The PROINFA Contribution for CO_2 Emission Reduction

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Abstract

The aim of the present paper is to determine the contribution of the wind power projects in PROINFA for the CO_2 emission reduction. The governmental Program of Incentive for Alternative Sources of Energy (PROINFA) intends to install 3,300 MW of renewable energy, with 1,100 MW of wind energy. Two states in the Northeast Region (Ceará and Rio Grande do Norte) and two states in the South Region (Rio Grande do Sul and Santa Catarina) have reached the limit per state of 20% of the total wind power capacity to be installed. The operation is to begin in December 2006.

1. Introduction

The Kyoto Protocol was adopted at the Third Session of the Conference of the Parties in Kyoto, Japan on December 11^{th}, 1997; the protocol will enter into force when not less than 55 Parties to the Convention, accounting for at least 55 percent of the 1990 total CO_2 emissions of the Annex I Parties (OECD countries and countries that are undergoing the process of transition to a market economy), have ratified the Protocol. The overall emission reduction target for Annex I Parties as a group is at least 5 percent below 1990 levels to be achieved by the commitment period 2008 to 2012.
As a flexibility mechanism, the Clean Development Mechanism (CDM) was proposed to assist Parties not included in Annex I (developing countries) in achieving sustainable development and to assist Annex I countries in achieving compliance with their emission reduction commitments. In this way, there is the possibility of trading the emission commitment of individual countries, sectors and companies.

Renewable energy can play an important role in meeting the goal of replacing large parts of fossil fuels. As an example, the European Commission, in its White Paper on Renewable Sources of Energy, set the goal for wind energy of 40 GW of installed capacity in 2010, which could produce 80 TWh/y of electricity and save 72 million tonnes/y of CO_2 per year [REW, 2000]. In the developing countries, wind energy converters, characterized for a low impact on the environment, can play a great role in order to achieve low-carbon intensive energy systems to supply the increasing energy demand [Carvalho, 2003].
With the regulation of the Program of Incentive for Alternative Sources of Energy (PROINFA) on March 2004, Brazil starts to regulate the forms of investments for obtaining energy through three forms of alternative sources: wind, biomass and small hydroelectric plants. The governmental Program intends to install 3,300 MW of renewable energy, with 1,100 MW of wind energy. Through PROINFA, the country can avoid a significant emission of CO_2 in the atmosphere [PROINFA].

2. PROINFA Wind Parks and Co_2 Emission Reduction

The PROINFA has, as a criteria to avoid concentration, a limit per state of 20% of the total wind power capacity to be installed. As can be seen in Table 1, 2 states in the Northeast Region (Ceará and Rio Grande do Norte) and 2 states in the South Region (Rio Grande do Sul and Santa Catarina) have reached this limit.

Table 1: Distribution per Brazilian state of the PROINFA wind parks

State	Power (MW)
Paraíba	0.35
Pernambuco	27.55
Bahia	192.1
Ceará	220.0
Rio Grande do Norte	220.0
Rio Grande do Sul	220.0
Santa Catarina	220.0
TOTAL	**1,100.0**

The estimation of the annual energy production by wind parks is now made for the states of Ceará and Rio Grande do Norte. As described in table 1, these two states are responsible for 40% (440 MW) of the PROINFA wind power plants.
The methodology is based on the energy model worksheet of the RETScreen International software. The core of the tool consists of standardized and integrated renewable energy project analysis software that can be used worldwide to evaluate the energy production, life-cycle costs and greenhouse-gas emission reductions for various types of renewable energy technologies [RETSCREEN].
The number of wind turbines is related with the to be installed power in the states. A nominal power of 1.5 MW per turbine was considered. That leads to the use of approximately 293 turbines. This value and other input data used in the software are listed in table 2.

Table 2: Input data used in RETScreen

Input data	Value
Annual average wind speed*	9.3 m/s
Height of wind measurement*	40 m
Shape factor	4.0
Wind shear exponent	0.13
Average atmospheric pressure	101.3 kPa
Annual average temperature	27ºC
Grid type	Central-grid
Number of turbines	293
Array losses	15%
Airfoil soiling losses	5%
Other downtime losses	5%
Miscellaneous losses	5%

* [Governo do Ceará, 2000]

The array losses are caused by the interaction of the wind turbines with each other through their wakes. The airfoil soiling losses are caused by soiling of the blades, e.g. from insects. Accumulation of such detritus affects the aerodynamic performance of the blades.

The other downtime losses are the result of scheduled maintenance, wind turbine failures, station outage and utility outage. The miscellaneous losses represent losses of energy production due to starts and stops, off-yaw operation, high wind and cut-outs from wind gusts; they also include any parasitic power requirements and any transmission line losses from the wind energy project site to the local distribution grid.

Considering adjustments due to local pressure and temperature, and reduction due to losses, the annual renewable energy delivered is 980 GWh/y. Considering transmission and distribution losses of 10%, electricity generation of 882 GWh/y is determined for wind power.
Using the RETScreen greenhouse gases (GHG) emission reduction analysis worksheet, a natural gas power plant is considered as a reference electricity system to be displaced by the PROINFA wind parks, so giving the main data as listed in table 3.

Table 3: Main data of the natural gas power plant to be displaced (reference case)

Fuel type	**Natural gas**
CO_2 emission factor	56.1 kg/GJ
CH_4 emission factor	0.003 kg/GJ
NO_2 emission factor	0.001 kg/GJ
Fuel conversion efficiency	45%
Transmission and distribution losses	10%
GHG emission factor	502 kg CO_2/MWh

With the values of the end-use annual electricity delivered by the wind parks (882 GWh/y) and the GHG emission factor of the natural gas power plant (502 kg CO_2/MWh), a GHG emission reduction of 443 x 10^3 tonnes/y of CO_2.
Carbon trading prices of CO_2 may vary from US$ 0.25/ tonne up to US$ 10/ tonne, depending on the quality of the emission reduction and the requirements of the buyer [Drummond, 2002]. Considering a price scenario with the ton of CO_2 remaining below US$ 10, a maximal value of US$ 44 millions per year is expected for participants in GHG emission markets in the Brazilian states of Ceará and Rio Grande do Norte.

3. Conclusion

The Brazilian energy matrix profile is changing, due both to the lack of potential for new large hydropower plants and to national economic and social development. Simultaneously, urgent measures are needed for a reduction in carbon emissions worldwide. Therefore, the Clean Development Mechanism (CDM) can be useful for developing countries to achieve sustainable development. In the case of Brazil, a challenge for the future is to deal simultaneously with the supply of the country's growing energy demand and issues affecting domestic policies with respect to local environmental problems and GHG emissions.

The Brazilian States of Ceará and Rio Grande do Norte concentrate the greatest wind energy potential in the country, being responsible for 40% (440 MW) of the PROINFA wind power plants. As a scenario, generation by the wind parks of 882 GWh/y and a annual GHG emission reduction of 443 x 10^3 tonnes/y of CO_2; that means a maximal value of US$ 44 million/y for participants in GHG emission markets in these states.

References

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