www.ioirp.com
International Journal of Innovative Research in Technology, Science & Engineering (IJIRTSE)
ISSN: 2395-5619, Volume – 2, Issue – 5. May 2016

ENERGY MANAGEMENT OF A HYBRID POWER SYSTEM BASED ON RENEWABLE ENERGY SOURCES IN DC MICRO GRID

Joseph Varghese
PG Student (PSE),
Dept. of EEE,
SNS college of Technology,
Coimbatore, Tamilnadu, India
evjoseph@gmail.com

Karthick R
Associate professor,
Dept. of EEE,
SNS college of Technology,
Coimbatore, Tamilnadu, India
Karthick.ketti@gmail.com

A*bstract* –This paper will optimized energy management of the hybrid unit which includes a photovoltaic (PV), a fuel cell (FC), an electrolyzer (EL) and a battery.The system was designed to guarantee the power flow management between the energy sources and the storage elements.The aim of the system is to provide a permanent supply to the isolated site by adapting production to consumption according to the storage level.The control of hybrid power production unit under different types of power generation and load demand was illustrated using MATLAB/SIMULINK software.

Index Terms – **Energy management, Hybrid power, renewable energy,Dc micro grid .**

I. INTRODUCTION

As stand-alone power system Hybrid Renewable Energy System (HRES) are becoming popular for providing electricity in remote areas. A hybrid energy system consists of two or more renewable energy sources are used to increase the system efficiency. There are many renewable sources, combined together could provide an uninterruptable power supply.

Photo voltalic cell is commonly used for an isolated places to generate electricity. [1]-[4].

Energy is converted into dc and stored in energy storage elements, and then it is inverted to ac and given into the utility grid.Battery energy storage is used to avoid power outage or power surges in power system.Using the power grid the energy loss will get reduse.

However, existior getting high efficiency and compact appliances are powered by dc, dc is getting by converted by rectifying.

Power loss is reduse by using DC-distribution about 7%, saved and 33% space, Investment also reduse by

about 15% and increased reliabilityby about 200%.Here the system has, green power generator, energy storage element, dc appliance and equipment, and energy management system (EMS) with a fuzzy controller are used.

For design of the green energy systems, There is a control method is required to optimize energy distribution of a microgrid system. So that model construction is necessary for solar energy and storage devices, The lithium-ion batteries are used to simulate dynamic changes of the renewable energy distribution. The design concept of this study was to increase the useful life of lithium batteries and to include charge and over discharge protection mechanisms.

As in Fig. 1, the system configuration are includes five blocks: power generator, energy storage equipment, dc-bus regulator, dc load, and EMS.

The power generator includes PV panels and fuel cells. The fuel cells provide base power for the emergency loads when the system is operated during a power failure. Maximum power point trackers are used in PV panels to draw maximum power, which is fed into the dc grid. The dc loads are connected to the dc grid and supplied from the grid directly.

If there is power shortage, the bidirectional inverter will take power from the ac grid and it is operated in rectification mode with power factor correction to regulate the dc-grid voltage.

During the power failure, the Li-ion battery firstly discharged to supply power for a short-time interval and if the failure lasts longer (e.g., 2 min), the fuel cell will start supplying power.Here the battery discharger will be also responsible for dc-grid voltage regulation if the bidirectional inverter is not

www.ioirp.com
International Journal of Innovative Research in Technology, Science & Engineering (IJIRTSE)
ISSN: 2395-5619, Volume – 2, Issue – 5. May 2016

in operation. If the bidirectional inverter is in operation, the battery can be charged.

If there is residual power on the dc grid, the battery can be charged depending on its status, and/or the bidirectional inverter can be operated in grid-connection mode to sell power and regulate dc-grid voltage to 380 ± 20 V. The overall system operation will be monitored and controlled by the EMS, so each module in the system has to communicate with the EMS based on RS-485 or ZigBee communication protocol. TheEMSwill command the modules when to operate and collect operational status. However,in emergency situations, such as excessive current, voltage or temperature, the modules will protect themselves without a command from the EMS, but the modules still have to inform the EMS of their current status.

The proposed fuzzy control is to optimize energy distribution and to set up battery state of charge (SOC) parameters. The control algorithm takes the priority of selling electricity as the premise of energy distribution to allow remaining power generated by the renewable energy of the electrical grid sold through the connected mains grid.

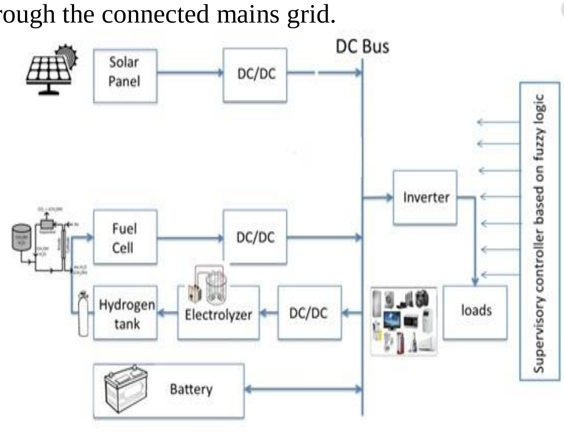

Fig 1 Block Diagram of Hybrid System

II. MODELING OF RENEWABLE COMPONENTS

A.Modeling of Solar cell

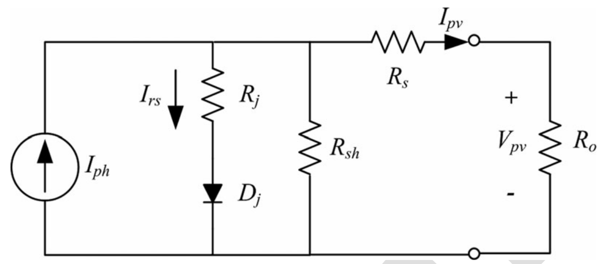

Figure 2 Equivalent circuit of solar cell

Solar panel current equation can be expressed as,

$$I_{pv} = n_p I_{ph} - n_p I_p [\exp\left(\frac{q}{kTA}\frac{Vpn}{n_s}\right) - 1] \qquad (1)$$

where *V*pv is output voltage of solar panels, *I*pv is output current of solar panels, *ns* is number of solar panels in series, *np* is number of solar panels in parallel,

k is the Boltzmann constant (1.38 × 10−23 J/K), *q* is electron charge (1.6 × 10−19C), *A* is ideality factor (1–2), *T* is surface temperature of the solar panels (K), and *Irs* is reverse saturation current.

$$I_{ph} = [I_{scr} + \propto (T - T_r)] \frac{s}{100} \qquad (2)$$

where *I*scr is the short-circuit current at reference temperature *Tr* and illumination intensity 1 kW/m2 , *α* is the short-circuit current temperature coefficient of the solar panels, and *S*is the illumination intensity (kW/m2).

This study used Sharp NUS0E3E solar modules, each with a power rating of 180 W, as the photovoltaic device of the microgrid system. This study used a solar 5 kW power system, generated by two photovoltaic arrays in parallel, where each arraywas built with 14 solar panels in series[5]-[6].

B.Lithium-Ion Battery Modeling

Eq. (3) is the discharge equation and (4) the charge equation of the lithium-ion battery

$$f1\ (it\ i^*i) = E0 - K \cdot \frac{Q}{Q-it} .i^* \text{-} k.\frac{Q}{Q-it}.\ it + A.\exp(\text{-}B.it)\ (3)$$

$$f2\ (it\ i^*i) = E0 - K \cdot \frac{Q}{it-0.1.Q} \cdot i^* - K \cdot \frac{Q}{it-0.1.Q} \cdot i^* - K \cdot \frac{Q}{Q-it} \cdot i^* + A \cdot \exp(-B \cdot it) \qquad (4)$$

where *E*0 is initial voltage (V), *K* is polarization resistance (Ω),*i*∗ is low-frequency dynamic current (A), *i* is battery current (*A*),itis the battery extraction capacity (Ah), *Q* is maximum battery capacity (Ah), *A* is exponential voltage (V), *B* is exponential capacity (Ah)−1 .SOC of the battery is an important factor, which is calculated by SOC = 100[7]-[10].

C. Fuel Cell Modeling

Fuel cells provide a high efficiency clean alternative to today's power generation technologies. The polymer electrolyte membrane (PEM) fuel cell has gained some acceptance in medium power commercial applications such as creating backup power, grid tied distributed generation, and electric vehicles [1]. Theoutput voltage *E* of the PEM fuel cell is represented as

$E = En - (-Vact + Vohm + Vcon)$ (5)

where *En* is Nernst voltage, *V*act is the activation over potential, *V* ohm is ohmic over potential, and *V* con is concentration.[11]-[14].

III ENERGY MANAGEMENT SYSTEM

As shown in Fig. 1, the system configuration of the proposed dc micro grid system includes five major blocks. To design an accurate controller of the proposed micro system, the dynamic mathematical models of the power sources (PV, fuel cell), dc/dc converters (buck-boost, buck, and phase shifted full-bridge converters), bidirectional converter (symmetrical full-bridge converter), and bidirectional inverter (full bridge inverter) of the integrated micro-system are necessary.[15]

However, the modeling, analysis, and design of the proposed integrated dc micro system are not simple. To maintain the battery SOC with EMS, the fuzzy controller is needed to meet design specifications, because the control for EMS is a low response component and the models of dc/dc converters, dc/ac converters of the micro-dc micro grid system are unnecessary. Additionally, the dc micro system is a nonlinear system and fuzzy logic can offer a practical way for designing nonlinear control systems.

Fuzzy control theory is designed and implemented in EMS for the dc micro grid system to achieve the optimization of the system. The design criterion requires that both the photovoltaic device and the wind turbine are supplied by a maximum power point tracker to maintain the maximum operating point. The difference between actual load and total generated power is taken into account for Li-ion battery in charge and discharge modes. The life cycle and SOC of the battery are in direct proportion. To improve the life of the Li-ion battery, we can control and maintain the SOC of battery with fuzzy control.

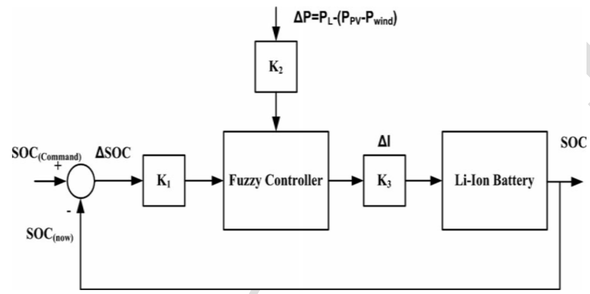

Figure 3 Block diagram of fuzzy control to maintain the desired SOC of the battery.

A)*Fuzzy Control*

Fuzzy control is a tool of quantitative expression for concepts that could not be clearly defined. A fuzzy control system is based on fuzzy-logic thinking in the design of how a controller works. The so-called fuzzy logic is to establish a buffer zone between the raditional zero and one, with logic segments of none-zero and none-one possible.

It allows a wider and more flexible space in logic deduction for the expression of conceptual ideas and experience. A fuzzy controller differs from a raditional controller in that it employs a set of qualitative rules defined by semantic descriptions

The fuzzy controller is applied in the proposed microgrid power supply system, as shown in Fig.3.To obtain the desired SOC value, the fuzzy controller is designed to be in charging mode or discharging mode for the proposed microgrid system. The input variables of the fuzzy control are ΔSOC and Δ*P* and output variable is Δ*I*. The definition of input and output variables are listed as follows:

$\Delta SOC = SOCcommand - SOCnow$

$\Delta P = PL - Ppv$

The power difference Δ*P* is between required power for load and the total generated power of the microgrid. The fuel cells only provide base power for the emergency loads when the system fails. The generated power comes from solar power *P*pv, wind turbine *P*wind and power load *PL* for the proposed system. The input and output membership functions of fuzzy control contain five grades: NB (negative big), NS (negative small), ZO (zero), PS (positive small), and PB (positive big). If the Δ*P* is negative, it means that the renewable energy does not provide enough energy to the load. Thus, the battery must operate in charging mode; if the ΔSOC is negative, it means that the SOC of the battery is greater than the demand SOC. Thus, the battery must operate in discharge mode.[16].

V SIMULATION RESULTS

The simulation result for the proposed system using fuzzy controller is in below figures. The fig 4 gives the output voltage and power of solar power. The figure 5 shows the overall simulation diagram. Where the system has pv system, fuel cell, battery and the load. The figure 6 shows the output of the simulation .

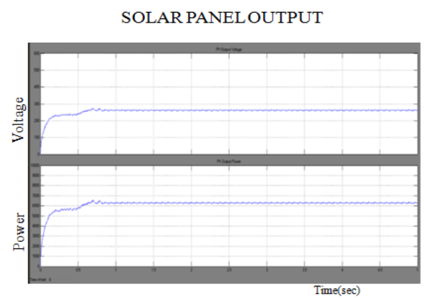

Figure 4 output voltage of solar

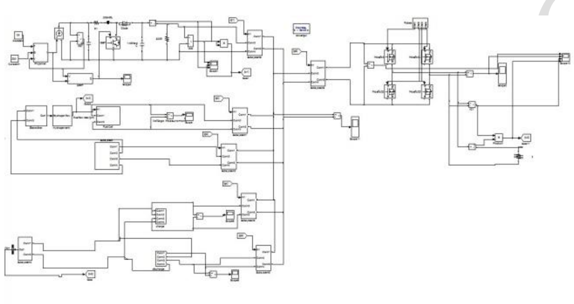

Figure 5 Overall simulation diagram

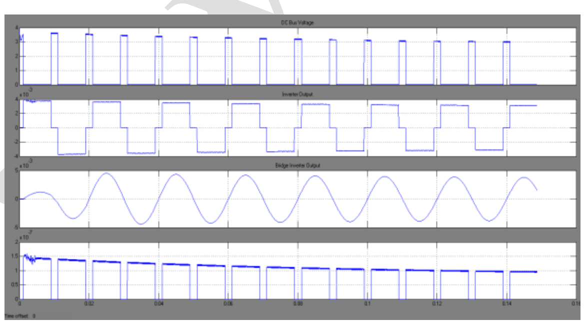

Figure 6 output of the system

V. CONCLUSION

This paper presents the modeling, analysis, and design of fuzzy control to achieve optimization of an energy management system for a dc microgrid system. From the simulation results, the system achieves power equilibrium, and the battery SOC maintains the desired value for extension of battery life by using the control rules for a dc microgrid. Additionally, the optimization rules can be included in the intelligent microgrid management system, and the system can conduct data communication and control operating status of subsystems. The management system takes advantage of the design to control microgrid with power equilibrium, and achieves optimal control of the dc micro grid system.

REFERENCE

[1] Tao Zhou and Bruno François, *Senior Member, IEEE* "Energy Management and Power Control of a Hybrid Active Wind Generator for Distributed Power Generation and Grid Integration" ieee transactions on industrial electronics, vol. 58, no. 1, january 2011

[2] AchrafAbdelkafi, LotfiKrichen, "Energy Management Optimization of a Hybrid Power Production UnitBasedRenewable Energies,"Electrical Power and Energy Systems 62 (2014) 1–9.

[3] Rong-JongWai, Shih-JieJhung, Jun-JieLiaw and Yung-Ruei Chang, "Intelligent Optimal Energy Management Systemfor Hybrid Power Sources IncludingFuel Cell and Battery," IEEE transactions on power electronics, vol.28, no. 7, July2013.

[4] Tao Zhou and Bruno François,"Energy Management and Power Control of a Hybrid Active Wind Generator for Distributed Power Generation and Grid Integration," IEEE transactions on industrial electronics, vol. 58, no. 1, January2011.

[5] M. H. Nehrir, C. Wang, K. Strunz, H. Aki, R. Ramakumar, J. Bing, Z. Miao, and Z. Salameh, "A Review of Hybrid Renewable/Alternative Energy Systems for Electric Power Generation: Configurations, Control, and Applications," IEEE transactions on sustainable energy, vol. 2, no. 4, October 2011.

[6] Malathy S. and Ramaprabha R," Modelling and simulation of matlab/simulink based lookup table model of solar photovoltaic module," ARPN Journal of Engineering and Applied Sciences, VOL. 8, NO. 11, NOVEMBER 2013

[7] Xu She, Alex Q. Huang, FeiWanga and Rolando Burgos, "Wind Energy System withIntegrated Functions of Active Power Transfer, Reactive Power Compensation, and Voltage Conversion," IEEE transactions on industrial electronics, vol. 60, no. 10, October 2013.

[8] Natalia Angela Orlando, Marco Liserre, Rosa Anna Mastromauro and AntonioDell'Aquila, "A Survey of Control Issues in PMSG-Based Small Wind-Turbine

Systems," IEEE transactions on industrial informatics, vol. 9, no. 3, August 2013.

[9] MehmedEroglu, ErkanDursun,SuatSevencan,Junseok Song,SuhaYazici Osman Kilic,"A Mobile Renewable House using PV/Wind/Fuel Cell Hybrid Power System,"International journal of hydrogen energy 36 (2011).

[10] Pablo Garcia,Juan P.Torreglosa,Luis M.Fernandez, "Optimal Energy Management System for Stand-alone Wind turbine,Photovoltaic,Hydrogen,Battery Hybrid system with Supervisory Control based on Fuzzy Logic,"Elsevier journal of hydrogen energy 38(2013) 14146-14158.

[11] Yun Wanga,Ken S.Chen Jeffrey Mishler,Sung Chan Cho,Xavier CordobesAdroher, "A Review of Polymer Electrolyte Membrane Fuel Cells Technology, Applications and needs on Fundamental Research,"Applied Energy 88 (2011) 981–1007.

[12] S.J. Peighambardoust,S. Rowshanzamir,M. Amjadi,"Review of the Proton Exchange Membranes for Fuel Cell Applications," International Journal of hydrogen energy 35 (2010).

[13] Mustafa A. Al-Refai, "Matlab/Simulink Simulation of Solar Energy StorageSystem, "International Journal of Electrical, Robotics, Electronics and Communications Engineering" vol. 8, no. 2, 2014.

[14] F.Méziane,A. Khellaf and F.Chellali, "Study and dimensioning of aWindElectrolyzer-Fuel Cell System for the Power Supply of an Isolated Site,"Revue des EnergiesRenouvelables SIENR'12 Ghardaïa (2012) 381 – 391.

[15] Thanaa F. El-Shatter,Mona N. Eskander, Mohsen T. El-Hagry, "Energy Flow and Management of a Hybrid Wind/PV/Fuel Cell Generation System,"Energy Conversion and Management 47 (2006) 1264–1280