Development of a Model for the Establishment of a Hydro Electric Power Generating Plant

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Abstract

Nigeria as a nation has suffered a lot when it comes to the availability of electricity. A clear comparison between this nation’s electric power supply and other countries revealed the present incessant electric power supply in the country. The average power per capita (watts per person) in the United States is 1,377 Watts. In Canada, it is as high as 1,704 Watts per person and in South Africa, it is 445 Watts per person. The average power per capita in Australia is 1,112 Watts and in New Zealand it is 1,020 W per person. Whereas, the average power per capita (watts per person) in Nigeria is 14 W person. The power system structure is characterized with a lot of faults and outages. These electric power problem has destroyed the industrial processes in the country. As a result, unemployment has increased in the country. As at February, 2020, according to the Federal Government of Nigeria, the number of unemployed youths in the country is 23 million. Data from the International Transparency in the United State stated that there are 40 million unemployed youths in the country. This has increased crime rates among the youths. The country experience a high level of hardship, insecurity and socio-economic disorder as results. Therefore, there is an urgent need to solve this incessant supply of electric power in the country. Hence, a detail study of Akure132/33kV substation Network of the Benin Electricity Distribution Company under which there are 84,264 customers was carried out.

Introduction

The Federal Government of Nigeria promised to increase the power output by launching nine power plant projects in the country. But many of the power projects have been abandoned. After over 30 years, many of them were never completed. Even when all these projects are 100% completed, the total generating capacity in the country from the old power generating plants and these new projects will just be 8,274 MW. The average electricity consumed in watts per person in Nigeria will just be 45.97 Watts/person. Where-as, the average power per capita (watts per person) in the European Union with a population of 513,949,445 is 615Watts/person, in the United States it is 1,377 Watts/person. In China, a country with population of 1,373,541,000, the average power per capita (watts per person) is 492 Watts/person- In South Africa, it is 445 Watts per person. The average power per capita in Australia is 1,112 Watts, in Russia it is 854 W per person and in Canada, it is as high as 1,704 Watts per person as shown in table 1.
The lists of the said ongoing power projects in country are 1) 1700 Megawatts Hydro Power Plant Zungeru power plant in Niger state: This project was first conceived in 1982, but was abandoned due to lack of funds, corruption and dispute among the parties involved. Construction started again in 2016 and is expected to be completed by 2019. Though never completed. 2) 240 Mega Watts Afam Power Plant: Afam Power Plc is a thermal power plant located in the gas rich Rivers State. It is expected to be completed by December 2017. However, this power project has never been completed. 3) 40 Mega Watts Kashimbilla Hydro Power Plant Located in Taraba state: the construction of this 40 Mega Watts Kashimbilla power plant started in March 2017 and it is expected to be running by the end of the year 2017. Again, this Hydro Power Plant is not yet in operation. 4) 215 Mega Watts Kaduna Power Plant: This power project contract in Kaduna state was awarded in 2009 and it was expected to be completed within 36 months. However, the project experienced great delay due to inadequate budgetary allocation and corruption among Nigerian Politicians. It was expected to be running before the end of year 2017. This power plant has not been completed up till today. 5) 450 Megawatts Azura Power Plant: Azura Thermal power station is a natural gas powered electricity generation plant with a proposed capacity of 1,500 megawatts, under construction in Edo state, Nigeria. It is an IPP project, with its first phase under construction. It is expected to be commissioned in 2018 but never completed. 6) 40 Mega Watts Gurara Power Plant in Kaduna state: it was estimated that the completion of the Gurara Hydro plant would generate additional 30 megawatts. Again, the project experience great delay due to inadequate budgetary allocation and corruption in the country. 7) 29 Mega Watts Dadinkowa Hydro Power Plant Located in Gombe State: the construction of the Dadinkowa plant is expected to be completed in November, 2017. Yet, this power plant is still incomplete. 8) 10 Mega Watts Katsina Wind Power Plant: The N4.4 billion Katsina Wind power plant project was awarded to a French company in 2010 and was scheduled for completion in 2012. However, the project has been stalled due to corruption and other several reasons. No completion date has been announced yet” AdeolaOpeyemi, 2016. 9)Mambilla Power Station: The Mambilla Power Station, one of Nigeria's biggest dam projects is a projected hydro power plant which will be connected to three dams across the Donga River in Taraba State, Nigeria, with a generating capacity of 3,050 megawatt. These projects were never completed up till year 2020.

Finally, the total generating capacity from these new 9 power plant projects, even when completed, is 4,774 MW. The present power generating capacity in Nigeria is estimated to be 6,803 megawatts, with average working capacity of 3,500 MW. Hence, the total generating capacity in the country will only become 11,577 MW (6,803 +4,774). The total power generated in the country will only be 8,274 MW (3,500 + 4,774MW) and the average electricity consumed in watts per person in Nigeria will just be 45.97 Watts/person even after completion.

In order to provide solution to this incessant problem, a detail study of Akure132/33kV substation Network of the Benin Electricity Distribution Company under which there are 84,264 customers was carried out. Reliability index of the distribution system were estimated. A model for establishing a hydro Electric Power Generating Plant was developed. Hence, procedure for varying the value of the output power generated in the generating station was also developed.

Table 1. Electricity Energy Consumption in the World from the World Fact Book

| Rank | Country/Region | Electricity consumption (kW-h/yr) | Year of Data | Source | Population | As of | Average energy per capita (kWh per person per year) | Average power per capita (watts per person) |
|------|----------------|----------------------------------|--------------|--------|------------|-------|------------------------------------------------|------------------------------------------|

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| Rank | Country/Region       | Electricity consumption (kW·h/yr) | Year of Data | Source | Population | As of | Average energy per capita (kW·h per person per year) | Average power per capita (watts per person) |
|------|----------------------|----------------------------------|--------------|--------|------------|-------|---------------------------------------------------|-----------------------------------------------|
|      | World                | 21,776,088,770,300               |              | CIA    | 7,322,811,468 | 2016  | 2,674                                            | 309                                           |
| 1    | China                | 5,920,000,000,000                | 2016         | CIA    | 1,373,541,000 | 2016  | 4,310                                            | 492                                           |
| 2    | United States        | 3,911,000,000,000                | 2015 EST.    | CIA    | 323,995,528  | 2016  | 12,071                                           | 1,377                                         |
| 3    | European Union       | 2,771,000,000,000                | 2013 EST.    | CIA    | 513,949,445  | 2016  | 5,391                                            | 615                                           |
| 4    | India                | 1,408,624,400,000                | 2016 EST.    | CSO\[2\] | 1,266,883,598 | 2016  | 1,122                                            | 128                                           |
| 5    | Russia               | 1,065,000,000,000                | 2014 EST.    | CIA    | 142,355,415  | 2016  | 7,481                                            | 854                                           |
| 6    | Japan                | 934,000,000,000                  | 2014 EST.    | CIA    | 126,702,133  | 2016  | 7,371                                            | 841                                           |
| 7    | Germany              | 533,000,000,000                  | 2014 EST.    | CIA    | 80,722,792   | 2016  | 6,602                                            | 753                                           |
| 8    | Canada               | 528,000,000,000                  | 2014 EST.    | CIA    | 35,362,905   | 2016  | 14,930                                           | 1,704                                         |
| 9    | Brazil               | 518,000,000,000                  | 2014 EST.    | CIA    | 205,823,665  | 2016  | 2,516                                            | 287                                           |
| 10   | Korea, South         | 495,000,000,000                  | 2014 EST.    | CIA    | 50,924,172   | 2016  | 9,720                                            | 1109                                          |
| 11   | France               | 431,000,000,000                  | 2014 EST.    | CIA    | 66,836,154   | 2016  | 6,448                                            | 736                                           |
| 12   | United Kingdom       | 309,000,000,000                  | 2014 EST.    | CIA    | 64,430,428   | 2016  | 4,795                                            | 547                                           |
| 13   | Italy                | 291,000,000,000                  | 2014 EST.    | CIA    | 62,007,540   | 2016  | 4,692                                            | 535                                           |
| 14   | Saudi Arabia         | 272,000,000,000                  | 2014 EST.    | CIA    | 28,160,273   | 2016  | 9,658                                            | 1,102                                         |
| 15   | Taiwan               | 249,500,000,000                  | 2015 EST.    | CIA    | 23,464,787   | 2016  | 10,632                                           | 1,213                                         |
| 16   | Mexico               | 238,000,000,000                  | 2014 EST.    | CIA    | 123,166,749  | 2016  | 1,932                                            | 220                                           |
| 17   | Spain                | 234,000,000,000                  | 2014 EST.    | CIA    | 48,563,476   | 2016  | 4,818                                            | 550                                           |
| 18   | Australia            | 224,000,000,000                  | 2014 EST.    | CIA    | 22,992,654   | 2016  | 9,742                                            | 1,112                                         |
| 19   | Iran                 | 218,000,000,000                  | 2014 EST.    | CIA    | 82,801,633   | 2016  | 2,632                                            | 300                                           |
| 20   | South Africa         | 212,000,000,000                  | 2014 EST.    | CIA    | 54,300,704   | 2016  | 3,904                                            | 445                                           |
| 21   | Turkey               | 207,000,000,000                  | 2014 EST.    | CIA    | 80,274,604   | 2016  | 2,578                                            | 294                                           |
| 22   | Indonesia            | 195,000,000,000                  | 2014 EST.    | CIA    | 258,316,051  | 2016  | 754                                              | 86                                            |
| 23   | Thailand             | 164,000,000,000                  | 2014 EST.    | CIA    | 68,200,824   | 2016  | 2,404                                            | 274                                           |
| 24   | Egypt                | 143,000,000,000                  | 2014 EST.    | CIA    | 94,666,993   | 2016  | 1,510                                            | 172                                           |
| 25   | Ukraine              | 143,000,000,000                  | 2014 EST.    | CIA    | 44,209,733   | 2016  | 3,234                                            | 369                                           |
| 26   | Poland               | 142,000,000,000                  | 2014 EST.    | CIA    | 38,523,261   | 2016  | 3,686                                            | 420                                           |
| 27   | Malaysia             | 131,000,000,000                  | 2014 EST.    | CIA    | 30,949,962   | 2016  | 4,232                                            | 483                                           |
| 28   | Sweden               | 127,000,000,000                  | 2014 EST.    | CIA    | 9,880,604    | 2016  | 12,853                                           | 1,467                                         |
| 29   | Norway               | 126,400,000,000                  | 2014 EST.    | CIA    | 5,265,158    | 2016  | 24,006                                           | 2740                                          |
| 30   | Vietnam              | 125,000,000,000                  | 2014 EST.    | CIA    | 95,261,021   | 2016  | 1,312                                            | 149                                           |
| 31   | Argentina            | 116,000,000,000                  | 2014 EST.    | CIA    | 43,886,748   | 2016  | 2,643                                            | 301                                           |
| 32   | Netherlands          | 108,000,000,000                  | 2014 EST.    | CIA    | 17,016,967   | 2016  | 6,346                                            | 724                                           |
| Rank | Country/Region      | Electricity consumption (kW-h/yr) | Year of Data | Source | Population | As of  | Average energy per capita (kWh per person per year) | Average power per capita (watts per person) |
|------|---------------------|----------------------------------|--------------|--------|------------|--------|-------------------------------------------------|-------------------------------------------|
| 33   | United Arab Emirates | 96,000,000,000                   | 2014 EST.    | CIA    | 5,927,482  | 2016   | 16,195                                          | 1848                                      |
| 34   | Kazakhstan           | 91,000,000,000                   | 2014 EST.    | CIA    | 18,360,353 | 2016   | 4,956                                           | 565                                       |
| 35   | Philippines          | 90,797,891,000                   | 2016         | DOE[1] | 102,624,209| 2016   | 885                                             | 101                                       |
| 36   | Pakistan             | 82,000,000,000                   | 2014 EST.    | CIA    | 201,995,540| 2016   | 405                                             | 46                                        |
| 37   | Finland              | 81,000,000,000                   | 2014 EST.    | CIA    | 5,498,211  | 2016   | 14,732                                          | 1681                                      |
| 38   | Belgium              | 81,000,000,000                   | 2014 EST.    | CIA    | 11,409,077 | 2016   | 7,099                                           | 810                                       |
| 39   | Venezuela            | 78,000,000,000                   | 2014 EST.    | CIA    | 30,912,302 | 2016   | 2,523                                           | 288                                       |
| 40   | Austria              | 69,750,000,000                   | 2015 EST.    | CIA    | 8,711,770  | 2016   | 8,006                                           | 913                                       |
| 41   | Chile                | 66,000,000,000                   | 2014 EST.    | CIA    | 17,650,114 | 2016   | 3,739                                           | 426                                       |
| 42   | Czech Republic       | 60,000,000,000                   | 2014 EST.    | CIA    | 10,644,842 | 2016   | 5,636                                           | 643                                       |
| 43   | Colombia             | 60,000,000,000                   | 2014 EST.    | CIA    | 47,220,856 | 2016   | 1,270                                           | 145                                       |
| 44   | Israel               | 59,830,000,000                   | 2014 EST.    | CIA    | 8,174,527  | 2016   | 7,319                                           | 835                                       |
| 45   | Switzerland          | 58,000,000,000                   | 2014 EST.    | CIA    | 8,179,294  | 2016   | 7,091                                           | 809                                       |
| 46   | Bangladesh           | 55,500,000,000                   | 2015 EST.    | CIA    | 157,826,578| 2017   | 351                                             | 40                                        |
| 47   | Kuwait               | 54,000,000,000                   | 2014 EST.    | CIA    | 2,832,776  | 2016   | 19,062                                          | 2176                                      |
| 48   | Greece               | 53,000,000,000                   | 2014 EST.    | CIA    | 10,773,253 | 2016   | 4,919                                           | 561                                       |
| 49   | Algeria              | 49,000,000,000                   | 2014 EST.    | CIA    | 40,263,711 | 2016   | 1,216                                           | 138                                       |
| 50   | Romania              | 48,000,000,000                   | 2014 EST.    | CIA    | 21,599,736 | 2016   | 2,222                                           | 253                                       |
| 51   | Uzbekistan           | 48,000,000,000                   | 2014 EST.    | CIA    | 29,473,614 | 2016   | 1,628                                           | 185                                       |
| 52   | Singapore            | 47,180,000,000                   | 2014 EST.    | CIA    | 5,781,728  | 2016   | 8,160                                           | 931                                       |
| 53   | Portugal             | 46,000,000,000                   | 2014 EST.    | CIA    | 10,833,816 | 2016   | 4,245                                           | 484                                       |
| 54   | Hong Kong            | 42,000,000,000                   | 2014 EST.    | CIA    | 7,167,403  | 2016   | 5,859                                           | 668                                       |
| 55   | Iraq                 | 42,000,000,000                   | 2014 EST.    | CIA    | 38,146,025 | 2016   | 1,101                                           | 125                                       |
| 56   | New Zealand          | 40,000,000,000                   | 2014 EST.    | CIA    | 4,474,549  | 2016   | 8,939                                           | 1020                                      |
| 57   | Peru                 | 39,000,000,000                   | 2014 EST.    | CIA    | 30,741,062 | 2016   | 1,268                                           | 144                                       |
| 58   | Qatar                | 34,000,000,000                   | 2014 EST.    | CIA    | 2,258,283  | 2016   | 15,055                                          | 1718                                      |
| 59   | Belarus              | 33,000,000,000                   | 2014 EST.    | CIA    | 9,570,376  | 2016   | 3,448                                           | 393                                       |
| 60   | Denmark              | 32,000,000,000                   | 2014 EST.    | CIA    | 5,593,785  | 2016   | 5,720                                           | 653                                       |
| 61   | Bulgaria             | 31,000,000,000                   | 2014 EST.    | CIA    | 7,144,653  | 2016   | 4,338                                           | 495                                       |
| 62   | Morocco              | 29,000,000,000                   | 2014 EST.    | CIA    | 33,655,786 | 2016   | 861                                             | 98                                        |
| 63   | Slovakia             | 28,360,000,000                   | 2014 EST.    | CIA    | 5,445,802  | 2016   | 5,207                                           | 594                                       |
| 64   | Serbia               | 26,910,000,000                   | 2014 EST.    | CIA    | 7,143,921  | 2016   | 3,766                                           | 430                                       |
| 65   | Bahrain              | 25,000,000,000                   | 2014 EST.    | CIA    | 1,378,904  | 2016   | 18,130                                          | 2069                                      |

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|------|------------------------------------|----------------------------------|--------------|--------|------------|-------|---------------------------------------------------|---------------------------------------------|
| 66   | Ireland                            | 25,000,000,000                   | 2014 EST.    | CIA    | 4,952,473  | 2016  | 5,047                                             | 576                                         |
| 67   | Oman                               | 25,000,000,000                   | 2014 EST.    | CIA    | 3,355,262  | 2016  | 7,450                                             | 850                                         |
| 68   | Nigeria                            | 24,000,000,000                   | 2014 EST.    | CIA    | 186,053,386| 2016  | 128                                               | 14                                          |
| 69   | Hungary                            | 21,550,000,000                   | 2015 EST.    | CIA    | 9,874,784  | 2016  | 2,182                                             | 249                                         |
| 70   | Ecuador                            | 21,000,000,000                   | 2014 EST.    | CIA    | 16,080,778 | 2016  | 1,305                                             | 149                                         |
| 71   | Azerbaijan                         | 20,000,000,000                   | 2014 EST.    | CIA    | 9,872,765  | 2016  | 2,025                                             | 231                                         |
| 72   | Puerto Rico                        | 19,000,000,000                   | 2014 EST.    | CIA    | 3,578,056  | 2016  | 5,310                                             | 606                                         |
| 73   | Iceland                            | 17,000,000,000                   | 2014 EST.    | CIA    | 335,878    | 2016  | 50,613                                            | 5777                                        |
| 74   | Syria                              | 17,000,000,000                   | 2014 EST.    | CIA    | 17,185,170 | 2016  | 989                                               | 112                                         |
| 75   | Croatia                            | 16,970,000,000                   | 2014 EST.    | CIA    | 4,313,707  | 2016  | 3,933                                             | 449                                         |
| 76   | Jordan                             | 16,000,000,000                   | 2014 EST.    | CIA    | 8,185,384  | 2016  | 1,954                                             | 223                                         |
| 77   | Lebanon                            | 16,000,000,000                   | 2014 EST.    | CIA    | 6,237,738  | 2016  | 2,565                                             | 292                                         |
| 78   | Dominican Republic                 | 15,140,000,000                   | 2014 EST.    | CIA    | 10,606,865 | 2016  | 1,427                                             | 162                                         |
| 79   | Tunisia                            | 15,000,000,000                   | 2014 EST.    | CIA    | 11,179,995 | 2016  | 1,341                                             | 153                                         |
| 80   | Cuba                               | 15,000,000,000                   | 2014 EST.    | CIA    | 25,115,311 | 2016  | 597                                               | 68                                          |
| 81   | Korea, North                       | 15,000,000,000                   | 2014 EST.    | CIA    | 11,134,588 | 2016  | 1,347                                             | 153                                         |
| 82   | Slovenia                           | 13,000,000,000                   | 2014 EST.    | CIA    | 1,978,029  | 2016  | 6,572                                             | 750                                         |
| 83   | Turkmenistan                       | 13,000,000,000                   | 2014 EST.    | CIA    | 5,291,317  | 2016  | 2,456                                             | 280                                         |
| 84   | Tajikistan                         | 12,000,000,000                   | 2014 EST.    | CIA    | 8,330,946  | 2016  | 1,440                                             | 164                                         |
| 85   | Mozambique                         | 12,000,000,000                   | 2014 EST.    | CIA    | 25,930,150 | 2016  | 462                                               | 52                                          |
| 86   | Kyrgyzstan                         | 11,000,000,000                   | 2014 EST.    | CIA    | 5,727,553  | 2016  | 1,920                                             | 219                                         |
| 87   | Sri Lanka                          | 11,000,000,000                   | 2014 EST.    | CIA    | 22,235,000 | 2016  | 494                                               | 56                                          |
| 88   | Zambia                             | 11,000,000,000                   | 2014 EST.    | CIA    | 15,510,711 | 2016  | 709                                               | 80                                          |
| 89   | Bosnia and Herzegovina             | 11,000,000,000                   | 2014 EST.    | CIA    | 3,861,912  | 2016  | 2,848                                             | 325                                         |
| 90   | Myanmar                            | 11,000,000,000                   | 2014 EST.    | CIA    | 56,890,418 | 2016  | 193                                               | 22                                          |
| 91   | Uruguay                            | 10,000,000,000                   | 2014 EST.    | CIA    | 3,351,016  | 2016  | 2,984                                             | 340                                         |
| 92   | Lithuania                          | 9,900,000,000                    | 2014 EST.    | CIA    | 2,854,235  | 2016  | 3,468                                             | 395                                         |
| 93   | Sudan                              | 9,900,000,000                    | 2014 EST.    | CIA    | 36,729,501 | 2016  | 269                                               | 30                                          |
| 94   | Georgia                            | 9,800,000,000                    | 2014 EST.    | CIA    | 4,928,052  | 2016  | 1,988                                             | 227                                         |
| 95   | Paraguay                           | 9,700,000,000                    | 2014 EST.    | CIA    | 6,862,812  | 2016  | 1,413                                             | 161                                         |
| 96   | Libya                              | 9,300,000,000                    | 2014 EST.    | CIA    | 6,541,948  | 2016  | 1,421                                             | 162                                         |
| 97   | Democratic Republic of the Congo   | 9,300,000,000                    | 2014 EST.    | CIA    | 81,331,050 | 2016  | 114                                               | 13                                          |
| 98   | Costa Rica                         | 9,200,000,000                    | 2014 EST.    | CIA    | 4,872,543  | 2016  | 1,888                                             | 215                                         |
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|------|---------------------------|---------------------------------|--------------|--------|------------|-------|---------------------------------------------------|------------------------------------------|
| 99   | Ghana                     | 9,200,000,000                   | 2014 EST.    | CIA    | 26,908,262 | 2016  | 341                                               | 39                                       |
| 100  | Trinidad and Tobago       | 9,100,000,000                   | 2014 EST.    | CIA    | 1,220,479  | 2016  | 7,456                                             | 851                                      |
| 101  | Guatemala                 | 8,915,000,000                   | 2014 EST.    | CIA    | 15,189,958 | 2016  | 586                                               | 66                                       |
| 102  | Estonia                   | 8,200,000,000                   | 2014 EST.    | CIA    | 1,258,545  | 2016  | 6,515                                             | 743                                      |
| 103  | Angola                    | 8,100,000,000                   | 2014 EST.    | CIA    | 20,172,332 | 2016  | 401                                               | 45                                       |
| 104  | Zimbabwe                  | 8,000,000,000                   | 2014 EST.    | CIA    | 14,546,961 | 2016  | 549                                               | 62                                       |
| 105  | Panama                    | 7,800,000,000                   | 2014 EST.    | CIA    | 3,705,246  | 2016  | 2,105                                             | 240                                      |
| 106  | Albania                   | 7,793,000,000                   | 2014 EST.    | CIA    | 3,038,594  | 2016  | 2,564                                             | 292                                      |
| 107  | Kenya                     | 7,600,000,000                   | 2014 EST.    | CIA    | 46,790,758 | 2016  | 162                                               | 18                                       |
| 108  | Bolivia                   | 7,500,000,000                   | 2014 EST.    | CIA    | 10,969,649 | 2016  | 683                                               | 78                                       |
| 109  | Macedonia                 | 6,960,000,000                   | 2014 EST.    | CIA    | 2,100,025  | 2016  | 3,314                                             | 378                                      |
| 110  | Latvia                    | 6,800,000,000                   | 2014 EST.    | CIA    | 1,965,686  | 2016  | 3,459                                             | 394                                      |
| 111  | Ethiopia                  | 6,700,000,000                   | 2014 EST.    | CIA    | 102,374,044| 2016  | 65                                                | 7                                        |
| 112  | Luxembourg                | 6,200,000,000                   | 2014 EST.    | CIA    | 582,291    | 2016  | 10,647                                            | 1215                                     |
| 113  | Cameroon                  | 6,100,000,000                   | 2014 EST.    | CIA    | 24,360,803 | 2016  | 250                                               | 28                                       |
| 114  | Ivory Coast               | 5,800,000,000                   | 2014 EST.    | CIA    | 23,740,424 | 2016  | 244                                               | 27                                       |
| 115  | El Salvador               | 5,700,000,000                   | 2014 EST.    | CIA    | 6,156,670  | 2016  | 925                                               | 105                                      |
| 116  | Mongolia                  | 5,600,000,000                   | 2014 EST.    | CIA    | 3,031,330  | 2016  | 1,847                                             | 210                                      |
| 117  | Honduras                  | 5,300,000,000                   | 2014 EST.    | CIA    | 8,893,259  | 2016  | 595                                               | 68                                       |
| 118  | West Bank                 | 5,200,000,000                   | 2014 EST.    | CIA    | 2,697,687  | 2016  | 1,927                                             | 220                                      |
| 119  | Yemen                     | 5,200,000,000                   | 2014 EST.    | CIA    | 27,392,779 | 2016  | 189                                               | 21                                       |
| 120  | Armenia                   | 5,100,000,000                   | 2014 EST.    | CIA    | 3,051,250  | 2016  | 1,671                                             | 190                                      |
| 121  | Tanzania                  | 5,000,000,000                   | 2014 EST.    | CIA    | 52,482,726 | 2016  | 95                                                | 10                                       |
| 122  | Afghanistan               | 4,700,000,000                   | 2014 EST.    | CIA    | 33,332,025 | 2016  | 141                                               | 16                                       |
| 123  | Macau                     | 4,500,000,000                   | 2014 EST.    | CIA    | 597,425    | 2016  | 7,532                                             | 859                                      |
| 124  | Nicaragua                 | 4,412,000,000                   | 2014 EST.    | CIA    | 5,966,798  | 2016  | 739                                               | 84                                       |
| 125  | Moldova                   | 4,305,000,000                   | 2014 EST.    | CIA    | 3,510,485  | 2016  | 1,226                                             | 139                                      |
| 126  | Cambodia                  | 4,100,000,000                   | 2014 EST.    | CIA    | 15,957,223 | 2016  | 256                                               | 29                                       |
| 127  | Laos                      | 3,900,000,000                   | 2014 EST.    | CIA    | 7,019,073  | 2016  | 555                                               | 63                                       |
| 128  | Nepal                     | 3,900,000,000                   | 2014 EST.    | CIA    | 29,033,914 | 2016  | 134                                               | 15                                       |
| 129  | Cyprus                    | 3,900,000,000                   | 2014 EST.    | CIA    | 1,205,575  | 2016  | 3,234                                             | 369                                      |
| 130  | Brunei                    | 3,766,000,000                   | 2014 EST.    | CIA    | 436,620    | 2016  | 8,625                                             | 984                                      |
| 131  | Botswana                  | 3,700,000,000                   | 2014 EST.    | CIA    | 2,209,208  | 2016  | 1,674                                             | 191                                      |
| 132  | Namibia                   | 3,700,000,000                   | 2014 EST.    | CIA    | 2,436,469  | 2016  | 1,518                                             | 173                                      |
| Rank | Country/Region       | Electricity consumption (kW-h/yr) | Year of Data | Source | Population | As of | Average energy per capita (kW per person per year) | Average power per capita (watts per person) |
|------|----------------------|----------------------------------|--------------|--------|------------|-------|-------------------------------------------------|-------------------------------------------|
| 133  | Papua New Guinea     | 3,000,000,000                    | 2016 EST.    | CIA    | 6,791,317  | 2016  | 441                                            | 50                                        |
| 134  | Senegal              | 3,000,000,000                    | 2014 EST.    | CIA    | 14,320,055 | 2016  | 209                                            | 23                                        |
| 135  | Kosovo               | 2,887,000,000                    | 2016 EST.    | CIA    | 1,883,018  | 2016  | 1,533                                          | 175                                       |
| 136  | Montenegro           | 2,800,000,000                    | 2016 EST.    | CIA    | 644,578    | 2016  | 4,343                                          | 495                                       |
| 137  | Jamaica              | 2,800,000,000                    | 2016 EST.    | CIA    | 2,970,340  | 2016  | 942                                            | 107                                       |
| 138  | Uganda               | 2,700,000,000                    | 2016 EST.    | CIA    | 38,319,241 | 2016  | 70                                             | 8                                         |
| 139  | Mauritius            | 2,600,000,000                    | 2016 EST.    | CIA    | 1,348,242  | 2016  | 1,928                                          | 220                                       |
| 140  | Gabon                | 2,100,000,000                    | 2016 EST.    | CIA    | 1,738,541  | 2016  | 1,207                                          | 137                                       |
| 141  | Bhutan               | 2,085,000,000                    | 2016 EST.    | CIA    | 750,125    | 2016  | 2,779                                          | 317                                       |
| 142  | New Caledonia        | 2,000,000,000                    | 2016 EST.    | CIA    | 275,355    | 2016  | 7,263                                          | 829                                       |
| 143  | Malta                | 2,000,000,000                    | 2016 EST.    | CIA    | 415,196    | 2016  | 4,817                                          | 549                                       |
| 144  | Suriname             | 1,900,000,000                    | 2016 EST.    | CIA    | 585,824    | 2016  | 3,243                                          | 370                                       |
| 145  | Malawi               | 1,900,000,000                    | 2016 EST.    | CIA    | 18,570,321 | 2016  | 102                                            | 11                                        |
| 146  | Bahamas              | 1,600,000,000                    | 2016 EST.    | CIA    | 327,316    | 2016  | 4,888                                          | 558                                       |
| 147  | Guam                 | 1,500,000,000                    | 2016 EST.    | CIA    | 162,742    | 2016  | 9,217                                          | 1052                                      |
| 148  | Swaziland            | 1,500,000,000                    | 2016 EST.    | CIA    | 1,451,428  | 2016  | 1,033                                          | 117                                       |
| 149  | Mali                 | 1,400,000,000                    | 2016 EST.    | CIA    | 17,467,108 | 2016  | 80                                             | 9                                         |
| 150  | Liechtenstein        | 1,360,000,000                    | 2012         | CIA    | 37,937     | 2016  | 35,848                                         | 4092                                      |
| 151  | Madagascar           | 1,300,000,000                    | 2016 EST.    | CIA    | 24,430,325 | 2016  | 53                                             | 6                                         |
| 152  | Burkina Faso         | 1,200,000,000                    | 2016 EST.    | CIA    | 19,512,533 | 2016  | 61                                             | 7                                         |
| 153  | Niger                | 1,200,000,000                    | 2016 EST.    | CIA    | 18,638,600 | 2016  | 64                                             | 7                                         |
| 154  | Togo                 | 1,100,000,000                    | 2016 EST.    | CIA    | 7,756,937  | 2016  | 141                                            | 16                                        |
| 155  | Benin                | 1,000,000,000                    | 2016 EST.    | CIA    | 10,741,458 | 2016  | 93                                             | 10                                        |
| 156  | Curacao              | 968,000,000                      | 2008 EST.    | CIA    | 149,035    | 2016  | 6,495                                          | 741                                       |
| 157  | Congo, Republic of the | 900,000,000                   | 2016 EST.    | CIA    | 4,852,412  | 2016  | 185                                            | 21                                        |
| 158  | Guinea               | 900,000,000                      | 2016 EST.    | CIA    | 12,093,349 | 2016  | 74                                             | 8                                         |
| 159  | Barbados             | 900,000,000                      | 2016 EST.    | CIA    | 291,495    | 2016  | 3,087                                          | 352                                       |
| 160  | Mauritania           | 800,000,000                      | 2016 EST.    | CIA    | 3,677,293  | 2016  | 217                                            | 24                                        |
| 161  | Lesotho              | 800,000,000                      | 2016 EST.    | CIA    | 1,953,070  | 2016  | 409                                            | 46                                        |
| 162  | Guyana               | 800,000,000                      | 2016 EST.    | CIA    | 735,909    | 2016  | 1,087                                          | 124                                       |
| 163  | Fiji                 | 800,000,000                      | 2016 EST.    | CIA    | 915,303    | 2016  | 874                                            | 99                                        |
| 164  | Aruba                | 800,000,000                      | 2016 EST.    | CIA    | 113,648    | 2016  | 7,039                                          | 803                                       |
| 165  | French               | 700,000,000                      | 2016 EST.    | CIA    | 285,321    | 2016  | 2,453                                          | 280                                       |
| Rank | Country/Region               | Electricity consumption (kW·h/yr) | Year of Data | Source | Population | As of | Average energy per capita (kWh per person per year) | Average power per capita (watts per person) |
|------|-----------------------------|----------------------------------|--------------|--------|------------|-------|------------------------------------------------|------------------------------------------|
| 166  | South Sudan                 | 694,100,000                      | 2012 EST.    | CIA    | 12,530,717 | 2016  | 55                                               | 6                                        |
| 167  | Jersey                      | 630,100,000                      | 2004 EST.    | CIA    | 98,069     | 2016  | 6,425                                            | 733                                      |
| 168  | Bermuda                     | 600,000,000                      | 2014 EST.    | CIA    | 70,537     | 2016  | 8,506                                            | 971                                      |
| 169  | Cayman Islands              | 600,000,000                      | 2014 EST.    | CIA    | 57,268     | 2016  | 10,477                                           | 1196                                     |
| 170  | U.S. Virgin Islands         | 600,000,000                      | 2014 EST.    | CIA    | 102,951    | 2016  | 5,828                                            | 665                                      |
| 171  | Marshall Islands            | 600,000,000                      | 2014 EST.    | CIA    | 73,376     | 2016  | 8,177                                            | 933                                      |
| 172  | Andorra                     | 562,400,000                      | 2012         | CIA    | 85,660     | 2016  | 6,565                                            | 749                                      |
| 173  | Rwanda                      | 500,000,000                      | 2014 EST.    | CIA    | 12,988,423 | 2016  | 38                                               | 4                                        |
| 174  | Burundi                     | 400,000,000                      | 2014 EST.    | CIA    | 11,099,298 | 2016  | 36                                               | 4                                        |
| 175  | Belize                      | 400,000,000                      | 2014 EST.    | CIA    | 353,858    | 2016  | 1,130                                            | 129                                      |
| 176  | Djibouti                    | 400,000,000                      | 2014 EST.    | CIA    | 10,485,800 | 2016  | 38                                               | 4                                        |
| 177  | Haiti                       | 400,000,000                      | 2014 EST.    | CIA    | 93,186     | 2016  | 3,219                                            | 367                                      |
| 178  | Seychelles                  | 300,000,000                      | 2014 EST.    | CIA    | 10,817,354 | 2016  | 27                                               | 3                                        |
| 179  | Somalia                     | 300,000,000                      | 2014 EST.    | CIA    | 164,464    | 2016  | 1,824                                            | 208                                      |
| 180  | Saint Lucia                 | 300,000,000                      | 2014 EST.    | CIA    | 535,858    | 2016  | 149                                              | 17                                       |
| 181  | Antigua and Barbuda         | 300,000,000                      | 2014 EST.    | CIA    | 93,581     | 2016  | 3,205                                            | 365                                      |
| 182  | Cabo Verde                  | 300,000,000                      | 2014 EST.    | CIA    | 553,432    | 2016  | 542                                              | 61                                       |
| 183  | Eritrea                     | 300,000,000                      | 2014 EST.    | CIA    | 5,869,869  | 2016  | 51                                               | 5                                        |
| 184  | Faroe Islands               | 300,000,000                      | 2014 EST.    | CIA    | 50,456     | 2016  | 5,945                                            | 678                                      |
| 185  | Gambia                      | 300,000,000                      | 2014 EST.    | CIA    | 57,728     | 2016  | 5,196                                            | 593                                      |
| 186  | Greenland                   | 300,000,000                      | 2014 EST.    | CIA    | 4,299,944  | 2016  | 69                                               | 7                                        |
| 187  | Liberia                     | 300,000,000                      | 2014 EST.    | CIA    | 392,960    | 2016  | 763                                              | 87                                       |
| 188  | Maldives                    | 300,000,000                      | 2014 EST.    | CIA    | 11,852,462 | 2016  | 16                                               | 1                                        |
| 189  | Chad                        | 200,000,000                      | 2014 EST.    | CIA    | 52,329     | 2016  | 3,821                                            | 436                                      |
| 190  | Saint Kitts and Nevis       | 200,000,000                      | 2014 EST.    | CIA    | 5,507,257  | 2016  | 36                                               | 4                                        |
| 191  | Central African Republic    | 200,000,000                      | 2014 EST.    | CIA    | 6,018,888  | 2016  | 33                                               | 3                                        |
| 192  | Sierra Leone                | 200,000,000                      | 2014 EST.    | CIA    | 51,430     | 2016  | 3,888                                            | 443                                      |
| 193  | Turks and Caicos Islands    | 200,000,000                      | 2014 EST.    | CIA    | 29,328     | 2016  | 6,819                                            | 778                                      |
| 194  | Gibraltar                   | 200,000,000                      | 2014 EST.    | CIA    | 111,219    | 2016  | 1,798                                            | 205                                      |
| Rank | Country/Region                        | Electricity consumption (kW-h/yr) | Year of Data | Source | Population | As of    | Average energy per capita (kWh per person per year) | Average power per capita (watts per person) |
|------|--------------------------------------|----------------------------------|--------------|--------|------------|----------|------------------------------------------------------|--------------------------------------------|
| 196  | Micronesia, Federated States of       | 178,600,000                      | 2002         | CIA    | 104,719    | 2016     | 1,705                                               | 194                                        |
| 197  | Timor-Leste                           | 125,300,000                      | 2014 EST.    | CIA    | 1,261,072  | 2016     | 99                                                  | 11                                         |
| 198  | British Virgin Islands                | 100,000,000                      | 2014 EST.    | CIA    | 34,232     | 2016     | 2,921                                               | 333                                        |
| 199  | Saint Vincent and the Grenadines      | 100,000,000                      | 2014 EST.    | CIA    | 102,350    | 2016     | 977                                                 | 111                                        |
| 200  | American Samoa                        | 100,000,000                      | 2014 EST.    | CIA    | 54,194     | 2016     | 1,845                                               | 210                                        |
| 201  | Samoa                                | 100,000,000                      | 2014 EST.    | CIA    | 198,926    | 2016     | 502                                                 | 57                                         |
| 202  | Equatorial Guinea                     | 91,140,000                       | 2014 EST.    | CIA    | 759,451    | 2016     | 120                                                 | 13                                         |
| 203  | Dominica                              | 90,210,000                       | 2014 EST.    | CIA    | 73,757     | 2016     | 1,223                                               | 139                                        |
| 204  | Western Sahara                        | 83,700,000                       | 2014 EST.    | CIA    | 587,020    | 2016     | 142                                                 | 16                                         |
| 205  | Solomon Islands                       | 79,050,000                       | 2014 EST.    | CIA    | 635,027    | 2016     | 124                                                 | 14                                         |
| 206  | Sao Tome and Principe                 | 65,100,000                       | 2014 EST.    | CIA    | 197,541    | 2016     | 329                                                 | 37                                         |
| 207  | Vanuatu                               | 55,800,000                       | 2014 EST.    | CIA    | 277,554    | 2016     | 201                                                 | 22                                         |
| 208  | Tonga                                 | 46,500,000                       | 2014 EST.    | CIA    | 106,513    | 2016     | 436                                                 | 49                                         |
| 209  | Saint Pierre and Miquelon            | 41,850,000                       | 2014 EST.    | CIA    | 5,595      | 2016     | 7,479                                               | 852                                        |
| 210  | Comoros                               | 40,920,000                       | 2014 EST.    | CIA    | 794,678    | 2016     | 51                                                  | 5                                          |
| 211  | Guinea-Bissau                         | 31,620,000                       | 2014 EST.    | CIA    | 1,759,159  | 2016     | 17                                                  | 2                                          |
| 212  | Cook Islands                          | 31,620,000                       | 2014 EST.    | CIA    | 9,556      | 2016     | 3,308                                               | 377                                        |
| 213  | Kiribati                              | 27,900,000                       | 2014 EST.    | CIA    | 106,925    | 2016     | 260                                                 | 29                                         |
| 214  | Nauru                                 | 23,250,000                       | 2014 EST.    | CIA    | 9,591      | 2016     | 2,424                                               | 276                                        |
| 215  | Montserrat                            | 21,390,000                       | 2014 EST.    | CIA    | 5,267      | 2016     | 4,061                                               | 463                                        |
| 216  | Falkland Islands                      | 13,950,000                       | 2014 EST.    | CIA    | 2,931      | 2016     | 4,759                                               | 543                                        |
| 217  | Saint Helena, Ascension and Tristan da Cunha | 9,300,000   | 2014 EST.    | CIA    | 7,795      | 2016     | 1,193                                               | 136                                        |

The detailed study of Akure132/33kV substation Network of the Benin Electricity Distribution Company under which there are 84,264 customers was carried out. Reliability index of the distribution system were estimated. A model for establishing a Hydro Electric Power Generating Plant was developed. A monogram for varying the value of power generated in the generating station was also developed. Power Generation and Improvement techniques for the generation, transmission and distribution of electricity were also established.
Reliability index of the distribution network of the study area were determined as follows.

System Average Interruption Frequency Index (SAIFI)

\[
SAIFI = \frac{\text{Total number of sustained customers interruption in a year}}{\text{Total number of customer served}}
\]

System Average Interruption Duration Index (SAIDI)

\[
SAIDI = \frac{\text{Total duration of sustained interruption in a year}}{\text{Total number of customer served}}
\]

Customer Average Interruption Frequency Index (CAIFI)

\[
CAIFI = \frac{\text{Total number of annual customer interruptions}}{\text{Total number of customers affected}}
\]

Customer Average Interruption Duration Index (CAIDI)

\[
CAIDI = \frac{\text{Total Duration of Sustainable interruption in a year}}{\text{Total number of customer interruptions}}
\]

Average Service Availability Index (ASAI)

\[
ASAI = \frac{\text{Customer hours of available service}}{\text{customer hours demanded}}
\]

Average Service Availability Index (ASUI)

\[
ASUI = \frac{\text{Customer hours of unavailable/service in a year}}{\text{customer hours demanded in a year}}
\]

The Need for Improvement of Electricity in Nigeria

Improvement on power generation, transmission and distribution of electricity in the country is the only solution to the incessant electrical power supply which has grounded many activities and destroyed many industrial processes in the country. Otherwise, the present poor industrial systems, high unemployment rates, crimes, suffering and untimely deaths in the country will continue to increase. This is because industrial development, employment, production of good and services of any country is directly proportional to the electrical energy consumed by the citizens of that country. Also, more efforts should be given to fault clearing systems and improvement in the reliability of the system. The Federal Government of Nigeria needs to genuinely privatize only the distribution aspect of electricity in Nigeria as this is the normal practice in the developed countries. The present privatization of the electrical generating stations in the country is a wrong method of privatization. Instead, individual or organization who is/are interested in electric power generation should establish his/her generating plants and supply excess power generated to the national grid.

Analysis of Ondo Road Feeder Results

Mean time between failure stands at an average of 491.46 hours between year 2010 and 2017. That means there will be an average of one failure in every 491.46 hours. Mean down time along the feeder is 195.6 hours. This result shows that the supply of electricity along the feeder is characterize with high number of failures. Availability of electric power along feeder is 73.34 %. But the reliability of the feeder is 1.83904 X 10^{-7} i.e. 0.00000018 %

\[
\begin{align*}
SAIFI &= 0.002734 \text{failure/customer} \\
CAIFI &= 0.005088 \text{interruption/consumer} \\
SAIDI &= 0.27556 \text{hour/customer} \\
CAIDI &= 100.8
\end{align*}
\]
ASAI = 0.827397 or 82.7397%  ASUI = 0.172603 or 17.2603%

**Ijapo Feeder Results**

The failure rate of the feeder is 0.0017706 failure/hour. Mean time between failure stands at an average of 564.78022 hours between year 2010 and 2017. The Mean down time along the feeder within this period is 205.32967 hours. This result shows that the supply of electricity along the feeder is also characterize with high number of failures. Availability of electric power along the feeder is 73.337614%; while the reliability of the feeder stands at an average of 1.84 x 10^{-7} = 0.0000184%

| Metric | Value |
|--------|-------|
| SAIFI | 0.002432 failure/customer |
| CAIFI | 0.003902 interruption/consumer |
| ASAI  | 0.827397 or 82.7397% |
| SAIDI | 0.306445 hour/customer |
| CAIDI | 126 hours |
| ASUI  | 0.172603 or 17.2603% |

**Oba Ile Feeder Results**

The failure rate of the feeder between year 2010 and 2017 is 0.001855034 failure/hour. Mean time between failure stands at an average of 539.07 hours. Mean down time along the feeder is 198.61 hours. This result shows that the supply of electricity along the feeder is characterize with high number of failures. Availability of electric power along Oba Ile feeder is 73.08%, but the reliability of the power system which is 8.778 x 10^{-8} i.e 0.000008778% is a very poor one.

| Metric | Value |
|--------|-------|
| SAIFI | 0.002138275 failure/customer |
| CAIFI | 0.002439 interruption/consumer |
| ASAI  | 0.792922 or 79.2922% |
| SAIDI | 0.323236 hour/customer |
| CAIDI | 151.1667 hours |
| ASUI  | 0.207078 or 20.7078% |

**Alagbaka Feeder Results**

The failure rate of the feeder between year 2010 and 2017 is 0.0018089 failure/hour. Mean time between failure stands at an average of 552.83 hours. Mean down time along the feeder is 208.913 hours. The result shows that the supply of electricity along the feeder is characterize with high number of failures. Availability of electric power along the feeder is 72.574% whereas the reliability along the feeder is approximately equal to zero i.e. 1.315 x 10^{-7}

| Metric | Value |
|--------|-------|
| SAIFI | 0.002866 failure/customer |
| CAIFI | 0.004276 interruption/consumer |
| ASAI  | 0.801826 or 80.1826% |
| SAIDI | 0.355374 hour/customer |
| CAIDI | 124 hours |
| ASUI  | 0.198174 or 19.8174 |

**Oke Eda Feeder Results**

The failure rate of the feeder between year 2010 and 2017 is 0.00185 failure/hour. Mean time between failure stands at an average of 540.46875 hours. Mean down time along the feeder is 189.53 hours. This result shows that the supply of electricity along the feeder is characterize with high number of failures. Availability of electric power along the feeder is 74.0368%, while the reliability 9.1542 x 10^{-8} (0.0000091542%) shows that unemployment, crime, hardship and untimely death will persist in the country if power production does not increase to at least 100,000 MW.

| Metric | Value |
|--------|-------|
| SAIFI | 0.0023015 failure/customer |
| CAIFI | 0.00406 interruption/consumer |
| ASAI  | 0.813470r 81.347% |
| SAIDI | 0.31339 hour/customer |
| CAIDI | 136.167 hours |
| ASUI  | 0.18653 or 18.653% |

**Oyemekun Feeder Result**

The failure rate of the feeder between year 2010 and 2017 is 0.00216577 failure/hour. Mean time between failure stands at an average of 461.728972 Hours. Mean down time along the
Reservoir feeder is 193.224 hours. This result shows that the supply of electricity along the feeder is characterized with high number of failures. Availability of electric power along the feeder is 70.498%, while the reliability is 5.772 \times 10^{-9} i.e. 0.0000005772 %

\begin{align*}
    \text{SAIFI} &= 0.002328 \text{failure/customer} & \text{SAIDI} &= 0.374736 \text{hour/customer} \\
    \text{CAIFI} &= 0.003563 \text{ interruption/consumer} & \text{CAIDI} &= 161 \text{hours} \\
    \text{ASAI} &= 0.797831 \% & \text{ASUI} &= 0.202169 \% \\
\end{align*}

while the reliability of the feeder is approximately equal to zero i.e. 8.642 \times 10^{-8}

\begin{align*}
    \text{SAIFI} &= 0.00249 \text{failure/customer} & \text{SAIDI} &= 0.33749 \text{hour/customer} \\
    \text{CAIFI} &= 0.00416 \text{ interruption/consumer} & \text{CAIDI} &= 135.462 \text{hours} \\
    \text{ASAI} &= 0.798973 \% & \text{ASUI} &= 0.20103 \% \\
\end{align*}

**Isikan Feeder Results**

The failure rate of the feeder between year 2010 and 2017 is 0.001882279 failure/hour. Mean time between failure stands at an average of 531.2708 hours during the eight years. Mean down time along the feeder is 198.7292 hours. Again, this results show that the supply of electricity along the feeder is characterized with high number of failures. Availability of electric power along the feeder is 72.7768%, but the reliability of the feeder is 6.914 \times 10^{-8}

\begin{align*}
    \text{SAIFI} &= 0.003577 \text{ failure/customer} & \text{SAIDI} &= 0.392801 \text{hour/customer} \\
    \text{CAIFI} &= 0.004462 \text{ interruption/consumer} & \text{CAIDI} &= 109.8125 \text{hours} \\
    \text{ASAI} &= 0.79943 \% & \text{ASUI} &= 0.20057 \% \\
\end{align*}

**Modelling of Hydro Electric Power Generating Plant**

In order to provide solution to the present incessant electrical power supply in the country, this research work established a model for the establishment of Hydro Electric Power Generating Plants from the abundant potential dams in the country. Hydro-electric power stations require the utilization of energy in falling water for the rotation of water turbine and the rotor situated in an alternator for the generation of electricity. They are generally located in hilly areas where dams can be built conveniently and large water reservoirs can be obtained. In a hydro-electric power station, water head of height $H_S$ is created by constructing a dam across a river or lake. From the dam, water is led to a water turbine. The water turbine captures the energy in the falling water and changes the hydraulic energy (i.e. product of head and flow of water) into mechanical energy at the turbine shaft. V.K Metha and Rohit Metha, (2010), Oshin O.A, Adanikin Ariyo, Abiodun Onile, (2017). The turbine drives the alternator which converts mechanical energy into electrical energy. A hydro electric power plant is modelled in this research work and the results presented in tables 3.1 - 3.3 and figures 3.1-3.5

![Figure 1. Hydro Electric Power Plant Power House](image)

The power generated in a hydro-electric power station is given in the equation below
Power Generated = \int \left[ \frac{(h_s - h - h_1) g A}{L} \right] dt + q_c g [h_s - h - h_1]

Where

a. \( L \) = incompressible conduit length of the penstock L
b. \( A \) = cross sectional area of the penstock in m\(^3\)
c. \( \ell \) = density of water
d. \( q \) = discharge rate in m\(^3\)/sec = \( \int \left[ \frac{(h_s - h - h_1) g A}{L} \right] dt \) + \( q_c \)
e. \( h_s \) = static head of water column in meters
f. \( h_1 \) = loss in height because of friction in the penstock in meters
g. \( h \) = head of turbine admission in meters
h. \( T_w \) = water time constant or water starting time

The rate of change of the discharge rate with respect to time is equal to \( \frac{d q}{d t} \)

Where system operating discharge rate = \( \frac{d q}{d t} = \frac{(h_s - h - h_1) g A}{L} \)

Flow rate \( q = \int \left[ \frac{(h_s - h - h_1) g A}{L} \right] dt \) + \( q_c \)

Power Generated = \( \ell \left\{ \int \left[ \frac{(h_s - h - h_1) g A}{L} \right] dt \right\} + q_c \) g [h_s - h - h_1]

Then, Power Generated = \( \ell \left\{ \int \left[ \frac{(h_s - h - h_1) g A}{L} \right] dt \right\} + q_c \) g [h_s - h - h_1]

In a Hydro- Electric Power Plant, the value of \( \int \left[ \frac{(h_s - h - h_1) g A}{L} \right] dt \) is negligible

Hence, Power Generated = \( \ell \) \( q_c \) g [h_s - h - h_1]

This research work analysed the performance of the modelled Hydro Electric Power Plant and the following results were obtained.

Table 2. Variation of Power Generated – Discharge Rate From The Modelled Hydro-Electric Power Generating Plant Unit 1

| S/N | Density of water | Discharge rate | Acc (g) x Turbine Eff (0.92) | h | h1 | hs-h-h1 | Power Generated in kW |
|-----|-----------------|----------------|-------------------------------|---|----|--------|------------------------|
| 1   | 1000            | 34             | 9.025                         | 65 | 6  | 0.264  | 58.736                 |
| 2   | 1000            | 40             | 9.025                         | 68 | 6  | 0.264  | 61.736                 |
| 3   | 1000            | 46             | 9.025                         | 70 | 6  | 0.264  | 63.736                 |
| 4   | 1000            | 52             | 9.025                         | 72 | 6  | 0.264  | 65.736                 |
| 5   | 1000            | 58             | 9.025                         | 74 | 6  | 0.264  | 67.736                 |
| 6   | 1000            | 64             | 9.025                         | 76 | 6  | 0.264  | 69.736                 |
| 7   | 1000            | 70             | 9.025                         | 78 | 6  | 0.264  | 71.736                 |
| 8   | 1000            | 76             | 9.025                         | 80 | 6  | 0.264  | 73.736                 |
| 9   | 1000            | 82             | 9.025                         | 82 | 6  | 0.264  | 75.736                 |
| 10  | 1000            | 88             | 9.025                         | 84 | 6  | 0.264  | 77.736                 |

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Figure 2. Power generated in a Hydro-Electric Power Generating Plant, Unit 1a

Power Generated from the Modelled Hydro-Electric Power Generating Plant Unit 2 Under Varying Discharge Rate and Gross Head ($H_S$)

Table 3. Power generated from the modelled Hydro-Electric Power Generating Plant, Unit 2a

| S/N | Density of water | Discharge rate | Acc (g) x Turbine Eff | $H_S$ | $h$ | $h_1$ | $h_s-h-h_1$ | Power Generated in kW |
|-----|-----------------|----------------|-----------------------|------|-----|-------|-------------|-----------------------|
| 1   | 1000            | 34             | 9.025                 | 65   | 6   | 0.264 | 58.736     | 18023.1416            |
| 2   | 1000            | 40             | 9.025                 | 68   | 6   | 0.264 | 61.736     | 22286.696             |
| 3   | 1000            | 146            | 9.025                 | 70   | 6   | 0.264 | 63.736     | 83981.7404            |
| 4   | 1000            | 74             | 9.025                 | 72   | 6   | 0.264 | 65.736     | 43901.7876            |
| 5   | 1000            | 58             | 9.025                 | 74   | 6   | 0.264 | 67.736     | 35456.4092            |
| 6   | 1000            | 64             | 9.025                 | 76   | 6   | 0.264 | 69.736     | 40279.5136            |
| 7   | 1000            | 70             | 9.025                 | 78   | 6   | 0.264 | 71.736     | 45319.218             |
| 8   | 1000            | 124            | 9.025                 | 80   | 6   | 0.264 | 73.736     | 82517.9576            |
| 9   | 1000            | 82             | 9.025                 | 82   | 6   | 0.264 | 75.736     | 56048.4268            |
| 10  | 1000            | 88             | 9.025                 | 84   | 6   | 0.264 | 77.736     | 61737.9312            |

Figure 3. Power generated from the modelled Hydro-Electric Power Generating Plant, Unit 2b

Figure 3. Characteristics of the power generated – discharge rate from the modelled Hydro-Electric Power Generating Plant and the discharge rate, Unit 2

Discharge rate cubic metre/sec
Power Generated from the Modelled Hydro-Electric Power Generating Plant Unit 3

Table 4. The result of the power generated from the modelled Hydro-Electric Power Generating Plant, Unit 3

| S/N | Density of water | Discharge rate | Acc (g) x Turbine Eff | Hs | h | h1 | hs-h-h1 | Power Generated in kW |
|-----|-----------------|----------------|-----------------------|----|---|----|---------|----------------------|
| 1   | 1000            | 92             | 9.025                 | 97 | 6 | 0.264 | 90.736 | 75338.1008          |
| 2   | 1000            | 40             | 9.025                 | 68 | 6 | 0.264 | 61.736 | 22286.696           |
| 3   | 1000            | 128            | 9.025                 | 70 | 6 | 0.264 | 63.736 | 73627.8272          |
| 4   | 1000            | 74             | 9.025                 | 72 | 6 | 0.264 | 65.736 | 43901.7876          |
| 5   | 1000            | 86             | 9.025                 | 112| 6 | 0.264 | 105.736| 82066.9964          |
| 6   | 1000            | 64             | 9.025                 | 76 | 6 | 0.264 | 69.736 | 40279.5136          |
| 7   | 1000            | 70             | 9.025                 | 78 | 6 | 0.264 | 71.736 | 45319.218           |
| 8   | 1000            | 124            | 9.025                 | 80 | 6 | 0.264 | 73.736 | 82517.9576          |
| 9   | 1000            | 82             | 9.025                 | 82 | 6 | 0.264 | 75.736 | 56048.4268          |
| 10  | 1000            | 88             | 9.025                 | 84 | 6 | 0.264 | 77.736 | 61737.9312          |

Figure 5. Characteristics of the power generated from the modelled Hydro-Electric Power Generating Plant and the discharge rate, Unit 3b

Conclusion

The research work also evaluated the occurrence of faults and outages in the Distribution Network Area for a period of 8 years (2010 -2017. The research work also established a model for the establishment of Hydro Electric Power Generating Plant in the country. When the results of this research work are utilized, it will be easy to establish more efficient Hydro Electric Power Plants in the country. The performance and the efficiency of the modelled power plant will also increase through the use of this model.

References

Adegboyega, G.A, Adu, M.R and Melodi A.O (2010), Power Losses in Distribution System and Solutions; Akure as a case study, FUTAJET, vol. 6, No.2, page 75-80

Oshin O.A, Adanikin Ariyo, Abidun Onile, January, 2017, Incessant and Unreliable Power Supply in Nigeria: Causes, Effects and Solutions, LAP Lambert Academic Publishing, Omni Scriptum GmbH & Co. KG, Deutschland Germany ISBN-13-978-3-659-74972-8,

Burke James J. (1994), Power Distribution Engineering Fundamental and Applications, Marce Dekker Inc. New York, page 125-127

Desphande, M.V (1984), Electrical Power System Design, Tata Mc Graw-Hill Publishing Company Limited, New Delhi, page 56-78
Oshin O.A, Adanikin Ariyo, Fakorede Ebenezer, Joseph Ojotu, February, 2019, Incessant Power Supply in Nigeria and the need for the Design and Production of 100,000MW Power Plant, IJSER, Paper ID 10113705,

Gupta B.R (2010), Power System Analysis and Design, S.Chand Company Limited New Delhi pages 593 – 611

Kothari D.P and Nagrath, I. J (2008) Power System Engineering, second edition, Mc Graw – Hill, New Delhi, page 1 – 12, 146 – 159, 456 – 557

Monterrosa Carlos (2011), Fault Analysis in Electrical works and distribution Lines, Green and co Ltd, London, page 77

Fortesque, C. L (1918), Method of symmetrical coordinate Applied to the solution of Polyphase networks

Oshin O.A, Adanikin Ariyo, Fakorede Ebenezer, Joseph Ojotu, April, 2018, Power System Engineering Principle First Edition, (GNU General Public License), Lulu Press incorporations, Morrisville, North Carolina, United States, April, 2018/ Lambert Academic Publishing, Omni Scriptum GmbH & Co. KG, Deutschland Germany ISBN- 978-613-9-83114-20,

Suriyamongkol, Dan (2002), Thesis on Non-Technical losses in Electrical Power System, Fritz J and Doloras H., Ohio University, USA page 2-3, 8, 11-30, 54-66

Oshin Ola Austin, June, 2019 Fault Evaluation & Improvement of Electric Power Distribution Network, Lambert Academic Publishing, Omni Scriptum GmbH & Co. KG, Deutschland Germany ISBN- 978-3-659-79429-2,

World Fact Book, Electricity Energy Consumption in the Worl, 2016

Ronne-Hansen, J. (1997), A General Model for Representing Arbitrary Un-symmetries in Various Types of Network Analysis, IEEE Transaction on Power System, Vol. 12 No. 3

Oshin Ola Austin, Engr. Adanikin Ariyo and Fakorede Ebenezer, December, 2018

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