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Research Paper

Microgrid Simulation with Matlab/Simulink Components

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ABSTRACT

A microgrid was modeled and simulated with matlab/simulink components for the Federal University of Agriculture Abeokuta (FUNAAB), Ogun State to manage the power supply challenge because Power supply is becoming more complex as a result of increasing population, expansion and improper planning of government and individuals. To address this trend, there is need to develop a model capable of efficiently managing the power supply system. In this study Electrical loads and facilities audits were carried within the University campus. Matlab/simulink was used to model a microgrid for FUNAAB. The modeled microgrid of the proposed power houses was simulated and the waveforms obtained were compared with that of Power Holding Company of Nigeria (PHCN). Facilities audit revealed that FUNAAB had a total power generator rating of 6130kVA. From the load audit the generator capacity could be aggregated into three power houses of 2 x 2000kVA and 1 x 1950kVA. The remaining 3 x 60kVA generators were left unaggregated to serve as auxiliary/back up. The total power from PHCN was 2100kVA and 2 x 2000kVA for the proposed power houses 1 and 2 when synchronized. Comparison of PHCN power waveform and that of proposed power houses 1 and 2 showed that these proposed power houses could adequately supply the whole power network of FUNAAB. However, there would be need to upgrade the power transformer of rating 2000kVA (11/0.415kV) to 2 x 2500kVA (11/ 0.415kV) for this purpose and for future expansion. The proposed power house 3 could then serve as a backup. The modeled microgrid could be used in the development of supply infrastructure for estates, communities, organizations and establishments.

KEYWORDS*: Modeled, developed, supply, expansion, backup, establishment*

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I. INTRODUCTION

Microgrid is an aggregation of loads and micro sources operating in as a single system providing both power and heat. The majority of the micro sources must be power electronics based to provide the required flexibility to insure operation as a single aggregated system. This control flexibility allows the microgrid to present itself as a single controlled unit which meets local needs for reliability and security. In addition microgrids have the capability to isolate themselves from the utility power grid in case of faults in the grid, in order to protect the micro sources and loads within the microgrid. This operation is called the islanded mode, in which the microgrid operates independently until stability is restored in the utility grid. Microgrid contains an energy manager within them which is responsible for maintaining balance between energy demand and supply within the microgrid by the use of energy management strategy, while making sure certain criteria such as minimizing operating cost, fuel consumptions, emissions etc are met. A microgrid is a collection of distributed power generators and loads acting together, (Lasseter *et al.*, 2002).

Micro grid is a power supply network in which a cluster of small on-site generators provide power for a small community such as homes, parks, and office buildings. The increasing interest in micro grid is changing the dependency on the conventional centralized power system. In a centralized power system, power is transmitted from a large source to several utilities through a transmission line and a centralized control and hence can create shortcomings in the efficiency power supply. During disturbances, the generation and the loads of a micro grid can be separated from the main distribution system to isolate the loads from the disturbance and thereby maintaining the continuity and reliability of the service without harming the main transmission grid, (Robert and Paolo, 2004).

In the micro grids, alternative energy sources such as renewable can be integrated with local consumptions (Katiraci et al., 2005) and are more efficient and initiate less environmental issues. This, in turn, enables performance optimization and enhances the supply reliability (Moldernik et al., 2010). Furthermore, since micro grids are to be on or near the site which they are to supply, losses due to transmitting electricity is relatively minimized, which makes micro-grids even more useful (Marshal, 2004). Finally, micro grids can be modified according to the needs of the site it will be servicing. For example, it can be used only for lighting purpose or for working on big machinery.

As discussed earlier, micro grid encourages the use of renewable energy sources. Although renewable energy resources, such as wind and solar, enhance the generation capability of a micro grid and address the environmental concerns (Leite da Sila, 2010 et al.,), they impose economic operation and stability challenges to the micro grid due to their unpredictable nature. Power fluctuations caused by intermittent nature of the renewable should be smoothed to serve the demand more appropriately and competently. Modern micro grids are regarded as small power systems that confine electric energy generating facilities, from both renewable energy sources and conventional synchronous generators, and customer loads with respect to produced electric energy (Smallwood, 2002). They can be connected to the main grids or operated as isolated power systems (Katiraci *et al., 2005*).

Justification for Microgrids

The arrangement of a modern large power system offers a number of advantages.

Large generating units can be made efficient and operated with only relatively small number of personnel. The interconnected high voltage transmission network allows the generator reserve requirement to be minimized, the most efficient generating plant to be dispatched at any time, and bulk power to be transported large distances with limited electrical losses. The distribution network can be designed for unidirectional flows of power and sized to accommodate customer loads only. However, over the last few years a number of influences have combined to lead to the increased interest in micrografts schemes (Jenkins, 2000). The policy drivers encouraging microgrids are:

a. Reduction in gaseous emissions (Carbon monoxide).
b. Energy efficiency.
c. Deregulation.
d. Diversification of energy sources.
e. National power requirement.

II. METHODOLOGY

This chapter explained the methodology adopted in this research. It explains the study designs, materials and methods that were adopted from collecting data from the field and how it was applied to model of the microgrid.

The data used in this study were from works and services of this university; data were collected from logbooks and were analyzed with Matlab. The materials used were: Utility grid, transformers ratings and generators ratings in the university Matlab / Simulink package allows for the following: Simulation and Management of data.

Method

The objectives were achieved by simulations. Firstly, a micro grid model was developed, which comprise of a utility grid, generators, transformers, loads, and the simulation was performed by matlab/simulink version R2012a.

Table 3: List of transformers and generators in FUNAAB

S/N	Equipment	Rating (kVA)	Type	No
1	Transformer	2000	Power transformer	1
2	Transformer	2500	Power transformer	1
3	Transformer	500	Distribution transformer	16
4	Transformer	300	Distribution transformer	4
5	Generator	1000	Low voltage	1

6	Generator	800	Low voltage	1
7	Generator	500	Low voltage	4
8	Generator	250	Low voltage	5
9	Generator	200	Low voltage	3
10	Generator	100	Low voltage	3
11	Generator	60	Low voltage	3

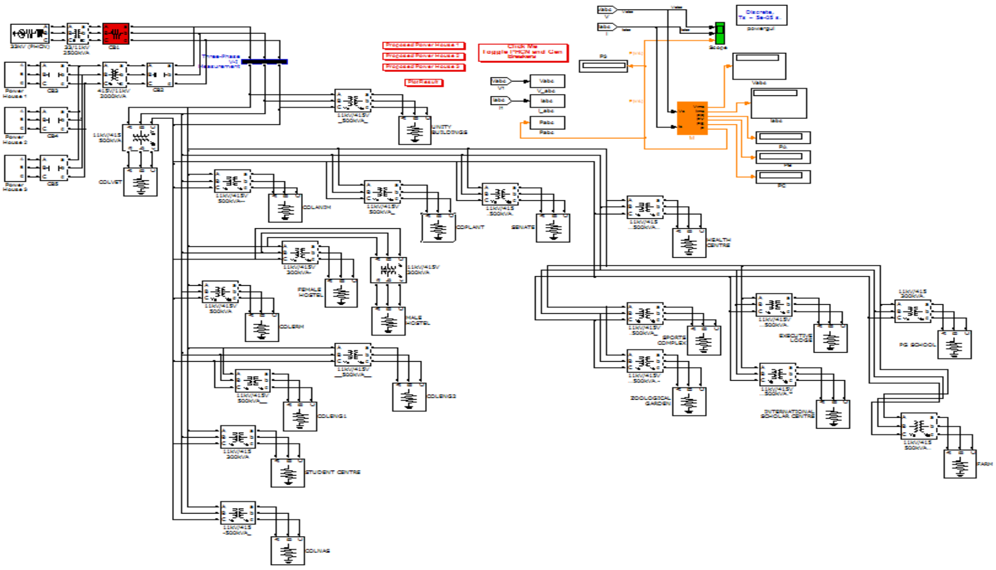

Figure 1: Microgrid developed for Federal University of Agriculture,Abeokuta**.**

Simulation of microgrid

The simulation of microgrid was done after Sympower systems block was utilized to assemble the circuit as showed in Figure 1, Figures 3 and 4 showed microgrid simulation voltage and current to the network and Figure 2 showed simulation power with connection to PHCN. Also, Figures 6 and 7 showed microgrid simulation with connection to proposed power house 1 and Figure 8 showed the microgrid simulation when synchronized proposed house 1 and 2.

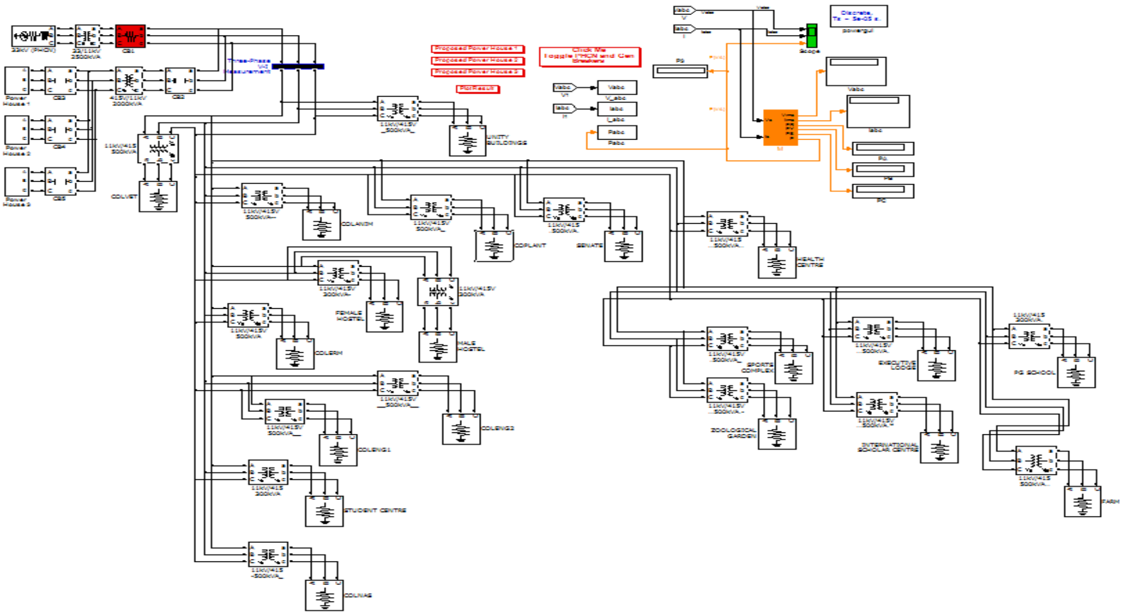

Figure 2: Microgrid Simulink model connected to PHCN model

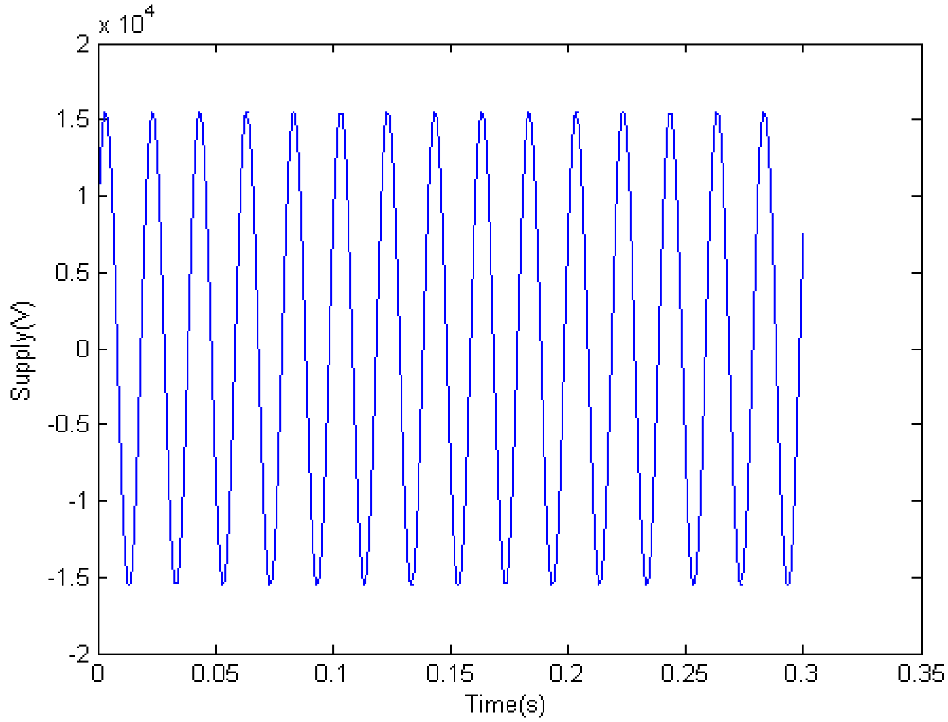

Figure 3: Waveform of supplied voltage to the network

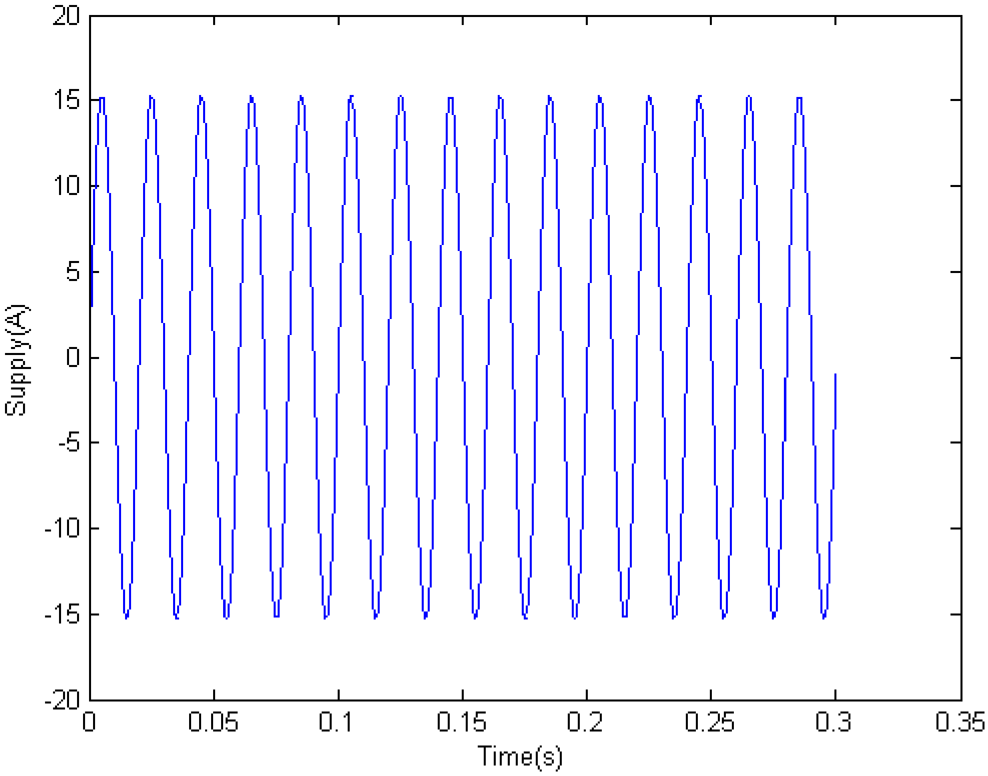

Figure 4: Waveform of supplied current to the network

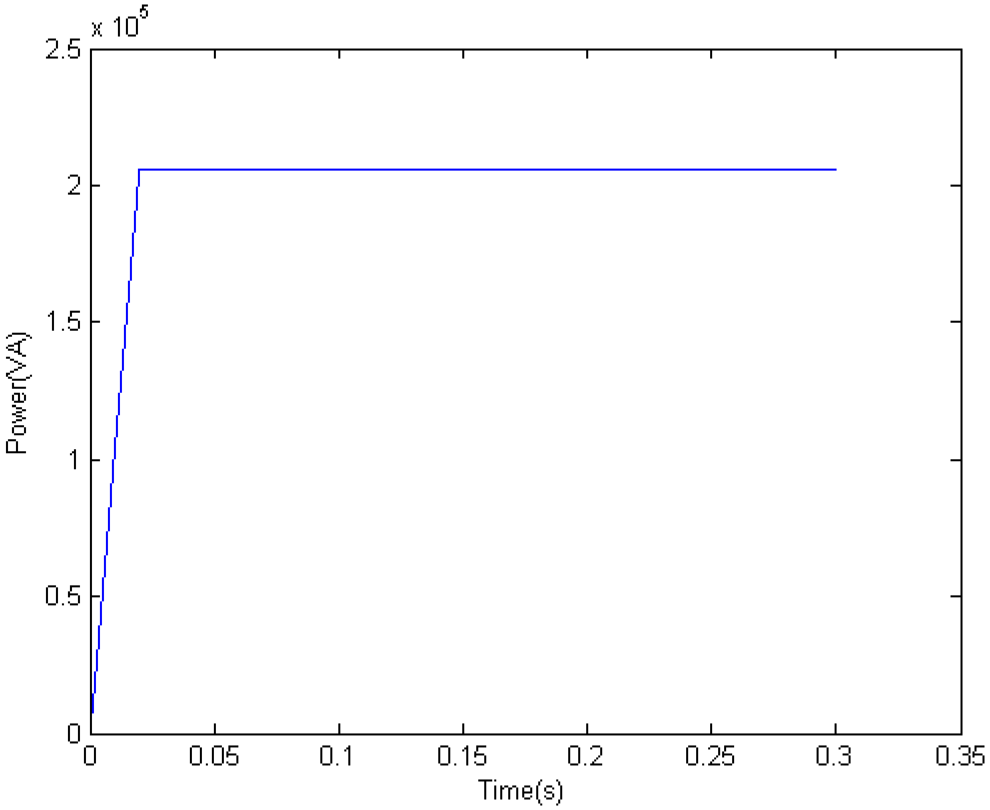

Figure 5: Waveform of supplied power from PHCN to the network

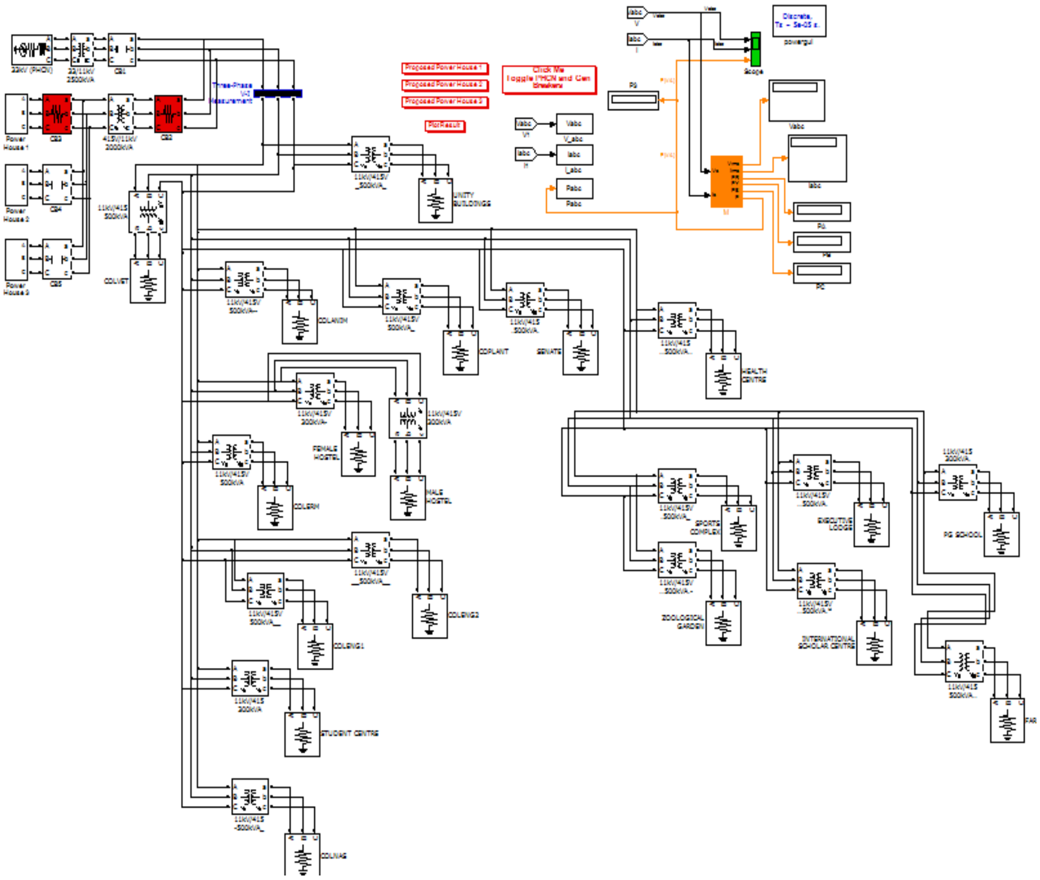

Figure 6: Microgrid Simulink model connected to proposed Power House 1

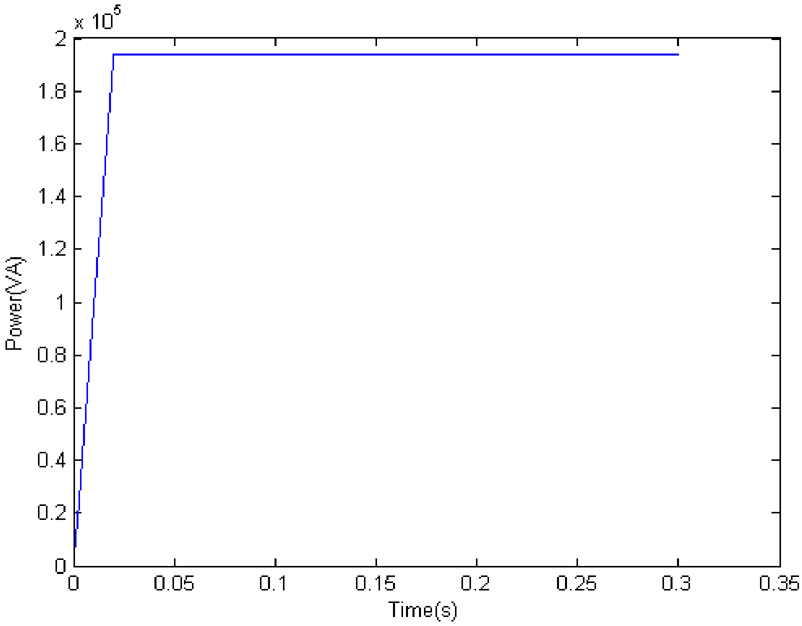

Figure 7: power supplied to the network by power house 1

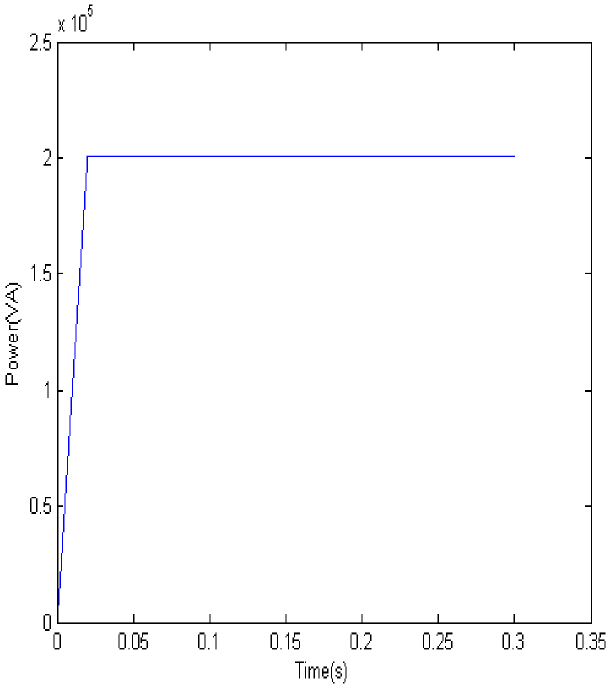

Figure 8: Waveform of power supplied to the network when synchronized power house 1 and 2

The waveforms above represented the voltage and current supplied to the network, with the power supplied to the network (P) given as:

$$P = V_{AB}I_A + V_{BC}I_B + V_{CA}I_C \tag{1}$$

Since:

$$V_{AB} = V_{BC} = V_{CA} = V_{rms} \tag{2}$$

Therefore:

$$P = V_{rms}(I_A + I_B + I_C) \tag{3}$$

But:

$$I_A = I_B = I_C = \frac{I_{rms}}{\sqrt{3}} \tag{4}$$

Then:

$$P = V_{rms}(\frac{I_{rms}}{\sqrt{3}} + \frac{I_{rms}}{\sqrt{3}} + \frac{I_{rms}}{\sqrt{3}}) \qquad (5)$$

$$P = V_{rms}\left(\frac{I_{rms}}{\sqrt{3}} + \frac{I_{rms}}{\sqrt{3}} + \frac{I_{rms}}{\sqrt{3}}\right) = 3V_{rms}I_{rms} \times \frac{1}{\sqrt{3}} \qquad (6)$$

$$P = \sqrt{3}V_{rms}I_{rms} \qquad (7)$$

III. DISCUSSION

The power supply from PHCN is 2500 KVA (2000kw) and this always caters for the whole power network. The power waveform in Figure 2 when PHCN supplied to the microgrid was simulated and modeled with equation 4 was around 2.1X10^{4}KVA with PHCN currently catered for the whole power network of Federal University of Agriculture, Abeokuta in Ogun State and the incomer from PHCN is 2500 kVA.

Similarly, from the power waveform obtained from the simulation of proposed power house 1 (2000 KVA) which is around 1.9x10^{5}VA in figure 6, which is lower to that of PHCN that is currently cater for the whole network, proposed power house 1 can only cater for 80% of the network. To improve the supply power to the network, two of the three proposed power houses can be synchronized together; this will effectively cater for the whole power network. When proposed power houses 1 and 2 were synchronized, we have 2.0x10^{5}VA this was showed in figure 8, which is closer to that of PHCN; this shows that when 2 of these proposed power houses are synchronized can adequately cater for the whole power network and the one that is not synchronized (proposed power house 3) can serve as auxiliary/back up.

Microgrid is an alternative idea to support the grid, it can be applied in a street, estates, community or a locality (towns and villages),organizations and establishments.

Energy storage should be incorporated to the power network to cater for sudden energy demand increase.

The three proposed power houses should be centrally controlled by a control panel so as to be able to switch on/off more generators from the aggregated generators when the needs arise and to be able to monitor what is going in the network. The following schedules were suggested for the present power house:

I. PGS, Mamuood Yakubu, COLERM Phase II, 500 Seater Computer, Student Centre & Student Hostels
II. Industrial Park and COLMAS
III. COLENG, IFSERAR ,COLERM
IV. COLANIM, COPLANT, JAO & Senate
V. Unity building, Works & Services, Hostel & COLVET
VI. Sports Complex & Health Centre
VII. Executive Lodge & CENIP

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