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A Review Article on simulation and Study of Utility Grid Connected PV Array and Fuel Cell

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ABSTRACT

Main purpose of this paper is to suggest an electricity generation system based on renewable energy sources to fulfill the electrical demand of remote areas of a developing country like India. The suggested system is composed of photovoltaic array and fuel cell stack. The system is known as Solar PV- Fuel cell system. The optimization and the simulation of the proposed system were performed on MTLAB/SIMULINK software. In order to determine the optimal combination of the system, different combinations of PV arrays, Fuel cell, were selected on the basis of the Net Present Cost (NPC). In the recent times the utilization of renewable energy sources has gained many advantages in today's generation and among them is the PV cell which is attracting research scholars on day to day basis. In this paper the mathematical modelling of Photovoltaic cell (PV) using MATLAB MATLAB/SIMULINK tool is done. Maximum power point tracking (MPPT) is used for increasing the efficiency of the used PV. Due to the change in solar irradiance from day to night various problem arises. This problem is solved by integrating PV arrays with the Solid Oxide Fuel Cell (SOFC) and battery thus forming a standalone hybrid PV-SOFC-Battery generation system. Certain disadvantage of the PV system is that the output voltage is low so we need to boost its voltage using boost converter so that five level inverter would convert it into alternating form. The whole of the hybrid standalone system is connected to grid. The modelling of PV, SOFC and the five level inverter are done using SIMULINK in MATLAB.

Keywords: *PV arrays, MATLAB, MPPT, SIMULINK*

INTRODUCTION

Electricity is the most essential ingredient to upgrade thesocio-economic condition and to alleviate poverty of acountry. The electricity supply has a great impact on the national economy. Reliable and sufficient electricity supplyhas a great positive impact on our GDP and GDP is one of thekey measures to understand the economy of a country.Thermal plants run by coal, oil & gas are the major popular and used ways to generate electricity. In today's world, maximum amount of the global electrical demand is met by using the fossil fuels such as petroleum, coal, and natural gas. The electricity demand is increasing very rapidly, as a result the reserve of the fossil fuel under the Earth is also decreasing at the same rate and it is also estimated that within upcoming few decades the existing reserve of the fossil fuel will be used up if we continue to use the fossil fuel at this rate. In this paper main focus was given on electrification of the Char [island] areas. Life of the villagers in remote villages is so miserable. The areas are completely inaccessible and can only be reached by boat and foot. The people living there are exposed to nature and due to the daily tides, the land gets flooded on a regular basis. In this paper a comparatively new energy solution is suggested for those isolated villages and the proposed model will be the alternative

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to diesel generators and batteries. This paper mainly includes something new for our country [India] i.e. fuel cell included in the stand alone power system. Stand-alone power system is an off grid power system that usually operates with renewable energy sources. Standalone power system is mostly used for remote areas.

With the rapid increase in demand of power from the consumers it has forced the power companies to switch to non-renewable sources of energy as a remedy to meet the power demand. Non-renewable source of energy is a clean energy with reasonable cost when compared to renewable sources. As the fossil fuels are getting depleted day by day and due to its detrimental effect on environment and increasing cost day by day, it has forced researchers to work on alternate sources of energy like the energy like sun, wind energy, tidal energy, fuel cell, etc. but the recent use of the Photovoltaic Arrays (PV) in various places on earth as a source of electrical energy has caught much attention. In PV arrays electricity is obtained by transforming the irradiation of PV array. The PV system and the storage battery system produce low voltage so dc-dc boost converter can be used to increase the voltage which makes possible for the PV system to be connected to the utility grid. The Fuel cell can also be used as a source of no renewable energy. The fuel cell connected with the PV system makes a hybrid standalone system. The solar irradiation varies throughout the day so in order to draw maximum power some algorithm must be used such as MPPT. Various types of MPPT algorithms have been discovered, here Perturb and Observe (P&O) technique has been used. Grid connected PV system helps us to maximize the power developed by PV arrays and transfer to the grid under various circumstances.[8-11]

LITERATURE REVIEW

Kazi Kawser Hossain, TaskinJamal[1] 2015 has studied about the use of fuel cell and PV array under the topic "Solar PV-Hydrogen Fuel Cell System forElectrification of a Remote areas in Bangladesh."Main objective of this paper is to suggest an electricity generation system based on renewable energy sources to fulfill the electrical demand of remote areas of a developing country like Bangladesh. The suggested system is composed of photovoltaic array and fuel cell stack. The system is known as Solar PV-Fuel cell system. The optimization and the simulation of the proposed system were performed with MATLAB/SIMULINK software. In order to determine the optimal combination of the system, different combinations of PV arrays and Fuel cell were selected on the basis of the Net Present Cost (NPC).

The main aim of this work was to propose a reliableelectrical energy supply solution for the underprivilegedisolated regions of Bangladesh. The installation of electricalsystem to supply electricity with an energy storage systemstrongly depends on the economic viability of the system.Therefore, the proposed system was analyzed both technicallyand economically.

Yasuhito Hidaka, Koji Kawahara[2] 2011studied about the use of fuel cell and PV array under the topic "Modeling of a Hybrid System of Photovoltaic andFuel cell for Operational Strategy in Residential Use." In India, a photovoltaic solar energy system has been widely utilized as an alternative energy source to fossil fuel at a residential area. The output of photovoltaic cellsharply changes according to weather conditions. Therefore, a certain power storage device is required to smooth the output and to meet electricity demand equivalent to a demanding load. A fuel cell is a promising candidate for long term

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energy system because hydrogen is supplied continuously. This paper presents the modeling and operational strategy of a hybrid system of PV and fuel cell. The proposed system is consists of PV array, fuel cell stack, and power conversion devices. If the photovoltaic system is not able to supply power to the household load, the fuel cell system compensates a power requirement together with the utility Grid. The behavior of the proposed hybrid system is verified by numerical simulation using MATLAB/Simulink.

This paper presents the modelling and simulation of ahybrid system of PV and FC with hydrogen storage. MATLAB/Simulink makes modelling and simulation easy as a programming tool. The FC system is stable for longterm power supply. However, a lot of electrical energy isneeded to generate hydrogen. At the present, we have beenstudying how hydrogen should be consumed within a certainperiod from the viewpoint of economy efficiency.

Juniku Matsuura *et al*[3] 2014 studied about the use of fuel cell and PV array under the topic "Optimal Control of a Hybrid System ofPhotovoltaic and Fuel Cell in Residential Use." In recent years, a photovoltaic solar energy systemhas widely spread on residential areas as an alternative energyof a fossil fuel. Since the output of photovoltaic (PV) cell sharply varies according to weather conditions, a power storage device is required to smooth the output and to fulfill electricity demand equivalent to the load. Such devices are effective and are also a backup power at the time of a disaster like the Great East Japan Earthquake. A fuel cell (FC) is a promising candidate for long term energy system as hydrogen is supplied stably. We have proposed a hybrid system of PV and FC in residential use. The proposed system consists of PV array, FC stack and power conversion devices. This paper deals with a mixed integer programming problem for determining the amount of hydrogen flow and remaining amount of hydrogen in the storage tank. We verify the effectiveness of the proposed method through numerical simulations.

In this paper, we have proposed a hybrid system of PVarray and FC stack, EL, hydrogen tank, and power conversiondevices. In order to minimize the running cost of the system, we consider a mixed integer programming problem fordetermining the amount of hydrogen flow and hydrogenremaining amount in the storage tank. Numerical simulationsclarify the effectiveness of the proposed method in the limitedconditions. We, of course, recognize that handling of theuncertain load or PV output is insufficient in the simulations.In addition to these things, there are a few future issues inverifying the capacity of FC and tank installations.

D. Sabaripandiyan and S. Arul Daniel[4] 2010studied about the use of fuel cell and PV array under the topic "A Comparative Review on Small Scale Integration ofHybrid Fuel Cell and PV Generating Systemto Utility Network." A comparative review is presented for integrated

PEM Fuel Cell and Photovoltaic generating system to single phase utility grid. For this system different techniques of common coupling for integration have been investigated. For both common AC bus and Common DC bus integration schemes, twodifferent current control techniques have been investigated. Thesimulation result shows that common DC bus integration with PIcurrent controller in series hysteresis limiter has fewer harmonic and more efficient than conventional current controller and Common AC bus Integration.

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Hybrid schemes are useful to offset the intermittence ofrenewable resources such as photovoltaic array. Hybridschemes based on PV array and PEM fuel cells have been Investigated in this paper comparisons are drawn betweenschemes with a common DC bus and a scheme with acommon AC bus. Simulation results confirm that the schemewith DC bus is more efficient that AC bus system.Furthermore DC bus system supplies power with lesser THDas compared to AC bus system.

Andres Salazar-Llinas *et al*[5]2014 studied about the use of fuel cell and PV array under the topic "Dynamic Power Control of a PV- Fuel CellHybrid Energy System Used in DC Motor Applications" A control structure for a hybrid renewable energy source connected with a direct current (DC) motor is proposed. The energy system is composed by a Photovoltaic (PV) array as the primary power source and a Fuel-Cell (FC) as a secondary power source. The control system has been developed to ensure motor speed regulation and maximum power generation of the energy sources under any environmental and load conditions, for instance low irradiance levels or a high demand in the load torque. A simulation of the system using real environmental data is presented in this research work

P. Thounthong *et al* [6]2010 studied about the use of fuel cell and PV array under the topic "Control Algorithm of Renewable EnergyPower Plant Supplied by Fuel Cell/Solar Cell/Supercapacitor Power Source." A renewable energy hybrid power plant, fed by photovoltaic (PV) and fuel cell (FC) sources with a supercapacitor storage device and suitable for distributed generation applications, is proposed in this thesis work. The PV array is used as the main generator; the Fuel Cell acts as a secondary power source, feeding only the insufficiency power (steady-state) from the PV array; and the supercapacitor functions as an auxiliary source for supplying the deficiency power (transient and steady state) from the PV array and the Fuel Cell. Using the nonlinear method of approach based on the flatness property, we propose simple solution for the dynamics, optimization, stabilization, and robustness problems in the hybrid power system. This is the key innovative contribution of this research work.

The prototype small-scale power plant studied wascomposed of a PEMFC system (1.2 kW), a PV array (0.8kW), and a supercapacitor module (100 F). Experimental results in MATLAB/SIMULINK laboratory authenticates the excellent control algorithm during load cycles.

Shiv Shankar Yadav, K.S. Sandhu[7] 2018studied about the use of fuel cell and PV array under the topic "A Grid connected Hybrid PV/Fuel Cell/Battery using five level PWM Inverter." in the recent times the utilization of renewable energy sources has gained many advantages in today's generation and among them is the PV cells which is attracting research scholars on day to day basis. In this paper the mathematical modelling of Photovoltaic cell (PV) using MATLAB/SIMULINK tool is done. Maximum power point tracking (MPPT) is used for increasing the efficiency of the used PV. Due to the change in solar irradiance from day to night various problem arises. This problem is solved by integrating PV arrays with the Solid Oxide Fuel Cell (SOFC) and battery thus forming a standalone hybrid PV-SOFC-Battery generation system. Certain disadvantage of the PV system is that the output voltage is low so we need to boost its voltage using boost converter so that five level inverter would convert it into alternating form. The whole of the hybrid standalone system is

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connected to grid. The modelling of PV, SOFC and the five level inverter are done using SIMULINK in MATLAB.

This research work takes in account of maximum power point tracking (MPPT) methodology for the PV and also the fuel system connected to a three phase multi-level pulse width modulation inverter. Perturb & Observe (P&O) technique one of the various methodologies of MPPT is used for tracking maximum power. After simulation the output obtained from PV is then given to boost converter device for boosting it. Two boost converters have been utilized to boost the obtained voltage. The maximum tracked output of the PV Array is boost to 220 volt by the Boost converter. The Battery and SOFC are used for storage purpose. And three phase Five level inverter design which is used to convert DC into AC is discussed in detail. PWM based inverter which gives sinusoidal output voltage. PI control technique has been utilized for controlling the voltage and frequency of grid.

CONCLUSIONS

The intuitive of each individual chapter have been included in the respective chapters. The point wise summary of the final conclusion drawn from thise thesis are shown below:

- PV array is simulated and effect of environmental conditions on its characteristics is studied.
- Fuel cell power is obtained according to the procedure of the proposed model.
- The result obtained are free from harmonics and disturbances.
- Fuel cell is studied and simulated .
- Maximum power point of operation is tracked for pv array system.
- This system is connected with the utility grid .
- The utility grid supplies power at the peak load conditions and takes power at light load condition.
- MPPT is integrated with the system for improving efficiency of the system.
- This system is desinged for considering the adverse conditions and it works good in a condition of high power reqirement.

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