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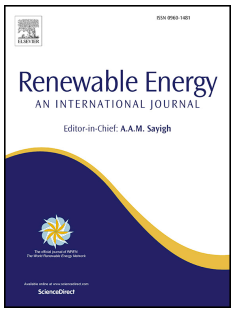

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A. Tapia, P. Millán, F. Gómez-Estern

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Integer programming to optimize Micro-Hydro Power Plants for generic river profiles

A. Tapia[a], P. Millán[a], F. Gómez-Estern[a]

[a] *Universidad Loyola Andalucía, Departamento de Ingeniería, Sevilla, Spain*

Abstract

This paper addresses the problem of designing an optimal micro-hydro power installation in rivers with generic profiles, when micro-hydro schemes are studied. This is geared towards the application of Micro-Hydro Power Plants to supply marginal isolated areas using small Pelton wheels, where both technology and resources are limited. For this purpose, a model of a Pelton micro-hydro plant is first developed. Subsequently, a discretization of the river profile is made, on the basis of which a set of integer variables are proposed, being the model transformed then into an integer optimization problem. Finally, the effectiveness of the proposed method is showed through a specific design problem. The application of the developed method is especially interesting when designing micro-hydro plants to provide electricity to isolated populations, where both technology and resources are limited.

Keywords: integer programming, micro-hydro power plants, penstock optimization

1. Introduction

Hydropower is one of the oldest renewable energy sources used to generate electrical power, whereby it has established itself as the most frequently used one around the world, providing 19% of the planet's electricity [1], and also the most efficient one [2]. By virtue of the versatility of the modern water turbines, this energy source is suitable not just for mass energy supply, but also for the supply of small isolated areas, where due to geographic or economical issues, electricity grid access is not available [3] [4]. In this context, renewable energy technologies can make an important contribution to solving the basic energy needs with a minimal impact. Although several technologies, such as photovoltaic [5], wind [6] and bio-mass [7] systems, are succesfully used within this purpose, Micro-hydro Power Plants (MHPP) have been proved as the most affordable method of dealing with energy poverty [8] [9], being considered the cheapest option for off-grid pico generation [10]. Although mass manufactured propeller systems, like Pelton and Turgo wheels [8] [11] and Francis turbines, represent the usual equipment in MHPP [12] [13], pumps working as turbines (PAT) [14] [15], and locally made systems are also a frequent option.

Notwithstanding the above, there are some challenges posed by the typical context of these micro hydro installations. The limited resources, together with the lack of qualified manpower, can cause that the available resources are not used in the most efficient way, in particular, due to the decisions related to the design of the plant and its most relevant parameters, that are mostly based on experience and know-how. For all this, the development of automatic design tools is particulary important, much more so when important factors are usually neglected.

The emplacement of the turbine and the dam, together with the penstock layout is particularly relevant, since its influence on the plant performance and cost is clear [16]. However, this problem has received little attention in the related literature [17] [18] [19].

Email addresses: atapia@uloyola.es (A. Tapia), pmillan@uloyola.es (P. Millán), fgomezestern@uloyola.es (F. Gómez-Estern)