IMPLEMENTATION OF HYBRID GRID SYSTEM MODELING OF PV/WIND/FUEL CELL FOR REMOTE AREA WITH MATLAB/SIMULINK

Kundan Kumar[1], Anoop Kumar[2]
Department of Electrical Engineering, IES college of technology, Bhopal, India

ABSTRACT: Renewable energy systems are of importance as being modular, nature-friendly and domestic. Among renewable energy systems, a great deal of research has been conducted especially on photovoltaic effect, wind energy and fuel cell in the recent years. This paper describes dynamic modeling and simulation results of a small wind-photovoltaic-fuel cell hybrid energy system. The hybrid system consists of a 500 W wind turbine, a photovoltaic, a proton exchange membrane fuel cell (PEMFC), ultra-capacitors, an electrolyze, a boost converter, controllers and a power converter that simulated using MATLAB solver. This kind of hybrid system is completely stand-alone, reliable and has high efficiency. In order to minimize sudden variations in voltage magnitude ultra capacitors are proposed. Power converter and inverter are used to produce ac output power. Dynamics of fuel-cell component such as double layer capacitance are also taken into account. Control scheme of fuel-cell flow controller and voltage regulators are based on PID controllers. Dynamic responses of the system for a step change in the electrical load and wind speed are presented. Results showed that the ability of the system in adapting itself to sudden changes and new conditions. Combination of PV and wind renewable sources is made the advantage of using this system in regions which have higher wind speeds in the seasons that suffers from less sunny days and vice versa.
Keywords: Wind Energy; Photovoltaic; Fuel-Cell; Hybrid Energy Systems; Dynamics of Energy System

I. INTRODUCTION

The rapid depletion of fossil fuel resources on a world- wide basis has necessitated an urgent search for alternative energy sources to meet to the present day demands. Alternative energy resources, such as solar and wind energies, are clean, inexhaustible and environment friendly potential resources of renewable energy options. It is prudent that neither a standalone solar nor a wind energy system can provide a continuous supply of energy due to seasonal and periodical variations [1-3]. To solve these drawbacks conventional battery storage has been used. But batteries can store a limited amount of power for a short period of time. For long-term storage electrical power produced by wind turbines or PV arrays can be converted into hydrogen using an electrolyzer for later use in fuel cell. So these conventional batteries can be replaced with fuel cells as non-polluting and high efficiency storage devices. Advantages in wind and PV energy technologies are the main reason of using hybrid Wind/PV configurations, and fuel-cells can be work in parallel with Wind/PV system as the device which can save and generate electrical energy where it is necessary. In addition the excess heat from a fuel-cell can also be used for space heating or for the residential hot water. This kind of energy storage in hydrogen form that uses energy from wind turbine or PV to produce hydrogen for later use is being studied at the hydrogen research institute [4,5]. The idea of an ultra-high-efficiency (UHE) hybrid energy system consisting of wind turbine, a photovoltaic and fuel cell exists in [6,7]. In [8] a management system is designed for a Wind-PV-Fuel cell hybrid energy system to manage the power flow between the system components in order to satisfy the load requirements. In [9] a simple and economic control with DC-DC converter is used for maximum power point tracking and hence maximum power extraction from the wind turbine and photovoltaic

II. SYSTEM CONFIGURATION

System configuration of the proposed hybrid energy can be considered as a complete eco-friendly power generation system because the chief energy source and storage system are all environment friendly. When there is additional solar generation available, the electrolyzer isactivated to produce hydrogen, which is then delivered to the hydrogen storage tanks. If the H2 storage tanks become full, the excess power will be diverted to the dump load. When there is a shortage in PV power generation, the Fuel cell stack will begin to produce power using hydrogen from the reservoir tanks. Different energy sources are connected to the AC bus through appropriate power electronic interfacing circuits. The hybrid system is designed to supply power to five homes in a rural area. A typical hourly residential load demand for rural homes is used. The total hourly average load demand is shown in Figure 1.

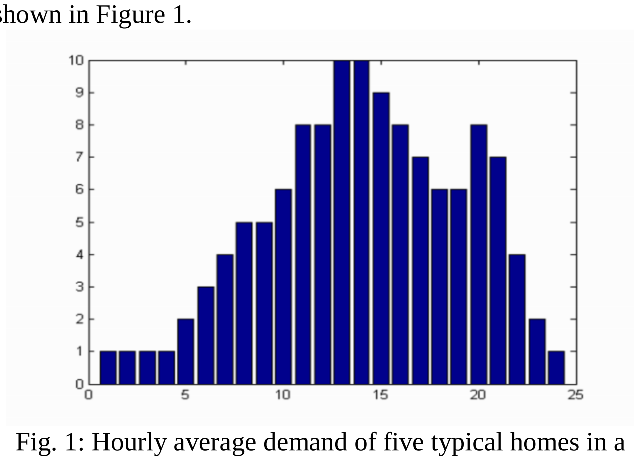

Fig. 1: Hourly average demand of five typical homes in a rural area.

III. SYSTEM COMPONENT CHARACTERISTICS

To design an overall power management strategy for the system and to examine the system performance, dynamic models for the main components in the proposed hybrid energy system have been developed using MATLAB/Simulink.

A. Photovoltaic

PV effect is a simple physical process through which solar energy is converted directly into electrical energy. The physics of a solar cell, is similar to the p-n junction diode. In a PV array higher the irradiance, the higher are the short-circuit current (Isc) and the open-circuit voltage (Voc). As a result, the larger will be the output PV power. Temperature plays avital role in the PV performance. It is noted that lower the temperature, the greater is the maximum power and higher the open circuit voltage.

B. Fuel Cell

The PEMFC model is operated under continuous channel pressure with uncontrolled input fuel flow into the Fuel cell. The FC will adjust the input fuel flow according to its load current to maintain the channel pressure constant. The characteristic curve can be divided into three areas. The voltage drop across the Fuel cell related with low currents is because of the activation loss inside the Fuel cell; the voltage drop in the middle of the curve is due to the ohmic loss in the FC stack; and as a result of the concentration loss, the output voltage at the end of the curve will drop suddenly as the load current rises.

C. Electrolyzer

An electrolyzer is a device that yields hydrogen and oxygen from water. In divergence to the electro chemical reaction occurring in an FC to produce electricity, an electrolyzer converts electrical energy into chemical energy stored in hydrogen. For a given electrolyzer, within its rating range, the higher the dc voltage applied, the greater is the load current. So, by applying a higher dc voltage, more H2 can be generated.

IV. PROPOSED WORK

4.1 Proposed Work

The economic analysis and environmental impacts of integrating a photovoltaic (PV) array and diesel-fuel power systems for smart villages. MATLAB Simulink is used to match the load with the demand and apportion the electrical production between the PV and diesel-electric generator. The economic part of the model calculates the fuel consumed, the kilo watt hours obtained per gallon of fuel supplied, and the total cost of fuel.

The environmental part of the model calculates the 2, particulate matters (PM), and the x emitted to the atmosphere. Simulations based on an actual system in the remote district of Bihar were performed for three cases:

1) Fuel Cell
2) Diesel-battery; and
3) PV with diesel-battery using a one-year time period.

The simulation results were utilized to calculate the energy payback, the simple payback time for the PV module, and the avoided costs of 2, x, and PM. Post-simulation analysis includes the comparison of results with those predicted by Hybrid Optimization Model for Electric Renewable.

V. PROPOSED METHODOLOGY

We have looked at the following technologies, ie small wind turbines, solar PV systems (PVS), batteries and diesel generators to support smart villages. In the hybrid system, the electric demand of the laboratory is coupled to AC, the diesel generator is connected to the AC power of the grid and the solar panel, wind turbine and batteries are connected to both sides of the DC. The conventional diesel generator (DG) is used to supplement the renewable energy system for peak loads and during periods of weak neutral system resources.

VI. SIMULATION & RESULT

Smart Villages are the need of the hour as development is needed for both rural and urban areas for better livelihood and technology will offer effective solution. The technological support already exists at the urban side and there is a tremendous pressure on urban landscapes due to migration of rural people for livelihood. Smart Villages will not only reduce this migration but also irrigate the population flow from urban to rural area as well.

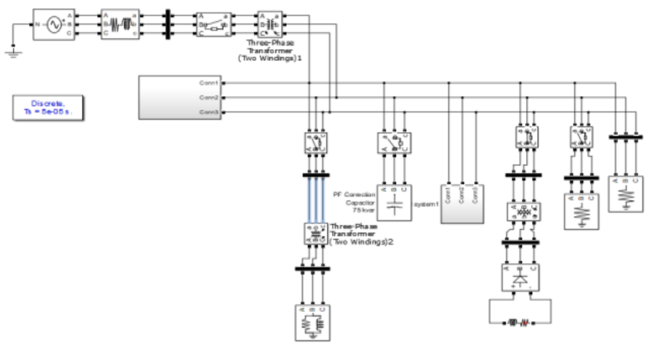

Figure 6.1.Top level Model

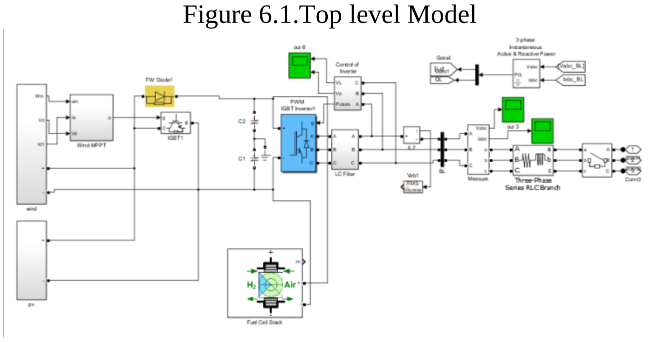

Figure 6.2 PV/Wind/Fuel Subsystem

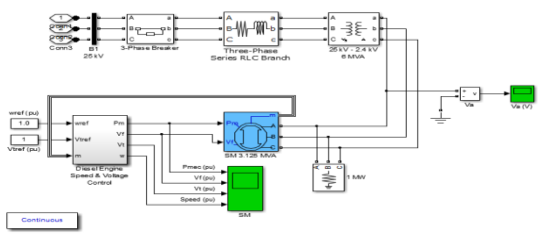

Figure 6.3 Diesel subsystem

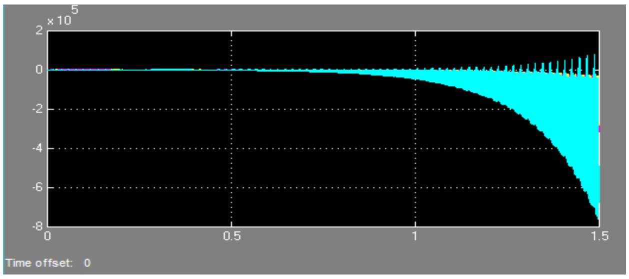

Figure6.4. Output voltage of PV subsystem

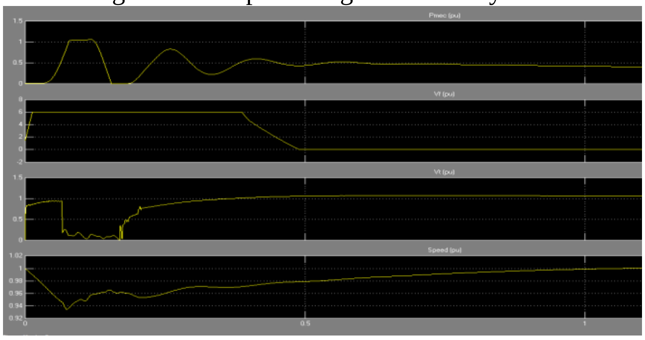

Figure 6.5. Output of Diesel subsystem

The alternator with battery and inverter is the most economical solution for the three boxes for download. PV, wind turbine, diesel generator with battery and inverter system is also a very good replacement solution has low electricity cost and net current cost. Although the cost of electricity from the proposed system is higher than the electricity of the grid, but because of the need to protect the environment and the current standard of living of rural communities, this hybrid system will play a good role country, such as India. The integrated model provides great efficiency for people to make this energy extremely intelligent.

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