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AN ASSESSMENT OF SMALL HYDRO POWER (SHP) POTENTIAL IN SOME RIVERS WITHIN BENIN-OWENA RIVER BASIN DEVELOPMENT AREA

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ABSTRACT

The need for rural transformation as well as the Ecological /environmental problems resulting from large hydro power stations from medium and large dams, nurtured the idea of renewable energy as viable option. This led to a stakeholder forum initiated and organized by the United Nation Industrial Development Organization (UNIDO) in collaboration with Energy Commission of Nigeria (ECN) held in Nigeria in 2002. The forum rekindle the necessity to exploit the hydro power potential of swift flowing streams, rivers and rivulets for small/mini/macro hydro power in the River Basin system in Nigeria as has been successfully implemented in some other countries of the world. This paper presents a broad view of the activities of UNIDO and ECN in promoting the general concept of Small Hydro-Power in Nigeria. It also emphasis on World Meteological Organization (WMO) for meteological information required for the study and design of SHP scheme. The technical and economic viability of the four on-going SHP schemes located in Okhunmwan River at Ugonoba community, (Edo State) Ogbonmwan River at Evboro II (Edo State), Owena River at Ogundele and Sokoto community, (Ondo State) and Oye River at Itapaji, (Ekiti State) were assessed. The four schemes were found to be viable and construction works have started on them. While the Owena and Oye projects had the Dam, reservoir and bottom outlet in place, the Ugonoba and Evboro do not have these which is additional cost to the schemes. However, the Federal Government is providing the hydraulic structures, a weir and other hydraulic structures in the case of Okhunmwan and UNIDO in the case of Ogbomwan. The status of the construction works in the four sites were also presented and assessed. The slow pace of

work on these projects has been attributed to the inadequate provision of fund to the federal government agencies handling the project by the federal government. It was concluded that feasibility studies and design be carried out on other potential River sites as these are abound. Execution of these projects could be on public/private partnership.

1.0 INTRODUCTION

The main Electricity supply in Nigeria has been by the Nigerian Electric Power Authority (NEPA), renamed Power Holding Company of Nigeria (PHCN) now unbundled to Generation, Transmission and various distribution companies. While the Generation and Transmission companies are still controlled by the Federal Government, the various distribution companies are owned and managed by private distribution companies. This energy sector has for long time been the only electric utility authorized to generate, transmit and distribute electricity all over the country. It has been generating electricity from HYDRO POWER stations on Rivers Niger and Kaduna (Kainji and Jebba and Shiroro hydro power stations respectively) since 1960s. These are very large hydropower stations with large and extensive hydraulic structures (dams, spillways, etc) and equally large and extensive reservoirs.

These large hydropower stations have over the years been associated with large scale ecological/environmental problems that re-occur annually. These problems have invariably led to agitations by the local inhabitants living along the banks of these rivers who are directly affected by the re-occurring flood menace. This has led to agitation by government officials (of Local Councils and States) of the affected areas, for establishment of a Hydro Power Producing Area Development Commission (HYPADEC). (Ajose, S.O. 2004).

The Nigerian Electricity Supply Company (NESCOM) is an electric power utility not well known to most electric consuming Nigerians. Established as a private electric utility company more than 75 years ago at Kurra Falls (in 1929) on the Jos Plateau, to serve mainly the electric energy needs of the mining industry (tin, columbite, etc) at that time, it is by definition a Small Hydro Power (SHP) generating facilities. It generates electric power from a total of eight power stations on Rivers Bagel, Kurra and Lere with a total installed capacity of about 33Mw. (Esan 2003).

Small Hydro Power (SHP) schemes are by definition (for Nigeria), electric power facilities with generating capacities less than 10Mv. However, this definition varies from one country to another and from one organization (international/multilateral) to another (Table 1a and 1b).

2.0 BACKGROUND OF THE STUDY

While most developed countries produce significant amount of electricity from large scale hydro power schemes, a country like China produces more than 19,000Mv of electricity from over 45,000 (SPH) schemes. These small hydropower schemes have the advantages of being independent of the National Electricity Grid network, hence can be operated locally. An SHP scheme supplies electricity for domestic water supply, irrigated agriculture and aquaculture with the supply of power to energize the pump. (Esan 2003).

Small hydropower potentials are enormous in Nigeria but mostly untapped. The identical total potential ranges between 3,500 and 4,414Mw (Table 2). A few other small hydropower schemes exist in Nigeria; the Oyan Dam and Ikere Gorge SHP plants (9.0Mw and 6.0Mw respectively) built by Ogun-Oshun River Basin Development Authority, the Bakolori Dam SHP plant (3.0Mw) built by Sokoto-Rima River Basin Development Authority (IMO, E.E.2020).

UNIDO in collaboration with the Energy Commission of Nigeria (ECN) and the Chinese Government has funded the development of two pilot SHP projects in Nigeria at Enugu and Bauchi in collobaration with Anambra-Imo and Upper Benue River Basin Development Authorities respectively. (Ohunakin, O.S et al 2011).

3.0 Programme Initiatives/SHP Development

In a United Nations “Economic Report on Africa 2000” only about 34% (mainly in the urban areas) households in Nigeria have access to constant electricity supply. This means that over 60% of the populations who live mainly in the rural areas do not have access to electricity, with the resulting under development and poverty leading to heavy migration to urban centers in search of better opportunities and greener pastures.

SHP Definition and Classification

Table 1a: Definitions of Small, Mini and Micro Hydro Plants.

S/N	COUNTRY	MICRO (KW)	MINI (KW)	SMALL (MW)
1	U.S	<100	100 – 1000	1 – 30
2	U.S	<100	100 – 1000	-
3	China		<500	0.5 – 25
4	USSR	<100	-	0.1 – 30
5	France	5-5000	-	-
6	India	<100	100 – 1000	1 – 15
7	Brazil	<100	100 – 1000	1 – 30
8	Various	<100	<1000	<10
9	*UNIDO	<100	101-2000	2 – 10
10	*IN-SHIP	<100	101-500	0.5 – 10

UNIDO: United Nation Industrial Development Organization

IN-SHIP: International Network for Small Hydro Power

Table 1b: Station capacity in kw.

	MICRO	MINI	SMALL
UNIDO	<100	101 – 2000	2000 – 10000
IN-SHIP	<100 (<0.1mw)	101 – 500 (0.1 – 0.5mw)	501 – 10000 (0.5 – 10mw)
ESHA			10000
OLADE	<50		501 – 5000
CHINA	<100	100 – 500	501 – 25000

Source: Guide Book on Small Hydro Power Development in Nigeria, 2004.

Table 2: Identified SHP Potentials in River Basin Systems in Nigeria.

			Numbers		
S/N	River basin	Viable river	Existing dams	River sties	Total theoretical power (mw)
1	Sokoto Rima RBDA	9	14	54	1004.0
2	Hadeija-Jama' are	5	24	36	149.0
3	Chad	8	15	25	89.0
4	Niger (Upper and Lower)	24	12	54	650.0
5	Upper Benue	26	13	74	985.0
6	Lower Benue	13	12	34	560.0
7	Cross River	11	N/A	38	350.0
8	Anambra-Imo	14	2	34	120.0
9	Benin-Owena	13	2	36	320.0
10	Ogun-Oshun	14	10	24	187.0
11	Niger Delta	N/A	N/A	N/A	

N/A: Not Available.

Source: Guide Book on Small Hydro Power Development in Nigeria 2004.

In order to ameliorate the above stated problems, the issues of easy access to sustainable energy supply has become crucial to accelerated development. The employment of a strategy to provide access to sustainable energy to rural populations using energy resources that are locally available has become imperative.

It was on this basis that the United Nations Industrial Development Organization (UNIDO) and the Energy Commission of Nigeria (ECN) organized a stakeholder's forum on Renewable Energy for Rural Industrialization in November, 2002, in collaboration with the Federal Ministries of Power and Steel, Industry, Environment, Water Resources, Science and Technology and Agriculture and Rural Development. The forum's communiqué contained some major recommendations, among which are:

1. To promote renewable energy resources especially those resources that are locally available such as small and micro hydro potentials of swift flowing streams, rivers and rivulets.
2. To undertake (i) above using the existing facilities of the River Basin Development Authorities (manpower and infrastructures)
3. To undertake a comprehensive training programme for relevant staff of those Authorities and other agencies, locally and abroad. (Basir, D. 2004).

The above major recommendations led to the signing of the memorandum of understanding (MOU) between UNIDO's International Centre for Small Hydro Power (IC SHP) based in Hangzhou, China and ECN for cooperation in tapping small/mini/micro hydro power potentials through technical assistance, training and demonstrations (pilot) projects. Thereafter, UNIDO in Nigeria and ECN undertook reconnaissance visits to the operational areas of five River Basin Development Authorities to identify prospective pilot project sites. Two favorable sites in Enugu and Bauchi states within the operational areas of Anambra Imo and Upper Benue River Basin Development Authorities were recommended for further investigations and technical feasibility studies by a team from IC SHP, Hangzhou, China. Two other SHP activities (refurbishment) were later included with the two initial pilot projects to be undertaken under the MOU for technical assistance. The two refurbishment projects are for the complete overhauling of the electro mechanical components of the small hydropower (SHP) schemes at Oyan and Bakolori dams in Ogun Oshun and Sokoto-Rima River Basin Development Authorities respectively.

In implementing the training component of the MOU, UNIDO's office in Nigeria and ECN has so far organized the following capacity building workshops:

1. Training of trainers Workshop on small Hydro Power Development (May, 2003), Owerri, Nigeria.
2. Financing Sensitization forum for stakeholders of projects in the 1st phase of SHP Programme (July, 2003), Abuja, Nigeria.
3. Information dissemination on Possible window for financing of Small Hydro Power (SHP) projects in Nigeria (September, 2003). Abuja, Nigeria.
4. Sustainable Delivery of Small Hydro Power (SHP) in Rural Areas of Nigeria. Policy issues (November, 2003). Abuja, Nigeria.
5. Project Appraisal Seminar for SHP Trainers (November, 2003). Abuja, Nigeria.
6. Capacity Building in Small Hydro Power (SHP) for the Provision of Rural Energy (May, 2004 and 2005). Bauchi and Abeokuta. Nigeria respectively.

Participants were from Stakeholders Ministries and Organizations such as the River Basin Development Authorities, Federal Ministries of Agriculture and Rural Development. Water resources, science and Technology, Power and steel and the energy research centers in Nigeria.

At the close of the trainers workshop at owerri in May, 2003 all participating River Basin Development Authorities and other agencies were directed to go back and form technical teams in their respective establishments and undertake reconnaissance surveys to Identify potentials small/mini/micro hydro sites, collect all available/relevant data, maps and other necessary information and thereafter prepare viable project proposals for these sites. This directive led to the formation of a Technical Team in Benin Owena River Basin Development Authority (BORBDA) which undertook the necessary surveys and came up with four viable projects proposal, namely:

1. Okhunwan River Small Hydro Power Projects, to be located at Ugonoba community on the Benin Agbor/Asaba Highway, about 25km from Benin City, Edo State.
2. Evboro II Small Hydro Power Project to be located on River Ogbonwan in Ovboro II Village Ovia North East Local Government Area, Edo State.
3. Owena River Small Hydro Power Project to be located between Ogundele and Sokoto Villages in Ondo State.
4. Oye River Small Hydro Power Project located within the vicinity of Itapaji in Ekiti State.

These four proposals were certified for implementation by the International Centre for Small Hydro Power (IC SHP) Hangzhou, china and UNDO.

4.0 WMO Initiatives

Benin-Owena River Basin Development Authority established a hydrological network monitoring programme in 1980 with assistance from the World Meteorological Organization (WMO). It consisted initially of 24 hydrological stations and six meteorological observatories within the geographical boundaries of Edo, Delta, Ondo and Ekiti States (see Fig. 1). Since 1992, additional hydro stations and observatories have been established and as at date, the total stands at 27 and 8 respectively.

5.0 STUDY AREA

The study area is the Benin-Owena River Basin catchment area. The catchment area lies between longitude $5^o01'$ and $54^o5'$ east and latitude $7^o17'$ and $8^o15'$. The basin area is $51.40km^2$ and covers four states; Edo, Ekiti, Ondo and Northern senatorial district of Delta State (River Basin Decree 35).

The major rivers in the basin are Benin River and Owena River and drain into the two main rivers are many other tributaries (River Basin Decree 1987).

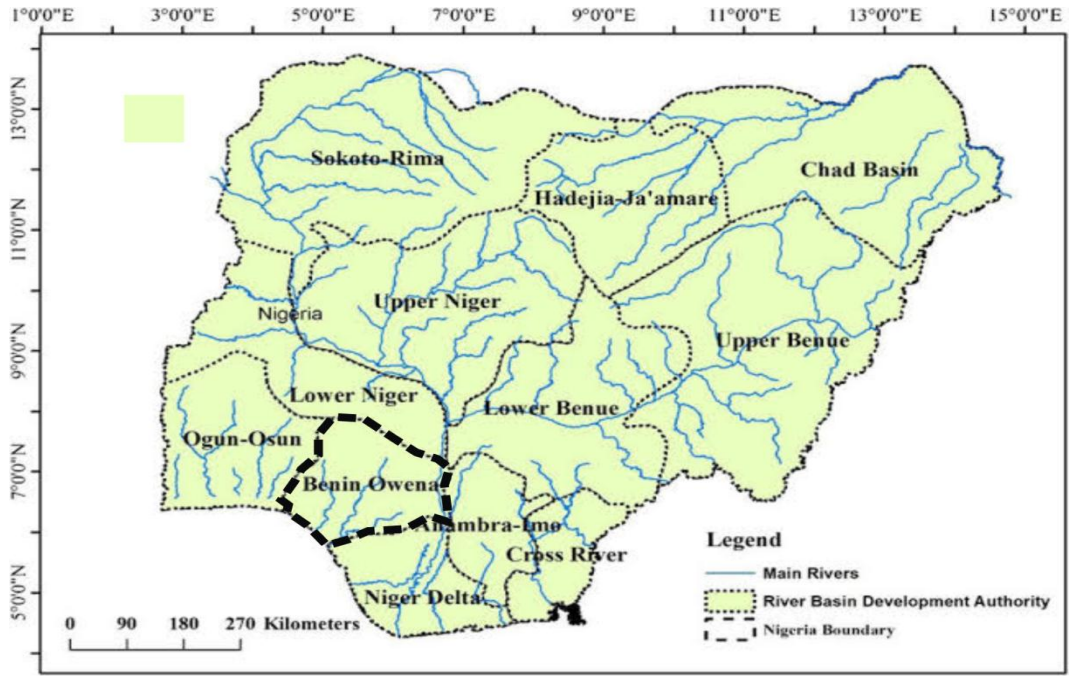

Figure 1: Map of River Basins, some Rivers with the study area-Benin-Owena River Basin Development Authority Catchment.

6.0 Evaluation/Consideration

The technical evaluation of potential sites for small Hydro Power (SHP) developments took cognizance of the availability of data and the reliability of such data from the hydro gauging stations and observatories. A large percentage of all the rivers and streams were subjected to both base line studies and field investigations while priority attention was paid to those rivers and streams where reliable data are already available continuously and properly being collected. Other important elements included the presence of hydraulic structures such as dams, weirs, etc. the ruggedness of the terrain (sleep slopes, hills, etc). the availability of space for construction of power houses and other civil structures with priority given to rural communities. The availability of relevant information, materials such as topographic maps (scale 1:50.000). Aerial photographs, geologic maps, etc. were of valuable importance during the study and location of the sites.

7.0 Edo State Okhunwan River

Benin Owena River Basin Development Authority (BORBDA) operates 14 hydro-gauging stations and 3 meteorological observatories in Edo State, among which are the two dams operated by the state urban water board - (Ikpoba and Ojirami) and three weirs (Ogba, Iyagun and ugbalo) for water supply. Two hydro-gauging stations exist downstream of the two dams, on Ikpoba river within Benin city, an Urban Centre and Onyami river, near Imafun, about 25km downstream. Because of Urban Nature of Benin City and distance of the gauging station on Onyami River from Ojirami dam, those two rivers were disqualified from further consideration. Rather, Okhunwan River that flows across the Benin Agbor/Asaba highway at Km 25, close to a cluster of rural communities (Ugonoba, Ugoneki, Aduhananhan, Ugomosom, Okhuaihe etc) and Ogbonmwn River near Evboro II which flows through Evboro I and II were found to be adequate for Small Hydro-Power (SHP) projects even on any section of the rivers. The pre-feasibility study of the two projects shows the following salient feature described below.

7.1 Technical Viability-Okhuwan River

With the catchment area of 245.35km^3 the river has an average normal (discharge) flow rate of 8.33m^3/sec and a reservoir capacity balance of 0.415 x 10^{9}m^3 (Tables 3a, 3b) available for hydro power generation annually.

7.2 Ogbomwan River

With a catchment area of 234.42km^2, average discharge of 7.99 and reservoir capacity of 0.276x 10^9m^3 (Table 3a,3b).

Table 3 A: Hydraulic Parameters (Discharges).

S/N	YEAR	Okhuanwan River Discharges (m^3/sec)			Ogohnwan River Discharges (m^3/sec)			Owena River Discharges (m^3/sec)		
		Maximum	Mean	Minimum	Maximum	Mean	Minimum	Maximum	Mean	Minimum
1	2010	7.85	7.20	4.36	6.70	6.20	5.70	11.56	6.86	4.37
2	2011	7.95	5.88	4.51	6.85	6.42	5.98	4.49	3.12	1.64
3	2012	9.95	7.35	5.95	8.71	7.60	6.50	21.89	13.10	6.51
4	2013	11.54	9.63	7.09	9.75	7.61	7.65	15.27	9.34	4.30
5	2014	10.11	8.28	7.16	9.30	8.82	8.35	19.98	7.35	3,53
6	2015	14.10	11.63	9.16	10.18	9.97	9.76	11.83	6.52	2.67
7	2016	-	17.99	9.87	9.86	9.33	8.87	17.65	10.38	4.66
8	2017	-	-	-	-	-	-	22.10	12.56	5.35
9	2018	-	-	-	-	-	-	8.44	5.47	3.02
10	2019	-	-	-	-	-	-	11.62	7.03	2.53
Average Annual Discharge Values		10.83	8.85	6.87	8.69	7.99	7.54	14.48	8.17	3.86

Source: Hydrological! Year Book Vol. 1-4 (Benin-Owena River Basin Development Authority).

Table 3 B: Hydraulic parameters (Run-off).

		TOTAL RUN-OFF VOLUME (10^9 M^3)		
S/N	Year	Okhunnwan River	Ogbonmwan river	Owenan river
1	2010	0.186	0.161	-
2	2011	0.231	0.111	-
3	2012	0.557	0.351	0.410
4	2013	0.262	0.139	0.295
5	2014	0.374	0.240	-
6	2015	0.878	0.656	0.206
7	2016			0.328
8	2017			0.396
9	2018			0.173
10.	2019			0.222
Average Yearly Total Run-Off		0.417	0.276	0.290

Source: Hydrological Year Book Vol. 1-4 (Benin-Owena River Basin Development Authority).

Provision of a small earth dam of 12m height with 1.5m freeboard across the river, the hydro power potentials is estimated using the basic equation:

P_{II}=f(q,h) =9.81 qh $^{n}t^{n}$ G F……..……(I)

Where P_{II}=hydropower output (in Kw or Mw)

q=discharge (flow rate) in m^3/sec

h=effective head (in meters)

^{n}t= turbine efficiency

"G =generator efficiency

F=Load factor (=Design Dependent. 0.75 is assumed for humid tropic areas with relatively high-flow).

7.3 Okhunwan River

The hydro power potential is tentatively estimated as:

P_u = 0.75x9.81 x 8.85m^3/s x10.5m =0.68mw

= 684kw

7.3.1 Economic Viability

Capacity of hydro-power scheme	:	0.68Mw
Operating Time	:	24hours
Energy to be produced	:	0.68x24x365x10^3 Gwh yr=5.96 Gwh/
Expected Net production	:	90% of 5.96Gwh/hr=5.36Gwh/yr
Tariff	:	N12.25/Kwh shall be assumed
Revenue: Cost of Energy to be	:	5.36Gwh/yr x10^6xN12.25/Kwh per annum.
Produced from this scheme	:	₦65, 660, 00.00 P.A

7.3.2 Financial Analysis

For a project investment to be economically viable, the Accounting Rate of Return (A.R.R) must exceed 10%. In this project, the A.R.R is 17% which means that by all financial indices, it is economically not viable. This is due to the non-availability of any hydraulic structure on the river system. The cost of emplacing hydraulic structure such as the dam and in-take structure and other necessary ancillary facilities. This is being carried out by the federal Government through the Benin-Owena River Basin development Authority.

7.4 Ogbomwan River

Pu = 0.75 x 9.81 x 7.99$m^3/_s$ x 10n

= 0.62 m_w

7.4.1 Economic Viability

Capacity of hydro-power scheme = $0.62m_w$

Operating Time = 24 hours

Energy to be Produced = $0.62 \times 24 \times 365 \times 10^3$Gwh/yr = 5.43Gwh/yr

Expected Net Production = 90% of 5.43 = 4.9Gwh/yr

Revenue: Cost of Energy to be

Produced from this scheme = 12.25Kwh shall be assumed

Revenue = $12.25 \times 4.90 \times 10^6$ Kh/yr

= ₦60,000,000.00

7.4.2 Financial Analysis

For a project investment to be economically viable, the accounting Rate of Return (A.R.R) must not exceed 10%. In this project, the A.R.R is 16.7% which means that by all financial indices, it is economically not viable. This is due to non-availability of any hydraulic structure on the river system. The cost of emplacing hydraulic structures such as dam or weir and in-take structure and other necessary ancillary facilities. In this case these facilities are being put in place by the UNIDO regional office in Nigeria.

Table 4: Technical/Finacial Evaluation.

TECHNICAL						FINANCIAL			
S/N	**River**	**Averge annual dischaege (mc^3/sec)**	**Instaled shp capacity (mw)**	**Energy producation (gwh^0/yr)**	**Expected net production (90%) (gwh/yr)**	**Cost of energy prods per annum**	**Estimate cost of project (₦)**	**Return on investment (years)**	**Accounting rate of return (%)**
1	Okhuanwan	8.83	0.68	5.98	5.34	65,660,00	386,400,000	6	17
2	Ogbonmwan	7.99	0.62	5.43	4.90	60,000,000	358,590,000	6	16.7
3	Owena	3.42	0.55	4.82	4.34	53,165,000	478,500,000,00	9	11.1
4	Oye	2.0	0.31	2.72	2.44	30,500,000,00	448,820,000,00	15	6.8

Source: pre-Feasibility Studies for Small Hydro power Project (Benin-Owena River Basin Development Authority, 2006).

The total project cost of this SHP scheme, is estimated at ₦386,000.00 (Table 4). With a net energy production of 5.36 Gwh/yr and the realizable income of ₦65,660,000.00 per annum, the return on the financial investment on this project will take a period of almost 6years (Table 4). This is likely to scare most investors' except those with government backing. Government must therefore come up with such incentives as tax exemption for a number of years and favourable tariffs must be allowed for first few years of operation.

7.5 Oye Dam Itapaji Shp-Ekiti State

The hydro-gauging station on Oye River at Itapaji is one of the foremost, built in 1980, under the WMO assisted Network. Monitoring programmer, downstream of Ele dam. This water scheme is operated by the state water Corporation as a water supply scheme, supplying treated water to thirteen communities 2003. A new hydro-gauging station was installed on the same River Oye up-stream before the dam.

7.5.1 Technical Viability-Oye River

Oye dam water supply scheme was commissioned in1980. The hydraulic structures include a rolled earth and concrete dam of 400m length and height of 24m, a concrete spillway of 120m (length) and an intake sump. PHCN's facilities are on ground at the Head works at Itapaji and neighboring communities but they has been no electricity supply since the construction of these facilities. An average normal flow (discharge) for the dam is 8.33m3/sec and a reservoir capacity balance of 0.192×10^9 m^3. Available for hydro power generation per year with a discharge of $2m^3/_s$ through the tail race=0.75 x 9810 x $2.0m^3$/5 x 21m= 0.31Mw.

Economic Viability

Capacity of hydro power scheme	:	0.31Mw
Operating Time	:	24hours
Energy to be produced	:	03.1x 24x 365x 10^{-3} Gwh/yr
		2.72Gwh/yr
Expected Net production	:	90% of 2.72Gwh/yr
	=	2.44Gwh/yr
Tariff	:	₦12.25/Kwh shall be assumed
Cost of energy to be produced	:	2.44Gwh/yrx10^6x₦12.25/Kwh
From this scheme	=	N30,500,000.00 per annum

7.5.2 Financial Analysis

The Accounting Rate of Return for this project is 6.8% (Table 4). The SHP project is therefore viable and can further be investigated by any interested investor. With an estimated cost of project totaling ₦448,820.00 (Table 4) for a 0.3/Mw SHP capacity, it is expected that the net energy production of 2.44Gwh/yr will be sold to realize the sum of ₦30,500,000.00 per annum (Table 4) therefore it is also estimated that the financial investment for the

construction of the SHP plant will be fully paid back in about 15 years-time inclusive of all financial changes (interest rates and taxes) and the cost of scheme.

7.6 Owena Dam-Ondo State

Except for the low-lying reverine areas in the south, most of the rivers and streams flow through terrains that are adequate for small Hydro power (SHP) development.

A total of seven hydro-gauging station and two meteorological observatories are operated and monitored by BORBDA in this state. These include two hydro-gauging stations on Owena River along Akure ondo and Akure-llesha Road and one meteorological observatory at the Owena Multipurpose Dam site. All these hydraulic structures make the sites of these water supply scheme potential sites for Small Hydro power (SHP) project. Construction materials (sand, granitite and gravel stones) are abundant and easily accessible.

Human settlements are dense and close to one another, making the connection of load centers easy and cheap for localizes grid network.

The features described above, combined with the presence of the new Owena multi-purpose dam already in place, were responsible for the two neighboring communities of Ogundele and Sokoto being chosen as load centers for the Small Hydro-power (SHP) scheme on Owena River.

7.6.1 Technical Viability

Owena Multi-purpose dam was completed in 2006.It is an earth dam structure spanning a length of 1.34km and a height of 21.844m less the freeboard. About 20km down-stream of this dam is the old Owena waterworks, along Akure Ondo Road. The new dam has been so designed to release water continuously, 24 hours a day, downstream, part of which is to serve the old waterworks through the in-take tower already in place. The total normal flow (discharge) rate is 8.17m^3/sec and a reservoir capacity balance of 0.232 x $10^9 m^3$/s. The discharge available for SHP through the bottom outlet is 3.42$m^3/_s$.

Considering the above: 0.75 x 9810 x 3.42 $m^3/_s$ x 21.844

= 550kw

= 0.550Mw

7.6.2 Economic Viability

Capacity of hydro-power scheme	:	0.550
Operating Time	:	24hours
Energy to be produced	:	$0.55x24x365xGwh/yr10^{-3}$
	:	4.82 Gwh/yr
Expected Net production	:	90% of 4.82 Gwh/yr
	=	4.34 Gwh/yr
Tariff		₦12.25/Kwh shall be assumed for this scheme
Cost of Energy to be produced	:	Gwh/yr x 10^6
x		₦ 12.25/Kwh
From this scheme annum	=	per 53,165,000 per annum

7.6.3 Financial Analysis

The Accounting Rate of Return (A.R.R) for this SHP projects is estimated at 11.2% it is viable and can further be investigated by any interested investor.

The estimated cost of the project is ₦478,500,000.00 exclusive of the dam and in-take structures which have been built by Benin-Owena River Basin Development Authority through direct Federal Government funding. About ₦53.165million will be realized per annum from the sale of a net energy production of 4.34Gwh/yr with a tariff of ₦12.25/Kmh. The return of investment will be realizable within a period of 9years, which is feasible with medium-term financing facilities.

8.0 Obseration

The following considerations would be relevant in decision making.

1. There are no hydraulic structures on ground within the Okhunwan and ogbomwan rivers system
2. The minimum life expectancy of any SHP scheme is 25years.
3. The feasibilities studies undertaken for this four project indicate attractive economic viability for serious investors, indigenous or foreign.
4. The returns on investment are quite encouraging.

With minimum life expectancy of 25 years for SHP schemes. It is encouraging to note a recovery period of 7 and 11 years for Oye and Owena rivers SHP schemes respectively while

the 17 years required for Okhunmwan and Ogbonmwan River SHP scheme is understandable. This can be adduced to the additional cost required for the civil works.

9.0 Benefit of SHP

Small Hydro Power (SHP) schemes make use of renewable, indigenous and already available natural resources, water, which is a renewable resource not subjected to market forces, like oil and gas for instance.

Multi-purpose reservoir SHP projects, unlike the run-of-river schemes can help to finance multi-purpose benefits such as:

- Irrigation for food supply
- Domestic and industrial water supply
- Flood production
- Discharge regulation downstream for irrigation improvement.

SHP scheme can represent energy independence for many local communities (rural and semi-urban), hence it can be locally owned since the cost of construction is not beyond the means of cooperatives. Local government Authorities and State.

10.0 On-Going SHP Projects

10.1 Okhunmwon River Shp (10.1)

Date of award of contract	-	2011
Contractor/designer	-	Detec Nig Ltd
Revised Contract son	-	₦386,400,000.00

Scope of work/percentage completion as at May 2022

1.	Clear site	-	100%
2.	Diversion work	-	100%
3.	Construction of retaining wall	-	80%
4.	Construction of weir	-	80%
5.	Construction of forebay	-	40%
6.	Construction of penstock	-	0%
7.	Supply and installation of turbine	-	0%
8.	Electrification of the communities	-	0%
	Overall % completion	-	40%

10.2 Ogbonmwon River SHP

Date of award of contract Sept 2008

Contract/Designer: AQUA-ALPHA DRILLING NIG LTD

Revised Contract sum - ₦258,590,000.00

Scope of work/percentage completion as at May 2022

1.	Clear site	-	100%
2.	Construction of diversion work	-	100%
3.	Construction weir	-	60%
4.	Construction of intake structure/wing walls	-	0%
5.	Construction of conveyance systems	-	0%
6.	Construction of forebay	-	0%
7.	Construction of power house	-	0%
8.	Construction of tail race	-	0%
9.	Installation of turbine	-	0%
10.	Electrification of the community	-	0%
	Overall of completion	-	40%

10.3 Owena Dam SHP

Date of award of contract - 2012

Revised contract sum - ₦478,500,000.00

Scope of work/percentage completion

1.	Clear site	-	100%
2.	Construction of Site office	-	100%
3.	Construction of the penstock	-	0%
4.	Construction of the tail race	-	0%
5.	Construction of the power house	-	0%
6.	Supply and installation of turbine	-	0%
	Overall % completion	-	5%

The funding for the project from the onset was wholly from the Federal Government through the Benin-Owena River Basin Development Authority budgetary provision. The arrangement has over the years suffering some setback. The new arrangement is for the completion of the project through private partnership (PPP).

10.4 Oye Dam SHP

Date of award	-	2009
Revised contract sum	-	₦448, 820,000.00

Scope of work/percentage completion

1. Clear site	-	100%
2. Construction of penstock	-	100%
3. Supply of turbine	-	100%
4. Construction of civil works for the turbine	-	0%
5. Construction of tail race	-	0%
Power house (Available)		
Overall % completion	-	50%

11.0 CONCLUSION

1. From the assessment undertaken so far the four ongoing small Hydro-power projects in the Benin-Owen River Basin Development Authority (BORBDA) catchment area indicate they are viable economically sand financially.
2. Owena and Oye River SHP schemes have the hydraulic structure such as the Dam spillway and bottom outlet from where the construction of the SHP schemes are on-going.
3. The Okhunmwan and Ogbomwan River SHP schemes hydraulic structure are the weir, conveyance structure, forebay etc. The construction of the structures are at various stages of completion as indicated in the project status.
4. The slow pace of the construction works on these projects is due to inadequate release of fund by the Federal Government through the Benin Owena River Basin Development Authority **(BORBDA)** budgetary provision. However the Owena River SHP has migrated to public – private partnership (PPP).
5. The SHP schemes when completed will have multiplier effects on the rate of development of the Local Communities. It will also stimulate agro-allied industries as commercial activities since constant electricity supply will be assured.
6. The scheme when complete will facilitate rapid development of the rural area and curb rural-urban migration as cottage industries that will create employment will eventually come on stream.

7. There exist various streams and rivers in the catchment area that can be developed into SHP scheme for the benefit of rural communities and investment by Local, State Government, corporate entities and individual.

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