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DESIGN OF SIMULINK-BASED GRID CONNECTED PV CELLS AND WIND-BASED ENERGY GENERATING SYSTEM

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ABSTRACT
Renewable energy sources have displaced traditional energy sources, with significant advances in photovoltaic (PV) and solar cell technology propelling these renewable energy sources (RES) to the forefront of all other RES. PV-based systems have begun to be widely employed in home applications that are connected to the electrical grid, and grid-connected PV power generating systems are now commonplace all over the world. PV producing devices have also been utilized to supplement wind turbines. As a result, hybrid generation systems based on PV and wind technology are being researched for power generation. MATLAB/SIMULINK was used to create a grid-connected PV cell and wind-based energy generation system in this study.
Keywords: Photovoltaic Cell, wind Energy, Hybrid system, grid connection, renewable energy sources and Simulink. wind energy system, modeling, simulation

1. INTRODUCTION
Since the beginning of the last century, fossil fuelhas been and still is the main energy source to meet the world's increased energy demand. The generation of electric power from the above stated non conventional sources is somewhat relatively old. But the thing we are interested is that these sources are highly un-reliable [1]. The main focus is to be laid to reduce the intermittent nature of these energy sources and allow continuous supply with minimum outages. There are many methods proposed in maintaining the
continous supply to meet the load demand. The best among them is that is to provide a Battery energy storage system(BESS).By providing this one also has to ensure that these sources needed to be operated in such a way that the output from them should be maximum [2-3]. The improved quality of life is pushing the world's energy consumption year after year. As a result of extensive fossil fuelconsumption, millions of tones of pollutant gaseshave been released into the atmosphere, which is believed to be the main cause of global warming [4]. There is growing high pressure on governments around the world to meet future energy demand and to reduce CO_2 emissions at the same time. During the years 2007 and 2008, oil prices hit their highest ever since the Second World War. The world realized that oil is nolonger a cheap energy source [5]. Besides thesudden increase in oil prices, more scientific evidence has pointed out that burning fossil fuel is the main reason behind global warming and climate changes [6-7]. The reasons above and theexpected growth of the world's energy demands have put world leaders under heavy pressure to invest and investigate new sustainable sources of energy, to reduce CO_2 emissions and to close the gap of the predicated increases in future energy demand. The HPS can be defined as the combination of multi-power generators and storage devices which are connected to each other and controlled to meet a certain power demand [8-9]. As mentioned earlier, solar and wind power are sensitive to weather changes, while currently FCs are still very expensive and need a pure or high concentration of hydrogengas [10-12]. As a result, a combination of many power generators and storage components is required to form a multi-source HPS to improve reliability and availability,to meet energy demand. HPS can be utilized to power any load, whether as a stand-alone or connected to existinggrid power generation,

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in remote areas, such as wireless communication antenna, villages, well water pumps etc., or in any remote, rural areas. Combining more than one source of energy generators with a good control system hasimproved system quality and reliability [13-14]. Hybrid systems have attracted researcher attention worldwide. The model is a computer simulation based on a mathematical model which describes the characteristics and behaviour of the actual system [15]. There are many computer programmes that can be used to perform a simulation model. One of the most widely used programs in simulation is Matlab/Simulink. The mathematical relation between model input and output data is then derived for all the systemcomponents.

2. PHOTOVOLTAIC CELL (PV)

The term "photovoltaic" comes from the Greek word (phos) meaning "light", and "voltaic",meaning electrical, from the name ofthe Italian physicist Volta, after whom a unit of electrical potential, the volt, is named. The term "photovoltaic" has been in use since 1849. The photovoltaic (or photovoltaic cells) is a device that converts solar radiation directly into DC electrical energy. The only fuel photovoltaic needed to produce electricity is sunlight. When sunlight hits a PV cell, the photons of the absorbed sunlight dislodge the electrons from the atoms of the cell. The free electrons are forced to move through the cell, creating and filling in holes in the cell. It is this movement of electrons and holes that generates electricity. The conversion process of sunlight into electricity is known as the photovoltaic effect. A simple solar cell consist of solid state p-n junction fabricated from a semiconductor. material (usually silicon).In dark, the IV characteristic of a solar cell has an exponential
characteristic similar to that of a diode. However when the solar energy (photons) hits on the solar cell, energy greater than the band gap energy of the semiconductor, and release electrons from the atoms in the semiconductor material, creating electron-hole pairs. simplest equivalent circuit of a solar cell is a current source in parallel with a diode. The output of the current source is directly proportional to the solar energy (photons) thathits on the solar cell. During darkness, the solar cell is not an active device; it works as a diode,
i.e. a p-n junction. It produces neither a current nor a voltage.

Solid-Oxide Fuel Cell (SOFC):

In order to understand the system behavior and optimize performance of the system, a simulation model of the complete proposed system was developed in Matlab/Simulink. The first step was to build an "accurate" mathematical model of Fuel Fell C. This would be then followed by modelingthe PV, batteries and load. The electrolyte of SOFC is a solid electrolyte called non-porous ceramic compound. SOFC can be fuelled by either Carbone Monoxide (CO) or hydrogen. Fig.1 shows reaction on both sides of the cathodeand anode. SOFCs operate at a very high temperature of about 800-1000^{0}C with overallexpected efficiencies of about 50 to 60.

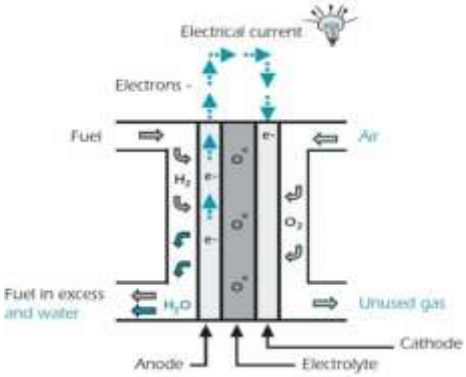

Fig 1. Cathode and anode reaction

Solid Oxide Fuel Cell

A Precious-metal catalyst can be removed when operating SOFC at about 1,000^{0}C which will reduce fuel cell cost. As another advantage of SOFC, it can operate with higher sulphur content fuel unlike other types of fuel cell. Due to the suitability of using SOFCs to generate electricity in medium and large scale, SOFCs can be used to power buildings and/or factories. Disadvantages of

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high temperature operation are the slow start-up, and durability and reliability problems. Frequent start up and shut down can lead to operation start-up problems.

3. PROPOSED HYBRID NON-CONVENTIONAL POWERGENERATING SYSTEM

The proposed system presents power-control strategies of a grid-connected hybrid generation system with versatile power transfer. This hybrid system allows maximum utilization of freely available renewable energy sources like fuel cells and photovoltaic energies. The technical details of a micro-grid are specified in the details of the individual sources (here a photovoltaic array and SOFC) and their associated power electronics. Fig. 2 shows the general structure of the developed model. A possible inverter configuration for the systems will be set out. Connecting them to a load and to the mains supply was discussed. Finally, a possible format for connecting them as a micro-grid was considered and discussed in terms of the physical reality of such systems. Developed Matlab/Simulink model is shown in Fig. 2. SOFC and PV system are connected to the inverter and the grid via DC/DC converters in this system. he ionic transported species are oxygen ions that allow the use of hydrogen and carbon monoxide as well as directly applied methane as fuels while the oxidant is oxygen provided by air. The state-of-the art SOFC consists of an yttrium-stabilized zirconia (YSZ) as the electrolyte, a ceramic metallic composite, a Ni-YSZ cermet as the fuel electrode and a ceramic composite of strontium doped lanthanum manganite and YSZ as the air electrode. The SOFC is, therefore, an all-solid state system for which different designs may apply. SOFC model was developed in Matlab/Simulink. The Constant parameters of the SOFC system are the inputs of the model and voltage, current and power determined from the proposed model. All input parameters are evaluated in these blocks and outputs parameters are generated according to these parameters.

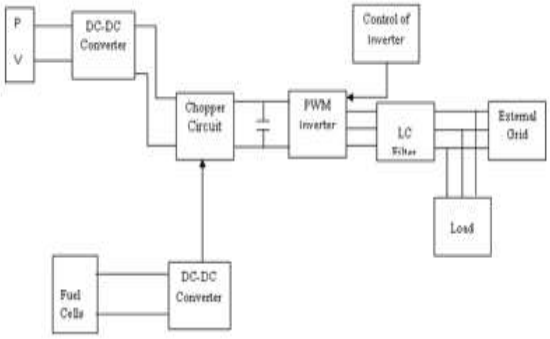

Fig.2. Proposed Hybrid grid based on PV Celland Fuel Cells

4. SIMULATION RESULTS

The PV module current, voltage and power in STC (Standard Test Conditions, 250C and 1000 W/m2 as shown in Fig. 3. Developed PV module model runs with the change of module temperature and insolation so PV module IeVcurves under different insulation values can be obtained from the model and these curvesindicated in Fig. 4. Input voltage, reference current and output current are the inputs of the DC/DC converter model. Model generates a DC voltage output of the model. Simulation results of this model can be seen in Fig. 5. The AC currentand voltage of the inverter can be seen in Fig. 6.

These parameters are also suitable for grid connection of the proposed Hybrid power generation using PV cells and Fuel Cells.

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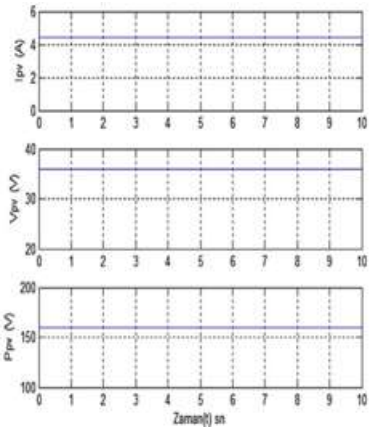

Fig.3. PV model output voltage, current and power.

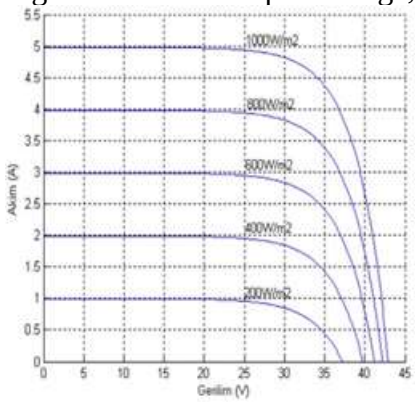

Fig.4. PV module IeV curves under different insolation values

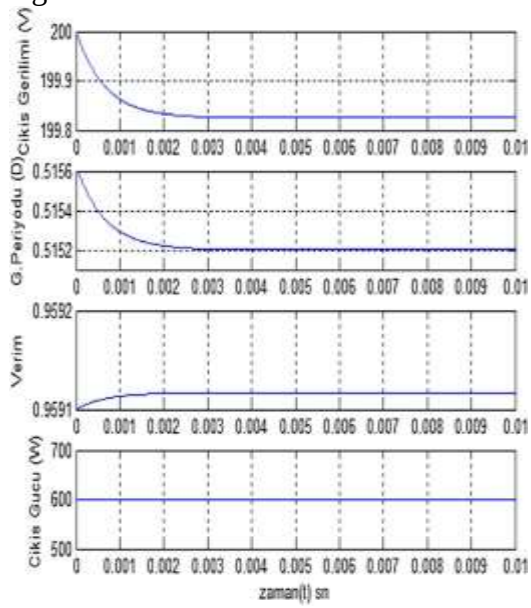

Fig.5. DC/DC converter simulation results

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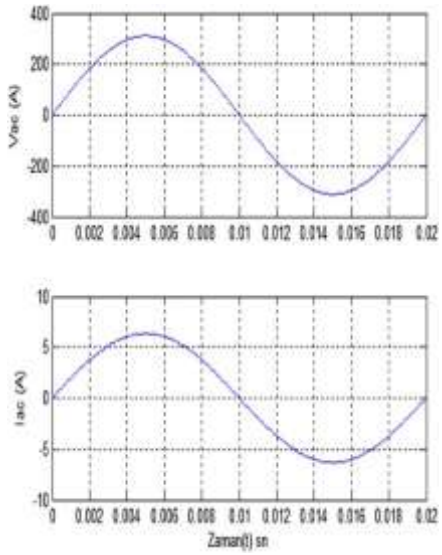

Fig.6. AC voltage and current of inverter

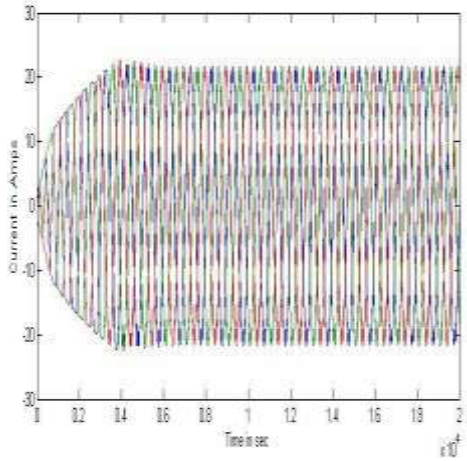

Fig.7 Output currents of the proposed hybridpower generation system

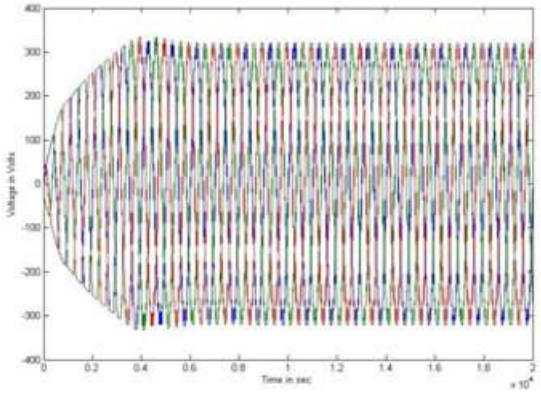

Fig.8 Output Voltages of the proposed hybridpower generation system

CONCLUSION

The modeling of hybrid grid using Fuel Cells andPV cell for power system configuration is donein MATLAB/SIMULINK environment. In thisstudy, a grid connected fuel cell and PV hybrid power generating system was developed with Matlab Simulink. The Output current and voltage of PV system was used for input of DC/DC boost converter and its output was used for the input of the inverter. The PV system was connected to the grid and solid oxide fuel cell (SOFC) system wasused for supporting the DC bus of the hybrid power generating system. All results obtained from the simulations of proposed hybrid power system were presented in this paper. The hybrid grid can provide a reliable, high quality and more efficient power to consumer. The hybrid grid may be feasible for small isolated industrial plants with both PV systems and wind turbine generator as the major power supply.

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