Simulation PV Hydro Power Hybrid systems

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Abstract : The Energy systems based on renewable resources face several difficulties of acceptance, mainly due to the high initial costs and the low final revenue. One way to improve the effectiveness of these systems is to use more than one source of energy, especially when the sources used have some kind of complementarily. An interesting combination is obtained with the use of hydroelectric and solar energy resources, which allows to take advantage of the complementarily between two sources and allows to investigate the storage of energy in water tanks and batteries. Configurations with a DC bus would support demands of up to 1kW at 2kW, while configurations involving an AC bus would obviously reach higher power. In this article, hydroelectric photovoltaic systems are analyzed, some configurations are characterized, operational strategies are analyzed, the effects of complementarily over time between energy sources are discussed and evaluated.

IndexTerms **- Hybrid energy systems, energetic complementarity, micro hydro energy system, PV solar energy system**

I. INTRODUCTION

Generation systems based on more than one energy source, and at least one renewable one, certainly require higher initial investment. A hydroelectric and photovoltaic power plant allows the study of a generation system based on complementary sources [1] and in which energy can be accumulated in both reservoirs and batteries. The combination of hydropower and photovoltaic energy in the same generation system seems improbably viable, due to the still very high costs of photovoltaic installations. However, while maintaining the trends of increased power generation from photovoltaic modules worldwide in recent years, significant cost reductions should be noted. In addition, this combination can reduce the costs of deployed facilities in sites with small hydropower potential, where interconnection costs are prohibitive.

This paper characterizes some configurations of hydroelectric photovoltaic uses, discusses operational strategies and effects of the complementarity in time between the energy availabilities. It also presents results of an expedited evaluation of the complementarity in time In the end, provides a preliminary estimate of the costs involved in the implementation of this type of generation system. A hybrid photovoltaic hydroelectric system is then constituted by the two generators, one hydroelectric and another photovoltaic, for the consumer loads and for the electric wiring for their interconnection. A control and protection system must manage the use of generators and the handling of loads, as well as protect them against risk situations. If the system contains two buses, it must still contain devices for power conversion, as well as transformers to match the buses' voltages. The system may also contain energy accumulators, which strongly influence the formulation of operating strategies and assume great importance in systems based on renewable sources. The most common are the reservoirs for accumulation of water and batteries, and can be used compressed air reservoirs or flyers. Batteries or other devices for energy accumulation may still have a mitigating effect on electromechanical transients in the turbine system generating hydroelectric power.

II. BRIEF DESCRIPTION OF THE PROJECT

The proposed project discusses the possibility of using Hydro-Solar PV-Wind hybrid power system for low-cost electricity production in order to satisfy the energy load requirement of a particular area. With regards to several researches done in the field of hybrid power system, the use of optimum size of such hybrid power system can help to reduce the overall cost of generation without having the need to use a storage system alongside the inverter. The Wind power system (AC-DC-AC) and PV system, which are complementary in operation with regards to timing, can help to generate active power while they cannot supply the reactive power demanded by the system load. This project is proposed to design a switching pattern of the inverter in such a way that it can convert the solar power into active power and generate reactive power within the inverter. This project also studies the possibility of operating the hydro generator to produce mainly reactive power and share with the PV-Wind system that generates active power. The main idea of the proposed project is to integrate the PV and Wind units into an isolated hydro generating unit.

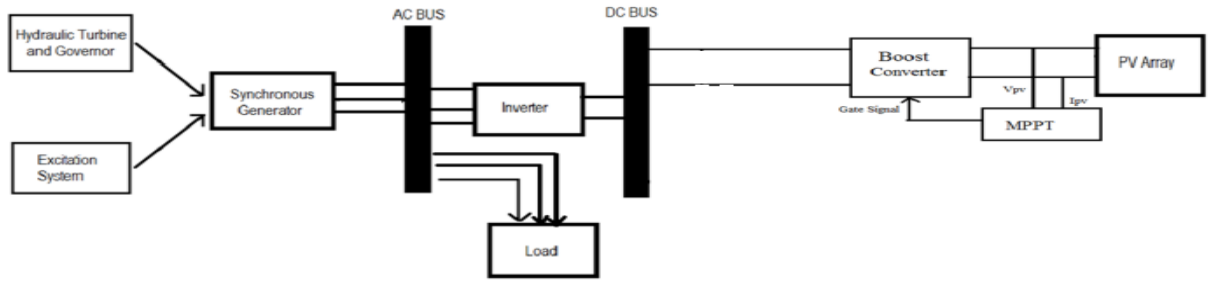

Figure1 Block Diagram of the proposed Hybrid PV-Hydro System

The above shown block diagram of the proposed scheme under study consists of a PV solar unit, and a hydro unit. A common inverter is accompanied with the system and a common AC bus is formed together with the hydro unit. The main concern of the project is to make balance between reactive power demand of the load and reactive power generation to maintain the system voltage within the acceptable values. A MATLAB Simulink program is proposed for modeling the entire system. The simulation is done to incorporate control system for automatic regulation and extraction of required powers from the hybrid system. The conversion of solar energy to useable electrical energy requires several components such as PV array, and DC-toDC Converter

(Boost converter). An array of solar cells converts solar energy into a usable amount of DC power. The uses AC-DC converter and forms a common DC bus with the PV system. A 3- phase inverter is designed that converts the DC output power from the common DC bus of the PV System to AC power, while also generating the reactive power as per the load requirement within the inverter. The voltage is transformed to a suitable level by the converter and inverted to AC by a 3-phase inverter and then injected to the common bus. The reactive power is generated either by the synchronous generator or within the inverter as per the capacity and requirement.

III. LITERATURE REVIEW

An extensive study on several papers, regarding the optimization of renewable energy for power generation and grid connection, published in journals were done.

Diaf et al. [2] proposed a hybrid PV-Wind system in which the AC power form the wind is directly supplied to the load via un-interruptible power supply (UPS). The excess power, if available, is used to charge the battery through an AC/DC converter. The power obtained from the PV is also used in charging the battery via a DC/DC converter. In case of peak load, power is supplied from battery to the load through a DC/ AC converter.

Hashimito et al. [3] discussed stand-alone wind-PV hybrid system with a secondary backup battery that ensures uninterruptable supply of electricity to a radio base station in an island. Their system consists of cylindrical PV modules mounted on wind generator pole to save installation space and cost. Relationship between system idle time and backup battery capacity was studied and battery bank was designed to bring the system idle time to zero.

Sharaf and El-sayed[4] discussed application of wind-PV hybrid system in a micro grid. Their system is consisted of a common DC and common AC collection bus interface. The system employs permanent magnet DC generator to convert the wind kinetic energy into DC power. The power obtained from PV, which is also DC, is connected to common DC bus.

Bakos[5] performed the feasibility study of wind-pumped hydro storage system assisted by diesel generator in case of power shortage. The system is designed as a wind farm which supplies to the load first. Excess energy if available is used for pumping water from lower tank to the higher reservoir so that the excess energy is stored as hydro potential energy. When wind farm is incapable of covering the whole load, the hydro system is called into operation and energy is supplied from both wind and hydro. If further energy deficiency exists, then deficit power is supplied by the diesel generator. The water reservoir acts as an energy storage so it is designed based on energy autonomy days. Monte Carlo analysis considering the linear characteristic of wind energy system and undamaged hydro system has been performed to verify the feasibility.

Bekele and Tedesse[6] suggested a PV-hydro-wind hybrid system which can supply uninterrupted electricity for a village in Ethiopia. HOMER was used to optimize six small hydropower potentials together with wind PV systems. Due to the limitations of HOMER to handle more than one hydro resource at a time, optimization was performed by taking a nominal hydropower with total sum capacity of all small sites. Besides the primary purpose of lighting, they have considered electricity for cooking and running flour mills along with TVs and radio in their load calculation.

Saheb-Koussa et al. [7] presented results of techno-economic analysis of PV/wind/diesel hybrid system. For all the six sites they studied, they found out that stand alone PV is a better solution considering the economic aspects. But there would be deficit during the winter season, and using a hybrid system overcome this effect. Their study suggested that hybrid system would be reliable but is not economic.

Fadaeenejad et al. [8] studied PV-wind-battery hybrid and PV-wind-diesel- battery hybrid with aim of rural electrification in Malaysia. For optimization of HRES iHOGA software developed by Dr. Rodolfo, Dufo-Lopez has been used. This study suggested PV-wind-battery hybrid as a better option. In a similar analysis, Goodbodyet al.23 performed the study on integration of renewable energy systems in Ireland. System optimization was carried using HOMER, diurnal and seasonal variation of load was taken into consideration for optimization. This study has also considered space heating in the application of HRES and cost of fuel to do so, but the capital, maintenance or replacement cost is not taken into account due to limitations of HOMER. Ireland has high wind potential so wind energy was found to feature in most of stand-alone or grid connected hybrid systems. Biogas harvesting with large biodigester was suggested to be cost-efficient for large community. Even though some regions simulated contains hydropower in the optimal design, the installation was found to be difficult in those regions because of the geographical constraints.

Akikur et al. [9] carried a study on standalone solar and hybrid systems. Solar-wind hybrid, solar-hydro hybrid, solar-wind-diesel hybrid and solar-wind-diesel hydro/biogas hybrid have been discussed, and viability and significance of solar energy (both in standalone and hybrid form) in global electrification have been shown in this study.

Djamel and Abdallah[10] discussed power quality control of grid connected windsolar hybrid system that employs a battery connected in the common DC bus. Though the system is said to be grid connected much has not been discussed. A fixed speed wind turbine has been employed so power control on high wind speed has been done by stall control. Power control in PV has been done by employing MPPT tracking that uses perturb and observe (P&O) method.

Meshram et al. [11] proposed a hypothetical grid connected solar-hydro hybrid system. As solar energy is abundant in summer, grid connected solar system supplies the power while hydro system is cutoff during operation. Similarly during rainy season when water is abundant, grid connected hydro system is brought in operation and solar system is cut off. During other season the system operates in hybrid mode. The proposed system has 10kW solar capacity and 7.5 kW hydro capacity.11kV AC line is used to transmit the electricity form production site; it is then connected to 132 kV, 2500 MNA grid line through step down transformer, before supplying to customer supply; it is stepped down to 415 V for household usage.

Ismail et al.[12] performed a feasibility study and techno-economic analysis of a PV system with batteries and micro turbine-micro turbine acting as backup supply in the system. Component sizing and optimization have been performed by iterative method to minimize cost of energy (COE) production. Comparison of standalone PV, micro turbine and hybrid system is also performed in this study. The study found that COE of standalone micro turbine was cheaper with very small difference. Sensitivity analysis of the system has also been performed by considering project life time, cost of natural gas, PV panels, battery bank, bidirectional inverter and charge regulator. The sensitivity analysis result showed hybrid system as the better alternative. In similar study Daud and Ismail designed and analyzed a PV-wind-diesel hybrid system for a family house in Palestine considering efficiency, reliability along with the dumped electric power. A software that is capable of changing the variable of hybrid energy system was developed to perform the analysis. High quantity of dump energy was found during the simulation because the system is designed for the

worst case. In order to utilize the dump energy power supply to street light, water pumping has been suggested. Economic analysis of this system in terms of COE hybrid system lags behind purchasing grid electricity. The study concludes that if remote location, subsidy levels, cost of renewable energy equipment and environmental effects are taken into account then hybrid systems justify their use. In another study, the same authors analyzed PV-battery-diesel hybrid system which concluded the hybrid system as best alternative when the diesel generator is used as backup source. Kalantar and Mousavi also performed similar kind of study and proposed wind-solar-micro turbine-battery hybrid system. In their system the microturbine and battery act as a backup power supply during energy deficiency

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IV. RESULTS AND DISCUSSION

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