



International Conference on Sustainable Design, Engineering and Construction

## Developing Sustainable Infrastructure for Small Hydro Power Plants through Clean Development Mechanisms in Colombia

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### Abstract

Developing sustainable infrastructure projects in Colombia requires special instruments leading to implementing Clean Development Mechanisms (CDM). For this reason, different financing alternatives to traditional methods for developing Small hydropower (SHP) projects should be evaluated. This analysis shows the country's potential for developing SHP projects thanks to the numerous mighty rivers that generate electrical power. Furthermore, CDM is a globally used method to finance SHP projects. Hence, this paper proposes that the Colombian domestic demand could be met through these projects. The large hydropower plants, besides complementing the domestic demand, can export the remnant power. Additionally, the SHPs development cycle, particularly their financial phase is also analyzed. The results of this study show that sustainable funding mechanisms encourage the development of infrastructure in Colombia. Also, CDM would increase the development of power generating projects and these can be used in other sectors such as water, waste management, and highways.

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Peer-review under responsibility of the organizing committee of ICSDEC 2016

*Keywords:* Sustainable Infrastructure; Clean Development Mechanism (CDM); Small Hydro Power (SPH).

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## 1. Introduction

Power is an important factor for the economic development of countries and its demand increases day by day. All human activities are directly linked to the use of power; it fulfills our basic needs. The annual total greenhouse gas (GHG) emissions derived from the global energy supply sector continues to increase. Combustion of fossil fuels still dominates the global energy market that is striving to meet the ever-increasing demand for heat, electricity and transport fuels [1].

In order to fulfill the current human needs, 81.3% of the energy used on the planet is generated from the burning of fossil fuels, being petroleum, natural gas, and coal the main sources. It is known that this type of power generation has resulted in the emission of greenhouse gases (GHGs) and that the accumulation of pollutants in the atmosphere is one of the causes of the climate changes observed [2]. According to this framework, the Kyoto Protocol (KP) has encouraged CDM aiming at two precise objectives:

The first one is to help the countries listed in Annex I (developed countries with transition market economies that signed the Kyoto Protocol) fulfill their KP commitment. The second one seeks for guaranteeing the transfer of environmentally sound technologies to the developing countries through the establishment of CDM projects from the most advanced nations leading to create benefit and encourage sustainable development in the developing countries. When a company considers a CDM project as a source of revenue and business feasibility, the ultimate goals of this project are issuing and trading CERs [3].

Several authors have discussed the transition from the traditional power systems to the renewable power ones through CDM projects as well as their social, economic and environmental effects. They have proved total emission reductions as a result of implementing renewable power systems in remote zones [4], [5], [6], [7], [8]. Any SHP, depending on its implementation details, may be configured as a CDM, since it is an alternative for the generation of clean, renewable electrical energy [3]. Also, several authors argue that SHPs cause little or no environmental effect, and might be considered as sources of clean energy [9]. According to Purohit [10], small hydropower projects could be of interest under the CDM because they directly displace greenhouse gas emissions while contributing to the sustainable rural development, if developed correctly.

On the other hand, other researchers like [3], [11], [12], [13] have assessed small hydropower projects as eligible for GHG emission reduction. It has been shown that renewable power technologies such as SHP can contribute to global sustainability through GHG mitigation [6], [14]. Additionally, other studies conducted in developing countries have shown that investments in more efficient technologies, the sound use of energy and the substitution of fossil fuels by renewable ones actually reduce the emissions of greenhouse gases.

Since SHP projects represent a significant source of renewable energy, which reduces GHG emissions, it is conceivable to find an opportunity for development in the CDM market; this increases the interest of investors [15]. Colombia and particularly, the Antioquia region present a substantial, high quality hydroelectric potential thanks to the combination of its natural waterfalls, mighty rivers and stable geological conditions [14]. Likewise, it presents an acceptable electrical connectivity that assists the transfer of power as well as road infrastructure. This fact grants access to the zones where these kinds of projects are established. These characteristics make Antioquia's power plants suitable for developing sustainability and obtaining benefits from carbon credits without negatively affecting the environment. Given this scenario, SHPs constitute a major opportunity for sustainable development in this nation.

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