generate harmonics for both systems whether connected to grid or off grid which would reduceto a major extent by having proper power management, improve and advanced control equipment and iteration facilities, and optimum power generation by hybrid systems. The paper presents an overview of best possibledesign of hybrid systems with necessary parameter control and sizing, advanced switching equipment and control for online grid system andoff line grid in integration with PV, wind systems and fuel cell system.

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