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# A technical discussion on microhydropower technology and its turbines

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ABSTRACT

Shortage of electricity supply and other forms of modern energy is serious in most of the developing countries, contributing to low economic and social development. The situation is worse in rural communities, which are often marginalised from grid-based electricity supply because of economic and technical reasons. Currently, development agencies involved in rural power supply in developing countries recommend microhydropower (MHP) as the most robust and reliable source of off-grid power generation. However, in scholarly articles, MHP technology is not popular compared to other renewable energy technologies. This may have contributed to its limited application in off-grid power supply in some countries. Availability of scholarly literature on MHP as the case with wind and solar energies can therefore help to scale-up the level of discourse on the technology among both technical and non-technical stakeholders.

In this paper, the MHP technology has been reviewed in general and the turbines in particular. General description of the technology including challenges and factors for successful implementation of the technology has been given. It has been found that technological issues are among the major challenges and that the turbine is one of the critical technological components of the MHP project. The paper has reviewed common MHP turbines, focusing on their operating principles, merits and demerits with respect to MHP and suitable operating conditions. Factors to consider when selecting suitable turbine for the site and procedure for selecting the turbine have also been outlined in the paper. The paper has been written in a tutorial manner so that the discussions therein, though technical, are shared with stakeholders of different professional backgrounds. It is hoped that the paper provides additional knowledge on MHP technology and in particular on turbines that are used in MHP supply. This can lead to better practical implementation of the technology.



**Contents**



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## 1. Introduction

There is shortage of electricity supply and other forms of modern energy in most of the developing countries. Sub-Sahara African region is the worst hit, yet the region is endowed with several resources from which modern forms of energy can be generated, for example hydropower [1]. Lack of capacity to exploit natural resources into modern forms of energy as well as limitations in industrial application of the generated energy may explain the reasons for the shortage of energy supply. In most of the developing countries, shortage of electricity is worse in rural communities who are often marginalised from grid-based electricity supply due to economic and technical reasons. Currently, the requirement for inclusive national economic growth and development has heightened the importance of rural electrification. Rural electrification is achieved through grid extension (on-grid), mini-grid and isolated individual home power systems.

On-grid rural electrification is generally expensive. Sparseness of rural settlements and difficult terrain, in most cases, prohibitively increase the transmission costs of on-grid rural electrification projects. Therefore, it is not a surprise to note that most governments and international development organisations have prioritized on mini-grid and isolated individual home power systems for rural electrification.

In countries with perennial rivers in mountainous topography, microhydropower (MHP) is one of the recommended technologies for rural electrification using mini-grid system, for example in Nepal [2]. Microhydropower technology uses water in a stream that flows through a head to generate power when the water turns a turbine (detailed in Section 2.1). MHP is a well-tested technology and some of the developed nations once relied upon it for power supply before venturing into large-scale hydropower systems. Currently, some emerging economies like China, India and Brazil use the technology to supplement their grid-based electricity supply. In many developing countries, the emergence of energy reform programmes and incentives for promotion of renewable energy technologies has created a favourable environment for development of MHP technology.

### 1.1. *Some advantages and challenges of microhydropower technology*

In comparison with solar PV system of the same investment cost, MHP plant is robust to supply diverse power requirements of a typical rural community. The power requirements can be for household, institutional and small-scale industrial purposes. On this basis, international organisations such as Practical Action and United Nations Industrial Development Organisation recommend MHP technology as one of best off-grid electricity supply technologies. MHP is also one of the most efficient, long lasting and reliable forms of renewable energy for electricity generation [3]. For a well-installed and maintained system, the operating life of the MHP plant may reach up to 50 years [4]. Unlike solar PV and wind energy systems, the MHP favours local participation. Practical Action, a charitable organisation that has some involvements in alternative energy supply in developing countries, states that MHP standout as the most adaptable technology to the local conditions and that the technology has great potential for sustainability [5].

MHP is a renewable energy technology because the energy resource ‘falling water’ is replenishable as the fuel (falling water) is part of the hydrological cycle. The MHP project is not associated with significant environmental degradation because of reduced levels of construction activities and negligible capacity of water impoundment. This is one of the major advantages of MHP systems over large-scale hydropower projects. In addition, being a form of renewable energy with no gaseous emissions, MHP systems are among the options for climate change mitigation and therefore, they are candidates for international carbon trading opportunities such as the Clean Development Mechanism.

Previously, the MHP technology was relatively expensive, partly because of its expensive system components like mechanical-hydraulic power governing system, penstock and turbine. Currently, with the advent of low cost electronic load controllers, use of cheap PVC penstocks and availability of low cost turbines, the investment cost of the MHP system has been reduced significantly. With no direct energy cost and minimum maintenance and operation costs, the life cycle cost of MHP are lower than other alternative energy sources such as portable petroleum oil fired electric generators (gensets).

Despite the availability of MHP potential in many developing countries, level of MHP development is still low compared to other renewable energy technologies. Technological challenges are some of the reasons for the underdevelopment of the technology. In the case of sub-Saharan Africa, Klunne [6] observes that lack of ability to locally manufacture critical system components such as turbines is considered is one of the major technological challenges. An increase in availability of technical scholarly literature on MHP technology, as it is with wind and solar energies, can help scale-up the level of discourse on the technology among both technical and non-technical stakeholders. This can help to scale-up the level of MHP development in countries that have the potential.

As already stated, turbine is one of the critical components of the MHP plant. In fact, dissemination of MHP technology is largely centred on the development of low-cost turbines. In addition, choice of turbines can affect economic and technical performance of the MHP project. Development of low-cost turbines have largely been championed by charitable non-governmental organisations, such as the GTZ and Practical Action. To the knowledge of the authors, these organisations are not involved in scholarly publications. In addition, most of the reported studies on microhydropower do not have comprehensive reviews on turbines. As such, technical information on MHP turbines is relatively deficient in scholarly literature. It is important, therefore, to review the MHP turbines to contribute on the existing MHP knowledge.