

STATE COMMUNICATION

1st DIRECT AND INDIRECT GREENHOUSE GASES ANTHROPOGENIC EMISSIONS INVENTORY OF SAO PAULO STATE

1st Direct and Indirect Greenhouse Gases Anthropogenic Emissions Inventory of Sao Paulo State

Executive Summary and Additional Remarks

The State Policy on Climate Change

Due to the increase in the atmospheric concentrations of Greenhouse Gases (GHG) and the consequent global climate changes, not only the national governments members of the United Nations Framework Convention on Climate Change (UNFCCC)¹, but also the state and municipal governments, have made all and every effort in estimating the emissions of those gases aiming for helping society identify the local priorities and the adoption of more adequate measures in order to reduce such emissions. In that sense, the Government of Sao Paulo State, on November 9, 2009, published the Act n. 13,798², institutes the State Policy on Climate Change (PEMC), regulated by Decree 55,947³ of June 24, 2010 (SÃO PAULO, 2010).

In the Article 6 of that Law (13,798/2009) are defined the guidelines for the elaboration, the updating on regular basis and the publication of anthropogenic emissions inventories, described by sources and removals, by means of sinks, of the GHG not controlled by the Montreal Protocol, by using methods comparable both national and internationally. Mainly in the GHG Emissions Inventory of Sao Paulo State, by widening the legal framework, the emissions of the gases controlled by the Montreal Protocol were included, once they also contribute to the greenhouse effect increase. In the Article 7 of the same Law, is the definition of the State Communication, which includes the Emissions Inventory in its structure.

This document deals with the 1st Direct and Indirect Greenhouse Gases Anthropogenic Emissions Inventory of Sao Paulo State, including the gases controlled by the Montreal Protocol for the period from 1990 to 2008. It is the result of the consolidation of 26 Reference Sector Reports developed by excellence institutions and experts. Those reports were available to Public Reading in the website of CETESB for around ten month.

Sao Paulo State in the National Context

The GHG National Inventory, in a country with the size and diversity of Brazil, is an organizational challenge that demands statistic data that sometimes simply either do not exist or lack the quality needed for the estimations on the topic. In that sense, the National Communication⁴ plays its role in a clear and transparent way with all the other methodological principles settled by the

¹ BRASIL. MCT. Artigo 4: Obrigações. In: INC/ FCCC. **Convenção sobre Mudança do Clima**. Translated by MCT. Brasília, DF: MCT, 1992.

² SÃO PAULO (Estado). Lei Estadual n. 13.798/2009. **Diário Oficial do Estado de São Paulo**. Sao Paulo: November, 10, 2009a.

³ SÃO PAULO (Estado). Decreto n. 55.947/2010. **Diário Oficial do Estado de São Paulo**. Sao Paulo: June, 25, 2010.

⁴ BRASIL. MCT. **Segunda Comunicação Nacional do Brasil à Convenção-Quadro das Nações Unidas sobre Mudança do Clima**. Brasília: MCT, 2010. 520 p.

Intergovernmental Panel on Climate Change⁵ according to the national reality of GHG emissions. Nevertheless, even with the high quality of this document, we should consider that, even because it is not one of the objectives of its elaborators, the National Communication does not provide the government and the society of Sao Paulo State with the necessary information for the development of a Policy on Climate Change adequate for the local reality.

On the other hand, aiming for comparing the results of the Inventory of Sao Paulo State with those of Brazil, other information are presented next: according to the Brazilian Institute for Geography and Statistics (IBGE)⁶, in 2008, the national GDP was R\$3.0 trillion, while the Sao Paulo State GDP was R\$1.0 trillion, what means the economy of the State produces 33% of the national wealth. The same publication points out the national *per capita* income in that year were R\$16,000, while the *per capita* income in the Sao Paulo State was R\$24,500.

According to the World Bank⁷, the GDP of Brazil in 2009 was the eighth largest in the world, corresponding to US\$1.6 trillion. By keeping the ratio of 2008, between the GDP of Sao Paulo and the national one, the GDP of Sao Paulo could have been estimated, in the World Bank list, at US\$0.51 trillion in 2009. Comparing that data to the GDP, out of the 193 countries surveyed by the World Bank, Sao Paulo State would be the 19th in the rank, being overcome, in the Americas, by the economies of the USA (1st – US\$14.1 trillion, Brazil (8th – US\$1.6 trillion, Canada (10th – US\$1.3 trillion) and Mexico (14th – US\$0.87 trillion).

1st Direct and Indirect Greenhouse Gases Anthropogenic Emissions Inventory of Sao Paulo State

Sao Paulo State emitted in 2005, 88,844 Gg_{CO2} and, including the other GHG, 139,811 Gg_{CO2eq}.

Estimations for the Period from 1990 to 2008

This Inventory considered the GHG listed in Annex A of the Kyoto Protocol⁸: carbon dioxide (CO₂), methane (CH₄), nitrous oxide (N₂O), hydrofluorocarbon (HFC), perfluorocarbons (PFC) and hexafluoride (SF₆). The emissions of the Indirect GHG were also considered (IPCC, 1996⁹, 2000a): nitrogen oxide (NO_x), carbon monoxide (CO) and the volatile organic compounds (VOC). Besides that, the emissions of the chlorofluorocarbons (CFC) and the hydrofluorocarbons (HCFC) were also estimated, substances that, besides contributing to the global warming, destroy the ozone layer and, for that, are controlled by the Montreal Protocol. The GHG were estimated by sectors, as determined by IPCC (1996, 2000a and 2006): Energy, Industrial Processes, Agriculture, Land Use, Land-use Change, and Forestry, and Waste.

⁵ IPCC. **Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories**. IPCC National Greenhouse Gas Inventories Programme. Hayama, Japan: IGES, 2000.

_____. **Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventory**. Reporting Instructions [Houghton, J.T; Meira Filho, L.G; Lim, B.; Tréanton, K.; Mamaty, I; Bonduki, Y.; Griggs, D.J.; Callander, B.A (eds.)]. Bracknell: IPCC, OECD, IEA, 1997.

EDITOR'S NOTE: The State Communication uses the year of 1996 as reference. Nevertheless, it was only published in 1997.

⁶ IBGE. **Produto Interno Bruto a preços correntes e Produto Interno Bruto per capita, segundo as Grandes Regiões, as Unidades da Federação e os Municípios: 2004-2008**. Rio de Janeiro, 2010.

⁷ WORLD BANK. **Gross Domestic Product 2009**. World Development Indicators Database. World Bank, December, 15, 2010.

⁸ PROTOCOLO DE QUIOTO. **Anexo A: Gases de Efeito Estufa e Categorias de Setores/Fontes**. Brasília, CF: 1997.

⁹ EDITOR'S NOTE: The State Communication uses the year of 1996 as reference. Nevertheless, it was only published in 1997.

The method adopted for the elaboration of the Inventory, in order to generate an estimation comparable to the national one and other international and subnational ones, was IPCC's Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories – Guidelines 1996, published in 1997; the Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories – Good Practice Guidance 2000, published in 2000; the Good Practice Guidance for Land Use, Land-use Change and Forestry – Good Practice Guidance 2003, published in 2003; and the 2006 IPCC Guidelines for National Greenhouse Gas Inventories – Guidelines 2006.

Reference Year

The State Law, n. 13,789/2009 defines the year 2005 as reference, for a target to be reached in 2020. That's why the reference year for the Inventory is 2005. Aiming for generating a historic series, the emissions of 1990 and 2008 were also estimated.

GHG and CO_{2eq} Emissions

The emissions presented in the carbon dioxide equivalent unit (CO_{2eq}) refer to the GHG emissions using as equivalence metrics the Global Warming Potential (GWP) within 100 years. Considering that for different verification sources it is possible to identify differences in the GWP, the factors applied in this estimation were obtained in IPCC¹⁰.

The Inventory Elaboration Coordination

The elaboration of the Inventory involved a total of 320 researchers and 120 institutions, both governmental and private. 08 meetings of the inventory network were held in the auditorium of the Sao Paulo State Environment Agency (CETESB), with the attendance of a total of 400 participants to the set of meetings. The elaboration project of the inventory, supported by the British Government, started on May 2008 and was finished on March 2011, fulfilling the schedule agreed between CETESB and the British Government.

Results of the Emissions Estimation in Sao Paulo State

Next, in Table 1, we have the results of the Inventory of the GHG emissions and removals in Sao Paulo State for the years 1990, 1994, 2000, 2005 and 2008¹¹.

Comparison of the Results in Sao Paulo State to the Results of Brazil

Aiming for comparing the emissions in Sao Paulo State to those of Brazil, in Table 2 are presented the results of the GHG estimations in Brazil for the years 1990, 1994, 2000 and 2005, and in Table 3, the comparison of the results of Sao Paulo to those of Brazil. The same way, such comparison for the year 2005 is presented for the different sectors of the economy in Table 4.

¹⁰ IPCC. **Mudança do Clima 1995**: A Ciência da Mudança do Clima. Sumário para Formuladores de Políticas e Sumário Técnico do Relatório do Grupo de Trabalho I. Traduzido pelo MCT. Brasília: MCT, 2000.

¹¹Due to the large amount of information from 1990 to 2008, we decided to present, in this summary, the results of only some years. These were the same selected from the Executive Summary of the National Communication, except the year 2008 (BRASIL, 2010a).

Table 1. GHG Emissions and Removals in Sao Paulo State in 1990, 1994, 2000, 2005 and 2008

Sector	Year	unit	CO ₂	CH ₄	N ₂ O	HFC-134a	SF ₆	CFC-11	CFC-12	CFC-113	HCFC-22	HCFC-141b	CO	NOx	VOC
Energy	1990	Gg	56,395	16	1								571	369	219
	1994		64,795	19	2								637	427	284
	2000		80,161	22	2								802	541	372
	2005		78,584	30	3								804	514	345
	2008		85,335	35	3								867	549	353
	Var. 90/00	42	40	70								40	46	70	
	Var. 90/05	%	39	88	130							41	39	57	
Var. 90/08		51	124	182							52	48	61		
Industrial Processes	1990	Gg	3,396	1.1	10.5	NE	0.001	0.7	0.1	0.26	0.7	NE	4	1	59
	1994		3,268	1.0	16.2	NE	0.001	1.2	0.2	0.09	0.9	NE	9	2	84
	2000		4,577	1.5	19.8	0.3	0.002	1.4	0.2	0.02	1.8	NE	11	3	146
	2005		4,577	1.5	19.8	0.3	0.002	1.4	0.2	0.02	1.8	NE	11	3	146
	2008		12,218	NE	NE	0.9	0.002	0.0	0.2	-	3.0	1.1	20	5	214
	Var. 90/00	35	36	88	NA	23	109	130	-94	170	NA	221	220	146	
	Var. 90/05	%	274	36	116	NA	54	NA	71	NA	215	NA	383	382	212
Var. 90/08		260	NA	NA	NA	69	NA	68	NA	349	NA	471	469	260	
Agriculture	1990	Gg	931	734	31								1.29	0.11	
	1994		2,009	770	34								1.63	0.14	
	2000		1,462	782	35								1.07	0.09	
	2005		1,476	792	38								1.48	0.13	
	2008		1,462	678	38								1.58	0.13	
	Var. 90/00	57	7	13								-17	-17		
	Var. 90/05	%	58	8	23							15	15		
Var. 90/08		57	-8	23							23	21			
Land Use, Land-use Change, and Forestry	1990	Gg	NE												
	1994		NE												
	2000		-1,333												
	2005		-3,918												
	2008		-3,282												
	Var. 90/00	NA													
	Var. 90/05	%	NA												
Var. 90/08		NA													
Waste	1990	Gg	0.01	278	-										
	1994		12.70	301	0.001										
	2000		19.04	365	0.001										
	2005		16.92	445	0.001										
	2008		19.69	438	0.001										
	Var. 90/00	NA	31	NA											
	Var. 90/05	%	NA	60	NA										
Var. 90/08		NA	58	NA											
Net Total	1990	Gg	60,722	1,028	42	NE	0.001	0.7	0.1	0.26	0.7	NE	576	371	278
	1994		70,085	1,091	51	NE	0.001	1.2	0.2	0.09	0.9	NE	648	429	368
	2000		84,886	1,171	56	0.3	0.002	1.4	0.2	0.02	1.8	NE	814	544	518
	2005		88,844	1,268	63	0.6	0.002	0.03	0.2	NE	2.1	0.8	823	519	530
	2008		95,752	1,152	41	0.9	0.002	0.04	0.2	NE	3.0	1.1	889	554	567
	Var. 90/00	40	14	33	NA	23	109	130	-94	170	NA	41	47	86	
	Var. 90/05	%	46	23	49	NA	54	NA	71	NA	215	NA	43	40	90
Var. 90/08		58	12	-3	NA	69	NA	68	NA	349	NA	54	50	104	
Greenhouse gases emissions only for means of information, not included in the inventory															
Biomass Fuels	1990	Gg	33,786												
	1994		37,528												
	2000		36,094												
	2005		53,195												
	2008		76,505												
	Var. 90/00	7													
	Var. 90/05	%	57												
Var. 90/08		126													

Note: NE: Not estimated; NA: Not applicable; - : Value zero.
Blank: Emissions not provided by the IPCC methods.

Table 2. GHG Emissions and Removals in Brazil in 1990, 1994, 2000 and 2005

Sector	Year	unit	CO ₂	CH ₄	N ₂ O	HFC-23	HFC-125	HFC-134a	HFC-143a	HFC-152a	CF ₄	C2F ₆	SF ₆	CO	NOx	VOC	
Energy	1990	Gg	179,948	427	8.5									14,919	1,781	1,022	
	1994		206,250	382	9.0										14,438	1,996	974
	2000		289,958	388	9.6										11,415	2,334	860
	2005		313,695	541	12.1										11,282	2,388	958
	Var. 90/00		61	-9	14										-23	31	-16
	Var. 90/05		74	27	43										-24	34	-6
Industrial Processes	1990	Gg	45,265	5.1	10.7	0.12	—	0.0004	—	—	0.302	0.026	0.01	365	8	322	
	1994		48,703	6.5	16.3	0.157	—	0.0685	—	—	0.323	0.028	0.014	510	11	382	
	2000		63,220	8.9	19.9	—	0.0071	0.4713	0.0075	0.0001	0.147	0.012	0.015	542	14	474	
	2005		65,474	9.2	22.8	—	0.1249	2.2819	0.0929	0.1748	0.124	0.01	0.025	626	18	599	
	Var. 90/00		40	73	87	-100	NA	108,876	NA	NA	-52	-56	54	48	69	47	
	Var. 90/05		45	79	114	-100	NA	527,498	NA	NA	-59	-61	153	71	128	86	
Solvent and Other Product Use	1990	Gg														350	
	1994															435	
	2000															473	
	2005															595	
	Var. 90/00															35	
	Var. 90/05															70	
Agriculture	1990	Gg		9,539	334									2,543	219	NE	
	1994			10,237	369									2,741	233	NE	
	2000			10,772	393									2,131	181	NE	
	2005			12,768	476									2,791	237	NE	
	Var. 90/00			12.9	17.6									-16,201	-17		
	Var. 90/05			33.9	42.7									9,7523	8		
Land Use, Land-use Change, and Forestry	1990	Gg	766,493	1,996	14									17,468	496	NE	
	1994		830,910	2,238	15.4									19,584	556	NE	
	2000		1,258,345	3,026	20.8									26,476	752	NE	
	2005		1,258,626	3,045	20.9									26,641	757	NE	
	Var. 90/00		64	52	52									52	52		
	Var. 90/05		64	53	53									53	53		
Waste	1990	Gg	24	1,227	9												
	1994		63	1,369	10.8												
	2000		92	1,658	12.4												
	2005		110	1,743	14												
	Var. 90/00		276	35	37												
	Var. 90/05		349	42	54												
Total	1990	Gg	991,731	13,195	376	0.12	—	0.0004	—	—	0	0.026	0.01	35,296	2,504	1,693	
	1994		1,085,925	14,233	421	0.157	—	0.0680	—	—	0.323	0.028	0.014	37,273	2,797	1,791	
	2000		1,611,615	15,852	455	—	0	0.4710	0.007	0.0001	0.147	0.012	0.015	40,563	3,280	1,807	
	2005		1,637,905	18,107	546	—	0.125	2.2820	0.093	0.175	0.124	0.01	0.025	41,339	3,399	2,152	
	Var. 90/00		63	20	21	-100	NA	108,876	NA	NA	-52	-56	54	15	31	7	
	Var. 90/05		65	37	45	-100	NA	527,498	NA	NA	-59	-61	153	17	36	27	
Bunker Fuels	1990	Gg	5,231	0.01	0.15									23	NE	NE	
	1994		4,339	0.01	0.12									19	NE	NE	
	2000		14,627	0.60	0.23									201	118	24	
	2005		15,759	0.66	0.24									221	132	26	
	Var. 90/00		NA	NA	NA									NA	NA	NA	
	Var. 90/05		NA	NA	NA									NA	NA	NA	
Biomass Fuels	1990	Gg	187,962														
	1994		190,896														
	2000		180,471														
	2005		243,606														
	Var. 90/00		-4														
	Var. 90/05		30														

Note: NE: Not estimated; NA: Not applicable; - : Value zero; 0: Value lower than 1.

Blank – Emissions not provided by the IPCC Methods. Source: Brazil (2010a).

Table 3. Ratio Estimates of GHG Emissions in Sao Paulo State and Brazil

Sector	Year	Unit	CO ₂	CH ₄	N ₂ O	HFC-134a	SF ₆	CO	NOx	VOC
Energy	1990	%	31	4	13			4	21	21
	1994		31	5	17			4	21	29
	2000		28	6	20			7	23	43
	2005		25	5	22			7	22	36
Industrial Processes	1990	%	8	22	98	NA	13	1	12	18
	1994		7	16	99	NA	9	2	22	22
	2000		7	17	99	54	11	2	22	31
	2005		7	17	87	11	6	2	17	24
Agriculture	1990	%	NA	8	9			0.1	0.050	
	1994		NA	8	9			0.7	0.005	
	2000		NA	7	9			0.6	0.004	
	2005		NA	6	8			0.6	0.005	
Land Use, Land-use Change, and Forestry	1990	%	0							
	1994		0							
	2000		-0,1							
	2005		-0,3							
Waste	1990	%	1	23	1					
	1994		20	22	1					
	2000		21	22	1					
	2005		15	26	1					
Net Total	1990	%	6	8	11	NA	13	2	15	16
	1994		6	8	12	NA	9	2	15	21
	2000		5	7	12	55	11	2	17	29
	2005		5	7	12	27	8	2	15	25

Note: NA: Not applicable.

Table 4. GHG Emissions in Sao Paulo State and Brazil in 2005

Sector	Sao Paulo		Brazil		SP/BR (%)
	Emission	Share	Emission	Share	
	(Gg _{CO2eq})	(%)	(Gg _{CO2eq})	(%)	
Energy	80,017	57.2	328,808	15.0	24.3
Industrial Processes	20,610	14.7	77,939	3.6	26.4
Agriculture	29,818	21.3	415,754	19.0	7.2
Waste	9,366	6.7	41,048	1.9	22.8
LULUCF	0.0	0.0	1,329,053	60.6	0.0
Total	139,811	100	2,192,602	100.0	6.4

Figure 1 show the GHG emissions in Sao Paulo State and Brazil in the year 2005. Figure 2 shows the distribution of the GHG emissions in Sao Paulo State and Brazil, where one is able to notice the most relevant economic areas in both local and national levels.

Finally in Table 5, comparing the GHG emissions and the GDP of the Sao Paulo State and Brazil, we conclude that the economy of the Sao Paulo State is responsible for 33% of the national GDP and 6.5% of the total of GHG of the country. In other words, for each R\$1,000 earned in the Country, 0.72 t_{CO2eq} are emitted, while in Sao Paulo State, the same earnings correspond to 0.14 t_{CO2eq}, which is equal to 20% of the national index.

Figure 1. GHG Emissions in Sao Paulo State and Brazil in 2005 (Gg_{CO₂eq})



Figure 2. GHG Emissions in Sao Paulo State and Brazil in 2005 (%)

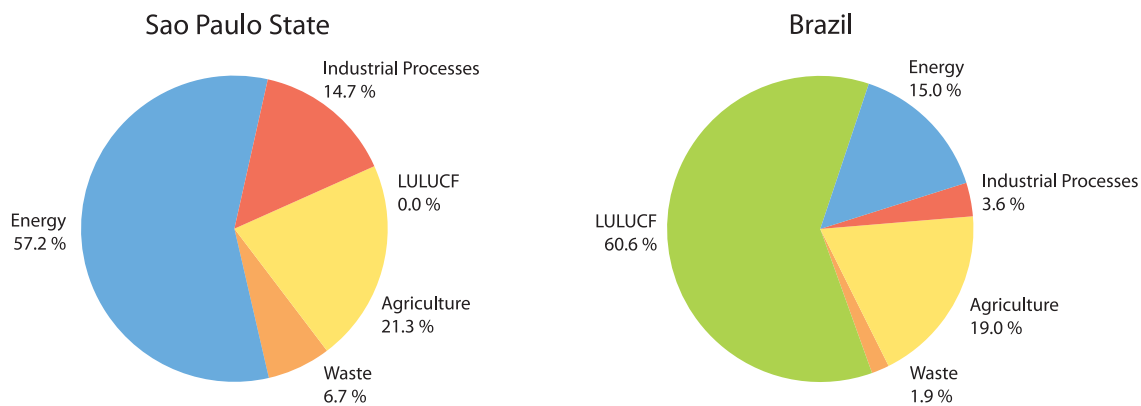


Table 5. GHG Emissions (2005) and GDP in Brazil and Sao Paulo State

	GHG Emissions	GDP	Emission Intensity
	10 ⁹ t _{CO₂eq}	10 ⁹ (1000 R\$)	t _{CO₂eq} (1000 R\$) ⁻¹
Brazil	2.19	3.03	0.72
Sao Paulo	0.14	1.00	0.14

CO₂ Emissions in 2005 in Sao Paulo State

CO₂ Emissions According to the Involved Sectors in Sao Paulo State, in the Period 1990-2008 – Highlights for the Year 2005 (Gg)

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
	[Gg _{CO₂} .year ⁻¹]									
Energy	56,395	58,043	58,629	59,725	64,795	67,095	74,634	79,800	80,748	81,278
Industrial Processes	3,396	3,540	3,046	3,011	3,268	3,724	4,300	4,738	4,744	4,495
Agriculture	931	968	1,509	1,589	2,009	1,479	1,512	1,639	1,583	1,410
Waste	0.01	0.31	20.36	8.21	12.70	12.70	12.70	13.31	13.22	16.58
LULUCF	NE	NE	NE	NE	NE	0	0	0	0	0
Total	60,722	62,552	63,205	64,333	70,085	72,311	80,460	86,189	87,088	87,200

	2000	2001	2002	2003	2004	2005	2006	2007	2008	
	[Gg _{CO₂} .year ⁻¹]									
Energy	80,161	78,298	75,852	76,636	77,996	78,584	79,375	83,221	85,335	
Industrial Processes	4,577	3,978	3,864	3,394	3,418	12,685	12,281	12,968	12,218	
Agriculture	1,462	1,380	1,408	1,691	1,327	1,476	1,805	1,865	1,462	
Waste	19.04	16.92	16.92	16.92	16.92	16.92	17.98	18.84	19.69	
LULUCF	0	0	0	0	0	0	0	0	0	
Total	86,219	83,672	81,140	81,738	82,758	92,762	93,478	98,074	99,034	

Note - NE: Not estimated; LULUCF: Land Use, Land-use Change, and Forestry.

Reproduction of Table II.2 of the 1st Direct and Indirect Greenhouse Gases Anthropogenic Emissions of Sao Paulo State, CETESB (2011)¹, p. 54.

CO₂ emissions in 2005 in Sao Paulo State is 92,762,000 t.

¹ CETESB. 1st Direct and Indirect Greenhouse Gases Anthropogenic Emissions of Sao Paulo State. State Communication. Sao Paulo: CETESB, 2011. 174p.

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