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Economic Analysis of Proposed Bosso, Chanchaga and Tagwai Dams Hydroelectric Power Plants

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ABSTRACT

The economic analysis of Bosso, Chanchaga and Tagwai dams proposed storage and off-shore hydroelectric power was conducted. Regression equation was used to estimate the cost of civil engineering work, cost of electromechanical equipments and total cost of establishing the storage and off-shore hydroelectric power plants in each of the dams by summing up the cost of civil engineering work and cost of electromechanical equipments. The result showed that the estimated total cost of establishing Bosso, Chanchaga and Tagwai dams proposed storage hydroelectric power plants were; ₦ 12,205,311,783, ₦ 19, 466,230,000 and ₦ 16, 734, 495, 000 respectively while the estimated total cost of establishing Bosso, Chanchaga and Tagwai off-shore hydroelectric power plants were; ₦ 3, 208, 563,000, ₦ 4,055,384,000 and ₦ 4, 099, 907, 055 respectively.

High emissions of greenhouse gases have caused significant changes in the atmosphere, as such it is important to move toward the use of sustainable energy resources. These resources include, for example, solar power, wind power, and hydropower. The hydropower systems use kinetic energy in running water to generate electrical or mechanical energy. The water runs through the hydroelectric power turbine and flows back to the river for other further utilization. Hydropower as a renewable energy resource has many benefits including low operating and maintenance costs, no pollution nor greenhouse gas emissions, high efficiency (about 60–80%) and long-life equipment. Many researchers have developed different methods of determining the correlations for the cost of different components of hydropower plants and the cost of their components based on the actual quantities of various items having general rates. The cost as a function of cost-sensitive parameters for different types of generators and turbines were determined and investigated a series of equations to determine the electro-mechanical equipment costs from the basic parameters such as net head and power. The equations depend upon the type of hydro turbines, i.e. Kaplan, semi Kaplan, Pelton, and Francis turbines. Other correlations of cost were developed based on the water head, installed capacity, and ratings such as rated kVA and power factor (PF), as cost-influencing parameters. A correlation to determine the cost of the equipment and proved that the cost of the electro-mechanical equipment decreased with the increase in the water head (Hatata, *et al.* 2019).

Urbanization, industrialization, economic development, and employment generation and population growth have made the development of power generation inevitable. Energy is very important for the development of transportation and infrastructures (Anaza *et al.* 2017). Energy is a requirement for modernization. Presently, many people does not have access to electricity worldwide and it is estimated that 80% of the people without access to electricity live in rural areas with no hope that the population will drop by 2030 (Alie,2016).

In a study carried out by Can *et al.* (2024), they found that initial investment cost per kW was $ 3,300, but data available from United States energy statistics showed initial investment cost on hydroelectric power project was predicted at $ 3,200 per kW.

According to Oluruntoba, 2014, small hydropower plant is identified appropriate technologies for available head range between 7.5m and 400m designed for any of the identified dams with cross flow turbine, vertical and horizontal shaft Francis turbine. The Engineering Economics of small hydropower plant development showed that the revenue from electricity in the area of his study, using the year 2010 template to be unviable with

present worth of - ₦8,165,965.56 and Annual worth of - ₦1,328,051.59 for 10-year target and present worth of - ₦3,794,686.01 and annual worth of - ₦446,515.99 for 20-year target. The revenue from electricity using year 2012 template was estimated to be viable with present worth of ₦7,961,477.31 and Annual worth of ₦1,296,557.54 for 10-year target, present worth of ₦18,550,186.28 and annual worth of ₦2,778,093.14 for 20-year target

Ibrahim (2024) noted that two basic parameters crucial in the economic analysis of small hydropower plants are the investment cost and annual cost, which influence the total cost of the plant. The investment cost covers the construction cost and electromechanical cost. The annual cost is determined based on; depreciation cost, maintenance cost, operational cost, replacement cost, staff salary, landscaping cost and supply cost, with annual inflation factor being put into consideration. In his study of ten small streams selected from Euphrates and Tigris Basins for hydroelectric power generation, he observed that when the cost benefit was greater than 1, the investment in hydroelectric power was meaningful and also observed that the capacity factor of all the plants in the streams were close with the least being 0.37 and maximum being 0.48 and the mean being 0.42. The study found out that the small hydropower to be established would make profit by financing themselves for a period varying from 2.28 years to 4.97 years. From the study of Ibrahim, (2024), it is well established that small hydroelectric power gives profit.

According to Pawel *et al*., (2025), the installation cost breakdown for small run-off river hydropower plants are; 50% for construction cost, 30% for mechanical equipments and 20% for electrical equipments. Africa and Europe have the highest cost of installation at $3,000-$4,000 per kW and India has $2,000 per kW while Chine has the least installation cost of $1,829 per kW

Aydin and Gezegin, (2024) reported that the cost of maintenance and repair of hydroelectric power plant is $4,000 multiplied by the installed capacity

Arsenio *et al*., (2024) in their study on marginal market price, price upward deviation and downward price deviation for a pumped storage hydroelectric power plant, noted that when both the hydropower power plant and the integrated PV system are operated independently, the economic benefit was more profitable up to 6% and the joint operation of the plants was better economically, when the marginal price was low to optimize operation. They noted that it was economically viable to use the PV supplied energy to pump water from the lower hydropower reservoir into the upper reservoir and store the water and only use the water to operate the turbine to generate electricity and sell when the market price of the electricity was high earning up to 1.6% profit

Etienne and Vatis, (2024) noted that increasing hydroelectric power generation has both positive and negative impacts on electricity prices on short and long time bases, increase in shares of hydroelectric power in the energy sector leads to increase in variation of electricity cost on short term basis and also leads to significant price reduction on long time basis. They found that economic growth has a positive impact on the variation of power price with exchange rates having negative impact on electricity pricing on short time basis. They suggested participation of Small and Medium Enterprises (SME's) in renewable energy production to reduce price volatility.

MATERIALS AND METHODS

Methodology

The economic analysis of the proposed hydroelectric power was done based on the calculation of the cost of various components of the plants such as the civil engineering components and electromechanical components in United States Dollars ($) per kW and then multiplied by 5000 kW capacity for storage power plants and 2000 kW capacity for off shore power plants to get the cost for establishing the plants in United State Dollars, based on Hatata *et al.* (2019) regression equations and then the value of the cost converted to naira at the current exchange of ₦1,700 to $1 in Nigeria, as at the time of the economic analysis in November 2024.

i. The cost of construction of diversion and Intake was calculated using equation (1) as

$$C_{ID} = 186.216P^{-0.2368} \times H^{-0.597} \quad (1)$$

ii. The cost of construction of powerhouse was calculated using equation (2) as

$$C_{PH} = 1389.16P^{-0.2351} \times H^{0.2351} \quad (2)$$

iii. The total cost of construction of civil engineering components comprising diversion, intake and powerhouse was calculated using equation (3) as

$$C_C = C_{ID} + C_{PH} \quad (3)$$

vi. The cost of Francis turbine was calculated using equation in (4) as

$$C_T = 30462P^{-0.560135} \times H^{-0.127243} \quad (4)$$

v. The cost of generator was calculated using equation (5) as

$$C_G = 10486P^{-0.1855} \times H^{-0.2083} \quad (5)$$

vi. The cost of mechanical and electrical auxiliaries was calculated using equation (6) as

$$C_A = 612.87P^{-0.1892} \times H^{-0.2118} \quad (6)$$

vii. The cost of transformer and switch yard equipment was calculated using equation (7) as

$$C_{TR} = 281P^{-0.1803} \times H^{-0.2075} \quad (7)$$

iii. The cost of generator was calculated using equation (8) as according to Dol *et al*. (2016) follows

$$C_T = 2015P^{0.824} \times H^{-0.478} \quad (8)$$

ix. The total cost of electromechanical equipments was calculated using equation (9) as

$$C_{EM} = C_T + C_G + C_A + C_{TR} \quad (9)$$

x. The total cost (C_T) of establishing the proposed hydroelectric plants was done by summing up the cost of the civil engineering components, cost of switchyard equipments and cost of electromechanical components as shown in equation (10)

$C_T = C_C + C_{EM}$ (10)

RESULTS AND DISCUSSION

Economic Analysis of Proposed Bosso Storage Hydroelectric Power Plant

i. Cost of Construction of Intake and Diversion Weir in $ per kW is

$C_{ID} = 186.216P^{-0.2368}$x $H^{-0.597}$ P = 5000 kW, H= 3 m

$C_{ID} = 186.216 \times 5000^{-0.2368} \times 3^{-0.597} = 186.216 \times 0.1337 \times 0.5190$ =$ 12.86 per kW

Converting the per 5000 kW, C_{ID} = $ 12.86 x 5000 = $64,300 Converting the cost in $ to ₦ at ₦1700 to $1, C_{ID} =$64,300 x 1700 = ₦ 109,310,000

This implies that the cost construction of intake and diversion weir for the proposed Bosso storage hydroelectric power plant was estimated at ₦109,310,000.

ii. Cost of Construction of Powerhouse in $ per kW is

$C_{PH} = 1389.16P^{-0.235} \times H^{-0.0585}$, $C_{PH} = 1389.16 \times 5000^{-0.235} \times 3^{-0.0585} = 1389.16 \times 0.1351 \times 0.9378$ = $175.98 per kW, Converting the cost to 5000 kW, C_{PH}= $175.98 x 5000 =$ 877, 909. 14

Converting the cost in $ to ₦ at ₦1700 to $1, C_{PH}= $ 877, 909. 14 x 1700 = ₦1,495,845,533

Total cost of civil engineering work (C_C) = Cost of construction of intake and diversion weir (C_{ID}) + Cost of construction of powerhouse (C_{PH})

$C_C = C_{ID} + C_{PH}$= ₦109,310,000 + ₦ 1, 495, 845,533 = ₦1, 569,155,533

The estimated cost of construction of power house for proposed Bosso storage hydroelectric power plant was estimated at ₦ 1, 495,845,533. The estimated total cost of civil engineering work comprising the coat of intake and the cost of power house put together stood at ₦ 1, 569, 155,533.

iii. Cost of Purchase of Francis Turbine in $ per kW is

$C_T = 30462P^{-0.560135} \times H^{-0.127234}$, $C_T = 30462 \times 5000^{-560135} \times 3^{-0.127234} = 30462 \times 0.0084738 \times 0.8695$ = $224.44 per kW, Converting the cost to 5000 kW capacity of the plant C_T = $224.44 x 5000 = $1,122,200, Converting the cost of the 5000 kW capacity to naira

C_T = $1,122,200 x 1700 = ₦ 1,907,740,000

iv. Cost of Purchase of Generator in $ per kW is

$C_G = 10486.65P^{-0.1855} \times H^{-0.2083}$, $C_G = 10486.65 \times 5000^{-0.1855} \times 3^{-0.2083} = 10486.65 \times 0.2060 \times 0.4082$, C_G = $881.77, Converting the cost to 5000 kW capacity of the plant, C_G = $ 881.77 x 5000 = $ 4,408,850, Converting the cost in $ to ₦, C_G = $ 4,408,850 x 1700, C_G = ₦ 7,495,045,000

v. Cost of Purchase of Transformer and Switchyard Equipments in $ per kW is

$C_{TS} = 281P^{-0.8103} \times H^{-0.2075}$, $C_{TS} = 281 \times 5000^{-0.8103} \times 3^{-0.2075} = 281 \times 0.2153 \times 0.7962$, C_{TS} = $ 48.17 per kW, Converting the cost by 5000 kW capacity plant is, C_{TS} = $ 48.17 x 5000 = $ 240,847.5, Converting the cost in $ to ₦ is

C_{TS} = $ 240,847.5 x 1700, C_{TS} = ₦ 409,440,750

vi. Cost of Purchase of Mechanical and Electrical Auxiliary Equipment in $ per kW is

$C_A = 612.87P^{-0.1892} \times H^{-0.2118}$, $C_A = 612.87 \times 5000^{-0.1892} \times 3^{-0.2118} = 612.87 \times 0.1996 \times 0.7924$

C_A = $ 96.93 per kW, Converting the cost to 5000 kW capacity plant, C_A = $ 96.93 x 5000 = $ 484, 655, Converting the cost in $ to ₦, C_A = $ 484, 655 x 1700, C_A = ₦ 823,930,500

Total cost of electromechanical equipments (C_{EM}) is

$C_{EM} = C_F + C_G + C_{TS} + C_A$

C_{EM} = ₦ 1,907, 740,000 + ₦ 7,495,045,000 + ₦ 823, 930,500 + ₦ 409, 440, 750

C_{EM} = ₦ 10, 636,156,250. 00k

The estimated total cost of electromechanical equipments was ₦ 10, 636,156, 250.00k.

Total cost (C_{Total}) of establishing proposed Bosso hydroelectric power plant is

$C_{Total} = C_C + C_{EM}$ = ₦ 1,569,155, 533 + ₦ 10,636,156,250 = ₦ 12,205,311,783.00k

Economic Analysis of Proposed Chanchaga Storage Hydroelectric Power Plant

i. Cost of Construction of Intake and Diversion Weir in $ per kW is

$C_{ID} = 186.216P^{-0.2368}$x $H^{-0.597}$ P = 5000 kW H= 7 m

$C_{ID} = 186.216 \times 5000^{-0.2368} \times 7^{-0.597} = 186.216 \times 0.1337 \times 0.3200$ =$ 7.93 per kW

Converting the per 5000 kW, C_{ID} = $ 7.93 x 5000 = $39,650

Converting the cost in $ to ₦ at ₦1700 to $1, C_{ID} =$ 39, 650 x 1700 = ₦ 67,450,000

ii. Cost of Construction of Powerhouse in $ per kW is

$C_{PH} = 1389.16P^{-0.235} \times H^{-0.0585}$, $C_{PH} = 1389.16 \times 5000^{-0.235} \times 7^{-0.0585} = 1389.16 \times 0.1351 \times 0.8924$ = $785.96 per kW, Converting the cost to 5000 kW, C_{PH}= $785.96 x 5000 =$ 3,929,800, Converting the cost in $ to ₦ at ₦1700 to $1, C_{PH}= $ 3,929,800 x 1700 = ₦6,680,660,000

Total cost of civil engineering work (C_C) = Cost of construction of intake and diversion weir (C_{ID}) + Cost of construction of powerhouse (C_{PH})
$C_C = C_{ID} + C_{PH}$= ₦ 67,405,000 + ₦ 6,680,660,000 = ₦ 6,748,065,000

iii. Cost of Purchase of Francis Turbine in $ per kW is
$C_T = 30462P^{-0.560135} \times H^{-0.127234}$, $C_T = 30462 \times 5000^{-560135} \times 7^{-0.127234}$ = 30462 x 0.0084738 x 0.6550 = $ 169.08 per kW, Converting the cost to 5000 kW capacity of the plant C_T = $ 169.08 x 5000 = $ 845,400, Converting the cost of the 5000 kW capacity to naira
C_T = $ 845,400 x 1700 = ₦ 1,437,180,000

iv Cost of Purchase of Generator in $ per kW is
$C_G = 10486.65P^{-0.1855} \times H^{-0.2083}$, $C_G = 10486.65 \times 5000^{-0.1855} \times 7^{-0.2083}$ = 10486.65 x 0.2060 x 0.6668 C_G = $ 1,440.45
Converting the cost to 5000 kW capacity of the plant, C_G = $ 1440.45 x 5000 = $ 7,200,000
Converting the cost in $ to ₦, C_G = $ 7,200,000 x 1700, C_G = ₦ 10,224,000,000

v. Cost of Purchase of Transformer and Switchyard Equipments in $ per kW is
$C_{TS} = 281P^{-0.8103} \times H^{-0.2075}$, $C_{TS} = 281 \times 5000^{-0.8103} \times 7^{-0.2075}$ = 281 x 0.2153 x 0.6678
C_{TS} = $ 40.40 per kW, Converting the cost by 5000 kW capacity plant, C_{TS} = $ 40.40 x 5000 = $ 202,000, Converting the cost in $ to ₦, C_{TS} = $ 202,000 x 1700, C_{TS} = ₦ 343,400,000

vi. Cost of Purchase of Mechanical and Electrical Auxiliary Equipment in $ per kW is
$C_A = 612.87P^{-0.1892} \times H^{-0.2118}$, $C_A = 612.87 \times 5000^{-0.1892} \times 7^{-0.2118}$ = 612.87 x 0.1996 x 0.6622
C_A = $ 81.01 per kW, Converting the cost to 5000 kW capacity plant, C_A = $ 81.01 x 5000 = $ 405,050, Converting the cost in $ to ₦, C_A = $ 405, 050 x 1700, C_A = ₦ 688,585,000
Total cost of electromechanical equipments (C_{EM}) is
$C_{EM} = C_F + C_G + C_{TS} + C_A$
C_{EM}= ₦ 1, 437,180,000 + ₦ 10,224,000,000 + ₦ 343,400,000 + ₦ 688,585,000
C_{EM} = ₦ 12, 693,165,000. 00k
Total cost (C_{Total}) of establishing proposed Chanchaga hydroelectric power plant is
$C_{Total} = C_C + C_{EM}$ = ₦ 6,748,065,000 + ₦ 12,698,165,000 = ₦ 19,446,230,000.00k

Economic Analysis of Proposed Tagwai Storage Hydroelectric Power Plant

i. Cost of Construction of Intake and Diversion Weir in $ per kW is
$C_{ID} = 186.216P^{-0.2368} \times H^{-0.597}$
P = 5000 kW
H= 4 m
$C_{ID} = 186.216 \times 5000^{-0.2368} \times 4^{-0.597}$ = 186.216 x 0.1337 x 0.4371 =$ 10.83 per kW
Converting the per 5000 kW, C_{ID} = $ 10.83 x 5000 = $54,150, Converting the cost in $ to ₦ at ₦1700 to $1, C_{ID} =$ 54, 150 x 1700 = ₦ 92,055,000

ii. Cost of Construction of Powerhouse in $ per kW is
$C_{PH} = 1389.16P^{-0.235} \times H^{-0.0585}$, $C_{PH} = 1389.16 \times 5000^{-0.235} \times 4^{-0.0585}$ = 1389.16 x 0.1351 x 0.9221 = $950.72 per kW, Converting the cost to 5000 kW, C_{PH}= $950.72 x 5000 =$ 4,753,600
Converting the cost in $ to ₦ at ₦1700 to $1, C_{PH}= $ 4,753,600 x 1700 = ₦8,081,120,000
Total cost of civil engineering work (C_C) = Cost of construction of intake and diversion weir (C_{ID}) + Cost of construction of powerhouse (C_{PH})
$C_C = C_{ID} + C_{PH}$= ₦ 92,055,000 + ₦ 8,081,120,000 = ₦ 8, 173,175,000

iii. Cost of Purchase of Francis Turbine in $ per kW is
$C_T = 30462P^{-0.560135} \times H^{-0.127234}$, $C_T = 30462 \times 5000^{-560135} \times 4^{-0.127234}$ = 30462 x 0.0084738 x 0.8307 = $ 214.43 per kW, Converting the cost to 5000 kW capacity of the plant C_T = $ 214.43 x 5000 = $ 1,072,150, Converting the cost of the 5000 kW capacity to naira
C_T = $ 1,072,150 x 1700 = ₦ 1,822,655,000

iv Cost of Purchase of Generator in $ per kW is
$C_G = 10486.65P^{-0.1855} \times H^{-0.2083}$, $C_G = 10486.65 \times 5000^{-0.1855} \times 4^{-0.2083}$ = 10486.65 x 0.2060 x 0.7492, C_G = $ 1,618.45, Converting the cost to 5000 kW capacity of the plant, C_G = $ 1,618.45 x 5000 = $ 8, 092, 250, Converting the cost in $ to ₦
C_G = $ 8,092,250 x 1700, C_G = ₦ 13,750,825,000

v. Cost of Purchase of Transformer and Switchyard Equipments in $ per kW is
$C_{TS} = 281P^{-0.8103} \times H^{-0.2075}$, $C_{TS} = 281 \times 5000^{-0.8103} \times 4^{-0.2075}$ = 281 x 0.2153 x 0.7501
C_{TS} = $ 45.38 per kW, Converting the cost by 5000 kW capacity plant, C_{TS} = $ 45.38 x 5000 = $ 266,900, Converting the cost in $ to ₦, C_{TS} = $ 266,900 x 1700, C_{TS} = ₦ 385,730,000

vi. Cost of Purchase of Mechanical, Electrical and Auxiliary Equipment in $ per kW is
$C_A = 612.87P^{-0.1892} \times H^{-0.2118}$, $C_A = 612.87 \times 5000^{-0.1892} \times 4^{-0.2118}$ = 612.87 x 0.1996 x 0.7456
C_A = $ 91.21 per kW, Converting the cost to 5000 kW capacity plant, C_A = $ 91.21 x 5000 = $ 456,050, Converting the cost in $ to ₦, C_A = $ 456, 050 x 1700, C_A = ₦ 775,285,000
Total cost of electromechanical equipments (C_{EM}) is
$C_{EM} = C_F + C_G + C_{TS} + C_A$

C_{EM} = ₦ 1, 822,655,000 + ₦ 13,750,825,000 + ₦ 385,730,000 + ₦ 775,285,000
C_{EM} = ₦ 16, 734,495,000. 00k
Total cost (C_{Total}) of establishing proposed Chanchaga hydroelectric power plant is
$C_{Total} = C_C + C_{EM}$ = ₦ 8, 173,175,000 + ₦ 16,734,450,000 = ₦ 24,907,625,000.00k

Economic Analysis of Proposed Bosso Off-shore Hydroelectric Power Plant

i. Cost of Construction of Intake and Diversion Weir in $ per kW is
$C_{ID} = 186.216P^{-0.2368}x\ H^{-0.597}$
P = 2000 kW
H= 4.99 m
$C_{ID} = 186.216 \times 2000^{-0.2368} \times 4.99^{-0.597} = 186.216 \times 0.1653 \times 0.3830$ =$ 11.79 per kW
Converting to 2000 kW plant capacity, C_{ID} = $ 11.79 x 2000 = $58,950, Converting the cost in $ to ₦ at ₦1700 to $1, C_{ID} =$58,950 x 1700 = ₦ 100,215,000

ii. Cost of Construction of Powerhouse in $ per kW is
$C_{PH} = 1389.16P^{-0.235} \times H^{-0.0585}$, $C_{PH} = 1389.16 \times 2000^{-0.235} \times 4.99^{-0.0585} = 1389.16 \times 0.6411 \times 0.9103$ = $810.70 per kW, Converting the cost to 2000 kW plant capacity is
C_{PH}= $ 810.70 x 2000 = $ 1,621,400, Converting the cost in $ to ₦ at ₦1700 to $1, C_{PH}= $ 1,621,400 x 1700 = ₦ 2, 756,380,000
Total cost of civil engineering work (C_C) = Cost of construction of intake and diversion weir (C_{ID}) + Cost of construction of powerhouse (C_{PH})
$C_C = C_{ID} + C_{PH}$= ₦100, 215,000 + ₦ 2, 756,380,000 = ₦ 2, 856,595,000

iii. Cost of Purchase of Bulb Turbine is
$C_T = 2015P^{0.824} \times H^{-0.478}$, $C_T = 2015 \times 2000^{-0.824} \times 4.99^{-0.478} = 2015 \times 524.87 \times 0.4680$ = $ 494,142.48, Converting the cost in $ to ₦ at ₦ 1,700 to $ 1, C_T = $ 494,142 x 1700 = ₦ 840,041,400.

iv. Cost of Purchase of Transformer and Switchyard Equipments in $ per kW is
$C_{TS} = 281P^{-0.8103} \times H^{-0.2075}$, $C_{TS} = 281 \times 2000^{-0.8103} \times 4.99^{-0.2075} = 281 \times 0.2540 \times 0.7164$
C_{TS} = $ 39.69 per kW, Converting the cost by 2000 kW capacity plant
C_{TS} = $ 39.69 x 2000 = $ 79,380Converting the cost in $ to ₦, C_{TS} = $ 79,380 x 1700
C_{TS} = ₦ 134,946,000

vi. Cost of Purchase of Mechanical and Electrical Auxiliary Equipment in $ per kW is
$C_A = 612.87P^{-0.1892} \times H^{-0.2118}$, $C_A = 612.87 \times 2000^{-0.1892} \times 4.99^{-0.2118} = 612.87 \times 0.2374 \times 0.7115$
C_A = $ 103.52 per kW, Converting the cost to 2000 kW plant capacity, C_A = $ 103.52 x 2000 = $ 207, 040, Converting the cost in $ to ₦, C_A = $ 207,040 x 1700, C_A = ₦ 351,968,000
Total cost of electromechanical equipments (C_{EM}) is
$C_{EM} = C_T + C_{TS} + C_A$
C_{EM} = ₦ 840,042,216 + ₦ 134,946,000 + ₦ 351,968,000, C_{EM} = ₦ 1,326,956,216
Total cost (C_{Total}) of establishing proposed Bosso off-shore hydroelectric power plant is
$C_{Total} = C_C + C_{EM}$ = ₦ 2, 856,595,000 + ₦ 351,968,000 = ₦ 3,208,563,000

Economic Analysis of Proposed Chanchaga Off-shore Hydroelectric Power Plant

i. Cost of Construction of Intake and Diversion Weir in $ per kW is
$C_{ID} = 186.216P^{-0.2368}x\ H^{-0.597}$
P = 2000 kW
H= 1.08 m
$C_{ID} = 186.216 \times 2000^{-0.2368} \times 1.88^{-0.597} = 186.216 \times 0.1653 \times 0.6860$ =$ 21.12 per kW
Converting to 2000 kW plant capacity, C_{ID} = $ 21.12 x 2000 = $ 42, 240
Converting the cost in $ to ₦ at ₦1700 to $1, C_{ID} =$ 42,240 x 1700 = ₦ 71,808,000

ii. Cost of Construction of Powerhouse in $ per kW is
$C_{PH} = 1389.16P^{-0.235} \times H^{-0.0585}$, $C_{PH} = 1389.16 \times 2000^{-0.235} \times 1.88^{-0.0585} = 1389.16 \times 0.6411 \times 0.9637$ = $ 858. 26 per kW, Converting the cost to 2000 kW plant capacity is
C_{PH}= $ 858.26 x 2000 = $ 1, 716, 200, Converting the cost in $ to ₦ at ₦1700 to $1, C_{PH}= $ 1, 176, 200 x 1700 = ₦ 1, 999,540,000
Total cost of civil engineering work (C_C) = Cost of construction of intake and diversion weir (C_{ID}) + Cost of construction of powerhouse (C_{PH})
$C_C = C_{ID} + C_{PH}$= ₦ 71,808,000 + ₦ 1,999,540,000 = ₦ 2, 071,348,000

iii. Cost of Purchase of Bulb Turbine is
$C_T = 2015P^{0.824} \times H^{-0.478}$, $C_T = 2015 \times 2000^{0.824} \times 1.88^{-0.478} = 2015 \times 524.87 \times 0.7395$ = $ 782,104.48, Converting the cost in $ to ₦ at ₦ 1,700 to $ 1
C_T = $ 782,104 x 1700 = ₦ 1, 329, 576, 800

iv. Cost of Purchase of Transformer and Switchyard Equipments in $ per kW is
$C_{TS} = 281P^{-0.8103} \times H^{-0.2075}$, $C_{TS} = 281 \times 2000^{-0.8103} \times 1.88^{-0.2075} = 281 \times 0.2540 \times 0.8772$
C_{TS} = $ 62.61 per kW, Converting the cost by 2000 kW plant capacity, C_{TS} = $ 62.61 x 2000 = $ 125,220, Converting the cost in $ to ₦, C_{TS} = $ 125,220 x 1700, C_{TS} = ₦ 212,874,000

v. Cost of Purchase of Mechanical and Electrical Auxiliary Equipment in $ per kW is

$C_A = 612.87P^{-0.1892} \times H^{-0.2118}$, $C_A = 612.87 \times 2000^{-0.1892} \times 1.88^{-0.2118} = 612.87 \times 0.2374 \times 0.8749$
C_A = \$ 127.29 per kW, Converting the cost to 2000 kW plant capacity, C_A = \$ 129.29 x 2000 = \$ 258,580, Converting the cost in \$ to ₦, C_A = \$ 258,580 x 1700, C_A = ₦ 439,586,000
Total cost of electromechanical equipments (C_{EM}) is
$C_{EM} = C_T + C_{TS} + C_A$
C_{EM} = ₦ 1,329,576,800 + ₦ 212,874,000 + ₦ 439,586,000, C_{EM} = ₦ 1, 982, 036,800
Total cost (C_{Total}) of establishing proposed Chanchaga off-shore hydroelectric power plant is
$C_{Total} = C_C + C_{EM}$ = ₦ 2, 071,348,000 + ₦ 1,982,036,800 = ₦ 4,053,384,000

Economic Analysis of Proposed Tagwai Off-shore Hydroelectric Power Plant

i. Cost of Construction of Intake and Diversion Weir in \$ per kW is
$C_{ID} = 186.216P^{-0.2368} \times H^{-0.597}$
P = 2000 kW
H= 5.90 m
$C_{ID} = 186.216 \times 2000^{-0.2368} \times 5.90^{-0.597} = 186.216 \times 0.1653 \times 0.3466$ =\$ 10.67 per kW
Converting to 2000 kW plant capacity, C_{ID} = \$ 10.67 x 2000 = \$ 21,300
Converting the cost in \$ to ₦ at ₦1700 to \$1, C_{ID} =\$ 21,300 x 1700 = ₦ 36,210,000

ii. Cost of Construction of Powerhouse in \$ per kW is
$C_{PH} = 1389.16P^{-0.235} \times H^{-0.0585}$
$C_{PH} = 1389.16 \times 2000^{-0.235} \times 5.90^{-0.0585} = 1389.16 \times 0.6411 \times 0.9014$ = \$ 802.78 per kW
Converting the cost to 2000 kW plant capacity, C_{PH}= \$ 802.78 x 2000 = \$ 1, 605,560
Converting the cost in \$ to ₦ at ₦1700 to \$1, C_{PH}= \$ 1, 605,560 x 1700 = ₦ 2,729,452,000
Total cost of civil engineering work (C_C) = Cost of construction of intake and diversion weir (C_{ID}) + Cost of construction of powerhouse (C_{PH})
$C_C = C_{ID} + C_{PH}$= ₦ 36,210,000 + ₦ 2,729,452,000 = ₦ 2,765,662,000

iii. Cost of Purchase of Bulb Turbine is
$C_T = 2015P^{0.824} \times H^{-0.478}$, $C_T = 2015 \times 2000^{0.824} \times 5.90^{-0.478}$ = 2015 x 524.87 x 0.4281 = \$ 452,764.15, Converting the cost in \$ to ₦ at ₦ 1,700 to \$ 1
C_T = \$ 452,764.15 x 1700 = ₦ 769,699,055

iv. Cost of Purchase of Transformer and Switchyard Equipments in \$ per kW is
$C_{TS} = 281P^{-0.8103} \times H^{-0.2075}$, $C_{TS} = 281 \times 2000^{-0.8103} \times 5.90^{-0.2075} = 281 \times 0.2540 \times 0.6919$
C_{TS} = \$ 49.38 per kW, Converting the cost by 2000 kW plant capacity, C_{TS} = \$ 49.38 x 2000 = \$ 98,760, Converting the cost in \$ to ₦, C_{TS} = \$ 98,760 x 1700, C_{TS} = ₦ 167,892,000

v. Cost of Purchase of Mechanical and Electrical Auxiliary Equipment in \$ per kW is

$C_A = 612.87P^{-0.1892} \times H^{-0.2118}$, $C_A = 612.87 \times 2000^{-0.1892} \times 5.90^{-0.2118} = 612.87 \times 0.2374 \times 0.6867$
C_A = \$ 99.91 per kW, Converting the cost to 2000 kW plant capacity, C_A = \$ 99.91 x 2000 = \$ 199,820, Converting the cost in \$ to ₦, C_A = \$ 199,820 x 1700, C_A = ₦ 399,694,000
Total cost of electromechanical equipments (C_{EM}) is
$C_{EM} = C_T + C_{TS} + C_A$
C_{EM} = ₦ 769,699,055 + ₦ 167,892,000 + ₦ 399,694,000, C_{EM} = ₦ 1,337,285,055
Total cost (C_{Total}) of establishing proposed Tagwai off-shore hydroelectric power plant is
$C_{Total} = C_C + C_{EM}$ = ₦ 2,762,662,000 + ₦ 1,337,285,055 = ₦ 4, 099,907,055

CONCLUSION

The economic analysis of the cost of establishing proposed Bosso, Chanchaga and Tagwai storage hydroelectric power of the values of ₦12,205,311,789.00k, ₦19,446,230,000.00k and ₦ 24, 907,625,000.00k respectively shows that establishing the storage hydroelectric power plants are feasible. The economic analysis of the cost of establishing proposed Bosso, Chanchaga and Tagwai hydroelectric power plants with the values of ₦ 3, 208, 563, 000.00k, ₦ 4,055,384,000.00k and ₦ 4, 099, 907, 055.00k respectively shows that establishing the off shore hydroelectric power plants are feasible.

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