FEASIBILITY STUDY REPORT FOR OKURA DAM HYDROPOWER PROJECT , KOGI STATE

PART – I: EXECUTIVE SUMMARY

Bureau of Public Private Partnerships, Kogi State Government requested UNIDO Regional Centre for Small Hydro Power in Africa, Abuja to assess the power potential on using the existing dams at Osara, Okura and Omi which were primarily built for irrigation and other industries and a project on Ofu river for hydro-power generation. The UNIDO team visited the state from 13th March to 16th March 2017 to do a pre-feasibility study. Since the potential in these sites is attractive, UNIDO decided to conduct a detailed study for these sites.

Okura River is located near Ofejiji village in Dekina Local Government Area of Kogi State, Nigeria. The existing dam can be used with increased height for the power generation. A 500m long penstock will deliver this water to the powerhouse at a gross head of 20m. The design flow rate of 10 m^3/s will generate 1.5 MW.

Okura Dam Micro hydro project will bring sufficient electricity to uplift the economic activities of the region. Many villages near the Okura dam will get connected to the power plant. All the communities have expressed their desire to have this project and their unconditional support to the implementation.

There is also a private entrepreneur, Dr. Jacob Abdullahi, Chairman, Winner Power Garden who built and owns this dam. The federal Ministry of water resources had issued a water use permit to this company on 26th March 2015 for the construction of an earth dam. The company also has an embedded license (to generate and use electricity without transferring to the national grid). The company has acquired over 21000 hectares of land around the dam area.

		UNIT/DETAIL
Project Name	Okura Micro hydro Project	
Location (Village, district , region)	Ofejiji village Dekina Local Goverment area of Kogi State, Nigeria	
Developer (Physical address and contact details including telephone contacts)	Dr. Jacob Abdullahi, Chairman, Winner Power Garden	
Position/project layout including GPS coordinates in accordance to the datum and coordinate system : • Dam • Forebay • Surge Tank • Power house • Switch Yard • Interconnection arrangement /delivery point	N7° 24.917' E7° 18.995' Not applicable Not applicable N7° 25.021' E7° 18.729' Power has to be evacuated to the villages of Ochaja, Ofejiji, Okaga, Okura Olafia.	
Purpose, objective and scope of the project	To modify the existing dam potential to generate 1.5 MW to meet the requirement of the villages and to supply power to the thriving cashew nut industry..	

Hydrological Features at the Dam site	
Catchment Area	770 km^2
Mean Annual Flow	9.1m^3/s
Normal Average Flow – Wet season	15.1m^3/s
Normal Average Flow – Dry season	0.8 m^3/s
Design Flow	10.7 m^3/s
Flow (1,000y flood event)	Dam design document not available
Flow (100y flood event)	Dam design document not available
Reservoir	
Reservoir	Yes
Normal Water Level (NWL)	208 masl
Minimum Operating Level	198 masl
Surface area at NWL	1.8 km^2
Live Storage Volume	9 x 10^{6}m^3
Dead Storage Volume	1 x 10^{6}m^3
Water retention time	6 days
Length of river impounded	6 km
Number of downstream tributaries	None
Useful reservoir life	25 years
Present Use of Water	
Water used for irrigation	Less than 1 m^3/s
Water used for drinking purposes	Less than 1 m^3/s

Water used for other settlement/industry purposes (please specify activities)	None now. But once the power plant is implemented, cashew nut processing industries will grow.	m^3/s
Dam		
Dam Construction	TBD	
Type	Earthen	
Slope	TBD	m/m
Crest elevation	210	m
Crest length	350	m
Maximum height Volume	208 1.25×10^6	m m^3
Diversion facilities (please specify)		
Length	Intake tower	m
Diameter/cross-section Diversion flow	 10	m m^3/s
Spill way		
Type		
Crest Elevation	208	m
Maximum flood level	210	m
Width Discharge	100 50	m m^3/s
Water Conveyance system		
Length Discharge	No Canal	m m^3/s
Fore-bay/Surge tank		
Design water level	146	mAD
Static water level	145	mAD
Penstock		
Penstock construction	Two pipesin parallel	
Total length	500	m
Horizontal length	400	m
Diameter	1.5 (12mm wall thickness)	m
Power facilities		
Power House type		
Type of turbine	Francis, Horizontal axis	
Gross head surge bay-power house Design discharge	20 10.7	m m^3/s

Length of tailrace channel	5	m
Installed capacity	1.5	MW
Distribution / Transmission facilities		
Transformer type	A hermetically sealed step up transformer	
Transformer rating	2000 kVA	
Transmission line type	HV, three phase	
Line voltage	33	kV
Line length	13.5	km
Line capacity Proposed conductor size	2 10	MVA mm^2
Proposed conductor material	ACSR	
Technical Loss factor along the line	8.1	Percentage
Power Production		
Total Efficient Capacity	1.5	MW
Average generation during wet season	1.5	MW
Average generation during dry season	1.0	MW
Mean Annual Power Production during Peak Periods		GWh
Mean Annual Power Production during Shoulder Periods		GWh
Mean Annual Power Production during off-peak Periods		GWh
Mean Annual Total Power Production	9.66	GWh
Capacity factor	58	%
Plant factor *(The ratio of the average power load of the plant to its rated capacity)*	74	%
Average Generation for own use	NA	MW
Annual Power Production for own use	NA	GWh
Economics and Financials		
Investment Costs based on detailed underlying assumptions	7.5 million	USD
Annual Operational costs based on detailed underlying assumptions	50,000	USD/year
Annual Revenue from Operation	1 million	USD/year
Net Present Value (NPV)		USD
Internal Rate of Return (IRR)	18%	%
Pay-Back Period (PBP)	5	Years
Environmental and Social Indicators		
Distance to nearest residential zone	1000	m
Distance to nearest protected area	N.A	km (or “inside”)
Access roads through protected areas		km total

Labour requirement for construction	30000 man days	Average number
Labour camp accommodation needed	100	Number of persons
Personnel requirement for operations Environmental Flow	5 1.5	Number of persons m^3/s
Fish species diversity Land acquisition required	Not known Already acquired	No. of fish species m^2
Required resettlement		Number of persons
Compensation for land access/use		Number of persons
Cultural heritage sites within project affected area		Number of sites

PART II- MAIN REPORT

1 INTRODUCTION

1.1 Background

With a population of over 170 million, Nigeria is the most populous country in Africa and the eighth most populous country in the world. According to the United Nations, one in six Africans is Nigerian. It is a regional power, listed among the "Next Eleven" economies, and a member of the Commonwealth of Nations.[1] But Sadly, on the economic front, the country seems to be stagnant at the best. The main factor that hinders the development as perceived by many is the power sector. Nigeria is ranked 172 out of 187 countries by world Bank on the " ease of getting electricity"[1].

The Energy Commission of Nigeria (ECN) together with the International Atomic Energy Agency (IAEA) projected a demand of 15,730 MW for 2010 and 119,200 MW for 2030 under the reference scenario (7% yearly economic growth)[2]. Many studies indicate that the current gap between supply and demand is already very high (1:3) and that, it will become worse if the same reliance on fossil fuels is continued.

In order to bring a solution to these problems, the Federal Government of Nigeria (FGN), in its Power Sector Reform Roadmap (2013), set ambitious targets to increase installed hydro to 5,690 MW, thermal to over 20,000 MW and renewable 1000 MW capacities by 2020[3] . The targets also aim at diversifying Nigeria's energy mix to reduce its natural gas dependence.

Federal Government of Nigeria through the Federal Ministry of Power and Federal Ministry of Water Resources (FMWR) are undertaking studies of irrigation dams in the country to identify their potential for SHP integration and development.

Bureau of Public Private Partnerships, Kogi State Government requested UNIDO Regional Centre for Small Hydro Power in Africa, Abuja to assess the power potential on using the existing dams at Osara, Okura and Omi which were primarily built for irrigation and other industries and a project on Ofu river for hydro-power generation. The UNIDO team visited the state from 13th March to 16th March 2017 to do a pre-feasibility study. Since the potential in these sites is attractive, UNIDO decided to conduct a detailed study for these sites.

1.2 Project Objective

Okura Dam hydro power project will use the natural resource, namely, the Okura river water, a perennial river in the state to generate electricity to meet the energy demands of the five rural communities in the region. Kogi state is , as the rest of the country, facing a severe shortage of power supply options and this project will take care of these few communities and thereby improving the local economy through small agricultural processing industries .

The proposed mini-grid project aims at providing reliable, clean and affordable electricity access to communities in Dekina Local Government Area of Kogi state. The overall objective of this

[1] www.doingbusiness.org/data/exploretopics/getting-electricity

[2] A. S. Sambo, 2008, Matching Electricity Supply with Demand in Nigeria, Fourth Quarter, International Association for Energy Economic, p. 33

[3] The Presidency of the Federal Republic of Nigeria, August 2013, Roadmap for Power Sector Reform, Revision1, p. 24-25

project is to improve the quality of life of rural communities through provision of electricity services to households, enterprises and institutions. The project outcomes will include the following:

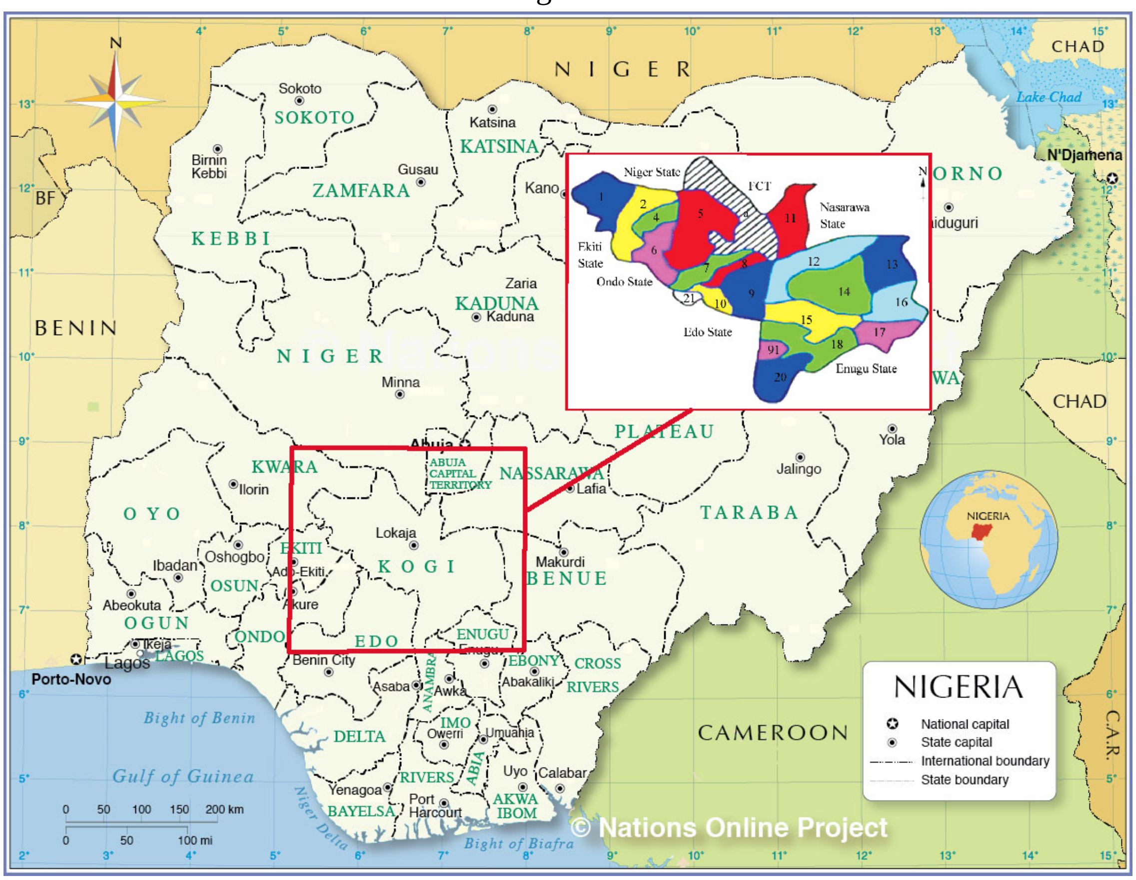
- Supply of reliable, affordable electricity
- Increased Value addition and other small industries for the rural areas
- Reduced pollution – both indoor and outdoor
- Increased facilities to health services

1.3 Feasibility Study Objective

UNIDO sent a technical team to assess the potential and to provide broad guidelines to design and implement the hydro-power project in the Okura dam area. The objective is also to ascertain the technical and economical viability of the proposed project. The FS will provide topographical data, hydrological data, analysis of historical rainfall data using flow duration curve, as well as assess the environmental and social impact that might arise from developing these sites.

2 DESCRIPTION OF PROJECT AREA

Kogi is a state in the central region of Nigeria. It is also popularly called as the Confluence State because the confluence of River Niger and River Benue is at its capital, Lokoja. The State has twenty one (21) local government areas and is located in the middle belt or what is historically referred to as the North Central area of Nigeria.



The state experiences two major seasons, dry and wet seasons which favours the growth of varieties of food and cash crops. The major economic activities of the people are farming, fishing, services and government employees. The major crops grown are yam, cassava, and rice while the cash crops include cashew, oil palm, and Neem tree. Kogi State is also abundantly endowed with Iron Ore, Limestone and coal.

2.1 Project location with coordinates and relevant site maps

The proposed project site is in the vicinity of *Ofe Jiji* village of Dekina Local Government Area.

The existing dam site is connected by a 800 metre long mud road from the Lokoja- Ankpa highway A233. The road in present status can not allow heavy vehicles to pass. The powerhouse is 500m downstream of the dam site and a new road has to be built.

2.1.1 Physical & Salient features of the project site

The Okura river originates at about 40 km upstream of the dam site. The catchment area is approximately 770 km^2. The river originates near Oji-Aji at an elevation of about 367m and the length of the river upto the dam is about 35 km. The estimated area of the reservoir is 2 sqkm with a projected storage volume of 10 m^3.

2.1.2 Load profile and electricity demand

This project will bring enormous benefits to the five communities near the project area. The details are given in the following table.

	Name of community	Distance from power house in km	Number of house-holds [2]	Connected domestic load[4]
1	Ochaja	2.75	200	40 kW
2	Okagu	3.5	150	30 kW
3	Okura Olafia	8.5	400	80kW
4	Okura Sawmill	4.5	200	40 kW
5	Ofejiji	1.7	150	30 kW

2.1.2.1 Ochaja

The village Ochaja is about 3 km downstream from the dam. The survey team met with the village chief Mr. Musafa Ibrahim. He was in the middle of a community meeting when we arrived. So it was possible to interact with all the community members. The community showed a lot of enthusiasm for the project and assured full support for its implementation.

The community has three primary schools, two secondary schools (one each for boys and girls) and one agricultural training center. It has four churches and three mosques/ prayer halls.

On the commercial side, the village has five hair dressers, 15 palm oil extractor mills, 11 units of garri mills, 16 bore-wells operated by petrol engines. The village also has a Kogi state broadcasting radio station which is functioning now only for couple of hours now because of shortage of power.

Grid transmission is present in the village but there has been no power on these lines since six months.

As the whole area is under cashew nut cultivation, this community produces/sells about 5000T of unprocessed cashew nuts. 80 kg bag usually sells at 30 to 50,000 Naira. Taking the lower price,

[4] 200 watts per household

the annual income from the cashew nut is 1.875 billion Naira (5.2 million USD). Value addition and the additional income from this is discussed under a separate topic.

Cocoa Research Institute of Nigeria (CRIN) has a research campus near this village. They have small processing machines to make cashew juice and nut products.

Almost all the households have small petrol generators powering small washing machines and televisions. Health facility is very poor in the village. The community needs a good health clinic.

2.1.2.2 Okagu

Okagu is about 4 km from the dam site. The access road is in bad state. Main crops of Casava and Cashew-nuts. Casava is hand-processed. There are about 150 households in this village. Each family harvest about 20 bags of cashew-nuts – each bag contains 80 kgs. The total production is about 225T.

There is one diesel mill tp grind the palm pulp.

2.1.2.3 Okura-Olafia

The biggest of all the villages near the power project is at 8.5 km away. 99% of all households have a generator. Electricty was there till two years back. But the supply got disrupted when a few poles fell down and no repair work was undertaken. The tariff was paid collectively – a few well-to-do families were paying the tariff for the entire community. The information given on this was very vague. Most probably, the non-payment of tariff may have resulted in disconnection.

Yam, Casava, Okra, tomatoes, pepper are some of the crops gown here. Cashew-nut is a major cash crop. 1500 MT per year is harvested and sold from this village. One tone is sold at about 700 USD.

The community has a few welding workshops and processing mills. All of these are powered by privately owned generators.

2.1.2.4 Okura Saw-mill

It is halfway in between the powerhouse and the Okura olafia village. There is a transformer installed in the village which is said to be in good repair. But no there is no supply of electricity for the last six months.

There are five diesel mills to process maize and four mills for palm kernel. Quite a few carpenters are there in the village.

There are also about 1000 orange trees in the village. Now the fruits are locally consumed and a lot of them go waste.

The number of households is not known. The estimated cashew nut production here is about 400 Tonnes.

Based on the estimates, in the absence of data, The total present peak load on the system will be 349 kW. A load chart is shown below showing the different loads across the hours of the day.

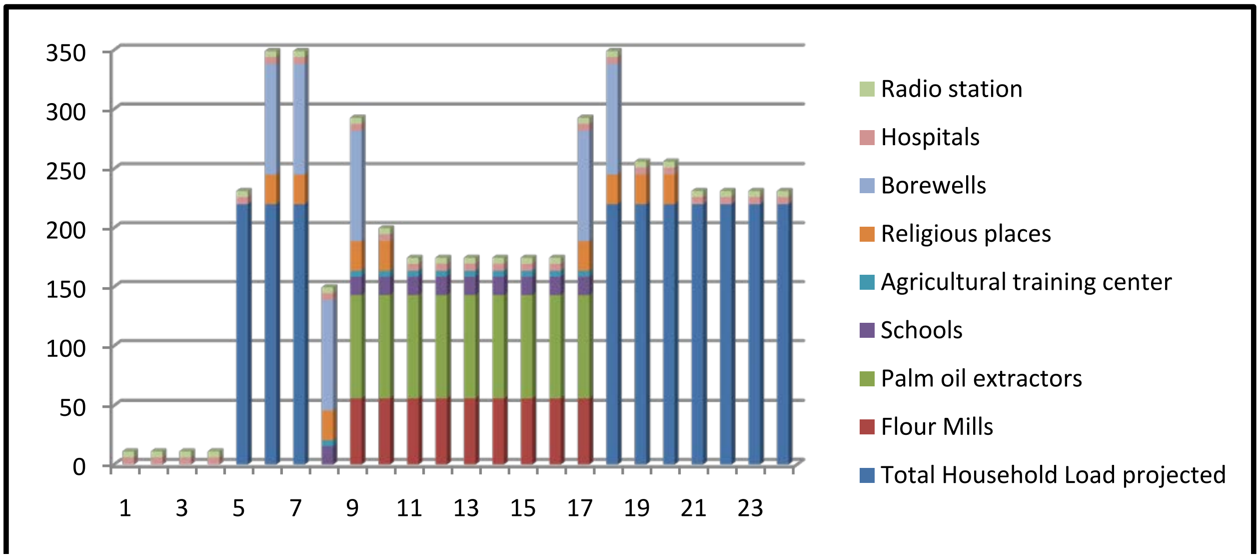


Figure 1 : Load profile for the selected communities

The peak load, i.e. 429 kW, is experienced at 06:00 and 18:00 hours as per the above chart. Since all load points will not be turned on simultaneously, peak load should be multiplied by diversity factor (DF) for the realistic values. The new peak load is known as after diversity maximum demand (ADMD). Diversity factor is normally considered as 0.8.

ADMD = MD x DF = 429 x 0.8 = 343.2 kW ≈ 345 kW

2.1.2.5 Future projections

The population of the state has been steadily increasing at the rate of 3.5% per year from 2006. The total number of households may increase to 1500 from the present 1100 in ten years – requiring an additional 80 kW at the present consumption rate. If the consumption rate also increases to 300W instead of the present 200W per house-hold, the total energy requirement for this sector will be 450 kW.

The small scale industry consisting of oil and flour mills is projected to grow at that same rate of population growth, then the this load may reach from the present 143 kW to 193 kW.

Considering all the other loads in the same was, the total increased load in ten years will be 690 kW.

With the installed capacity of 1.5 MW, the project can easily meet the future demands of the communities nearby.

In the short term, there will be 1 MW of power available for the new economic activities like cashew processing, orange juice making, etc.

2.1.3 Demographic and Socio-economic parameters

A detailed survey was conducted by visiting the nearby communities to assess the energy requirements. Based on the survey, it was found out that there are five different types of load centers i.e. households, Churches/mosques, future small enterprises, street lights, and schools. Large commercial entity, business centers, high rise buildings or any other medium enterprises are not present near the project site.

During the last Census carried out in 2006, the population of Dekina LGA was 260,968 and it was projected to have a population of 352,300 in 2016.

There are three main ethnic groups in Kogi state: Igala, Ebira and Okun with the Igalas being the largest group.

The main occupation of the area is agriculture. 90% of the population is engaged in agriculture though mostly it is subsistence farming. They produce crops for their immediate family needs and sell only when in excess. Farmers use mostly local hand made tools for farming. The region has arable land supporting cultivation of Yam, sorghum, maize, cassava and vegetables. Coffee, Cashew and cocoa are the cash crops that are grown here.

A few Fulani nomadic are found in the region and they are involved mainly in cattle grazing.

2.2 Cashew Industry

The cashew industry focuses on low-end raw nut production, losing substantial income to countries like India and Vietnam by not focusing on value added products like the cashew kernel.

The total quantity of cashew nut kernel production in this project area is estimated to be in the range of 7000 to 7500 MT per year. The average selling price per tonne is USD 800. The total income is 6 million USD.

The true fruit of the tree is a small kidney shaped nut that hangs below a much larger false fruit (see Figure 2). The edible false fruit, called cashew apple, is pear-shaped, with a waxy appearance, and turns yellow when ripe. The unripe cashew apple is astringent and slightly acidic. When ripe, it has a characteristic apple flavor and can be eaten fresh or dried or processed into juices, jellies and wines. The nut consists of a smooth tough shell surrounding an edible kernel. This kernel is what the tree is primarily valued for. The cashew shell contains a corrosive phenol, cashew nut shell liquid (CNSL), which must be extracted before the shell can be removed to yield the kernel. CNSL has found many applications in the polymer-based industries -the most important use is in the manufacture of brake linings and clutch facings in the automotive industry. Covering the kernel is a thin tannin rich skin, the testa, which must also be peeled away before the kernel can be consumed. The following table gives the various uses of the different parts of the fruit.

Input	Products	Description and Uses
Nuts	Kernels:	Raw nuts are processed into kernels by boiling, cracking, decorticating and roasting.
Apple	Prunes:	Cashew prunes, produced by boiling the cashew apple in molasses, is very similar to dehydrated prunes or dates.
Apple	Juice:	Cashew fruit is pulped by grating or pounding and the juice is pressed out and strained. Cashew juice has five times more citric acid than orange juice and is thus a good source of preservation acid medium when mixed with other fruit juices or vegetables.
Apple	Wine:	The juice from the cashew fruit can be processed into wine using the conventional method of producing fruit wines. The alcoholic content averages 18%.
Apple	Pulp:	The fibrous pulp obtained after extracting juice from the cashew apple can be used as animal feed or dried and processed into diet fiber biscuits.
Shell	CNSL:	Extracted from the cashew shell, Cashew Nut Shell Liquid (CNSL) is used in the manufacturing of paints, varnishes, resins and brake linings.
Shell	Fuel Wood	After extraction of the shell liquid, the spent shells are used as a processing fuel.

Table 1: Cashew Products

The Nigerian Cashew nut has a yield ratio of 25% - meaning for a tonne of raw cashew nuts 250 kgs of kernel is produced. The retail price of roasted kernels ranges from 14000 to 25000 USD per tonne. It can be seen that a little value addition can bring in substantial additional income to the cashew growing regions.

The processing steps include

1. drying of raw nuts,
2. steaming the raw nuts,
3. cooling,
4. cutting to separate shell from kernel,
5. drying the kernel,
6. peeling,
7. grading and packing.

An average of 8 to 10 kWh of electricity is required for producing one kg of cashew kernel. Considering the total production in these villages, the total energy requirement is 15GWh. With 1 MW of available power, about half of the production could be processed to cashew kernels, consuming about 7 GWh. The additional income by processing half of the produce (3500 MT of raw cashew) will be 2.75 million USD per year.

A few of the fruits are consumed locally and a vast quantity is left just to rot. The fruit pulp can be used to make juice and wine; the leftover after this process is a good animal feed.

3 TOPOGRAPHICAL SURVEYS

A team led by Engineer Rufai prepared the topographic maps for the dam. A maximum head of 8m is available at the site. The dam height could be raised by another 12m giving a gross head of 20m for power generation.

Topographic maps were prepared for the downstream and upstream areas of the dam.

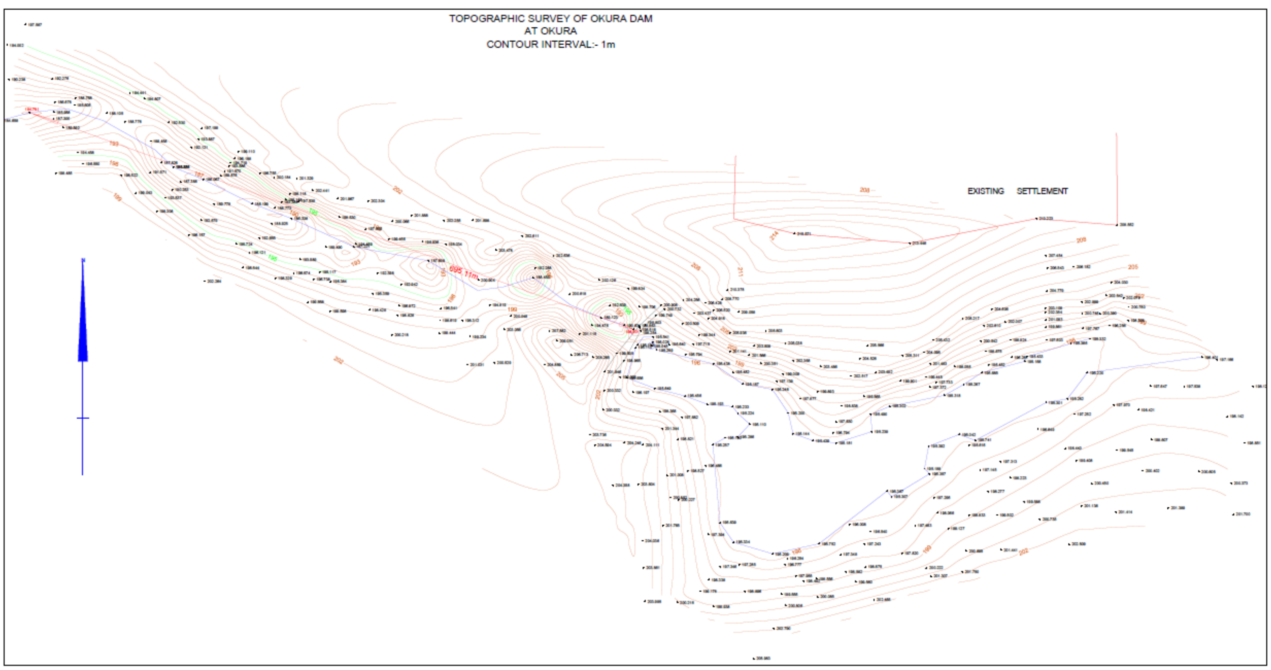


Figure 2 Topographic survey map the project area

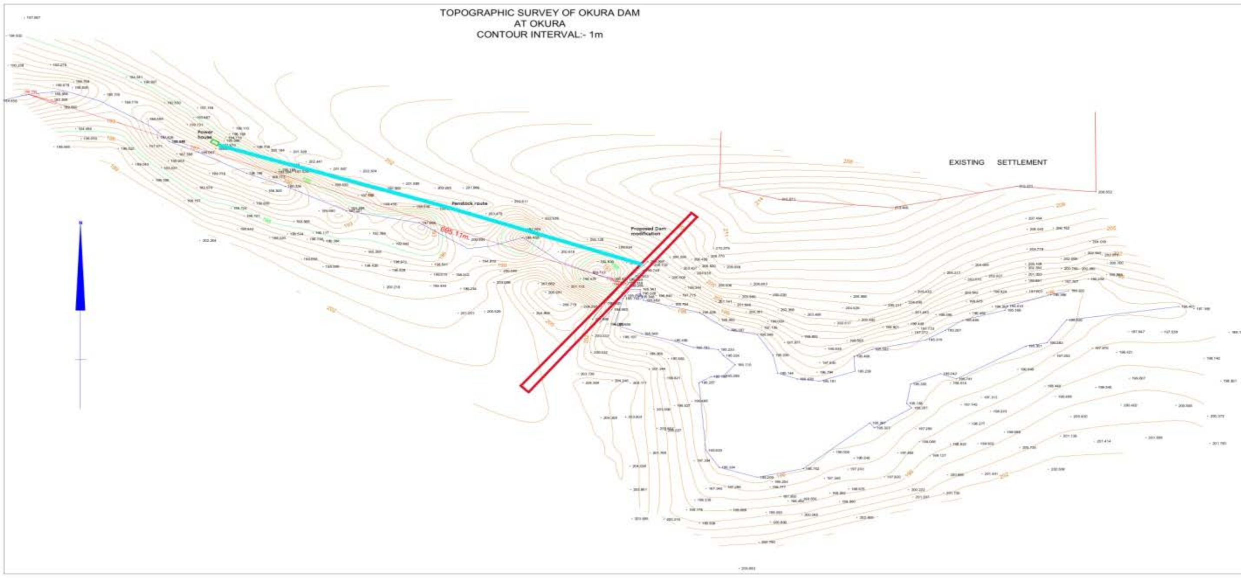


Figure 3 Okura topographic map with components details

The existing dam's crest level is at 198 masl. The height has to be increased to 210 masl which will give a gross head of 20m for the power generation.

A detailed survey of the reservoir area which will be upto the level of the 210 m contour line has to be carried out.

The reservoir area, after the increased height, is calculated using the google earth application. The following picture shows the proposed reservoir area. It is clear from the picture that few farmes from Ofejiji nad Okura sawmill communities may have to compensated for the submerged land.

4 HYDROLOGICAL AND SEDIMENTATION STUDIES

Sedimentation is not a factor for the power scheme as this is a dam-storage power plant. But sedimentation studies need to be conducted for the increase of the height of the dam. This is not covered in this assignment.

4.1 Catchment characteristics

Okura River is the main source of water for people within its catchment area. The catchment area consists of humid tropical rain forest of Nigeria and hence the river is perennial. It is part of topographic sheets 248 and 268. The mean annual rainfall for the Kogi state is about 1200mm. The vegetation of the area is typical of the derived savannah and consists of short to tall trees. However, the toposequence is covered with grasses and scattered shrubs. The topography of this land is strongly undulating. The land is used for the cultivation of the following crops; yam, cassava, groundnut, maize and vegetables.

Okura River is located near Ofe- Jiji village in Dekina Local Government Area of Kogi State, Nigeria. It was built by a local entrepreneur , Dr. Abdullah in 2005 to develop the village as a eco-tourist destination.

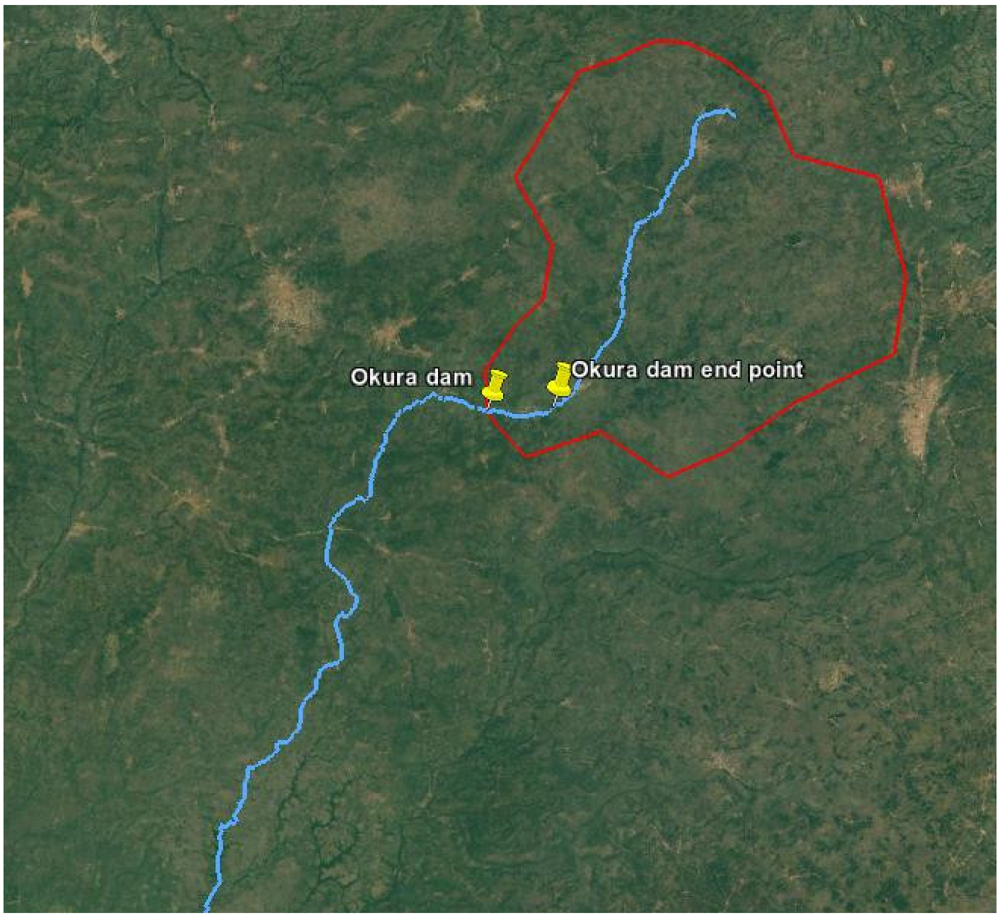


Figure 4 Catchemt area of Okura Dam

Okura River joins Imabolo River in Egabada (Kogi State) and further flow southwards before joining the Ofu River and the 'three-in-one' river empties into the Anambra River. There are no flow data available for the Okura and Ofu rivers.

4.2 Rainfall, climate and precipitation data analysis

Rainfall data recorded in Lokoja Kogi state station is used in this analysis. Data from 1995 to 2016 is obtained and the average monthy rainfall is presented below.

Month	Average rainfall in mm
Jan	1.1
Feb	8.3
Mar	29.0
Apr	120.1
May	174.4
Jun	142.5
Jul	215.4
Aug	213.5
Sep	191.8
Oct	151.9
Nov	5.3
Dec	0.5
Total	1253.8

As it can be seen, April to October is the wet season with peak rainfalls in July and August. The catchment area above the existing dam is shown in Figure 4. The total area is about 770 km^2. The run-off characteristics for the region is not well-established. As the catchment area is said to be full of tropical rain forests, run-off can be assumed to be high. We have taken 30% for this DPR to arrive at the component sizing for the scheme.

The total run-off in a year = 1.253 x 770 x 10^6 = 964,810,000 m^3

The average flow rate = 30.6 m^3/s

The flow rate was measured with a conductivity meter during the visit to the site in December 2017. The flow was measured to be 20.8 m^3/s downstream of the dam. Previous studies indicate a mean river flow rate of 35 m^3/s.

4.3 Flow Duration Curve

With limited available data, a FDC was prepared. Q57 is selected as design flow. This flow will be available for nearly 7 months.

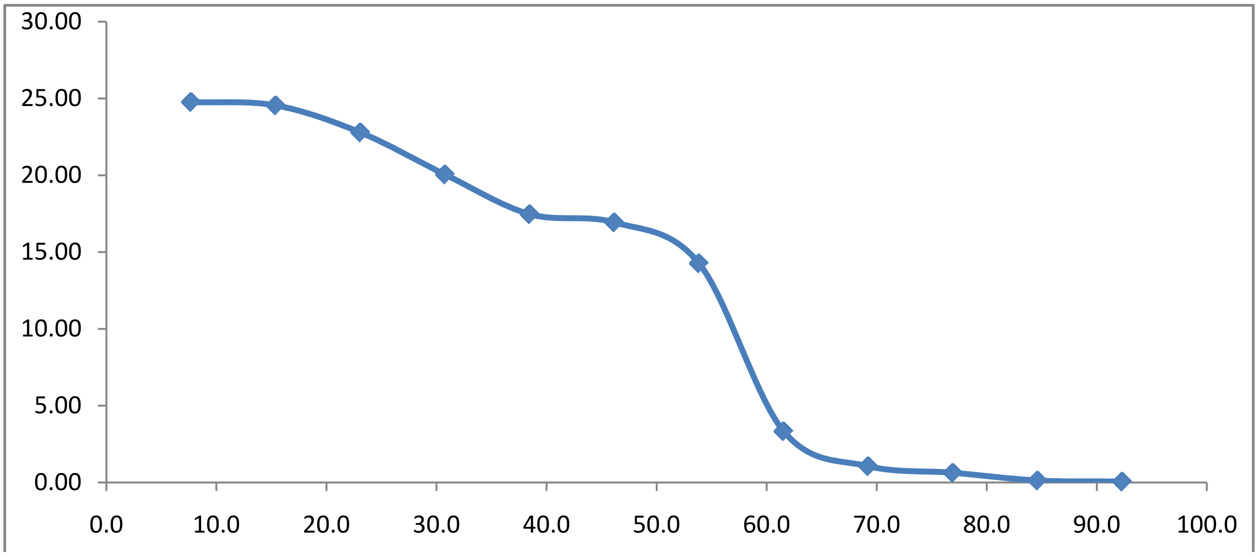


Figure 5 FDC for Okura River

5 GEO-TECHNICAL STUDIES

A detailed geo-technical study was not within the scope of this visit. The major rock types that occur in this state are migmatites, augen gneiss and biotite gneiss while there are minor occurrences of rock types like pegmatites, and quartzo-feldspathic veins.

Water-table in the region is quite high as indicated by a few open wells. The people of the area are predominantly subsistence farmers who use the available land for farming and the river water for washing, drinking and other domestic needs.

The flood plains of the Niger and Benue river valleys in Kogi State have the hydromorphic soils which contain a mixture of coarse alluvial and colluvial deposits . The alluvial soils along the valleys of the rivers are sandy, while the adjoining laterite soils are deeply weathered and grey or reddish in colour, sticky and permeable. The soils are mostly coarse textured, ranging from loamy to sandy loam in the surface horizons and from sandy loam to clay in the subsurface horizon.

These conditions don't pose any major issue for civil construction.

6 SUMMARY OF ENVIRONMENT AND SOCIAL IMPACT ASSESSMENT (ESIA)

6.1 Environmental Impacts

The proposed site already has a small dam. The hydropower project will increase the height by 10m. This in turn will submerge land upstream. Most of this land is not used for agriculture.

The ecological problems in the state are not necessarily peculiar to it. Some of these include leaching, erosion and general impoverishment of the soil. These problems are compounded by the annual bush burning of the savannah that further exposes the top soil to more erosion. Floods pose a problem on the flood plains during the rainy season: but the project area is not in flood plains.

6.2 Social Impacts

To the extent that over 90% of the people of the project area depend on agriculture and land based resources for livelihood, significant acquisition of land for this project without proper mitigation measures will expose some social groups to economic vulnerability.

6.2.1 Local Dispute Resolution Procedure

Information about the traditional administrative structure within these communities is similar and shows that the governance structure is hierarchical formed around the traditional leadership. For example, community governance hierarchy follows a systematic order of household head, ward head, districts or clan chief and the Obaru as the head of the community. The Obaru in each community reports to Olubunu or the apex King in the LGA.

The communities build their administrative structure around this chain of command which is based on the size of the population or domain that each leader has within his constituent/community.

There exists a traditional mechanism for dispute resolution in the communities structured after the order of the administrative command described above. An aggrieved person is required to lodge his/her complaint to the head of the ward or clan. A matter that is not adjudicated satisfactorily at this level is taken to the Obaru Council.

6.3 Assessment of significance of environmental and social impacts

Being an existing dam site, and a marginal increase in the reservoir area, there is no significant impact noticed. An in-depth study was not carried out at this stage. When the project moves onto the next stage of detailed technical design, this study could be taken up. There is also an earlier environmental impact study carried out by the entrepreneur which can be considered.

7 PROJECT OPTIMIZATION

7.1 Estimation of Power and Energy Production

7.1.1 Plant capacity

The proposed capacity of the power plant is 1.5 MW. The available head, after raising the dam height is 20m. The design flow is 10.7 m^3/s.

7.1.2 Plant factor

The plant factor 0.74 for this project will be quite high as the stream is perennial and the design flow is Q57.

7.1.2.1 Annual energy

The generation profile is given in the table below:

	Power kW	**Energy kWh**
Jan	400	297,600
Feb	400	268,800
Mar	500	372,000
Apr	1500	1,080,000

May	1500	1,116,000
Jun	1500	1,080,000
Jul	1500	1,116,000
Aug	1500	1,116,000
Sep	1500	1,080,000
Oct	1500	1,116,000
Nov	1000	720,000
Dec	400	297,600
Total		9,660,000
Installed capacity		13,140,000

The plant factor is 0.74

7.2 Cost Estimates

The total project cost is estimated to be 7.5 million USD. Approximate Break-up of civil costs are given below:

	Item	Quantity	Units	Rate, USD	Total, USD
1	1500mm ID MS pipe (440 kg/m) - 2 pipes	500	m	500	2,200,000
2	Cement	15000	bags	10	150,000
3	Soil - impermeable core	5000	m3	10	50,000
3	Sand	4000	m3	10	40,000
4	Gravel 25mm	2500	m3	35	87,500
5	Rubble stones for foundations	6000	m3	9	54,000
6	16mm and 8 mm steel	40000	kgs	9	360,000
7	Power house site	5m X 4m	area		
8	Bricks	21000		0.3	6,300
9	Skilled labour (masons)	2000	man days	15	30,000
10	Semi-skilled labour	25000	man days	5	125,000
	Sub total				3,102,800
	Contingency	10%			310,280
	Total cost of civil works				3,413,080

The electro-mechanical equipment cost is estimated to be 2 million USD ad the total transmission cost is estimated to be 2 million USD.

7.3 Economic Analysis

With the total project cost of 7.5 million USD, the benefits are enormous both in short term and long term. As discussed in the earlier section, the area is one of best cashew-nut growing regions of the country. But there is not a single processing unit adding value to the produce. By providing a reliable power supply and access to processing facilities can bring in an additional income of 2.5 million USD per year to the region's farming communities. Indirect benefits are innumerable: with increased incomes, health, education, common infrastructure will all become better.

The tariff charged in Nigeria is in different slabs: taking an average of 40 Naira/ kWh (10 cents), the IRR of the project is 18%

8 PROJECT DESCRIPTION AND BASIC DESIGN

The project site has an existing small earth dam. This dam will be modified. The proposed dam will be of embankment type dam with 15m height providing a total head of 20m.

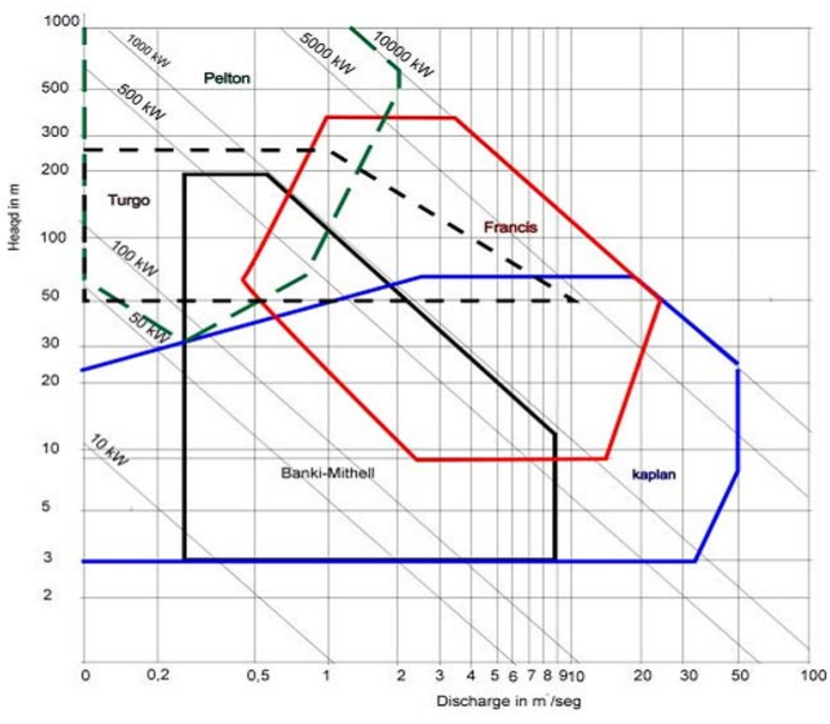
The powerhouse location is at about 500m from the dam site. It will have two turbine units to handle the flow variations effectively. The turbines will be of Francis type reaction turbines.

The tail race will be 5m long and leads the water back to the stream.

Penstock will be of mild steel and two pipes are suggested. Each pipe will be of 1.5m diameter and 12mm thick wall.

Four villages will be connected to this power plant. The total transmission line distance is over 13.5 km. The generated voltage will be stepped up to 33 kV by a transformer. Radial network. This network is not very reliable in terms of outage frequency because when one feeder experience fault, the whole downstream consumers are disconnected. However, it has the advantage of minimum cost and time of construction. However, with proper design standards, we can minimize the outage to an acceptable level.

8.1 Turbine choice



The Francis water turbine, named after its inventor James Francis, is a radial flow reaction type of water turbine design in which the entire turbine wheel assembly is immersed in water and surrounded by a pressurized spiral casing. The water enters the casing under pressure and is guided through a set of fixed or adjustable slots called guide vanes around the casing which direct the flow of water to the turbines blades at the correct angle.

The turbine is of horizontal axis type for this site.

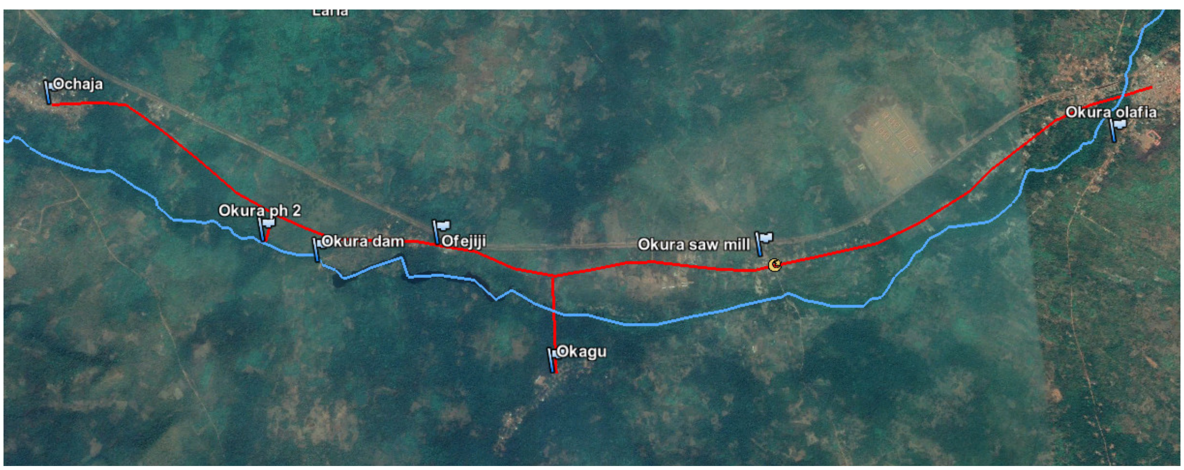
8.2 Generator

A three phase AC synchronous generator with horizontal arrangement and air cooled as per the IEC regulations is considered for this project. Two sets of generators will be installed which can also be synched with each other through a power electronics panel.

Each unit has a synchronization microcomputer automation device to perform synchronism connecting to the grid. Switchyard is also equipped with a set of microcomputer automation synchronization device and a set of manual synchronization device, mainly used to finish synchronism connecting to net of main transformer and 33 kV line.

9 DISTRIBUTION / TRANSMISSION LINE AND CONNECTION TO THE GRID

The following figure gives the transmission arrangement.



The total length of the transmission is 13.5 km. The main feeder line will be of 33 kV and step down transformers will be used at load centers.

10 OPERATION AND MAINTENANCE REQUIREMENTS

Most of the operation will be automatically controlled with SCADA. A team of 5 operators will manage the power plant to monitor the proper functioning of components. The plant will have two turbines to enable continuous power generation even during breakdowns / maintenance shut-downs.

The maintenance requirements are mainly desilting the dam once in a year, checking the seepage losses in the dam, fixing penstock leaks, transmission line issues, etc. For the T&D management, a team of five line-men will be needed.

11 PROJECT RISK ASSESSMENT AND MITIGATION

The private developer has already invested a large amount of money to buy the land needed and to build the dam. He has also obtained the necessary license for generating power at this site. He is willing to take it to the completion.

12 CONCLUSIONS AND RECOMMENDATIONS

The following conclusions are made:

1. Okura hydro project is technically and financially feasible.
2. Installed capacity and energy: The installed capacity of the plant is 1500 KW (2 x 750 KW) with a design discharge of 10.7 m^3/s and gross head of 20 m. The gross energy production is 9.66 GWh
3. This project site is already licensed to the developer and the PPA is finalized.
4. About 13.5 km long, 33 kV transmission line will be required from the project powerhouse to the five village communities.
5. A construction period of 18 months has been considered.

Based on the findings of this study, the project is financially attractive. It is recommended the detailed design for the dam & reservoir, penstock alignment, powerhouse and transmission& distribution design be initiated immediately.

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[1] Energy Sector Study – GIZ NESP 2015-16 report

[2] Data awaited from Mr. Donald Adgidzi. The figures given are rough estimates based on the visits to the village.