Published by :
http://www.ijert.org

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 6 Issue 01, January-2017

Photovoltaic and Fuel Cell Hybrid Generating System Grid Simulation and Harmonics Analysis

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***Abstract*— As of late, hybrid photovoltaic-fuel cell energy system have been mainstream as energy generation system for various applications. This paper proposes a hybrid system comprising of photovoltaic and fuel cell to understand a dependable force supply for grid connected loads. Both the sources are worked autonomously or in conjunction according to prerequisite. The developed photovoltaic and fuel cell hybrid model might be straightforwardly connected with dc-side of the voltage source inverter utilized for utility grid PV and fuel cell interaction as a part of request to assess its execution. The dynamic model of photovoltaic and fuel cell hybrid generating system is simulated in matlab/Simulink environment.**

Keywords*— PV Array, Fuel Cell, Harmonics, active power, Reactive power

I. INTRODUCTION

In recent years the development in the field of renewable energy sources has attracted a lot of attention from both the researchers and industrialist since few decades. This attention is mainly due to the energy crises like fossils fuel shortage, suddenly increases oil rates, an earth-wide temperature boost and harm to environment and biological community. There are various renewable energy sources but some of them gained good accolades in last few decades due to their potentiality [1]. Hybrid power system consolidate two or more sources of renewable energy into one or more customary energy sources [2-4]. The renewable vitality sources, for example, photovoltaic and wind don't convey a steady power, yet because of their complementarities their combination gives more ceaseless electrical output. Hybrid power system are for the most part free from expansive interconnected systems and are regularly utilized as a part of remote zones [5,6]. The reason for Hybrid power system is to deliver as much energy from renewable energy sources to guarantee the load request. The increase in power demand and growth in fuel price, we have to develop alternative energy technologies solar energy sources are one of them. These energy sources are ecological benevolent, diminishes transmission and dissemination misfortunes, crest load shaving, can be utilized as reinforcement sources and so on. Fuel cell (SOFC) is a promising gadget as it is effective, particular and can be set at any site for enhancing framework effectiveness [7]. Thus a Photovoltaic and Fuel Cell Hybrid generating system ends up being best to give a dependable force source to grid connected applications than a system involving a solitary asset. This proposed work show a grid connected photovoltaic and fuel cell hybrid generating system [8]. With a specific end goal to associate into people in general grid, photovoltaic and fuel cell hybrid power must be inverted first. However, this procedure will create harmonics also, voltage waveform distortion. Therefore, the harmonics of the photovoltaic and fuel cell hybrid generating system must be recognized, dissected and filtered. The paper proposes a hybrid photovoltaic and fuel cell generating system to figure it out a reliable power supply for a system associated basic load. The power modelling unit comprises of two DC-DC boost converters where one of them is encouraged by a photovoltaic array and the other by a fuel cell. The output of the two DC-DC converters is associated with a typical DC-bus. The power from the DC-connection is sustained to the utility grid through the VSC (Inverter). The control circuit for the VSC (inverter) which separated from sustaining active power to the utility grid additionally gives reactive power. Figure 1 shows the single line diagram of Photovoltaic and Fuel Cell Hybrid generating system.

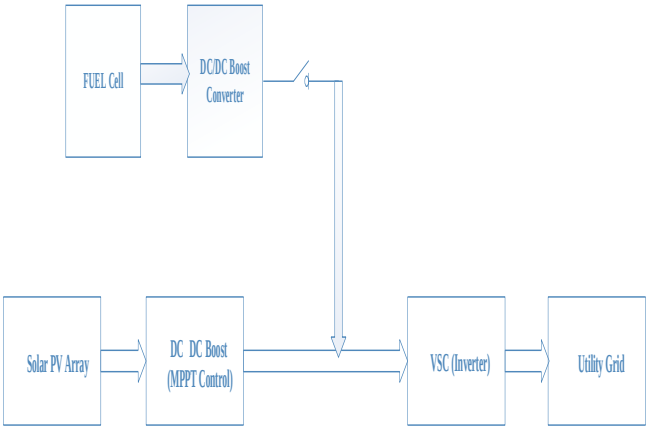

Fig. 1 Single line diagram of Photovoltaic and Fuel Cell Hybrid generating system

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II. MATHEMATICAL MODELLING OF PV-FUEL CELL SYSTEM

The power circuit of the proposed hybrid Photovoltaic and Fuel Cell generating system comprises of two DC-DC boost converters. One of the converters is nourished by the photovoltaic exhibit and the other by the fuel cell. The P&O MPPT control calculation is executed in the DC-DC boost converter associating the PV exhibit to the DC bus. This guarantees extraction of most extreme power from the photovoltaic array under all conditions. The distinction of required power and the photovoltaic power is given by the fuel cell and controlled through proper control of DC-DC boost converter interfacing the fuel cell to the dc bus. The power from the DC-connection is encouraged into the utility grid through a VSC (inverter). An inductive channel is associated at the yield of the inverter to decrease the sounds presented by the inverter [8].

A. Photovoltaic Cell Model

Various PV cells together structures PV modules, which assist interconnected in arrangement and parallel way to frame PV exhibits for desired voltage and current output levels. Numerous identical circuits have been proposed [9-12] keeping in mind the end goal to evaluate the conduct of the photovoltaic cell. The mathematical model of photovoltaic cell is to be entitled by a steady current source with a diode associated in parallel as appeared in [13] Figure 2. This model has consistent current source (I_{SC}), associated with a diode an arrangement resistance (R_S) and shunt resistance.

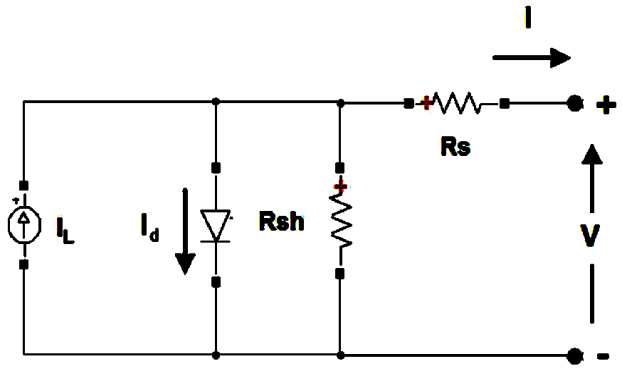

Figure 2. Single Diode exponential model of solar cell

The diode I-V characteristics for a module are characterized by the conditions

$$I_d = I_o\left[exp\left(\frac{V_d}{V_T}\right) - 1\right] \quad (1)$$

$$V_T = \frac{kT}{q} \times nl \times N_{cell} \quad (2)$$

A genuine recreation model was produced by utilizing these parameters appeared as in Table 1.The internal Simulink model of sunlight based PV system is appeared in Figure 3.

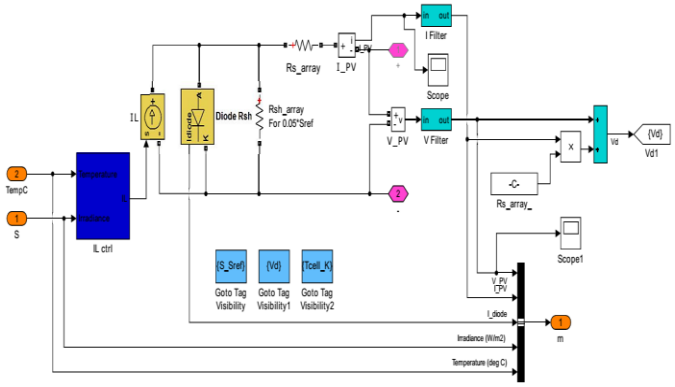

Fig.3. Simulink Model of Solar PV Cell

B. PV MPPT Control Algorithm [14]

The P&O technique works occasionally increasing then again decrementing the output terminal voltage of the PV furthermore, contrasting the power got in the present cycle with the power of the past cycle. On the off chance that the voltage fluctuates furthermore, the power increases, the control system changes the working point in that direction, generally change the operating point the other way. Once the direction for the change of current is known, the current is changed at a consistent rate. This rate is a parameter that should be conformed to permit the harmony between speedier reactions with less fluctuation in steady state. The flowchart of this calculation is exhibited in Figure 4. A adjusted variant is acquired when the means are changed as per the separation of the MPP, bringing about higher productivity. A continuous inconvenience in P&O techniques is that the output terminal voltage of the PV is perturbed each MPPT cycle notwithstanding when the MPP is come to, bringing about loss of power.

C. Mathematical model of SOFC (Fuel Cell) [15]

A fuel cell works like a battery by changing over the compound vitality into electrical vitality, however it contrasts from a battery in that the length of the hydrogen and oxygen is supplied it will deliver DC power consistently. Fuel cells assume an imperative part in dispersed era as a result of their focal points, for example, high productivity, no toxin gasses furthermore, particular structure adaptability. The operation of fuel cell components is anticipated on the response of hydrogen with oxygen to create water.

$$2H_2 + O_2 = H_2O \quad (3)$$

So as to concentrate current, and hence control, from a Fuel cell, the on top of response ought to be isolated into 2 half responses. In a SOFC, these half-responses take the structure

$$H_2 + O^{=} = H_2O + 2e^{-} \quad (4)$$

$$O_2 + 4e^{-} = 2O^{=} \quad (5)$$

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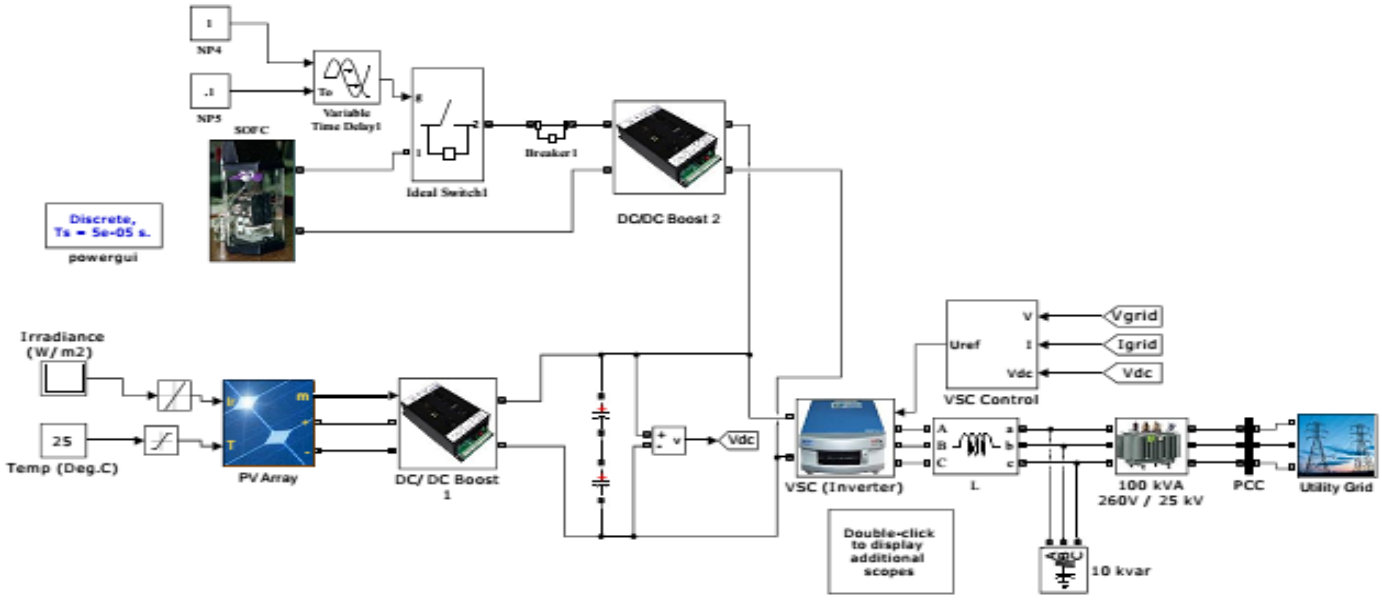

Fig.3. Test circuit developed in Matlab Simulink

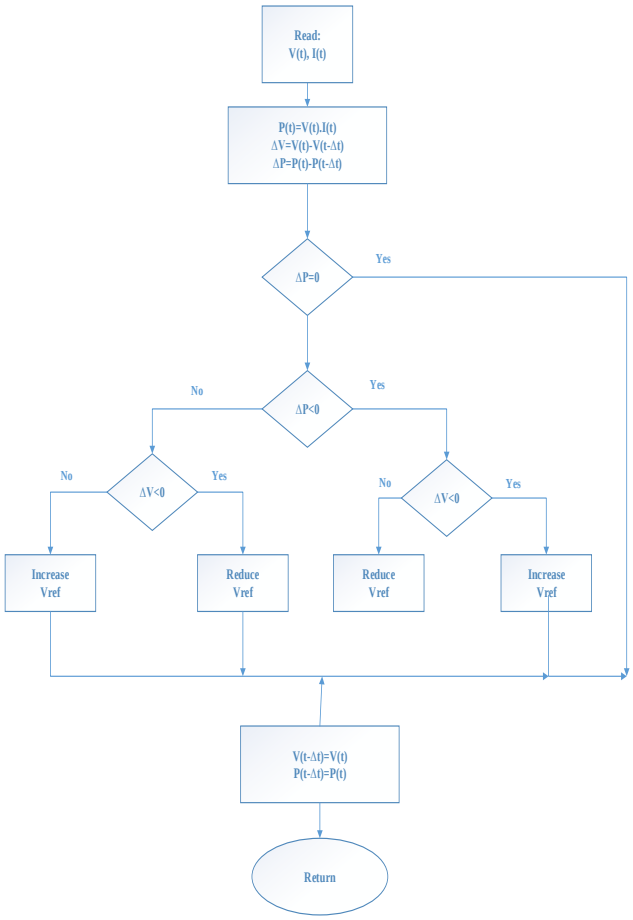

Figure. 4 Flowchart of the P&O Algorithm

The proposed Fuel Cell model [15] is shown in Fig.5.

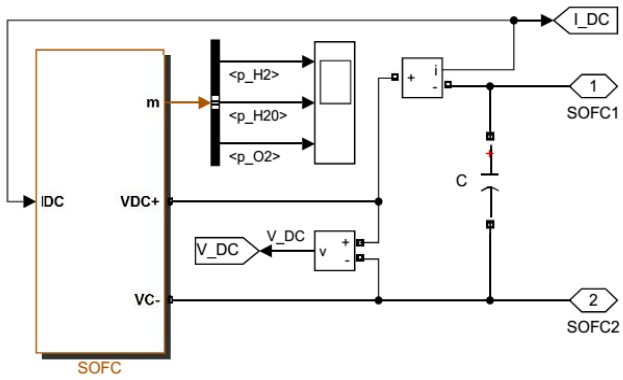

Fig.5 SOFC Model developed in MATLAB

Fig.6 shows the proposed grid connected photovoltaic and fuel cell hybrid generating system that has been developed in matlab Simulink environment.

III. SIMULATION RESULT AND ANALYSIS

The proposed Photovoltaic and Fuel Cell Hybrid generating system connected with grid model is executed using Matlab/Simulink simulation Interface and generated result are given below. This Simulation was executed for 3 seconds. The Photovoltaic and Fuel Cell Hybrid generating system connected with grid system is evaluated with PV Array & fuel cell both.The fuel cell is come in Circuit after 0.1 second. PV array current and voltage under Standard Test Condition, 250C and 1000 W/m2) showed up in Fig. 7. PV array worked of string of PV modules associated in parallel comprise of 64 parallel string. Every string comprises of module associated in arrangement and can have 5 arrangement associated module for each string. These outcomes match with the Sun Power SPR-315E-WHT-D sun powered exhibit.

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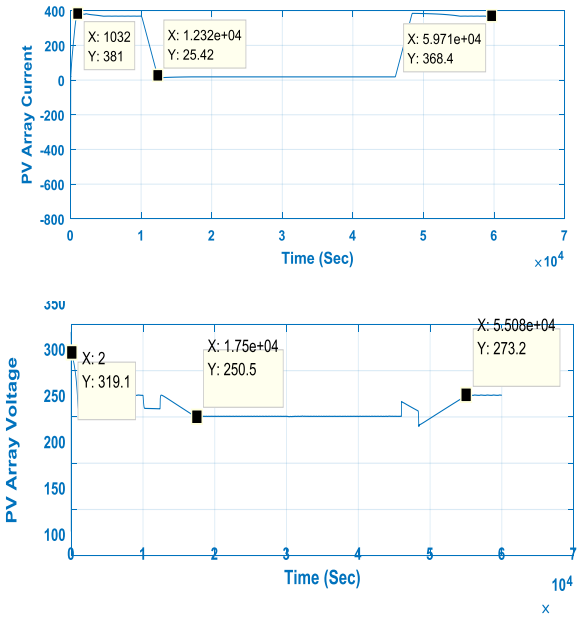

Fig.7. Photovoltaic Model Output current and output Voltage

Sun Power SPR-315E-WHT-D sun oriented module current voltage (I-V) curve was gotten from the created model and it can be seen in Fig. 8 I-V curve confirms the PV board cut off current value and open circuit voltage value. And also p-v curve is shown in fig. 9.

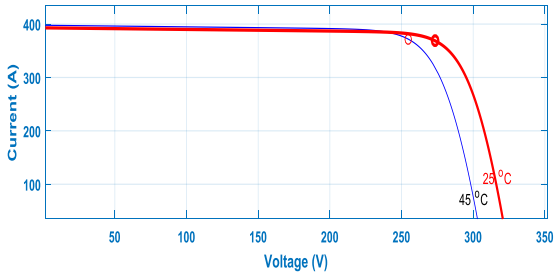

Fig.8. I-V Characteristics of Photovoltaic Module

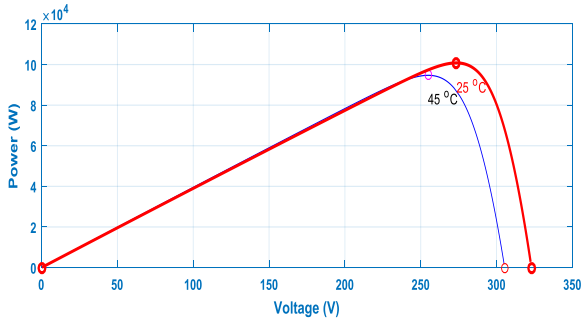

Fig.9. Photovoltaic module P-V Curve

PV module current altogether changes when the insolation changed and this change is greater than the voltage change and is shown in fig. 10.

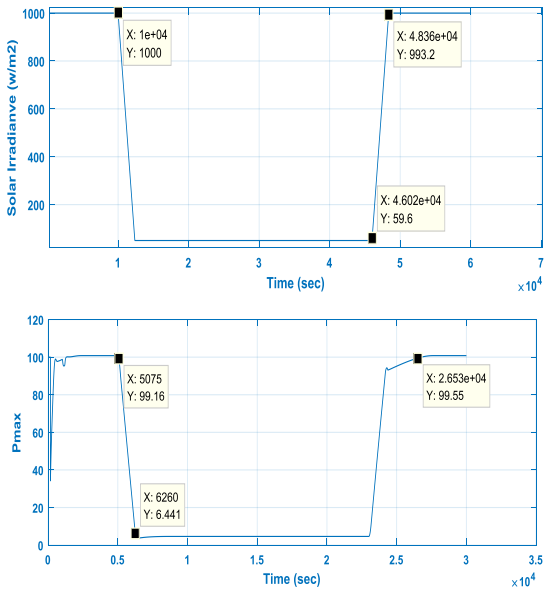

Fig. 10 Photovoltaic module irradiance and Maximum Output Power

Inverter model was used for interfacing SOFC and PV framework to the utility system. DC/DC converter yield voltage feds the DC side of the inverter and desired current is another commitment of the inverter. A Voltage Source Converter (VSC) changes over the 500 V DC to 260 V AC and keeps solidarity power part. A 100-kVA 260V/25kV three-phase coupling transformer is used to interface the converter to the utility network. The framework model includes regular 25-kV flow feeders and 120-kV practically identical transmission framework. 3-stage current and voltage and adjustment record of VSC are likewise showed up in fig. 11.

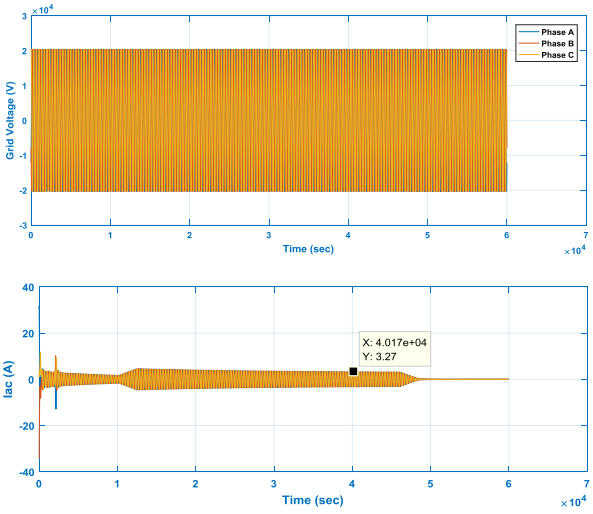

Fig. 11 Grid AC voltage and Current

It is observed that the designed filter works satisfactorily and the output wave forms are sinusoidal. Fig. 12 shows the active and reactive power waveforms. The FFT analysis is done for filter output for different values of inductor 'L' and capacitance 'C' of LC filter. FFT analysis is displayed in Fig. 13.

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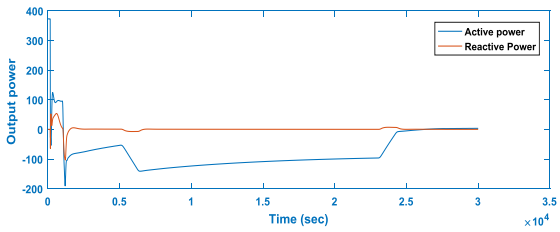

Fig.12. Active power and Reactive power of grid

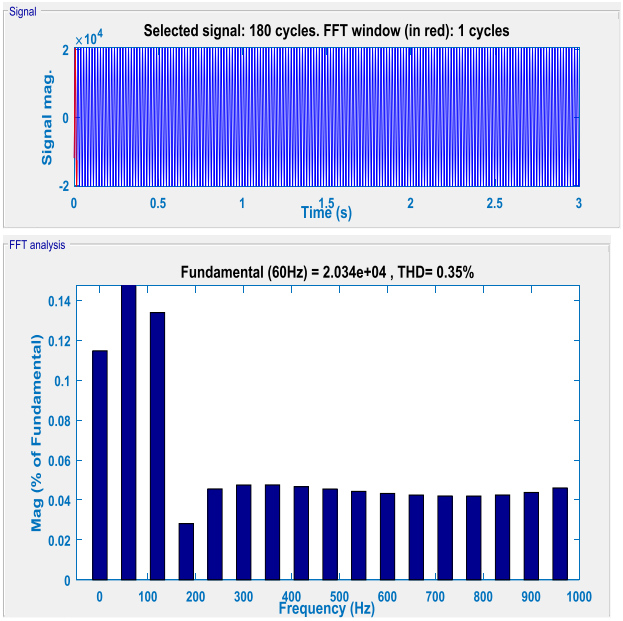

Fig. 13. Grid current spectrum for an irradiance of 1kW/m^2

IV. CONCLUSION

The paper presents a new Photovoltaic and Fuel Cell Hybrid generating system connected with Grid system. Instead of connecting the photovoltaic and fuel cell sources to the grid with VSC (inverters), the energy sources are first connected to a common dc bus by separate DC-DC converters and then connected to the grid through a VSC (inverter). The proposed system works flexibly, exploiting maximum solar energy and optimum energy from fuel cell. Appropriate control schemes have been designed for the inverter incorporating the active filtering capability thus compensating for reactive and harmonic power of PCC load as well and thus maintaining the grid current of good quality. All outcomes results from the simulated photovoltaic and fuel cell hybrid power system were clarified in the paper.

REFERENCES

[1] Pacheco, V. M., et al. "Stand-alone photovoltaic energy storage system with maximum power point tracking." Applied Power Electronics Conference and Exposition, 2003. APEC'03. Eighteenth Annual IEEE. Vol. 1. IEEE, 2003.

[2] Mcgowan JG, Manw ell JF. Hybrid/ PV/diesel system experienc es. Revue Renewabl e Energy 1999;1 6:928e33.

[3] Belhamel M, Moussa S, Kaabeche A. Production of electricity of a hybrid system (WindePhotovoltaiceDiesel). Review of Renewable Energy 2002:49e54.

[4] El Khadimi A, Bachir L, Zeroual A. Sizing optimization and techno-economic energy system hybrid photovoltaic e wind with storage system. Renewable Energy Journal 2004;7:73e83.

[5] Saheb-Koussa D, Koussa M, Belhamel M, Haddadi M. Economic and environmental analysis for grid-connected hybrid photovoltaicewind power system in the arid region. Energy Procedia 2011;6:361e70.

[6] Kaldellisa JK, Kavadiasa KA, Koronakis PS. Comparing wind and photovoltaic stand-alone power systems used for the electrification of remote consumers. Renewable and Sustainable Energy Reviews 2007;11:57e77.

[7] Djamila Rekioua and Ernest Matagne, "Optimization of Photovoltaic Power Systems", Springers, 2012.

[8] Mehta, Gitanjali, and S. P. Singh. "Design and analysis of photovoltaic-fuel cell hybrid distributed generation system." 2013 IEEE 39th Photovoltaic Specialists Conference (PVSC). IEEE, 2013.

[9] Minwon Purk, Bong-Tue Kim, In-Kmn Yu, 2001, "A novel Simulation Method for PV Power Generation Systems using Real Weather Conditions", Industrial Electronics, 2001 Proceedings ISIE 2001, IEEE International Symposium Vol.1 P. 526-530.

[10] W. Chen, H.Shen, B. Shu, H. Qin and T. Deng, "Evaluation of performance of MPPT devices in PV systems with storage batteries," Renewable Energy, vol. 32, no. 9, July 2007, pp. 1611-1622.

[11] Huan-Liang Tsai, Ci-Siang Tu, Yi-Jie Su, "Development of Generalized Photovoltaic Model Using MATLAB/SIMULINK", Proceedings of the World Congress on Engineering and Computer Science WCECS, San Francisco, USA, 2008.

[12] Francisco M, González-Longatt, "Model of Photovoltaic Module in Matlab™", 2do congresoı beroameri cano de estudıantes de ıngenıeríaeléctrı ca, electrónıca y computacıón, 2005, pp.1-5.

[13] Prashant Singh, Sujil A, Prabhat Kumar "Battery (NiCd) Charging Analysis of Stand¬Alone 300w Solar Photovoltaic System at Constant Solar Insolation", International Journal of Electrical and Electronics Engineers (IJEEE) Volume 07, Issue 01, pp. 310¬317, ISSN: 2321 -2055 (E), Jan- June 2015.

[14] De Brito, Moacyr AG, et al. "Comparative analysis of MPPT techniques for PV applications." Clean Electrical Power (ICCEP), 2011 International Conference on. IEEE, 2011.

[15] Fleming, Eric M., and Ian A. Hiskens. " Dynamics of a microgrid supplied by solid oxide fuel cells." Bulk Power System Dynamics and Control-VII. Revitalizing Operational Reliability, 2007 iREP Symposium. IEEE, 2007