# ECONOMIC VIABILITY OF A SMALL HYDROPOWER PLANT AT ONUAKU RIVER, ABIA STATE NIGERIA

**BY**

**CHINYERE OBINNA AJALA**

**MSC/ENG/8665/2011-2012**

**APRIL, 2014**

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**A PROJECT SUBMITTED TO THE SCHOOL OF POSTGRADUATE STUDIES,
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DEPARTMENT OF MECHANICAL ENGINEERING,
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AHMADU BELLO UNIVERSITY, ZARIA**

**APRIL, 2014**

## DECLARATION

I hereby declare that this Project titled "**Economic viability of Small Hydro Power Plant at Onuaku River, AbiaState Nigeria"** was written by me in the Department of Mechanical Engineering under the supervision of Dr. D.S. Yawas and Dr. F.O Anafi. The information derived from the literature has been duly acknowledged in the text and in the form of references provided. No part of this work has been produced for another degree or diploma at any institution.

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| --- | --- | --- |
| Name of Student | Signature | Date |

## CERTIFICATION

This project titled; "**Economic viability of Small hydropower Plant at Onuaku River, Abia State Nigeria"** meets the regulations governing the award of the degree of Masters in Engineering Management (MEM) of Ahmadu Bello University, and is approved for its contribution to knowledge.

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## DEDICATION

This work is dedicated to the Lord Almighty and to my beloved parents Mr. and Mrs. S.N Chinyere

## ACKNOWLEDGEMENTS

This Project was successfully completed with the help, cooperation and contributions of a number of people.

I wish to express my gratitude to Dr. D.S. Yawas and Dr. F.O Anafi, the project supervisors, whose invaluable assistance, corrections and frank suggestions made the completion of this work possible.

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Finally and above all, I thank Almighty God for His protection and guidance throughout the period of my course.

## ABSTRACT

In this study the financial and economic feasibility of OnuakuRiver in Aku community of Abia state was evaluated using indicators like the Net Present value (NPV), Payback Period, Benefit cost ratio (BCR) and Internal Rate of Return (IRR) to ascertain the feasibility and viability of the project. Here the breakeven point of the project, profit, cash flow, present and future value of project as well as the expected yearly revenue of the project is shown in advance within the economic life or span of the project. Furthermore a sensitivity analysis to show the responds of the project to both variation in investment cost and the price of electricity, was also carried out using a Microsoft excel based platform to carry out the computations.With an investment cost of less than ₦12million, a net present value of three million six hundred and thirty thousand, fifty seven naira fifty eight kobo,(₦3,630,057.58) was gotten at the 30 years life span of the project with an internal rate of return of 14.25%. Also from the analysis a project payback period of ten years which is timely enough for the client or investor to recover the investment made on a project that can span up to thirty years (minimum) - fifty years (maximum). The benefit cost ratio of the project from analysis is **1.23** which is above unity. Furthermore, sensitivity of the project to variations in investment cost showed that the project is sensitive to variation in the investment cost, as a 30% increase in investment cost throws the project into a negative NPV, and an IRR less than the hurdle rate of 12%. The sensitivity to the variation in the price of electricity shows how the project responds to reduction in electricity price, as a reduction by 20% in electricity price, throws the project into a negative net present value making the project not viable at 20% reduction in electricity price. Hence the results from the analysis above have provided additional information for the decision makers, client and the design engineer to see reasons why this project should be embarked on.

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# LIST OF ABBREVIATION

BCR- Benefit Cost Ratio

CDM- Clean Development Mechanism

ESHA- European Small Hydropower Association

ECN- Energy Commission of Nigeria

ESPR- Electric Power Sector Reform

GHG- Green House Gas

IRR- Internal Rate of Return

IEA- Intentional Energy Association

kW- Kilowatt

MW- Megawatts

NPV- Net Present Value

NASENI- National Agency for Science and Engineering Infrastructure

NEPR- National Electric Power Reforms

NERC- Nigerian Electrify Regulatory Commission

NESI – Nigerian ElectricitySupply Industry

PBP- Payback Period

RetScreen- Renewable Energy technology Screen

REMP- Renewable Energy Master Plan

REA- Rural Electrification Agency

Ref- Rural Electrification fund

RETF- Renewable Energy Technology Fund

ROI-Return on Investment

SHP- Small Hydro Power

UNDP- United Nations Development Programme

# CHAPTER ONE

## INTRODUCTION

### 1.1 Background of the Study

All living things depend on energy for survival, and modern civilizations will continue to thrive only if existing sources of energy can be developed to meet the growing demands, hence Energy is ***"Life"*** Energy is ***"Existence",*** it is the dividing line between the rich and the poor, between the developed, developing and the underdeveloped (Ohunakins et al., 2011). For a country to grow beyond its subsistence economy, tackle the problem of poverty, the country will need to have minimum access to energy services for the larger proportion of its population (Ohunakins et al., 2011). However, in Nigeria energy supply has been epileptic in nature, causing the socio-economic status of the country to be downgraded (Ohunakins et al., 2011).

Nigeria's energy demand increases with an increase in population, but power supply has remained unreliable and insufficient with a country generation capacity of about 3500 MW as at 2011 (Okeke, 2011). Nigeria as a nation has started feeling the impact of adverse climate change, that may be attributed to the overdependence on fossil fuel fired power plants which is the main source of greenhouse gas emissions (GHG), coupled with activities of manufacturing industries, oil prospecting firms and deforestation, to mention but a few.

Renewable energy (RE) has been identified as the only alternative of addressing these problems. RE is energy derived from an energy source that can generate itself through natural processes within a relatively short period; unlike fossil type resources that take millions of years to form and which is not regenerative. Examples of such energy sources include: Hydropower, wind, solar, tidal, biomass, wave, ocean thermal and

geothermal (RETscreen, 2012). Hydropower amongst other renewable sources mentioned offers a clean and sustainable source for rural power, 24hours a day and even all through the year, provided there is water to power the turbines, causing little or no emissions to the ecosystem (RETScreen, 2005).

Inspite of abundance water resources that abound in all states and local government areas in Nigeria, hydropower remains an underutilized resources for electric power generation in Nigeria.

### 1.1.1 Hydropower

Hydropower is the power generated by using the potential energy stored in flowing water. It is a renewable energy source suitable for rural electrification in developing countries like ours. It is a proven technology that can be connected to the main grid, used as a stand- alone/ off-grid mode. When integrated with irrigation systems and community water supply scheme, the cost sharing effect reduces the cost of electricity production. Hydro power plants are robust and long lasting, easier to install and manage (compared to large hydro power installations) and may not require high investments in transmission lines, when connected in off-grid/decentralized modes, since end users are quite close to the source of generation. In China, the use of small scale hydropower to achieve rural electrification, started in the 1950s, with a strong lead from the government; presently, there are over 600 counties (accounting for 30% of all china counties) that rely mainly on small scale hydropower for electricity,serving over 300 million people (NASENI, 2010).

To overcome the increasing demand for electricity, new energy facilities are under construction all around the world. Fossil fuel fired power plants are the main source of greenhouse gas emissions which increase the threat of climate change. The countries all

around the world are trying to supply their increasing demands for electricity with clean energy technologies. Hydropower as sustainable and renewable resource is one of the major sources of power, which the country looks forward to in the nearby future, though a significant portion of the economically viable hydropower potential of Nigeria has not been harnessed, thus very few hydropower plants are under construction and in program to harness this economically viable potential (NASENI,2010).

### 1.1.2 Small hydro project development

The development of small hydro power (SHP) projects typically takes from 1 to 5 years to complete, from conception to final commissioning (ESHA, 1998). This time is required to undertake studies and design work, to receive the necessary approvals and to construct the project. Once constructed, small hydro plants require little maintenance over their useful life, which can be well over 50 years (ESHA, 1998). Normally, one part-time operator can easily handle operation and routine maintenance of a small hydro plant, with periodic maintenance of the largercomponents of a plant usually requiring help from outside contractors.The technical and financial viability of each potential small hydro project are very site specific. Power output dependson the available water (flow) and head(drop in elevation). The amount of energy that can be generated depends on the quantity of water available and the variability of flow throughout the year. The economics of a site depends on the power (capacity) and the energy that a project can produce, whether or not theenergy can be sold, and the price paid for the energy. In an isolated area (off-grid and isolated-grid applications) the value of energy generated for consumption is generally significantly more than for systems that are connected to a central-grid. However, isolated areas may not be able to use all the available energy from the small hydro plant and, may be unable to use the energy when it is available because of seasonal variations in water flow and energy consumption. A conservative,

"rule-of-thumb" relationship is that power for a hydro project is equal to seven times the product of the flow (Q) and gross head (H) at the site (P = 7QH)(RetScreen, 2012). Producing 1 kW of power at a site with 100 m of head will require one-tenth the flow of water that a site with 10 m of head would require. The hydro turbine size depends primarily on the flow of water it has to accommodate. Thus, the generating equipment for higher-head, lower-flow installations is generally less expensive than for lower-head, higher-flow plants. The same cannot necessarily be said for the civil works components of a project which arerelated much more to the local topography and physical nature of a site.

### 1.1.3 Types of small hydro developments

Small hydro projects can generally be categorized as either "run-of-river developments" or"water storage (reservoir) developments," which are described in more detail below.

**a) Run-of-river developments**

"Run-of-river" refers to a mode of operation, in which the hydro plant uses only the water that is available in the natural flow of the river (ESHA, 1998), "Run-of-river" implies that there is no water storage and that power fluctuates withthe stream flow. The power output of run-of-river small hydro plants fluctuates with the hydrologic cycle, so they are often best suited to provide energy to a larger electricity system. Individually, they do not generally provide much firm capacity. Therefore, isolated areas that use small hydro resources often require supplemental power. A run-of-river plant can only supply all of the electrical needs of an isolated area or industry if the minimum flow in the river is sufficient to meet the load's peak power requirements (RETscreen, 2012).

Run-of-river small hydro can involve diversion of the flow in a river. Diversion is often required to take advantage of the drop in elevation that occurs over a distance in the river. Diversion projects reduce the flow in the river between the intake and the powerhouse. A diversion weir or small dam is usually required to divert the flow into the intake, as shown in figure 2.1.

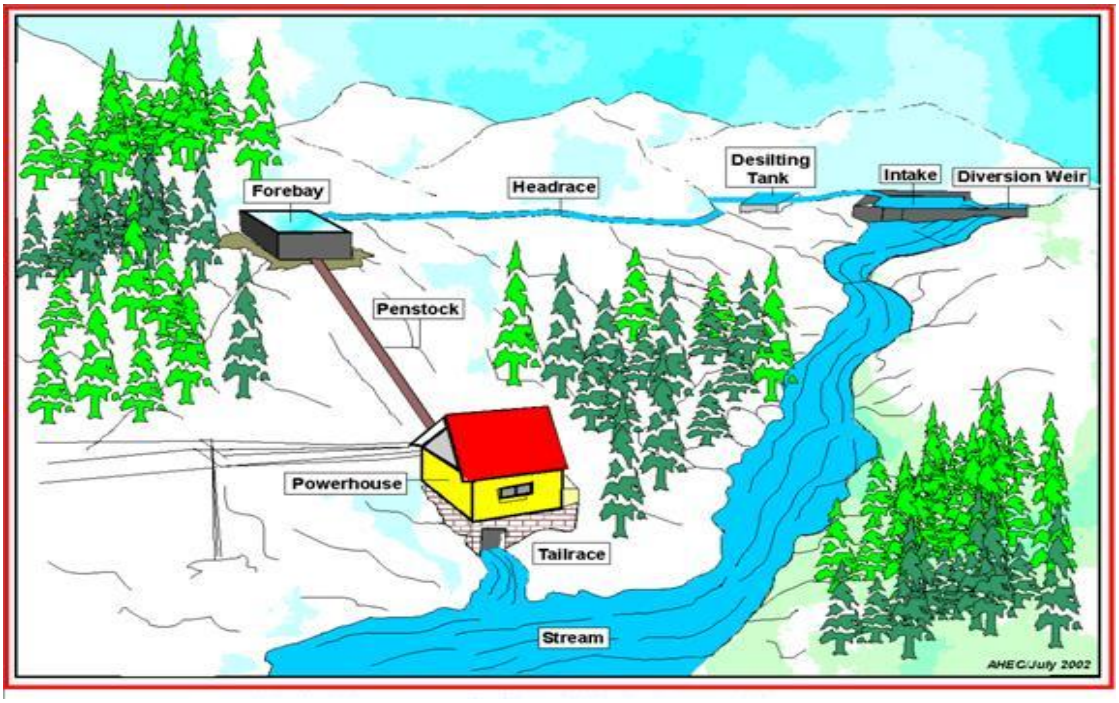



Figure 2.1Typical Arrangement of a Run-off - scheme Small Hydro Power Station (Source: NASENI SHP, 2010)

**b) Water storage (reservoir) developments**

For a hydroelectric plant to provide power on demand, either to meet a fluctuating load or to provide peak power, water must be stored in one or more reservoirs. Unless a natural lake can be tapped, providing storage usually requires the construction of a dam or dams and the creation of new lakes. This impacts the local environment in both negative and positive ways, although the scale of development often magnifies the negative impacts. This often presents a conflict, as larger hydro projects are attractive because they can provide "stored" power during peak demand periods. Due to the economies of scale and the complex approval process, storage

schemes tend to be relatively large in size. The creation of new storage reservoirs for small hydro plants is generally not financially viable except, possibly, at isolated locations where the value of energy is very high. Storage at a small hydro plant, if any, is generally limited to small volumes of water in a new head pond or existing lake upstream of an existing dam. Pondage is the termused to describe small volumes of water storage. Pondage can provide benefits to small hydro plants in the form of increased energy production and/or increased revenue. Another type of water storage development is “pumped storage” where water is “recycled”between downstream and upstream storage reservoirs. Water is passed through turbines to generate power during peak periods and pumped back to the upper reservoir during off-peak periods. The economics of pumped storage projects depends onthe difference between the values of peak and off-peak power. Due to the inefficiencies involved in pumping versus generating, the recycling of water results in a net consumption of energy. Energy used to pump water has to be generated by other sources. The environmental impacts that can be associated with small hydro developments can vary significantly depending on the location and configuration of the project. The effects on the environment of developing a run-of-river small hydro plant at an existingdam are generally minor and similar to those related to the expansion of an existing facility (RETscreen, 2012). Development of a run-of-river small hydro plant at an undeveloped site can pose additional environmental impacts. A small dam or diversion weir is usually required. The most economical development scheme might involve flooding some rapids upstream of the new small dam or weir. The environmental impacts that can be associated with hydroelectric developments that incorporate water storage (typically larger in size) are mainly related to the creation of a water storage reservoir. The creation of a reservoir

involves the construction of a relatively large dam, or the use of an existing lake to impound water. The creation of a new reservoir with a dam involves the flooding of land upstream of the dam. The use of water stored in

the reservoir behind a dam or in a lake results in the fluctuation of water levels and flows in the river downstream. A rigorous environmental assessment is typically required for any project involving water storage.

### 1.1.4 Hydro projects engineering phases

According to Belvoir (2005), there are normally four phases for engineering work requiredto develop a hydro project. Note, however, that for small hydro, the engineering work isoften reduced to three phases in order to reduce costs. Generally, a preliminary investigationis undertaken that combines the work involved in the first two phases described below. The work, however, is completed to a lower level of detail in order to reduce costs. Whilereducing the engineering work increases the risk of the project not being financially viable,this can usually be justified due to the lower costs associated with smaller projects.

**i) Reconnaissance surveys and hydraulic studies**

This first phase of work frequently covers numerous sites and includes: map studies;delineation of the drainage basins; preliminary estimates of flow and floods; anda one day site visit to each site (by a design engineer and geologist or geotechnicalengineer); preliminary layout; cost estimates (based on formulae or computer data);a final ranking of sites based on power potential; and an index of cost.

**ii) Pre-feasibility study**

Work on the selected site or sites would include: site mapping and geological investigations(with drilling confined to areas where foundation uncertainty would havea major effect on costs); a reconnaissance for suitable borrow areas (e.g. for sand andgravel); a preliminary layout based on materials known to be available; preliminaryselection of the main project characteristics (installed capacity, type of development,etc.); a cost estimate based on major quantities; the identification of possible environmentalimpacts; and production of a single volume report on each site.

**iii) Feasibility study**

Work would continue on the selected site with a major foundation investigation programme;delineation and testing of all borrow areas; estimation of diversion, designand probable maximum floods; determination of power potential for a range of damheights and installed capacities for project optimization; determination of the projectdesign earthquake and the maximum credible earthquake; design of all structures insufficient detail to obtain quantities for all items contributing more than about 10%to the cost of individual structures; determination of the dewatering sequence andproject schedule; optimization of the project layout, water levels and components;production of a detailed cost estimate; and finally, an economic and financial evaluationof the project including an assessment of the impact on the existing electricalgrid along with a multi-volume comprehensive feasibility report (Belvior, 2005).

**iv) System planning and project engineering**

This work would include studies and final design of the transmission system; integrationof the transmission system; integration of the project into the power networkto determine precise operating mode; production of tender drawings and specifications;analysis of bids and detailed design of the project; production of detailedconstruction drawings and review of manufacturer's equipment drawings. However,the scope of this phase would not include site supervision or project management,since this work would form part of the project execution costs (Belvior, 2005).

## 1.2 Statement of problem

In the wake of uncertainty about availability of fossil fuels and the adverse effects of pollution, plus degradation of the environment, new and renewable sources of energy are gaining importance day by day. Hydropower is one of the most attractive sources of renewable energy, however the inability to convince investors through proper economic viability analysis or insufficient technicalknowhowon the part of the design engineer to conduct proper economic feasibility and financial viability of such projects has greatly militated against the growth and development of the scheme in Nigeria, coupled with other factors, as there are many SHP projects abandoned and others yet to be harnessed.These set back has had its own fair share in the limited or total lack of access to electricity in rural communities, as Small hydro power (SHP) projects are mostly rural targeted projects, hence a major cause of underdevelopment and limited wealth generation capabilities amongst rural dwellers, as constant and available electric supply, drives the growth of cottage and small scale industries, by providing light, heat and power for productive uses and communication, that results in improved life styles and economies of rural dwellers. This work seeks to address basically the economic viability of SHP projects and its computation for financial investment decision.

### 1.3 Aim and Objectives of Work

The aim of this work is to conduct a feasibility study, on the economic viability of Onuaku River small hydropower project, in Aku community in Isuikwato local government area of Abia state. The specific objectives are;

i) To determine the costof installation per kW, the expected energy to be generated, expected yearly revenue within the project life.

ii) To appraise the economic viability of the Onuaku project in terms of economic indicators like the Payback Period (PBP), Net Present Value (NPV), Internal Rate of Return (IRR), and Benefit Cost Ratio (BCR)

iii) To compute for the generation profit or net profit yearly.

iv) To show the financial inflow and out flow of cash

v) To carry out a sensitivity analysis on the project

### 1.4 Significance of the Study

Proper economic viability study of a Small hydropower project is Significant to the client and even the private and Government at large in the following

a) To forecast the Risk or gains ahead before financial commitment or project financing is made.

b) To show that the economic metrics of the project are highly favorable

c) To show different level of cash flow during and after the project implementation.

### 1.5 Scope of the Study

Small hydropower has a key role in reducing the greenhouse gas emissions and adverse environmental effects of fossils fuel consumption. However, the design of SHP projects is not an easy task, as each project is site specific and needs detailed and challenging engineering computations to optimize the benefits of the projects. In this study, primary attention was focused on the economic appraisal of Onuaku Small hydropower plant, using both the static and dynamic methods of economic analysis. However, for the sake of completeness, variables like the estimated cost of project, Installation cost, expected revenue, generation cost, alternative energy cost per year, and the generation profit after tax, was considered. Finally a sensitivity analysis was conducted, to know the effects of a change in variables like the investment cost and the electricity sale price on the project.

# CHAPTER TWO

# LITERATURE REVIEW

## 2.1 History of Hydropower

"About 2000 years ago, during the first century B.C., it was discovered that the force of moving waters can be use to ease human labor by rotating shafts and cogwheels to mills for grinding grain and sawing wood, operate hammers in the ironworks of western Europe and industrial power."(U.S. Department of energy, 2008). Renewable energy has been seen as the way forward to reduce the emission of carbon dioxide in the atmosphere, thus hydro energy "is the energy that moving water provides. It is so called because water is two atoms of hydrogen plus one atom of oxygen. Energy from moving waters is considered renewable energy, Hydro energy or waterpower has been considered as a renewable form of energy and it is the main renewable energy used around the world. It yields electricity in an essential special way than fossil fuels, the electricity is derived from falling waters which runs through a constructed dam its movement turns the turbines thereby generating electricity which is refers to as hydro electric power.

### 2.1.1 Definition of hydropower energy

The generation of energy from water can be explained by the law of conservation of energy. The potential energy of flowing water is converted to kinetic energy in the penstock. The kinetic energy of the flowing water turns the blades of the turbine, where it is converted to mechanical energy. Finally, the turbine shaft rotates the generator and the final product, electrical energy is generated. The power generated by using the potential energy of the flowing water is given by the following formula (ESHA, 1998):

P =npgQH

.....**2.1**

where;

P is the power in watts

n is the general efficiency of the plant

p is the density of water in $kg/m^3$

g is the gravitational acceleration in $m/s^2$

Q is the discharge, passing through the turbine in $m^3/s$

H is the gross head of the water in m (elevation differences between the fore bay and the tail water) (ESHA, 1998)

**:.**P = 7 x Q× H wherenpg = 7

……..**.....2.2**

## 2.2 Small Hydropower

### 2.2.1 Definition of small hydropower

There is no internationally accepted definition for small hydropower. In China, small hydropower can refer to capacities up to 25 MW, in India the limit is 15 MW; whereas the limit in Sweden is 1.5 MW. However, a general agreement of 10 MW capacities is being accepted by European Small Hydropower Association, European Commission and International Union of Producers and Distributors of Electricity (Linsand Laguna, 2005). Moreover, within the range of small hydropower, depending on the installed capacity, the type of the plant is named as; mini, micro, and pico hydropower as shown in Table 2.1 below, which have an upper limit for installed capacity as; 1 MW, 100 kW and 5 kW, respectively (Taylor et al., 2006).

Table 2.1 Classification of Hydropower Plants by Size of Facility (NASENI SHP PROJECT MANUAL, 2010)

| **Classification of Hydropower Plants According to Facility Size** | |
|---|---|
| Large Hydropower | More than 50 MW |
| Medium Hydropower | 30 MW to 50 MW |
| Small Hydropower | 100KW to 30 MW |
| Micro Hydropower | 5KW to 100 KW |
| Pico-hydropower | Less than 5 KW |

**Note:** China classifies Micro and Pico Hydropower as Small Hydropower, which will also be used for this project.

### 2.2.2 Small hydropower potential in nigeria

Nigeria ranked high in hydropower potential in Africa with 20,000 MW except from Congo DR and Ethiopia as shown in Table 2.2, 2.3 and 2.4 belowrespectively. Nigeria has a gross exploitable large hydro potential of 14,750 MW out of which 14% amounting to 1930 MW is harnessed, contributing approximately 30% of total installed grid connected electricity generation according to Sambo,(2005). The Energy commission of Nigeria(ECN) also stated that SHP has been presence in Nigeria since 1923, which is 45 years before the commission of Kanijidam.Water resources for the development of SHP abound in all states of Nigeria, in fact flowing water bodies classified as “Small” in Nigeria can generate between 100-200kW. The fact is that there is no local Government area in the country that does not have at least one of such water bodies that can be used to generate electricity through SHP. (Ajani, 2008). In 2004, according to REMP, there is an estimate of 277 sites with a capacity of 3500 MW,

which represents 23% of the nation´s hydropower potential in addition to the 734 MW that had been surveyed in 1980 in some states. Nigeria has about 239 large, medium and small dams (NASENI, 2010). Forty of these dams already have hydropower components in them, like the power house, penstock etc. hydropower can also be integrated into all the others dams currently used for irrigation and water supply. Water released from these dams for either for ecological flows or irrigation can be rechanneled into a power house to generate electricity before being finally released for the original purposes (NASENI, 2010)

Table 2.2: Newly Surveyed Potential Small Hydropower (SHP) Sites in Nigeria.

| S/N | States | Pontential | Cumulative Power Estimate(MW) |
|---|---|---|---|
| 1 | Adamawa | 3 | 28.600 |
| 2 | AkwaIbom | 13 | |
| 3 | Bauchi | 1 | 0.150 |
| 4 | Benue | 10 | 1.306 |
| 5 | Cross River | 5 | 3.000 |
| 6 | Delta | 1 | 1.000 |
| 7 | Ebonyi | 5 | 1.399 |
| 8 | Edo | 5 | 3.828 |
| 9 | Ekiti | 6 | 1.2472 |
| 10 | Enugu | 1 | |
| 11 | FCT | 6 | |
| 12 | Gombe | 2 | 35.099 |
| 13 | Imo | 71 | |
| 14 | Kaduna | 15 | 25.000 |

| | | | |
|---|---|---|---|
| 15 | Kano | 2 | 14.000 |
| 16 | Katsina | 11 | 234.340 |
| 17 | Kebbi | 1 | |
| 18 | Kogi | 2 | 1.050 |
| 19 | Nassarawa | 3 | 0.454 |
| 20 | Niger | 11 | 110.580 |
| 21 | Ogun | 13 | 15.610 |
| 22 | Ondo | 1 | 1.300 |
| 23 | Osun | 8 | 2.622 |
| 24 | Oyo | 3 | 1.062 |
| 25 | Plateau | 14 | 89.100 |
| 26 | Sokoto | 1 | |
| 27 | Taraba | 9 | 134.720 |
| 28 | Yobe | 5 | |
| 29 | Zamfara | 16 | |
| 30 | Kwara | 4 | 5.200 |

Source: NASENI SHP, 2010

Table 2.3 Existing Small Hydropower Schemes in Nigeria

| S/No | River | State | Installed Capacity |
|---|---|---|---|
| 1 | Bagel I<br>Bagel II | Plateau<br>Plateau | 1.0MW<br>2.0MW |
| 2 | Ouree | Plateau | 2.0MW |
| 3 | Kurra | Plateau | 8.0MW |
| 4 | Lere I<br>Lere II | Plateau<br>Plateau | 4.0MW<br>4.0MW |
| 5 | Bakalori | Sokoto | 3.0MW |
| 6 | Tiga | Kano | 6.0MW |
| 7 | EziohaMgbowo | Enugu | 30KW |
| 8 | Waya dam | Kano | 150KW |
| **Total** | | | **30.0** |

Source: NASENI SHP, 2010

Table 2.4 On-Going SHP Scheme by the Federal Government

| S/N | LOCATION | INSTALLED CAPACITY |
|---|---|---|
| 1 | Dadin-Kowa | 30MW |
| 2 | Obudu- cattle ranch | 1MW |
| 3 | Ehvboro | 40KW |

Source: NASENI SHP, 2010

## 2.3 Government Policy Towards Small Hydropower Plants

The federal government of Nigeria has witness the failure of the thermal plants because of the Inadequate supply of gas to the station and the ethnical dispute over the area of the Niger Delta. Electricity generation from renewable energy source has been encourage in the developed countries and the main fiscal instruments they used to promote the investment are fed-in-tariffs, quota obligation, tender and energy tax

exemptions (Kucukali and Baris, 2009). However to achieve the road map towards electricity, there is need for the government to look into the existing energy sources and introduce full exploitation and promotion, which can come in form of SHP, since there are a lot of potentials and it would be regarded as a potential most stable and economically clean energy in Nigeria. The reform through the National Electric Power Policy (NEPP) has encouraged the private sector to apply for and obtain a license to build and operate a power plant as far as it generates more than 1 MW. With the establishment of the Rural Electrification Agency (REA) and Rural Electrification Fund (REF), whose main objective is to encourage investments towards the renewable energy resources in Nigeria. According to NERC, an individual can construct, own or operate an off-grid power plant, but it would not exceed 1 MW, which is seen in the Electric Power Sector Reform Act (EPSR) of 2005 and this exemption from holding a license encourages investment in the mini and micro SHP generation in those area of off-grid which are seen in the rural areas.NERC has in recent times issued a total of 29 licenses, which includes 20 for grid connection, two each for embedded and distribution and five others for off grid generation. Those in operation are five in number while four others are ready for commissioning, six out of the eight grids generators are in operation while the remaining two will start up as soon as possible. But with this entire framework towards upholding the electricity sector and private sector investment, it all seems that all the investment was channelled to fossil-based sources (oil and gas) and not in the hydropower and other renewable sources that are visible in Nigeria, I guess it is because of the non existence of a quality hydrological database in the country. So private investors in the renewable sources would be based of importation and marketing, since NEPP and NEP has encouraged investment towards the maximum utilization of SHP potentials, they foresee the feasibility of the hydropowerpotentials to exceed 29,800

GWh/year and this was calculated before the enactment of NEPP.The incentive policies that have been set up to encourage investment in the power sector are as follows (Lukman, 2003)

- A tax holiday of up to five years.
- Exemption from duty Taxes on imported equipment.
- Capital and investment allowances which can be carried forward and used after tax holiday period.
- Manufacture of transformers, meters, control panels, switchgear, cables and other electrical related equipment are considered as pioneer product or industry. As a result, there is tax holiday of 5 to 7 for investors who invest in these areas.
- Power plants using gas are assessed under the companies income tax act at a reduced rate of 30%.
- 100% foreign ownership of electricity plants and a repatriation of profit with a 5% withholding tax.

## 2.4 Financing SHP in Nigeria

The cost of financing any renewable energy project is very high and has a long-term financing period, since the technology is not within the country and where a country economy has unfavorable macro-economic conditions. So a special fund called the Renewable Electricity Trust Fund (RETF) was enacted by the Federal Government of Nigeria to encourage the expansion of renewable electricity in the country, which would be managed by the Rural Electricity Fund (REF); they shall promote, support and provide renewable electricity through private and public sector participation. According to International Energy Agency (IEA), Nigeria would benefit a lot of grants from investment in the renewable projects since investment towards sustainable electricity is been put in place by the Nigerian government. The Federal government has also

announced that by April 2011, the tariff for electricity would be increase in other to encourage investors´ return on investment. The Federal government has stated this through the NERC, maintaining that it was ready to work with the National Mathematical Centre in the development of mathematical models for tariff setting in the Nigerian Electricity Supply Industry (NESI).

## 2.5 Components of Small Hydropower Schemes

The main components of run-of river schemes can be divided into two headings; civil works and electromechanical works. The civil works of a run-of river SHP scheme include water conveyance structures, head pond or forebay, penstock, powerhouse and tailrace structures. Turbine, generator, governor, and regulator are the electromechanical components of a run-of river scheme.

## 2.6 Advantages and Disadvantages of Small Hydropower

Small hydropower is a sustainable resource. (Lins and Laguna, 2004) states that "SHP meets the needs of the present without compromising the ability of future generations to meet their own needs."

Small hydropower plants are among the cheapest systems to generate electricity. It is a well-known technology open to new technological developments. SHP has a high untapped potential especially in developing countries (ESHA, 1998). The main characteristics of small hydropower plants are their flexibility and reliable operation. Moreover, depending on the rapid demand changes, its fast start up and shutdown response is an important advantage (Dragu et al., 2001). Small hydropower plants are using water to generate electricity therefore the electricity generation is independent from the changes in fuel costs (Dragu et al., 2001). Without any harm or decrease to its resource it can satisfy the energy demand (Lins and Laguna, 2004). Moreover, SHP

schemes recovers the waste that flows with the river flow with its trash racks, thus it helps the maintenance of river basins (Pelikan et al., 2006).

Small hydropower is a clean energy source, thus it is environmentally friendly. It does not pollute the environment and does not generate greenhouse gases. Pelikan et al. (2006) states that "one GWh of electricity produced by small hydropower means a reduction of 480 tonnes of emitted carbon dioxide".Moreover, small hydropower schemes have long life span and very limited maintenance is required.

Another advantage given by (Lins and Laguna, 2004) is that SHP schemes are located within the borders of one country, thus, there will be no disruption by international political events.

On the other hand, there are some disadvantages of small hydropower plants. For example, seasonal variations of the river flow results in variations in energy generation. These low flow seasons limits the firm power of the plant (Paish, 2002). Dragu et al. (2001) states some adverse effects of small hydropower schemes on fish life. First of all, weir of the plant acts like a barrier which effect the fish movement. Secondly, especially young fish swimming downstream can be killed by the blades of the turbine. Thirdly, the spilled water will be supersaturated with the gas in the air. The gas bubbles in the water will kill the fish if they absorb it. Lastly, warm water will be collected at the surface of the reservoir, while cold water will be present at the bottom. This will result in a decrease in the oxygen level in the cold water in which most species of fish cannot survive.

Another disadvantage is the size and the flow of the river will limit the future site expansions at the demand for power increases (Alternative Energy, 2006).

One problem associated with SHPs in Nigeria is public opposition. The critics of SHP in Nigeria claim that diversion of most of the water from its natural bed into channels and tunnels causes the water quality and quantity to decrease at the downstream of the diversion. This causes the fish species and various microorganisms living in the river to decrease, and in some cases endangered species to become extinct. Moreover, the critics claim that since the water is carried by canals or tunnels to a downstream location, the groundwater is not fed; therefore, the groundwater water table gets lower. They claim that in the long run this may result in drought (KaradenizİsyandadIr, 2010). The summary of the advantages and disadvantages are shown in Table 2.5

Table 2.5 Summary of Advantages and Disadvantages of SHP (NASENI SHP, 2010)

| **ECONOMIC ASPECTS** | |
|---|---|
| **Advantages** | **Disadvantages** |
| Provides low operating and maintenance costs | Precipitation dependent |
| Provides long life span (50 to 100 years and more) | Requires long-term planning |
| Includes proven technology | Requires long-term agreements |
| Creates employment opportunities | Requiresmultidisciplinary involvement |
| Saves fuel | |
| Can provide energy independence by exploiting national resources<br>Optimizes power supply of other generating options (thermal and intermittent renewables) | |
| **SOCIAL ASPECTS** | |

| Advantages | Disadvantages |
|---|---|
| Leaves water available for other uses | Local land use patterns will be modified |
| Provides opportunities for construction with a high percentage of local manpower | Waterborne disease vectors may occur |
| **ENVIRONMENTAL ASPECTS** | |
| **Advantages** | **Disadvantages** |
| Produces no atmospheric pollutants | Barriers for fish migration, fish entrainment |
| Neither consumes nor pollutes the water it uses for electricity generation purposes | Modification of hydrological regimes |
| Produces no waste | Modification of aquatic habitats |
| Avoids depleting non-renewable fuel resources (i.e., coal, gas, oil) | Water quality needs to be monitored/managed |
| Can result in increased attention to existing environmental issues in the affected area. | Species activities and populations need to be monitored/managed |

## 2.7 Economic Analysis

The estimation of the investment cost constitutes the first step of an evaluation. An investment in a small hydropower scheme entails a certain number of payments extended over the project life, and procures some revenues, also distributed over the same period. The payment includes a fixed component called the capital cost and a variable component, which is the operation and maintenance expenses (ESHA, 1998). The economic analysis can be made either by including the effect of inflation or

omitting it. Working in constant monetary value has the advantage of making the analysis essentially independent of the inflation rate (ESHA, 1998). In any economic analysis involving economic value, there are always two variables, money and time **(**ESHA,1998**)**. A certain amount of money paid or received at a point in time has a different value, if it is paid or received at another point in time. Money can be invested during a certain period of time, with the guarantee of a certain benefit. The term "present value", describes a monetary amount now, i.e. at a point in time other than that at which it is paid or received. It is mathematically given as (Akinsulire,2009)

$$= \frac{1}{(1+r)^n}$$

**…….2.3**

where

r = Discount rate (%)

n = time (years)

The economic analysis compares and shows if a project should be embarked on, or abandoned. From an economic view point a hydropower plant, differs from a conventional thermal plant, because its investment cost per kW is much higher but the operating cost are extremely low, since there is no need for fuel (ESHA, 1998).

### 2.7.1 Components of economic analysis

It is invariably impossible evaluating the economic viability of a project without having estimate of key components like the Capital cost of project, Annual generation cost, cost of installation, annual benefits, Operation and maintenance cost (O&M) etc coming to fore. Hence we have the following

a) **Capital Cost**: this is the sum of money invested in the project before it's fully put into use or operation, which is given by the budget estimate of a project design. It consist of direct expenditures (Civil, electrical, mechanical works), indirect expenditures (supervision, administrative legal etc.)

b) **Annual Generation Cost**: this is the capital investment cost divided by the yearly generation, given as(HRC training manual, 2006):

$$\text{Generation Cost} = \frac{\text{Capital Investment Cost}}{\text{Total yearly generation}} \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \mathbf{2.4}$$

c) **Annual Benefits:** these are the resulting net yearly revenues expected from selling the electricity produced, after deducting the operation and maintenance cost, at constant value money (Akinsulire, 2007). It is estimated that the benefit from the project should have a nine point five percentage increment (9.5%) to cover for fuel price escalation factor, depending on the prevaling fuel escalation rate at the moment (RETScreen, 2012 )

d) **Operation and Maintenance:** the operation and maintenance cost of hydropower is a variable factor that involves salary, materials,depreciation, repair & overhaul expenses, staff welfare etc. For small hydropower scheme it is estimated at a range between four to seven percentages of the total investment cost (UNDP, 2012**).** Though in most cases, it's estimated on a site specific bases.

e) **Discount Rate;** the discount rate is a concept related to the NPV method. The discount rate is used to convert costs and benefits to present values to reflect the principle of time preference (HM Treasury, 2003). As at 2012, the prevailing discount rate published by the Central Bank of Nigeria, stood at twelve percentage (12%)(Trading economies, 2012).

f) **Depreciation:**Depreciation is an income tax deduction that allows a taxpayer to recover the cost or other basis of certain property (Helfert, 2000). It is an annual allowance for the wear and tear, deterioration, or obsolescence of the property. Depreciation begins when a taxpayer places property in service for use in a trade or business or for the production of income. The property ceases to be depreciable when the taxpayer has fully recovered the property's cost or other basis or when the taxpayer retires it from service, whichever happens first. The straight line method of calculating depreciation is shown below.

Annual Depreciation Expence =

$$\frac{\text{Cost of Fixed Asset} - \text{Residual Value}}{\text{Useful Life of Asset (years)}} \quad \text{.....2.5}$$

## 2.8 Methods of Economic Evaluation

When appraising the economic viability of a hydropower project, the easiest and fastest method is to compare the ratio of the total investment, to the power installed or the ratio of the total investment to the annual energy produced for each year project (Helfert, 2000), nevertheless this criterion does not determine the profitability of the scheme because the revenues are not taken into account, but constitutes a first evaluation criterion. There are basically two methods of economic analysis of a project; they are the Static and the Dynamic methods (ESHA, 1998)

### 2.8.1 Static method

The static method do not take the opportunity cost into consideration, examples of such method are the Payback method and the return on investment (Helfert, 2000)

a) **Payback Method (PBP);** the PBP method determines the number of years required for the investment capital to be offset by resulting benefits (Helfert, 2000). The required number of years is termed the Payback period, recovery or

breakeven point (Helfert, 2000). The measure is usually calculated on a before tax basis and without discounting, i.e. neglecting the opportunity cost of capital. The payback ratio should not exceed a maximum period of ten years (10) if the small hydro project is to be considered profitable (RETScreen, 2012). However this method presents obvious drawbacks which prevent the ranking of projects. The method takes no account of the time value of moneyand neither does it take account of the earnings, after initial investment is recouped. Despite the above limitations, the payback method continues to be very popular and widely put to use, particularly where there is a high degree of uncertainty. it is mathematically given as(Abolarin, 2012)

Payback Period = $\frac{\text{capital investment cost}}{\text{Annual Cash inflows}}$ ..... **2.6**

**b) Return on Investment Method;** the return on investment (ROI) calculates the average annual benefits, net of yearly cost. It is mathematically given as

ROI = $\left(\frac{\text{Average Annual net benefits}}{\text{Original book value}}\right) *$ 100..... **2.7**

### 2.8.2 Dynamic methods

This method of financial analysis take in to account, total cost and benefits, over the life cycle of the investment and the timing of cash flows (ESHA, 1998), examples of these methods are the Net Present Value (NPV), Internal Rate of Return (IRR) and the Benefit Cost Ratio (BCR)

**a) Net Present Value;** in the NPV method, the revenues and cost of a project are estimated and then discounted and compared with the initial investment. The preferred option is that with the highest Net Present Value. Projects with negative NPV should be rejected, because the Present Value of the Stream of benefits is

insufficient to recover the cost of the project (Akinsuilire, 2009), compared to other investment appraisal techniques, such as IRR and the discounted payback period. The NPV is viewed as the most reliable technique to support investment appraisal decisions (Helfert,2000). The NPV is mathematically given as(HRC training manual, 2006);

$$NPV = \sum_{J=1}^{30} \frac{(B_j - C_j)}{(1 + i_s)^j} \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots . \ldots \mathbf{2.8}$$

where

n = Project life Span of 30 years

j = Increment in years

$B_j$ = Benefit at j years

$C_j$= Cost of O & M at j years

$i_s$= Discount rate

**b) Internal Rate of Return;** the IRR is the discount rate, at which the present value of the periodic benefits (revenues less operating and maintenance cost) is equal to the present value of the initial investment (ESHA, 1998). In other words, the method calculates the rate of return an investment is expected to yield. The preferred option is that with the IRR greatest in excess of a specified rate of return or discount rate (Van and James, 2007). A process of trial and error, whereby the net cash flow is computed for various discount rates, until its value is reduced to zero, usually calculates the rate of return. It is worth noting that under certain circumstances, there may be either no rate of return solution or multiple solutions (ESHA, 1998). Hence it is expected to choose from the IRR values that converge very close to zero, as the project IRR. Mathematically the IRR is given

as**(**HRC 2006**):**

$$NPV = \sum_{J=1}^{30} \frac{(B_j - C_j)}{(1+EIRR_s)^j} =$$

0……**2.9**

where

EIRR = the value or rate of IRR that equals the NPV to zero.

Hence we calculate by interpolation the discount rate that makes the NPV to be

Zero by the formula below;

$$\text{Lower Discount Rate} + \text{Diff of two discount rate } [\frac{\text{NPV at lower disc rate}}{\text{Sum of NPV at two disc rate}}] =$$

0……**2.10**

**c) Benefit Cost Ratio (BCR) or Profitability index;** the BCR or Profitability index, is thediscounted net revenues divided by the initial investment. The preferred option is that with the ratio greatest in excess of one (Howe and Charles, 2000). In any event, a project with a benefit cost ratio of less than one should generally be discarded. The advantage of this method is its simplicity, because it gives the investor an Idea of the benefit on every one naira invested in the project.Mathematically the IRR is given as**(**HRC Training manual, 2006)

$$B/C = \frac{\sum_{j=1}^{30} \frac{B_j}{(1+i_s)^j}}{\sum_{j=1}^{30} \frac{C_j}{(1+i_s)^j}} \text{.....} \mathbf{2.11}$$

wherethe parameters have the same meaning as previous equation above.

## 2.9 Sensitivity Analysis (Treatment of Uncertainty)

Several times when the project is under execution, certain things go wrong with the

project with the result that the desired benefits cannot be achieved within the stipulated time frame. For example, the actual execution of the project is delayed or the cost exceeds the original estimated cost (cost over-run). In such cases, the results get fairly changed. Many times, the IRR and NPV thus get reduced or the BCR becomes negative from positive. In order to take care of this problem, while the projects are under preparation or under examination, certain assumptions are applied for testing the viability of the project. For example, it is at times assumed that there will be a cost over-run by, say, 25% or a reduction in revenues, say, by 10% or a delay in getting the benefits, say, by three years and so on. Keeping one or two or all such assumptions in view, the streams of costs and benefits are re-drawn and the figures of costs and benefits are discounted and the NPV, BCR and IRR are re-worked out. This gives a fairly good picture as to what will be the fate of the projects if such mishaps occur. For the sensitivity analysis, it is very essential to carry out such an exercise in projects where high financial stakes are involved.

## 2.10 Onuaku Community Brief

Onuaku community is located in the south eastern part of the country, precisely in Uturu in Isuikwato local Gorvernment Area of Abia state. It was estimated from the last census of 2006 to have a population of 200 people, with about 50house holds. The people are predominantly subsistence farmers and hunters and speaks Ibo as their major language. The community is fast growing with many young men and migrants engaged in micro-economic activities. Social amenities, such as a general hospital,primary school and a post office are on ground.

## 2.11 Review of Past Works in the Area

Gonzalez et al.,(2011) provides a throrough insight into the benefits of investing in hydropower and attracting private investment on new projects.

Blerta, X (2009) studied the financial feasibility of eight hydropower plant scheme in Albania, to look at the financial sustainability of the project. The analysis confirmed the viability of the project, but pointed out some difficulties in the ability of servicing the debt.

Ekpok, E (2007) the article highlights on the principle and concepts of clean development mechanism (CDM) and how it can help a SHP project to be viable by the additional income generated from CDM component.

Aydin, B (2010) studied three consecutive hydropower projects and four alternative project formulations to these projects,evaluated using RETScreen. The results of the evaluations are compared and best formulations for the project identified.

Ajani E.(2011) completed a study on making SHP deployment for electricity generationviable and sustainable through the development of local manufacturing capacity for SHP equipment. The study highlights the development of SHP and its roles in achieving the united nations millennium development goals (UN-MDGS) in Nigeria through increased access to electricity, leading to job and wealth generation in rural communities. The study also discusses the challenges of deploying SHP for electricity generation in Nigeria.

NASENI (2009) completed the local design and fabrication of the 10kW Ketti SHP pilot project crossflow turbine.

NASENI (2009) completed the local design and fabrication of the first phase 35kW T15 cross flow turbine for the proposed installation at the Ikeji-Ile Ijesa SHP project.

HEC (1979) studied on the feasibility studies for SHP additions. The study provides technical data and procedural guidance for the systematic appraisal of the viability of a pontential SHP projects.

# CHAPTER THREE

# METHODOLOGY

## 3.1 Introduction

The previous chapter elaborated extensively on the literature review of Small hydropower and the economic analysis and Indicators used in appraising the viability of a project before capital budgeting is done. However in this chapter, the procedure adopted for gathering data, and how these data are analyzed are explained. To accomplish this task, the study is divided into three parts:

i. The first part of this work, seeks to address as well compute the major components of an economic analysis, like; an estimate of the capital cost, annual generation cost, cost of installation, expected revenue, annual benefit, comparism between the economic benefit of SHP to fossil fuel, that will aid in computation of the cash flow analysis

ii. The second part shows the cash flow analysis using an excel based platform to compute the PBP, NPV, IRR, BCR and the year to year profitability of the project. Here the O&M and the annual benefit column on the excel sheet will be computed on a compounding basis, because of their variable nature in practice.

iii. A sensitivity analysis to show the effect of variables like an increase in investment cost and reduction in the price of electricity price on the project will be verified.

## 3.2 Description of the Project Site

The OnuakuSHP project gets its name from the Aku River, the water source for the SHP, which is a perennial source of water with sufficient discharge also in the dry season. Aku community lies in the Eastern part of Nigeria, precisely in Uturu, Isuikwato local Government area of Abia state, within longitudes $7.00^{o}$ and $7.20^{o}$ east, and latitudes $8.40^{o}$ and $9.00^{o}$N. Detailed measurement and calculations were carried out to get parameters like the estimated power, flow, Head and the type of small hydropower scheme to be implemented by the National Agency for Science and Engineering Infrastructure (NASENI) of which i did the verification of data gotten by NASENI, for the purpose of authenticating the accuracy of data used, in course of this work.

## 3.2 Feasibility Analysis

The detailed technical feasibility study was carried out by the National Agency for Science and Engineering Infrastructure (NASENI), through field work. The power to be generated for the SHP is determined largely based on the demand of the local community and survey was carried in 2011 to collect information, regarding the demand for power in the locality and the villager's willingness to pay for the electricity supplied. In the demand survey the head count of the villagers according to households and rural demand, such as for offices, schools and so on were also calculated. The survey also included the technical and socio-economic issues important for the project, but as highlighted in the limitations of this project, those factors are beyond the scope of this study. The feasibility analysis also included the survey regarding hydrological, geographical and topographical information needed, prior to the actual design of the system components. The site survey was also carried out by the Agency to determine the flow (Q), and head (H) required for the required power output of the project. The gross

head was measured to be 7.8m by on field design survey by the use of a topographic map of that area and altimeter (NASENI SHP, 2011). The flow of 0.04$m^3$/s (lean flow) and 0.346$m^3$/s (wet flow) were gotten by the survey team,using the Velocity Area Method of flow measurement amongst other methods, like the weir method, salt dilution method, slope area method. The method employed for the flow measurement is thought to be accurate and quick. The summary of the data available from the feasibility analysis is provided in table 3.1 after proper verification exercise of the data gotten, by me.

Table 3.1 Summary of Data Gotten from the Feasibility Analysis on for Onuaku SHP Project (NASENI SHP, 2012)

| **Project Name** | **Onuaku SHP Project** |
|---|---|
| Catchment Area | $4.28x10^6$ $m^2$ |
| Gross head | 7.8m |
| Net head | 6.99m |
| Penstock length | 166m each |
| Design discharge | 0.04 $m^3$/s -0.346 $m^3$/s |
| Number of turbines | 2 |
| Capacity | 17kW (2kW:15kW) Locally fabricated |
| Turbine type | Cross flow |
| Total energy | 92,845.44 |
| River source | AKu / Evo river |
| No of households | 50 |
| Length of weir | 3m |
| Scheme type | Run- off- river |

### 3.3 Load Survey Analysis

Data for the load survey was first conducted by NASENI Engineers and verified by me,to ascertain the energy demand and consumption pattern of Aku community. The detailed energy consumption pattern which shows the estimated power demand of the people to be 20kW is shown in the table 3.2, 3.3 and 3.4 respectively.

Table 3.2 Domestic Load ofAku Community

| S/N | Item | No Of House Holds | Average Power Required (Kw) | Total(Kw) |
|---|---|---|---|---|
| 1 | Lighting | 50 | .1 | 5 |
| 2 | Power outlet (Refrige-Ration,radio,tv) | 50 | 0.05 | 2.5 |
| | | | | |
| | | | **Sub total** | 7.5 |

Source: Present research survey

Applying diversity factor (DF) of 0.65%, we have (7.5x 0.65) kW

Hence our domestic load becomes=4.875kW

Table 3.3 Commercial load of Aku Community

| S/N | Item | No | Average Power( Kw) | Total(Kw) |
|---|---|---|---|---|
| 1 | Grinding machines | 2 | | |
| | i) Industrial type | | | |
| | ii) Domestic type | | 5.00 | 10.00 |
| 2 | Public houses(bars) | 4 | | |
| | i) Light points | | 0.08 | 0.32 |
| | ii) Power outlets. | | 0.05 | 0.20 |
| 3 | Grocery stores | 4 | | |
| | i) Lights points | | 0.1 | 0.40 |
| | ii) Power outlets | | 0.05 | 0.20 |
| 4 | Market centre (provisional) | 2 | | |
| | i) Lights points | | 0.1 | 0.2 |
| | ii) Power outlets | | 0.05 | 0.10 |
| 5 | Poultry farm | 1 | | |
| | i) Lights points | | 0.1 | 0.10 |
| | ii) Power outlets | | 0.05 | 0.05 |
| | | | **Sub total** | **11.57** |

Source: Present research survey

Applying diversity factor 0.7% (DF=0.7,) we have (11.75x07) kW

Hence our commercial load is 8.099

Table 3.4 Social Load of Aku Community

| S/N | Items | No | Average Power Req.(Kw) | Total(Kw) |
|---|---|---|---|---|
| 1 | schools | 3 | | |
| | i) Light points | | 0.20 | 0.60 |
| | ii) Power outlets | | 0.05 | 0.15 |
| 2 | Churches | 2 | | |
| | i) Light points | | 3.20 | 6.40 |
| | ii) Power outlets | | 0.50 | 1.00 |
| 3 | Health centre | 1 | | |
| | i) Light points | | 3.14 | 3.14 |
| | ii) Power outlets | | 2.04 | 2.04 |

Source: Present research survey

Applying diversity factor (DF) of 0.6% we have (0.6x13.33)kW,Hence the Social load of Aku Community is 7.99.

Total estimated load:

I Domestic Load – 4.875kW

II Commercial Load – 8.099kW

III Social Load – 7.998kW

**Total Load** **20.972kW**

# CHAPTER FOUR

# RESULTS AND DISCUSSION

## 4.1 Results of the Study

Following detailed technical survey conducted by NASENI, the results of the cost of the project after a proper bill of engineering measurement and evaluation carried out by me, the estimated cost of the project is summarised in table 4.1

Table 4.1 Estimated cost of project

| **Items** | **Cost (₦)** |
|---|---|
| **Direct costs** | |
| Civil Engineering | 7,602,722.85 |
| Turbine- generator | 1,209,155.85 |
| **Total Direct cost Foreseen** | **8,812,155.85** |
| **Contingencies (unforseen)** | |
| 10% of electromechanical cost | 120,943.3 |
| 10% of civil engineering | 760,272.285 |
| **Total direct cost (contingencies plus total direct cost foreseen)** | **9,693,371.43** |
| **Indirect Cost** | |
| Engineering cost (12% of direct & contingencies) | 1,163,204.57 |
| Admin &others (5% of direct & contingencies) | 969,373.143 |
| **TOTAL CAPITAL COST** | **11,232,184** |

### 4.1.1 Cost of installation per kW

From equation 2.4

$$\text{Installation cost} = \frac{\text{Total Capital Investment Cost}}{\text{Capacity ofPlant}}$$

$$= \frac{11{,}232{,}184}{17}$$

$$= ₦660{,}706.71$$

### 4.1.2 Energy generation

The power generation from the project can be all year round, considering the two regimes of flow i.e Lean and Moderate flow regimes

a) **Moderate Flow regime:** from equation 2.1

   $P = Q_m Hg$

   Where $Q_m$=moderate flow, H = net head, and g= constant=7

   P = 0.347 x 6.99 x 7 = 16.93kW

   But the operating time = 24hours,

   Duration of moderate flow within a year = Eight months (240 days)

   Hence

   Energy Produced = 16.95kW x24hours x 240 days

   = 97,516.80kWh

   Expected net production = 90% of total Energy (losses due to friction, bends etc)

   = 97,517.80 x 0.90

   = 87,765.12kWh

b) **Lean flow regime:** from equation 2.1

$P = Q_L Hg$

Where $Q_L$=Lean flow, H= net head, and g = constant = 7

P = 0.04 x6.99 x 7 =1.96kW

But the operating time = 24hours,

Duration of lean flow within a year =four months (120 days)

Hence,

Energy produced = 1.96kW x 24hours x120days

= 5,644.80kWh

Expected net production = 90% of total Energy

= 5,644.80 x 0.90

= 5,080.32kWh

Total Energy Generation =Energy at moderate flow+ Energy at lean flow

$Energy_{Total} = Energy_{MF} + Energy_{LF}$

= (87,765.80+ 5,080.32) kWh

= 92,845.44kWh

### 4.1.3 Expected revenue

With a net production of 92,845.44kWh, all year round, the power generation is projected using a tariff rate of 12.38 Naira per kWh of electricity (Aderinokun, 2011)

Hence the expected yearly revenue is calculated thus as

= Energy produced yearly x tariff rate

= 92,845.44 x 12.38

= ₦1,149,426 Naira

### 4.1.4 Depreciation

The depreciation of the asset according to the straight line method is given below, from equation 2.5

$$\text{Depreciation} = \frac{\text{Cost of asset} - \text{Residual value}}{\text{useful life of assets (years)}}$$

$$= \frac{11{,}232{,}184 - 0}{30}$$

= ₦311,609.2

### 4.1.5 Operation and maintenance cost

Small hydro power requires huge investment cost initially, but during its operation requires very little cost to maintain and run the equipments since it requires no fuel, but uses water as it primary source of fuel for its day-day operation. The operation and maintenance cost of these work is estimated as shown in Table 4.2.

Table 4.2 Operation and Maintenance Cost of Project

| **Description** | **Rate(₦)** | **Amount Annually (₦)** |
|---|---|---|
| Wages | 18,000/worker | 216,000.00 (one operator) |
| Depreciation | - | 311,609.20 |
| Repairs | - | 70,000 |
| Total | - | 561,609.20 |

### 4.1.6 Alternative Energy Cost per year

Total diesel fuel consumption per month – 3000litres/month (Gen.operator)

Price of diesel/litre ---- ₦ 103.00

Cost ---- 3000ltr/ month x 103.00 = ₦309,000.00/month

Cost of fuel per year---------309,000.00/month x 12 = **₦3,708,000/year**

## 4.2 Payback Period

With a project cost of ₦11.2 million, and a varied net cash flow as shown in table 4.3 below, the project would be completely paid for in ;

$$\text{Payback period} = \frac{\text{Investment cost}}{\text{Annual cash flow}} \text{ from equation 2.6}$$

$$= \frac{11{,}232{,}184}{1{,}149{,}421}$$

= 10years (approx)

## 4.3 Net Present Value

Table 4.3 below shows that the cash flow analysis gave an NPV of 3,630,057.58 at the 30 years life span of the project base on the following assumptions.

a) 12% discount rate (trading economics, 2012)

b) Project life span of 30 years (ESHA, 1998)

c) 9.5% of energy escalation on annual benefit (National bereau of statistics, 2013)

Table 4.3 Cash Flow Analysis For Project NPV: from equation 2.8

| YEAR | CAPITAL COST (₦) | O&M(5% Capital cost) (₦) | ANNUAL BENEFIT(9.5% Escalation) (₦) | NET ANNUAL BENEFIT (₦) | PRESENT VALUE FACTOR (i=12%) | NET PRESENT VALUE(NPV) (₦) |
|---|---|---|---|---|---|---|
| 1 | 11,232,184 | | | -11,232,184 | 0.892857 | -10028735.71 |
| 2 | | 561,609.20 | 1,149,421 | 587,811.80 | 0.797194 | 468599.9681 |
| 3 | | 589689.66 | 1258616 | 668,926.30 | 0.71178 | 476128.5525 |
| 4 | | 619174.143 | 1378185 | 759,010.40 | 0.635518 | 482364.8128 |
| 5 | | 650132.85 | 1509112 | 858,979.20 | 0.567427 | 487407.8628 |
| 6 | | 682639.493 | 1652478 | 969,838.20 | 0.506631 | 491350.212 |
| 7 | | 716771.467 | 1809463 | 1,092,691.60 | 0.452349 | 494278.1881 |
| 8 | | 752610.041 | 1981362 | 1,228,752.00 | 0.403883 | 496272.3317 |
| 9 | | 790240.543 | 2169591 | 1,379,350.90 | 0.36061 | 497407.7669 |
| 10 | | 829752.57 | 2375703 | 1,545,950.10 | 0.321973 | 497754.5487 |
| **11** | **11,821,464.70** | **871240.198** | **2601394** | **1,730,154.20** | **0.287476** | **497377.9877** |
| 12 | | 914802.208 | 2848527 | 1,933,724.70 | 0.256675 | 496338.9552 |
| 13 | | 960542.319 | 3119137 | 2,158,594.60 | 0.229174 | 494694.1681 |
| 14 | | 1008569.44 | 3415455 | 2,406,885.50 | 0.20462 | 492496.4571 |
| 15 | | 1058997.91 | 3739923 | 2,680,925.20 | 0.182696 | 489795.0165 |
| 16 | | 1111947.8 | 4095216 | 2,983,268.00 | 0.163122 | 486635.6395 |
| 17 | | 1167545.19 | 4484261 | 3,316,716.10 | 0.145644 | 483060.9375 |
| 18 | | 1225922.45 | 4910266 | 3,684,343.70 | 0.13004 | 479110.5467 |
| 19 | | 1287218.57 | 5376741 | 4,089,522.90 | 0.116107 | 474821.3206 |
| 20 | | 1351579.5 | 5887532 | 4,535,952.40 | 0.103667 | 470227.5107 |
| 21 | | 1419158.48 | 6446847 | 5,027,688.90 | 0.09256 | 465360.9363 |
| 22 | | 1490116.4 | 7059298 | 5,569,181.50 | 0.082643 | 460251.1422 |
| 23 | | 1564622.22 | 7729931 | 6,165,309.00 | 0.073788 | 454925.5482 |
| 24 | | 1642853.33 | 8464275 | 6,821,421.40 | 0.065882 | 449409.5872 |
| 25 | | 1724996 | 9268381 | 7,543,384.80 | 0.058823 | 443726.8361 |
| 26 | | 1811245.8 | 10148877 | 8,337,631.20 | 0.052521 | 437899.1376 |
| 27 | | 1901808.09 | 11113020 | 9,211,212.20 | 0.046894 | 431946.7143 |
| 28 | | 1996898.49 | 12168757 | 10,171,858.70 | 0.041869 | 425888.2756 |
| 29 | | 2096743.42 | 13324789 | 11,228,045.70 | 0.037383 | 419741.1181 |
| 30 | | 2201580.59 | 14590644 | 12,389,063.50 | 0.033378 | 413521.2191 |
| | | | | | | **3,630,057.58** |

**4.4 Internal Rate of Return**

The IRR is an indicator to measure the financial return on investment of an income generating project and is used in investment decision. In general the decision rule is that as long as the IRR of the project is greater than discount rate or the hurdle rate, then you accept the project.

Table 4.4 below, is seen that the upper and lower limit of discount gotten by Trial and error method are 12% - 14.52%, Hence we calculate by interpolation the discount rate that makes the NPV to be zero.

Lower Discount Rate + Diff of two discount rate $[\frac{\text{NPV at lower disc rate}}{\text{Sum of NPV at two disc rate}}]$from equation ...2.10

But lower rate = 12%

Difference of two disc rate = 14.52% -12 = 2.52%

NPV at hurdle discount rate of 12% = ₦3,630,057.54

NPV at upper discount rate = ₦-313.208

We have

$$\text{IRR} = 12 + 2.52\ [\frac{3,630,057.54}{3,630,057.54+313.208}]$$

$$= 12 + 2.25$$

IRR = 14.25%

Therefore with an IRR of 14.25%, the project NPV becomes zero.

Table 4.4 Cash Flow Analysis for Project IRR: from equation 2.9

| Year | Capital Cost(₦) | Net Annual Benefit(₦) | Present Value (i=12%) | Net Present Value(₦) | Present Value For IRR (i=14.52%) | Net Present Value For IRR(₦) |
|---|---|---|---|---|---|---|
| 1 | 11,232,184 | -11,232,184 | 0.892857 | -10028735.71 | 0.873202295 | -9807968.844 |
| 2 | | 587,811.80 | 0.797194 | 468599.9681 | 0.762482248 | 448196.0624 |
| 3 | | 668,926.30 | 0.71178 | 476128.5525 | 0.665801248 | 445371.9889 |
| 4 | | 759,010.40 | 0.635518 | 482364.8128 | 0.581379178 | 441272.8258 |
| 5 | | 858,979.20 | 0.567427 | 487407.8628 | 0.507661632 | 436070.7793 |
| 6 | | 969,838.20 | 0.506631 | 491350.212 | 0.443291302 | 429920.8364 |
| 7 | | 1,092,691.60 | 0.452349 | 494278.1881 | 0.387082982 | 422962.3236 |
| 8 | | 1,228,752.00 | 0.403883 | 496272.3317 | 0.338001749 | 415320.3308 |
| 9 | | 1,379,350.90 | 0.36061 | 497407.7669 | 0.295143902 | 407107.0111 |
| 10 | | 1,545,950.10 | 0.321973 | 497754.5487 | 0.257720333 | 398422.7675 |
| 11 | 11,821,464.70 | 1,730,154.20 | 0.287476 | 497377.9877 | 0.225041986 | 389357.3365 |
| 12 | | 1,933,724.70 | 0.256675 | 496338.9552 | 0.196507179 | 379990.776 |
| 13 | | 2,158,594.60 | 0.229174 | 494694.1681 | 0.171590519 | 370394.3676 |
| 14 | | 2,406,885.50 | 0.20462 | 492496.4571 | 0.149833235 | 360631.4392 |
| 15 | | 2,680,925.20 | 0.182696 | 489795.0165 | 0.130834725 | 350758.1151 |
| 16 | | 2,983,268.00 | 0.163122 | 486635.6395 | 0.114245182 | 340823.9995 |
| 17 | | 3,316,716.10 | 0.145644 | 483060.9375 | 0.099759155 | 330872.8006 |
| 18 | | 3,684,343.70 | 0.13004 | 479110.5467 | 0.087109923 | 320942.898 |
| 19 | | 4,089,522.90 | 0.116107 | 474821.3206 | 0.076064585 | 311067.8598 |
| 20 | | 4,535,952.40 | 0.103667 | 470227.5107 | 0.06641977 | 301276.9143 |
| 21 | | 5,027,688.90 | 0.09256 | 465360.9363 | 0.057997896 | 291595.3783 |
| 22 | | 5,569,181.50 | 0.082643 | 460251.1422 | 0.050643896 | 282045.0472 |
| 23 | | 6,165,309.00 | 0.073788 | 454925.5482 | 0.044222366 | 272644.55 |
| 24 | | 6,821,421.40 | 0.065882 | 449409.5872 | 0.038615071 | 263409.6721 |
| 25 | | 7,543,384.80 | 0.058823 | 443726.8361 | 0.033718769 | 254353.6482 |
| 26 | | 8,337,631.20 | 0.052521 | 437899.1376 | 0.029443306 | 245487.4286 |
| 27 | | 9,211,212.20 | 0.046894 | 431946.7143 | 0.025709963 | 236819.9214 |
| 28 | | 10,171,858.70 | 0.041869 | 425888.2756 | 0.022449998 | 228358.2117 |
| 29 | | 11,228,045.70 | 0.037383 | 419741.1181 | 0.01960339 | 220107.7605 |
| 30 | | 12,389,063.50 | 0.033378 | 413521.2191 | 0.017117725 | 212072.5852 |
| | | | | **3630057.584** | | **-313.2083908** |

**4.5 Benefit Cost Ratio**

Thebenefit cost ratio of the project from discounted O& M cost, discounted investment cost and the discounted Annual benefit from the Table 4.5 below is given by

Total Discounted Cost = ₦6,061,119.81+ ₦10,028,735.71

= ₦16,089,855.52 and

Discounted benefit = ₦19,719,913.11

Hence b/c ratio = $\frac{19,719,913.11}{16,089,855.52}$.from equation 2.11

= 1.23

Table 4.5 Cash Flow Analysis For Benefit Cost Ratio:from equation 2.11

| YEAR | O&M (5% Capital cost )(₦) | Annual Benefit (9.5% escalation)(₦) | Present Value (i=12%) | Discounted Capital Cost (₦) | Discounted O&M(₦) | Discounted Annual Benefit (₦) |
|---|---|---|---|---|---|---|
| 1 | | | 0.8928571 | -10028735.71 | | |
| 2 | 561,609.20 | 1,149,421 | 0.7971939 | | 447711.4158 | 916311.3839 |
| 3 | 589689.66 | 1258616 | 0.7117802 | | 419729.4523 | 895858.0048 |
| 4 | 619174.143 | 1378184.5 | 0.6355181 | | 393496.3616 | 875861.1744 |
| 5 | 650132.8502 | 1509112 | 0.5674269 | | 368902.839 | 856310.7017 |
| 6 | 682639.4927 | 1652477.7 | 0.5066311 | | 345846.4115 | 837196.6236 |
| 7 | 716771.4673 | 1809463.1 | 0.4523492 | | 324231.0108 | 818509.1989 |
| 8 | 752610.0407 | 1981362.1 | 0.4038832 | | 303966.5726 | 800238.9043 |
| 9 | 790240.5427 | 2169591.5 | 0.36061 | | 284968.6618 | 782376.4288 |
| 10 | 829752.5698 | 2375702.6 | 0.3219732 | | 267158.1205 | 764912.6692 |
| 11 | 871240.1983 | 2601394.4 | 0.2874761 | | 250460.7379 | 747838.7257 |
| 12 | 914802.2082 | 2848526.9 | 0.2566751 | | 234806.9418 | 731145.897 |
| 13 | 960542.3186 | 3119136.9 | 0.2291742 | | 220131.508 | 714825.6761 |
| 14 | 1008569.435 | 3415454.9 | 0.2046198 | | 206373.2887 | 698869.7458 |
| 15 | 1058997.906 | 3739923.1 | 0.1826963 | | 193474.9582 | 683269.9747 |
| 16 | 1111947.802 | 4095215.8 | 0.1631217 | | 181382.7733 | 668018.4128 |
| 17 | 1167545.192 | 4484261.3 | 0.1456443 | | 170046.35 | 653107.2875 |
| 18 | 1225922.451 | 4910266.2 | 0.1300396 | | 159418.4531 | 638528.9998 |
| 19 | 1287218.574 | 5376741.5 | 0.1161068 | | 149454.7998 | 624276.1203 |
| 20 | 1351579.503 | 5887531.9 | 0.1036668 | | 140113.8748 | 610341.3855 |
| 21 | 1419158.478 | 6446847.4 | 0.0925596 | | 131356.7576 | 596717.6939 |
| 22 | 1490116.402 | 7059297.9 | 0.0826425 | | 123146.9603 | 583398.1025 |
| 23 | 1564622.222 | 7729931.2 | 0.073788 | | 115450.2752 | 570375.8234 |
| 24 | 1642853.333 | 8464274.7 | 0.0658821 | | 108234.633 | 557644.2202 |
| 25 | 1724995.999 | 9268380.8 | 0.0588233 | | 101469.9685 | 545196.8046 |
| 26 | 1811245.799 | 10148877 | 0.0525208 | | 95128.09544 | 533027.2331 |
| 27 | 1901808.089 | 11113020 | 0.0468936 | | 89182.58948 | 521129.3037 |
| 28 | 1996898.494 | 12168757 | 0.0418693 | | 83608.67763 | 509496.9532 |
| 29 | 2096743.418 | 13324789 | 0.0373833 | | 78383.13528 | 498124.2534 |
| 30 | 2201580.589 | 14590644 | 0.0333779 | | 73484.18933 | 487005.4084 |
| | | | | | | |
| | | | | -10028735.71 | **6061119.813** | **19719913.11** |

### 4.6 Generation profit

Profit = Benefit from Energy Sale – Energy Sale Cost –Energy Sale Tax

Profit after Income Tax= Sale Profit-Income Tax

Note: a tax holiday of five years is granted (NERC) at a company tax rate of 32%, as shown in Table 4.6.

**Table 4.6 Yearly generation profit after tax**

| **ITEMS/YEAR** | **2** | **3** | **4** | **5** | **6** | **7** |
|---|---|---|---|---|---|---|
| **Income From Energy Sale (₦)** | 1,149,421 | 1,258,615.99 | 1,378,184..52 | 1,509,112.04 | 1,652,477.68 | 1809463.06 |
| **Energy Sale Cost (₦)** | 561,609.20 | 589,689.66 | 619,174.14 | 650,132.85 | 682,639.49 | 716,771.46 |
| **Sale Profit (₦)** | 587,811.8 | 668,926.3 | 759,010.4 | 858,979.2 | 969,838.2 | 1,092,691.6 |
| **Income Tax (₦)** | - | - | - | - | - | 349,661.31 |
| **Profit After Income Tax (₦)** | 587,811.8 | 668,926.3 | 759,010.4 | 858,979.2 | 969,838.2 | 743,030.28 |

| **ITEMS/YEAR** | **8** | **9** | **10** | **11** | **12** | **13** |
|---|---|---|---|---|---|---|
| **Income From Energy Sale (₦)** | 1,981,362.05 | 2,169,591.45 | 2,375,702.64 | 2,601,394.39 | 2,848,526.86 | 3,119,136.91 |
| **Energy Sale Cost (₦)** | 752,610.04 | 790,240.54 | 829,752.56 | 871,240.19 | 914,802.20 | 960,542.31 |
| **Sale Profit (₦)** | 1,228,752.0 | 1,379,350.9 | 1,545,950.1 | 1,730,154.2 | 1,933,724.7 | 2,158,594.6 |
| **Income Tax (₦)** | 393,200.64 | 441,392.00 | 494,704.03 | 553,649.34 | 618,791.9 | 690,750.2 |
| **Profit After Income Tax (₦)** | 835,551.36 | 937,958.9 | 1,051,246.06 | 1,176,504.85 | 1,314,932.8 | 1,467,844.4 |

| ITEMS/YEAR | 14 | 15 | 16 | 17 | 18 | 19 |
|---|---|---|---|---|---|---|
| **Income From Energy Sale (₦)** | 3,415,454.92 | 3,739,923.13 | 4,095,215.83 | 4,484,261.34 | 4,910,266.16 | 5,376,741.45 |
| **Energy Sale Cost (₦)** | 1,008,569.43 | 1,058,997.90 | 1,111,947.80 | 1,167,545.19 | 1,225,922.45 | 1,287,218.57 |
| **Sale Profit (₦)** | 2,406,885.5 | 2,680,925.2 | 2,983,268.0 | 3,316,716.1 | 3,684,343.7 | 4,089,522.9 |
| **Income Tax (₦)** | 770,203.36 | 857,896.06 | 954,645.76 | 1,061,349.15 | 1,178,989.98 | 1,308,647.32 |
| **Profit After Tax (₦)** | 1,636,682.14 | 1,823,056.14 | 2,028,622.24 | 2,255,366.95 | 2,505,353.72 | 2,780,875.58 |

| ITEMS/YEAR | 20 | 21 | 22 | 23 | 24 | 25 |
|---|---|---|---|---|---|---|
| **Income From Energy Sale (₦)** | 5,887,531.89 | 6,446,847.42 | 7,059,297.92 | 7,729,931.22 | 8,464,274.69 | 9,268,380.79 |
| **Energy Sale Cost (₦)** | 1,351,579.50 | 1,419,158.47 | 1,490,116.40 | 1,564,622.22 | 1,642,853.33 | 1,724,995.99 |
| **Sale Profit (₦)** | 4,535,952.4 | 5,027,668.9 | 5,569,181.5 | 6,165,309.0 | 6,821,421.4 | 7,543,348.8 |
| **Income Tax (₦)** | 1,451,504.77 | 1,608,854.05 | 1,782,138.08 | 1,972,898.88 | 2,182,845.85 | 2,413,871.62 |
| **Profit After Tax (₦)** | 3,084,447.63 | 3,418,814.88 | 3,787,043.42 | 4,192,410.12 | 4,638,575.55 | 5,129,477.18 |

| ITEMS/YEAR | 26 | 27 | 28 | 29 | 30 | |
|---|---|---|---|---|---|---|
| **Income From Energy Sale (₦)** | 10,148,876.97 | 11,113,020.28 | 12,168,757.21 | 13,324,789.14 | 14,590,644.11 | |
| **Energy Sale Cost (₦)** | 1,811,245.79 | 1,901,808.08 | 1,996,898.49 | 2,096,743.41 | 2,201,580.58 | |
| **Profit Before Tax (₦)** | 8,337,631.2 | 9,211,212.2 | 10,171,858.7 | 11,228,045.7 | 12,389,063.5 | |
| **INCOME TAX(32% Of Profit) (₦)** | 2,668,041.98 | 2,947,587.9 | 3,254,994.78 | 3,592,974.62 | 3,964,500.32 | |
| **Profit After Tax (₦)** | 5,669,589.22 | 6,263,624.3 | 6,916,863.92 | 7,635,071.08 | 8,424,563.18 | |
| | | | | | **Profit Sum** | **83,560,163.89** |

## 4.7 Sensitivity Analysis

### 4.7.1 Sensitivity to Investment Cost

Table **4.7** below shows the sensitivity of project NPV and IRR to changes in Investment Cost as it affects the economic indicators used in appraising this work.

Table 4.7Sensitivity to investment cost

| Percentage increase in Investment cost | NPV of Investment (Million ₦) | Project IRR |
|---|---|---|
| 10% | 2.23 | 13.34% |
| 20% | 1.12 | 12.62% |
| 30% | -0.01 | 11.99% |

### 4.7.2 Sensitivity to Electricity Price

Table 4.8 below shows the sensitivity of the project on reduction of electricity price to see how it affect the project NPV and IRR.

Table 4.8 Sensitivity to electricity

| % decrease in price of electricity | NPV of Investment (Million₦) | Project IRR |
|---|---|---|
| -10% | 0.96 | 12.64% |
| -20% | -1.43 | 10.98% |

## 4.8 Discussions

The focus is on investment decisions which have to be made in spite of the uncertainties associated with the projects like this one. I have evaluated the viability and profitability of this project based on the following assumptions outlined above, as well as the

prevailing economic realities of the country. Also the project is 100% fully financed by by the Aku development union, with approval from the rural electricity agency (REA).

### 4.8.1 Investment cost, operation and maintenance costs and expected annual revenue

#### i) Investment Costs

From table 4.1, the Analysis of estimated investment cost for the proposed hydro power project is given in this section. The investment costs are accurate, cost received as a result of bills of engineering measurement and evaluation prepared by professionals involved in the feasibility study. The estimated investment cost is ₦11,232,184with the civil works having bulk of the percentage of the project sum. 10% of the capital cost of the project was set aside for contingencies, in line with standard practice. The results above also showed an installation cost of ₦660, 706.71, meaning that it cost ₦660, 706.71 to install a kW of the power. This shows how expensive it cost to install a kW of electricity initially using SHP, which is far less than the amount of investment for similar investment in fossil fired plants, which has a high maintenance and operation cost, that will surpass the initial investment spent in SHP with time. Thus making the fossil fired fuel more expensive than the hydro scheme in the future

#### ii) Operation and Maintenance Cost

From table 4.2, the total operation and maintenance cost for the first year was projected at ₦561,609.20, which is roughly 5% of the investment cost. A key portion of the operation and maintenance cost is the depreciation calculated using the straight line method. From the figure above the O&M for the hydro plant is low compared with the ₦3,708,000/year of generating an equivalent power using the fossil fuel power plants. A statement that clearly supports from our literature review, that the investment cost of a

SHP is high but has low running cost compared to the fossil fuel powered plant, as shown in this work. Though the operation and maintenance cost from our cash flow analysis increases annually by a 5% compounding rate to carter for tears and worn out parts, repairs etc that may be very common as the plant is continuously used coupled with the well known fact that as machineries or system becomes old, they require higher operation and maintenance cost to sustain and keep them in good working conditions.

**iii) Expected annual revenue or Turn over**

From table 4.3, With a power generation all year round both in wet and dry season projected at 92,845.44kWh, thus a net production all year round power output of 92,845.44kWh was achieved. To enable us assess the benefit from electricity sale of the project, a tariff rate NGN12.38/kWh was attached. This gives an annual turnover of ₦1.149,421 million. The project cost and revenue are based on Nigerian Naira. For the purposes of the financial analysis, we have assumed a project life span of 30 years, though from our literature review, small hydropower plants are robust in nature can span up to 50 years or more. Furthermore the energy escalation factor of 9.5%, computed on a compounding basis on the annual benefit column of the cash flow analysis, to take care of inflation in prices of fuel was considered, Causing variations in the year to year annual benefit on the column, which can be justified by price variations in fuel prices, that characterized our present day system today.

### 4.8.2 Economic Indicators or ratios

When appraising a project, it is pertinent not to use one method or indicator to show if the project is economically viable, hence several economic tools or indicators were used to ascertain the economic viability of Onuaku SHP project. This tool will be discussed below as they support in determining the viability of the project according to their specific decision rules that support them as reviewed in the chapter two of this work.

**a Payback Period or Breakeven point**

With a project cost of ₦11,234,184 million, and a varied net cash flow as shown in Table 4.1, the project would be completely paid for in 10 years (Year 2021), meaning that an investor will recoup its initial capital within a ten years period, if the project is implemented and put into full operation. Recall also from our literature review that this method is the fastest and most used method to show the economic potential of a project, but cannot be relied alone on to ascertain the viability of a project, because it does not show the year to year variations in cash flow and does not take into account the time value of money. According to the decision rule, from our literature review, the shorter time for the project to pay back its initial investment, the better. From our analysis here, ten years is considerable short a period for an investment that spans over 30 years minimum and 50 years and above, to yield.Hence it is very key to undertake this project.

**b Net Present Value**

From table 4.4 the project net present value was estimated at ₦3,630,057.54. Having returned a positive NPV is an indication that the project is viable according to our decision rule from our literature review. The implication of returning a positive NPV after all discounting have been made to carter for the time or present value of money, is an indication that the project can pay for all its cost and able to withstand variations and

fluctuations in price indices.Compared to other investment appraisal techniques such as the IRR and the discounted payback period, the NPV is viewed as the most reliable technique to support investment appraisal decisions.

**c Internal Rate of Return**

The IRR is an indicator to measure the financial return on investment of an income generating project. From table 4.4, the IRR of the project is 14.25% higher than the hurdle rate of 12% that correspond to the opportunity cost of capital. According to our decision rule in our literature review, that states that as long as the IRR of the project is greater than the discount rate, the project is viable. The implication of this statement goes as far as letting the investor understand, that even at a higher hurdle rate, say 14.25%, the project will still break even.

**d Benefit Cost Ratio or the profitability index**

From table 4.5 we got that the profitability index of the project is 1.23. According to our decision rule, a project with a benefit of less than one should be discarded. Hence the profitability index of Onuaku SHP site is above unity from calculation. This implies that on every one naira invested in this project, a benefit of 0.23 kobo is realized, which is an 18.7% benefit on every one naira spent. Hence from our decision rule this project is viable based on the result from our calculation.

### 4.8.2 Generation profit

The result from table 4.6 projected that a total net profit estimated at ₦83,560,163.89of will be gotten at the expiration of the 30 year span of the project. Which is very good compared to the investment cost on this project.A tax holiday of five years making reference to the literature review of this work, was also granted by law by the National electricity Regulatory commission of Nigeria on small hydro power project not above 1MW. The project showed from calculation, commensurable volume of profit during the span of the project.

### 4.8.3 Sensitivity analysis

The financial performance of the project is based on the most likely scenario. However, in real life, situations are always as assumed hence the need to vary some of our assumptions to enable us see the impact of such on our financial forecasts. Variables such as investment cost, selling price of electricity and operation and maintenance cost would normally be subjected to variations with a view to determining their impacts on the project performance financially. However, because the project we are appraising here is a renewable energy project, the inputs in terms of O&M are usually very low hence the emphasis will be on the investment cost and revenue components.

**a Sensitivity to Investment Cost:**

The project IRR is 14.25% on an investment cost of ₦11.2 million approximately. An increase of 20% in the investment cost from table 4.7would still be tolerable while a 30% increase would result in negative NPV and a project IRR of 11.86%. In summary we can safely assume that our project is very sensitive to increase in the investment cost.

**b Sensitivity to Electricity Price**

The selling of electricity is the main source of revenue for the small hydro power plant. A selling price of ₦12.38/kwh was used as the base, which returned an IRR of 14.25%. Rather than an increase in price variation, we have chosen to decrease the tariff to establish the responsiveness of the profitability to the pricing regime. The project has shown from table 4.8, more sensitivity to pricing as price decrease of 20% has thrown the project's NPV to negative and the IRR dropping to 10.98%. Hence with the project NPV dropping to negative and the IRR dropping below the discount rate, at a price decrease of 20% electricity price is an indication that the project will not be viable at 20% reduction in electricity price. Therefore we can confidently forecast that our project is price sensitive.

# CHAPTER FIVE

# CONCLUSION AND RECOMMENDATION

## 5.1 Conclusion

From the results and discussion of the study, the following conclusion can be drawn:

An installation cost of ₦660,706.71 is required to install a kW of power, with an investment cost of ₦11,232,184 and an annual generating capacity of 92,845.44kWh, yielding an annual revenue of ₦1,149,421 before tax for the first year of operation.

A project payback period of ten years which is timely enough for the client or investor to recover its initial investment made on a project that can span up to thirty years (minimum) - fifty years (maximum).

A net present value of three million six hundred and thirty thousand, fifty seven naira fifty eight kobo only, (₦3,630,057.58) was gotten, thus an indication that the project is viable according to the decision rule that states that a positive Net present value at expiration or life span of the project of 30 years is an indication of a viable project.

Also with a project internal rate of return of 14.25%, higher than the discount rate of 12%, is also a key indicator that embarking on this project will yield returns on investment. At an IRR of 14.25% the project breaks even.

The benefit cost ratio of the project from analysis is 1.23 which is above unity, an indication of positive returns on investment according to our decision rule, from the literature review.

A generation profit within the span of the project is estimated at ₦83,560,163.89, showing a commensurable profit after tax, for a project with investment cost of ₦11,232,184.

Sensitivity of the project to variations in investment cost showed that the project is sensitive to variation in the investment cost, as a 30% increase in investment cost throws the project into a negative NPV, and an IRR less than the hurdle rate of 12%. The sensitivity to the variation in the price of electricity shows how the project responds to reduction in electricity price, as a reduction by 20% in electricity price, throws the project into a negative net present value making the project not viable at 20% reduction in electricity price. Hence, the results from the analysis above haveprovided additional information for the decision makers, client and the design engineer to see reasons why this project should be embarked on.

**5.2 Recommendation**

After using a profit based business case to appraise the economic viability of the project to enable the investor take informed decisions, with an investment cost of less than ₦12million, yielding a positive NPV of ₦3,363,057.58 with IRR and benefit cost ratio of 14.25% and 1.23 respectively, and a project breakeven point of 10years, It is clear that based on the assumptions used, the project is thereby recommended for implementation under this conditions

a) That the investment cost of the project should not be increased above 30%, as the project is sensitive to variation in investment cost, as it will throw the NPV to negative and the IRR less than the 12% hurdle rate.
b) That the electricity price should not be reducedbelow 20%, as this action will throw the project NPV to negative, therefore making the project not to be viable.
c) That a dam be constructed to allow for peak supply of electricity all-round the year, to avoid energy economic waste.

d) There should be load shedding, to accommodate for the insufficient power demand of the people. That is at day, the power supply be focused on the industrial and social facilities, while at night be focused on residential areas.

e) An alternative RE and less expensive power supply like the solar panels be incorporated in this project, to supplement for energy supply during the less busy times of the day and to augment for power at peak period.

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