GRID INTEGRATION OF HYBRID GENERATION

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ABSTRACT

In all over the world the wind and solar energies are the most available among other renewable energy sources In the current years, the power electronic systems the production of electricity from wind and photovoltaic energy sources have increased significantly. In grid integration of hybrid generation, the performance of the wind/PV hybrid system is studied under different grid perturbation conditions. Based on the level solid oxide fuel cell (SOFC) dynamic model for power system studies and the analysis of the SOFC operating conditions. To determine the maximum electrical efficiency the nonlinear programming(NLP) method was used. SOFC focus on the constraints of fuel utilization factor, stack temperature and output active power. The grid-connected SOFC were obtained by solving the NLP problem using by the power consumed by the air compressor. In order to deliver the stable power to the load, a large battery bank is required, which enhances the size of the system, cost and also causes environmental pollution. The use of battery can be avoided by directly connecting the hybrid system to the grid. The work consists of modeling and simulation of wind and photovoltaic hybrid energy system inter-connected to electrical grid through power electronic interface. The power conditioning of the system is implemented to control power electronic circuits and system performance which is evaluated for different input power levels and load variation.

Keywords: Triconex, DCS, SCADA, EEMUA, PAM..

I. INTRODUCTION

Wind energy scheme generates power in the form of AC with different voltage and frequency levels in case of variable speed operation. Solar energy system generates power in the form of dc voltage and the level of DC voltage depending on temperature and irradiation levels. Both of these systems require power electronic interface for inter-connection with the grid. Varying DC output voltage of the photovoltaic system suitable to change in input parameters like irradiation and temperature can be controlled using a boost up converter. AC voltage generated by the wind turbine generator can be converted to DC by using unrestrained rectifier and then, be synchronized using a boost converter[1] . A key problem is the integration of renewable energies into the existing grid. The grid system is used for analyzes the reasons for this deficit and assesses possible solutions.

A Hybrid Power System (HPS) utilizes two or more energy sources, power converters and storage devices. The main purpose of HPS is to combine multiple energy sources and storage devices which are set off of each other. Thus, higher efficiency can be achieved by taking the benefit of each individual energy source and device while overcoming their limits [2]. Current development in FC technology for grid improvement has showing its significant potential and considers an crucial energy source for the future power system. FC is a static energy source that generates electricity from hydrogen during electrolysis. The superior reliability, with practically zero noise level or no moving parts is an extra benefit of FC system as compared to the diesel generator. Main characteristics of FC include modularity, near zero emissions, fuel flexibility, best power quality, high efficiency and practically low noise levels. Other advantages of FC are the distributed and centralized configurations, variety of fuels, cogeneration options and reusability of exhaust gases for heating of buildings [3].

The combined use of FC with an Electrolyser (ELZ), hydrogen storage tanks and compressor component provide a new energy storage concept. Since, hybridization of FC loads with PV panels will, therefore, form an interchange energy conversion system where the FC acts as back up during low PV outputs to convince continued load demands. There are several types of FCs which are classified on the basis of their operating temperature ranges and type of electrolyte. For this Solid Oxide Fuel Cell (SOFC) is selected, because, it works at high temperatures (800 – 1000 °C) [4]. But, the main weak point in SOFC is their poor energetic response, gas starvation and load tracking delays [5]. When a SOFC is subjected to a step increase in load, it shows an immediate drop off of the voltage in the V-I curve and take several seconds to provide the required power. In the meantime, the SOFC may be starved of fuel, which can seriously affect the life time of SOFC [6]. This problem can be addressed by using a high energy density device such as a battery. Thus, the SOFC should be utilized under inhibited steady-state environment while the battery is supplying the demanded power. Without the battery bank, the SOFC system have to provide all the power demand, thus massive and increase the cost of the SOFC power plant.

II. LITERATURE REVIEW

The design and control strategy of an autonomous photovoltaic fuel-cell energy system has been developed and simulations have been performed in order to supply electricity to a DC-load without being connected to the electric grid. The all work is divided into two parts. In the first part each subsystem and different parameters are identified for each subsystem. The second part dealt with the design and setting up of various equipment which includes voltage and current sensors. The energy system having a photo voltaic (PV) panel, wind turbine and fuel cell (SOFC) for incessant power flow management. Fuel cells (storage & generating) are added to ensure constant power supply due to the discontinuous nature of solar and wind resources.

The grid integration system used to design and modelling of grid connected hybrid renewable energy power generation. The energy system having a photo voltaic (PV) panel, wind turbine and fuel cell (SOFC) for continual power flow management. Fuel cells (storage & generating) are added to ensure continual power supply due to the discontinuous nature of solar and wind resources. There are some drawbacks. For example, some authors include short energy system in their studies, while others concentrate on long term storage medium. Some authors describe power control of PV system while others challenge to tackle the energy management without providing power sharing among different energy sources and/or storage system. Most of the authors supported their work on the basis of virtual generated solar irradiance, temperature and weather patterns.

III. RENEWABLE ENERGY SOURCES

1. **SOLAR ENERGY** -The solar energy is an limitless source of energy which is originated from the sun. When Without changing the form the light and heat from the sun are used directly, then the technology

refers as a direct or passive technology of solar energy and when it used by converting the form of energy, that is called indirect or active technology of solar energy. The photovoltaic technology is the popular indirect way and the solar thermal system is the direct way to harvest the abundant energy. There are different types producing electricity from renewable energy sources. Accordingly, there are several ways of connecting the gained electricity with the existing grid.

2. **WIND ENERGY**-Wind energy is extracted from the wind. For extraction used the wind mill. It is renewable energy sources. For generation of electricity the wind energy needs less cost and maintenance cost is also less for wind energy system. Wind energy is present nearly 24 hours of the day. It has less emanation. Initial cost is also less of the system.

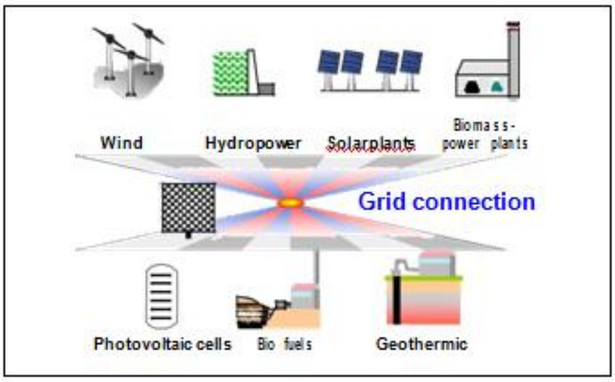

Fig. 1. Grid Connection

The sources are wind, hydro, solar, biomass, photovoltaic cells, bio fuels and geothermic as shown in Fig. 1. Except for photovoltaic cells the electricity is induced by asynchronous or synchronous generators. This operation creates co-current flows and gets throughout an inverted rectifier into the power grid.

IV. GRID INTERFACE TOPOLOGY OF SOFC

Fuel cells are electrochemical energy conversion devices like to batteries. The case of a SOFC based DG connected to a grid is considered in which the capacity of power supply by the DGs is less than the load demand i.e., the active power demand of load is more than DG capacity and hence grid and DG both will supply active power to the load. Thus, in this mode of operation a certain amount of power is scheduled to the load from the fuel cell DG and remaining power to load is supplied from the utility grid.

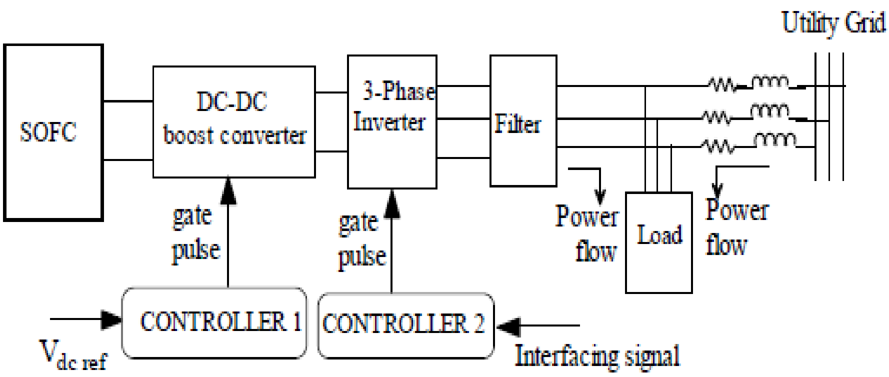

Fig. 2. Schematic diagram of grid connected DGs

If it reaches the steady-state the DGs autonomously operate with load. The phase difference between the DGs output voltage and the grid voltage decreases until the DGs output voltage is in phase with the grid voltage. After the DGs output voltage is synchronized with the grid voltage, the grid is connected to DGs and then the grid starts providing electric power to the load. For interfacing DGs to the distribution system there are various control strategies. The DG is operated either to control DG output current, active power and voltage at the point of common coupling (P-V mode) or active and reactive power output of DG.

V. INTEGRATION IN EXISTING GRID

To understand the problem of why the potential of renewable energy sources is not shattered, and have to consider the actual grid conditions and the resulting barriers. Grids are designed to transmit electrical electricity by large conventional power plants. An aggregation occurs by using transformers between the transmission and the distribution grid. The interconnection directly or indirectly allocates the electricity to connected users in a central way. In the distribution grid the voltage falls in the direction of the current flow. The refuse depends on resistance and inductance in the cable. These two factors grow with rising cable length. To provide all clients with enough voltage, a transformer somewhat increases the voltage at the beginning of a cable. Energy generation from renewable sources requires an installation of the plant in locations with a high energy supply, for example, in areas with a majestic wind velocity. Therefore, the installations are connected at different local points to the grid. In contrast to large power plants, renewable plants have less capacity and are integrated in lower grid levels. When decentralized generators integrate electricity in low-voltage lines, conditions can change and the power flows in the direction of the transformer. Voltage rise aggravates in practice if more and more distributed generators, particularly in rustic areas with mostly weak grids, are integrated. This barricade of insufficient grid capacity available for renewable energy is the main problem.

The integration of distributed energy producers critically influences the operation of the whole grid and calls for new requirements of the mains operation. Thus central large power plants are forced to work in part load and have other starts. These actions have negative effects on materials, efficiency, costs of generation and lead to additional input of fossil fuels and output of carbon dioxide. To avoid voltage rises, the grid has to be partially extended. The costs of grid support are often very high. The benefits of producing energy from renewable sources are often considered less important than the costs. Moreover, different power developers have highlighted that it is impossible to determine the available grid capacity so that they are unable to verify the technical and cost data of the grid connection presented to them by the grid operator. Furthermore, Distribution System Operators (DSO) are often linked to electricity generation companies. It is arguable whether such a DSO is fully objective towards independent renewable energy producers when the electricity generation company is involved in developing alternative energy programs. The insufficient simplicity of grid connection causes long lead times to obtain grid connection authorization.

VI. GRID INTEGRATION OF HYBRID SYSTEM

The integration of combined solar and wind power systems into the grid can help in dipping the overall cost and improving reliability of renewable power generation to supply its load. The grid takes overload renewable power from renewable energy site and supplies power to the site' loads when required. Common DC and

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common AC bus grid-connected to solar PV and wind hybrid system, respectively. The complete system is designed in two buses i.e., DC and AC bus. PV, SOFC, ELZ and battery make the architecture of DC bus, and the power conversion and transferring occurs between the components during a CEMCA. Domestic load and national grid are the parts of AC bus. The output voltages of PV and SOFC are synchronized and attuned through two non-isolated DC–DC boost converters. The boost converter is controlled during Proportional Integral Differentiator (PID) controller. The bidirectional power flow of battery with the rest of the system occurs through a buck boost converter. The buck boost converter is controlled through Proportional Integral (PI) controller. The output of DC bus provides the required power to the grid and grid-connected load through three phase inverter even if only one source is available. The inverter is controlled via hysteresis current control approach. It is important to describe that the projected HPS is flexible and, therefore, easily upgradable as long as a new PV, SOFC and battery are added to the existing ones without increasing the circuit complexity. In addition, it is also possible to add another parallel inverter to apply the said design with high efficiency[10]as shown in Fig 3.. The evaluation of the performance and stability of the proposed CEMCA necessitates the simulation of the integrated system over a period of time. Therefore, steady-state simulation models have been employed for each different unit.

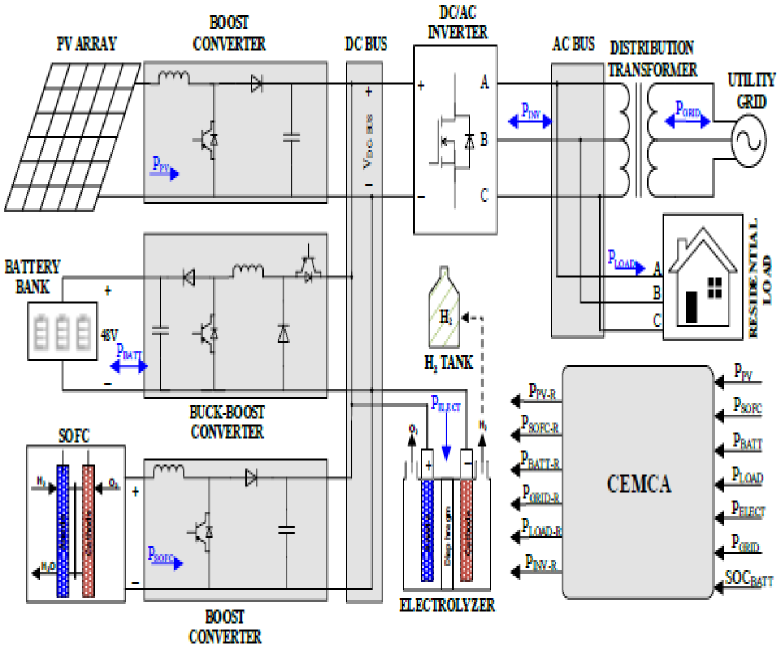

Fig. 3: Architecture of Proposed Hybrid Power System

VII. HYBRID SYSTEM CONFIGURATION

The block diagram of the wind/PV system for its grid connection is presented in Fig. 4. The wind power system with uncontrolled rectifier and dc-dc boost converter is connected to a DC bus. To connect the PV arrays are connected to DC bus, for that connection dc-dc boost converter is used. The wind and photovoltaic generators are controlled locally to get the maximum power extraction. For the analysis of the grid connected hybrid system, the DC and AC loads are considered[25]. The DC load is connected through a dc-dc resist converter to the DC bus. The rated voltages for DC load and AC load are 500 V and 415 V RMS respectively. In grid fixed

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operation mode, the grid side inverter is responsible for stable DC bus voltage and injects only active power to the grid with zero reactive power.

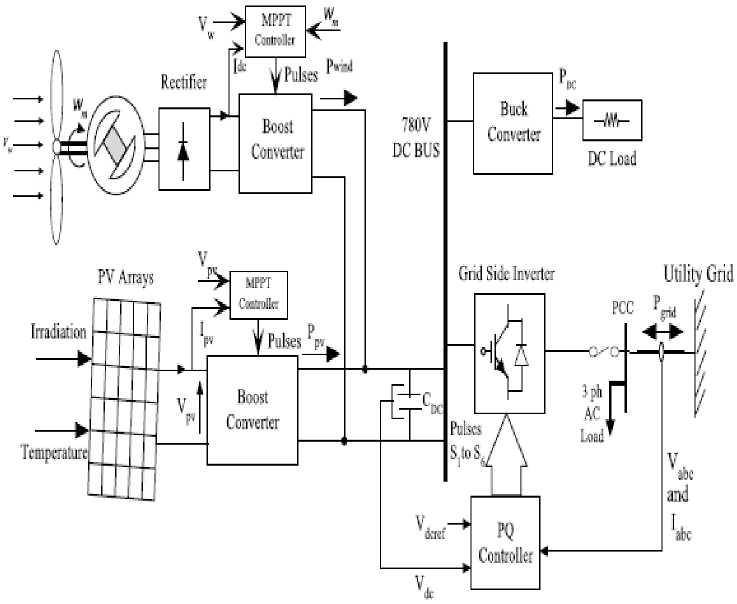

Fig. 4: Schematic diagram of hybrid system with and PV based DG system

Table 1. Main challenges and possible solutions for grid-connected system

SR. NO.	AUTHER'S NAME	CHALLENGES	SOLUTIONS
1.	B. Ernst, F. Reyer, and J. Vanzetta[11]	Voltage fluctuation due to variations in wind speed and irregular solar radiation	Series and shunt active power filters.
			Power compensators.
	S. K. Khadem, M. Basu, and M. F. Conlon [12]		Fixed/switched capacitor or static compensator.
	N. T. Linh [13]		Less sensitive customer's equipment to power disturbance/voltage distortions and utilities line conditioning systems.
2.	F. O. Resende and J. A. P. Lopes [14]	Frequency fluctuation for sudden changes in active power by loads	PWM inverter controller for regulating frequency in a micro grid.
3.	B. Ernst, F. Reyer, and J. Vanzetta[11][12][13]	Harmonics by power electronics devices and non-linear appliances.	PWM switching converter and appropriate filters.
4.	B. Ernst, F. Reyer, and J. Vanzetta[11], B. Ernst, F. Reyer, and J. Vanzetta [15]	Intermittent energy's impacts on network security	Accurate statistical forecasting and scheduling systems. Regression analysis approaches and algorithms for forecasting weather pattern, solar radiation and wind speed.
	D. A. Halamay, T. K. A. Brekken [16]		Increase or decrease dispatch able generation by system operator to deal with any deficit/surplus in renewable power generation.
	Y. J. Liu and C. W. Jiang [17] E.F. Camacho, T. Samad, M. Garcia-sanz, and I. Hiskens[18]		Advanced fast response control facilities such as Automatic Generation Control and Flexible AC Transmission System.
5.	B. Ernst, F. Reyer, and J. Vanzetta[11]	Synchronization	The most popular grid synchronization technique is based on phased-locked loop. Other techniques for synchronization include detecting the zero crossing of the grid voltages or using combinations of filters coupled with a non-linear transformation.

Table 2. Main Challenges and Possible Solutions for Stand-Alone System

SR. NO	AUTHER'S NAME	CHALLENGES	SOLUTIONS
1.	B. S. Borowy and Z. M. Salameh [19] Z. M. Salameh and B. S. Borowy [20]	High storage cost	Combining both PV solar and wind power will minimum the storage requirements and ultimately the overall cost of the system.
2.	R. Chedid and Y. Saliba [21]	Less usable energy during the year.	Integration of renewable energy generation with battery storage and diesel generator back-up systems.
3.	R. Chedid and Y. Saliba [21] A. N. Celik [22]	Intermittent energy / power quality	Integration of renewable energy generation with battery storage or fuel cell and in some cases with diesel generator back-up systems.
4.	A. N. Celik [22]	Protection	Suitable protection devices need to be installed for safety reasons including up grading of existing protection scheme in particular when distributed generators are introduced.
5.	D. B. Nelson, M. H. Nehrir, and C. Wang [23] N. A. Ahmed, M. Miyatake, and A. K. Al-Othman [24]	Storage runs out	Integrate PV and wind energy sources with fuel cells.
6.	D. B. Nelson, M. H. Nehrir, and C. Wang [23] N. A. Ahmed, M. Miyatake, and A. K. Al-Othman [24]	Environmental and safety concerns of batteries and hydrogen tanks.	Integrating PV and wind energy sources with fuel cells instead of large lead-acid. Batteries or super storage capacitors, leads to a non polluting reliable energy source. and reduces the total maintenance costs.

VIII. CONCLUSION

The performance of SOFC based DG system connected to grid has been conceded. In grid-connected mode, the voltage and frequency are controlled by the grid. Thus, the DG units are controlled to provide specified amount of real power depending upon the rating of the units. A control strategy has been developed using decouple method to control the active and automatic powers independently from the solid oxide fuel cell. It has provided a review of challenges and opportunities on integrating solar PV and wind energy sources for electricity generation. The main challenge for grid-connected system as well as the independent system is the irregular nature of solar PV and wind sources.

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