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Microhydro: Cost-effective, modular systems for low heads

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Abstract

This paper is an overview of a program that is in the final stages of developing a modular set of cost-effective microhydro schemes for site heads below those currently serviced by Pelton Wheels. The rationale has been that there is a multitude of viable low-head sites in isolated areas where microhydro is a realistic energy option, and where conventional economics are not appropriate, especially in Third World countries. The goals of this project have been to provide low-cost, soundly based turbine design solutions that systematically cover the 0.2–20 kW supply, that are uniquely resistant to debris blockage and are easily built by tradesmen of medium skills in regional workshops. The paper presents the results as a matrix of the most cost-effective penstocks matched to modular turbines using established electronic controls. It discusses practical issues of site selection and options for sites where exact matches are not achieved. It has been an object of the program to establish a benchmark for cost-effectiveness in the microhydro field.

Keywords: Microhydro; Hydro power; Renewable energy; Home energy; Low head; Remote power generation

1. Introduction

Hydroelectricity generation as a renewable energy source gives the serviced community independence from the world's fossil fuel fluctuations. While many of the larger hydro opportunities have already been tapped, there remain a multitude of smaller sites, often in the Third World countries, that are normally considered uneconomic to develop. It is frequently the case, however, that isolated families or communities would be quite prepared to raise funds, or undertake site works, installation and other aspects themselves. The biggest barrier is, that at this small scale, developing a custom system using consultants is prohibitively expensive [1,2]. For these reasons, the NZERDC in 1981 recommended the development of a locally made range of high- and low-head water turbines ([1], recommendation 4).

This program, ongoing since that time (e.g., Refs. [3,4]), has set out to address the recommendation. It provides designs for cost-effective microhydro systems, organized into a systematic range, from which the most appropriate modules can be selected for a given site.

This does not negate the need for proper site assessment, careful installation and professional commissioning. But it assures the site engineer of a proven, low-cost system if indeed the site is a viable one.

Microhydro is typically below about 20 kW. Above 25 kW is the "mini-hydro" realm, where the scale of investment is such that professional input is proportionally smaller and there is some advantage in building custom-made systems. The area of particular interest for the project discussed here is at heads and specific speeds below those of the Pelton wheel, where a number of solutions are already available (e.g., Ref. [5]). The scope for this project is shown in Fig. 1.

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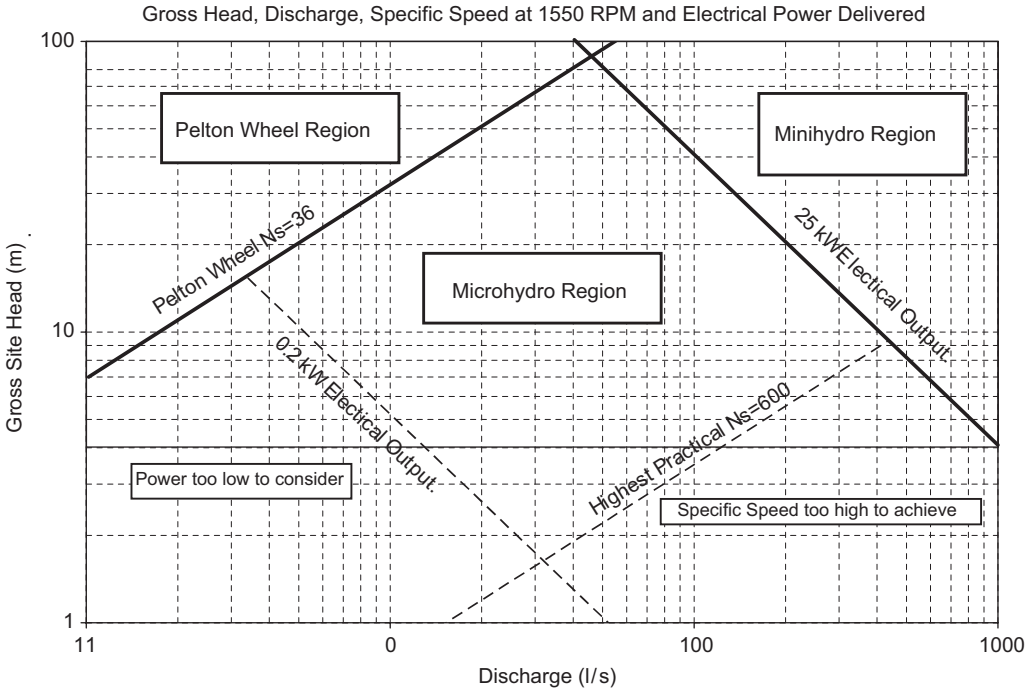

Fig. 1. The site head and discharge ranges defining the microhydro region.

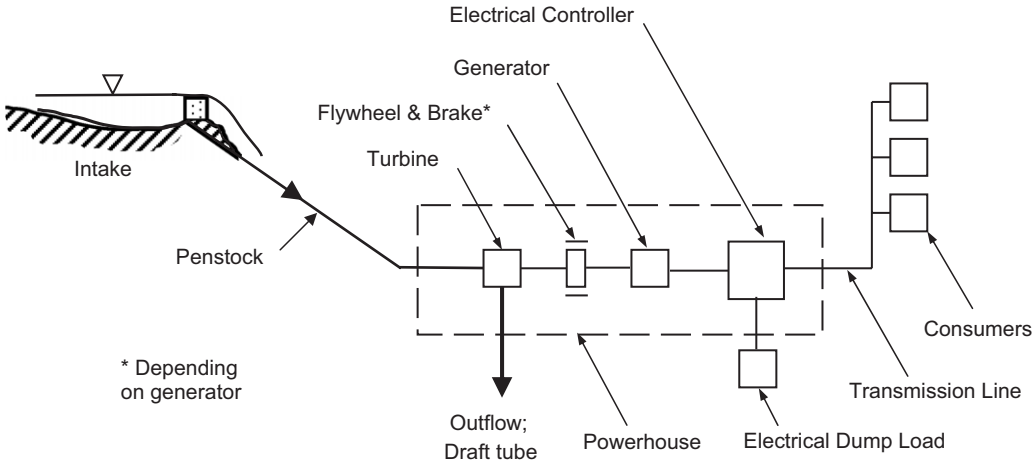

Fig. 2. Components of a typical medium-head microhydro installation.

2. Goals of this project

The goals of this project were to:

- Provide soundly based design solutions that systematically cover the 0.2 to 20 kW supply in this neglected lower-head area.
- Provide efficient turbine designs that are uniquely resistant to debris blockage, and easily built by tradesmen of medium skills in regional workshops.
- Provide modular component designs that are compatible across a range of schemes.
- An operation strategy that runs the machinery full time at maximum capacity and peak efficiency, requiring no hydraulic controls or guide vanes.
- Simple electrical and electronic management systems that deliver continuously at the 230 V and 50 Hz standard, without batteries or inverters.
- Provide the most economical solutions for all components consistent with long term, reliable operation.

The microhydro schemes proposed in this project are generally "run of the river" meaning they do not have a dam, but simply pipe water from an intake in the stream,