

## THE POTENTIAL OF HYDRO ENERGY AS THE RENEWABLE ENERGY ALTERNATIVES IN THE RURAL AREA

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**Abstract:** Hydro energy systems are broadly used around the world as renewable energy. The concept of hydro energy becomes the major energy alternative for fulfilling the energy demand, especially in the remote area. The type of micro-hydro power was the most applicable to meet electricity purposes. Micro hydropower system proposes an environment friendly used because of easy to operate and low operation cost, especially in the area which high water availability. This review paper focuses on the potential of hydro energy systems that are built in remote areas. This review revealed three types of hydropower systems, namely mini-hydropower, small hydro power, and micro hydro power. Out of these three types, micro hydro power can become the solution for electrification in remote areas. Micro hydro power installation was built with many types of technological approaches. Nevertheless, considering geographical purposes, the capacity of energy production, and sustainability of resources. Yet, several obstacles should be aware of such as power availability in remote areas. The technical issue and government support become the key to success in applying hydropower in the site of installation. Otherwise, conventional fossil fuel-based systems which are costly and unsustainable may require due to the operating system of micro-hydro power as well.

**Keywords:** Hydro energy, sustainability, micro hydropower, rural area

### INTRODUCTION

Energy is the most crucial part of life, especially in the household sector. The use of energy is increasingly widespread by humans so the need for energy continues to increase in various aspects of life, especially to drive the economic sector. Energy generation is a major factor that can affect social development and economic growth in almost all parts of the world [1]. Energy access, meanwhile, has been universally recognized as a major aspect of promoting socio-economic development in various parts of the world. In the era of sustainable development, the availability of clean, affordable, and modern energy is a condition that cannot be separated into various aspects of development [2].

The increasing use of fossil energy makes the availability of non-renewable energy decrease. Sources of decline in fossil fuels and environmental pollution concerns are pushing the factors to switch our generation sources for renewable energy. In the future, energy sources such as geothermal, biomass, solar, waves, and water can be the best alternative energy to meet energy needs within daily life. Among renewable energy resources, energy from water has gained the highest attraction because of operations that are environmentally friendly and do not require huge costs [3]. The use of renewable energy sources, for example, in large-scale electricity generation, is the best way to meet energy needs and reduce greenhouse gas emissions [4].

Nowadays, limited access to electricity is still the biggest problem in many parts of countries around the world. 14% of the world's population still faces these limitations in using electricity [5]. The

biggest factor in increasing the number of low electrification rates in rural areas, including remote areas to low population revenues due to the low income of the population. So, residents cannot install electricity. One solution to attribute this problem is to use Hydropower. Hydropower is an ancient electricity producer that implements the concept of a sustainable, feasible, inexpensive, and clean energy source. It is certainly very beneficial for people who have limited electricity, also supports many positive things like reducing air and water pollution and increasing local resources. Hydropower is considered one of the most ancient types of a sustainable, inexpensive, feasible, and clean source of energy. This provides many benefits for residents, such as reducing water and air pollution and increasing local resources [6]. Waterpower is believed to be more responsive containing management requirements. In addition, the resulting energy can be predicted compared to other power plants, because the hydropower plant can be directly managed and controlled by humans except in the case of a drought period [7]. The adoption of hydropower also took an important role in the economic and industrial development of the nineteenth century and even today remains an important factor in the development of low-carbon systems [8].

Hydropower has been used for more than one hundred years and is the most efficient and environmentally friendly renewable energy source [36]. Utilization of hydro power is predicted to reach 3606 TWh in 2020 of total global output in power plants [37]. Hydro power is categorized into various types, as described in Table 1.

**Table 1.** Types of hydro energy based on hydroelectric power generation capacity [12]

Type of hydro	Capacity range
Pico hydro	<5 kW
Micro-hydro	5 kW-100kW
Mini hydro	101 kW-2 MW
Small hydro	2001 kW-25 MW
Medium hydro	25001 kW-100MW
Large hydro	>100 MW

One of the hydroelectric power plants that can be installed in rural areas is the micro hydro system. Micro-hydro is very suitable to install because of its Eco-Sustainability and its wide application in the region, especially in rural areas [7]. Because rural areas have adequate water resources, the concept of micro-hydro is very suitable to be developed. Micro-hydro has proven to be the best supply choice compared to other renewable resources. Because the installation of micro-hydro systems is considered as the most economical choice for rural electrification [9]. There are many advantages of micro hydro power generation, including grid stability, reduced land requirements, good opportunities for technology exports, and economic development at the local scale [10].

This paper highlights the installation of micro-power plants in remote areas and describes micro-hydropower in contributing to the energy needs around this area, which have been implemented in several countries. Further reviews on the potential of micro hydropower plants as renewable energy sources in remote areas and the challenges and opportunities to promote renewable energy technologies are also included in this paper, followed by conclusions with recommendations for the development and adoption of renewable energy, especially micro hydro power plants.

## METHODS

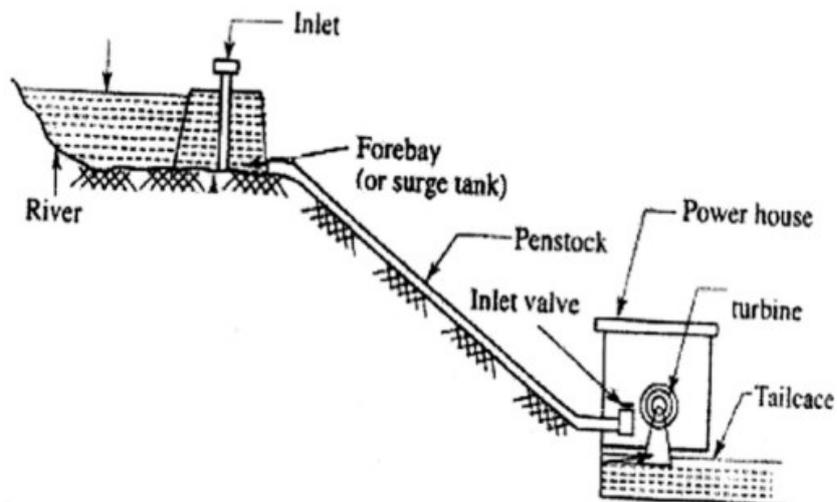
This article was prepared based on studies conducted through library research. This type of study utilizes primary, secondary, and tertiary library sources which can be obtained from libraries, both publications in paper form and computer files obtained from conventional libraries, online libraries, as well as publication indexing links from trusted publishers. Data analysis was carried out descriptively and narratively, namely by describing everything related to the object of study. The stages of literature analysis were carried out using qualitative analysis techniques, namely data collection, data reduction, data presentation, critical analysis and drawing conclusions.

## RESULT AND DISCUSSION

### 1. The potential of hydro-energy as a renewable energy source

There are several types of hydro energy that have been used to generate energy. For example, project several types of hydro energy have been used to produce energy as alternative energy. For example, a mini-hydro power plant project. This type of hydro energy is typically used in urban areas that are used to carry out potential green/blue infrastructure approaches to integrate flood risk management and renewable energy production [11]. Mini hydro is used by around 600 households for electricity. The use of mini hydro can increase the environmental value, ecology, and usefulness of the area. Because the approach and operating system are continuous. Besides reducing the risk of flooding. Mini hydro installations also apply to remote areas because the costs are relatively low and create new opportunities for rural and isolated communities. For urban and suburban areas, mini-hydro power can reduce the environmental impact of electricity production [8].

The second type of hydro energy is Small Hydro Power (SHP). This type of hydro energy is usually used in areas with hills and dense forest cover. In addition, some considerations regarding the application of SHP consist of isolation from the grid, transmission costs from the grid to the community, economic potential, population, and development goals [13]. Another type of hydro energy is micro-hydro power, which is mostly used in remote areas. Usually, micro hydro power uses flowing water to produce electricity using generators. When the energy generating capacity is 100 kW, it is considered as micro hydro power [14]. Micro hydro also has a flexible operation that allows the incorporation of other energy resources to produce hydrogen [15]. Micro-hydro power systems can also be used with channels connected to the channel. Electricity can be used to supply the burden of nearby villages and surplus energy will be put into the nearest 11-kV grid during rush hour. This system makes it possible to cover costs for 5 years [16]. Other micro-hydro power plants use turbines. It can produce more than 100 kW [17]. The installation of micro hydro power plants is shown on Figure 1.



**Figure. 1.** Micro hydro power plants' schematic

Micro-hydro power plants are usually installed where the mechanism does not depend on the public electricity supply network in very large quantities but supplies power to small groups of people, especially in remote areas. This is a relatively small resource that can be used to supply power to a small group of people. Fig. 1. shows a micro-hydro power scheme, where river water passes through the front tank and reaches the turbine. Turbines convert hydraulic power into mechanical energy and then that energy is converted into electrical energy by generators [18]. The hydraulic system consists of a valve control system, and it will be able to produce maximum power only if the gate valve remains fully open. The mechanical power generated is then entered into the electric unit consisting of a synchronous generator connected to the shaft to produce useful electrical power [19]. In addition, micro-hydro power can be the most affordable source of renewable energy over long distances due to multi-dimensional factors which include such as technical, economic, socio-cultural, institutional, and environmental [20].

## 2. The potential of micro-hydropower in Indonesia

Water has a very important role in humanity's survival in daily life for various aspects. In addition to meeting human needs, water can also be used as an energy source for power generation. Indonesia as a country that has abundant water resources has great potential in generating electricity from water sources both on a large and small scale [39]. However, according to data released by the Ministry of Energy and Mineral Resources, the use of water as an energy source in Indonesia has only reached around 6% of the existing potential, which is around 75.67 GW, and only about 4.2 GW has been utilized. In this case, the potential for mini/micro hydro development reaches around 450 MW, but only

about 230 MW has been utilized until 2008 [40]. PLTMH is a type of small-scale power plant (with a capacity of less than 100 kW) that uses hydropower as a source of propulsion, such as through irrigation canals, rivers, or waterfalls. PLTMH, which stands for Micro Hydro Power Plant, is one type of power plant that utilizes water as an energy source on a small scale. PLTMH operates by converting water discharge into electrical energy. Examples of water sources that can be used as MHP drivers include waterfalls, irrigation canals, and rivers [41]. The working principle of PLTMH is based on the utilization of potential water energy associated with the height of the waterfall (head) and water discharge. The higher the head, the greater the potential energy of water that can be converted into electrical energy [42].

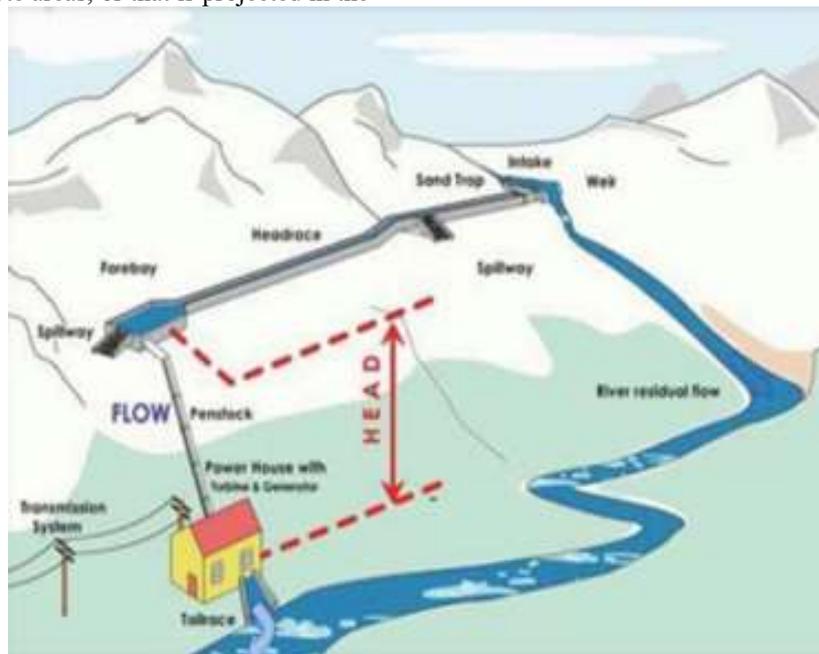
## 3. Micro-hydropower installation using multi-dimensions

The construction of a micro hydro power plant can overcome the problem of lack of electricity in remote areas. The development of power plants is classified into three categories, namely large-scale, mini, and micro. Micro-hydro power plants are one of the concepts of electricity generation that is produced through a turbine and air technology on a small scale. The application of the concept of micro-hydroelectric power can be useful for people who live in rural areas. For example, the use of micro-hydroelectric power plants has been installed in some remote areas in the country of Indonesia due to the availability of supporting water on small islands. However, for large-scale builders, the use of micro-hydroelectric power installations is not appropriate due to various environmental problems, and the energy capacity produced [21]. This small-scale power generation system (less than 200 kW) utilizes airflow energy, so micro-hydro is excellent to be developed.

Micro-hydro systems offer sufficient energy, especially for the lighting process in remote areas. Building a micro hydro power plant can preserve air resources, reduce climate change, and geothermal energy. Economically, operating costs are relatively cheap compared to using diesel generators. Meanwhile, according to [22], micro hydro power is more efficient than other renewable energy sources because it is environmentally friendly, and the installation process is quite simple and can be used in a relatively long time. Certainly, it depends on the resources in this water availability. The development of hydro energy does not require high costs like solar panels. Hydro Energy can be operated throughout the day, longer than solar power plants that can only be operated during the day. However, some of the results of the above report do not design long-term development of hydro energy, including data on energy generating capacity, although this is very important for the sustainability of needs in remote areas. The description of the design of hydro energy above is not suitable for electricity demand in remote areas, or that is projected in the

use of relatively large use in fast and long cycles. Due to a lack of power, it usually occurs during peak periods at night. [23] said that the design of micro-hydro energy into a very important part. [24] used a multi-dimensional method to develop hydro energy in more detail to see the potential in social, economic, and environmental aspects so that future hydro energy can be developed optimally.

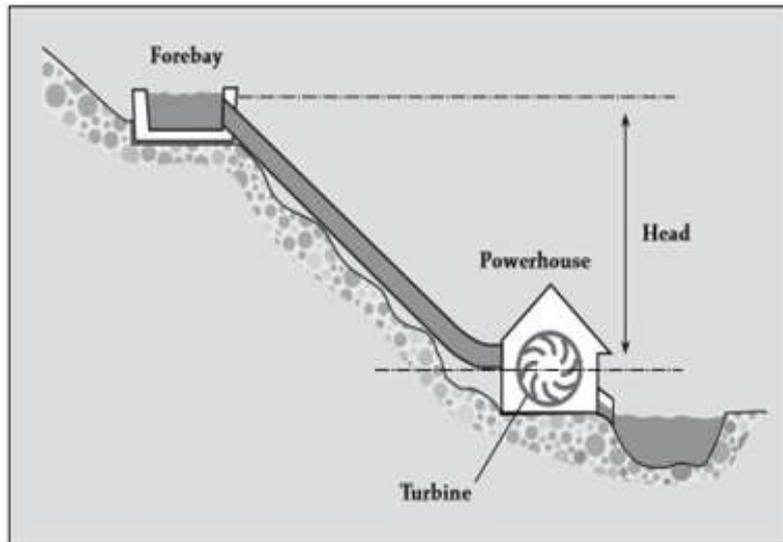
In principle, micro-hydro, uses different heights and the amount of exhaust air that is in the flow in irrigation channels, rivers, or waterfalls. [25] Airpower is obtained from energy obtained from the air that falls at a certain height or from a large volume. Therefore, high rainfall and high airflow can produce a lot of air powers. Airflow will be rotating the turbine shaft to provide mechanical energy. Energy is then transmitted to drive the generator and produce an electric current [26]. Some literature concerning hydro energy can be built with experimental methods with a variety of holistic and multi-dimensional approaches.



**Figure. 2.** Schematic of hydro energy system [27]

Hydro energy can be operated without any fuel. Besides, primary energy input in the form of mass water flow is not reduced, but only the energy used at a certain height is taken. The water flows to the river directly through the water carrier channel and then passes through the

penstock and ends at the turbine. After the turbine, water returns to the river, and only the energy that has been produced can be utilized because of deep cycles in the hydro energy system [28].



**Figure 3.** Water flow's process from a higher area to produce a certain power [29]

Some literature is related to energy development but does not explain Environmental factors, because hydro energy requires a supply of system energy without being related to the function of other components. [30] state the use of energy resources in the area can be used to

reduce carbon emissions and save the economy for a long time. Therefore, to ensure that everything is done, society, stakeholders, and the government must work together.



**Figure 4.** Sustainability aspects for developing hydropower.

Cheng et al. [22] reported that hydro energy is comparable to an electricity system that utilizes more than 65 million tons of coal energy and manages to save 167 tons of CO<sub>2</sub> emissions. China has proved that hydro energy has reduced the traditional way or the use of firewood for cooking so that the availability of wood to be maintained for more viable purposes. The campaign to replace fuel with solar or hydro power has made a major contribution to renewable energy for the community and the conservation of forest sustainability. Hydro energy in some countries can reduce 149 million m<sup>3</sup> of wood usage per year or about 65% of wood usage in a year. Therefore, hydro energy is the solution for forest destruction so far, it also makes energy savings and reduces carbon emissions.

**4. Micro hydropower in remote areas has been applied in many countries**

Regarding the increase of modernization, hydroelectric power becomes a great opportunity for green energy alternatives, for instance, global electricity was around 16% in 2010 and is expected to increase by 3.1% around the next 25 years. More than 150 countries rely on hydropower, and for part, Asia Pacific countries consumed about 32% of global hydropower in 2010 [29]. About 17% of domestic electricity demand in China came from hydroelectric power plants in 2010. In addition, hydropower sources produced 98-99% of electricity in Norway. Unlike Malaysia, about 42% of the land consists of plateaus, a total of 339 105 km<sup>2</sup>. From September to December and October to February, there is plenty of rainfall in western Malaysia around 2,500, and in East Malaysia 5,080. Heavy

rain and high-water heads produce large volumes of water that can produce hydropower energy [31].

Converting energy obtained from water into electricity can be used in remote areas of Malaysia that are converted using a micro-hydro system. This system is small, lean, and easy to control their efforts in the form of increased tariffs and availability of electricity [38]. Since July 2009, Micro-hydro has been built with a total of 30.3 MW, and the expected potential in 2020 is 490 MW [32].

Anyi [33] stated that micro-hydro power can become a good choice for rural communities in mountainous areas with high rainfall intensity such as Sarawak which is located adjacent to rivers flowing throughout the year; in a rural area, hydropower might be considered as a preference for electricity generation. In the use of solar energy systems and solar power, several things must be considered, especially for the installation process, and the steps that must be taken during extreme weather. At the same time, hydropower based on studies is very supportive in remote areas to fulfill electricity demand.

Pali [34] stated that self-installed photovoltaic pumping systems more often be compared with others in areas that are equipped with available networks needed. The community uses it to manage other basic needs as well as to fulfill electricity needs. It is used to pump air to the water store so that it can be used for public and household needs. The factory entertains the making of photovoltaic, pumped as turbines, using batteries, and burning diesel engines. Simulation optimization of the device size and factory management has been applied to get the best requirements.

Budiarso [35] revealed the new concept of small power plants isolated from the storage of hydro-pumped energy (PHES), wind is the main energy, specifically for areas that have replaced wells. It is suitable for use as a reservoir under the PHES system; water from the ground is stabilized and stored in a shelter above. A wind turbine uses a hydraulic pump to suck air from the well so that the function of the wind turbine is not to run an electric generator. This method is applied to operate Pico-hydro turbines and generators aiming to produce electricity. The appealing thing regarding this Scheme is that it is affordable, simple, and has a voltage energy board, even though the wind speed varies. In the unity of this system, both water storage in UR through electricity generation through hydropower and wind power take place simultaneously and continuously. Pico Hydro is the answer to improving the electrification ratio in remote areas.

## CONCLUSION

The use of micro hydro systems can overcome electricity shortages in remote areas. This technique does not require large production costs is environmentally friendly and is sustainable in the energy sector. This method utilizes the power of the air, which turns turbines in the air, which will produce hydropower. Hydro power will be converted into electrical energy. With hydro energy, especially micro hydro types, is the best solution for power generation, especially in areas located far away from the city. This is because there are many hydro power exists in waterways, rivers, and canals. Kinetic energy (due to flow) from this flow dapat diproses to produce electricity through hydrokinetic turbines. The availability of power plants in rural communities is a problem therefore many of them still rely on conventional fossil fuels that are expensive to meet daily needs and unsustainable to meet the needs of daily life. Some aspects to be considered installing micro systems in remote areas are the availability of water resources, the capacity to use energy and the technical requirements for installing power plants. Utilization of energy produced by the micro hydro system is not at a large capacity of usage it is recommended only for lighting purposes, if the user is in high amounts, the hydro energy system must be improved as well.

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