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The Impact of Integrating Renewable Energy Sources in Rural Communities Using an Intelligent Agent (A Case Study of Afikpo Community)

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Abstract: *This study is based on the investigation and simulation modelling of integrated renewable energy system in rural area. This work is aimed at analysing the various impact of integrating renewable energy sources in rural community through the design and implementation of integrated renewable energy system using an artificial neural intelligent agent. Afikpo North Local Government Area was taken as the location for the course of study. The data used was obtained from the Transmission Company of Nigeria(TCN) through the assistance of Enugu Electricity Distribution Company(EEDC).The energy demand of a selected cluster of Afikpo community was also gotten through feasibility studies carried out in the location. These data forms the input parameters for the modelling and analysis done on the impact of integrating renewable energy sources in rural community. MATLAB simulation showed that a high level of power stability was obtained when one or two renewable energy sources are been incorporated into the energy mix. Also the application of the artificial neural intelligent agent, showed that there can be constant/stable power supply and automatic switching (grid to renewable source and vice versa) in the energy mix. It is flexible and reliable.*

Key words: *Integrated Renewable Energy,Matlab/Simulink, Transmission Company Nigeria, and Distribution substation.*

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I. Introduction

The geographical entity known as Ehugbo (Afikpo) is situated in the southern part of Ebonyi State, Nigeria. It is bounded to the north by Unwana and Edda in Ubeyi and Afikpo south local Government Areas respectively, to the east by the Cross River and to the west by Amasiri in Amaoha local Government Area. Afikpo spans an area approximately 164 square kilometers in size. It is the second lagest city in Ebonyi State of Nigeria. Afikpo is a hilly area despite occupying a region low in altitude which rises 350 feet above sea level.

Energy is an integral part of a society and plays a pivotal role in its socio-economic development by raising the standard of living and the quality of life. The state of economic development of any region can be accessed from the pattern and consumption quality of its energy. Energy demand increase as the economy grows bringing along a change in the consumption pattern, which in turn varies with the source and availability of its energy, conversion loss and end-use efficiency (Shweta Singh;Usha Bajpai,2010).

Studies by Ngumah *et al.*, (2013) noted that Nigeria generate about 542.5 million tons of organic waste which can yield about 25.53 billion m^3 of biogas (about 169541.66mwh) and 88.19 million tons of biofertilizer, with an estimated, revenue generation of about 4.54 trillion ($29.29 billion) from both ventures. Wind energy is relatively available especially in the harmattan period (November – March) but currently there are limted reports in the literature on the impacts of wind energy in Ebonyi State. Also the impacts of geothermal energy is yet to be established in the State due to the insensitivity of most State Government in Nigeria to research and development (R & D) (Ebonyi State Citizen' Handbook, 2009).

As the country strives to increase power generation, it is obvious that conventional sources and grid extensions alone will not rapidly achieve the access and expansion target desired, neither will it net cost-effective.

The use of renewable energy is not new in the country. More than 150 years ago wood supplied most of our energy needs, which is the traditional method of consuming biomass resource.

As the use of coal, petroleum, natural gas expanded and increased, Nigeria became less reliant on wood as an energy source. Today, we are looking again at renewable resources to find new ways of utilizing them to help us meet our domestic energy needs particularly in the electricity sector (Ebonyi state Citizens', 2009).

The concept of Fuzzy Logic (FL) was conceived by Lotfi Zadeh, a professor at the University of California at Berkley, and presented not as a control methodology, but as a way of processing data by allowing partial set membership rather than crisp set membership or non-membership.

FL is a problem-solving control system methodology that lends itself to implementation in systems ranging from simple, small, embedded micro-controllers to large, networked, multi-channel PC or workstation-based data acquisition and control systems. It can be implemented in hardware, software, or a combination of both. FL provides a simple nay to arrive at a definite conclusion based upon vague, ambiguous, imprecise, noisy, or missing input information. FL's approach to control problems mimics how a person would make decisions, only much faster.

Linguistic variables are used to represent an FL system's operating parameters. The rule matrix is a simple graphical tool for mapping the FL control system rules. It accommodates two input variables and expresses their logical product (AND) as one output response variable.

This project investigates a close loop control of integrated renewable system using fuzzy logic control.

II. Aim And Objective

The aim of this proposed project is to investigate the impact of integrating renewable energy sources in Afikpo community and hence recommend the most efficient renewable energy source for the community as either standalone or back-up for grid supply.

III. Methodology

I RENEWABLE ENERGY

Solar Renewable Energy: Solar energy is an important energy source that can be harvested from nature free of cost. The earth's surface receives hundreds of times more energy from the sun than the worldwide demand. The collection of this energy and its conversion into a more useful source such as electrical power for daily usage is important; nevertheless, technologies have their own boundaries and difficulties that must be resolved before photovoltaic (PV) implementation on a large scale. Solar energy refers to the energy that comes from the sun. The abundance of solar radiation in Ebonyi state has been established (Nwankwo et al, 2011). Modern technological appliances of solar energy such as large scale domestic hot water system, solar pumps, solar powered bore-holes and use solar fridges in hospitals are still unknown in the states while use of solar cells as building integrated photo voltaic (BIPV) is still at a very low scale. In fact, the number of buildings lucky to have few solar panels on its roof is still less than fifty in the whole state. Other solar energy applications such as cameras for traffic control, weather monitoring, solar fans, solar clock, and modern applications of solar energy in agriculture (solar brooder, solar incubators, solar dryers, solar cooker and solar still) are yet to be introduced in Ebonyi state. (Nwofe P.A. Ekpe J.E. 2014).

Wind Renewable Energy: In Ebonyi state, the wind speed in most locations is low and may not be advisable to consider wind farm but domestic wind turbines in individual homes is a good option for hybrid consideration with solar PV system. (Ebonyi state citizen's Handbook, 2009).

Table 1 Overall Renewable Energy Data Collected in Nigeria

S/N	Resources	Reserve
1	Small Hydro power (provisional)	734MW
2	Fuel Wood	13,071,464 hectares of forestland
3	Animal Waste	61 million tonnes/year (estimated)
4	Crop residue	83 million tonnes/year (estimated)
5	Wind	2- 4 m/s (average)
6	Solar irradiation	3.5-7.0kWh/m^2–day (average)

II INVESTIGATIONS OF DEMAND ENERGY

The primary aim of this project is to ensure that the critical loads are protected by having constant power supply when renewable energy is incorporated to the grid.

Energy demand and power demand computation in Eke Community

School – 44.16KWH / 8.38KW, Cyber café – 20.5KWH / 1.75KW, Water factory – 99.39KWH / 10.026KW, Pharmacy – 186.58KWH / 20.575KW, Hospital – 214.17KWH/ 30.125KW, 3 – bedroom flat – 22.32KWH / 5.82KW. A Total of 40 houses in Eke community, and it were split into 5 groups of 8 houses. Each of the 8 houses is supplied by 20KW power. Each building is assigned 2KW amounting to 16KW, thus using the remaining 4KW as tolerance for the whole system.

III FUZZY LOGIC CONTROLLER

Fuzzy logic controller uses fuzzy set theory; hence it is an artificial intelligence which takes an analog input converting it into logic variable and gives the output by defuzzification. The variable is member of one or more sets, with a specified degree of membership. Fuzzy Logic Controller consists three main blocks which are:

1) Fuzzification 2) Fuzzy Interference System 3) Defuzzification

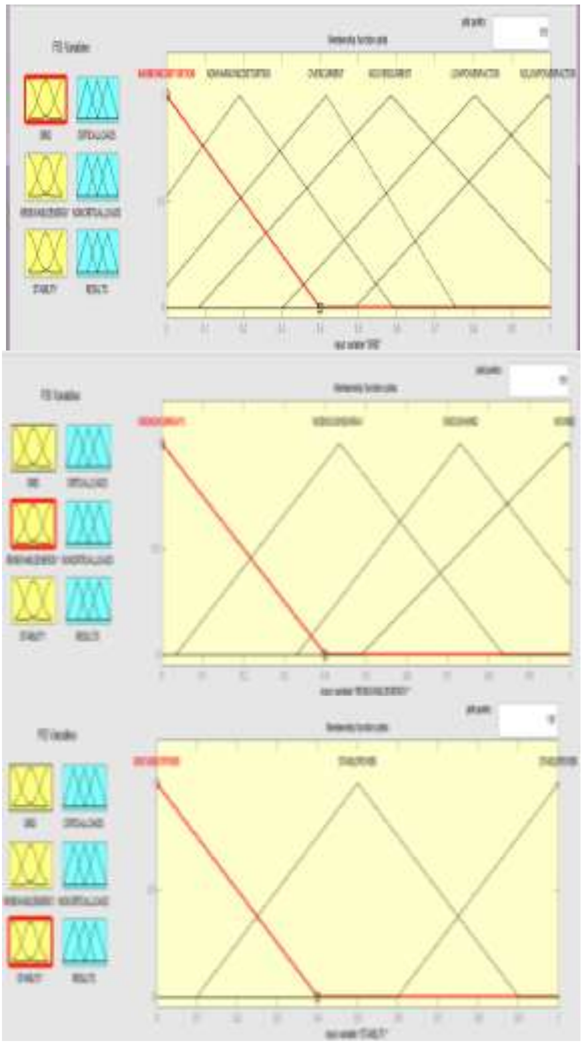
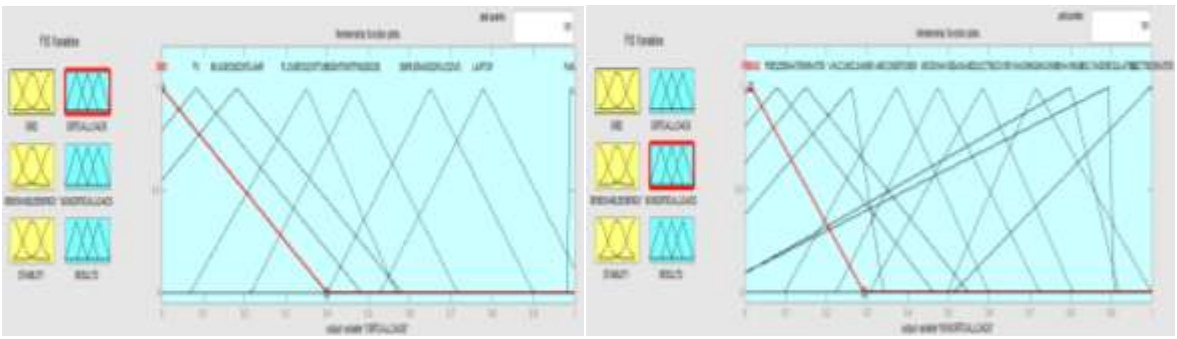


Figure 1: Membership function of Grid Analysis, Renewable Energy Analysis and Stability Analysis for the Impact of Integrating Renewable Energy Sources in Rural Communities Using an Intelligent Agent.



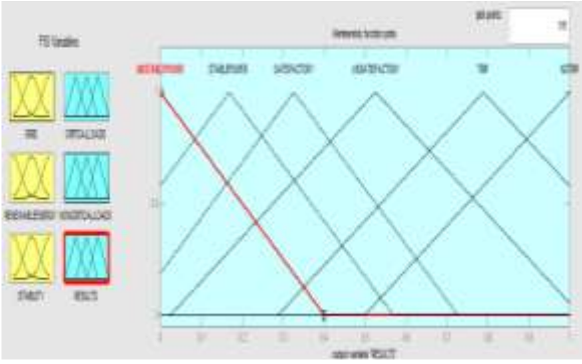


Figure 2: Membership Function for Critical Loads, Noncritical Loads and Results in Impact Of Integrating Renewable Energy Sources In Rural Communities Using An Intelligent Agent

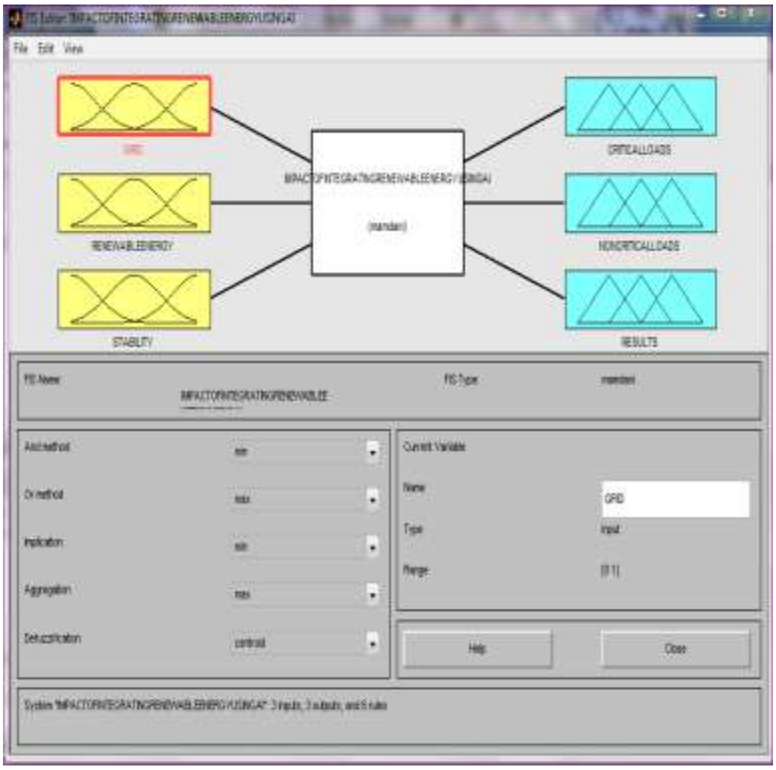


Figure 3: To design a fuzzy intelligent agent membership analysis for grid and renewable energy

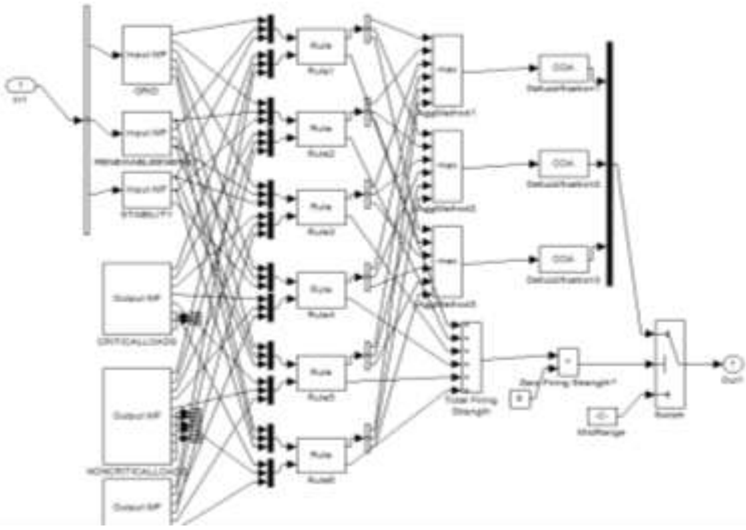


Figure 4: An Intelligent Agent Rules in Impact Of Integrating Renewable Energy Sources In Rural Communities

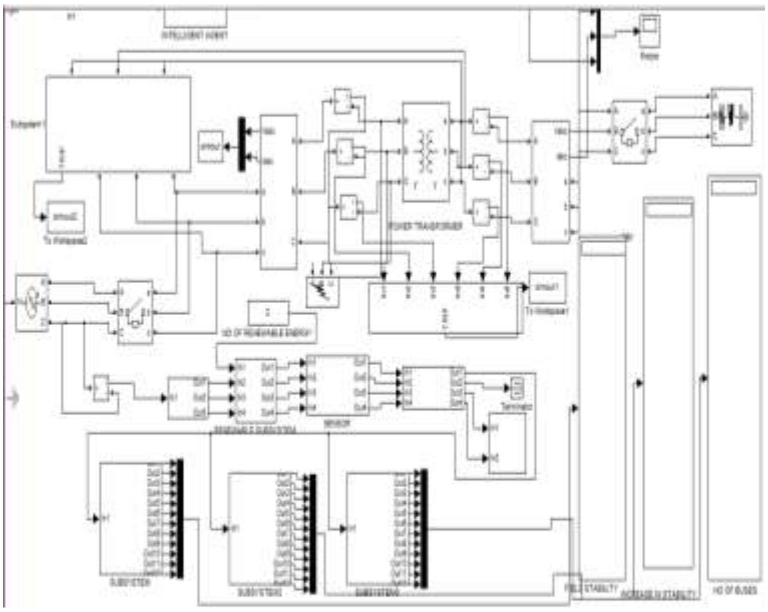


Figure 5: Designed Simulink model for the impact of integrating renewable energy sources in rural communities using an intelligent agent

Figure 6: Designed simulated visual basic for the impact of integrating renewable energy sources in rural communities using an intelligent agent.

IV. Result

Table 2 Grid power Vs Time

Grid Power (w)	0.3	0.3	0.3	0.3	0.4	0.4	0.4	0.4	0.3	0.3	0.3	0.3
Time (s)	1	2	3	4	5	6	7	8	9	10	11	12

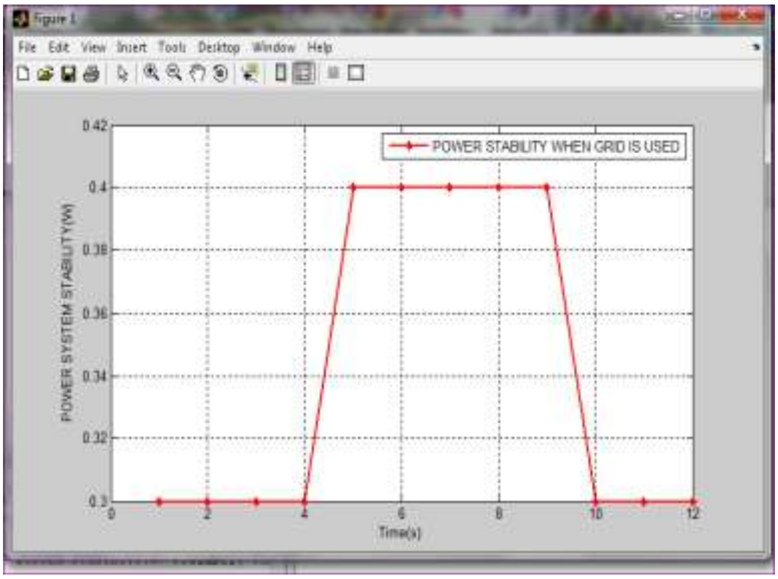


Figure 7: Plot of Grid Power Vs Time

The power stability was maximum at times 4,6,8 and 10 seconds at grid power of 0.4Kw while the grid power was minimum at 1,2 and 12 seconds at a gridpower of 0.3Kw.This shows that when power supply is only dependent on grid,there will be an unstable supply due to limited supply of electricity/power.

Table 3 Renewable Power Stability Vs Time

Renewable Power (w)	1.2	1.2	1.2	1.2	1.6	1.6	1.6	1.6	1.6	1.2	1.2	1.2
Time (s)	1	2	3	4	5	6	7	8	9	10	11	12

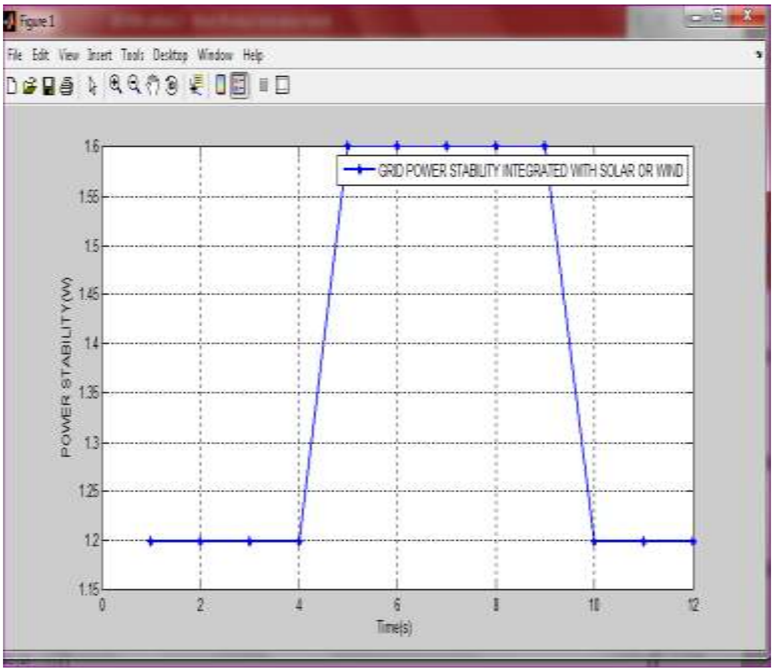


Figure 8: Plot of Grid Power stability when integrated with solar or wind.

The result above shows that when solar or wind renewable source is integrated into the energy mix,the power supply will be more stable than it is only dependent on grid due to the increase in power supply.

Table 4 Comparism between Grid and Renewable Energy Stabilities Vs Time

Grid Power (w)	0.3	0.3	0.3	0.3	0.4	0.4	0.4	0.4	0.3	0.3	0.3	0.3
Renewable Power (w)	1.2	1.2	1.2	1.2	1.6	1.6	1.6	1.6	1.6	1.2	1.2	1.2
Time (s)	1	2	3	4	5	6	7	8	9	10	11	12

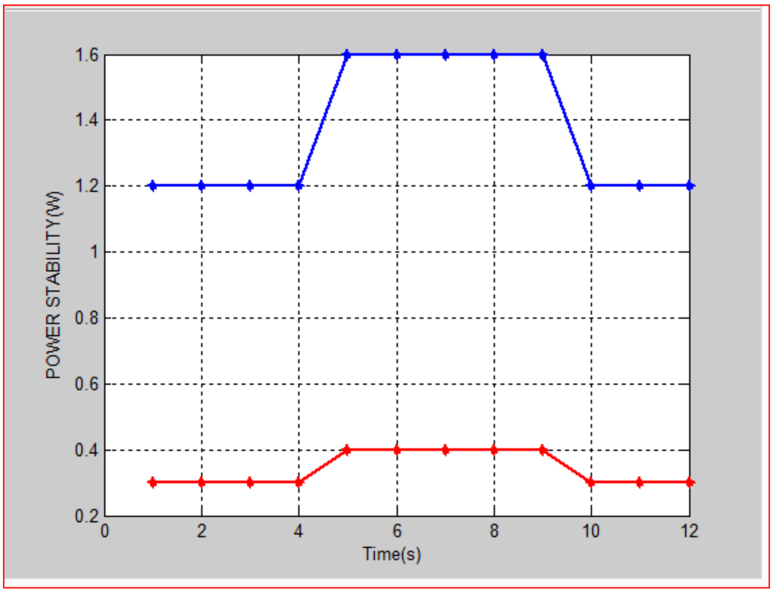


Figure 9: Plot of Grid and one Renewable Energy Stabilities Vs Time

The result above shows Comparism between Grid and Renewable Energy Stabilities Vs Time. It shows that the critical loads are more stable when renewable energy is used than when grid power is used. The plot shows that at time of 4,6, 8 and 10 seconds the renewable energy power is 1.6kw while grid power is 9.4kw.Hence, the integration of renewable energy in to the energy mix leads to an increase in power supply and power stability is maintained or made constant.

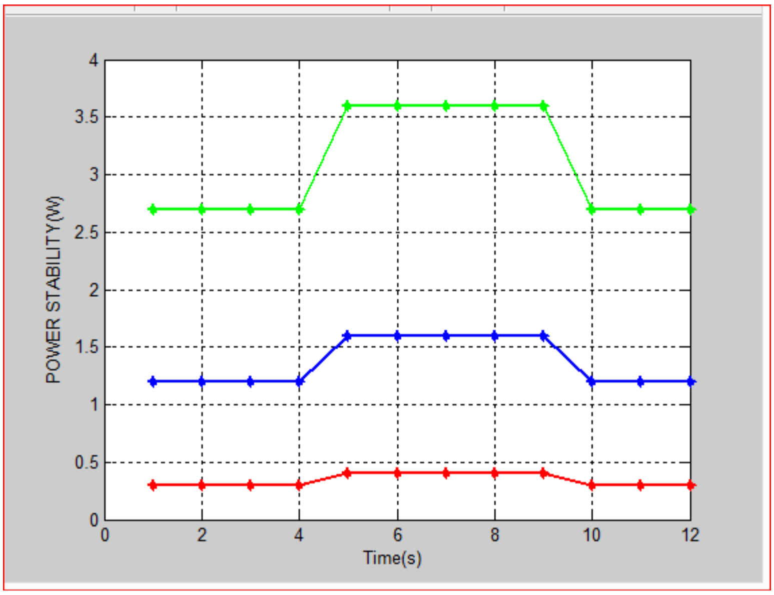


Figure 10: Plot of Grid and two Renewable Energy Stabilities Vs Time

The red plot shows the stability performance of grid power.While the blue plot shows the stability performance of grid and one renewable source.But when two renewable energy sources are been integrated into the grid system,there will be a better performance with respect to power stability. The green plot indicates the performance in power stability when two renewable energy sources are integrated into the grid system.

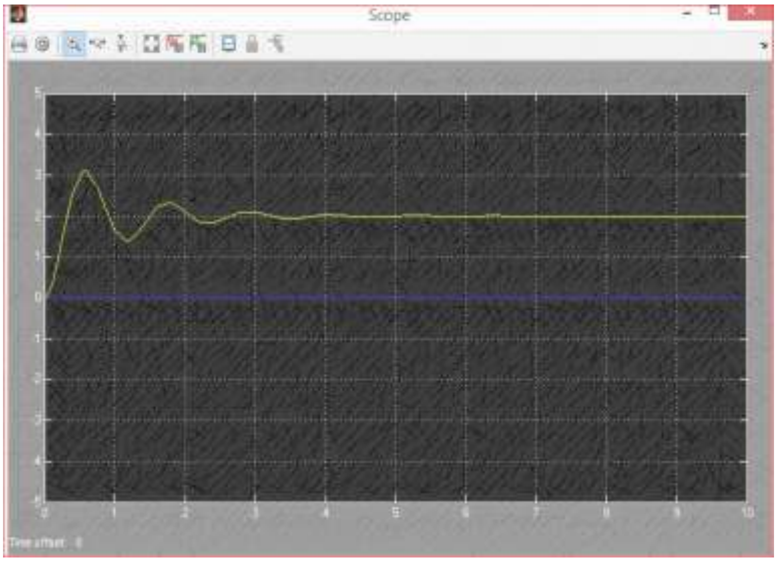


Figure 11: Graphical Simulation Done On Scope in the sumulink model

From the simulated graph above, it is seen that power supply was unstable for some time and became stable later. This is as a result of the performance of the artificial intelligent agent on the integrated system.

V. Conclusion

Considering what is available at present, Afikpo as a rural agrarian community was found to be lacking in the level of modern energy services. Wood fire is the main sources of energy used for cooking in the community. Grid is the main source of electricity available in the community and in the state (Ebonyi). Also it is seen that the Integrated renewable energy together with the Grid show a better performance, efficiency and reliability of constant power when compared with only integrated renewable or grid system.

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