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Technical note

The importance of clean development mechanism for small hydro power plants

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ABSTRACT

The present study sought to examine the importance of CDM for the implementation of small hydro in Brazil, assessing its advantages, disadvantages and limitations. An analysis of official documents of all SHPs in activity, under construction, and approved in Brazil was performed, including all existing CDM projects for small hydro in the country. A sensitivity analysis was performed to determine the point of zero net loss for CDM SHP projects, considering: minimum, maximum, and average Certified Emission Reduction (CER) values; minimum, maximum, and average costs of CDM project development, both for small and large scale activity; and variations in the internal rate of return (IRR). The main conclusion was that CDM for SHP in Brazil cannot be considered a subsidy for implementation of these projects, but may increase their revenue. It was found that, among the 431 SHPs which became active in the country since 2001, 339 did not implement CDM projects, suggesting that the importance of this mechanism as an incentive was uncertain. It was also found, under the investigated conditions, that investment in a CDM project requires a minimum installed capacity of approximately 11 MW to minimize the risks related to economic return. The variation in the value of the CER is more important than the variation of the Weighted Average Cost of Capital (WACC), as verified through sensitivity analysis. It was also found that CDM projects of large-scale activity, as well as small hydro projects in isolated systems, have a lower risk compared to small-scale projects which belong to the NIS (National Interconnected System).

1. Introduction

Energy is an essential input for economic development and its demand is increasing worldwide. Human activities are directly related to the use of energy, with per capita consumption being used as an indicator of economic and social development, and developed countries showing a significantly higher energy consumption than developing countries.

In order to fulfill current human needs, 81.3% of the energy used on the planet is generated from the burning of fossil fuels, with petroleum, natural gas and coal being 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 probable causes of the climate changes that have been observed [1].

Brazil has a privileged potential for hydro electricity generation: 78.2% of the electricity generated in the country originates from hydro. In 2010 Brazil was the second largest producer of hydropower in the planet, with 403 TWh, taking second place to China's 722 TWh. Considering installed capacity, Brazil's 79 GW takes third place, behind China, with 171 GW, and the US, with 100 GW. Finally, considering the hydro share in total domestic electricity generation, Brazil comes second, with 78.2%, behind Norway, which has 94.7% of its domestic electricity generated by hydropower [2].

Brazil has been making new investments to expand its hydroelectric generation. Currently, more than 18.8 TWh are under construction, 11.2 TWh of which correspond to Belo Monte plant [3].

Under this scenario, the generation of energy from renewable sources such as hydropower, Small Hydro Power (SHP), biomass, wind, tidal and solar have become important to continue the development process, supplying the growing demand for energy, with the advantage of offering "cleaner" energy.

There are currently two main incentive mechanisms for SHP projects in Brazil. The Clean Development Mechanism (CDM), which is international in scope, and the Incentive Program for Alternative Electric Energy Sources (PROINFA). The first is a global

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Table 1
SHPs with CDM projects and the situation of these enterprises according to ANEEL [5].

Status	Number	%	Power granted	Power %
Active SHPs	68	73.9	986.4	78.9
SHPs under Construction	9	9.8	118.0	9.4
Granted SHPs	11	12.0	119.3	9.5
SHPs without registration at ANEEL	4	4.3	26.9	2.2
Total	**92**	**100**	**1250.6**	**100**

Table 3
Emissions of CERs from CDM projects for power plants in Brazil in the period between the years 2008 and 2010.

CER issuance request at the UNFCCC	tCO_2
Previous periods	2,870,346
Issued for the current period	226,152
Request for Review	345,712
Total	**3,442,210**

solution established in Article 12 of the Kyoto Protocol, and the latter was implemented through Brazilian Law No. 10,438, in 2002.

The Clean Development Mechanism (CDM), created by the Kyoto Protocol to promote climate change mitigation, might help increase investor interest in SHPs. CDM projects enable the reduction of GHG emissions to be converted into carbon credits which can be traded in international markets. This may foster investment in SHPs, increasing their financial attractiveness, and drawing the attention of energy sector investors in the country. The usually small profitability of a SHP can be used to prove the additionality of the associated CDM project, demonstrating that an economically feasible project may obtain CERs.

A SHP, depending on details of project implementation, may be configured as a CDM, since it is an alternative for the generation of clean, renewable electric energy. Although several authors argue that SHPs cause little or no environmental impact, and might be considered a source of clean energy, Abbasi and Abbasi [4] found that, by considering the environmental impacts per kilowatt of power generated, SHPs cause environmental impacts no less significant than those of large centralized plants.

In this context, the current study investigates whether CDM can influence the outlook of SHPs in Brazil, based on official documents published by the Brazilian National Agency of Electric Energy (ANEEL), the Ministry of Science, Technology and Innovation (MCTI), the Ministry of Mines and Energy (MME), and the CDM Executive Board (UNFCCC).

2. Small hydro as CDM in Brazil

The Designated National Authority shows 51 PDD records for CDM projects involving 92 SHPs. These represent only 22% of the power of the SHPs in operation, construction and granted in the country since 2001.

As shown in Table 1, 68 SHPs with CDM projects are in operation generating “cleaner” energy, by reducing GHG emissions to the atmosphere, thus contributing to sustainable development. The projects listed as “under construction” and “granted” still have a long wait until RCEs may be issued, since GHG emission reductions must be verified after operation starts.

Regarding the regional distribution of SHPs with CDM projects in Brazil, the Southeast shows the highest number, with 36 projects, followed by the South with 26, Midwest with 22, North with 7, and Northeast with only one. Table 2 shows that there is not a perfect correlation between the number of SHPs in a region and the number of CDM projects, since the South presents the highest percentage of the SHPs in the country, but the second lowest regional percentage of SHPs with CDM projects The North region contains only 4.9% of the country’s SHPs with CDM projects, but, from a regional perspective, 33.3% of SHPs have CDM projects [5].

The South could have a wider participation in both the number of SHPs and CDM projects, but governmental bureaucracy at the State of Paraná has prevented or delayed several projects. The public administration of the state, by suspending the environmental licenses for such projects since 2003, prevented 137 SHPs to be installed in the state in recent years, holding back the sector and causing irreparable losses for entrepreneurs and for the State of Paraná [6].

Among the 92 SHPs with CDM project, 83 are part of the National Interconnected System distribution network, and only 9 are operating in isolated systems, seven in the North and two in the Midwest region, where they were installed to supply local demand and replace thermoelectric, diesel burning, plants.

The UNFCCC Executive Board, which is responsible for issuing Certificate of Reduced Emissions (CERs), received applications from 41 Brazilian projects, 36 among which were approved, 2 were not, 2 were withdrawn by the proponents and 1 is under review. According to the UNFCCC (2011) [7], the Executive Council could not conclude that the additionality of the project activity had been demonstrated in accordance to the requirements of the board. The subjectivity of proving the additionality of SHP CDM projects in the Indian Himalayas was approached by Tanwar [8], who conclude that current tools for proving additionality are difficult to use in real field conditions.

CDM and PROINFA are incentive programs for small hydropower projects. However, by opting for CDM, the investor foregoes PROINFA, since the latter hands partial project CDM rights to ELETROBRAS. Since PROINFA guarantees only part of the power generation of the enterprise, the investor may still apply for CDM on the percentage that is not assured.

Between January 2005 and July 2011, 67 SHPs which started operating in Brazil did not participate in any of these programs. Considering the 49 SHPs with PROINFA, the total reaches 116 SHPs potentially suitable for CDM application. At the time data was collected for analysis in the present study there were no CDM projects for SHPs proposed by ELETROBRAS at CIMGC nor at the UNFCCC.

Large scale CDM SHPs show an average of 38.7 MW per project, exceeding the 30 MW limit for a SHP, since CDM projects may include more than one SHP. Small-scale projects have an average 9.7 MW per project. Large scale projects have the advantage of

Table 2
Regional distribution of SHPs in Brazil since 2001.

Region	SHPs without CDM	% SHPs CDM in the region without CDM	SHPs with CDM	% SHPs with CDM in the country	Number of SHPs in the region	% total SHPs in the country
South	126	82.9	26	28.3	152	35.6
Southeast	98	73.1	36	39.1	134	31.4
Midwest	81	78.6	22	23.9	103	24.1
North	14	66.7	7	7.6	21	4.9
Northeast	16	94.1	1	1.1	17	4.0
Total	335		92	100.0%	427	100.0%