Multidisciplinary Journal of Akseprin Indonesia
Website : https://jurnal.akseprin.org/index.php/MJAI/about
e-mail : akseprin@gmail.com or mai@akseprin.org
PUBLISHER: Akademi Sertifikasi Profesi Internasional (AKSEPRIN)
ISSN 3025-0129 (online)
Pages 01-06, Vol. 2, No. 2, 2024

Received: 2023-02-01 Revised: 2023-04-19 Accepted: 2023-04-26 Published: 2024-06-22

The Potential of Rivers as Renewable Energy Power Plants

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ABSTRACT

Globally, the demand for cheap energy source has risen as a result of population growth, urbanization, and industrialization. While the electricity consumption in emerging nations like Nigeria is rising, the supply, which is often derived from fossil fuels is diminishing, leading to an energy crisis and pollution. Thus, in order to cover both the present and future energy needs, it is necessary to investigate alternate or renewable energy sources. This study seeks to offer a broad overview of the economic design consideration, practical implementation parameters, and interconnections of the key components of small hydropower plants for River Nnwankwo, in Ikot Ekpene local government area of Akwa Ibom State, Nigeria. The focus is to offer a foundational understanding of micro-hydro systems, planning, the advantages and limitations of micro-hydro energy estimation, which is a function of head and flow rate. If this exploitable source of energy could be harnessed using environmentally friendly technology, the entire energy situation in Ikot Ekpene sub urban which has a thriving population would be improved.

Keywords: Flow Rate; Hydroelectric Power; Pump Storage.

INTRODUCTION

Electric power is one of the ingredient which residential, industrial, and commercial consumers require. As most of the electric power supply targets have not been met, Nigeria's journey toward a sustainable electric power supply has been a protracted, somewhat strategic, but unremarkable process. Nigeria's generating system capacity continues to be irregular and unreliable and is unable to keep up with the rising load demand. Although the electricity sector has undergone significant reorganization, the initiatives do not appear to have an impact on the users' access to power. Thus, the establishment of effective damless mini and micro hydroelectric power plants that utilize the kinetic and partially potential energy of the water flow without the construction of dams is an urgent approach to be considered for small renewable energy. The most popular types of damless hydroelectric power plants are submersible, on floating pontoons, garland, and sleeve hydroelectric power plants. However,

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other designs are possible depending on the size of the river segment and the water flow rate. In Nigeria the potentials of small rivers that has potentials for small hydroelectric capabilities is clearly illustrated in table 2 (Ugwu et al., 2022; Kela et al., 2012; Okedu et al., 2020). On the hand, despite the drawbacks associated with them, such as the influence on the environment and the resource's steady depletion, more than 81% of the world's energy consumption originates from fossil fuels (Safarian et al., 2019). Despite the various forms of renewable energy, hydropower is one of the most efficient and dependable in terms of producing electricity globally, accounting for around 15.9% of worldwide electricity generation and 2.5% of the world's energy resource.as seen in table 3 and table 4 the energy access per capita in some African states is not adequate (Bozorg Haddad et al., 2011; Safarian et al., 2019).

. In a typical small hydroelectric power plant, to generate electricity, water must be in motion. When the water is falling by the force of gravity, its potential energy converts into kinetic energy. This kinetic energy of the flowing water turns blades or vanes in some hydraulic turbines, the form of energy is changed to mechanical energy. The turbine turns the generator rotor which then converts this mechanical energy into electrical energy and the system is called hydro-electric power station For run-of-river hydropower plants, a weir is often in charge of directing the river's water toward the intake.Usually, the water travels through a desilting tank before reaching the turbine. A canal might also transport water to a forebay, where it would subsequently be transported to a turbine by a penstock (Jung et al., 2021; Vougioukli, et al., 2017; Anaza et al., 2017; Jung et al., 2021). Nigeria is blessed with an abundance of natural resources, some of which may be quickly and inexpensively used to generate electricity, the energy type that is most commonly changed. Small hydropower resources are one of the ways the country generates electricity. Small rivers are used to produce hydroelectric power. A tiny river is generally understood to be one whose catchment area is less than 500 km2, or more specifically, less than 300 km2. Rivers, lakes, and streams with catchments smaller than 100 km2 are highly interesting from the perspective of minor hydropower production (Ebhota & Tabakov, 2018; Omojolaa & Oladejib, 2012). Today Ikot Ekpene has become a thriving metropolis that has experienced a surge in population and is in dire need of energy sources that can help ameliorate the epileptic power supply from public utility company (Udoh & Efiong, 2021). River Nnwankwo (aka inyang Nwankwo) untapped potentials is the focus of this research study in order harness its viability for small hydroelectric power (SHP) plant that can help generate energy for the needs of the ikot Ekpene sub urban inhabitants for the purposes ranging from irrigation for agriculture and other immediate power needs of the surrounding communities.

In accordance with FIG. 1, Ikot Ekpene is situated between latitudes 5° 10' and 5° 30' north of the equator and 7° 30' and 7° 45' east of the Greenwich Meridian. It is located on Akwa

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Ibom State's western flank. Its location makes it one of the Akwa Ibom State's economic entryways. Ikot Ekpene has a distinguished local government administration in Nigeria due to its transformation into a leading model in 1951. It shares a border with the local governments of Essien Udim, Obot Akara, and Ikono. The Ikot Ekpene Senatorial District, which now has 10 Local Government Areas, is headquartered in Ikot Ekpene. The wet season and the dry season, which define the study area's climate, alternate every year. The impact of excessive rainfall over evaporation is the amount of water that is available for surface water flow and groundwater recharge. Mid-November is when the dry season starts, and it lasts until March. For a brief time, the research region is covered by the entire continental tropical air mass, its accompanying north-easterly winds, and the accompanying dry and dusty harmattan haze. The mean annual temperature at Ikot Ekpene ranges from 26°C to 36°C all year round, making for extremely high temperature figures. The research area has relative humidity that fluctuates between 75% and 95%; the highest and lowest values are seen in July and January, respectively. According to Wokocha and Kamalu (2009), the research area's relief is typified by the coastal plain of southeast Nigeria

RESEARCH ELABORATIONS

The representation of mini and micro hydroelectric power facilities along a riverbed like that of River Unwankwo will require a substantial height difference which a pipe suffice. Water is drawn into the pipe from the stream in the top portion, where it enters the hydraulic unit in the lower portion as a result of gravity forces. The height difference is between two and three tens of meters. Such hydroelectric power stations should only be built on Mountain Rivers with a significant natural slope. They are quite efficient, but its construction necessitates high capital costs and has a bigger influence on the environment due to human activity. The most promising are small and mini damless hydroelectric power plants of the submersible type and hydroelectric power stations on floating pontoons with torsos or on pinholes for rivers with a small slope but with a flow velocity over 1 m/s. Although the power of these hydroelectric power plants often varies from several kW to 30–50 kW, and less frequently up to 100 kW, even these capacities may be adequate to supply electricity to small working camps, recreation facilities, or to operate a variety of independent telecommunication systems (Pandey & Kumar, 2015). There are numerous factors that need to be planned for and taken into account while designing a micro-hydroelectric power plant.

Getting solids out of the water before it enters the turbine is a crucial component of system design that is sometimes overlooked. If such a system is not put in place, the turbine may be damaged by sticks and stones and may perform worse due to leaves being stuck on the blades.

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This design's turbine will undoubtedly need cleaning at some point because it can never be completely removed.

These facilities, which are sometimes equated to batteries, store energy by pumping water via a penstock from a lower reservoir to a higher reservoir during periods of low power demand. The water is returned to the lower reservoir during periods of high demand, pushing the turbine to produce electricity. The greatest of these facilities, the Bad Creek Hydroelectric Station in Oconee County, South Carolina, which uses water from three artificial lakes to produce 1,065 MW of power is lower in capacity than its diversion and impoundment counterparts (Phillips et al.,2020).

From the dam or reservoir to the turbine, water is transported through the penstock. Materials, diameter, wall thickness, and joint style all describe a penstock; The material is chosen based on the terrain, ease of access, weight, jointing mechanism, and cost. The diameter is chosen to bring the amount of frictional losses inside the penstock down to a manageable level. The wall thickness is chosen to withstand the anticipated transient surge pressure as well as the highest internal hydraulic pressure.

RESULTS AND DISCUSSIONS

In a small hydroelectric power plant with respect to River Unwankwo, a penstock is a system of pipes used to move pressurized water from a reservoir (dam) to the turbines. Penstocks may be above or below ground and made of steel, reinforced or prestressed concrete, composite materials (fibreglass reinforced polyester, HDPE, etc.), or even cast iron, depending on the topography of the site and the technological options available at the time of their construction. Penstocks are designed to withstand the highest water pressure, particularly water hammer. In addition to being highly pricey, they are essential components of the water conductor system. Depending on the conditions at the site, the penstock may be put on the ground, embedded in concrete, or underground. The penstocks are equipped with extras such bell mouth intakes, expansion joints, manholes, matching components, and bends. The losses are estimated using the Darcy Weisbach Equation, and flow in the penstocks equals pipe flow (Kumar, 2022; Pandey & Kumar, 2015).

The vertical separation between the water surface level at the intake and tailrace for reaction turbines (like Francis and Kaplan turbines) and the nozzle level for impulse turbines (like Pelton, Turgo, and Cross-flow turbines) is known as the gross head (Hg). Modern electronic digital levels have a measurement accuracy of (0.4 mm) and automatically show height and distance in around (4) seconds. Global placement System (GPS) surveying is already common, and a handheld GPS receiver is perfect for preliminary mapping and field

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placement. The losses along its journey, such as open channel loss, trash rack loss, can be easily subtracted from the gross head to obtain the net head (Hn). Whenever the total amount of head is known, the net head (Hn) can be calculated by simply deducting any losses along the way, including friction loss in the penstock and losses from open channels, trash racks, intakes, and valves (Kumar, 2021; Samora et al., 2016; ESHA,2010).

The net head and maximum water flow rate, which must be defined by the river or stream where the turbine should be installed, influence the choice of turbine type, size, and speed. The maximum water flow capacity of the turbine must be calculated using the river or stream's flow duration curve since microhydroelectric power plants are typically constructed as run-of-the-river facilities. Plotting a flow duration curve, which displays for a specific spot on a river the percentage of time during which the discharge there equals or exceeds predefined values, is one method of organizing discharge data. It can be found in the hydro-graph if the data are arranged by magnitude rather than chronologically. The potential power of a stream can be estimated from the mean yearly flow. FDC can be created for specific time periods as well as specific years (Samora et al., 2016; ESHA, 2010).

CONCLUSIONS

As the demand for micro-hydro power increases globally, and the deteriorating power condition in Nigeria persist, it's critical to demonstrate to the public just how practical these systems are achievable in implementation of energy solutions when placed in the right environment. The sole prerequisites for microhydro power are water sources, turbines, generators, suitable design, and installation. This technology benefits everyone involved as well as the environment and globe at large. The available pressure head and water flow rate will be the major determining factors in the turbine selection. Impulse and reaction are the two primary modes of operation for a SHP. Water jets power impulse turbines, which are appropriate for high heads and low flow rates. Water-filled reaction turbines utilize the angular and linear velocity of the flowing water to run the rotor (usually at medium head). Controlled turbines can alter the amount of flow they pull by moving the inlet guide vanes or runner blades. For micro-hydro projects with a head of five meters or less and a water flow rate of one m3 per second or less, cross-flow turbines are seen to be the best option.

If this small hydropower plant is built using this natural resource (River Nwankwo), the community's electrical need will be permanently fixed and any extra energy will be added to the national grid. This would also lessen rural-urban migration, which occurs when farmers flee to metropolitan areas in pursuit of comfort. This lowers agricultural productivity, which could lead to a food shortfall. If investigated and implemented in Ikot Ekpene, a small

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hydropower plant will function superbly. There is need to explore other rivers in Akwa Ibom state that has similar characteristics like the one in this survey in order to build a formidable energy mix for the national grid.

ACKNOWLEDGEMENTS

Please acknowledge collaborators or anyone who has helped with the paper at the end of the text.

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