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A Current and Future State of Art Development of Hybrid Energy System Using Wind and PV-Solar

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Abstract-

The wind and solar energy are omnipresent, freely available, and environmental friendly. The wind energy systems may not be technically viable at all sites because of low wind speeds and being more unpredictable than solar energy. The combined utilization of these renewable energy sources are therefore becoming increasingly attractive and are being widely used as alternative of oil-produced energy. Economic aspects of these renewable energy technologies are sufficiently promising to include them for rising power generation capability in developing countries. A renewable hybrid energy system consists of two or more energy sources, a power conditioning equipment, a controller and an optional energy storage system. These hybrid energy systems are becoming popular in remote area power generation applications due to advancements in renewable energy technologies and substantial rise in prices of petroleum products. 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. The aim of this paper is to review the current state of the design, operation and control requirement of the stand-alone PV solar–wind hybrid energy systems with conventional backup source i.e. diesel or grid.

KEYWORD- Wind turbine, pv-solar cell.

1. Introduction

Recent research and development in Renewable energy sources have shown excellent potential, as a form of supplementary contribution to conventional power generation systems. In order tomeet sustained loaddemands during varying natural conditions, different energy sources and converters need to be integrated with each other for extended usage of alternative energy. Renewable energy sources, such as photovoltaic, wind energy, or small scale hydro provide a realistic alternative to engine-driven generators for electricity generation in remote areas. It has been demonstrated that hybrid energy systems can significantly reduce the total lifecycle cost of standalone power supplies in many situations, while at the same time providing a more reliable supply of electricity through the combination of energy sources . The widely used term hybrid energy system (HES) describes a stand-alone energy system , which combines renewable and conventional energy sources with lead-acid batteries for chemical storage, power conditioning equipment and a controller. The controller and power conditioning units are used to maintain the grid quality power . Alternatively, such systems are also known as integrated renewable energy systems (IRES). The concept of hybrid energy system is shown in Fig. 1 in this system the conventional systemeither diesel generator or grid are used as a back-up generator. Various hybrid energy systems have been installed in many countries over the last decade, resulting in the development of systems that can competewith conventional, fuel based remote area power supplies in many applications. Research has focused on the performance analysis [of demonstration systems and the development of efficient power converters, such as bi-directional inverters, battery management units. Maximum power point trackers . Various simulation programs are available, which allow the optimum sizing of hybrid energy systems. The recent state of art hybrid energy system technological development is the result of activities in a number of research areas, such as

Advances in electrical power conversion through the availability of new power electronic semiconductor devices, have led to improved efficiency, system quality and reliability. _ Development of versatile hybrid energy system simulation software; continuing advances in the manufacturing process and improve efficiency of photovoltaic modules. The development of customized, automatic controllers, which improve the operation of hybrid energy systems and reducemaintenance requirements. Development of improved, deep-cycle, lead-acid batteries for renewable energy systems. _ Availability of more efficient and reliable AC and DC appliances, which can recover their additional cost over their extended operating lifetime. _ The task for the hybrid energy system controller is to control the interaction of various system components and control power flow within the system to provide a stable and reliable source of energy. With the wide spread introduction of net-metering, the use of small isolated or grid connected hybrid energy systems is expected to grow tremendously in the near future. The aim of this paper is to review the current state of the design and operation of hybrid energy systems, and to present future developments, which will allow a further expansion of markets, both in industrialized and developing countries.

2. Pre-feasibility analysis of hybrid system

Climatic conditions determine the availability and magnitude of wind and solar energy at particular site. Pre-feasibility studies are based on weather data (wind speed, solar insolation) and load requirements for specific site. In order to calculate the performance of an existing system, or to predict energy consumption or energy generated from a system in the design stage, appropriate weather data is required. The global whether data could be obtained from internet and other sources like local metrological station. The global weather pattern is taken from NASA surface metrological station shown.

The red and yellow indicate high wind energy is available while theblue colors reflect lower wind energy potential zone. showsthe solar insolation level at different areas of the world. Wind andsolar hybrid system can be designed with the help of these globalweather patterns, for any location all over the world. Deciding on the best feasible solution will need to be done, on a site-to-sitebasis. Some sites can be best serviced by mains or grid power,others by generators, and some by combinations of the renewableenergy solutions described above. Some researchers used metrological station data for prefeasibilitystudy and design of hybrid energy system. Combinationof PV and wind in a hybrid energy system reduces the battery bank and diesel requirements. Feasibility of hybrid PV/wind energy system strongly depends on solar radiation and wind energy potential available at the site. Various feasibility and performance studies are reported to evaluate option of hybrid PV/wind energy systems.

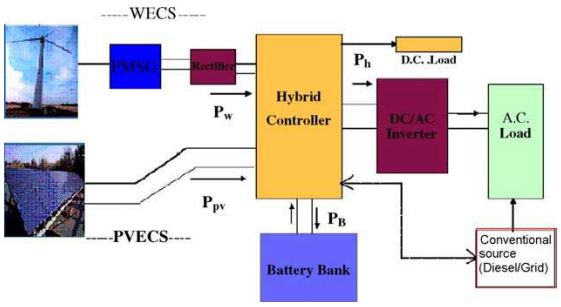

Fig. 1. Concept diagram of hybrid energy systems.

Photovoltaic array area, number of wind machines, and battery storage capacity play an important role in operation of hybrid PV/wind–diesel system while satisfying load. Celik proposed a technique to evaluate feasibility of hybrid PV/wind energy system using synthetically generated weather data. Ding and Buckeridge discuss the desired hybrid energy system consisting two or more renewable energy sources which has the advantage of stability, the objective of lighting pathway at the project site can be achieved by making use of the wind, solar and hydro energy sources. The information about local wind, a solar and hydro energy source indicates that a feasible hybrid energy system can be planned, modeled and designed for the above purpose. The collected data of the various energy sources was analyzed in order to plan for the structure of the system. Simulations and modeling were carried out over a period of 12months, allowing the statistical information about local weather to be truly representative. This model also allows anoptimal capacity of the hybrid energy system to be determined. Khan and Iqbal discussed a primary design and pre-feasibility analysis of a hybrid energy system for a household in or around St. John's, Newfoundland. He collected 1-year wind speed, solar radiation and power consumption data of a house in St. John's, Newfoundland which was used for the feasibility study of a hybrid energy system.

3. Unit sizing and optimization

After pre-feasibility study the selection of proper sizing of equipment is made based on weather data and maximum capacity. The unit sizing of integrated power system plays an important role in deciding the reliability and economy of the system. In this section, study by the different researchers discussing different methods to determining the wind generator capacity and the number of PV panels and other sources and number of battery needed for the stand-alone system is reviewed. Rahman and Chedid gives the concept of the optimal design of a hybrid wind-solar power

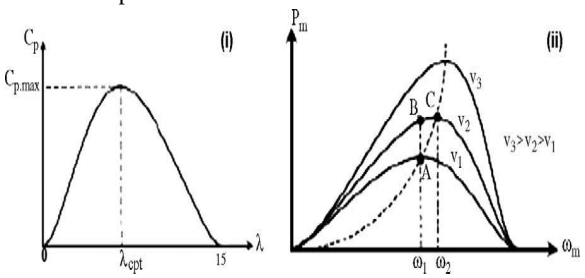

Fig. 5. (i) Power coefficient vs. tip speed ratio and (ii)output power vs. rotor speed for three different wind speed. system for either autonomous or grid-linked applications. They Proposed linear programming techniques to minimize the average production cost of electricity while meeting the load requirements in a reliable manner, and takes environmental factors into consideration both in the design and operation phases. Markvart described a procedure for determines the sizes of the PV array and wind turbine in a PV/wind energy hybrid system. Using the measured data of solar and wind energy at a given location, author employ a simple graphical construction to determine the optimum configuration of the two generators that satisfies the energy demand of the user throughout the year. Katti and Khedkar develop the algorithm uses hourly average wind speed, insolation, and power demand to determine the wind/PV generation capacities required to meet the demand without loss of power supply probability (LPSP). Elhadidy and Shaahid calculated optimum battery storage size for hybrid wind energy system by studying an impact of variation of battery storage capacity on hybrid power generation. Trade off between size of the storage capacity and diesel power required for the load, assuming a constant wind power output, was also reported by the authors. In 2006, Koutroulis et al. presented a methodology for optimal sizing of stand-alone PV/WG systems using genetic algorithms. They applied design approach of a power generation system, which supplies a residential household. Optimum size of hybrid PV/wind energy system can be calculated on an hourly basis or on the basis of daily average power per month, the day of minimum PV power per month, and the day of minimum wind power per month. Performance of hybrid PV/wind energy system was compared on hourly basis; by fixing the capacity of wind generators, yearly loss of load probability (LOLP) with different capacity of PV array and battery bank were calculated. Trade off curve between the battery bank and PV array capacity for given LOLP helps to find optimum configuration at least cost. They employs a linear programming techniques to minimize the average production cost of electricity while meeting the load requirements in a reliablemanner, and takes environmental factors into consideration bothin the design and operation phases.

Various optimization techniques such as linear programming probabilistic approach iterative technique dynamic programming , multi-objective genetic algorithm were used by researchers to design hybrid PV/wind energy system in a most cost effective way. In order to calculate reliability cost implications of hybrid PV/wind energy system in small isolated power systems. Karki and Billinton presented a Monte- Carlo simulation approach. Samarakou et al. compared results of two optimization techniques based on simplex and other algorithm for hybrid PV/wind energy system. They presented a method for assessment on the basis of loss of load probability (LOLP) to decide an optimal proportion of PV and wind generator capacities in hybrid PV/wind energy system; optimal system combination was selected on the basis of capital cost and annual autonomy level. Autonomy level of the system is defined in terms of LOLP and is been used to find system configuration . Protogeropoulos et al. have developed general methodology by considering design factor such as autonomy, for sizing and optimization. Ai et al. has presented a complete set of math calculation methods for optimum sizing of PV/wind hybrid system. In this method, the more accurate and practical mathematic models for characterizing PV module, wind generator and batteryare adopted; combining with hourly measured meteorological data and load data, the performance of a PV/wind hybrid system is determined on a hourly basis; by fixing the capacity of wind generators, the whole year's LPSP (loss of power supply probability) values of PV/wind hybrid

systems with different capacity of PV array and battery bank are calculated, then the trade-off curve between battery bank and PV array capacity is drawn for the given LPSP value; the optimum configuration which can meet the energy demand with the minimum cost can be found by drawing a tangent to the tradeoff curve with the slope representing the relationship between cost of PV module and that of the battery. Yang developed a conventional power plant and calculated optimal system configuration on the basis of Life cycle cost. National Renewable Energy Laboratory (NREL)'s, Hybrid Optimization Model for Electric Renewable (HOMER version 2.19) has been used as the sizing and optimization software tool . It contains a number of energy component models and evaluates suitable technology options based on cost and availability of resources. Analysis with HOMER requires information on resources, economic constraints, and control methods. It also requires inputs on component types, their numbers, costs, efficiency, longevity, etc.

4. Modeling of hybrid renewable energy system (HRES)

Components

Literature review reveals that over the last decades, HRES applications are growing rapidly and HRES technology has proven its competitiveness for remote area applications. It is observed that approximately 90% of studies reported are on design/economic aspects of HRES. However, fewer studies were reported on control of HRES. Utility interactive HRES has yet not gained the popularity. It is expected that within the next few years HRESbecomes competitive with utility grid power for wide spread distributed applications. Hence, there is a need to investigate potential and performance of PV and wind energy system to calculate level of penetration in existing networks of developed or developing countries in order to improve quality of power supply. The simulation results prove the operating principle, feasibility and reliability of this proposed system. Solar/diesel/battery hybrid power systems have been modeled for the electrification of typical rural households and schools in remote areas. Kolhe et al. elaborately discussed the analytical model for predicting the viability of hybrid PV/wind energy system with hydrogen energy storage for long-term utilization.

Conclusion

The hybrid energy systems are recognized as a viable alternative to grid supply or conventional, fuel-based, remote area power supplies all over the world. The literature review reveals that, renewable energy based low emission hybrid systems are not cost competitive against conventional fossil fuel power systems. However, the need for cleaner power and improvements in alternative energy technologies bear good potential for widespread use of such systems. Moreover, the rural households in industrialized and less developed countries attach high value to a reliable, limited supply of electricity. Community facilities such as rural hospitals, schools, telecommunication and water pumping stations can contribute significantly to the welfare of people and rural development. While it is recognized that technology can only be one aspect of community development, the renewable energy systems have demonstrated the potential to provide support in some of the basic infrastructure needs in remote and urban areas for different application.

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