POULTRY FARM COOLING SYSTEM BASED HYBRID DC MICROGRID

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Abstract- Since the fossil fuel exhausting and causes environmental problems, renewable energy is developing rapidly. More and more importance has been given in power generation through Renewable Energy Resources (RERs) worldwide to reduce the global warming. Many research works on DC microgrid have been conducted to facilitate the integration of various Distributed Energy Resources (DERs) and Energy Storage System (ESS). In recent years, the research attention on DC grids has been resurging due to technological advancements in power electronics and energy storage devices, and increase in the variety of dc loads and the penetration of DERs such as wind, solar, fuel cells and bio-gas etc., Many research activities are being done to harness more generation from DERs and flexible control of the above generation. An Adaptive Neuro-Fuzzy Inference System (ANFIS) based Energy Management System (EMS) is proposed to control inverters in Grid connected hybrid DC microgrid system. The hybrid system consists of Wind Turbines (WTs) and Solar Photovoltaic (PV) as a primary energy sources. The Grid connected DC microgrid system is designed to satisfy the load requirement efficiently and in case if the demand is low it will return the excess power to the AC Grid also. The operational capability of proposed Hybrid DC microgrid design concept is verified through various test conditions and the results obtained are discussed.

Keywords: Wind, Solar, Distributed Energy Resources, DC microgrid, Energy Storage System, Energy Management System, ANFIS

1. Introduction

The electricity requirements of the world including India are increasing at alarming rate and the power demand has been running ahead of supply. It is also now widely recognized that the fossil fuels (i.e., coal, petroleum and natural gas) and other conventional resources, presently being used for generation of electrical energy, may not be either sufficient or suitable to keep pace with ever increasing demand of the electrical energy of the world. Also generation of electrical power by fossil fuel based steam power plant causes pollution, which is likely to be more acute in future due to large generating capacity on one side and greater awareness of the people in this respect.

The recent severe energy crisis has forced the world to develop new and alternative methods of power generation. Energy generation from RERs is the solution, because it is unlimited and environment friendly. This proposed system is deals with Energy generation from RERs and their efficient control and utilization.

To ensure that the poultries remain productive, the poultry farms are required to be maintained at a comfortable temperature. Cooling fans, with power ratings of tens of kilowatts, are usually installed to regulate the temperature in the farms. Besides cooling the farms, the wind energy produced by the cooling fans can be harnessed using wind turbines (WTs) to reduce the demand on the grid. The major difference between the situation in poultry farms and common wind farms is in the wind speed variability. The variability of wind speed in wind farms directly depends on the environmental and weather conditions while the wind speed in poultry farms is generally stable as it is generated by constant-speed ventilation fans. Thus, the generation intermittency issues that affect the reliability of electricity supply and power balance are not prevalent in poultry farm wind energy systems.

Instead of one converter each for solar and wind energy system, standby converters should be provided to increase wind and solar generation reliable utilization.

Roof top solar system is proposed to harness the solar power. Since the roof top solar system is a fixed arrangement, there is no need of MPPT control system. The generation intermittency issues in solar generation due to environmental conditions can be suitably managed with the ESS and AC grid.

The criteria for synchronization in DC micro grid is only voltage as against the complex parameters like frequency, voltage and phase in AC grid and hence provides flexibility in controlling plug and play of generating units.

Micro grid is a group of interconnected loads and DERs within clearly defined electrical boundaries that acts as a single controllable entity with respect to the grid. A micro grid can connect and disconnect from the grid to enable it to operate in both grid-connected or island mode.

At any point of time, the entire system should satisfy load requirement efficiently. For this an ANFIS based EMS is proposed.

In future, DC loads will be a part and parcel of the electrical system. Variety of DC loads such as lighting, Electronic system, plug-in hybrid electric vehicle (PHEV) etc., will find a very important role.

By suitably controlling the DERs, DC grid, Energy Storage System and with the assistance of AC grid, Remote Area Power Supply (RAPS) efficiency, Reliability and Robustness can be improved.

2. Literature Survey

Many paper deals with the RERs integration and efficient ESS and their optimal control for reliable EMS in grid. Since the generation from RERs is generally intermittent, the power supply variability is the biggest concern. It is very important to predict the present generation and associated variability and also predict generation availability for efficient EMS. In order to predict the generation availability, optimal utilization and efficient control of the entire grid, various logic controls are used. The ESS is always associated with microgrid and important for storing excess energy from RERs and supply power at the time of requirement.

Various types of generators (PMSG and DFIG etc.,) available in WT energy generation, their efficiency and selection of generators for the particular applications are discussed. Various types of ESS available and their role in EMS are also discussed. Fast and reliable communication system is also necessary for executing the control operations in fast and reliable manner.

Standalone and Grid connected wind, solar system are discussed with their merits and demerits. Hybrid energy generation and their effective utilization and control are discussed.

AC distribution and DC distribution are analyzed and their merits and demerits also discussed.

Various control techniques are used and some of them are: PID control, voltage droop control, fuzzy control, genetic algorithms, Model predictive control, optimal power flow and pricing. Quality and Reliable power delivery to consumers at low cost is also considered.

3. Existing Method

Cooling fans, with power ratings of tens of kilowatts, are usually installed to regulate the temperature in the poultry farms. Besides cooling the farms, the wind energy produced by the cooling fans can be harnessed using wind turbines (WTs) to reduce the demand on the grid. The major difference between the situation in poultry farms and common wind farms is in the wind speed variability. The variability of wind speed in wind farms directly depends on the environmental and weather conditions while the wind speed in poultry farms is generally stable as it is generated by constant-speed ventilation fans. Thus, the generation intermittency issues that affect the reliability of electricity supply and power balance are not prevalent in poultry farm wind energy systems.

Battery Storage System is used as a buffer for storing excess energy from RERs and supplies the energy during the period of demand supply mismatch.

A model-based model predictive control (MPC) design is used for efficient EMS.

4. Proposed Method

Besides cooling the farms, the wind energy produced by the fixed speed cooling fans can be harnessed using wind turbines (WTs) to reduce the demand on the grid. Thus, the generation intermittency issues that affect the reliability of electricity supply and power balance are not prevalent in poultry farm wind energy systems. Roof top solar system is proposed to harness the solar power. The variation in generation from solar due to environmental conditions can be suitably managed with the Battery Storage system. Since the fixed speed wind turbine and fixed roof top solar system is proposed and hence no need of MPPT control. Hence, less complex control system is enough.

The criteria for synchronization in DC micro grid is only voltage as against the complex parameters like frequency, voltage and phase in AC grid and hence provides flexibility in controlling plug and play of generating units.

Wind generation is constant and will be available throughout the year in poultry farm based wind generation. But, solar generation availability is based on season and climatic condition. Whenever the solar generation available, it can be utilized to feed the load and assistance from AC distribution grid can be reduced.

An Adaptive Neuro-Fuzzy Inference System (ANFIS) based EMS for DC microgrid application is proposed.

There are six major areas in this system: RERs (WT and solar PV), DC mirogrid, Bi-directional inverters, Storage system, Point of Common Coupling (PCC), DC and AC loads. Efficient, Reliable and Economic EMS is done through ANFIS.

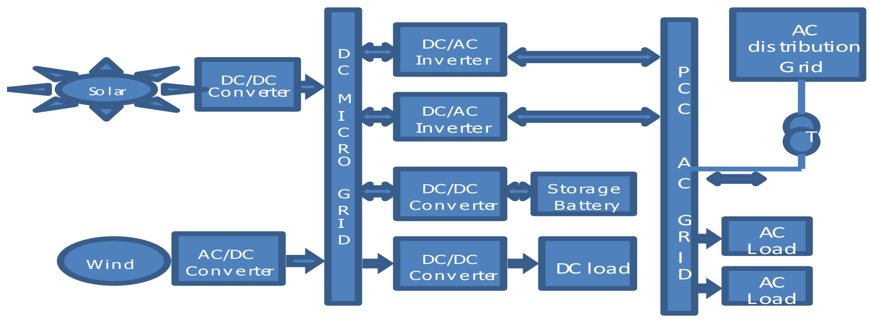


Fig.1. Overall block diagram configuration of proposed Hybrid DC microgrid system

System operation:

This system can operate either grid connected or islanded mode. AC output from Wind generators and DC output from solar generators are converted to DC voltage of desired level by the converters. The criteria for synchronization in DC grid is only voltage as against complex parameters like frequency, voltage and phase in AC grid and provides flexibility in controlling plug and play of generating units. The DC grid will supply DC loads by reducing another AC/DC conversion. A battery storage system will act like a buffer in managing demand supply gap. The storage system will be charge at its full capacity by the bi-directional converters. Inverter 1 & 2 will act as standby to each other. The reliability of power delivery will greatly improved by the standby inverter. The DC supply is converted to AC by bi-directional inverters and fed to the point of common coupling (PCC).

From PCC, AC loads can be fed through breaker and isolators. The coordination of the converters and inverters is achieved through a centralized ANFIS based EMS. Distribution grid AC supply will be utilized during normal operations, and feed the excess load requirement in case of DERs generation failure in grid connected microgrid system.

During the time of energy shortage, shedding of unimportant load will be done by the EMS to ensure reliability of system and vital consumers. During islanded operation, ESS will supply the load temporarily depends on the capacity. In grid connected microgrid system, exchange of power from and to AC distribution grid is possible depends on the DERs generation availability.

Advantages: 1) No intermittency problem from wind energy source. 2) Fixed Roof top solar system. 3) No MPPT requirement for wind and solar. 4) Storage system can be optimized based on the RERs generation and load requirement. 5) More generation expansion can be pumped to grid through additional battery storage and converters.

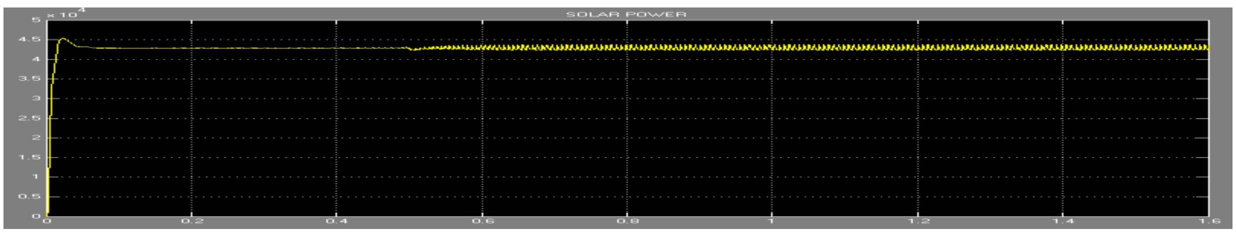
5.Simulation Analysis

The operational capability of proposed Hybrid DC microgrid design concept is implemented in MATLAB/Simulink and verified through various test conditions and the results obtained are discussed.

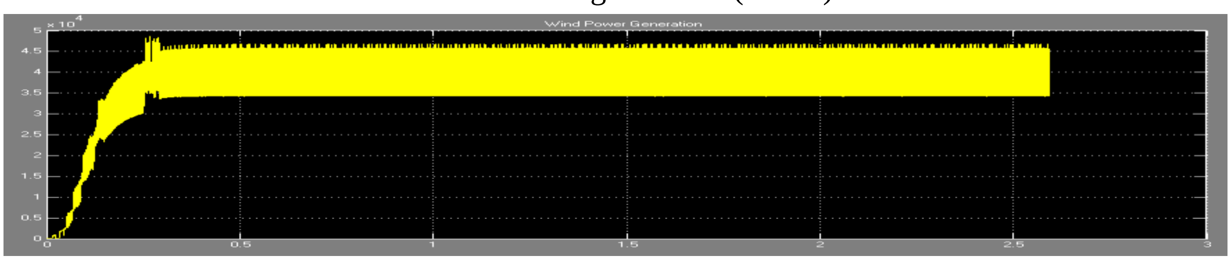
A. Test case 1: Solar – Wind generation maximum in Grid-connected operation

During the noon time and summer, solar generation will be maximum and is about 40 Kw. The wind generation is constant of about 45 kw. The DC load will take 10 kw from DC grid. The ESS is at the fully charged condition. The remaining 75 kw is converted by inverters 1 and 2 into 70 kw and fed to PCC. The AC load of 100 kw will be fed by RERs and AC distribution grid. 70 kw from RERs generation and 30 kw from AC distribution grid.

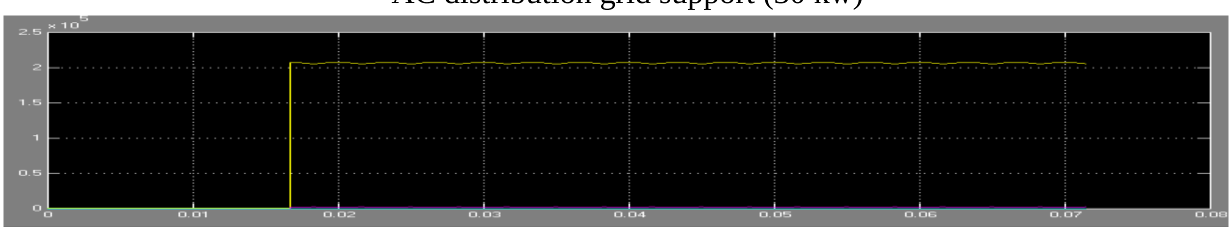
Solar Power generation (40 kw)



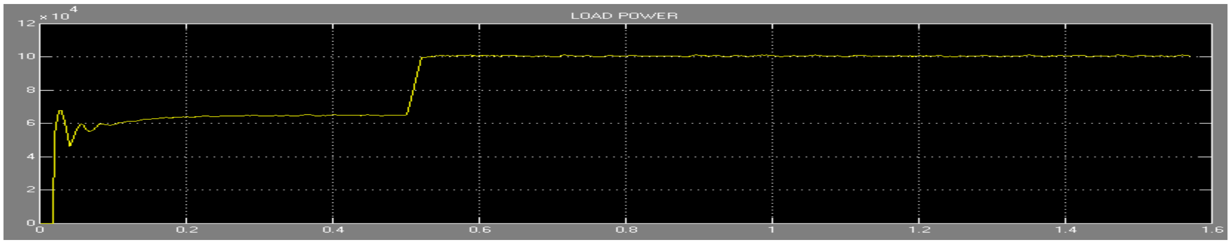
Wind Power generation (45 kw)



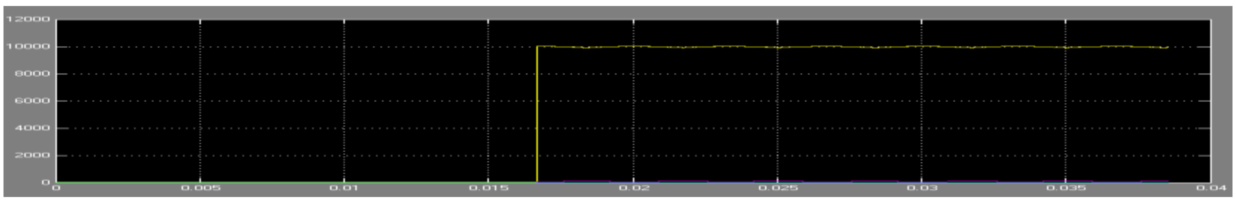
AC distribution grid support (30 kw)



AC Load power (100 kw)



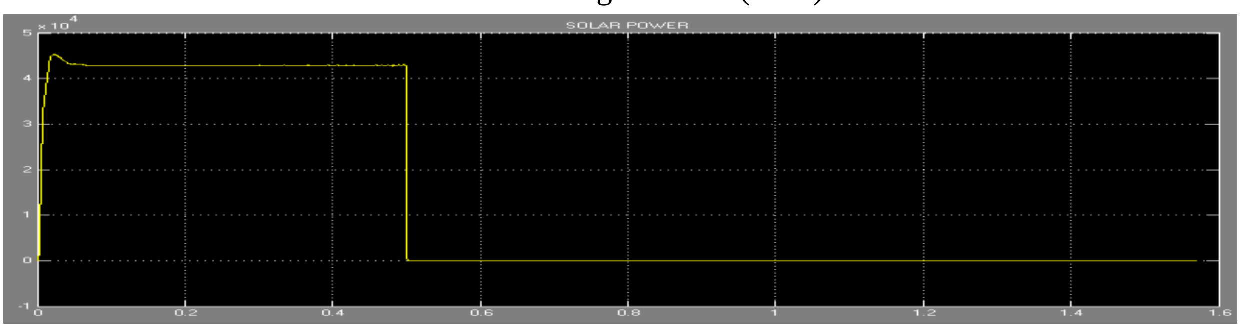
DC Load power (10 kw)



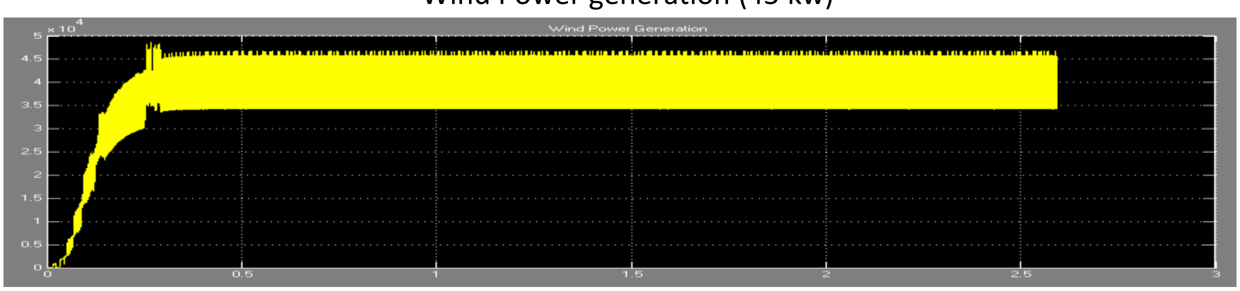
B. Test case 2: No Solar – Wind generation only in Grid-connected operation

During the night time and winter, solar generation will be 0 Kw. The wind generation is constant of about 45 kw. The DC load will take 10 kw from DC grid. The remaining 35 kw is converted by inverters 1 and 2 into 30 kw and fed to PCC. The AC load of 100 kw will be fed by RERs and AC distribution grid. 30 kw from RERs generation and 70 kw from AC distribution grid. The increased AC distribution grid support is done by ANFIS controlled EMS.

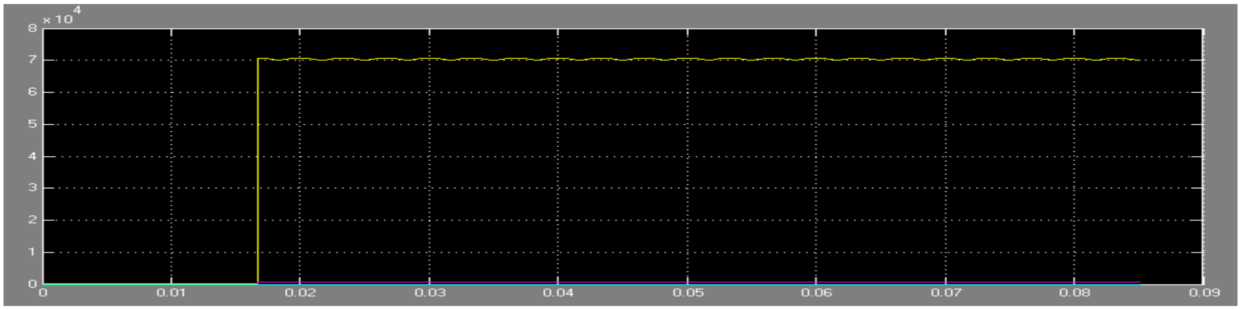
Solar Power generation (0 kw)



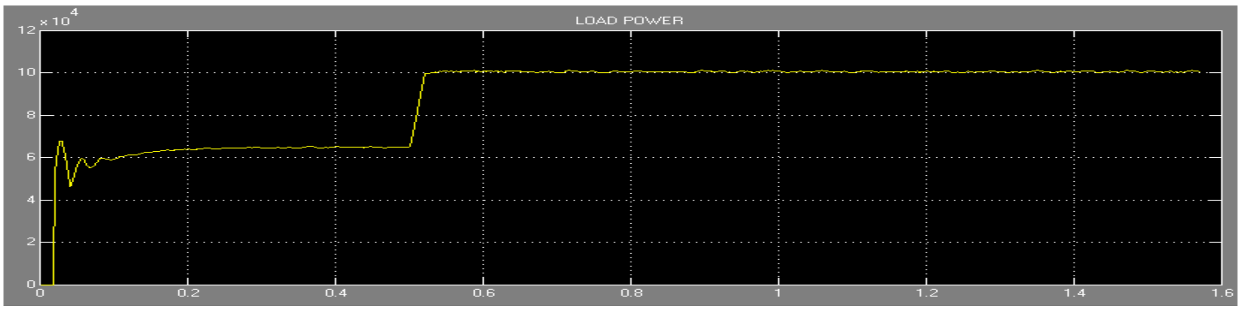
Wind Power generation (45 kw)



AC distribution grid support (70 kw) – Additional support received



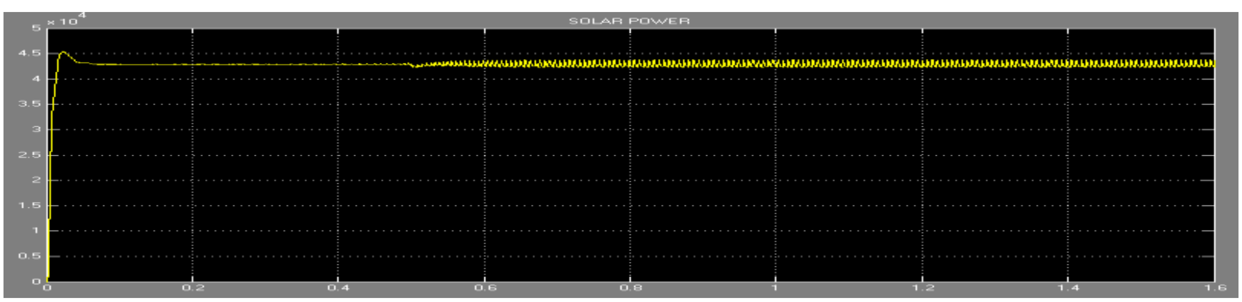
AC Load power (100 kw)



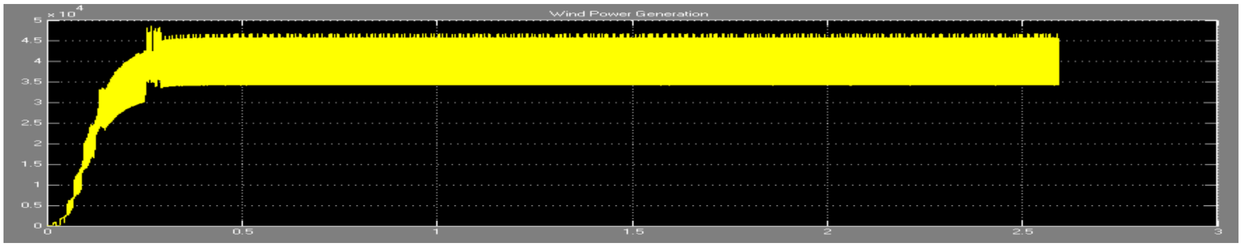
C. Test case 3: Islanded operation

When the microgrid operates islanded from the AC distribution grid, the total generation will be insufficient to supply for all the load demand. Under this condition ESS is required to supply the necessary power to ensure that the microgrid continues to operate stably. During that time, solar generation will be 40 Kw. The wind generation is constant of about 45 kw. The DC load will take 10 kw from DC grid. The remaining 75 kw is converted by inverters 1 and 2 into 70 kw and fed to PCC. The AC load of 100 kw will be fed by RERs with the assistance of ESS. The shortage of 30 kw will be immediately supplied through ESS by ANFIZ controlled EMS.

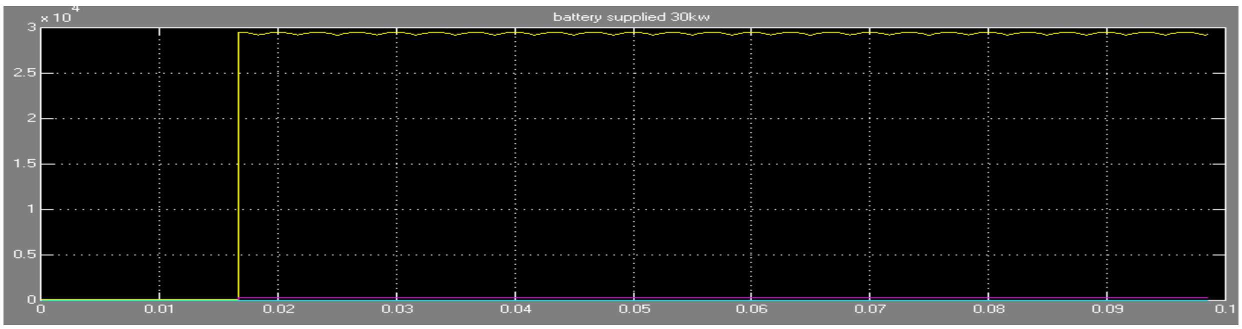
Solar Power generation (40 kw)



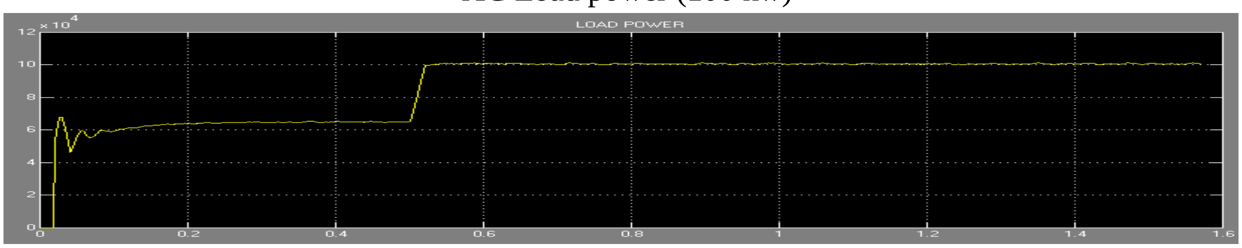
Wind Power generation (45 kw)



Battery Power generation (30 kw)



AC Load power (100 kw)



6. Conclusion

This project analysis and discuss about an ANFIS-based EMS of a grid-connected hybrid system for DC microgrid which is composed of RERs (Wind turbine, Solar PV and ESS). ANFIS-based EMS achieves better results, since it presents higher hybrid system efficiencies, and it is capable of injecting more energy into grid in quick than compare to the classical EMS. The results of simulation demonstrated that the proposed EMS allows a better control than the classical EMS and reliable operation in grid-connected application. The operation shows the right dynamic response of the hybrid system and inverter against sudden power variations and its effect on the DC bus voltage and waveform of the inverter output voltage and current. In this case, the inverter controlled with ANFIS presents lower error indexes. The operational feasibility was verified by MATLAB Simulation.

References

[1] K. T. Tan, Member, IEEE, B. Sivaneasan, Member, IEEE, X. Y. Peng, Student Member, IEEE, and P. L. So, Senior Member, IEEE, "Control and Operation of a DC Grid-Based Wind Power Generation System in a Microgrid".

[2] Nishad Mendis, Student Member, IEEE, Kashem M. Muttaqi, Senior Member, IEEE, Saad Sayeef, Member, IEEE, and Sarath Perera, Member, IEEE," Standalone Operation of Wind Turbine-Based Variable Speed Generators With Maximum Power Extraction Capability, IEEE Trans. Energy Convers., vol. 27, no. 4, pp. 822–834, Dec. 2012.
[3] Tomislav Dragi cevi´c, Student Member, IEEE, Josep M. Guerrero, Senior Member, IEEE, Juan C. Vasquez, Member, IEEE, and Davor Skrlec, Member, IEEE, "Supervisory Control of an Adaptive-Droop Regulated DC Microgrid with Battery Management Capability".
[4] Lie Xu,Senior Member, IEEE, and Dong Chen,"Control and Operation of a DC Microgrid With Variable Generation and Energy Storage".
[5] Dong Chen, Lie Xu, Senior Member, IEEE, and Liangzhong Yao, Senior Member, IEEE, "DC Voltage Variation Based Autonomous Control of DC Microgrids".
[6] Gedeon Niyitegeka, Jaeho Choi, and Yeonho Ok, " Improved Droop Control for Effective Load Sharing and Voltage Regulation in DC Microgrids".Chendan Li1, Federico de Bosio2, Sanjay K. Chaudhary1, M. Graells3, Juan C. Vasquez1, and Josep M. Guerrero1
[7] Microgrid Research Programme www.microgrids.et.aau.dk 1Department of Energy Technology, Aalborg University Aalborg, Denmark, "Operation Cost Minimization of Droop-Controlled DC Microgrids Based on Real-Time Pricing and Optimal Power Flow".
[8] Xiong Liu, Student Member, IEEE, Peng Wang, Member, IEEE, and Poh Chiang Loh, Member, IEEE, "A Hybrid AC/DC Microgrid and Its Coordination Control".
[9] Poh Chiang Loh, Ding Li and Yi Kang Chai School of Electrical and Electronic Engineering Nanyang Technological University Singapore, "Autonomous Operation of Hybrid AC-DC Microgrids with Progressive Energy Flow Tuning".
[10] Intelligent Distributed Generation and Storage Units for DC Microgrids—A New Concept on Cooperative Control Without Communications Beyond Droop Control.
[11] Dan Shen, Afshin Izadian, Senior Member, IEEE Energy Systems and Power Electronics Laboratory Purdue School of Engineering and Technology, Indianapolis 46202, USA, "Sliding Mode Control of A DC Distributed Solar Microgrid"