Inventory of Greenhouse Gas Emissions from Thermoelectric Power Plants (permanent sources) 2003 to 2008

December - 2009

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Eletrobras System

Inventory of the Greenhouse Gas Emissions from Thermoelectric Power Plants (permanent sources)

2003 to 2008

Conselho Superior do Sistema Eletrobras – CONSISE

(High Council of the Eletrobras System)

Operation, Planning, Engineering and Environment Committee – COPEM

Environmental Subcomittee – SCMA

Workgroup on Greenhouse Gas Emission – GT 3

December – 2009

HIGH COUNCIL OF THE ELETROBRAS SYSTEM – CONSISE

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1. INTRODUCTION

Sustainable development is a concept that has been consolidated for around 20 years. Despite being little understood until the end of the last century, we can observe that society is focusing more and more attention on the need to make natural resources available, or even to recover them, so that future generations will have the chance of using them. After all, water, air and earth, with all of their biodiversity, cannot any longer be considered as infinite resources, on the contrary. For this reason, recent surveys have shown that consumers are willing to pay more for products or services coming from companies that have **sustainable practices** in their business. Investors have also demonstrated a clear preference for allocating resources to companies committed with sustainability[5].

Therefore, the traditional economic-financial targets are no longer sufficient to demonstrate the sustainability of companies. In the world today, a new type of company is being better valued: the one that is careful with environmental and sociably responsible issues, also covering these dimensions, besides the economic-financial, in their strategic planning. In other words, they are corporations concerned with their insertion in the environment in which they operate and seek to consider the needs and concerns of their target audiences - clients, employees, communities, government, partners and suppliers. They involve the different internal sectors, reflecting the companies' performance in the social and environmental areas, in the relationship with suppliers, in their communication policy, in the production of reports, etc.

Thus, the objective of this new company is to add value to the shareholder in the long term. The success of this type of company is constantly pointed out by investors in the USA and in Europe, which, for some time, have began analysing in their prospection, indexes and reports on sustainability, besides other indicators, disseminated by the New York and London Stock Exchanges. Transparency with investors, high standards of corporate governance and management of human resources, guided by qualifying and satisfying their employees, are basic characteristics of this process.

Aware of this, Eletrobras has employed various actions in seeking to affirm itself as a sustainable company, examples of which are the adhesion to the Global Compact, the creation of its Sustainability Committee (of the *holding* and of the Eletrobras System), in order to coordinate the various actions employed in the affirmation as a company and as a sustainable group, and the creation of the Report on Sustainability 2008 according to the guidelines of the *Global Reporting Initiative (GRI)* recommended by the UN.

The determination to participate in the CDP - *Carbon Disclosure Project* and the GRI - *Global Reporting Initiative* only confirmed the urgency to set up a management system of GHG emissions in companies of the System. The need to identify the actions necessary to organize the report of information became

evident: do an inventory and manage direct and indirect emissions; define the methodology to calculate indirect emissions; and structure a data system to store the information.

The question of **greenhouse gas emission** (GHGE) always seemed relevant due to being the main vector responsible for **climate change**. Each company should incorporate the assessment of their risks in their business and activities, initiating projects that prepare their adaptation to inevitable changes in the work environment.

In order to have coherent performance in this direction, the first step is to make a survey of the GHG emissions originating from various activities inherent to each productive organization.

In the scope of the SCMA **-** Subcomitê de Meio Ambiente do Sistema Eletrobras (Environmental Subcommittee of the Eletrobras System), a chartered organization comprising managers from environmental areas in System Companies, it was found that no annual measurements were made uniformly yet, with appropriate standardization so as to allow, in the future, the control and reduction of emissions in various activities of the companies.

Thus, the SCMA, through Workgroup 3 (GT3) - Greenhouse Gas Emissions), created in 2005 the first Inventory of GHG emissions of thermoelectric power plants (based on 2005). This project was published in 2008 and became an important step, because it was the first report on GHG emissions of the Eletrobras System.

Based on the 2008 Work plan of the GT 3, the process of measuring GHG emissions in each company of the Eletrobras System focused on the direct emissions of **Thermoelectric Power Plants** with the purpose of obtaining a historical series and enabling the collation of results. As there was already information on 2005, relevant data for 2003, 2004, 2006, 2007 and 2008 was requested, The Multi-annual Inventory (2003 – 2008) present herein is the result of this project.

Henceforth, the intention is: to maintain the routine of keeping annual inventories of the direct emissions, i.e. associated to related activities of the System – generating electric energy; gradually, increasing the number of sources of emission to be measured, annually; determining the most adequate methodology so it is measured uniformly; and, verifying the possibility of establishing targets to reduce GHGE in activities of the System's companies.

Finally, it is important to mention the **Pacto de Tucuruí (Tucuruí Compact)**, of 29 September 2009, signed by all the presidents of the companies of the Eletrobras System, which came to formalize the commitment of working together to meet the targets of sustainability established. In this context, the integrated performance of the holding's Sustainability Committee and of

affiliated companies should be encouraged, in seeking measurable results both for the participation of the Eletrobras System in indicators of large visibility in the Brazilian and International markets, such as the ISE Bovespa and the *Dow Jones Sustainability Index* - DJSI, and for the ascension to Level 2 of Bovespa's Corporate Governance.

2. OBJECTIVE

This report, which contains the Inventory of greenhouse gas emissions (GHGE) originating from thermoelectric power plants (permanent sources) of the companies of the Eletrobras System, during the period from 2003 to 2008, has the purpose of supporting management in these emissions in the sense of incorporating, each year, new and more consistent information to enable the establishment of targets to reduce emissions in the Eletrobras System.

3. THE ELETROBRAS SYSTEM

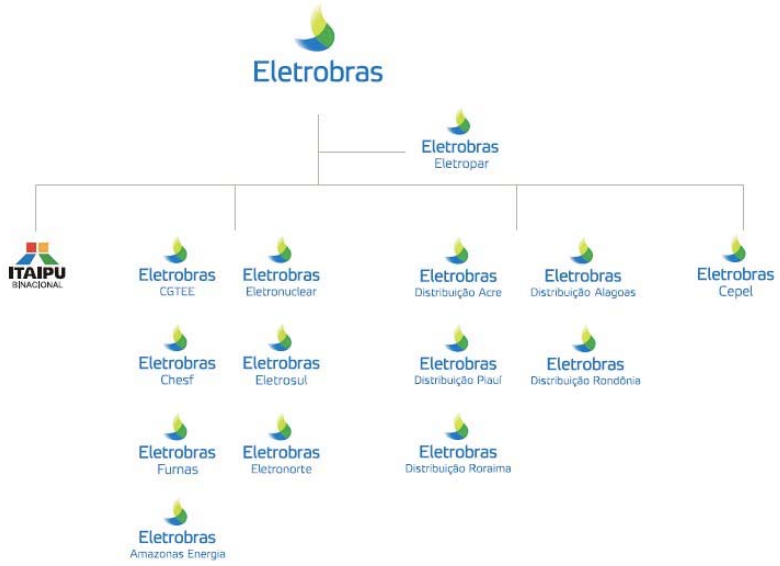
Eletrobras is a public and mixed capital corporation, created in 1962 to promote studies, projects and construction of power generation plants, transmission lines and substations, destined to supply electric energy in Brazil. Eletrobras has shares listed on the São Paulo Stock Exchange (Bovespa), Madrid, in Spain, and New York, in the USA. The federal Government has half the ordinary and preferential shares (52.45%) of Eletrobras and, for this reason, has stock control of the company[1].

As a *holding*, Eletrobras controls a large part of the systems of generation and transmission of electric energy in Brazil through six subsidiaries: Chesf, Furnas, Eletrosul, Eletronorte, CGTEE and Eletronuclear. Besides being a major shareholder of these companies, Eletrobras, on behalf of the Brazilian government, detains half the stock capital of Itaipu Binacional.

The *holding* also controls the Centro de Pesquisas de Energia Elétrica (Cepel) and Eletrobras Participações S.A. (Eletropar). Besides this, it works in the area of energy distribution through the following companies: Eletrobras Distribuição Acre, Eletrobras Distribuição Alagoas, Eletrobras Distribuição Piauí, Eletrobras Distribuição Rondônia, Eletrobras Distribuição Roraima and Amazonas Energia.

The organization of the Eletrobras System can be observed in Figure 1.

Figure 1 – The Eletrobras System

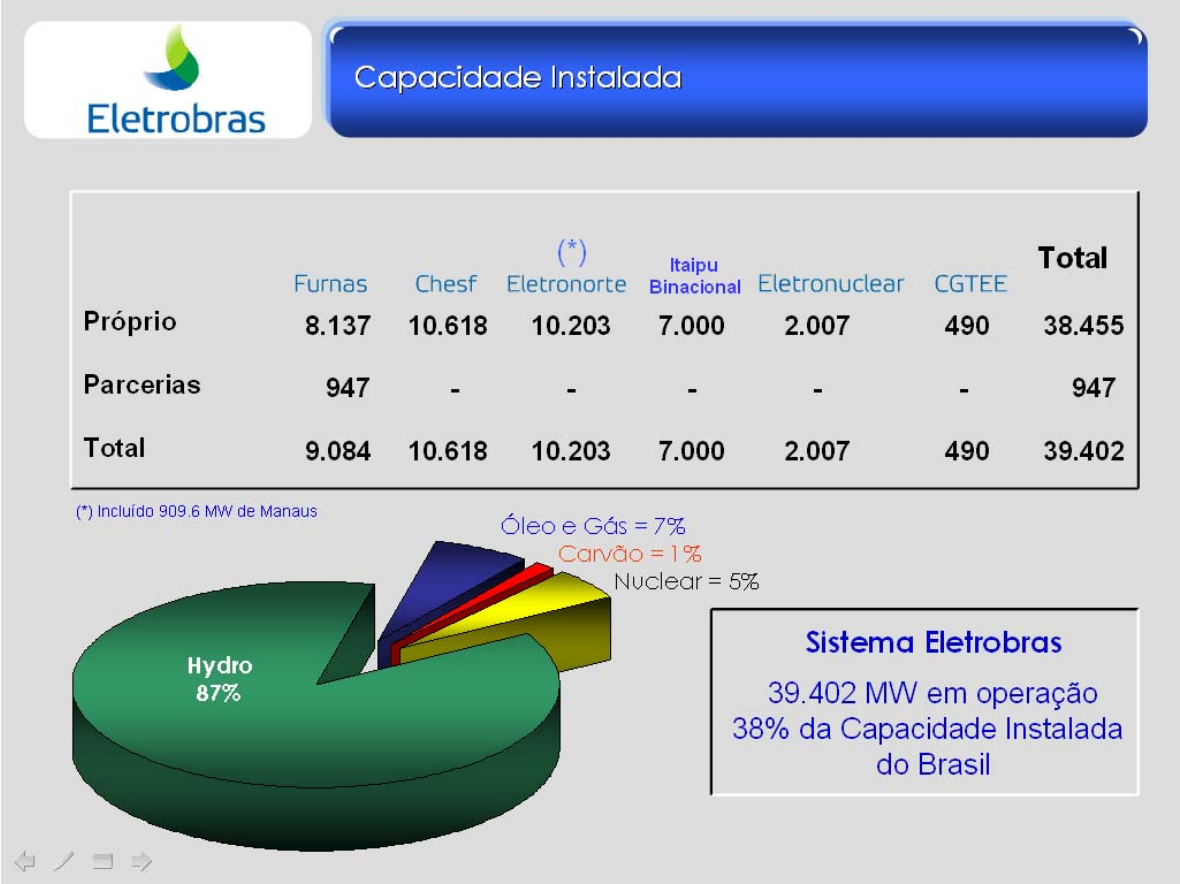


Source: ELETROBRAS 2010

The Eletrobras System includes thermoelectric power plants, thermal plants and fossil fuels (deriving from oil and coal) and nuclear plants. This variety of fuels is important for the smooth running of electric energy, because there are periods of water shortage and, also, some restrictions of complementarity between basins in different climatic regions.

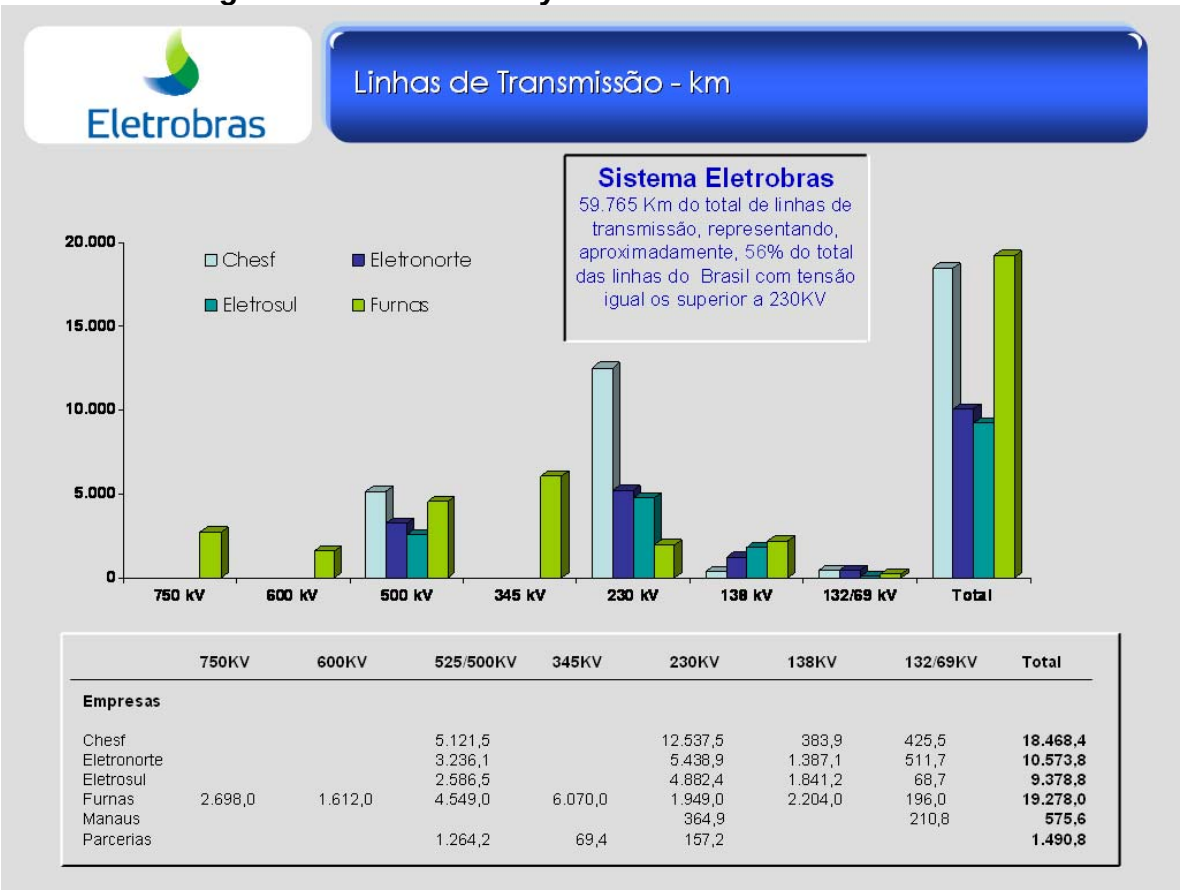
The generating capacity of the Eletrobras System, including half the potential of Itaipu belonging to Brazil is of 39,413 MW, corresponding to 38% of the domestic total. The transmission lines of the System have an extension of 59,856 km, representing almost 56% of the total number of lines in Brazil.

Figure 2 – Eletrobras System – capacity of generating electric energy



Source: ELETROBRAS 2009

Figure 3 – Eletrobras System – transmission lines



	750KV	600KV	525/500KV	345KV	230KV	138KV	132/69KV	Total
Empresas								
Chesf			5.121,5		12.537,5	383,9	425,5	**18.468,4**
Eletronorte			3.236,1		5.438,9	1.387,1	511,7	**10.573,8**
Eletrosul			2.586,5		4.882,4	1.841,2	68,7	**9.378,8**
Furnas	2.698,0	1.612,0	4.549,0	6.070,0	1.949,0	2.204,0	196,0	**19.278,0**
Manaus					364,9		210,8	**575,6**
Parcerias			1.264,2	69,4	157,2			**1.490,8**

Source: ELETROBRAS 2009

4. THE ENVIRONMENTAL SUBCOMMITTEE OF THE ELETROBRAS SYSTEM - SCMA AND WORKGROUP NO. 3

The SCMA – Environmental Subcommittee of the Eletrobras System – is a board comprising representatives from the environmental area of Eletrobras System companies and acts as a technical and institutional space that enables coherent performance, continuously enhanced, adjusted to the legislation in force and to the principles and guidelines established, in mutual agreement, expressed in the System's Environmental Policy. It also enables greater interaction between companies and enables the performance of articulated procedures in the necessary inter-institutional relations.

The first coordinating committee of the environmental activities of the electrical sector - COMASE, was created in **1988** as part of a set of measures to improve the institutional action of Eletrobras, in the environmental area, and which gathered technical representations from around 23 private and state companies from the sector. In 2003, it was replaced by the Environmental Committee of the Eletrobras System - COMAGE, subordinate to the High Council of the Eletrobras System - CONSISE. Due to the restructuring of CONSISE, in 2005, COMAGE was succeeded by the **Environmental Subcommittee - SCMA**, also under the Coordination of the Environmental Department of Eletrobras, subordinate to the Operation, Planning, Engineering and Environmental Committee - COPEM, which, in turn, is coordinated by Eletrobras' Engineering Board.

The companies of the Eletrobras System, since 2003, had taken the initiative to constitute a Work Group to deal with questions of climate change and, also in COMAGE, Work Group no. 3 was created, maintained in the current configuration of the SCMA under the title "Work Group on Greenhouse Gas Emissions", GT 3. Its main objective is the development of the systematic management of these emissions.

In the context of the GT 3, the first Inventory was created on the Emission of Greenhouse Gases originating from Thermoelectric Power Plants (based on 2005) of the Eletrobras System. Discussions on addressing the indirect emissions and treatment given to emissions imputed to hydroelectric generation are issues on the minutes of GT3 meetings. In addition, its integrants carefully monitor the evolution of scientific knowledge on the phenomena related to climate change and their rebuttal in the global and local policy. GT 3 also supports the Strategic R&D Project of ANEEL entitled "Balance of Carbon in Reservoirs of Hydroelectric Plants" strategically, to be developed in conjunction with the most representative research institutions of the country, and has the purpose of further developing the scientific knowledge on the processes of emission and absorption of these gases in the hydrous means, during a term of two to four years, in order to obtain a more realistic picture of the balance of emissions of the reservoirs.

5. CLIMATE CHANGE

Today, climate change is understood as the result of the increase of concentration of the greenhouse gas effect in the atmosphere, mainly of carbon dioxide (CO_2), resulting in global warming and its consequences. The increase of concentration of these gases into the atmosphere is attributed mainly to anthropogenic actions, among which are deforestation and the burning of fossil fuels, like oil, coal and natural gas. Deforestation and the burning of tropical forests is a serious problem related to global warming, especially in Brazil.

Before the Industrial Revolution, in the 18th century, the levels of carbon in the atmosphere were, on average, 280 ppm (parts per million). Currently, this concentration is at 379 ppm, which means an increase of 35.36%.

Although climate change has been studied by scientists for a very long time, it was in 1988 that the United Nations decided to form, as a result of the perception that human action could be having a strong influence on the earth's climate, the International Panel on Climate Change (IPCC). The organization is composed of scientific delegations from 130 governments to provide regular assessments on climate change.

In 1992, the problem received a new priority in the global political agenda, with the creation of the Climate Convention during the United Nations Conference on Environment and Development, held in Rio de Janeiro, and known as Rio-92. The Climate Convention has the main purpose of stabilizing the concentration of greenhouse gases in the atmosphere at a level that prevents an anthropic interference in the climatic system.

In 2007, the 2,500 scientists of the IPCC launched the fourth report on the panel assessment, which became one of the most mentioned projects in the whole world in discussions on climate change. In it, they classify man's responsibility for climate change as "unmistakable" and point out that the average global temperature will increase by 3 degrees Celsius until 2100. In Brazil, the climatic models indicate that there could be a warming of 4° to 6°C in some parts of the country, also in the Amazon, by the end of the century.

In order to halt the impacts of this new climatic reality, the world will have to spend 1% of its GDP (Gross Domestic Product) says the Stern Report, a study about the economic costs of the climatic changes requested by the British government to economist Nicholas Stern. The project also concludes that the cost of inaction could come to 20% of the global GDP[6].

Eletrobras was one of the main sponsors of Rio 92 – Earth's Summit. On this occasion, United Nations created the Climate Convention to study and establish guidelines for the sustainable approach of socio-economical activities in the whole planet. Since then, Eletrobras has been supporting research activities and meetings held and gatherings of the Climate Convention. One of the results of the Convention was the structuring of the Kyoto Protocol[7].

In the context of the Kyoto Protocol, Brazil, considered as a developing country, was not obliged to establish quantitative targets to reduce GHG emissions, contrary to developed countries (or in Annex 1) which established the targets, unfortunately not fulfilled. In the perspective of the meeting in December 2009, in Copenhagen (*United Nations Climate Change Conference in Copenhagen* – COP 15), Brazil will voluntarily assume a target to reduce emissions and will receive the benefits of a positive posture regarding climate change, besides evidently contributing towards stabilizing the carbon levels in the atmosphere.

Eletrobras, since 1992, develops and supports studies in the area of climate change, and participated and supported the Ministério de Ciência e Tecnologia – MCT (Ministry of Science and Technology), in the creation of the first national inventory[8], besides promoting the participation of Brazilian researchers and specialists in the Meetings of the Parties to the Kyoto Protocol.

Recently, addressing the different aspects of corporate sustainability, issues referring to climate change extended the environmental teams of the companies of the System, which are now part of the agenda of the Sustainability Committees. Thus, the systematic creation and disclosure of an inventory of greenhouse gases (GHG) are part of the actions employed by the Eletrobras System in trying to affirm the policy of sustainability, which will favor the image of the company and its market position, which is becoming more and more selective.

Although the Eletrobras System still does not have a plan to reduce emissions, it is important to highlight that the federal government designated the *holding* of the Eletrobras System, to manage the Programa de Incentivo às Fontes Alternativas de Energia Elétrica – PROINFA (Incentive Programme for Alternative Sources of Electric Energy). Considering that the target is to generate 3,300 MW through small hydroelectric plants (PCHs), eolic generators and biomass power plants, this total would prevent the equivalent of an emission of around 2.8 million tonnes of CO_2 into the atmosphere[9].

6. THE METHODOLOGY OF THE INVENTORY

Any initiative in the sense of making an inventory or communicating greenhouse gas emissions (GHGE), which are under the responsibility of a corporation, should be based on a consecrated and well defined methodology and should present, in the clearest possible way, all of the considerations and premises adopted to define the limits of responsibility and the content of the emissions presented.

In this sense, this inventory was based on guidelines and recommendations of the *"Greenhouse Gas Protocol Initiative – GHG Protocol*[3], developed by the

World Business Council for Sustainable Development – WBCSD and by the *World Resource Institute* – WRI, an international reference for the elaboration of the corporate inventory on greenhouse gases.

6.1 Definition of the Approach Used

According to the *GHG Protocol*, to declare the emissions of a corporation, two different approaches can be used to consolidate the data: the *control approach* or the *equity share approach*.

In general lines, the control approach consists of assuming that 100% of the emissions of a certain activity should be attributed to the company detaining the control over it. In this case, the control over the activity can be divided into *operational control*, when the company controls the operation of the activity; or *financial control*, when the company detains the means by which the activity is performed.

The other approach that could be adopted is the *equity share approach*. In this case, the rule adopted is that the responsibility of the emissions should be shared proportionally, i.e. financial and/or share participation of the company in an activity.
This inventory considered the **operational control approach**, i.e. a survey was made on the activities performed under the operational control of the companies that compose the Eletrobras System, which result in greenhouse gas emissions. The emissions originating from these activities are wholly attributed to the companies of the system.

6.2 Definition of the Scope of Inventory-related Activities

Greenhouse gas emissions could be the result of a set of activities performed, direct or indirectly, by a certain organization. These activities are performed in different areas of performance and many times could be quite different from each other, for example: generation and consumption of electric energy, transport, paper consumption, litter, etc. Thus, it is essential to define clearly the way of classifying the set of activities that generate emissions, in order to facilitate the presentation of results to society and prevent possible double counting in the process. The *GHG Protocol* classifies the emissions into three different scopes:

- Scope 1 – **direct** GHG emissions: resulting from sources that belong to the company or are controlled by it, i.e. emissions of its own equipment, such as: emissions of vehicles, boilers, turbines; fugitive emissions of SF_6 originating from circuit breakers and transformers; etc.

- Scope 2 – **indirect** GHG emissions: resulting from the consumption of electric energy supplied by the basic network (National Integrated System);

- Scope 3 - **indirect** GHG emissions: covers all forms of indirect emissions, such as: air travel by employees on business, litter transport, transport of employees to the workplace, etc.

According to the *GHG Protocol*, an inventory of GHG should be based on the following principles: **relevance, coverage, consistency, transparency and accuracy**. In relation to coverage, the Eletrobras System has the intention of including in its inventories the highest number of sources possible. It is important to observe that, the more sources that are considered, the more complex the systematics become related to the research, storage and processing of data to obtain the estimated emissions.

Seeking to preserve the consistency and accuracy of the information presented to society, the Eletrobras System chose to present in this Inventory (2003-2008) **the direct emissions resulting from the burning of fossil fuels in Thermoelectric Power Plants (UTEs**). This corresponds to the so-called permanent sources that, according to the *GHG Protocol*, correspond **to the first set of sources defined in scope 1**.

In the next edition (2010), two other sets of sources will be considered that, together with the permanent sources, compose scope 1: movable sources and fugitive emissions. **Indirect emissions** forecast in **scope 2** will also be considered. Once the systematics for research and service provision is implanted as a routine in companies for scopes 1 and 2, the projects will be concentrated in the incorporation of emissions resulting from sources listed in scope 3.

6.3 Procedures and Premises Adopted

In order to obtain the data of units of thermoelectric generation, such as fuel consumption, energy generated, and specific data on fuel, each company was requested, through the respective representative in the GT 3, to fill in electronic spreadsheets prepared for such, based on the *GHG Protocol*. In approximately one month, all of the companies with thermoelectric generation sent their spreadsheets to the coordination of the GT3. Those that did not have this type of generation sent their declaration.

In this cycle, the evaluation of consistency of the data and the analysis of the results were made by a representative of the Department of Energetic Optimization and the Environment - DEA of the CEPEL.

Secondary emissions were not accounted for, i.e. those associated with energy consumption in offices, of business trips, of fleets of vehicles, of suppliers, etc. Neither were emissions accounted for referring to losses in the transmission and distribution systems. These emissions should be incorporated in the following cycles of the inventory.

The methodology of the *Intergovernmental Panel on Climate Change-IPCC* was adopted. The value of the energetic content of the fuels consumed was calculated based on factors of conversion used by the National Energetic Balance - BEN 2008 (based on 2007). The source of the factors of emission used was the Initial National Communication of Brazil to the Convention Panel of the United Nations on Climate Change.

In this Inventory the operating rules for the thermoelectric power plants of the National Interconnected System (SIN) will not be analyzed since they are dispatched according to stipulations of the Operator of the National Electricity System - ONS.

This inventory has not been verified by any independent third party, but all the information and memories of calculation, including the identification of sources of data, were filed for a later consultation, if necessary.

An important consideration to be made is related to the participation of the hydroelectric generation in the generation park of the Eletrobras System. Until now, there is no consensus on a methodology for estimating GHG emissions from hydroelectric reservoirs. Eletrobras and some companies of the System have participated actively in the development of reliable technologies and methodologies so that the emissions from hydroelectric reservoirs could be done reliably.

6.4 Calculation methodology

The estimates of GHG emissions from fossil fuel burning were made using the *bottom-up* approach, considering the fuel consumption of each thermal unit and the carbon content of each fuel.

All GHG emissions were converted to Giga-grams (Gg) of carbon dioxide equivalent (CO_2-equivalent), applying the Global Warming Potential (GWP) values provided by the IPCC.

The following thermal facilities that generate electric power by fossil fuel burning were considered: Eletronorte Chesf, Furnas, CGTEE, Amazonas Energia and Eletronuclear (because they have auxiliary generators that run on diesel).

The emissions from land use and the balance of emissions, considering sources and culverts of undertakings of the Eletrobras System, were not considered. Only the liquid emissions from fossil fuel burning were considered.

6.4.1 – Calculation of CO_2 emissions

Step 1 - Calculation of **Energy Consumption:**
Through the forms that were sent by the companies, data on fuel consumption (CU) was obtained in mass or volume units, per year, for each generating unit. Energy consumption (CC) is obtained by using the following equation:

$$CC = CU \times Fconv \times Fcorr \times 0.04187 \quad (1)$$

Where:

CU	Fuel consumption (fuel unit);
CC	Energy consumption (TJ);
Fconv	Conversion Factor (tep / unit of fuel) 1;
Fcorr is	Correction Factor (0.95 solid & liquid - 0.9 for gas.)

In other words, the methodology guides the application of a correction factor of 0.95 for solid and liquid fuels, and 0.9 for gas fuels. Based on data from the BEN – 2008 National Energy Balance (based on 2007), multiply by 0.04187 to convert the energy content of toe to TJ.

Step 2 – Calculation of the **Amount of Carbon** (Gg C):

The following equation is applied:

$$QC = CC \times Femiss \times 10^{-3} \quad (2)$$

Where:

QC	Amount of carbon (Gg C)
CC	Energy consumption (TJ)
Femiss	Emission Factor (tC / TJ)

Step 3 – Calculation of the **Amount of Fixed Carbon** (Gg C):

In this case, the value of fixed carbon (QCF) is considered as equal to zero, because there is not any non-energetic consumption of carbon since all fuel is burned to generate electricity.

$$QCF = 0 \quad (3)$$

Step 4 - Calculation of **Liquid Emissions of Carbon** (Gg C):

The following equation is applied:

$$ELC = QC - QCF \quad (4)$$

Where:

QC	Amount of carbon (Gg C)
QCF	Amount of Fixed carbon (Gg C)
ELC	Liquid Emissions of Carbon (Gg C)

Step 5 – Calculation of **Actual Carbon Emissions** (Gg C):

The following application is applied:

$$ERC = ELC \times FCO \quad (5)$$

Where:
- ELC Liquid Emissions of Carbon (Gg C)
- FCO Fraction of Oxidized carbon (dimensionless)
- ERC Actual Carbon emissions (Gg C)

Step 6 - Calculation of **Actual Carbon Dioxide Emissions** (Gg CO_2):

The following equation is applied:

$$ER\ CO_2 = ERC \times (44/12) \quad (6)$$

Where:
- ERC Actual Carbon emissions (Gg C)
- ER CO_2 Actual Carbon Dioxide Emissions (Gg CO_2)
- (44/12) Ratio between the molecular weight of CO_2 and of C

6.4.2 - Calculation of CH_4 and N_2O Emissions

Step 1 - Calculation of **Energy Consumption**:

This step is identical to step 1 of the item 7.4.1. Energy consumption (CC) is obtained by using the following equation:

$$CC = CU \times Fconv \times Fcorr \times 0{,}04187 \quad (1)$$

Where:
- CU Fuel consumption (fuel unit);
- CC Energy consumption (TJ);
- Fconv Conversion Factor (toe / fuel unit) 1;
- Fcorr Correction Factor (0.95 solid and liquid - 0.9 for gas)

Step 2 - Calculation of **CH_4 and N_2O Emissions:**

$$E\ CH_4 = CC \times FE\ CH_4 \quad (7)$$

$$E\ N_2O = CC \times FEN_2O \quad (8)$$

Where:
- CC Energy consumption (TJ);

FE CH_4 CH_4 Emission factor (t CH_4 / TJ)
FE N_2O N_2O Emission factor (t N_2O / TJ)
E CH_4 CH_4 Emissions (t CH_4)
E N_2O N_2O Emissions (t N_2O)

Step 3 - Calculation of Equivalent Emissions of CH_4 and N_2O

$$E\ CH_4\ eq = GWP_{CH4} * E\ CH_4 \quad (6)$$

$$E\ N_2O\ eq = GWP_{N2O} * E\ N_2O \quad (7)$$

Where:
E CH_4 CH_4 Emissions (t CH_4)
E N_2O is N_2O Emissions (t N_2O)
GWP CH_4 Global warming potential of CH_4 (21)
GWP N_2O Global warming potential of N_2O (310)
E CH_4 eq CH_4 Equivalent Emissions (t CO_2eq)
E N_2O eq N_2O Equivalent Emissions (t CO_2eq)

7. RESULTS

This chapter presents estimated results for emissions of carbon dioxide (CO_2), methane (CH_4) and nitrous dioxide (N_2O) from permanent sources, such as the thermoelectric power plants of the group of companies of Eletrobras. The values of emissions are represented in units of Gg CO_2e (Giga-grams of CO_2 equivalent); carbon dioxide represents most of the emissions.

The amount of electricity produced by the thermoelectric power plants of the companies belonging to Eletrobras System companies from 2003 to 2008 will also be presented. The annual values of GHG emissions per company as well as of the whole system will be presented, creating a new indicator "GHG emissions per amount of electricity generated" (in Giga-grams of CO_2 equivalent per Gigawatt-hour).

EMIS/GER (Gg CO_2eq/GWh)

7.1 AMAZONAS ENERGIA

Amazonas Energia currently counts on two large parks of thermoelectric generation, one in Manaus, and the other formed by isolated systems serving the urban centres in the interior of the State of Amazonas. The results presented below correspond to the sum of the emissions and the values of energy generated by the two energy generating parks.

In the Manaus system, the emissions of three power plants were considered: Aparecida, Electron and Mauá that use fuel oil. Whereas the power plants of Cidade Nova, Flores and São Jose, did not enter the calculation due to lack of information.

The system in the interior is composed of 98 generating units, all from diesel oil. For lack of information, they did not enter the calculation data for 2003 and 2004. On the other hand, for all the other years (2005 - 2008), data was available for all 98 units.

AM 1 Table

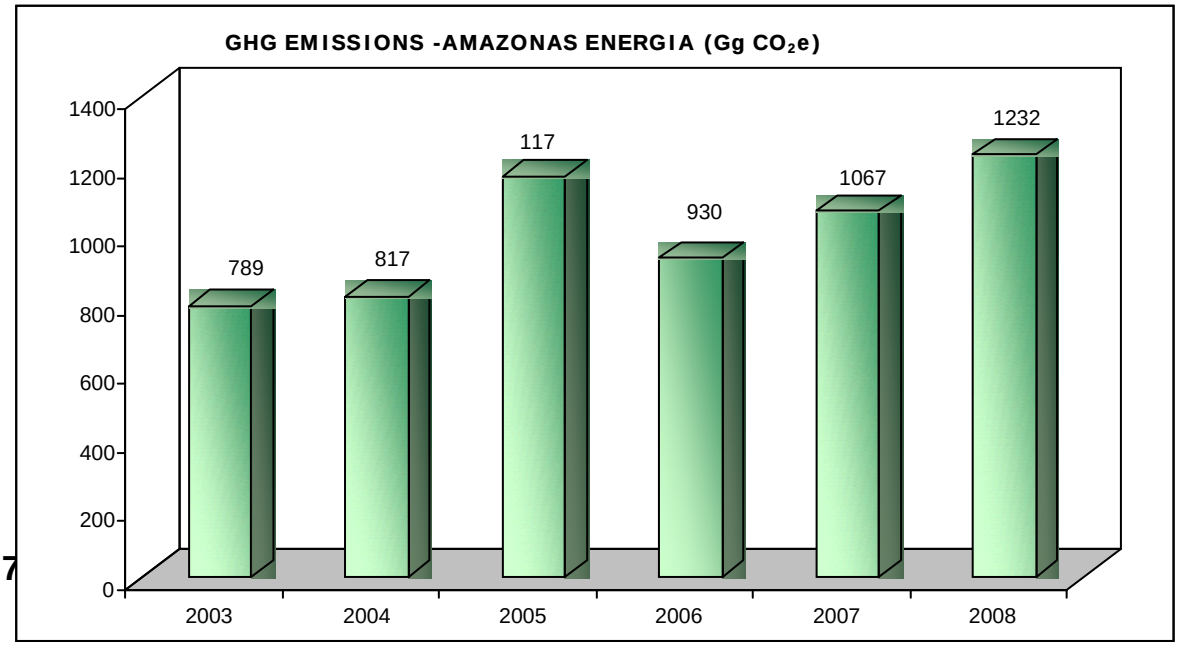
GHG	AMAZONAS ENERGIA – GHG EMISSIONS – PERMANENT SOURCES					
	2003	2004	2005	2006	2007	2008
CO_2 (Gg CO_2)	786.67	814.09	1,168.47	927.21	1,063.28	1,227.48
CH_4 (Gg CO_2e)	0.65	0.67	0.47	0.78	0.90	1.03
N_2O (Gg CO_2e)	1.91	1.98	1.40	2.31	2.65	3.05
SUBTOTAL (Gg CO_2e)	789.23	816.73	1,170.35	930.30	1,066.83	1,231.56

AM 2 Table

INDICATOR	AMAZONAS ENERGIA					
	2003	2004	2005	2006	2007	2008
EMISSIONS (Gg CO_2e)	789	817	1170	930	1067	1232
ENERGY GENERATED (GWh)	832	815	1324	1209	840	874
EMIS / GER (Gg CO_2e / GWh)	0.95	1.00	0.88	0.77	1.27	1.41

The GHG emissions in this period are directly related to meeting the demand of these systems, which is predominantly thermal. The interconnection of the Manaus system with the National Interconnected System (SIN) will be made through the Transmission Line of Tucuruí, in Manaus, which is now under construction. Thus, the trend is that the GHG emissions will decrease. Although the period of transition and adaptation should be considered, it cannot be determined yet.

Figure AM 1



CHESF, which has a generating park of about 10,000 MW, predominantly by hydrous source, has only one thermoelectric power station, UTE Camaçari in Bahia, with 350 MW of installed power, and operates on natural gas and diesel. Since the operation of this plant is subject to the SIN dispatch, we observed that in 2006, the generation was reduced, only 5 GWh, resulting in lower emissions. In 2008, on the contrary, Camaçari generated 569 GWh which increased the volume of the GHG emissions.

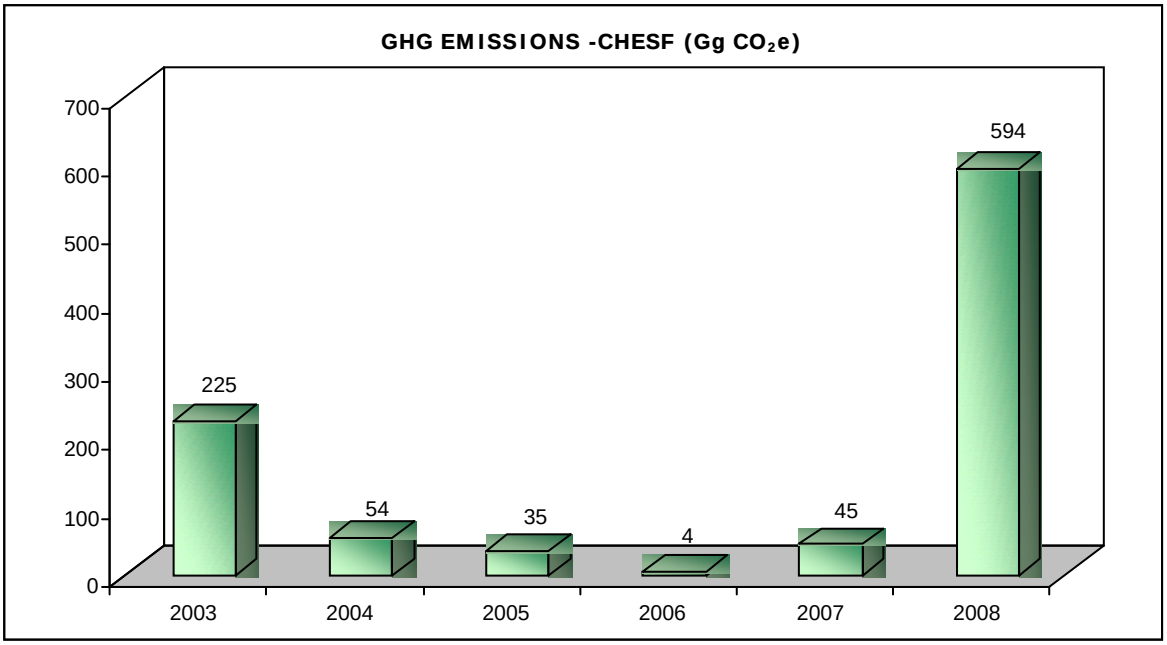
Table CH 1

GHG	CHESF – GHG EMISSIONS – PERMANENT SOURCES					
	2003	2004	2005	2006	2007	2008
CO_2 (Gg CO_2)	223.97	53.80	35.31	3.54	44.94	592.06
CH_4 (Gg CO_2e)	0.19	0.06	0.04	0.00	0.04	0.51
N_2O (Gg CO_2e)	0.57	0.41	0.11	0.01	0.11	1.50
SUB TOTAL (Gg CO_2e)	224.73	54.28	35.46	3.56	45.09	594.07

Table CH 2

INDICATOR	CHESF					
	2003	2004	2005	2006	2007	2008
EMISSIONS (Gg CO_2e)	225	54	35	4	45	594
ENERGY GENERATED (GWh)	266	85	49	5	41	569
EMIS / GER (Gg CO_2e / GWh)	0.85	0.64	0.73	0.71	1.10	1.04

Figure CH 1



7.3 FURNAS

The thermoelectric park in Furnas is composed of two plants, UTE Santa Cruz (766 MW) and UTE Campos (30 MW), both located in the State of Rio de Janeiro and conditioned to the SIN dispatch. Currently, UTE Santa Cruz is a generating plant prepared to generate natural gas. However, during the inventoried period, this plant used fuel oil and diesel oil. UTE Campos, which uses natural gas, was switched off for almost the entire period, operating only in 2008. In 2003, the highest levels of power generation of the thermal plants in Furnas were obtained and, consequently, the highest amount of GHG emissions.

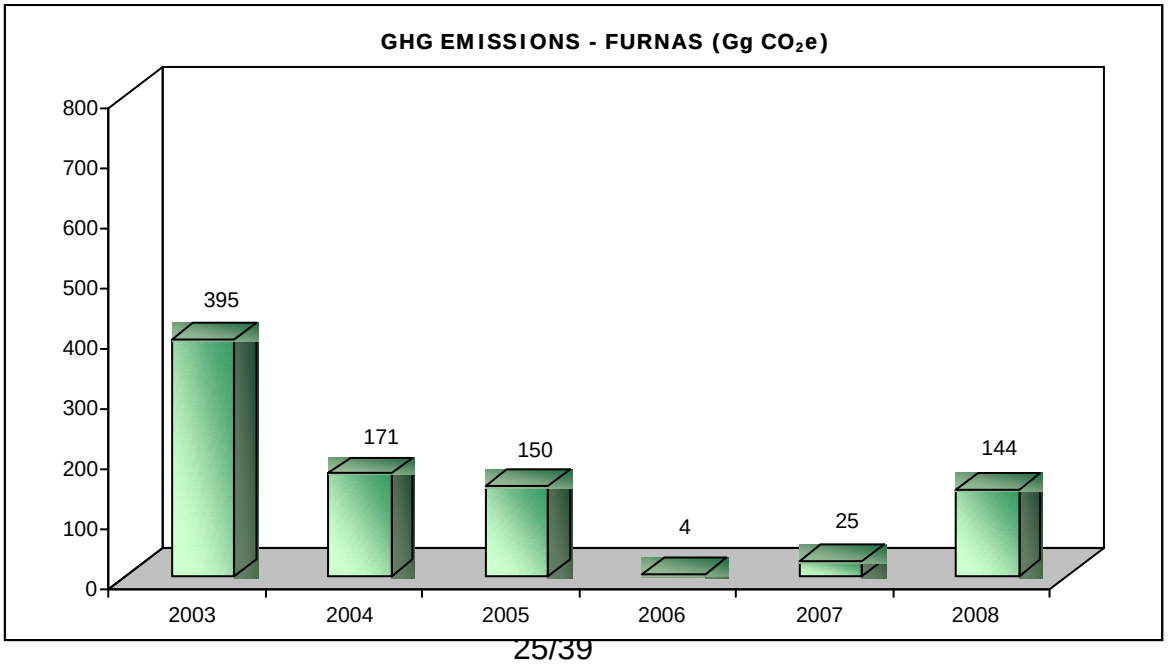
Table FR 1

GHG	FURNAS – GHG EMISSIONS – PERMANENT SOURCES					
	2003	2004	2005	2006	2007	2008
CO_2 (Gg CO_2)	393.50	169.99	149.4265	4.098	24.86	144.09
CH_4 (Gg CO_2e)	0.32	0.14	0.1159	0.004	0.02	0.09
N_2O (Gg CO_2e)	0.96	0.41	0.3423	0.010	0.06	0.26
SUB TOTAL (Gg CO_2e)	394.78	170.55	149.88	4.11	24.94	144.44

Table FR 2

INDICATOR	FURNAS					
	2003	2004	2005	2006	2007	2008
EMISSIONS (Gg CO_2e)	395	171	150	4	25	144
ENERGY GENERATED (GWh)	516	199	177	4	31	175
EMIS / GER (Gg CO_2e / GWh)	0,77	0,86	0,85	0,95	0,81	0,83

Figure FR 1



7.4 CGTEE

CGTEE owns the right to explore and produce electricity through its thermoelectric power plants located in the state of Rio Grande do Sul. The Thermoelectric Power Plants are: Usina Termelétrica Presidente Medici (Candiota II) - 446 MW; Usina Termelétrica São Jerônimo - 20 MW, and Nova Usina Termelétrica de Porto Alegre - NUTEPA - 24 MW.

The predominant primary source for generating electricity in CGTEE is coal. However on a smaller scale, diesel and fuel oil are also used. The emissions varied around the level of 2000 GgCO2e having a slight reduction in 2008.

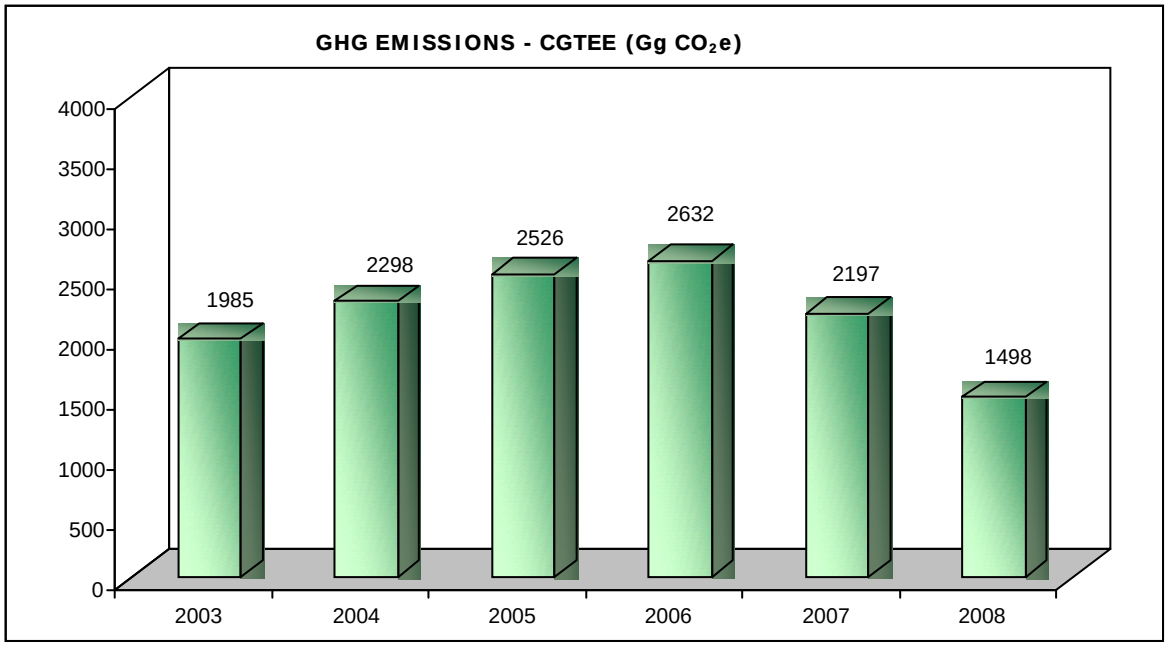
Table CG 1

GHG	CGTEE – GHG EMISSIONS – PERMANENT SOURCES					
	2003	2004	2005	2006	2007	2008
CO_2 (Gg CO_2)	1,974.41	2,286.47	2,512.55	2,617.92	2,185.42	1,489.90
CH_4 (Gg CO_2e)	0.49	0.55	0.60	0.63	0.54	0.38
N_2O (Gg CO_2e)	9.73	11.32	12.46	12.97	10.78	7.29
SUB TOTAL (Gg CO_2e)	1,984.63	2,298.34	2,525.61	2,631.52	2,196.73	1,497.57

Table CG 2

INDICATOR	CGTEE					
	2003	2004	2005	2006	2007	2008
EMISSIONS (Gg CO_2e)	1985	2298	2526	2632	2197	1498
ENERGY GENERATED (GWh)	1354	1526	1320	1762	1251	970
EMIS / GER (Gg CO_2e / GWh)	1.47	1.51	1.91	1.49	1.76	1.54

Figure CG 1



7.5 ELETRONORTE

The thermoelectric park of Eletronorte is divided into three systems: Acre, Rondônia and Amapá. Although the systems of Acre and Rondônia have been connected recently to the SIN (2009), during the period of this inventory these systems worked in isolation and therefore its operation was not conditioned to the dispatch of the SIN, but to local demand. There is hydroelectric generation in Rondônia (UHE Samuel) and in Amapá (UHE Coaracy Nunes), however, the thermal plants also operate continuously at base load, leading to emissions of the greenhouse gases presented below.

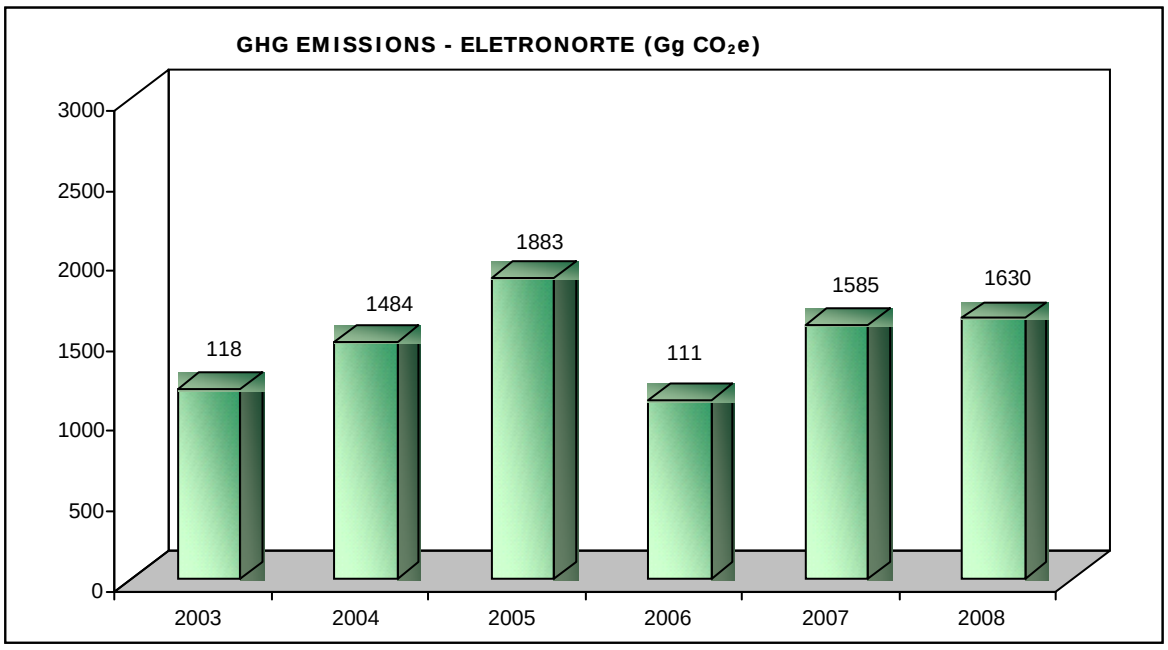
Table EN 1

GHG	ELETRONORTE – GHG E.ISSIONS – PERMANENT SOURCES					
	2003	2004	2005	2006	2007	2008
CO_2 (Gg CO_2)	1,183.41	1,479.35	1,876,53	1,111.85	1,579.31	1,624.80
CH_4 (Gg CO_2e)	1.00	1.24	1.57	1.23	1.32	1.35
N_2O (Gg CO_2e)	2.94	3.66	4.65	3.62	3.88	4.00
SUB TOTAL (Gg CO_2e)	1,187.35	1,484.25	1,882.75	1,116.70	1,584.51	1,630.15

Table EM 2

INDICATOR	ELETRONORTE					
	2003	2004	2005	2006	2007	2008
EMISSIONS (Gg CO_2e)	1187	1484	1883	1117	1585	1630
ENERGY GENERATED (GWh)	1514	1909	2206	2014	2330	2321
EMIS / GER (Gg CO_2e / GWh)	0.78	0.78	0.85	0.55	0.68	0.70

Figure EN 1



7.6 ELETRONUCLEAR

Eletronuclear has a park consisting of two thermonuclear power plants (Angra 1 and Angra 2), using as its source of heat the nuclear fission that occurs inside nuclear reactors. However, in the generation process, there is a small-scale burning of fuel (diesel) that is used in the auxiliary boilers and emergency diesel generators at both plants. It is important to note that, as the diesel oil consumption occurs on a very small scale, the indicator of GHG emissions per energy generated registers values which are well below those observed for the other companies of the Eletrobras System.

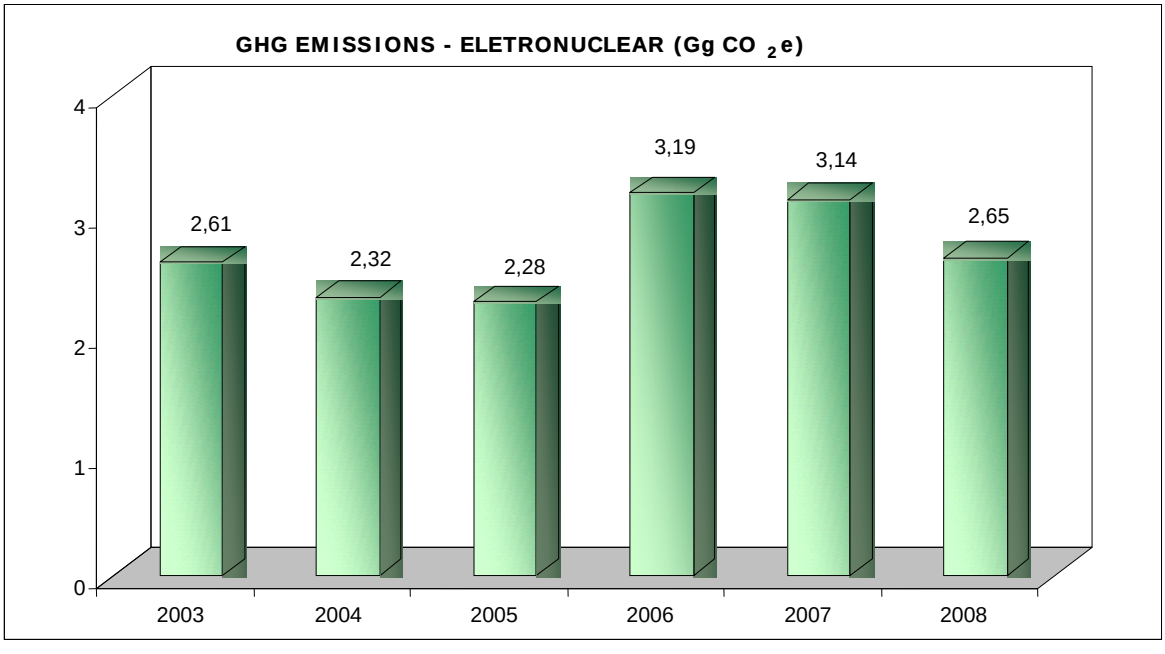
Table ENu 1

GHG	ELETRONUCLEAR – GHG EMISSIONS – PERMANENT SOURCES					
	2003	2004	2005	2006	2007	2008
CO_2 (Gg CO_2)	2.60	2.31	2.28	3.18	3.13	2.64
CH_4 (Gg CO_2e)	0.00	0.00	0.00	0.00	0.00	0.00
N_2O (Gg CO_2e)	0.01	0.01	0.01	0.01	0.01	0.01
SUB TOTAL (Gg CO_2e)	2.61	2.32	2.28	3.19	3.14	2.65

Table ENu 2

INDICATOR	ELETRONUCLEAR					
	2003	2004	2005	2006	2007	2008
EMISSIONS (Gg CO_2e)	2.61	2.32	2.28	3.19	3.14	2.65
ENERGY GENERATED (GWh)	3326	4125	3731	3399	2709	3515
EMIS / GER (Gg CO_2e / GWh)	0.0008	0.0006	0.0006	0.0009	0.0012	0.0008

Figure ENu 1



7.7 ELETROBRAS SYSTEM

The following tables show the aggregated values of emissions of greenhouse gases from fossil fuel burning in the thermal power plants of the companies of the Eletrobras system and the ratio between the sum of the emissions and the amount of energy generated.

Table SELB 1

GHG	ELETROBRAS SYSTEM – GHG EMISSIONS – PERMANENT SOURCES					
	2003	2004	2005	2006	2007	2008
CO_2 (Gg CO_2)	4,564.58	4,806.02	5,744.56	4,667.80	4,900.92	5,080.97
CH_4 (Gg CO_2e)	2.65	2.67	2.80	2.65	2.81	3.37
N_2O (Gg CO_2e)	16.11	17.79	18.96	18.92	17.50	16.11
SUBTOTAL (Gg CO_2e)	4,583.34	4,826.47	5,766.33	4,689.37	4,921.24	5,100.45

Table SELB 2

INDICATOR	ELETROBRAS SYSTEM					
	2003	2004	2005	2006	2007	2008
EMISSIONS (Gg CO_2e)	4583	4826	5766	4689	4921	5100
ENERGY GENERATED (GWh)	7807	8658	8807	8394	7202	8424
EMIS / GER (Gg CO_2e / GWh)	0.59	0.56	0.65	0.56	0.68	0.61

Figure SELB 1

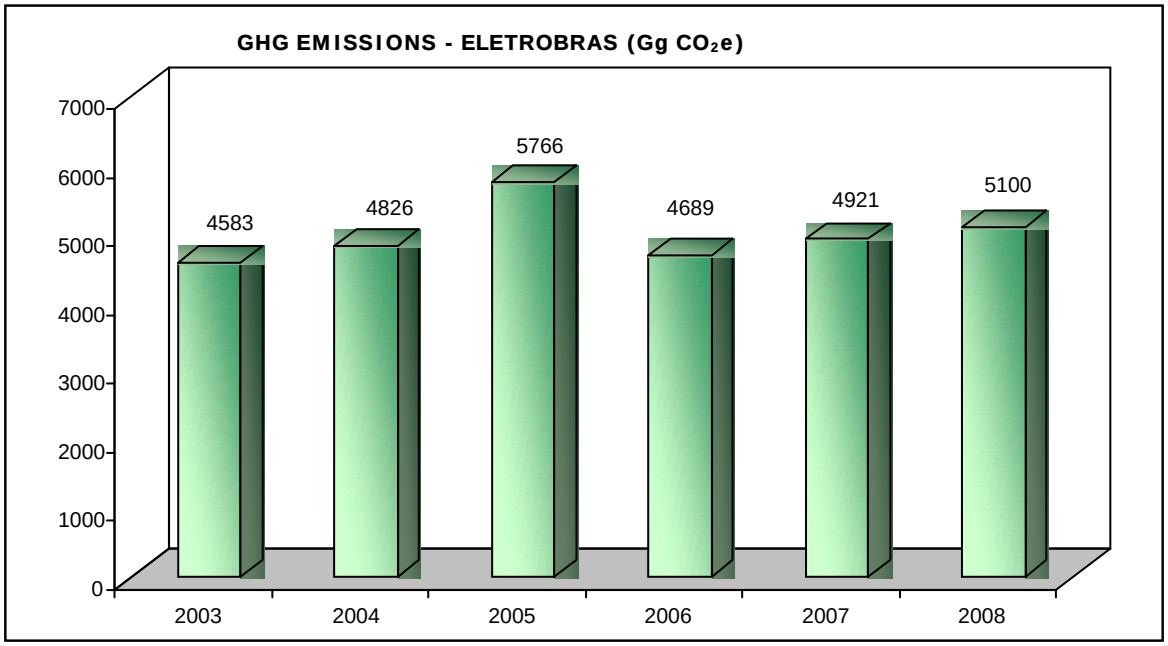


Table SELB 3

YEAR 2003		
COMPANY	**GHG EMISSIONS ($Gg\ CO_2e$)**	**COMPANY SHARE (%)**
AMAZONAS ENERGIA	789.23	17.22
CHESF	224.73	4.90
FURNAS	394.78	8.61
CGTEE	1,984.63	43.30
ELETRONORTE	1,187.35	25.91
ELETRONUCLEAR	2.61	0.06
SISTEMA ELETROBRAS	**4,583.34**	**100.00**

Figure SELB 2 - EMISSIONS IN 2003 (%)

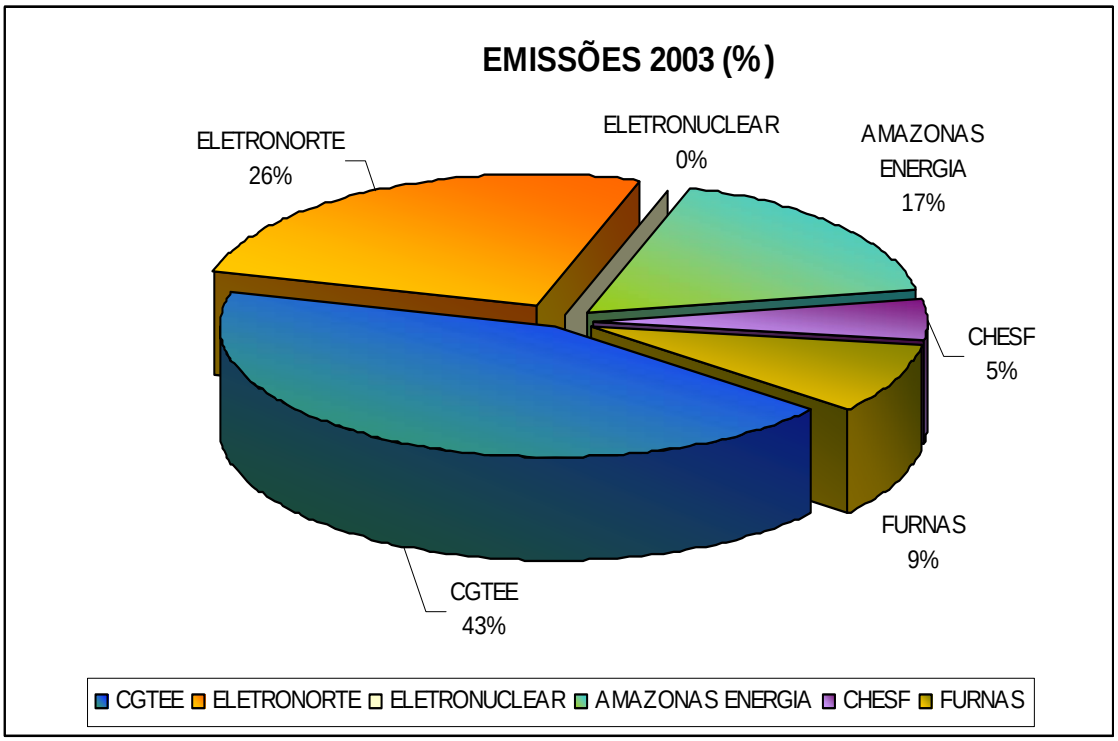


Table SELB 4

YEAR 2004		
COMPANY	**GHG EMISSIONS (Gg CO_2e)**	**COMPAY SHARE (%)**
AMAZONAS ENERGIA	816.73	16.92
CHESF	54.28	1.12
FURNAS	170.55	3.53
CGTEE	2,298.34	47.62
ELETRONORTE	1,484.25	30.75
ELETRONUCLEAR	2.32	0.05
SISTEMA ELETROBRAS	**4,826.47**	**100.00**

Figure SELB 3 - EMISSIONS IN 2004 (%)

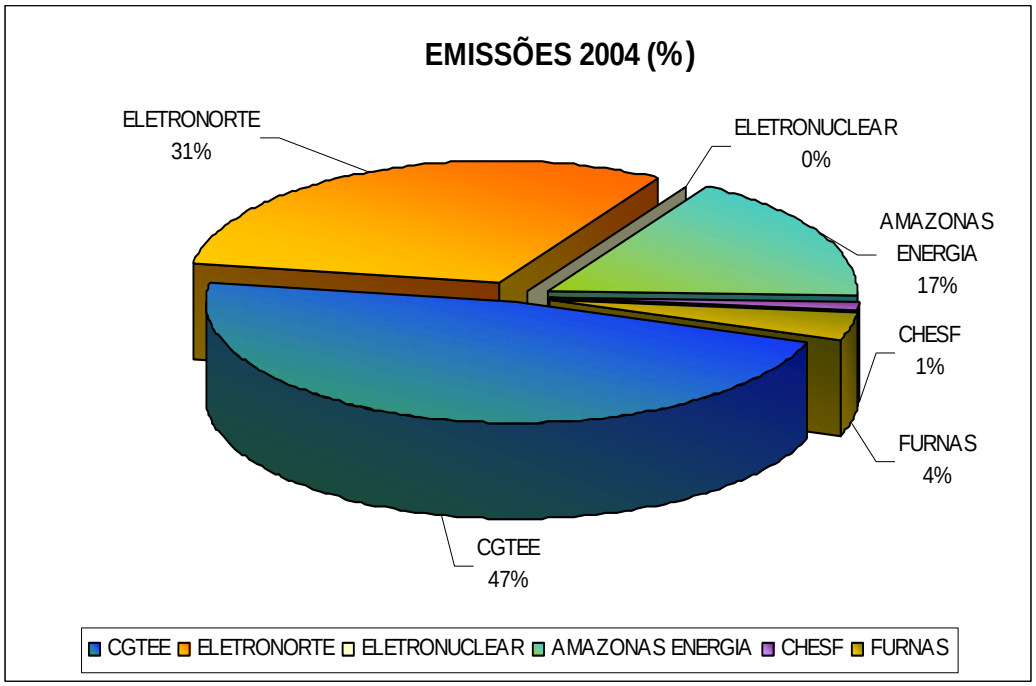


Table SELB 5

YEAR 2005		
COMPANY	**GHG EMISSIONS (Gg CO_2e)**	**COMPANY SHARE (%)**
AMAZONAS ENERGIA	1,170.35	20.30
CHESF	35.46	0.61
FURNAS	149.88	2.60
CGTEE	2,525.61	43.80
ELETRONORTE	1,882.75	32.65
ELETRONUCLEAR	2.28	0.04
SISTEMA ELETROBRAS	**5,766.33**	**100.00**

Figure SELB 4 - EMISSIONS IN 2005 (%)

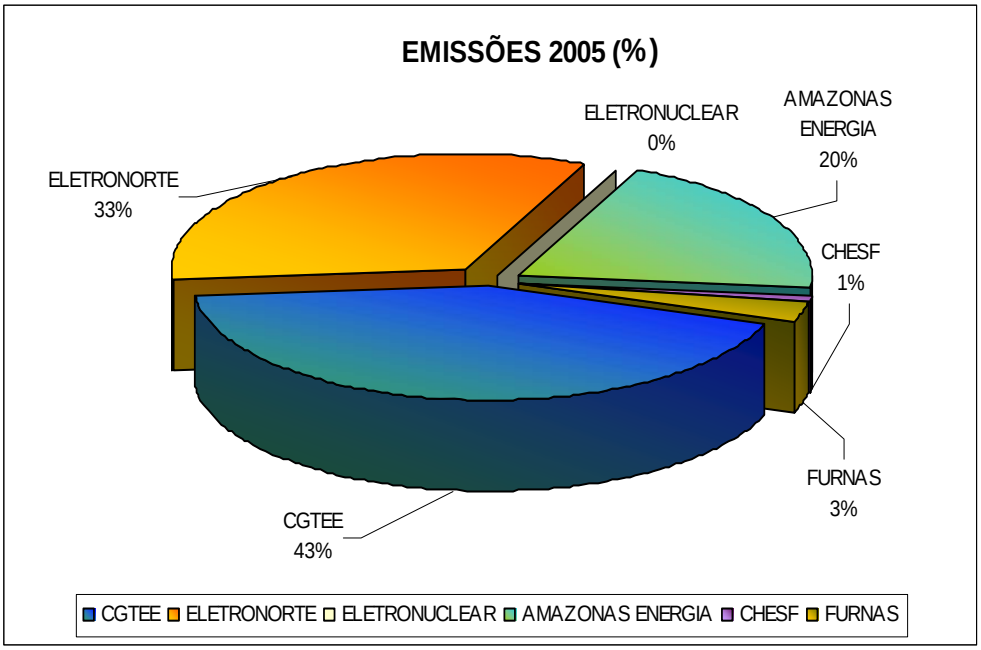


Table SELB 6

YEAR 2006		
COMPANY	**GHG EMISSIONS (Gg CO_2e)**	**COMPANY SHARE (%)**
AMAZONAS ENERGIA	930.30	19.84
CHESF	3.56	0.08
FURNAS	4.11	0.09
CGTEE	2,631.52	56.12
ELETRONORTE	1,116.70	23.81
ELETRONUCLEAR	3.19	0.07
SISTEMA ELETROBRAS	**4,689.37**	**100.00**

Figure SELB 5 - EMISSIONS IN 2006 (%)

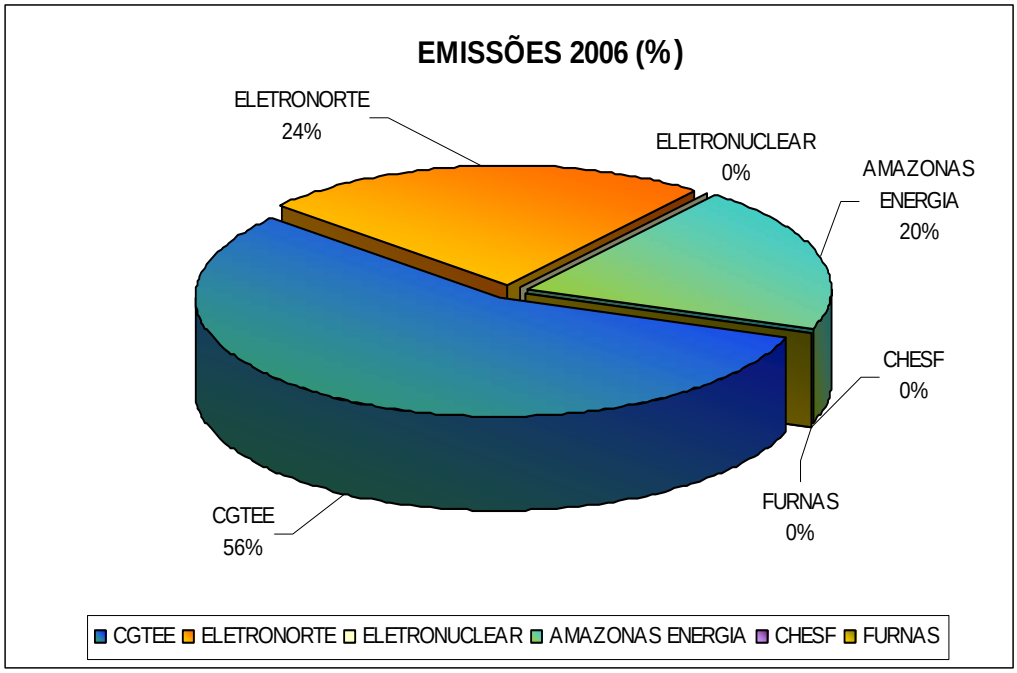


Table SELB 7

YEAR 2007		
COMPANY	**GHG EMISSIONS (Gg CO_2e)**	**COMPANY SHARE (%)**
AMAZONAS ENERGIA	1,066.83	21.68
CHESF	45.09	0.92
FURNAS	24.94	0.51
CGTEE	2,196.73	44.64
ELETRONORTE	1,584.51	32.20
ELETRONUCLEAR	3.14	0.06
SISTEMA ELETROBRAS	**4,921.24**	**100.00**

Figure SELB 6 - EMISSIONS IN 2007 (%)

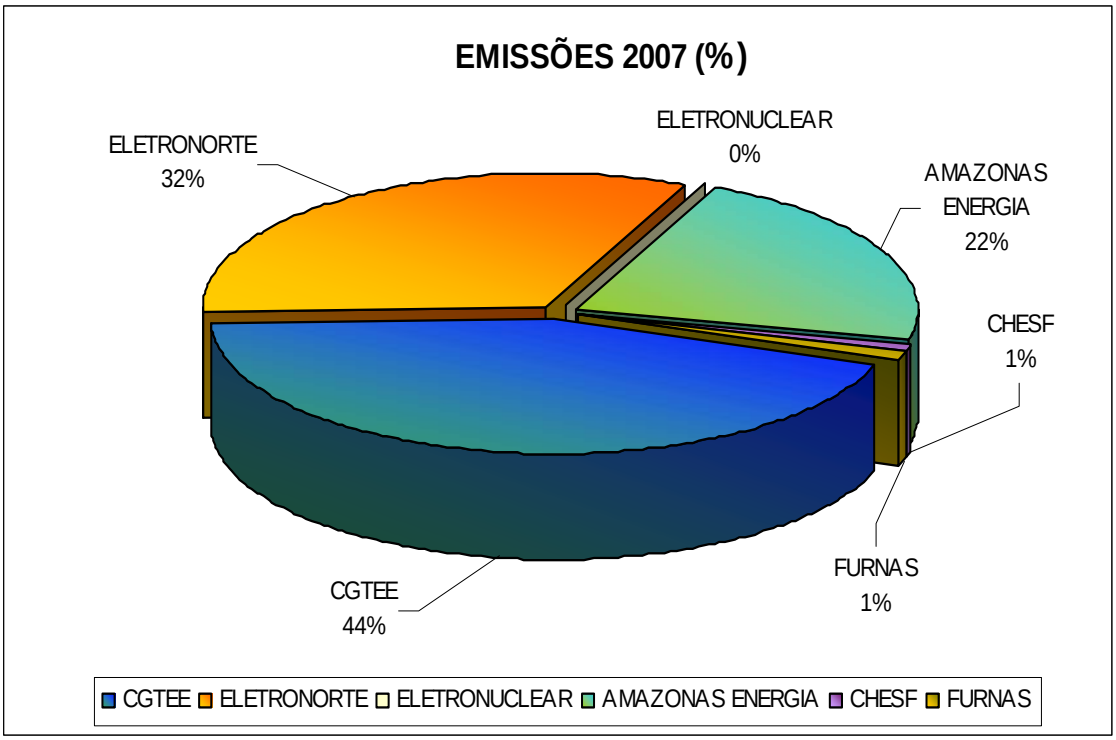
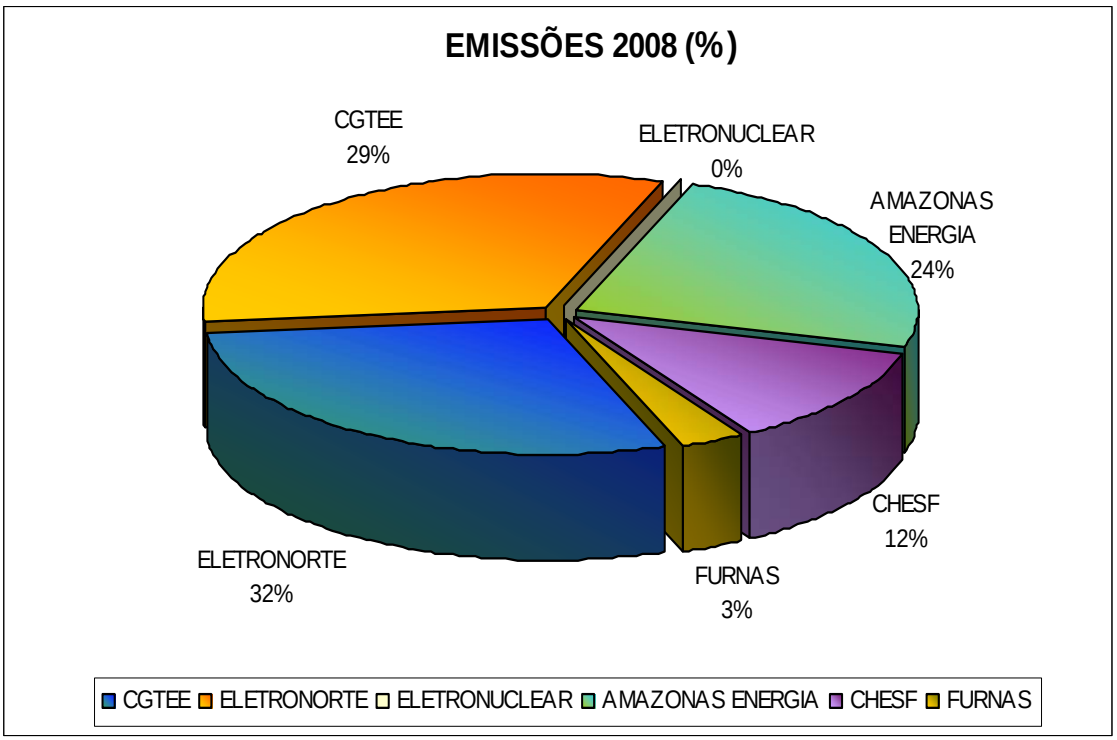


Table SELB 8

YEAR 2008		
COMPANY	**GHG EMISSIONS (Gg CO_2e)**	**COMPANY SHARE (%)**
AMAZONAS ENERGIA	1,231.56	24.15
CHESF	594.07	11.65
FURNAS	144.44	2.83
CGTEE	1,497.57	29.36
ELETRONORTE	1,630.15	31.96
ELETRONUCLEAR	2.65	0.05
SISTEMA ELETROBRAS	**5,100.45**	**100.00**

Figure SELB 7 - EMISSIONS IN 2008 (%)



8. FINAL CONSIDERATIONS AND FOLLOWING STEPS

In compliance with the Environmental Policy of the Eletrobras System, which aims to promote sustainable development and maintenance of the environment, this inventory consolidates and gives transparency to the amount of GHG emissions from thermal power plants of the Eletrobras System for the period between 2003 and 2008 .

During this period, the greenhouse gases (GHG) emissions that were calculated ranged from 4,565 to 5,745 Gg of CO_2 equivalent. Considering the amount of energy generated by the System, which ranged from 7,202 to 8,807 GWh, the emission factor for CO_2 of the Eletrobras System was between 0.56 and 0.68 $GgCO_2eq/GWh$. These values are considered low when compared to the emission factors of corporations in the same sector and of equivalent size in the world.

Aware of the importance of contributing to decrease the amount of carbon in the atmosphere, the Eletrobras System has supported actions that aim to expand the use of alternative sources of electric energy and energy efficiency, besides other initiatives for the development of studies and research.

Since the largest portion of the generating park of the Eletrobras system comes from a hydrous source, Eletrobras and some companies of the System have adopted actions so that possible emissions from hydroelectric reservoirs may be reliably estimated, promoting the development of methodologies and measurement technologies, and professional training. However, up to the present moment, in the national and international scenario, scientists have not reached a consensus on the most reliable methodology for estimating GHG emissions from hydroelectric reservoirs. For this reason, the hydroelectric generation is not being considered in the GHG Inventory of the Eletrobras System.

An important fact to emphasize is that the Eletrobras System, when applying resources from environmental compensation and environmental projects in their companies, contributes to the conservation of biodiversity in a total of 14,450,520 hectares of legally protected areas.

A key point to be included in the investment analysis process of the System is the **risk analysis** regarding climate change, considering both the physical vulnerability and the commitment of the proper functioning of the plants and facilities, due to events that may be attributed to climate change. It is therefore necessary to have a better risk management, a broader view of the business models and a greater affinity with the opportunities driven by climatic factors.

The concrete measures of the Eletrobras System for the posture of "pro-climate change" should be reported and disseminated publicly to keep society and the market adequately informed.

The following steps for the development or improvement of a management plan for air emissions of the Eletrobras System are presented below, and are not necessarily in any order of priority.

a) Conduct routine inventories of GHG so that the data can be presented in annual reports;

b) Implement a GHG inventory system covering scopes 1, 2 and 3 considered in the GHG Protocol;

c) In the 2010 edition of the GHG Inventory of the Eletrobras System:

- Account for technical losses in transmission and distribution, for a future analysis of fugitive GHG emissions associated with SF_6.

- Account for emissions from the vehicle fleet controlled by Eletrobras System companies (its own fleet and third party fleet).

- Account for secondary emissions on the consumption of electricity from the SIN acquired from local providers.

d) Promote the integration of GHG emission data and systematize them in the Project IGS Database - Socio-environmental Indicators for Corporate Sustainability Management of the Eletrobras System - to meet the targets of PAE 2009-2013 (ISE- BOVESPA and DJSI) and of other demands (CDP-Carbon Disclosure Project, etc.);

e) Include data from years prior to 2003 to improve the representativeness of the series;

f) Support the Sustainability Committee of the Eletrobras System and its deliberations, providing support on issues related to Climate Change;

g) To promote, monitor and participate in studies and research for the development of knowledge, technologies and methodologies for estimating GHG emissions in hydroelectric reservoirs;

h) Promote, monitor and participate in the development of studies and research on alternative sources of energy and energy efficiency as ways of reducing GHG emissions;

i) Develop a target plan for reducing GHG emissions for the Eletrobras System, considering its strategic planning and its environmental policy;

j) To support business initiatives and actions focused on energy efficiency and environmental conservation;

k) Include the record of air emissions (monitored, controlled or estimated) in compliance with the CONAMA Resolutions and legislation;

l) Promote, monitor and participate in research studies on the vulnerability of the Brazilian electrical system in relation to the consequences of climate change;

m) Promote, monitor and participate in studies, research and risk analysis of undertakings, considering the scenarios of declining rainfall and reduced flow in the rivers basins, and its incorporation of expansion strategies of the Eletrobras system;

n) To promote, monitor and participate in studies and research for adaptation and mitigation of the effects of climate change on undertakings of the Eletrobras System;

o) Monitor the development of regulations and rules relating to air emissions, especially the development of standardization norms of ISO 14000, which specifically deals with GHG emissions;

p) To participate in specific forums on Climate Change in Brazil and abroad, in particular the Brazilian Forum on Climate Change - FBMC, prioritizing those that have specific technical committees on the issue.

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