Eletrobras

Inventory of greenhouse gas emissions

base year 2011

june 2012

Eletrobras Companies

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June 2012

Climate Strategy Working Group (GT 3)
Environmental Subcommittee (SCMA)

Operation, Planning, Engineering and Environmental Committee (Copem)
Superior Council of the Eletrobras System (Consise)

Superior Council of the Eletrobras System – Consise

Operation, Planning, Engineering and Environmental Committee – Copem
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1. Presentation

In line with the Sustainability Policy of the Eletrobras companies and in compliance with Board of Executive Officers Resolution No. 1262, from 2010, which establishes a commitment to perform a yearly inventory of their greenhouse gas emissions, this documents presents the results obtained for the Inventory of Greenhouse Gas Emissions of the Eletrobras companies for 2011.

This document (2012 edition) comprises emissions of the following greenhouse gases (GHG):

- Carbon Dioxide (CO_2),

- Methane (CH_4),

- Nitrous Oxide (N_2O) and

- Sulfur hexafluoride (SF_6).

These emissions were calculated considering fifteen of the Eletrobras companies: CGTEE, Furnas, Chesf, Eletronorte, Eletronuclear, Eletrosul, Amazonas Energia, Itaipu Binational, Cepel, Eletrobras Distribuição Rondônia, Eletrobras Distribuição Piauí, Eletrobras Distribuição Acre, Eletrobras Distribuição Alagoas, Eletrobras Distribuição Roraima and the holding company itself.

As in previous editions, this inventory follows the methodology of the IPCC (2006) and the guidelines of the Greenhouse Gas Protocol (WRI, 2004) - GHG Protocol[1]. The following emissions were calculated:

• From Scope 1 (direct emissions): stationary sources (power plants, diesel generators and other stationary sources - LPG and natural gas used in kitchens and laboratories); mobile sources (road, airway and waterway) and fugitive emissions (sulfur hexafluoride "SF_6" and gas consumed in fire extinguisher refills);

• From Scope 2 (indirect emissions): electricity purchased from distribution grids and transmission and distribution losses;

• From Scope 3 (indirect emissions) emissions deriving from contracts with IPPs (Independent Power Producers), air travel, transportation of employees and inland logistics.

[1] GHG Protocol: standard corporate tool for accounting and reporting greenhouse gases emissions, released in 1998 and revised in 2004, internationally recognized and used worldwide by companies and governments to understand, quantify and manage their emissions.

It is noteworthy that there is a significant increase in information presented in this edition compared to previous years:

- ✓ The inclusion of two more companies: Eletrobras Distribuição Alagoas and Eletrobras Distribuição Roraima;
- ✓ The refinement of the Scope 1: breakdown of stationary sources in "own thermoelectric plants", "generators" and "other," and breakdown of road mobile sources into airway and waterway;
- ✓ New sources and the refinement of the Scope 2: emissions from losses in electricity distribution, and the allocation of transmission losses per company;
- ✓ New sources of the Scope 3: emissions from air travel, transportation of employees and inland logistics;
- ✓ The reporting of the estimated emissions of NO_x and SO_x from the Eletrobras companies.

2. Assumptions and procedures adopted

• The information needed to prepare the inventory was gathered in each of the companies by their respective representatives in the GT 3 - Climate Strategy Working Group created within the SCMA – Environmental Subcommittee of the Eletrobras Companies;

• With regard to organizational boundaries, this inventory, like in previous years, was based on operational control;

• Emissions related to losses in electricity transmission were calculated based on the Report Eletrobras Transmission losses Index 2011 (Technical Report ETPO-003/2011) provided by the transmission area of the holding company. This year, unlike the previous edition, the results of emissions of these losses are reported separately for each transmission company;

• In this edition, it was also computed the emissions from losses derived from distribution grids;

• Emissions of thermal generation from Independent Power Producers (IPPs), whose energy is purchased by Eletrobras Amazonas Energia, Eletronorte, Eletrobras Distribuição Rondônia and Eletrobras Distribuição Acre and resold to the final consumers, are quantified in Scope 3 and, therefore, separately from those emissions related to the own Eletrobras thermoelectric park, which is considered in Scope 1;

• The emission factors for petroleum-based fuels in Brazil are different from those used internationally due to the requirement to add a fraction of

sugarcane ethanol to these fuels, which reduces its pollution potential and modifies its carbon emission when burned;

• The emission factors used were taken from the *Second National Communication of Brazil to the United Nations Framework Convention on Climate Change*;

• The value of the energy content of the fuel consumed was calculated based on conversion factors listed in BEN - National Energy Balance 2011 (base year 2010);

• There was a change in the methodology for calculating emissions from electricity consumption (Scope 2), which does not account the energy used in the productive process of plants anymore;

• Although not considered emissions that contribute directly to global warming, this edition presents data of SOx and NOx emissions from the Eletrobras companies that have fossil fuel thermal power plants;

• Emissions from hydroelectric reservoirs in enterprises belonging to Eletrobras companies were not considered, since so far no scientific consensus exists in regards to a methodology that would make it possible to estimate GHG emissions for these reservoirs and calculate the balance of emissions (or net emissions) from water bodies;

• In this Edition, it is presented an estimate of carbon sequestered by forest area existing in the area of influence of Itaipu;

• This inventory has not been verified by an independent third party, nevertheless all the information and calculation logs, in addition to the identification of data sources, were archived for possible later verification.

Table 1. Evolution of the content and coverage of the GHG Inventories of the Eletrobras companies

	Edition 2008	Edition 2009	Edition 2010	Edition 2011	Edition 2012
Unit	Gg CO_2e	Gg CO_2e	t CO_2e	t CO_2e	t CO_2e
Coverage	2005	2003 to 2008	2009	2010	2011
Approach	Operational Control (GHG Protocol)	Operational Control (GHG Protocol)	Operational Control (GHG Protocol)	Operational Control (GHG Protocol)	Operational Control (GHG Protocol)
Metodology	IPCC 2006	IPCC 2006	IPCC 2006	IPCC 2006	IPCC 2006
Content	Only part of **Scope 1**: direct emissions from stationary sources (Thermoelectric plants)	Only part of **Scope 1**: direct emissions from stationary sources (Thermoelectric plants)	**Scope 1:** Direct emissions from stationary sources (Thermoelectric plants), mobile sources, fugitive emissions of SF_6 **Scope 2**: emissions by the amount of electricity purchased from the grid	**Scope 1**: Direct emissions from stationary sources (Thermoelectric plants), mobile sources, fugitive emissions (SF6 and fire extinguishers), other stationary sources (LPG, natural gas, diesel generator sets and auxiliary boilers) **Scope 2**: emissions by the amount of energy bought from the grid, transmission losses **Scope 3**: independent power producers (IPPs) Other sources: electricity	**Scope 1:** Direct emissions from stationary sources (Thermoelectric plants), mobile sources, fugitive emissions (SF_6 and fire extinguishers), other stationary sources (LPG, natural gas, diesel generator sets and auxiliary boilers) **Scope 2**: emissions by the amount of energy bought from the grid, transmission losses, distribution losses **Scope 3**: independent power producers (IPPs), air travel, inland logistics, transportation of employees
Gases	CO_2 CH_4 N_2O	CO_2 CH_4 N_2O	CO_2 CH_4 N_2O SF_6	CO_2 CH_4 N_2O SF_6	CO_2 CH_4 N_2O SF_6

3. Results

In 2011, the total GHG emission of the Eletrobras Companies was 9,367,574 tCO_2e, indicating an 8% increase in emissions compared to the previous year inventory – base year 2010 (8,666,945 tCO_2e). This is explained by the following factors:

• increased emissions of thermoelectric power plants (scope 1) due to its higher dispatch in 2011;

• incorporation of new emission sources: distribution losses (scope 2), air travel, inland logistics and transportation of employees (scope 3);

• increased data coverage, and

• inclusion of two more companies in the accounting of emissions (Eletrobras Distribuição Alagoas and Eletrobras Distribuição Roraima).

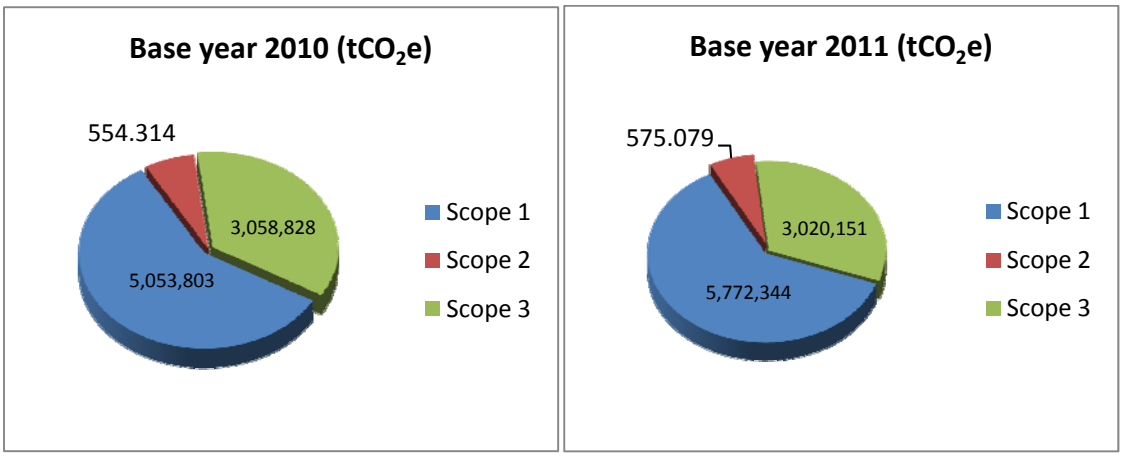

FIGURE 1. Eletrobras Companies comparative emissions by scope - base year 2010 and 2011

Figure 1 shows that there was little emission variation between each scope comparing 2010 and 2011 inventories. The main highlights are the increase in scope 1 emissions due to increased dispatch of thermoelectric power plants; the small increase in scope 2 is due to the incorporation of distribution losses emissions, although there was a significant reduction in the emissions from transmission losses. The latter ocurred due to a decrease of almost 50% in the average emission factor of the National Interconnected System between 2010 and 2011 (according to data published by the *Ministry of Science, Technology and Innovation* – MCTI, in portuguese).

Table 2 shows the overall result of this inventory (base year 2011), and Table 3 shows the temporal evolution of GHG emissions of the Eletrobras Companies since the year 2003.

TABLE 2. Overall greenhouse gas emissions from Eletrobras Companies - Base year 2011

Eletrobras Companies	Scope 1								Scope 2			Scope 3				SUBTOTAL BY COMPANY
	Stationary			Mobile			Fugitive									
	Tthermoelectric Plants	Generator Groups	Others	Road	Waterway	Airway	SF_6	Fire Extinguishers	Electricity Consumption	Transmission Losses	Distribution Losses	Independent Power Producers (IPPs)	Air Business Travel	Transportation of Employees	Terrestrial Logistics	
CGTEE	2,594,110	n.s.	1	343	n.s.	n.s.	n.s.	1.0	40	n.s.	n.s.	n.s.	386	353	3,653	2,598,888
Chesf	8,811	5	n.a.	4,513	n.s.	537	38,240	16.2	230	71,196	n.s.	n.s.	7,510	n.s.	n.a.	131,059
Furnas	123,863	12	26	1,287	5	153	104,046	34.6	463	168,105	n.s.	n.s.	1,513	n.s.	n.a.	399,507
Eletronorte	651,068	62	n.a.	7,007	6	n.s.	3,585	1.8	120	34,820	n.s.	1,257,058	3,234	n.s.	n.a.	1,956,962
Eletronuclear	n.s.	1,376	6	1,082	20	n.s.	n.s.	2.3	39	n.s.	n.s.	n.s.	338	1,853	3	4,720
Eletrosul	n.s.	51	10	1,716	n.s.	n.s.	3,677	2.3	435	55,421	n.s.	n.s.	223	312	n.a.	61,847
Amazonas Energia	2,210,331	n.s.	n.a.	970	n.s.	n.s.	0	12.9	3,247	n.s.	107,759	1,416,757	634	n.s.	n.a.	3,739,712
Itaipu	n.s.	n.s.	48	546	5	n.s.	7,170	0.9	68	n.s.	n.s.	n.s.	1,044	1,131	28	10,040
Cepel	n.s.	n.s.	2	23	n.s.	n.s.	24	0.7	129	n.s.	n.s.	n.s.	246	407	n.a.	832
Eletrobras Holding	n.s.	n.s.	n.s.	45	n.s.	n.s.	n.s.	1.1	160	n.s.	n.s.	n.s.	2,615	n.s.	n.a.	2,821
Distribuição Acre	323	n.s.	n.s.	148	n.s.	n.s.	201	0.2	27	n.s.	n.a.	115,685	388	n.s.	n.a.	116,772
Distribuição Alagoas	n.s.	2	0	1,930	n.s.	n.s.	n.a.	0.5	n.a.	n.s.	36,387	n.s.	n.a.	n.s.	4	38,323
Distribuição Rondônia	n.s.	1	n.s.	789	n.s.	n.s.	120	1.9	65	n.s.	26,706	203,794	673	n.s.	n.a.	232,149
Distribuição Roraima	n.s.	n.s.	n.s.	195	n.s.	n.s.	0	0.1	n.a.	n.s.	34,782	n.s.	n.a.	n.s.	n.a.	34,977
Distribuição Piaui	n.s.	1,638	16	2,048	n.s.	n.s.	72	2.6	99	n.s.	34,782	n.s.	309	n.s.	n.a.	38,967
Subtotal by Source	5,588,506	3,146	110	22,642	36	691	157,135	79	5,120	329,541	240,417	2,993,294	19,114	4,055	3,688	TOTAL
Subtotal by Type of Source	5,591,763			23,368			157,214		5,120	329,541	240,417	2,993,294	19,114	4,055	3,688	(tCO2e)
Subtotal by Scope	5,772,344								575,079			3,020,151				9,367,574

TABLE 3. Temporal evolution of GHG emissions from Eletrobras Companies

Company	2003	2004	2005	2006	2007	2008	2009	2010*	2011
CGTEE	1,984,630	2,298,340	2,525,610	2,631,520	2,196,730	1,497,570	1,483,830	1,340,799.59	2,598,887.64
CHESF	224,730	54,280	35,460	3,560	45,090	594,070	652,680	26,084.43	131,058.53
FURNAS	394,780	170,550	149,880	4,110	24,940	144,440	114,730	105,394.84	399,506.84
ELETRONORTE	1,187,350	2,298,340	1,882,750	1,116,700	1,584,510	1,630,150	1,667,670	490,439.11	1,956,961.89
ELETRONUCLEAR	2,610	1,484,250	2,280	3,190	3,140	2,650	6,070	7,905.53	4,720.10
ELETROSUL	–	–	–	–	–	–	8,690	11,347.53	61,846.69
AMAZONAS ENERGIA	789,230	816,730	1,170,350	930,300	1,066,830	1,231,560	4,002,700	4,641,068.47	3,739,711.53
ITAIPU	–	–	–	–	–	–	16,310	9,192.01	10,040.10
CEPEL	–	–	–	–	–	–	1,070	958.90	831.72
ELETROBRAS holding	–	–	–	–	–	–	180	328.54	2,821.01
ELETROBRAS D. Rondonia	–	–	–	–	–	–	–	1,396,266.92	232,149.13
ELETROBRAS D. Acre	–	–	–	–	–	–	–	96,033.61	116,771.61
ELETROBRAS D. Piauí	–	–	–	–	–	–	–	3,391.49	38,966.74
ELETROBRAS D. Alagoas	–	–	–	–	–	–	–	–	38,323.11
ELETROBRAS D. Roraima	–	–	–	–	–	–	–	–	34,977.23
Total	**4,583,340**	**4,826,470**	**5,766,330**	**4,689,370**	**4,921,240**	**5,100,450**	**7,366,540**	**8,666,946**	**9,367,574**

Considering that the amount of energy generated in 2011 from all sources of power generation used by Eletrobras companies was 199,601,937 MWh, being almost 89% from hydroelectricity, its rate of GHG emission (carbon intensity) remained stable, ranging from 0.0464 tCO_2e/MWh (2010) to 0.0469 tCO_2e/MWh (Table 4). This figure is considered low compared to other corporations of the same sector and of equivalent size in the world (Table 5).

TABLE 4. Eletrobras companies emission intensity

Company	Emissions (tCO_2e)	Total Net Generation (MWh)	Emission Intensity (tCO_2e/MWh)
CGTEE	2,598,888	1,620,086	1.6042
CHESF	131,059	48,663,272	0.0027
FURNAS	399,507	37,268,068	0.0107
ELETRONORTE	1,956,962	43,194,122	0.0453
ELETRONUCLEAR	4,720	14,350,893	0.0003
ELETROSUL	61,847	na	
AMAZONAS ENERGIA	3,739,712	8,743,496	0.4277
ITAIPU	10,040	45,762,000	0.0002
CEPEL	832	na	
ELETROBRAS Holding	2,821	na	
ELETROBRAS D. Acre	116,772	na	
ELETROBRAS D. Alagoas	38,323	na	
ELETROBRAS D. Rondonia	232,149	na	
ELETROBRAS D. Roraima	34,977	na	
ELETROBRAS D. Piauí	38,967	na	
TOTAL	9,367,574	199,601,937	0.0469

TABLE 5. Average emission intensity (tCO_2e/MWh) of the electricity sector in the world[2] in comparison with Eletrobras companies

	tCO_2/MWh
World[2]	0.520
OCDE[2]	0.440
Other countries[2]	0.600
Eletrobras companies	0.046

Source: International Energy Agency (IEA). Climate and Eletricity Annual, 2011

[2] Values for the year 2008.

4. Emissions of NO_x and SO_x

The oxides of sulfur and nitrogen (SO_x and NO_x) released in fossil fuel combustion processes by industrial boilers, thermoelectric power plants and vehicles are considered agents of rain or acid deposition, although this phenomenon also occurs through natural causes such as volcanic eruptions.

These oxides react with water suspended in the atmosphere forming sulfuric and nitric acids. These substances are deposited on the surface land, sometimes at very large distances from their places of origin, under the form of particles, rain, snow, frost, fog or dew, causing adverse effects, such as: damage to vegetation, impairing agricultural crops; compromising the quality of water resources, causing the death of aquatic and amphibian species and penetrating the underground aquifers; formation of fog affecting visibility; corrosion of buildings, monuments, textile fibers, metal structures and vehicles, and also affecting human health (respiratory and cardiac problems).

Due to its importance in the role of anthropogenic emissions in the world, this document incorporates estimates of SO_x and NO_x emitted by Eletrobras companies, though these gases are not included among those classified as greenhouse gases by the GHG Protocol. It is important to note that only those Eletrobras companies that have fossil fuel thermoelectric generation were considered, since this source represents the largest share SO_x and NO_x emissions..

In Brazil, fossil fuel thermoelectric generation is not a significant element of the electric matrix. Thermoelectric plants generally do not operate in full basis, complementing the hydro generation, when necessary. It is in industrial and dense urban areas that the highest concentration of these gases are found, often exacerbated by special weather conditions.

The methodology for calculating SOx emission is based on the sulfur content of each fuel and the amount of sulfur that is emitted to the atmosphere in the form of SOx in the burning process. This methodology does not take into account the technology to control emissions of SOx, which is often applied to industrial plants or power plants to reduce emissions of these gases.

The methodology for calculating NOx emissions is based on the estimate of the total gas emitted as a function of the amount of fuel consumed and the average emission factors, taking into account the type of fuel and the burn technology used.

In 2011, SO_x total estimated emission by Eletrobras companies was 76,481 tons. As shown in Figure 2, this quantity corresponds to emissions of six Eletrobras companies. The largest contribution to these emissions comes from CGTEE (62,247 ton), followed by Amazonas Energia (13 526 t), and

the lowest contribution comes from Eletronorte (666 ton), Furnas (39.25 ton), Chesf (0.82 ton) and Eletrobras Distribuição Acre (0.42 ton).

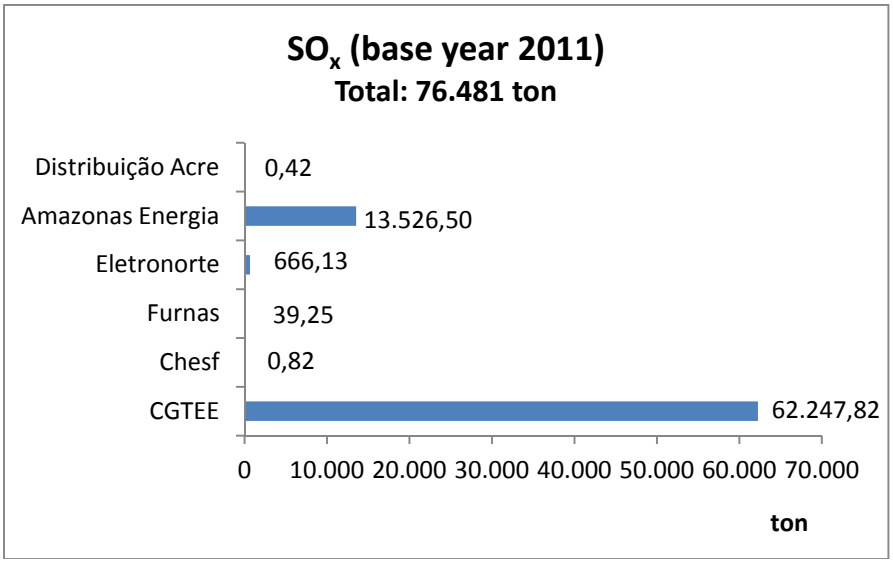

FIGURE 2. SO_X emissions of Eletrobras companies

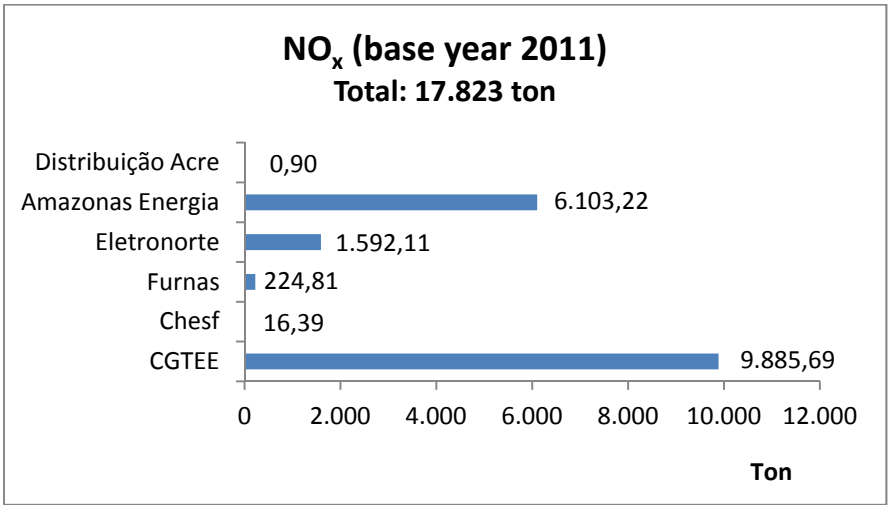

FIGURE 3. NO_X emissions of Eletrobras companies

NO_x emissions reached 17,823 ton in 2011. In descending order, the largest contribution to these emissions comes from CGTEE (9885.69 ton.), Amazonas Energia (6,103 ton.), Eletronorte (1,592 ton.), Furnas (224.81 ton.), Chesf (16 ton.) and Eletrobras Distribuição Acre (0.9 ton.) (FIGURE 3).

5. Pilot Project of forest carbon sequestration

Within the set of actions to offset GHG emissions, in 2011 Itaipu Binational planted a total of 241,584 seedlings, both in its protected areas (protection strip of the lake - Brazilian side - and biological refuges) as in partnership with municipalities in its area of influence (drainage area of the reservoir).

Thus, it is estimated that the amount of atmospheric CO_2 fixed only by seedlings planted last year corresponds to 686.96 t CO_2e. Considering the maintenance of all existing forest on the Brazilian side of the reservoir, the amount of carbon fixed in 2011 rose to 4,630,421 t CO_2e.

This is the first example of the effort undertaken by the Eletrobras companies in order to account the carbon sequestration in forest areas under its control. Itaipu's work is pioneer and will serve as a methodological basis for the measurement of carbon fixed in forest areas, allowing calculate, in the near future, the balance of emissions of the Eletrobras companies.

6. Climate Strategy Program

Eletrobras has been conducting annually the GHG Inventory of the Eletrobras companies, which seeks to cover the largest number of its organizational units, considering scopes 1, 2 and 3 of the GHG Protocol, and to disclosure publicly the results.

The company has been pursuing the following strategic actions coupled with its *Declaration of Commitment on Climate Change* (annex), published in May 2012:

• Support business initiatives and actions aimed at energy efficiency and conservation;

• Support actions to expand the use of renewable energy, especially wind and water sources;

• Accompany the progress of regulations and standards related to air emissions;

• Participate in specific forums on climate change in Brazil and abroad, in particular the Brazilian Forum on Climate Change (FBMC), prioritizing those with specific technical councils on the subject;

• Promotion, monitoring and participation in studies and research for the development of knowledge, technologies and methodologies for estimating GHG emissions in water bodies and hydroelectric reservoirs;

Simultaneously, to assist in the achievement of the goals of the Strategic Action Program (PAE 2009-2012) regarding the ISE-Bovespa and the Dow Jones Sustainability Index, as well as other important demands (Carbon Disclosure Project - CDP, ICO_2, etc.), it is underway the data integration of the GHG emissions inventory with the IGS base - The Environmental Indicators for Corporate Sustainability Management of the Eletrobras Companies.

To contribute to a better understanding of the processes that cause global warming, Eletrobras has been promoting the development of studies and research. This occurs especially with respect to the question of estimating GHG emissions in hydroelectric reservoirs. Eletrobras and its energy generating companies have actively participated in the development of technologies and methodologies to ensure that emissions from hydroelectric reservoirs can be estimated reliably, as is demonstrated by the Project Balcar (Carbon Balance) - Strategic R&D Project under ANEEL. This ongoing project aims at measuring GHG net emissions and other parameters in eight hydropower reservoirs and three sites where future reservoirs will be constructed (land and water environment), distributed throughout the country.

The environmental technical areas of Eletrobras companies have followed the evolution of international studies in this area of knowledge, and are aware that, in Brazil, there is a great diversity of cases to be examined. So far, despite numerous speculations, scientists still have not reached a consensus on the most reliable methodology for estimating GHG emissions of water bodies in general, and in particular that of hydroelectric reservoirs.

Therefore, once again, it is justified the non inclusion of estimates of potential GHG emissions from hydroelectric reservoirs in this inventory.

For the improvement of the GHG emissions management in a transparent and effective way, Eletrobras also search to:

• Develop a voluntary plan for the GHG emissions management of the Eletrobras companies, prioritizing: the replacement of the vehicle fleet and some stationary units for others that consume less carbon-intensive fuels; planting trees; reducing electrical energy consumption and losses in transmission/distribution; optimizing the use of sulfur hexafluoride (SF_6), and the adoption, wherever possible, of clean technologies and processes in all companies activities;

• Third part certification of the GHG Inventory of the Eletrobras companies;

• Promote, monitor and participate in the development of studies and research on renewable energy and energy efficiency as a means of reducing GHG emissions;

• Promote, monitor and participate in studies and researchs on the climate vulnerability of the Brazilian Electric System;

• Promote, monitor and participate in studies, research and risk analysis of projects, considering the scenarios of declining rainfall and reducing flows in rivers watershed, and its incorporation in the expansion strategies of the Eletrobras companies;

• Promote, monitor and participate in studies and researchs aiming at the adaptation and mitigation of Eletrobras companies to climate change;

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ANNEX

Eletrobras Declaration of Commitment on Climate Change

Eletrobras believes it is now time to help the transition to a new model of development based on a low-carbon economy, seeking new business opportunities and building, along with government and civil society, the basis for environmental, economic and social sustainability of the planet.

Guided by the goal of achieving standards of excellence in its operations Eletrobras declares to its employees, shareholders, customers, suppliers, business partners, governments and society its commitment to:

1st. Search an unified strategy for its companies to adopt practices that minimize or offset their emissions of greenhouse gases (GHG).

2nd. Prioritize in its project portfolio the participation of renewable energy sources.

3rd. Identify key risks and opportunities of climate change for the business of Eletrobras.

4th. Ensure the implementation of management actions related to GHG emissions by keeping a systematic and continuous process and the search for best practices.

5th. Assure internal and external public access to information, particularly through the "Inventory of emissions of greenhouse gases from Eletrobras Companies" yearly publication.

6th. Act to promote studies related to climate change, as an effort to identify and understand their impact on the Brazilian Electrical Sector, and seek new technologies to minimize its effects.

7th. Work on the supply chain, seeking to reduce greenhouse gases emissions of suppliers and customers.

8th. Support and take action on issues of standardization of climate change within government and civil society.