Brazilian Greenhouse Gases Emission Baselines from Electricity Generation

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Abstract

The objective of this paper is to present data available in the literature and to offer alternative methods to calculate greenhouse gases *(GHGs) emission baselines for the electricity generation sector in Brazil. From the analysis of the data collected, GHG emission patterns are identified and a standardized baseline is proposed.*

1. INTRODUCTION

One key aspect of the Clean Development Mechanism (CDM) of the Kyoto Protocol is the reference scenario (baseline) to calculate the emissions reductions achieved in a particular project. From paragraph 5 of article 12 of the relevant protocol, comes the following (UNFCCC, 1997):

> Emission reduction resulting from each project activity shall be certified … on the basis of … reductions in emissions that are additional to any that would occur in the absence of the certified project activity.

In the light of the above, GHG emission trends and patterns can be identified and possible scenarios can be calculated. However, no matter how detailed the numbers arising from these calculations are, they will still be approximations of possible future evolution. Therefore, the first difficulty arising from defining a specific baseline is the virtual impossibility to calculate exactly the emission reduction to be certified.

In order to facilitate these calculations, the President of the Sixth Conference of The Parties of the United Nations Framework Convention on Climate Change in The Hague, The Netherlands, in a negotiating paper (Pronk, 2000) proposed that:

> Parties agree that there should be opportunities for all Parties to participate in the CDM and decide that an equitable distribution of CDM projects will be fostered. Therefore, standardized baselines, which are based on appropriate Annex I average, may be used …

Using data from 1998 (IEA/OECD, 2000a) the average carbon emission baselines for the production of electricity in the annex-I countries is calculated[1] to be 168 kgC/MWh (616 $kgCO_2$/MWh). To give an idea of what a standardized baseline could be for the world, world electricity generation baseline was calculated (IEA/OECD, 2000b) and can be seen in table 1. Pronk in his suggestion indicated a second difficulty that can arise from the definition of baselines, namely, the equitable distribution of CDM projects.

[1] Emissions factors and fuel oxidized from IPCC (1996) and energy conversion efficiency factors of 40% (gas fuels) and 30% (liquid and solid fuels).

Table 1 - World Electricity Baseline (kgC/MWh)

2000	2010	2020
179.6	184.6	185.9

From the above one can see that calculating baselines is a complex task, not only technically but also politically. If complex and expensive procedures become mandatory for the certification of emission reductions, renewable energy electricity generation, typically small and medium scale projects, will not be fostered. Therefore, it will be necessary to define if the priority in the implementation of CDM projects is to verify precisely every single emission reduction certified or to "assist Parties not included in Annex I in achieving sustainable development and in contributing to the ultimate objective of the Convention", i.e., "to achieve … stabilization of GHGs concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system". In the following paragraphs we intend to show that these objectives are, unfortunately, excluding ones, i.e. rigorous baseline calculation renders small-scale projects expensive and thus unfeasible. First, a literature review is provided. Secondly, different case studies of possible calculations for the Brazilian greenhouse gas emissions baselines for electricity generation are presented. Finally, the paper proposes a standardized calculation as a possible solution for the problems described herein.

2. BRAZILIAN BASELINE EMISSIONS

The best starting point was considered to be determination of upper and lower emission baselines bounds for the interconnected and isolated electric systems using the installed capacity as that of December 1999 (table 2). Upper and lower bounds are related to electricity generated using only fossil fuel and all three systems (hydro + nuclear + thermo) respectively.

Table 2 – Brazilian Emission baselines upper and lower bounds for the interconnected grid

	Emission Baseline (kgC/MWh)
Fossil fuel only (upper bounds)	
Interconnected systems (S/SE/MW+N/NE)[2]	294.4
Isolated systems (Northern region)	243.7
All systems	280.1
All sources (lower bounds)	
Interconnected systems (S/SE/MW + N/NE)	15.82
Isolated systems (Northern region)	174.7
All systems	20.01

During the Brazil/U.S. Aspen Global Forum in Sao Paulo, Brazil, Meyers *et al.* (2000) presented a "method for estimating the types of electricity generation that are expected to be the marginal source during a given period. It provides a reasonable estimate of which source(s) is/are likely to be curtailed in response to the load reduction from projects". The basic idea is to determine the marginal carbon emission factor from the load duration curve on generating sources for the South/Southeast/Mid-West electricity system region. Marginal meaning simply the difference of the total generated energy and the hydro base load (table 3).

Table 3 - Brazilian S/SE/MW emissions baseline in kgC/MWh (Meyers *et al.*, 2000)

August 2003	August 2008
34	53

[2] S/SE/MW – South/Southeast/Midwest; N/NE – North/Northeast

Bosi (2000), in a paper on emission baselines methodologies, calculated potential emission credits for the electricity generation case based on recent capacity addition in 1997 (table 4). Recent capacity addition consisted of power plants/units that started operating in 1995 or later, or that were under construction at the time.

Table 4 – Emission baselines based on electricity capacity addition in Brazil (Bosi, 2000)

	(kgC/MWh)
All existing electricity capacity	13.36
Recent capacity addition – fossil fuel only	220.4
Recent capacity addition – all sources	29.45

Based on the expansion plan of the Brazilian Ministry of Mines and Energy (Eletrobras/MME, 2000) for the electricity system covering a ten-year period starting in 2000 until 2009, Esparta *et al.* (2001) calculated emission baselines according to the additional generation capacity installed from 2001, i.e. the baseline for 2001 accounts for all additional plants planed to be installed in that year, that for 2002 accounts for the plants added between 2001 and 2002, and so on (Figure 1).

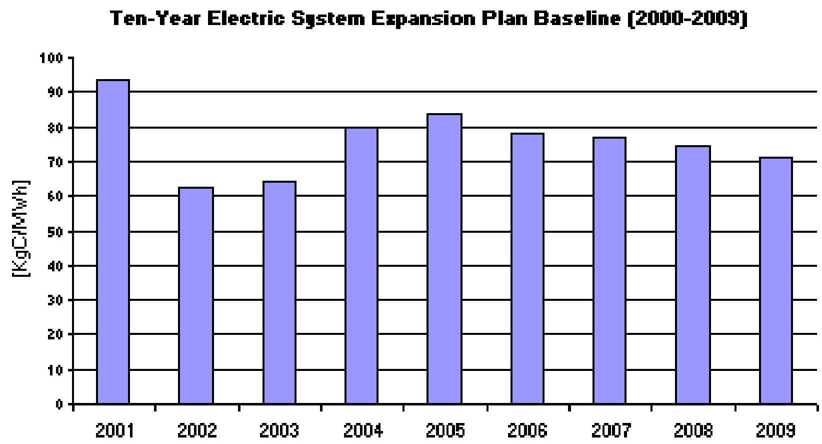

Figure 1 – Additional generation capacity emission baselines (Esparta *et al.*, 2001)

In the same article, the authors considered the electricity output to find the emission baseline evolution for the S/SE/MW interconnected system between January 1998 and August 2000 (Figure 2).

There are many possible interpretations of the data and trends presented. Some may be influenced by seasonal factors, strategic changes, utilities maintenance etc. Nevertheless, one unequivocal trend is the increase of fossil fuels share, i.e. the increase of GHGs emission in electricity generation in Brazil. The trend can be explained with the country strategic goal of reducing the dependence on a single source of electricity production, i.e., hydro. In this context, the increase of investments on thermal electricity generation, mainly using natural gas, becomes understandable. Here is where the carbon market can shift the trend towards an available obtainable but inefficiently used fuel, biomass (sugarcane bagasse, rice husk, wood chips, etc.), if it makes the investment as attractive as the use of natural gas.

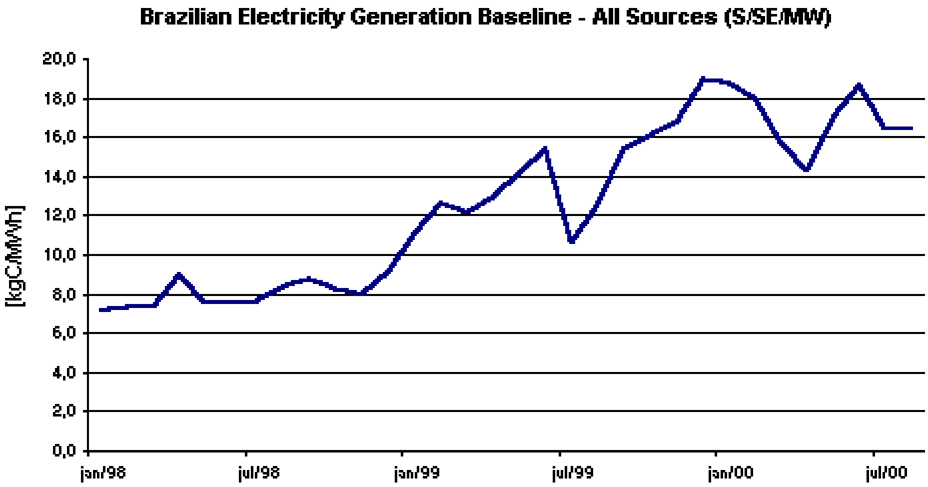

Figure 2 – Emission baselines based on electricity output (Esparta *et al.*, 2001).

3. LEAST-COST BASELINE ALTERNATIVE (MARGINAL DISPATCH)

Since it is impossible to determine exactly which project alternatives exist for a specific renewable energy project, one possible baseline scenario is the business-as-usual power generation of the national electricity grid. To identify which generation source will be displaced as the new renewable generation facility is dispatched, one possible alternative is to favor available generation sources with the lowest variable costs as calculated for the dispatch. In order to avoid using data that would differ significantly from the business-as-usual operation, as in the shortage period of 2001, a calculation from October 2000[3] is shown in table 5.

Table 5 – Variable dispatch cost – October 2000 (Source:ONS)

Plant Name	Fuel	Region	Cost (R$/MWh)
System	Hydro	S	0,00
Angra 1	Nuclear	SE	8,50
Angra 2	Nuclear	SE	8,50
P. Médici	Coal	S	27,74
J. Lacerda C	Coal	S	39,37
System	Hydro	N	41,45
J. Lacerda B	Coal	S	43,47
J. Lacerda A	Coal	S	50,37
Charqueadas	Coal	S	54,33
System	Hydro	NE	67,18
Figueira	Coal	S	78,48
Campos	Gas	SE	84,90
Igarapé	Fuel oil	SE	85,23
System	Hydro	SE	99,47
Piratininga	Fuel oil	SE	111,91
Alegrete	Fuel oil	S	112,67
St. Cruz	Fuel oil	SE	127,00
Camaçari	Fuel oil	NE	230,27

[3] October is the second last month of the dry season. The wet season goes from December to April and the dry season from May to November.

As in October 2000 the reservoir levels were already low in the Southeast and Northeast regions, to confirm if the thermo power plants were short-term marginal, i.e., if they were operated as peak load plants while hydro power plants were operated as base load plants, the capacity factors of different plants for the dry season of a year with normal to slightly low reservoir levels, 1998, were calculated (table 6). To build the table, data for the following plants in the S/SE/MW interconnected system were collected:

- S/SE/MW: 6 plants using coal (total installed capacity: 1395 MW), 5 plants using residual fuel oil (1305 MW) and 43 hydro plants (35641 MW).

Table 6 – S/SE/MW System – Weighted average capacity factors

	Hydro	Coal	Residual fuel oil
Feb./1998	62,87 %	35,64 %	13,96 %
May/1998	59,78 %	34,78 %	16,41 %
Aug./1998	60,92 %	40,22 %	16,82 %

Such figures stress that anytime that a fuel oil plant operates, it is the marginal source and therefore it should be considered as the baseline or a main component of the baseline for any additional thermal or non-hydro source.

Concerning the N/NE interconnected system, besides ten hydro plants (14260 MW) there are only two thermal plants, one plant using residual fuel oil (Camaçari, 290 MW, with a medium capacity factor of 2.92% from July 1998 and August 2000) and one plant using diesel oil (São Luís, 116 MW, not used in the period). One could conclude that a regional baseline for the region should be that of hydro plants. But the analysis of new feasible plants indicates a quite different trend. Today, for the N/NE region there are twelve feasible power plants in different phases (from already under construction to concession granted), seven will use natural gas as fuel (1856 MW, 78,9% of the planned new installed capacity) and five hydro (496 MW). From this perspective a renewable energy power plant would probably substitute a thermal power plant, the one with the higher operating costs, thus the baseline would be that of natural gas.

4. CONCLUSION

There are reasonable arguments to support each alternative presented in this document concerning the calculation of greenhouse gases emission baselines from electricity generation in the interconnected system in Brazil. The values range from almost GHGs free emissions to that of substituting generation using residual fuel oil (about 250 kgC/MWh). It is clear that a political decision is necessary to define the calculation of the actual baseline. With that in mind, we consider that the real question while defining the baseline is:

- What kind of public policy would help to achieve the stabilization of GHGs concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system?

In our opinion, the policy must be the one that would only support fossil-fuel free (GHG emissions free) electricity generation. It is not effective if not impossible to try to measure precisely every kilogram of GHG avoided. With a very restrictive policy of certified emissions reductions only large-scale projects would be able to afford the costs of monitoring and certification. In other words, typical renewable energy projects, being inherently small to medium scale ones, could be virtually excluded from the "carbon-market". Assuming that the idea is to create a market to support carbon-free electricity generation, only standardized procedures would be effective. Therefore, we propose the assignment of a worldwide standardized baseline for electricity generation using renewable energy sources considering a widely available technology adopting the lowest carbon-intensity fossil fuel – i.e. about 137 kgC/MWh; which refers to natural gas with 99.5% fuel oxidation and 40% energy conversion efficiency.

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