An Overview on the Design of Micro Grid Control System and Management of Renewable Energy

Engr. Edicha, Enebi Abubakar

Electrical and Electronic Engineering Department, Petroleum Training Institute, PMB 20, Effurun, Nigeria

***Abstract*— This research is about the design and construction of a Micro-gird control system and its ability to manage renewable energy sources. The renewable energy source used in this project is solar energy source and wind energy source. The micro-grid power network is a system for improved effectiveness, unwavering quality and safety with smooth integration of sustainable power source through computerized control. The microcontroller is the fundamental piece of the embedded system. The microcontroller controls the entire system based on the instruction given to it during the installation stage. In this project, a control system is designed and implemented which enables communication between different components of the Micro-grid. Here, the main aim is to implement a micro-grid that can serve the loads connected to each distributed generation (DG) effectively while managing the energy sources.**

***Keywords:* Micro-grid, solar, wind, batteries, energy supply, generation and distribution.**

I. INTRODUCTION

The today's world, the reduction of greenhouse gas emission from the conventional thermal power plants is quite necessary. For the decrease of green house gases from the electrical power sources, the electrical energy producers are presently walking towards utilization of sustainable power sources (RESs) (Bull, 2001). In general, these sources are small incapacity and thus are mostly connected at distribution voltage level and are known as distributed generation (DG). This localized grouping of electricity generation, storage, and loads that normally operate connected to a centralized utility grid is called a Micro-grid.

Aims and Objectives of the Project

The aim of this project is to present optimal configuration and control strategies to ensure secure, reliable and efficient operation of a micro-grid including photovoltaic productions (PV), battery energy storage system (BESS) and any other source of energy which may include wind, biomass, etc. The main objective of the energy management system is to ensure the rational use of energy while minimizing its cost. The objectives of this project are described as follows:

i. Modeling and optimal sizing of a Micro-grid system using renewable energy source such as solar and wind energy.
ii. Reliability of power supply and ensuring diversity of energy supply.
iii. Sustainable distribution of electrical power and improvisation of failure of any other the connected renewable energy source at the load end.

II. MICROGRID STRUCTURE

A Micro-grid is a solitary, controllable, autonomous power system including distributed generation (DG), load, energy storage (ES), and control systems, in which DG and ES are legitimately associated with the client side in parallel. The main components of micro-grid contain multiple distributed energy resources, such as wind turbines and solar panels; local loads, such as commercial and residential; and energy storages, such as batteries and fly wheels. The difficulties of micro-grid include integrating all energy sources, working in a steady and reliable condition, and managing the imbalance among loads and generating sources. The micro-grid can improve the total distribution system by coordinating the generation and load to build the vigor and unwavering quality of the system in both modes of operation.

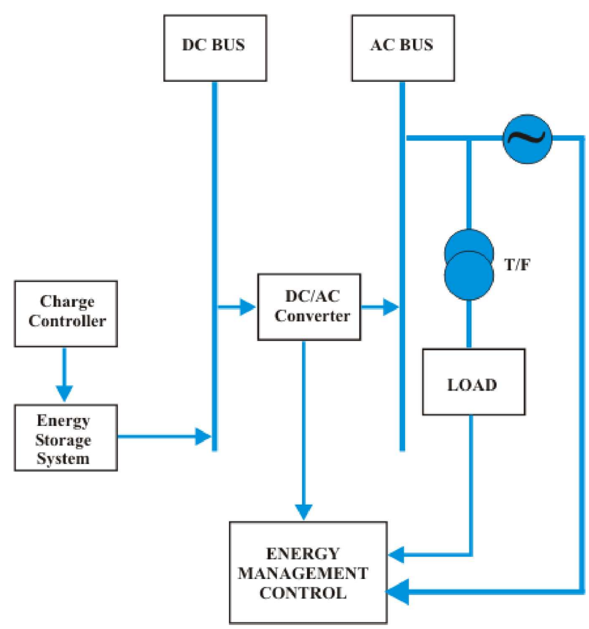

Fig. 1: Block Diagram representation of the micro-grid Control system using solar and Wind energy.

A. Operation modes of the Micro-grid system

A micro-grid may operate either in grid connected or in islanded mode, and grid connected operation.

1. Grid-Connected Operation

In grid-connection mode, the micro-grid is connected to an exchanges power with the distribution system of the utility grid via PCC. Fig. 2, shows the diagram of transfer between operation modes.

i. When the micro-grid stops operation, it can transfer to grid connected mode directly by grid connection control; when it is connected to the grid, it can be disconnected from the grid by disconnection control.
ii. When the micro-grid stops operation, it can transfer to is landed mode directly by disconnection control, and when it is in islanded operation, it can be connected to the grid-by-grid connection control.
iii. The micro-grid can be shut down by shutdown control when operated in parallel with the grid or in islanded mode.

B. Islanded Operation

Islanded activity implies that the micro-grid is detached from the distribution system of the main-grid at the PCC following a grid failure or as booked, and that the DGs, ESs, and loads inside the micro-grid work autonomously. In islanded mode, since the power generated by the micro-grid system itself is commonly small and deficient to satisfy the demand of all loads; it is critically important to prioritize loads dependent on their important and assurance of constant power supply to important loads.

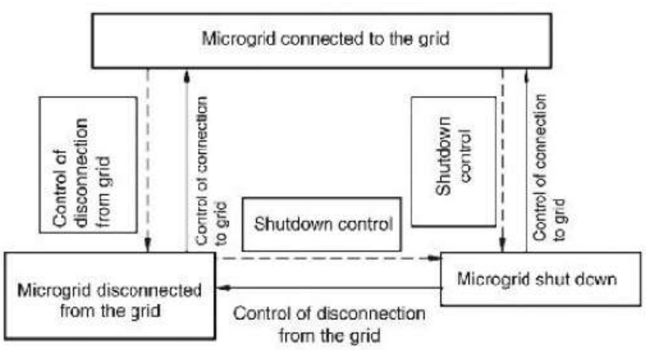

Fig.: 2. Transfer between operation modes

III. SIMULATION OF THE MICROGRID

One of the major function of the micro-grid control system, it's the ability to sustain steady power supply by automatically switching to a more efficient source of renewable available at an instant of time (i.e. where utility source becomes unavailable). Another useful property of the micro-grid, it's in the energy management system, which involves load shedding corresponding to the renewable energy in operation, hence maximizing its efficiency. For the purpose of the project, we would be considering both raining and sunny periods, assuming a fixed value of solar temperature and wind speed respectively.

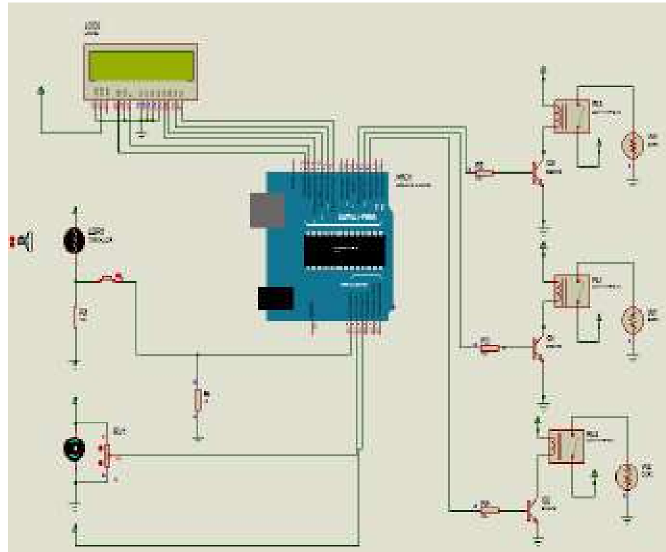

Fig.3.Proposed simulation diagram using proteus design software

A. Rainy day scenario

Ideally, a rainy day period will amount to more wind speed (m/s) as average solar panel surface temperature (^{0}C) tends to its lowest value (minimum). Using Petroleum Training Institute Effurun, Delta state environment as a case study, we take the minimum average temperature to be 16^{o}c corresponding to 0.04v on the simulation meter.

The table1shows the grid simulation for rainy scenario at minimum temperature value for solar panel (16^{o}c at 0.04v).

TABLE 1: GRID SIMULATION FOR RAINY PERIOD

S/N	Average simulation wind speed (volts)	Average wind Speed (m/s)	Power generation (watts)	Load response
1	0.05	0.075	2.9	X
2	0.5	0.15	29.9	✓
3	1.0	1.5	60.1	✓
4	1.5	2.25	90.0	✓
5	2.0	3.00	120.2	✓
6	2.5	3.75	150.2	✓
7	3.0	4.5	180.1	✓
8	3.5	5.25	210.3	✓
9	4.0	6.00	240.2	✓
10	4.5	6.75	270.4	✓

B. Sunny day scenario

Consequently, a sunny day will amount to more solar panel surface temperature (°c), but there will still be some amount of wind speed (m/s), hence, we take the minimum average wind speed on a sunny day to be 0.3m/s corresponding to 0.2v. The table 2 shows the grid simulation for sunny scenario at minimum wind speed value for wind turbine (0.3m/s at 0.2v).

Table 2: Grid simulation for Sunny period

S/N	Average simulation solar panel temperature (volts)	Average solar panel temperature (°c)	Power generation (watts)	Load response
1	0.04	16	2.9	X
2	0.24	17	14.4	✓
3	0.45	18	27.3	✓
4	0.83	20	50.2	✓
5	1.67	22	100.0	✓
6	2.50	23	150.2	✓
7	3.33	25	200.3	✓
8	4.17	30	250.2	✓
9	4.55	31	273.0	✓
10	4.76	32	285.9	✓

IV. RENEWABLE ENERGY GENERATION PATTERN

The renewable energy generation pattern in Figure 4 shows the simultaneous variation of wind and solar generation Synchronized for 24hrs of the day. It can be observed that during the first four hours of the day, the solar power was at its minimum till sunshine period started from 7am. But in this period there was some amount of wind power generation as ample wind velocity was available between 12.01 and 6am. While from 7am to 6pm, solar was mostly in use as it had more efficiency. The remaining hours of the day, the wind was in operation considering the drop solar surface temperature.

Table 3: Input variables for renewable energy sources for a 24hrs day

Time (hours)	Average solar panel surface temperature (°c)	Average wind speed (m/s)
0	16	3.0
1	16	2.9
2	16	2.7
3	16	2.6
4	17	2.7
5	17	2.3
6	18	1.1
7	20	0.8
8	20	0.6
9	22	0.6
10	23	0.6
11	25	0.3
12	32	0.3
13	32	0.4
14	31	0.5
15	30	0.5
16	23	0.4
17	22	0.3
18	20	0.3
19	18	0.8
20	17	0.9
21	17	0.9
22	17	1.1
23	16	2.9

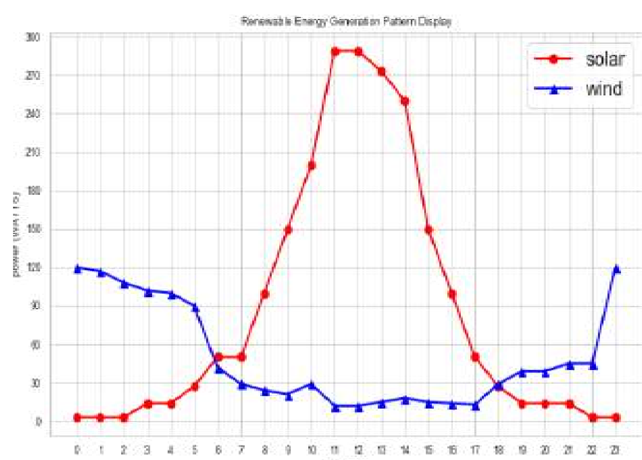

Fig. 4: A Graph of Renewable Energy Synchronization for A 24hours Period

V. LOAD VARIATION PATTERN

As shown in figure 5, the load between 12 to 7am was met by the wind energy. After which, the solar was in operation from 7am to 6pm.Whilefrom 7am to10.30am, the load was consistent hence maintaining constants power consumption during that period of the day. The peak of the load curve occurred at around 7pm amounting to1.8kw in the evening when domestic housing load was powered.

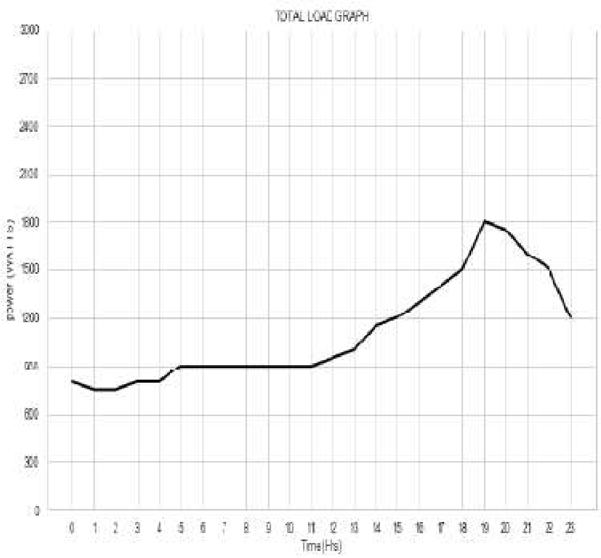

Fig.5: Total load graph

VI. CONCLUSION

The construction of the Micro-grid control system and its energy management was a gradual process from gathering of materials to testing of components and simulation of the project. The project was intended to supply 300watts of energy as model having two renewable energy sources comprising of solar and wind to serve as source of alternative energy besides the utility power generation. The construction was a successful one and worked efficiently as intended. The solar cell and wind turbine acted as a source of charger to the battery and inverting the power stored using an inverter into usable power for any load. The power output was usable form any domestic appliances that are sensitive to having sinusoidal inputs.

VII. RECOMMENDATION

Although the objectives of this project have been achieved, as previously stated, the micro-grid system needs to build a protection based on control to switch a solar panel or a wind turbine instead of all the distributed energies, in view of this, a centralized protection system for the Micro-grid control system should be incorporated to cater for surges that may arise due to sudden load change demand, system failure and soon. Since all the renewable sources are not available at the same time, a combination of various power sources should be deployed to meet the load depending upon the load demand during a particular period. To make the energy management system more reliable, a battery power control mechanism is implemented.

Hence, there would be need to add up more batteries to meet up with the running time and the system load capacity since the system had an adjusted wattage. That is more batteries could be added to increase the capacity of the system to accommodate more load.

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