PRE FEASIBILITY STUDY REPORT FOR OSARA 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.

National Iron ore Mining Company was started with the technical expertise of erstwhile USSR in 1979, located at Itakpe Hill close to Okene in Kogi state of FGN. The main purpose was to produce and supply 100% of the Iron Ore requirements of Ajaokuta Steel company.

Osara dam project was conceived mainly for the washing of particles from mined iron ore at the Ajaokuta Steel and Iron industry. The construction started in 1980. It was completed by 1987. But since the steel industry is not operational now for over twenty years, except for a small quantity of water being used for irrigation and fish ponds, the dam is not in use.

		UNIT/DETAIL
Project Name	Osara Micro hydro Project	
Location (Village, district , region)	Osara dam, Okehi LGA of Kogi State, Nigeria	
Developer (Physical address and contact details including telephone contacts)	National Iron Ore Mining Company, KM 15, Okene-Lokoja Road Itakpe, Kogi State Nigeria	
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° 42.096' E6° 21.177' Not applicable Not applicable Power has to be evacuated to the factory	
Purpose, objective and scope of the project	To modify the existing dam potential to generate 300 kW to partially meet the requirement of the steel industry.	

Hydrological Features at the Dam site	
Catchment Area	531 km^2
Mean Annual Flow	3.1m^3/s
Normal Average Flow – Wet season	4.8 m^3/s
Normal Average Flow – Dry season	0.6 m^3/s
Design Flow	4.3 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)	146 masl
Minimum Operating Level Surface area at NWL Live Storage Volume Dead Storage Volume	140 masl 5.6 km^2 23 x 10^6m^3 1 x 10^6m^3
Water retention time	6 days
Length of river impounded	6 km
Number of downstream tributaries	None
Useful reservoir life	25 years old, another 50 years life
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.	m^3/s
Dam		
Dam Construction		
Type	Earthen	
Slope		m/m
Crest elevation	152.5	m
Crest length	1500	m
Maximum height Volume	25 23×10^6	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		
Total length	100	m
Horizontal length	100	m
Diameter	1.0 (12mm wall thickness)	m
Power facilities		
Power House type		
Type of turbine	Kaplan, Propeller turbine	
Gross head surge bay-power house Design discharge	8 4.5	m m^3/s

Length of tailrace channel	5	m
Installed capacity	250	kW
Distribution / Transmission facilities		
Transformer type	A hermetically sealed step up transformer	
Transformer rating	400 kVA	
Transmission line type	HV, three phase	
Line voltage	33	kV
Line length	9	km
Line capacity Proposed conductor size	0.5 50	MVA mm^2
Proposed conductor material	ACSR	
Technical Loss factor along the line	6	Percentage
Power Production		
Total Efficient Capacity	300	kW
Average generation during wet season	250	kW
Average generation during dry season	100	kW
Mean Annual Power Production during Peak Periods	1.83	GWh
Mean Annual Power Production during Shoulder Periods		GWh
Mean Annual Power Production during off-peak Periods		GWh
Mean Annual Total Power Production	1.83	GWh
Capacity factor	70	%
Plant factor *(The ratio of the average power load of the plant to its rated capacity)*	70	%
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	750000	USD
Annual Operational costs based on detailed underlying assumptions	7500	USD/year
Annual Revenue from Operation	180000	USD/year
Net Present Value (NPV)		USD
Internal Rate of Return (IRR)		%
Pay-Back Period (PBP)		Years

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

Osara Dam hydro power project will use the natural resource, namely, the Osara river water, a perennial river in the state to generate electricity to meet the energy demands of the steel Ore company. 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 overall objective of this project is to provide power for the base-loads of the iron ore company with captive power generation. The project outcomes will include the following:

- Supply of reliable, affordable electricity

[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

- Increased Value addition and other small industries for the rural areas
- Reduced pollution – both indoor and outdoor
- Increased facilities to health services

1.3 Pre 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 Osara dam area. The objective is also to ascertain the technical and economical viability of the proposed project. The PFS 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.

The largest steel & iron industry in Nigeria. Ajaokuta steel industry was established in 1971 on a

24,000 hectare land in Kogi State. This mighty industry has unfortunately been left moribund for a long period of time, but recently over the years, concerted efforts has been made by the Nigerian government to ensure its full capacity functioning. This industry is viewed as the main building block for the industrialization of Nigeria.

2.1 Project location with coordinates and relevant site maps

The existing dam and the intake can be used with minor modifications for the power generation. The powerhouse will be built near the present water outlet canal. The generated power will be supplied through the dedicated transmission lines to the steel factory which is the owner of this project

2.1.1 Physical & Salient features of the project site

The Osara river originates at about 35 km upstream of the dam site. The catchment area is approximately 530 km^2. The river originates near xxx at an elevation of about 450m and the length of the river upto the dam is about 35 km. The estimated area of the reservoir is 5.6 km^2 with a projected storage volume of 23 m^3.

2.1.2 Load profile and electricity demand

The proposed micro hydro power plant can only meet the base load requirement of the steel plant. Any surplus energy could be shared with the communities around the steel plant. No data is available on this.

2.1.3 Demographic and Socio-economic parameters

3 TOPOGRAPHICAL SURVEYS

A team led by Engineer Rufai prepared the topographic maps for the dam. A maximum head of 14 m is available at the site. The usable gross head will be 10m. The downstream of the dam is very

flat and there is no way to increase the operating head by moving the powerhouse downstream. Topographic maps were prepared for the dam.

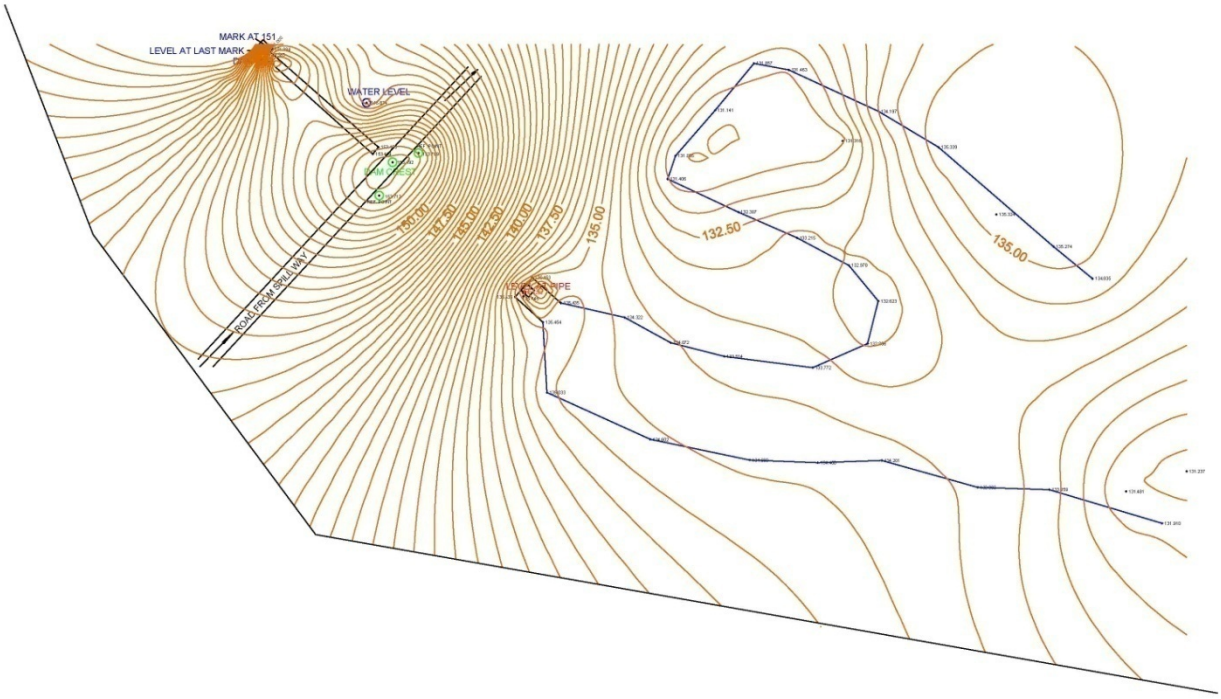


Figure 1 Topographic survey map the project area

The existing dam's crest level is at 152.5 m asl. At the time of measurement the water level was at 146.8m asl. The minimum usable level is assumed to be 141m asl. The water level at discharge point lies at about 131.2m asl. It is possible to get a gross head of 10 m for the power generation.

4 HYDROLOGICAL AND SEDIMENTATION STUDIES

Except for the drawings, the original design manual of the dam is missing/ damaged. Conducting a detailed sedimentation study is beyond the scope of this mission.

Dam design details missing. General geological features can only be considered.

4.1 Catchment characteristics

Osara River is the main source of water for people within its catchment area. The catchment area characteristics are unknown – data awaited from the department/ministry.

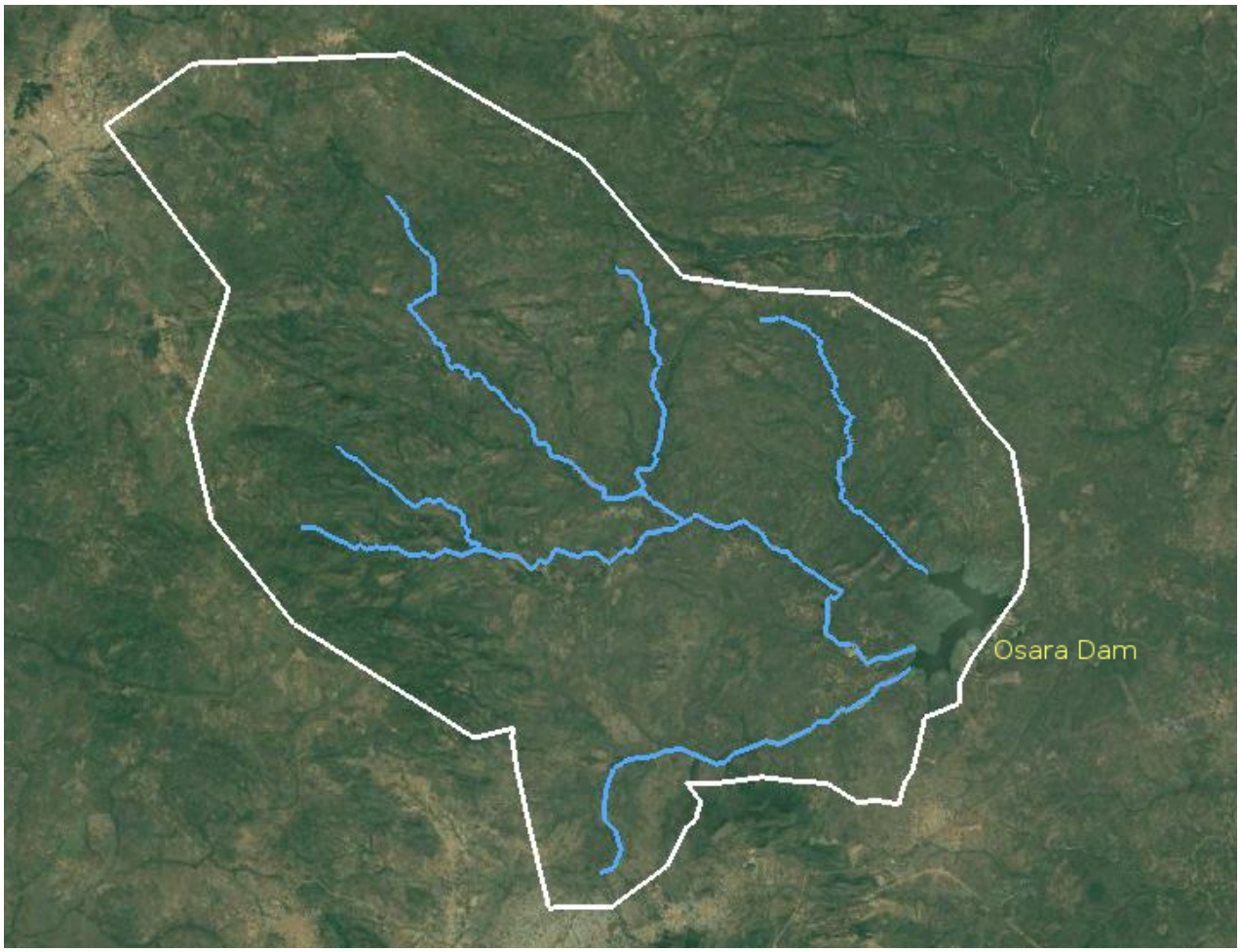


Figure 2 Catchemt area of Osara Dam

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	8.9
Feb	19.5
Mar	56.2
Apr	109.5

May	177.0
Jun	191.6
Jul	187.2
Aug	173.2
Sep	268.3
Oct	172.3
Nov	25.5
Dec	8.8
Total	1398.2

As it can be seen, April to October is the wet season with peak rainfalls in June and September. The catchment area above the existing dam is shown in Figure 4. The total area is about 530 km^2. The run-off characteristics for the region is not well-established. As the catchment area is said to be barren, run-off can be assumed to be low . We have taken 13% for this DPR to arrive at the component sizing for the scheme.

The total run-off in a year = 1.398 x 530 x 10^6 x 0.13= 96,322,200 m^3

The average flow rate = 3.05 m^3/s

4.3 Flow Duration Curve

With limited available data, a FDC was prepared. Q50 is selected as design flow. This flow will be available for nearly 7 months.

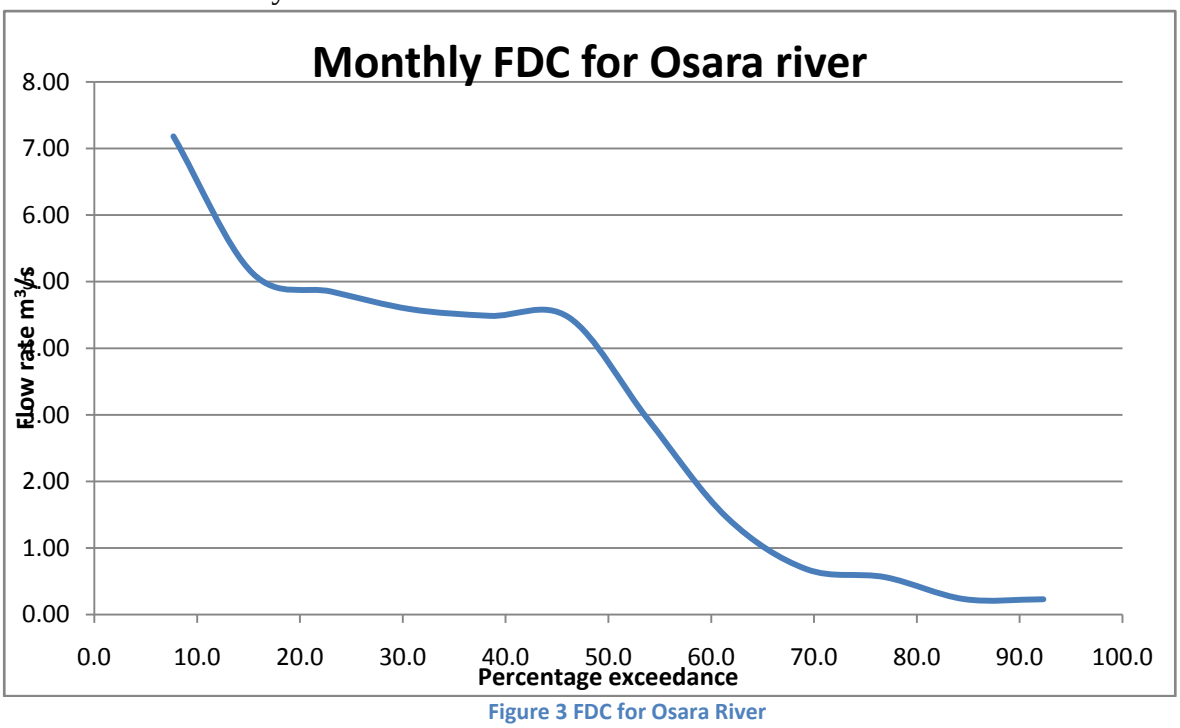


Figure 3 FDC for Osara River

5 GEO-TECHNICAL STUDIES

A detailed geo-technical study was not within the scope of this visit.

6 SUMMARY OF ENVIRONMENT AND SOCIAL IMPACT ASSESSMENT (ESIA)

6.1 Environmental Impacts

The proposed site already has a dam. No further damage to environment is possible.

6.2 Social Impacts

The available power is just sufficient for the iron and steel ore company's base loads. As such it is not possible to supply power to the nearby village communities. This could create some issues.

6.2.1 Local Dispute Resolution Procedure

6.3 Assessment of significance of environmental and social impacts

Being an existing dam site, 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.

7 PROJECT OPTIMIZATION

7.1 Estimation of Power and Energy Production

7.1.1 Plant capacity

The proposed capacity of the power plant is 300 kW. The available head, is 10m. The design flow is 4.5 m^3/s.

7.1.2 Plant factor

The plant factor 0.7 for this project will be quite high as the stream is perennial and the design flow is Q50.

7.1.2.1 Annual energy

The generation profile is given in the table below:

	Power kW	Energy kWh
Jan	150	111,600
Feb	100	67,200
Mar	100	74,400
Apr	100	72,000
May	250	186,000
Jun	300	216,000
Jul	250	186,000
Aug	200	148,800
Sep	300	216,000
Oct	300	223,200
Nov	300	216,000
Dec	150	111,600
Total		1,828,800
Installed capacity		2,628,000

The plant factor is 0.7

7.2 Cost Estimates

The total project cost is estimated to be 0.75 million USD. Approximate Break-up of costs are given below:

The electro-mechanical equipment cost is estimated to be 0.3 million USD and the total civil works cost is estimated to be 0.4 million USD.

8 PROJECT DESCRIPTION AND BASIC DESIGN

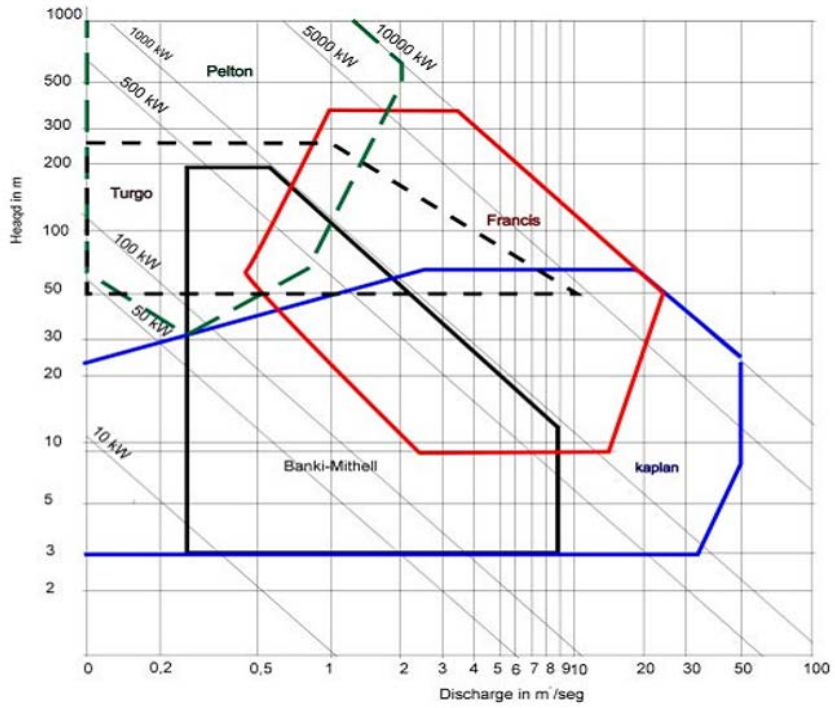
The project site has an existing small earth dam. The powerhouse location is at about 50m from the dam site. It will have a single unit turbine. The turbine will be of Kaplan type reaction turbine.

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

Existing pipe from the intake tower can be used as penstock after inspection and cleaning. It has a diameter of 1000mm.

Transmission line is already in place installed by the steel company to run the pump unit of the dam. There are actually two sets of lines – one as a back up. Unfortunately there was no back up for power requirement.

8.1 Turbine choice



The specific speed (metric) for this site lies between 550 to 1200. Kaplan (propeller) turbine is in this range.

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 total length of the transmission is 10 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 3operators will manage the power plant to monitor the proper functioning of components.

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.

11 CONCLUSIONS AND RECOMMENDATIONS

The following conclusions are made:

1. Osara hydro project is technically and financially feasible.
2. Installed capacity and energy: The installed capacity of the plant is 250 KW with a design discharge of 4.5 m^3/s and gross head of 8m. The gross energy production is 1.5 GWh
3. This project site is already licensed to the developer.
4. About 10 km long, 33 kV transmission line is already in place.
5. A construction period of 15 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.

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