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# A Review of Hybrid Renewable Energy System for Interconnected with Electrical Utility

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***ABSTRACT:*** *The performance of power system is affectedby dynamic characteristics of hydraulic governorturbinesduring and following any disturbance, suchas occurrence of a fault, loss of a transmission line, arapid change of load or hydraulic transients.* The energy demand of many developing countries is more on day by day due to the growth of industrial, economic and social activities etc. *Accuratemodeling of hydraulic governor-turbines is essentialto characterize and diagnose the system responseduring an emergency. In this paper, the identification,development and implementation of hydraulicsystems in power plants System configurations, generation unit sizing, storage needs, and energy management and control are addressed.*

## I. INTRODUCTION

Unlike the conventional energy sources, the non-conventional energy sources are clean, reliable, and abundant in nature. The environmental degradation such as pollution, global warming, and greenhouse gas emissions which are caused by conventional sources of energy and accelerated by ever-growing industrial activities throughout the world is a concern for all [2]. The current researches, therefore, lay emphasis on harnessing renewable energy sources (RES) for generating electricity to supply power especially, to rural consumers where grid connection is not available [3].A second strategy is to achieve this goal consists of using renewable energy sources. Renewable resources and clean alternative energy power generation technologies have attracted much attention and concern because they have several advantages such as, less dependence on fossil fuel, availability of the resources which are free of cost, and lower harmful emissions to the atmosphere (i.e. environmental friendly) [4]. Renewable energy sources, such as wind, solar, micro hydro (MH), biomass, geothermal, ocean wave and tides, and clean alternative energy sources, such as fuel cells (FCs) and micro turbines (MTs), have become better alternatives for conventional energy sources. However, in comparison to conventional energy sources, renewable energy sources are less competitive due to their uncertainty, intermittency due to dependence on weather, and high initial cost. A renewable hybrid energy system consists of two or more energy sources, a power conditioning equipment, a controller and an optional energy storage system [5]. These hybrid energy systems are becoming popular in remote area power generation. Research and development efforts in solar, wind, and other renewable energy technologies are required to continue for, improving their performance, establishing techniques for accurately predicting their output and reliably integrating them with other conventional generating sources [7]. A number of intelligent computing methods have been utilized in these researches and most of them will be summarized in this paper.

## II. DESIGN OF HYBRID RENEWABLE ENERGY SYSTEMS

A. Technology selection and unit sizing In this design stage, the system's configuration is synthesized [1], i.e. which types of generation technologies will be allocated and integrated to build a hybrid system. This is very crucial aspect in the design, since there are usually many alternative possibilities related to which individual components will be included in a hybrid energy system

For a given hybrid energy system, this design stage would be to determine [5]:

- Renewable energy type of system to be included.
- The number and capacity of renewable energy units to be installed.
- Whether a back-up unit, such as dieselgenerator, fuel cell etc. would be included in the system.
- Whether energy storage would be integrated intothe system.
- Whether the system is stand-alone or grid connected.

The selection of the technology depends on the availability of renewable resources for particular site where the system is to be installed in which the local weather conditions play an important role for taking decision. Based on the weather statistics (hourly data), a feasibility study for different possible combinations of renewable sources is studied using optimization techniques to get the optimum configuration. Then the number and size of the selected components is optimized in order to get an economical, efficient, and reliable system [3]. Component sizing is important and widely and extensively studied.

 

Several factors or constraints directly influence the sizing of the system components e.g. system economics, greenhouse emission requirements, and system reliability. Over sizing of the components may lead to high system cost and therefore, the system may become economically unviable. sizing will reduce the initial cost but one has to compromise with system reliability [6]. For a particular load, different criteria constraints may be applied to the set of system components based on the objectives that have to be achieved. Some of the criteria constraints that are mostly considered while designing a hybrid energy system are: Reliability criteria: a number of methods are used to analyze the reliability of a hybrid energy systems including, loss of load probability (LOLP), loss of power supply probability (LPSP), and unmet load (UL) System cost criteria: system cost criteria may include total energy systems costs, capacity costs and societal costs. Design of hybrid energy systems has been extensively studied and numerous optimization techniques, such as linear programming [Genetic algorithms etc. have been employed for the optimum economic and reliable design of hybrid systems. Recently, many software packages, such as

*B. Integration Schemes*

RE/AE sources have different operating characteristics; it is, therefore, essential to have a well-defined and standardized framework/procedure for connecting them to form a hybrid system, or more widely a micro grid, where a local cluster of DG sources, energy storage, and loads are integrated togetherand capable of operating autonomously. A robust micro grid should also have “plug-and-play” operation capability. Adapted from the concept widely used in computer science andtechnology, plug-and-play operation here means a device configuration to perform its designed function,namely, generating power, providing energy storage capacity,or carrying out load control. A suitable system configurationand a proper interfacing circuit [also called power electronicbuilding block (PEBB)] may be necessary to achieve theplug-and-play function of a DG system [9]. There are many ways to integrate different AE power generationsources to form a hybrid system. The methods can begenerally classified into three categories: dc-coupled, ac-coupled, and hybrid-coupled the ac-coupled scheme canfurther be classified into power frequency ac (PFAC)-coupledand high-frequency ac (HFAC)-coupled systems these methods are briefly reviewed below [10].

Various possible configurations may be used for integration of the energy sources that form hybrid system are shown in fig. 1.

1. Series hybrid system, this can be of two forms centralized dc-bus and centralized ac-bus. In centralized dc-bus, all the energy sources, storage devices, and loads are connected to a dc-bus through appropriate electronic devices as shown in fig.1.

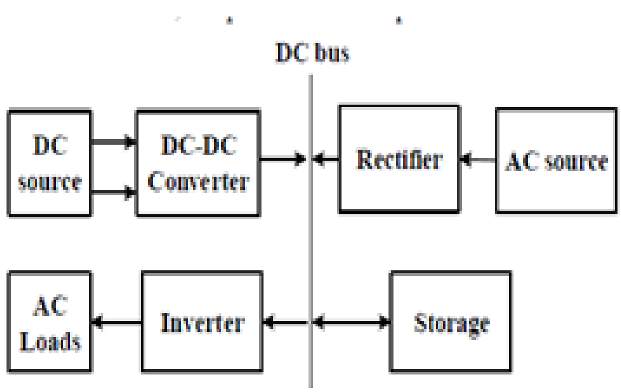


Fig1. DC Series

The dc-bus eliminates the need for frequency and voltage controls of individual sources connected to the bus and the power supplied to the load is not interrupted when diesel generator start. DC loads can be directly connected to the dc-bus which reduces the harmonics from the power electronic devices [11]. DC-bus configuration has low efficiency limitation because in case of both source and load are AC, the power passing through two stage conversions. Another limitation, the inverter must be rated for the peak load requirements and in case of inverter failure results in complete power loss to the load. In centralized ac-bus, all the energy sources, storage devices, and loads are connected to an ac-bus through appropriate electronic devices as shown in fig. 2

 

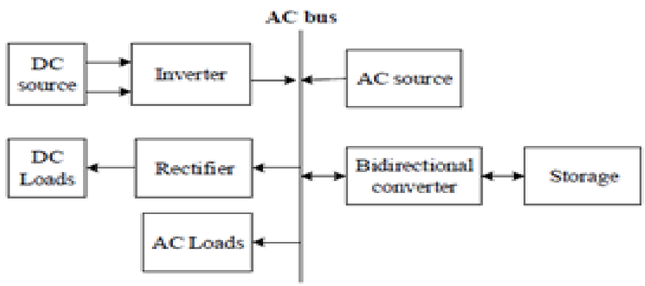


Fig 2. DC Series

It is modular configuration, which facilitates the growth to manage the increasing energy needs. It offers major constraint in the synchronization of the inverters and ac sources to maintain the voltage and frequency of the system. The undesiredharmonics introduced into the system by the use of inverters increases the level of power quality problems.

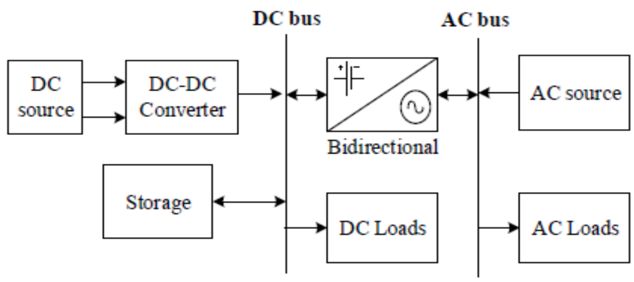


Fig3. Parallel

Parallel hybrid system, in this configuration the ac sources and loads are directly connected to ac-bus. While the dc sources and loads are directly connected to dc-bus. Bidirectional converter connects both the buses to permit the power flow between them. The inverter rating required is less than that of series configuration and the efficiency is higher. In addition, for the same inverter rating as that used in series configuration, the power supplying capacity of the parallel configuration is much more, configuration arrangement increases the system reliability and ensure the supply continuity. However, synchronization between the output voltage of the inverter and ac bus is needed[13].

Switched hybrid system as shown in fig 3, in which the ac sources, such as diesel generator, can directly be connected to the load leading to higher efficiency and synchronization in not needed.

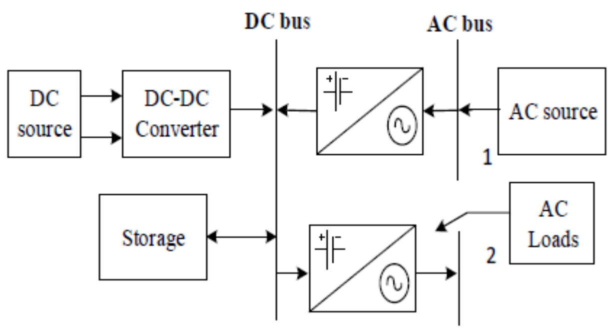


Fig4. Switched

This configuration, although popular, has several limitations that only one of the sources is connected to the load at a given instance. Furthermore, during switching between the sources, the power is interrupted.

*C. Grid connected systems*

Different grid connected configurations. The choice of the layout for particular location depends upon geographical, economical, and technical factors [11].

 

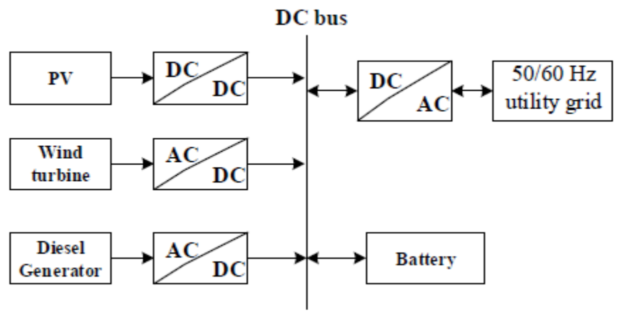


Fig.5 Centralized DC Bus

Centralized dc-bus architecture shown in Fig.5. The ac energy sources, such as wind and diesel generator, firstly deliver their power to rectifiers to be converted into dc before being delivered to the main dc bus bar. An inverter, main, takes the responsibility of feeding the ac grid from this dc bus [15]. Centralized ac-bus architecture shown in Fig. 6, the sources and the battery all are installed in one place and are connected to a main ac bus bar, through appropriate power electronic devices, before being connected to the grid [16].

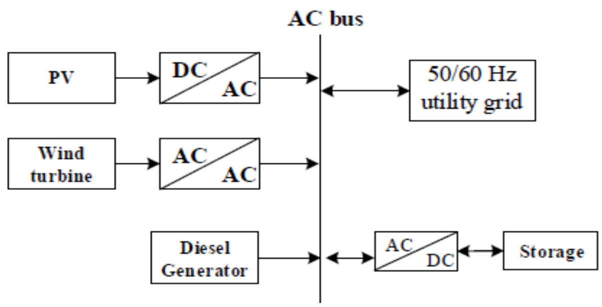


Fig 6. Centralized AC Bus

This system is centralized in the sense that the power delivered by all the energy conversion systems and the battery is fed to the grid through a single point distributed ac-bus architecture shown in Fig. 7

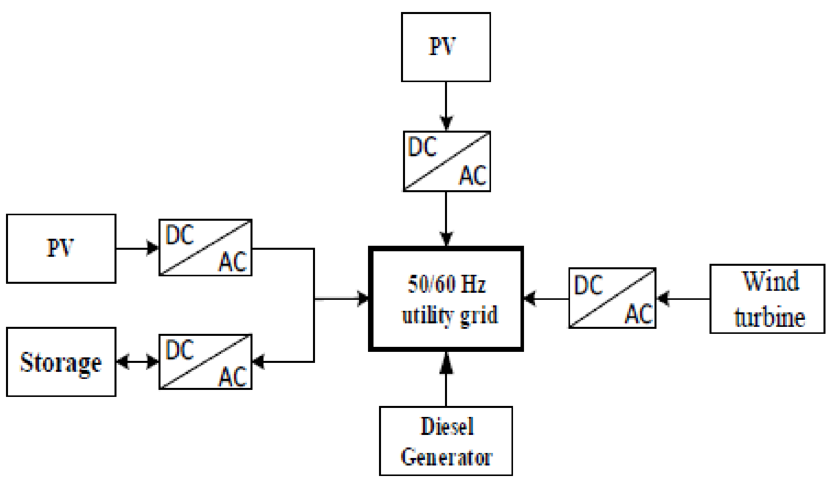


Fig 7 Distributed ac-bus

the power sources do not need to be installed close to each other, and they do not need to be connected to one main bus. The sources are distributed in different geographical locations and connected to the grid separately. The power produced by each source is conditioned separately to be identical with the form required by the grid.

 

## III. ADVANTAGES OF HYBRID SYSTEMS

1- A hybrid energy system can make use of the complementary nature of various sources, which increases the the overall efficiency of the system and improve its performance (power quality and reliability). For instance, combined heat and power operation, e.g. MT and FC, increases their overall efficiency or the response of an energy source with slower dynamic response (e.g. wind or FC) can be enhanced by the addition of a storage device with faster dynamics to meet different types of load requirements [14].
2- Lower emissions: hybrid energy systems can be designed to maximize the use of renewable resources, resulting in a system with lower emissions.
3- Acceptable cost: hybrid energy systems can be designed to achieve desired attributes at the lowest acceptable cost, which is the key to market acceptance. 4- They provide flexibility in terms of the effective utilization of the renewable sources.

## IV. ISSUES WITH HYBRID RENEWABLE ENERGY SYSTEMS

Though a hybrid system has a bundle of advantages, there are some issues and problems related to hybrid systems have to be addressed: 1- Most of hybrid systems require storage devices which batteries are mostly used. These batteries require continues monitoring and increase the cost, as the batteries life is limited to a few years. It is reported that the battery lifetime should increase to around years for the economic use in hybrid systems [15]. 2- Due to dependence of renewable sources involved in the hybrid system on weather results in the load sharing between the different sources employed for power generation, the optimum power dispatch, and the determination of cost per unit generation are not easy. 3- The reliability of power can be ensured by incorporating weather independent sources like diesel generator or fuel cell [12]. 4- The stability issue. As the power generation from different sources of a hybrid system is comparable, a sudden change in the output power from any of the sources or a sudden change in the load can affect the system stability significantly[13]. 5- Individual sources of the hybrid systems have to be operated at a point that gives the most efficient generation. In fact, this may not be occurring due to that the load sharing is often not linked to the capacity or ratings of the sources. Several factors decide load sharing like reliability of the source, economy of use, switching require between the sources, availability of fuel etc. Therefore, it is desired to evaluate the schemes to increase the efficiency to as high level as possible [18].

## V. CONCLUSION

This paper provides a summary of available approach and those currently under research for optimal design of hybrid RE/AE energy systems. Different approaches for system configuration of hybrid system are presented. Different approaches for system configuration, unit sizing, and control and energy management of hybrid systems are presented. Current status and future trends

of RE Power Generation, the challenges facing the widespread deployment of RE/AE systems, and research vision for the future of RE/AE power generation technologies have been discussed. Current status and future trends of RE power generation technologies have been discussed. The comprehensive list of references at the end of paper is included at the end of the paper for further research.

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