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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 513,949,445615 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.

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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 power* 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 incompleted. 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)**

ISSN: 2716-3865 (Print), 2721-1290 (Online)

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)
—	World	21,776,088,770,300	2014	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	1377
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[3]	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	1704
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	1102
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	1467
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

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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

ISSN: 2716-3865 (Print), 2721-1290 (Online)

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)
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	Congo, Democratic Republic of the	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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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)
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

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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)
133	Papua New Guinea	3,000,000,000	2014 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	2014 EST.	CIA	1,883,018	2016	1,533	175
136	Montenegro	2,800,000,000	2014 EST.	CIA	644,578	2016	4,343	495
137	Jamaica	2,800,000,000	2014 EST.	CIA	2,970,340	2016	942	107
138	Uganda	2,700,000,000	2014 EST.	CIA	38,319,241	2016	70	8
139	Mauritius	2,600,000,000	2014 EST.	CIA	1,348,242	2016	1,928	220
140	Gabon	2,100,000,000	2014 EST.	CIA	1,738,541	2016	1,207	137
141	Bhutan	2,085,000,000	2014 EST.	CIA	750,125	2016	2,779	317
142	New Caledonia	2,000,000,000	2014 EST.	CIA	275,355	2016	7,263	829
143	Malta	2,000,000,000	2014 EST.	CIA	415,196	2016	4,817	549
144	Suriname	1,900,000,000	2014 EST.	CIA	585,824	2016	3,243	370
145	Malawi	1,900,000,000	2014 EST.	CIA	18,570,321	2016	102	11
146	Bahamas	1,600,000,000	2014 EST.	CIA	327,316	2016	4,888	558
147	Guam	1,500,000,000	2014 EST.	CIA	162,742	2016	9,217	1052
148	Swaziland	1,500,000,000	2014 EST.	CIA	1,451,428	2016	1,033	117
149	Mali	1,400,000,000	2014 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	2014 EST.	CIA	24,430,325	2016	53	6
152	Burkina Faso	1,200,000,000	2014 EST.	CIA	19,512,533	2016	61	7
153	Niger	1,200,000,000	2014 EST.	CIA	18,638,600	2016	64	7
154	Togo	1,100,000,000	2014 EST.	CIA	7,756,937	2016	141	16
155	Benin	1,000,000,000	2014 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	2014 EST.	CIA	4,852,412	2016	185	21
158	Guinea	900,000,000	2014 EST.	CIA	12,093,349	2016	74	8
159	Barbados	900,000,000	2014 EST.	CIA	291,495	2016	3,087	352
160	Mauritania	800,000,000	2014 EST.	CIA	3,677,293	2016	217	24
161	Lesotho	800,000,000	2014 EST.	CIA	1,953,070	2016	409	46
162	Guyana	800,000,000	2014 EST.	CIA	735,909	2016	1,087	124
163	Fiji	800,000,000	2014 EST.	CIA	915,303	2016	874	99
164	Aruba	800,000,000	2014 EST.	CIA	113,648	2016	7,039	803
165	French	700,000,000	2014 EST.	CIA	285,321	2016	2,453	280

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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)
	Polynesia							
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	846,687	2016	472	53
177	Haiti	400,000,000	2014 EST.	CIA	10,485,800	2016	38	4
178	Seychelles	300,000,000	2014 EST.	CIA	93,186	2016	3,219	367
179	Somalia	300,000,000	2014 EST.	CIA	10,817,354	2016	27	3
180	Saint Lucia	300,000,000	2014 EST.	CIA	164,464	2016	1,824	208
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	2,009,648	2016	149	17
186	Greenland	300,000,000	2014 EST.	CIA	57,728	2016	5,196	593
187	Liberia	300,000,000	2014 EST.	CIA	4,299,944	2016	69	7
188	Maldives	300,000,000	2014 EST.	CIA	392,960	2016	763	87
189	Chad	200,000,000	2014 EST.	CIA	11,852,462	2016	16	1
190	Saint Kitts and Nevis	200,000,000	2014 EST.	CIA	52,329	2016	3,821	436
191	Central African Republic	200,000,000	2014 EST.	CIA	5,507,257	2016	36	4
192	Sierra Leone	200,000,000	2014 EST.	CIA	6,018,888	2016	33	3
193	Turks and Caicos Islands	200,000,000	2014 EST.	CIA	51,430	2016	3,888	443
194	Gibraltar	200,000,000	2014 EST.	CIA	29,328	2016	6,819	778
195	Grenada	200,000,000	2014 EST.	CIA	111,219	2016	1,798	205

ISSN: 2716-3865 (Print), 2721-1290 (Online)

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 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. 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.

ISSN: 2716-3865 (Print), 2721-1290 (Online)

Reliability index of the distribution network of the study area were determined as follows. System Average Interruption Frequency Index (SAIFI)

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

System Average Interruption Duration Index (SAIDI)

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

Customer Average Interruption Frequency Index (CAIFI)

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

Customer Average Interruption Duration Index (CAIDI)

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

Average Service Availability Index (ASAI)

$$\text{ASAI} = \frac{\text{Customer hours of availble service}}{\text{customer hours demnded}}$$

Average Service Availability Index (ASUI)

$$\text{ASUI} = \frac{\text{Customer hours of unavailble/ service in a year}}{\text{customer hours demnded in a year}}$$

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 %

SAIFI =0.002734failure/customer SAIDI = 0.27556hour/customer
CAIFI = 0.005088interruption/consumer CAIDI = 100.8

ISSN: 2716-3865 (Print), 2721-1290 (Online)

ASAI = 0.827397or 82.7397% ASUI = 0.172603or 0.17.2603 %

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 1.84×10^{-7} = 0.0000184 %

SAIFI =0.002432failure/customer SAIDI = 0.306445 hour/customer
CAIFI = 0.003902interruption/consumer CAIDI = 126hours
ASAI = 0.827397 or 82.7397 % ASUI = 0.172603 or17.2603 %

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 539.07hours. 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 8.778×10^{-8} i.e 0.000008778 % is a very poor one.

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

Alagbaka Feeder Results

The failure rate of the feeder between year 2010 and 2017 is 0.0018089failure/ hour. Mean time between failure stands at an average of 552.83hours. Mean down time along the feeder is 208.913hours. 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. 1.315×10^{-7}

SAIFI =0.002866failure/customer SAIDI = 0.355374hour/customer
CAIFI = 0.004276interruption/consumer CAIDI = 124 hours
ASAI = 0.801826or 80.1826 % ASUI = 0.198174or 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 9.1542×10^{-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.

SAIFI =0.0023015failure/customer SAIDI = 0.31339hour/customer
CAIFI = 0.00406interruption/consumer CAIDI = 136.167hours
ASAI = 0.81347or 81.347% 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

ISSN: 2716-3865 (Print), 2721-1290 (Online)

feeder is 193.224 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 70.498 %, while the reliability is 5.772 x 10^{-9} i.e 0.0000005772 %

SAIFI =0.002328failure/customer	SAIDI = 0.374736hour/customer
CAIFI = 0.003563 interruption/consumer	CAIDI = 161hours
ASAI = 0.797831or 79.7831%	ASUI = 0.202169or 20.2169%

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

SAIFI =0.00249failure/customer	SAIDI = 0.33749hour/customer
CAIFI = 0.00416interruption/consumer	CAIDI = 135.462
ASAI = 0.798973or 79.8973 %	ASUI = 0.20103or 20.103 %

Isikan Feeder Results

The failure rate of the feeder between year 2010 and 2017 is 0.001882279failure/ 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 characterize with high number of failures. Availability of electric power along the feeder is 72.7768%, but the reliability of the feeder is 6.914 x 10^{-8}

SAIFI =0.003577 failure/customer	SAIDI = 0.392801 hour/customer
CAIFI = 0.004462 interruption/consumer	CAIDI = 109.8125
ASAI = 0.79943 or0.79.943 %	ASUI = 0.20057 or 20.057 %

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 modelledin this research work and the results presented in tables 3.1 -3.3 and figures 3.1-3.5

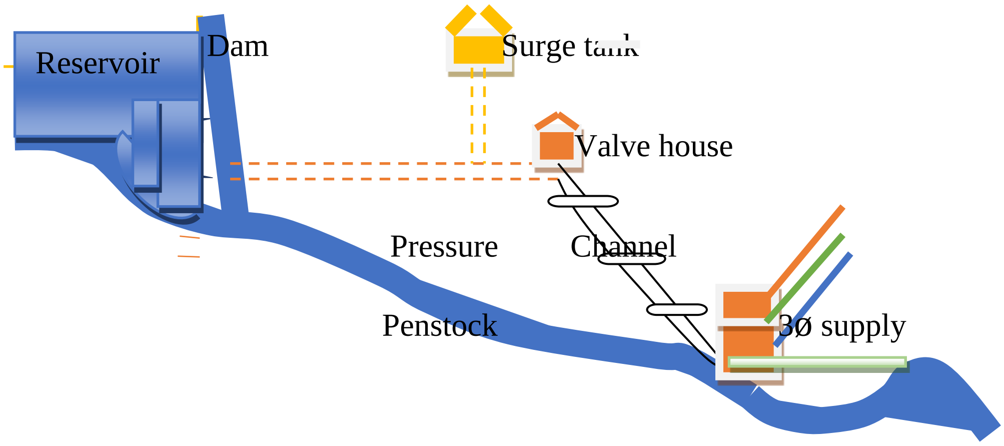

Figure 1. Hydro Electric Power Plant Power House

The power generated in a hydro-electric power station is given in the equation below

ISSN: 2716-3865 (Print), 2721-1290 (Online)

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

Where

a. L = incompressible conduit length of the penstock L
b. A = cross sectional area of the penstock in m^3
c. ℓ = density of water
d. q = discharge rate in m^3/ sec $= \int \left[\frac{(h_s - h - h_1)\, g\, A}{L}\, dt\right] + q_c$
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 $\frac{dq}{dt}$

Where system operating discharge rate = $\frac{dq}{dt} = \frac{(h_s - h - h_1)\, g\, A}{L}$

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

Power Generated = $\ell\, q\;\; g\, [h_s - h - h_1]$

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

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

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	Discahrge rate	Acc (g) x Turbine Eff (0.9	Hs	h	h1	hs-h-h1	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	46	9.025	70	6	0.264	63.736	26460.0004
4	1000	52	9.025	72	6	0.264	65.736	30849.9048
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	76	9.025	80	6	0.264	73.736	50575.5224
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

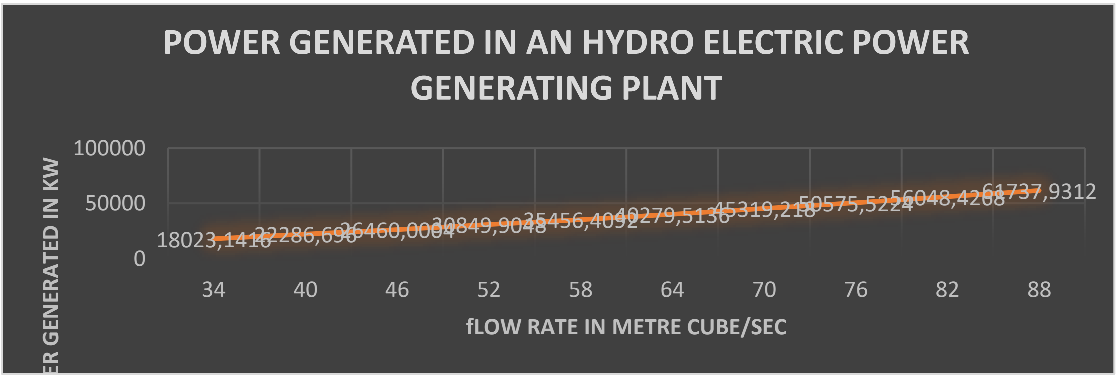

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Figure 2. Power generated in a Hydro-Electric Power Generating Plant, Unit 1a

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	Discahrge rate	Acc (g) x Turbine Eff	Hs	h	h1	hs-h-h1	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

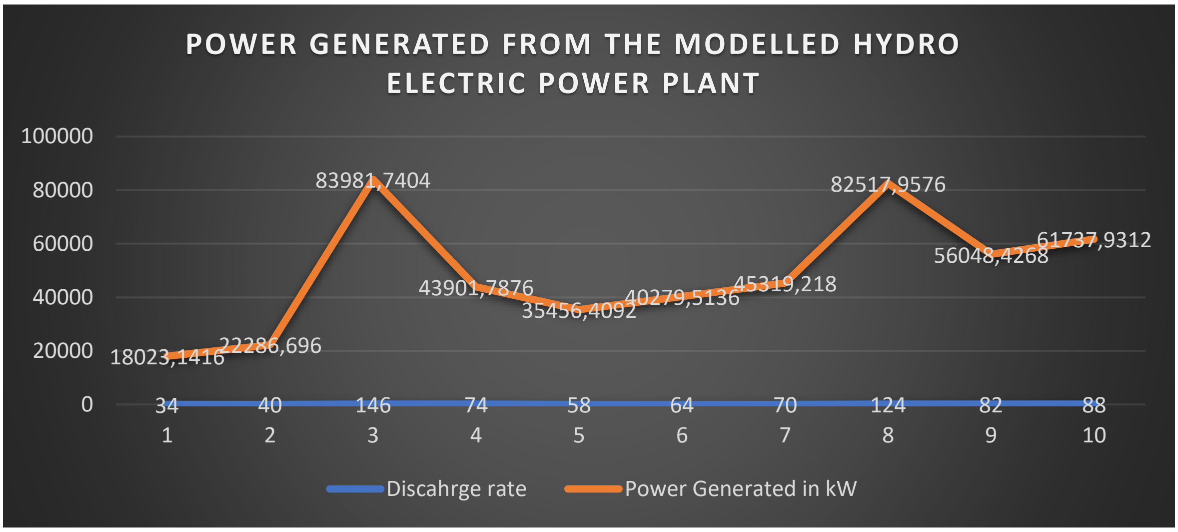

Figure 3. Power generated from the modelled Hydro-Electric Power Generating Plant,Unit 2b

. **Discharge rate cubic metre/sec**

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

ISSN: 2716-3865 (Print), 2721-1290 (Online)

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	Discahrge 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

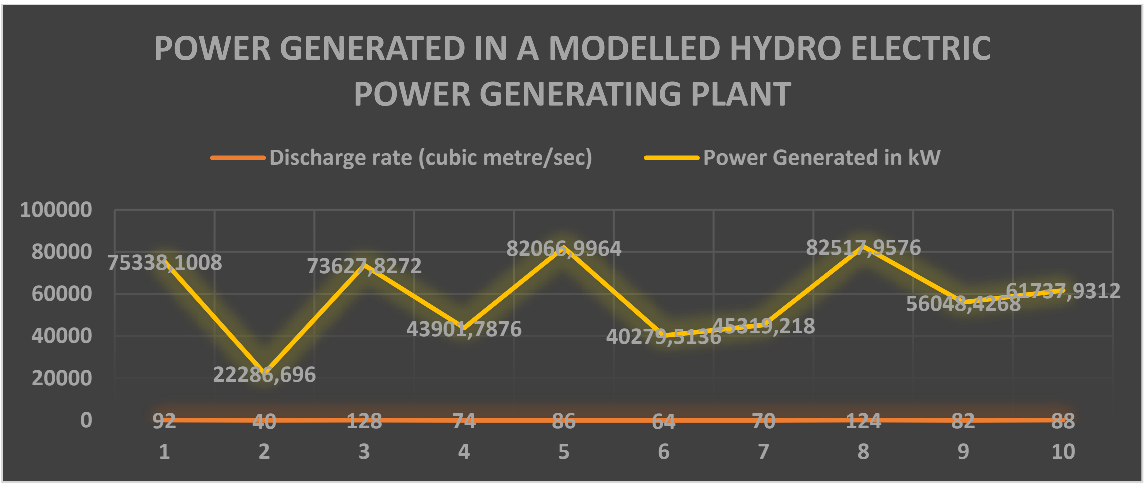

Figure 5. Characteristics of the power generated from the modelled Hydro-Electric Power Generating Plant and the discharge rate, Unit 3b

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.

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