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Enhanced Energy Efficiency through Reduction of Power Consumption in a Cell Site using Fuzzy Controller

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ABSTRACT

The highest power consumed in communication cell site has stamped the financial growth of this establishment. To overcome this enhanced energy efficiency through reduction of power consumption in base station or a cell site using fuzzy controller is introduced. To achieve this, it is done in this manner, characterizing cell site understudy and its power consumption, establishing that there is much energy consumed in the cell site, developing a rule base that will minimize the energy consumed in the cell site and designing a SIMULINK model for enhanced energy efficiency through reduction of power consumption in base station or a cell site using fuzzy controller. The results obtained are the highest conventional power consumed by the cell site in day 1 is 5764KW which tremendously reduce the economy of the communication network. On the other hand, the highest fuzzy controller power consumed is 5742kW. This shows that the power reduced when fuzzy controller is incorporated in the system is 22kW or 0.38% better than the conventional approach. And the highest conventional power consumed in day 10 by communication base station is 5686kW while that when fuzzy controller is incorporated in the system is 5664kW, with these results, it shows that the percentage improvement in power reduction when fuzzy controller is incorporated in the system is 0.4% better than the conventional method.

Keywords: Energy Efficiency, Power Consumption, Base Station, Fuzzy Controller

1. Introduction

The issue of energy efficiency is one of the major challenges facing wireless cellular network providers around the world today. In Nigeria, some cellular network providers have been greatly affected, resulting in the closing down of sites due to the problem of energy efficiency. To handle this situation, which deals with Power consumption reduction in a base station, various approaches have been adopted that led to the introduction of green communication techniques.

The evolution of mobile telephony started with zero generation (0G) in 1970s and later the first generation (1G), and then second generation was introduced as an improvement to 1G. The third and fourth generations (3G and 4G) followed up in the order, and now it is advent of fifth generation (5G).

The problem still remain that the PA energy efficiency is achievable only with the internal equipment, but not possible in external conditions like not knowing the number of users requesting access to the BS at time, hence altering the energy efficiency achieved with internal equipment. It is generally accepted that high bit error rate constitutes telecommunication low performance (Abubaka2018). Meanwhile (Akbari, 20011) strictly highlighted that to boos energy efficiency ultra-capacitor should be incorporated in the system. An egalitarian author (Akhilesh, 2012) strongly emphasized that wireless communication should be redefined to enhance its efficacy. (Bazzi, 2008) reemphasized that higher through put is the core functioning capability of multi radio efficiency.

2. Methodology

The following methodology were adopted in developing and designing a model for improved energy efficiency through power reduction at a cell site;

2.1 Characterizing Cell Site Understudy and its Power Consumption

In order to characterize the cell site under study and determine its power consumption, the type of base station (BS), configuration model, transceiver and power models were inspected. The cell site or base station or base transceiver station (BTS) is a microcell managed by IHS Towers West Africa Limited, with site No. IHS-EN-T4670 – 2G/3G/4G networks (Indoor / Outdoor Site), housing MTN Nig Ltd and Airtel Nig Ltd base station equipment at Mount Street by Idaw River Layout Awkunanaw, Enugu.

The site control (hop) about thirty (30) other MTN / Airtel base stations (Terminal and Fiber sites) within its coverage area, it handles transmission (TX) and reception (RX) of voice, data and streaming services.
In each day for any of the periods, measurements were taken for two (2) hours, with an interval of every fifteen (15) minutes, making it eight (8) times to repeat the measurement.
Note, in every 15 minutes, three (3) measurements are taken at interval of five (5) minutes, the highest of the three measurements is taken as the reading for the fifteen minutes.In the end, an average for the eight (8) intervals was taken for each day on different periods for all equipment.

For instance, on day 1 of 3rd October 2018, while the 3G BTS Airtel is with a current of 26.4 Amps, the 2G BTS MTN current was 25Amps. In each of reading, like in the 3G BTS Airtel the readings were measured for eight (8) intervals in every fifteen minutes of the hours of 13:30hrs to 15:30hrs (that is two hours), then the average was calculated. It has the following current readings of 26.5A; 25.9A; 26.8A; 26.7A; 26.9A; 25.9A; 25.8A and 26.6A for the intervals. The average is;

$$\boldsymbol{Average} = \frac{26.5 + 25.9 + 26.8 + 26.7 + 26.9 + 25.9 + 25.8 + 26.6}{8}$$

$$= 26.3875 \text{ Amps} \cong 26.4 \text{ Amps}$$

The sample of the measurement process for the 3G BTS Airtel is in table 2.1.

Table 2.1: Sample of the Measurement Process for the 3G BTS Airtel on Day 1 (13:30HRS to 15:30HRS)

INTERVAL	CURRENT (AMPS)
1st 15 mins **(13:30Hrs – 13:45Hrs)**	26.5
2nd 15 mins **(13:45Hrs – 14:00Hrs)**	25.9
3rd 15 mins **(14:00Hrs – 14:15Hrs)**	26.8
4th 15 mins **(14:15Hrs – 14:30Hrs)**	26.7
5th 15 mins **(14:30Hrs – 14:45Hrs)**	26.9
6th 15 mins **(14:45Hrs – 15:00Hrs)**	25.9
7th 15 mins **(15:00Hrs – 15:15Hrs)**	25.8
8th 15 mins **(15:15Hrs – 15:30Hrs)**	26.6
Total = (2 Hours) for one period.	$\mathbf{Aver} = \dfrac{\mathbf{26.5 + 25.9 + 26.8 + 26.7 + 26.9 + 25.9 + 25.8 + 26.6}}{\mathbf{8}}$ **= 26.3875 Amps ≅ 26.4 Amps**

The measurements were first carried out in the BTS equipment cabin which is the backbone of the cell site housing the transmitter and receiver modules. The BTS also is interconnected with equipment on the tower for transmission and hopping activities with other cell sites linked to the tower through the RF and microwave antennas.
At the end of the measurement taken, a summary of Twenty-Seven (27) days was calculated using;

$$\textbf{Total Power consumed} = P_{Con} = V_{Aver} \times I_T \quad \textbf{(Watt)} \qquad (3.2)$$

Where P_{Con} is the power consumed in (**Watt**)

V_{Aver} is the average voltage calculated from each day measurement (**Volt**).

I_T is the average total current consumed by the equipment in the cell site (**Amps**).

Day 1 at 13:30HRS – 15:30HRS on 3rd October 2018. (Off-Peak)

Total current = I_T = 109.8 Amps

Average Voltage = V_{Aver} = 52.5 Volts

Power consumed = $P_{Con} = I_T \times V_{Aver}$ = 109.8 x 52.5

= 5764.50 Watts

Day 2 at 11:00HRS – 13:00HRS on 4th October 2018. (Off-Peak)

Total current = I_T = 102.4 Amps

Average Voltage = V_{Aver} = 50.7 Volts

Power consumed = $P_{Con} = I_T \times V_{Aver}$= 102.4 x 50.7

= 5191.68 Watts

Day 3 at 15:00HRS – 17:00HRS on 5th October 2018. (Off-Peak)

Total current = I_T = 110.8 Amps

Average Voltage = V_{Aver} = 52 Volts

Power consumed = $P_{Con} = I_T x V_{Aver}$ = 110.8 x 52

= 5761.60 Watts

Day 4 at 10:00HRS – 12:00HRS on 6th October 2018. (Off-Peak)

Total current = I_T = 94.9 Amps

Average Voltage = V_{Aver} = 52.8 Volts

Power consumed = $P_{Con} = I_T$ x V_{Aver} = 94.9 x 52.8

= 5010.72 Watts

Day 5 at 14:00HRS – 16:00HRS on 9th October 2018. (Off-Peak)

Total current = I_T = 105.6 Amps

Average Voltage = V_{Aver} = 51.3 Volts

Power consumed = $P_{Con} = I_T$ x V_{Aver} = 105.6 x 51.3

= 5417.28 Watts

Day 6 at 10:30HRS – 12:30HRS on 11th October 2018. (Off-Peak)

Total current = I_T = 98.5 Amps

Average Voltage = V_{Aver} = 52.3 Volts

Power consumed = $P_{Con} = I_T$ x V_{Aver} = 98.5 x 52.3

= 5151.55 Watts

Day 7 at 16:00HRS – 18:00HRS on 12th October 2018. (Off-Peak)

Total current = I_T = 107.9 Amps

Average Voltage = V_{Aver} = 52.9 Volts

Power consumed = $P_{Con} = I_T$ x V_{Aver} = 107.9 x 52.9

= 5707.91 Watts

Day 8 at 12:00HRS – 14:00HRS on 15th October 2018. (Off-Peak)

Total current = I_T = 97.5 Amps

Average Voltage = V_{Aver} = 52.7 Volts

Power consumed = $P_{Con} = I_T$ x V_{Aver} = 97.5 x 52.7

= 5138.25 Watts

Day 9 at 15:30HRS – 17:30HRS on 17th October 2018. (Off-Peak)

Total current = I_T = 108.3 Amps

Average Voltage = V_{Aver} = 52.4 Volts

Power consumed = P_{Con}= I_T x V_{Aver} = 108.3 x 52.4

= 5674.92 Watts

Day 10 at 14:30HRS – 16:30HRS on 19th October 2018. (Off-Peak)

Total current = I_T = 106.9 Amps

Average Voltage = V_{Aver} = 53.2 Volts

Power consumed = P_{Con} = I_T x V_{Aver} = 106.9 x 53.2

= 5687.08 Watts

Day 11 at 13:00HRS – 15:00HRS on 20th October 2018. (Off-Peak)

Total current = I_T = 104.7 Amps

Average Voltage = V_{Aver} = 52.7 Volts

Power consumed = P_{Con} = I_T x V_{Aver} = 104.7 x 52.7

= 5517.69 Watts

Day 12 at 19:00HRS – 21:00HRS on 23rd October 2018. (Evening-Peak)

Total current = I_T = 160.8 Amps

Average Voltage = V_{Aver} = 53.7 Volts

Power consumed = P_{Con} = I_T x V_{Aver} = 160.8 x 53.7

= 8634.96 Watts

Day 13 at 18:00HRS – 20:00HRS on 26th October 2018. (Evening-Peak)

Total current = I_T = 151.1 Amps

Average Voltage = V_{Aver} = 53.7 Volts

Power consumed = P_{Con} = I_T x V_{Aver} = 151.1 x 53.7

= 8114.07 Watts

Day 14 at 20:00HRS – 22:00HRS on 27th October 2018. (Evening-Peak)

Total current = I_T = 144.3 Amps

Average Voltage = V_{Aver} = 52.4 Volts

Power consumed = P_{Con} = I_T x V_{Aver}= 141.3 x 52.4

= 7404.12 Watts

Day 15 at 18:30HRS – 20:30HRS on 28th October 2018. (Evening-Peak)

Total current = I_T = 151.7 Amps

Average Voltage = V_{Aver} = 53.3 Volts

Power consumed = P_{Con} = I_T x V_{Aver} = 151.7 x 53.3

= 8085.61 Watts

Day 16 at 19:30HRS – 21:30HRS on 2nd November 2018. (Evening-Peak)

Total current = I_T = 153 Amps

Average Voltage = V_{Aver} = 53.4 Volts

Power consumed = $P_{Con} = I_T \times V_{Aver}$ = 153 x 53.4

= 8170.20 Watts

Day 17 at 06:30HRS – 08:30HRS on 3rd November 2018. (Morning-Peak)

Total current = I_T = 131.4 Amps

Average Voltage = V_{Aver} = 52.8 Volts

Power consumed = $P_{Con} = I_T \times V_{Aver}$ = 131.4 x 52.8

= 6937.92 Watts

Day 18 at 07:00HRS – 09:00HRS on 6th November 2018. (Morning-Peak)

Total current = I_T = 125 Amps

Average Voltage = V_{Aver} = 53.3 Volts

Power consumed = $P_{Con} = I_T \times V_{Aver}$ = 125 x 53.3

= 6662.50 Watts

Day 19 at 08:00HRS – 10:00HRS on 7th November 2018. (Morning-Peak)

Total current = I_T = 121.2 Amps

Average Voltage = V_{Aver} = 52.4 Volts

Power consumed = $P_{Con} = I_T \times V_{Aver}$ = 121.2 x 52.4

= 6350.88 Watts

Day 20 at 07:30HRS – 07:30HRS on 9th November 2018. (Morning-Peak)

Total current = I_T = 124 Amps

Average Voltage = V_{Aver} = 53.6 Volts

Power consumed = $P_{Con} = I_T \times V_{Aver}$ = 124 x 53.6

= 6646.40 Watts

Day 21 at 06:45HRS – 08:45HRS on 16th November 2018. (Morning-Peak)

Total current = I_T = 122.3 Amps

Average Voltage = V_{Aver} = 52.2 Volts

Power consumed = $P_{Con} = I_T \times V_{Aver}$ = 122.3 x 52.2

= 6384.06 Watts

Day 22 at 06:00HRS – 08:00HRS on 17th November 2018. (Morning-Peak)

Total current = I_T = 127.8 Amps

Average Voltage = V_{Aver} = 53.4 Volts

Power consumed = $P_{Con} = I_T \times V_{Aver}$ = 127.8 x 53.4

= 6824.52 Watts

Day 23 at 07:45HRS – 09:45HRS on 20th November 2018.

Total current = I_T = 120.7 Amps

Average Voltage = V_{Aver} = 52.7 Volts
Power consumed = $P_{Con} = I_T \times V_{Aver}$ = 120.7 x 52.7
= 6360.89 Watts

Day 24 at 08:15HRS – 10:15HRS on 22nd November 2018. (Morning-Peak)

Total current = I_T = 117.5 Amps

Average Voltage = V_{Aver} = 52.7 Volts
Power consumed = $P_{Con} = I_T \times V_{Aver}$ = 117.5 x 52.7
= 6192.25 Watts

Day 25 at 08:15HRS – 10:15HRS on 26th November 2018. (Morning-Peak)

Total current = I_T = 128.8 Amps

Average Voltage = V_{Aver} = 53.3 Volts
Power consumed = $P_{Con} = I_T \times V_{Aver}$ = 128.8 x 53.3
= 6865.04 Watts

Day 26 at 08:30HRS – 10:30HRS on 27th November 2018. (Morning-Peak)

Total current = I_T = 122.1 Amps

Average Voltage = V_{Aver} = 53.1 Volts
Power consumed = $P_{Con} = I_T \times V_{Aver}$ = 122.1 x 53.1
= 6483.51 Watts

Day 27 at 06:15HRS – 08:15HRS on 28th November 2018. (Morning-Peak)

Total current = I_T = 125.4 Amps

Average Voltage = V_{Aver} = 53.1 Volts
Power consumed = $P_{Con} = I_T \times V_{Aver}$= 128.8 x 53.3

= 6658.74 Watts

Total Power consumed for the 27 days = 170098.78Watts =170.09878kW ≅ 170.1kW

Number of hours for the 27days at 2hours period = 27 x 2 = 54 hours

kWH = 170.1 x 54 =9185.4 kWH

₦60 = 1kWH

9185.4kWH = ₦ 9185.4 x 60 = **₦ 551,124.00**

The summary of these days is given in table 2.2. It can be seen that day12 power consumption was the highest at a period of 19:00hrs to 21:00hrs with 8634.96 Watts, while day4 was the lowest at a period of 10:00hrs to 12:00hrs with 5010.72 Watts.

This means that more users are usually in the network at a peak period of 19:00hrs downward. The average of the two days (i.e. day 12 and day 4) is taken to show the expected power consumption of the cell site, which is;

Table 2.2: Summary of Day 1 to Day 27 of the Measurement of Power Consumed

Day	Date	Period (Hrs)	Total Current (Amps)	Average Voltage (Volt)	Power Consumed (V_{Aver} x I_T) (Watt)	Remarks
1	03-10-18	13:30 - 15:30	109.8	52.5	5764.50	Off-Peak
2	04-10-18	11:00 - 13:00	102.4	50.7	5191.68	Off-Peak
3	05-10-18	13:00 - 17:00	110.8	52.0	5761.60	Off-Peak
4	06-10-18	10:00 - 12:00	94.9	52.8	5010.72	Off-Peak
5	09-10-18	14:00 - 16:00	105.6	51.3	5417.28	Off-Peak
6	11-10-18	10:30 - 12:30	98.5	52.3	5151.55	Off-Peak
7	12-10-18	16:00 - 18:00	107.9	52.9	5707.91	Off-Peak
8	15-10-18	12:00 - 14:00	97.5	52.7	5138.25	Off-Peak
9	17-10-18	15:30 - 17:30	108.3	52.4	5674.92	Off-Peak
10	19-10-18	14:30 - 16:30	106.9	53.2	5687.08	Off-Peak
11	20-10-18	13:00 - 15:00	104.7	52.7	5517.69	Off-Peak
12	23-10-18	19:00 - 21:00	160.8	53.7	8634.96	Evening Peak
13	26-10-18	18:00 - 20:00	151.1	53.7	8114.07	Evening Peak
14	27-10-18	20:00 - 22:00	141.3	52.4	7404.12	Evening Peak
15	28-10-18	18:30 - 20:30	151.7	53.3	8085.61	Evening Peak
16	02-11-18	19:30 - 21:30	153.0	53.4	8170.20	Evening Peak
17	03-11-18	06:30 - 08:30	131.4	52.8	6937.92	Morning Peak
18	06-11-18	07:00 - 09:00	125.0	53.3	6662.50	Morning Peak
19	07-11-18	08:00 - 10:00	121.2	52.4	6350.88	Morning Peak
20	09-11-18	07:30 - 09:30	124.0	53.6	6646.40	Morning Peak
21	16-11-18	06:45 - 08:45	122.3	52.2	6384.06	Morning Peak
22	17-11-18	06:00 - 08:00	127.8	53.4	6824.52	Morning Peak
23	20-11-18	07:45 - 09:45	120.7	52.7	6360.89	Morning Peak
24	22-11-18	08:15 - 10:15	117.5	52.7	6192.25	Morning Peak
25	26-11-18	07:15 - 09:15	128.8	53.3	6865.04	Morning Peak
26	27-11-18	08:30 - 10:30	122.1	53.1	6483.51	Morning Peak
27	28-11-18	06:15 - 08:15	125.4	53.1	6658.74	Morning Peak

$$P_{Aver}\text{ (Two days)} = \frac{PCon\ (Day4) + PCon(Day\ 12)}{2} = \frac{8634.96+5010.72}{2} = \mathbf{6822.84Watts}$$

To calculate the power consumed in day4 and day12

For day4;

Since ₦60 = 1kWH

1000Watts = 1kW

5010.72Watts = 5010.72/1000 = 5.01072kW

KWH = 5.01072 x 2 = 10.02144kWH

The cost becomes = 10.02144 x 60 = ₦ 601.30

For day 12;

Since ₦60 = 1kWH

1000Watts = 1kW

8634.96Watts = 8634.96/1000 = 8.63496kW

kWH = 8.63496 x 2 = 17.26992kWH

The cost becomes = 17.26992 x 60 =₦ 1,036.20

For the average of the two days (4 and 12); that is, 6822.84Watts

Since ₦60 = 1kWH

1000Watts = 1kW

6822.84Watts = 6822.84/1000 = 6.82284kW

KWH = 6.82284 x 2 = 13.64568kWH

The cost becomes = 13.64568 x 60 = ₦ 818.74

This is also equivalent to the average of day 4 and day 12 costs;

$$\frac{₦\,601.30 + ₦\,1,036.20}{2} = ₦\,818.75$$

2.2 Determination of the Module to Go on Sleep Mode and Its Power Requirement.

There are ten (10) equipment at which the measurements were carried out on the cell site, their voltages and currents readings were taken, and they were also listed for each day in tables C2 to C28 of Appendix C. From the measurements taken, the highest peak power consumption was on 23rd October, 2018 at 19:00Hrs – 21:00Hrs and the lowest peak power consumption on 6th October, 2018 at 10:30Hrs – 12:30Hrs. They are as follows;

i.	2G BTS MTN	1863 Watts	1153.22 Watts
ii.	3G BTS MTN	638.38 Watts	391.46 Watts
iii.	3G BTS Airtel	1965.12 Watts	1166.29 Watts
iv.	4G BTS Airtel	704.88 Watts	413.17 Watts
v.	DC Air-Conditioner	547.42 Watts	531.00 Watts
vi.	Microwave Unit 1	529.65 Watts	227.04 Watts
vii.	Microwave Unit 2	513.60 Watts	242.88 Watts
viii.	Microwave Unit 3	524.30 Watts	237.60 Watts
ix.	Microwave Unit 4	508.25 Watts	211.20 Watts
x.	Microwave Unit 5	834.60 Watts	427.68 Watts

From the readings recorded in the tables C2 to C28, equipment identified as the ones that consume more energy are;

i. 2G BTS MTN
ii. 3G BTS MTN
iii. 3G BTS Airtel
iv. 4G BTS Airtel
v. DC Air-conditioner
vi. Microwave Unit 5

This implies that the research will now be narrowed down to the equipment identified, which consumes more energy, which are six (6) in number. The DC Air-conditioner is support equipment for cooling purpose only, while the four (4) BTSs are the major ones consuming a lot of energy due to the presence of radio resource unit (RRU) or

radio base station (RBS) in them. The RRU contains power amplifiers, signal processing unit, and internal cooling facilities which consume about sixty-five percent of power in a BTS.
The microwave unit 5 will not be considered due to its transceiver function that must operate optimally for the base station controller (BSC) operation.
Since the BTSs irrespective of being used for 2G, 3G or 4G does the same function, only one BTS will be considered, as the outcome can still be implemented in any other BTS.

It means that a model or algorithm will be developed to monitor equipment chosen to know when they should go on sleep mode and saves energy.

2.3 Developing a Simulink Model for the Switching Algorithm

The developed Simulink model for the cell site understudy was shown in figure 2.1. The model was designed using the conventional approach of the cell site (i.e. the actual data collated from the cell site while in operation) and electrical and communication toolboxes in the Matlab environment.

To achieve the Simulink modeling, it is divided into three (3) sections of A, B, and C.

Section A – Power model
Section B – Communication model
Section C – Result / Display

In section A, three power modules comprising of public power (i.e. transformer) and direct current - diesel generator (DC – DG) were used for the modeling of power supply of cell site understudy. To coordinate the two sources, which were represented by one (1) generator blocks, a trip (i.e. relay) was used for regulation, while the simout block is used to ensure that voltage and current are regulated from the source. Also, there is the circuit block and subsystem block that coordinate the communication between the power module and circuit.
In section B, is mainly for the communication modules that function as BTS in the cell site. Some major blocks from the communication toolbox of the Matlab environment were used to design the radio resource units (RRUs) of the sector A, sector B and sector C for ease of monitoring for sleep mode against traffic.
In section C, the subsystem block is mainly used as readout of the condition of the cell site understudy to the factors modeled.
Establishing that there is much energy consumed in the cell site;

Table 2.3: Established Much Energy Consumed in a Cell Site

Days	Power consumption Watts
1	5764.50
2	5191.68
3	5761.60
4	5010.72
5	5417.28
6	5151.55
7	5707.91
8	5138.25
9	5674.92
10	5687.08
11	5517.69
12	8634.96

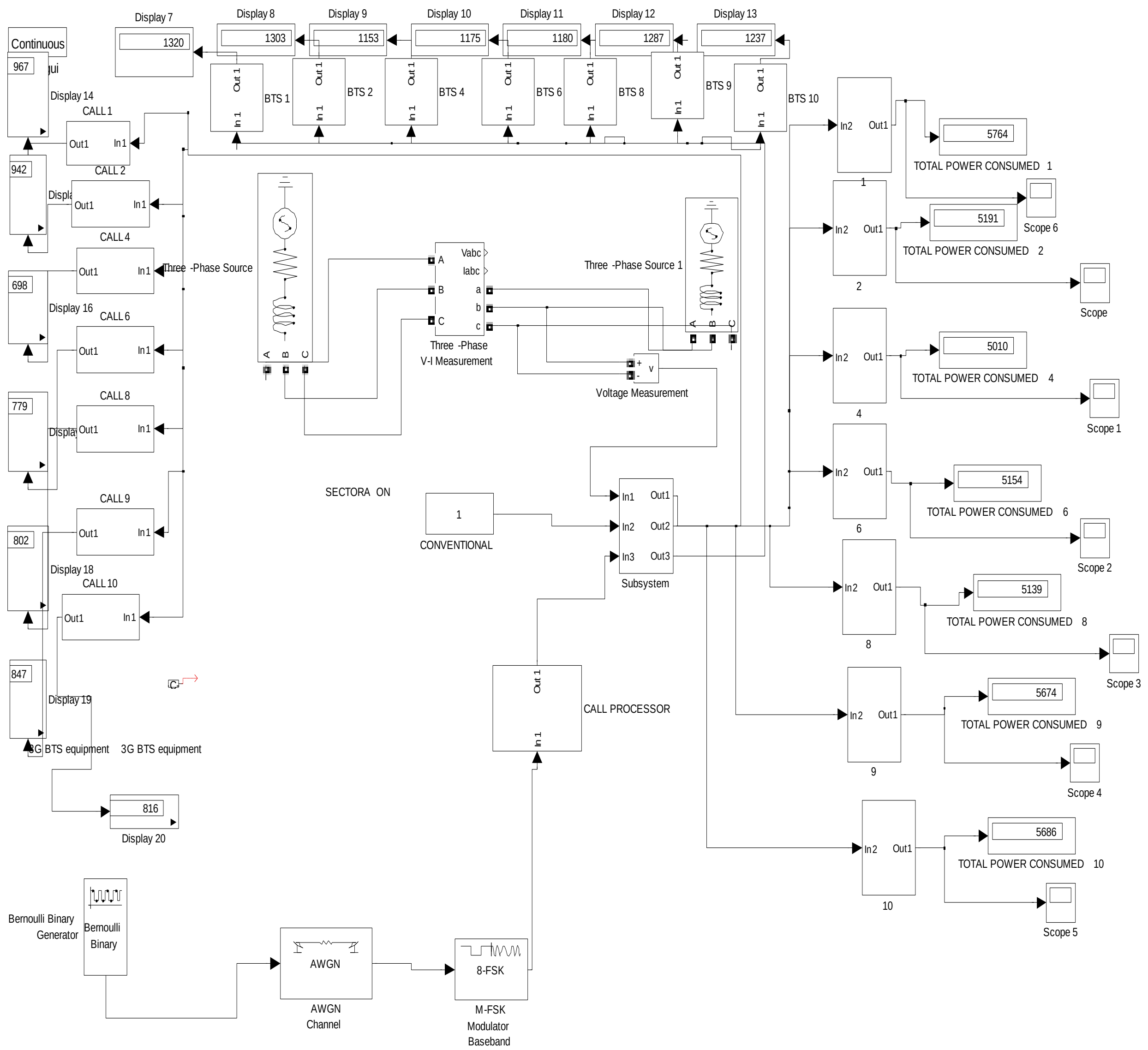

Fig. 2.1: Conventional Model for Enhanced Energy Efficiency through Reduction of Power Reduction in a Cell Site Using Fuzzy Controller

Figure 2.2 shows developed fuzzy inference system that will minimize the energy consumed in the cell site. It has two inputs of cell site energy and cell site congestion. It also has an output of result.

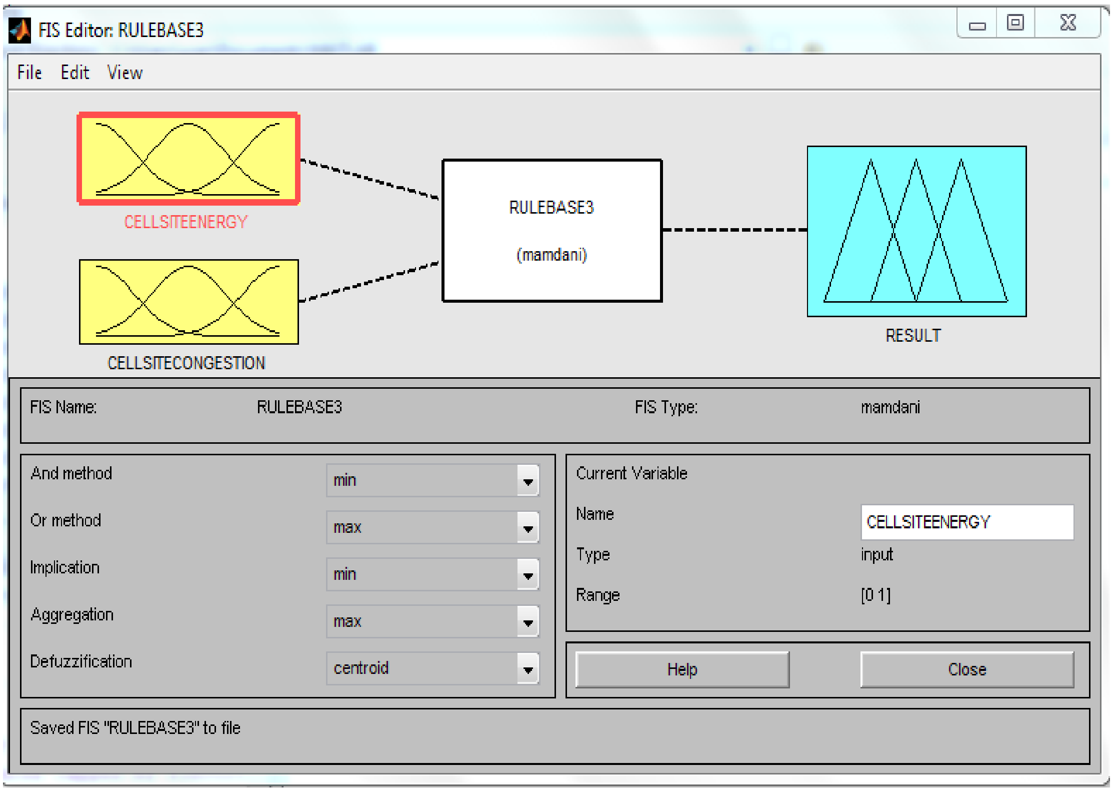

Fig. 2.2: Developed Fuzzy Inference System to Minimize the Energy Consumed a Cell Site

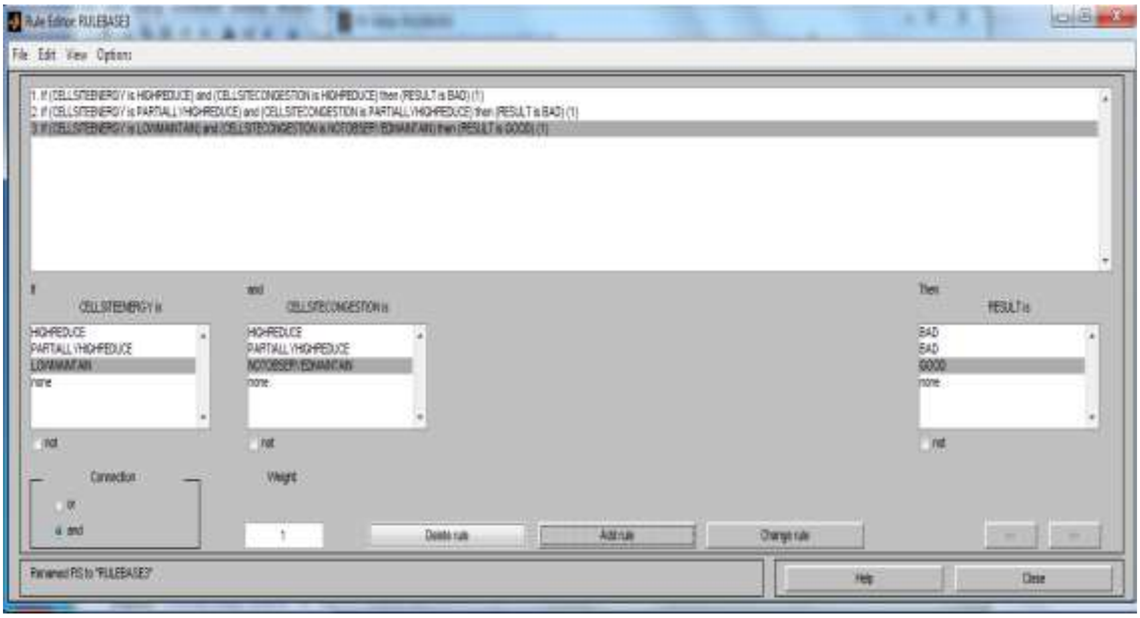

Fig. 2.3: Developed Rule Base to Minimize the Energy Consumed in a Cell Site

Figure 2.3 shows the developed rule base that will minimize the energy consumed in the cell site. The details of the stipulated rules are detailed in table 2.4.

Table 2.4: Details of Rule Base to minimize the energy consumed in the cell site

1	IF CELL SITE ENERGY IS HIGH REDUCE	AND CELL SITE CONGESTION IS HIGH REDUCE	THEN RESULT IS BAD
2	IF CELL SITE ENERGY IS PARTIALLY HIGH REDUCE	AND CELL SITE CONGESTION IS PARTIALLY HIGH REDUCE	THEN RESULT IS BAD
3	IF CELL SITE ENERGY IS LOW MAINTAIN	AND CELL SITE CONGESTION IS NOT OBSERVED MAINTAIN	THEN RESULT IS GOOD

To design a SIMULINK model for enhanced energy efficiency through reduction of power consumption in base station or a cell site using fuzzy controller

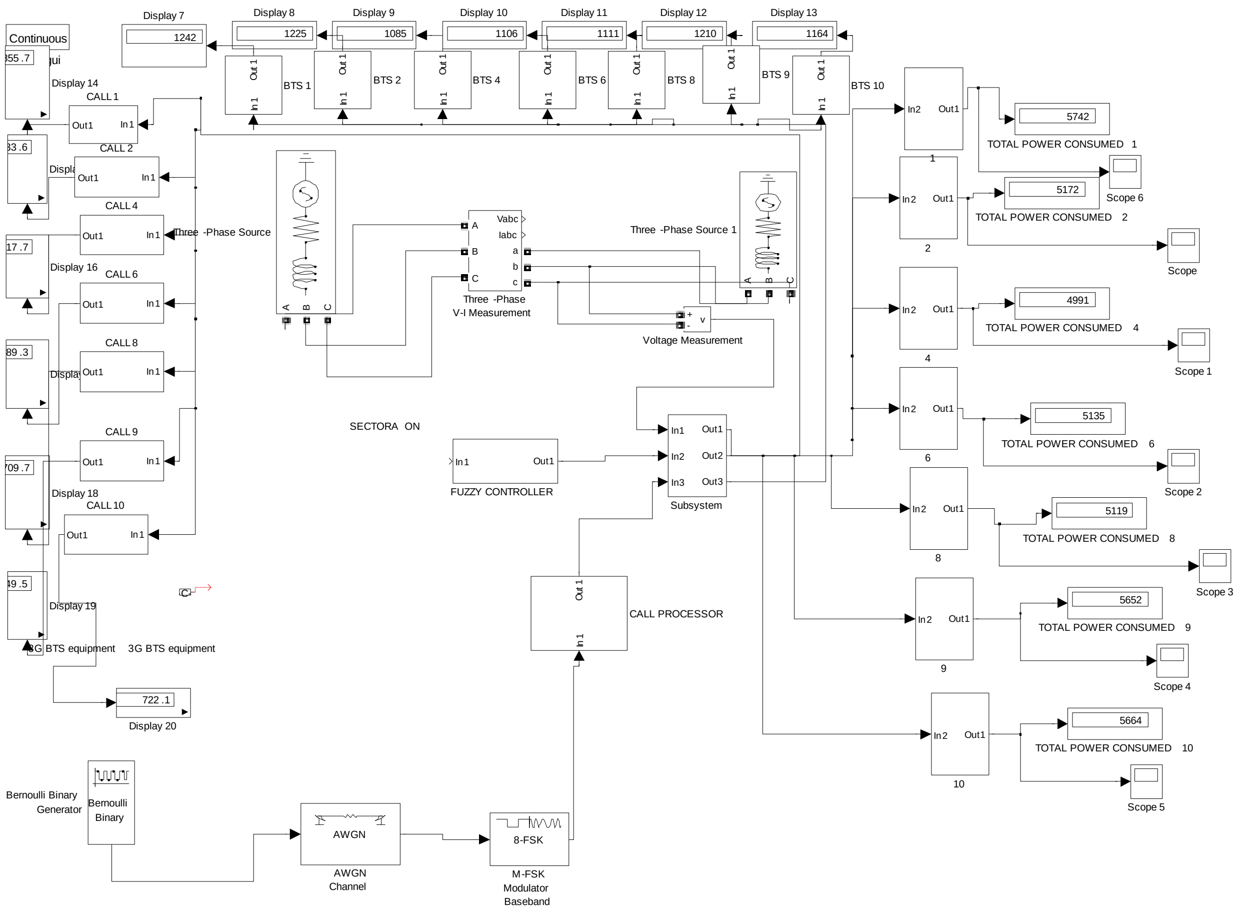

Fig. 2.4: Designed SIMULINK Model for Enhanced Energy Efficiency through Reduction of Power Consumption in a Cell Site Using Fuzzy Controller

The results obtained after incorporation of fuzzy controller in the conventional model are as shown in figures 3.1 and 3.2.

3. Results and Discussion

Table 3.1: Comparison of Conventional and Fuzzy Controller Power Consumed in Day 1

time(hr.)	conventional power consumed in day 1 in enhanced energy efficiency through reduction of power consumption in base station or a cell site (kw)	Fuzzy controller power consumed in day 1 in enhanced energy efficiency through reduction of power consumption in base station or a cell site (kw)
0	0	0
1	3600	3500
2	5000	4900
3	5300	5200
4	5764	5742
10	5764	5742

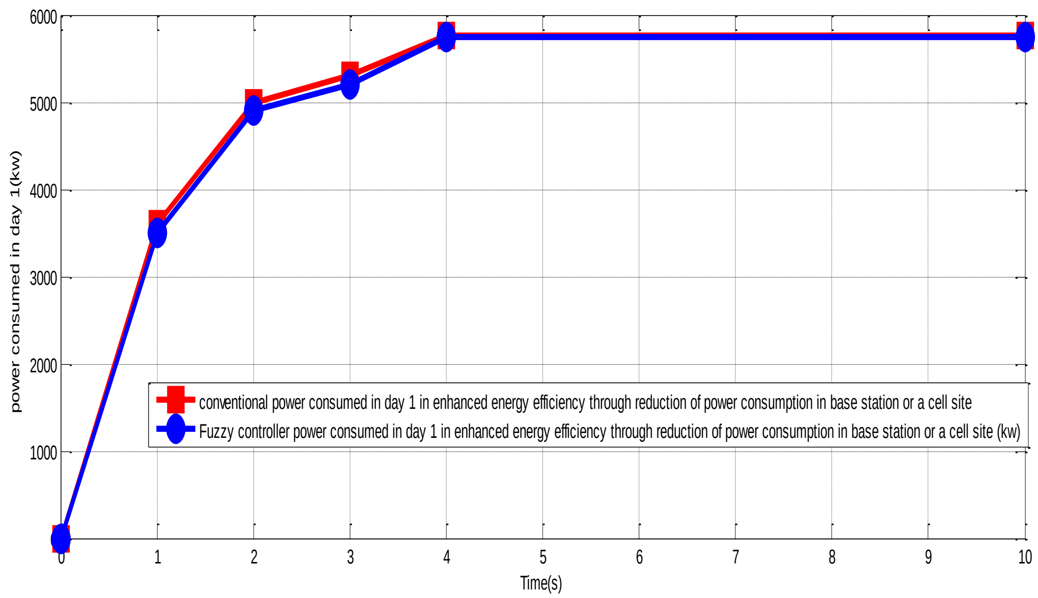

Fig. 3.1: Comparison of Conventional and Fuzzy Controller Power Consumed in Day 1

Figure 3.1 shows that the highest conventional power consumed by the cell site in day 1 is 5764KW which tremendously reduce the economy of the communication network. On the other hand, the highest fuzzy controller power consumed is 5742KW. This shows that the power reduced when fuzzy controller is incorporated in the system is 22KW or 0.38% better than the conventional approach.

Table 3.2: Comparing Conventional and Fuzzy Controller Power Consumed in Day 10

time(hr)	conventional power consumed in day 10 in enhanced energy efficiency through reduction of power consumption in base station or a cell site (kw)	Fuzzy controller power consumed in day 10 in enhanced energy efficiency through reduction of power consumption in base station or a cell site (kw)
0	0	0
1	3600	3500
2	5100	5000
3	5300	5200
4	5686	5664
10	5686	5664

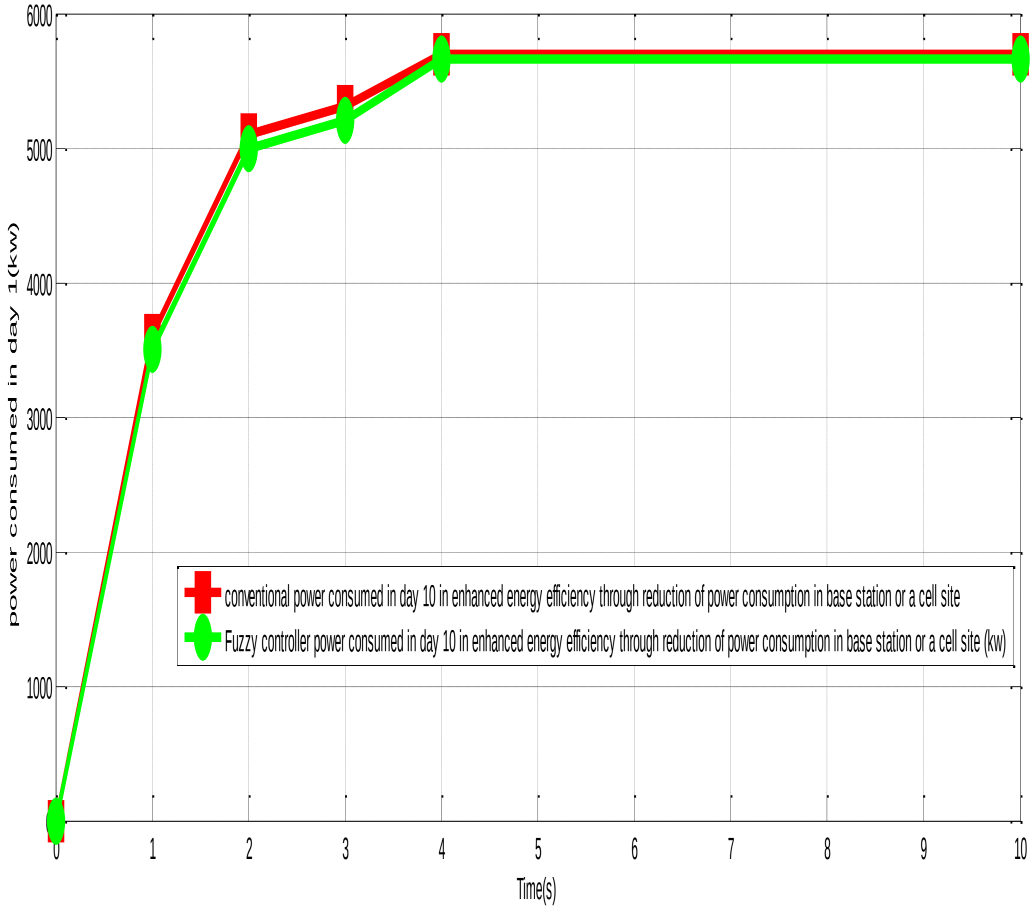

Fig. 3.2: Comparing Conventional and Fuzzy Controller Power Consumed in Day 10

Figure 3.2 shows comparing conventional and fuzzy controller power consumed in day 10. The highest conventional power consumed on day 10 by communication base station is 5686KW while that when fuzzy controller is incorporated in the system is 5664KW, with these results, it shows that the percentage improvement in power reduction when fuzzy controller is incorporated in the system is 0.4% better than the conventional method.

4. Conclusion

The increase in the power consumed in communication cell sites has attain to the peak thereby reducing the financial strength of the network. This increase in the power consumed by some communication site is subdued by introducing enhanced energy efficiency through reduction of power consumption in base station or a cell site using fuzzy controller. To achieve this, it is done in this manner, characterizing cell site understudy and its power consumption, establishing that there is much energy consumed in the cell site, developing a rule base that will minimize the energy consumed in the cell site and designing a SIMULINK model for enhanced energy efficiency through reduction of power consumption in base station or a cell site using fuzzy controller. The results obtained are the highest conventional power consumed by the cell site in day 1 is 5764KW which tremendously reduce the economy of the communication network. On the other hand, the highest fuzzy controller power consumed is 5742KW. This shows that the power reduced when fuzzy controller is incorporated in the system is 22KW or 0.38% better than the conventional approach. And the highest conventional power consumed in day 10 by communication base station is 5686KW while that when fuzzy controller is incorporated in the system is 5664KW, with these results, it shows that the percentage improvement in power reduction when fuzzy controller is incorporated in the system is 0.4% better than the conventional method.

References

Abhishek, Sharma. (2013). Generations of Wireless Communication. (From 0G to 5G) ROLL NO. - 935, E.C.E - 6TH SEM. A paper published in Academia.edu. https://www.academia.edu/3099956/Generations_of_Wireless_Communication._From_0G_to_5G_Abhi

Abubakar, Lamido Tanko. (2018). Evolution of Mobile Telecommunication with Respect To 1G 2G 3G and 4G Nigeria Communication Commission (2019) The Communicator – Issue #25 – Quarter 3/4 Edition.

Akbari, A., Imran, M.A., Tafazolli, R., and Dianati, M. (2011). Energy efficiency contours for single-carrier downlink channels. *IEEE Communications Letters*; 15(12).

Akhilesh, Kumar Pachauri., and Ompal, Singh. (2012). 5G Technology – Redefining wireless Communication in upcoming years, *International Journal of Computer Science and Management Research*, 1(1).

Amanna, A., (2009). Green Communications, Institute for Critical Technology and Applied Science (ICTAS) at Virginia Tech.

Fehske, A. J., Richter, F., and G. P. Fettweis., (2009). Energy efficiency improvements through micro sites in cellular mobile radio networks, in Proc. Of IEEE Green Comm, Honolulu, Hawaii.

Goldsmith, A. J., (2005). Wireless Communication, 1st Ed., New York: Cambridge University.

Karousos, A., The distortion of UWB Signals in the Environment, Ph.D. Thesis, University of Surrey.

Law A. M., (2007). Simulation Modeling and Analysis, 4th Ed., McGraw-Hill New York.

Mukherjee, A., Bhatt, S., Acherjee, Pal S., and De, D., (2013). Femtocell based green power consumption methods for mobile network, *Computer Networks*, (57)1, 62–178.