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Renewable Energy for Generation of Hydro-Electric-Power to Enhance Rural Telephony and Other Infrastructures

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Abstract: This study presents the use of renewable, hydro-electric-power energy in rural communities for telephony and other infrastructural development in Nigeria. The major source of power supply in Nigeria is through the National grid provided by power holding company of Nigeria and small contribution from independent power production IPP. Two rivers were used as a case study Ikpoba river in Benin City and Ibiekuma stream in Ekpoma, the catchments area, hydrograph and flow duration curve of the rivers were investigated. The results obtained from the investigation reveals that electrical power energy can be obtained from the rivers for the purpose of rural telephony and infrastructural development.

Key words: Catchments area, hydrograph and flow duration curves, uraltephony, renewable energy, Nigeria

INTRODUCTION

Much has been written and published on small hydropower project (Iversin, 1996). Some have been done, built and commissioned in many countries which have thought it wise to draw benefits from the research efforts of various investigations of this area of energy supply for the advancement and development of human life on earth. Many people know that adequate energy supply to all sectors of life and knowledge with skills are both simultaneously necessary for the Sustainable Economic Growth and Industrialization (SEGI) and the Agricultural Productivity and the related Agro-Allied Industries (APAAI) of a people or nation (Weaver, 1990). Therefore, we must spare nothing in making these two most important necessities as part of our lives. Because of this we have done some research on harnessing hydropower from some rivers.

The case studies are Ikpoba River, Ibiekuma River, which was used in establishing a general case study for the establishment of micro hydropower scheme in rural communities.

The establishment of Micro-hydropower scheme in rural communities in Nigeria will be the key to cottage industries evolution and other infrastructure development both in rural and semi rural areas. It will help to boost agro industries and improves telecommunication (GSM) in our rural areas, which will create both primary and secondary job, thereby reducing the rural urban drift of our youths.

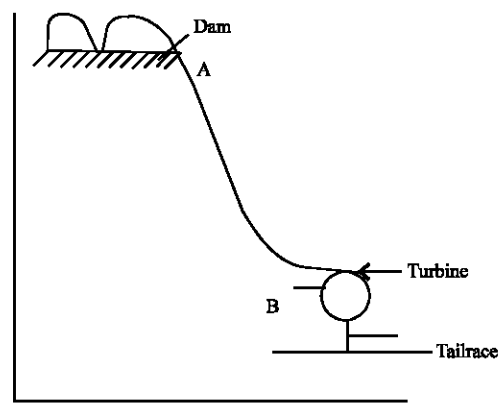

Fig. 1: Using dam to develop a head

The basic power equation is well known to be

$$P = 9.8\ QHg\eta \qquad (1)$$

Where:

- P = Power lost by water in falling or (flowing) from a point A to a point B along any path by any suitable means such as a river bed, a dam, open canal/channel.
- η = Efficiency of the turbine.
- Q = Flow ($m^3\ s^{-1}$).
- Hg = Gross head = drop in elevation from A to B as shown in Fig. 1.

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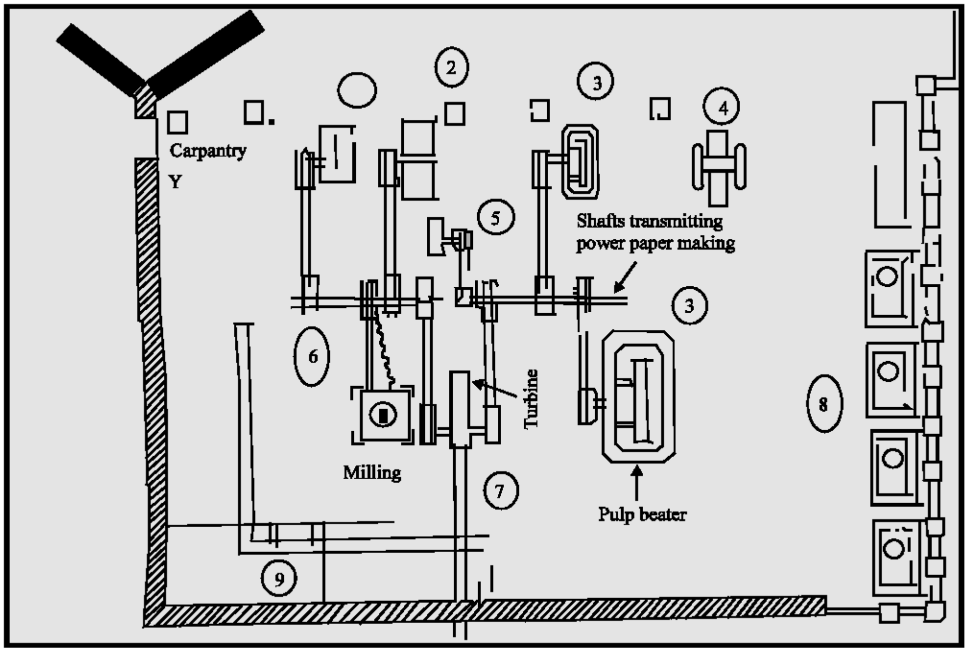

Fig. 2: A small Kw Turbine that can be used to drive machinery in a rural setup

In the hydro projects site, selection of water quantity and head are fundamental. This involves detailed studies, data and collection, which take into account the catchments area. The main cost is in evil works; namely dam or weir or run off scheme, intake, power conduit, fore bay, penstock, powerhouse and tailrace, which might be included in a small hydro, power scheme. Others are the turbines, electro mechanical parts and the overall aim of the small hydro scheme. This is usually to supply power to rural communities, which may not easily be connected to the national grid. The scheme can be planned to cover all power and energy needs of the community. To illustrate this point the case study of what happened in which the turbine directly drives a variety of machinery; in which case power generation of secondary benefit is shown in Fig. 2.

- Circular saw
- Planner
- Pulp beater
- Paper press
- Generator
- Grain mill
- Turbine
- Vats
- Wood store

The scheme can also be represented as a black box shown in Fig. 3, in some cases the project is planned as a comprehensive deal including turbines, generators, governing drives and associated electrical equipment (Stout, 1995). It is the whole unit that is often seen as "black box" a box containing assortments of electrical, mechanical and hydraulic devices into which water is fed, out of which electrical or mechanical power is drawn, is shown in Fig. 2. Factors influencing the choice of equipment are quality of water, site accessibility, climatic condition, altitude of location, variability of flow,

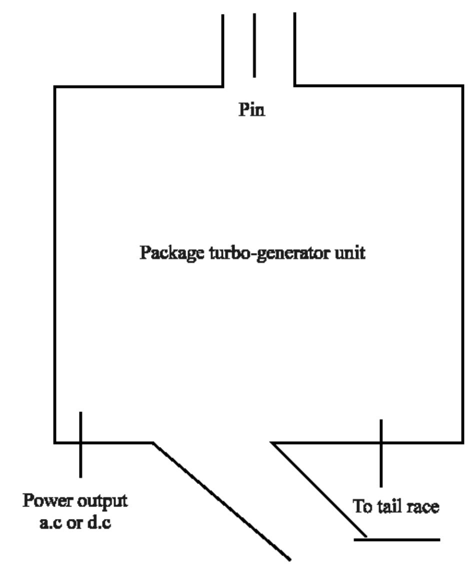

Fig. 3: Package of small hydro project as a black box

penstock, configuration, nature of load, method of operation and power house size, etc. (Smith, 1994).

The input flow head (Hg) and discharge of water Q in $m^3\ s^{-1}$ turbo power generating Unit (Black box"), providing needed power for the drives of the community (Dooge, 1997)

Figure 3 is a model representation of how renewable energy can be used to provide electricity to rural communities.

IKPOBA RIVER CASE STUDY

Catchment area of ikpoba river: This was thoroughly investigated,(Esan, 2000), giving an area of about 8.5 km^2 as shown in Fig. 4.

Arising from the catchment area study, we looked at the rivers hydrograph shown in Fig. 5, its flow duration curve in Fig. 6 and we showed the view of the hydrological cycle nature in Fig. 7.

Power estimate from ikpoba river: After considering all the factors, which affect the catchment areas extent of land, rainfall, land slope and the whole area, it can be shown that continuous power supply from Ikpoba river is

$$P = (9.81AYAc\ t\ g\ Hg/F)\ KW \qquad (2)$$

Where:

- A = Average annual rainfall for the catchment ($m\ yr^{-1}$).
- Y = Yield factor, for the catchment basin.
- Ac = Catchments Area Ac (Km^2).
- Hg = Theoretical Available Head, (m).
- t = Turbine efficiency.
- ηg = Generator efficiency.
- f = Load factor.

During the study it was shown that average rainfall (Jan, 2001 to Dec. 2006)=1.45 m/yr

$$Y = \text{Yield factor} = 30\%\ (\text{or } 0.3)$$

The penstock system will have a theoretical head Hg, the turbine investigated has a good mechanical efficiency of 0.77, whilst the generator efficiency is = 0.9, the load factor, F is 0.75, when used; these parameters are we obtain the Maximum Demand (MD) from the Average Power Demand (APD).

$$MD = APD/F \qquad (3)$$

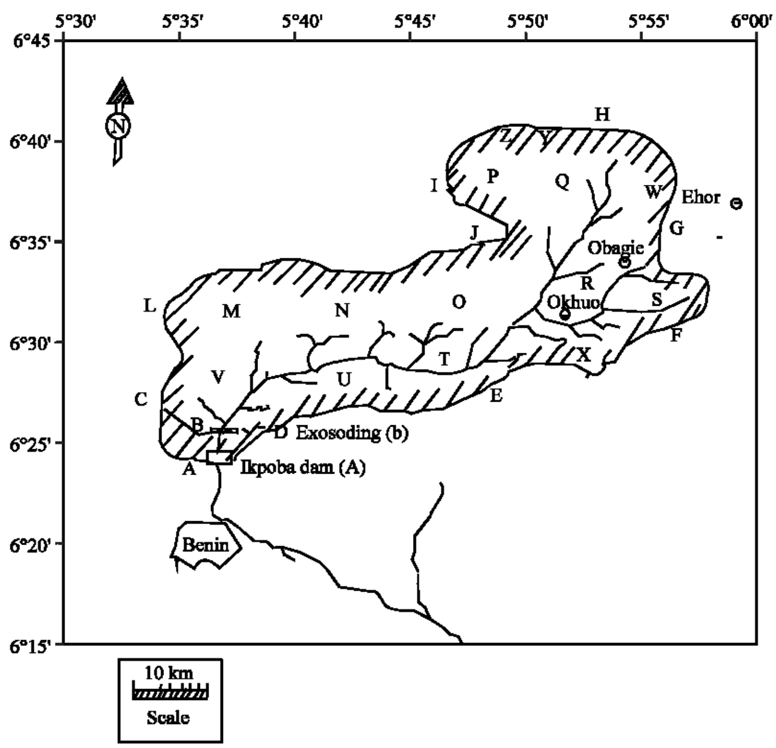

Fig. 4: Estimated catchment of Ikpoba river

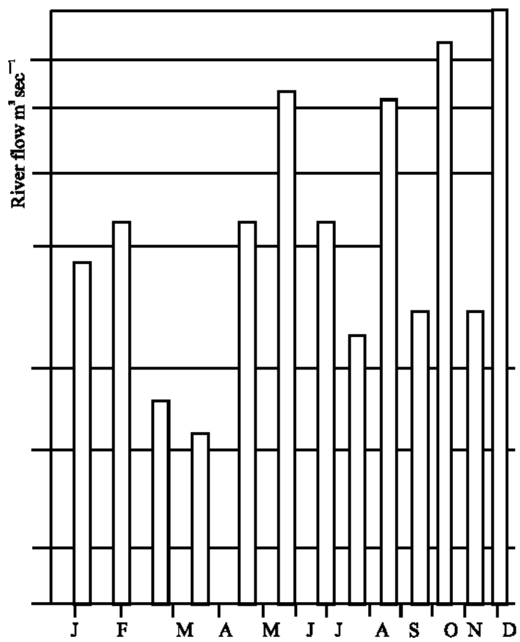

Fig. 5: Hvdrograph for Ikpoba river

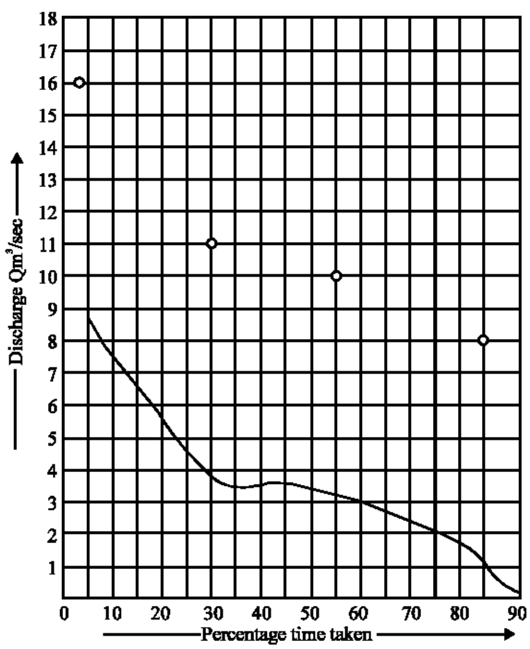

Fig. 6: Flow duration curve for Ikpoba River

By applying all the numerical values stated above to Eq. 2.

We have the maximum power,

$$P_{max} = g \times \eta t \times \eta g \times Hg \times Ac = 0.77 \times 0.9 \times 72.25 \times 9.81 = 491.2\ Hgkw \quad (4)$$

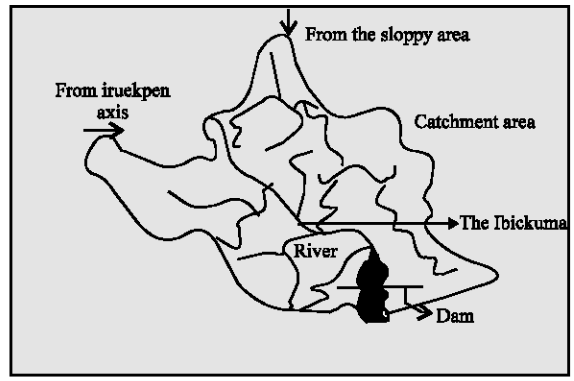

Fig. 7: Catchment area

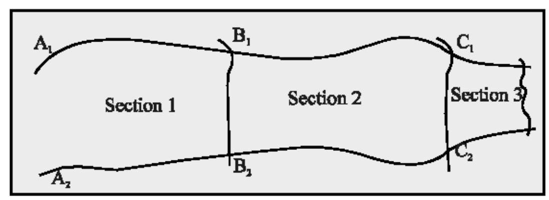

Fig. 8: Sectional investigation of Ibiekuma river

The effect of the of the yield factor (Y) can be used to investigate how the power output depends on it.

That is Eq. 4 may be written as a function of Y variation and for a given head, Hg the maximum power becomes

$$P_{max} = 491.2 Hgy\ Kw \quad (5)$$

That is Y may vary from one river to another, Eq. 4 is the first approximate general equation that tells us about the power capability of Ikpoba river when used as a drive for a small hydropower system. We may vary Y from zero to 30% for each value of Hg leading to Fig. 6, in this way variety of power outputs as functions of the head are possible. Obviously many rural communities with rivers/streams in Nigeria have the same parameter with that of Ikpoba river which can be used to develop a small hydro power scheme.

AN EXAGGERATED SKETCH OF THE IKPOBA RIVER BASING STORAGE AND SYSTEM

Estimated Catchment of the Ikpoba River

Yield factor: General estimated valeus (Silva, 2000)

Commercial and Industrial area	=	0.50
Forest area depending on soil formation	=	0.05-0.60
Farm lands area	=	0.05 - 0.30

Next we shall consider the effect of the general rainfall, about the catchment area on this power estimate, by using the authentic rainfall values taken for 5 years i.e. 2001, 2002, 2003, 2004, 2005 from January to December each year is shown in Fig. 5.

We can then use these parameters to estimate the approximate power that can be developed form the Ikpoba river by applying the basic laws of hydrostatics and Newton, given in Eq. 2

The investigation carried out in Ikpoba river and environs, with the measured values enable the sketching of the catchment area of the river shown in Fig. 4. while the data obtained from the investigation is shown in Fig. 5 which is the hydrograph for Ikpoba river and the flow duration curve for the river is shown in Fig. 6.

CASE STUDY OF IBIEKUMA RIVER

A water supply scheme project for Ambrose Alli University, Ekpoma was also investigated; a small hydropower source of 630.15 KW can be obtained from the river.

The Ibiekuma river is smaller than Ikpoba River. The catchment area was also investigated. Figure 7 shows the catchment area of Ibiekuma river to be 3.75 Km^2.

In, carryout the flow measurement of the river, the river was divided into 3 sections, as shown in Fig. 8, only section 2 where the river was dam was investigated. The length, Width and depth of were measured. For the surface speed a floating object was used, the physics mechanism, which is another technique for the determination of surface speed. The time taken for the float to move from one point to another was taken. These readings were also taken over a period of 3 years (2004-2006). The readings for the year 2006 are shown in Table 1.

Results analysis obtained from the section investigated from Ibiekuma river is shown in Table 2.

Sectional Area (A) = d×w

= 10.5×30 m

= 315 m^2

surface speed = Ss

$$Ss = \frac{\text{length}}{\text{Time}} = \frac{30\text{ m}}{194.6\text{ sec}}$$

= 0.1541 m/s.

Average speed, Sa = Ss×f

F = A constant factor for the type of river investigated and it has a value of 0.65.

Table 1: Readings taken for the year 2006 from Ibiekuma river

Months	Time taken for the float to move from point A to B (Sec)
January	196.8
February	195
March	195
April	197
May	196
June	195.4
July	195
August	194
September	195
October	192
November	192
December	192
Average time for the year 2006	194.6

Table 2: Results obtained from the section investigated from Ibiekuma river

Average time for object to move from point A to B 194.5 Sec	Width of river	Depth of river	Length of river
	30 m	10.5 m	30 m

Sa = $0.1541 \text{ m sec}^{-1} \times 0.65$

= 0.1002 m s^{-1}.

Discharge =Q = Sa×A

= $0.1002 \text{ m s}^{-1} \times 315 \text{ m}^2$

Q = $31.6 \text{ m}^3 \text{ s}^{-1}$.

The maximum power which can be generated;

P_{max} = η×g×Q×h

η = Efficiency of generator

g = Acceleration due to gravity (m sec^{-2})

Q = Stream discharge in $\text{m}^3 \text{ sec}^{-1}$.

h = Head in (m)

η = 77

sg = 9.81 m sec^{-2}

Q = 31.6 and h = 2.64 m

P_{max} = 77×9.81×31.6×2.64

= 630.15 kw (section 2 of the river)

From the maximum power that can be derived from Ibiekuma river, the investigation shown that appreciable Electrical power can be generated from the river.

CONCLUSION

From the investigation work carries out on Ikpoba River in Benin City and Ibiekuma river, Ekpoma. The results from this investigated work shows that Micro hydro Electric power scheme can be developed using all the parameters from the findings, i.e the catchments areas of the rivers, the flow/discharge of the river, the available head. When this useful knowledge is put into practice, micro hydro Electric power scheme can be developed in rural areas to improve our independent power production for the establishment of telephones and cottage industries in rural communities. The development of micro hydro electric power scheme in rural community will help in providing many auxiliary jobs like rural telephony system (GSM) and the rural communities can also benefit from the provision of basic electricity supply that will improve their standard of living.

Furthermore, the over dependent on the national grid for the supply of electrical energy both for the urban and rural dweller will be reduced, thereby reducing the incessant power outage in the 3rd world countries.

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