Legal aspects of introducing waste-to-energy (WTE) technology in Sao Paulo State of Brazil: The case studies of URE Barueri and city of Sao Paulo

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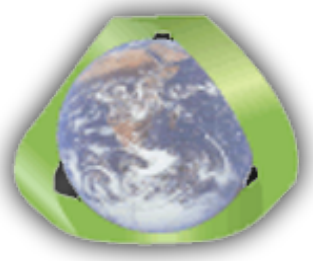

EXECUTIVE SUMMARY

Waste to Energy (WTE) has been incorporated into the sustainable solid waste management systems of several countries, like Japan, many European Union countries, and China, as the way to reduce the amount of municipal solid waste (MSW) disposed in landfills, reduce greenhouse gas (GHG) emissions to the atmosphere, utilize the chemical energy stored in post-recycling waste, and conserve land. There are more than 800 waste to energy (WTE) plants operating in the world but, still 80% of the post-recycling municipal solid wastes (MSW) are landfilled globally. This is due to several reasons, including misinformation, low level of solid waste collection and recycling, and required capital investment.

However, the high rates of world population growth and urbanization and the drive to reduce the use of fossil fuels and GHG emissions, are changing the scenario for the applicability of WTE technologies in developing countries. Brazil is one of these cases, since the country has been an active actor in the international discussions and agreements related to environmental issues, like the Convention of Biological Diversity, the United Nations Framework Convention on Climate Change (UNFCCC), the United Nations Convention to Combat Desertification, Agenda 21, and Sustainable Development Goals.

As a consequence of its active role in the international arena, Brazil has incorporated environmental concerns in the Brazilian legal system. For example, the National Solid Waste Policy Law (2010) includes energy recovery from waste as one of the options for environmentally-adequate disposal of solid waste. In fact, there are several national policies in Brazil regarding the legal aspects of implementing and operating WTE plants in Brazil.

This study focuses on the legal aspects related to the interconnections among urbanization, population growth, energy consumption, circular economy, integrated solid waste management and energy recovery from MSW in Brazil. Specifically, two case studies are examined in the State of Sao Paulo: a) The first WTE plant in the country, currently in the phase of licensing, the URE (Energy Recovery Unity) Barueri, located in the city of Barueri (population of about 246,000), 26.5 kilometers from the center of the city of São Paulo; b) a projected WTE to serve the city of Sao Paulo (population of about 12 million), the heart of the metropolitan Sao Paulo (population of about 20.3 million), the fifth largest megacity (United Nations Urbanization Prospects, 2014).

The first two chapters of this report discuss the connection between urbanization, energy, urban solid waste and circular economy. In chapter 3, the waste to energy technology and its environmental and GHG advantages, in comparison to sanitary landfilling are presented. Chapter

4 discusses the legal aspects related to the feasibility of the waste to energy plants in Brazil and in the State of Sao Paulo. Chapters 5 and 6 present two case studies and are followed by main conclusions and suggestions for future studies in this field.

The existing legal frameworks in Brazil and in the State of Sao Paulolo allow for implementation and operation of high standards WTE facilities, as the URE Barueri preliminary license and registration under the Clean Development Mechanism demonstrate. However, the Integrated Solid Waste Management Plan of the city of Sao Paulo and its main guideline against incineration reveal that there is a lack of public information about the technological advances of waste to energy plant during this century and confusion of the "incineraton" of the past with the modern WTE plants used throughout the world.

The recycling rates in Brazil, in the state of Sao Paulo, and the city of Sao Paulo are low in comparison with other countries at the same economic level. Therefore, there is an opportunity for increased recycling and also waste to energy activities in the country, both of which are supported by the National Solid Waste Policy, the National Environmental Policy and the Brazilian National Policy on Climate Change. As it has been shown in many developed countries, recycling and WTE complement each other and can be implemented to work together.

A detailed feasibility analysis of the economic and environmental incentives of building a WTE plant to serve the City of Sao Paulo should be conducted in the future, in order to entice investment on a waste to energy plant. Also, a study about the feasibility of implementation of the symbiosis model of the Kalundborg industrial park in strategic areas in Brazil should be carried out, considering the size of this country and the need for the improvement of waste management there.

ACKNOWLEDGEMENTS???

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I. Urbanization, cities and solid waste

The world cities generated approximately 1.3 billion tonnes of solid waste in 2011 and this volume is expected to increase to 2.2 billion tonnes by 2025. The solid waste management (SWM) costs are estimated to increase from $205.4 billion in 2011 to about $375.5 billion in 2025, (World Bank, 2012) and "uncollected solid waste contributes to flooding, air pollution, and public health impacts such as respiratory ailments, diarrhea and dengue fever" (Kyte, R., World Bank, 2012, Foreword), and emissions of greenhouse gases (GHG).

The urbanization growth is associated with an increase in the amount of municipal solid waste (MSW) that is generated. According to World Bank (2012), the MSW increased from 0.64 kg per person per day (0.68 billion tonnes per year) to 1.2 kg per person per day (1.3 billion tonnes per year) in the period of 2001 to 2011; by 2025, the per capita MSW generation is estimated to be about 1.42 kg/capita/day (2.2 billion tonnes per year) (Table 1).

Table 1 – Urban population and MSW, 2001, 2011, 2025

Year	Population		MSW		MSW	
	billion urban residents	Increase	kg/person/day	Increase	tonnes/year	Increase
2001	2.9	-	0.64	-	0.68	-
2011	3.0	3.4%	1.20	87.5%	1.30	91.1%
2025	4.3	48.3%	1.42	121.7%	2.20	223.5%

Source – adapted from World Bank, 2012

The data of Table 1 leads to the conclusion that while the population from 2001 to 2025 is expected to increase about 48.3%, the MSW (tonnes/year) is expected to increase by 223.5%, i.e., an increase of more than 4.6 times over urban population growth in the period of 2001 - 2025. SWM costs will increase 82.8% from 2011 to 2025, i.e., a 2 times more than urban population growth in the period of 2011 - 2025.

The urbanization has significantly increased since 1950, from 746 million to 3.9 billion people living in urban areas in 2014, and the projection for the world's urban population by 2050 is 6.4 billion (United Nations, 2014, p.1).

This whole scenario calls attention to the consequences of urbanization to MSW and its costs for the cities of Brazil. Urbanization will continue to grow in Latin America up to 2050 but with a steady decline of the average annual rate of change since 2000 (Figure 1).

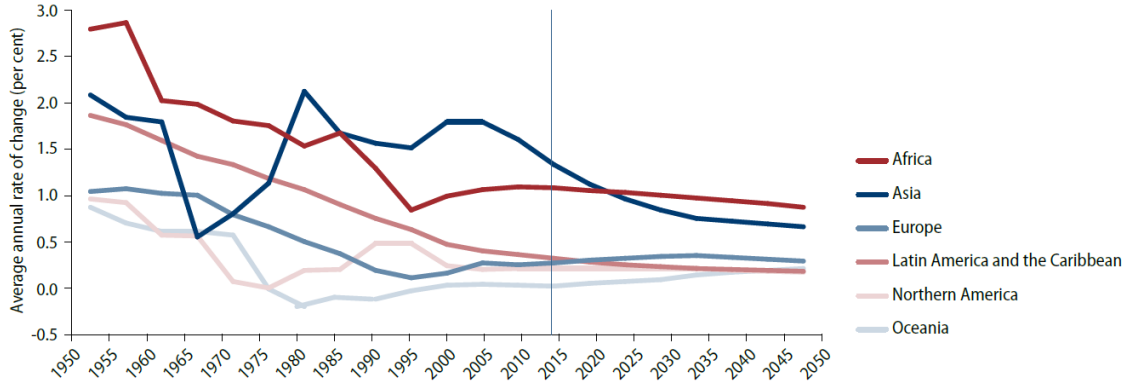


Figure 1– Average annual rate of change of the percentage urban by major areas, 1950–2050
Source - United Nations, 2014, p.8, Figure 4

In 2010, there were 10 cities with population over 10 million inhabitants (megacities) in the world and in 2014 this number more than doubled (28 megacities). Brazil has two of these megacities: Sao Paulo and Rio de Janeiro.

Brazil is the largest country in South America (geographical area of 8,515,767 km2) and also the most populated (204 million in 2015). The country is divided into 27 Sates and 5,570 municipalities. The State of Sao Paulo is the most important in Brazil, not only for being the most populated (44 million, accounting for 21.7% of the total Brazil population) (IBGE, 2015) but also for being the economic heart of the country (GDP = US$ 427 billion, 2013; about 30% of Brazil's GDP). About 56% of Brazil's population lives in 306 municipalities (5.5% of the total numbers of municipalities) (Figure 2).

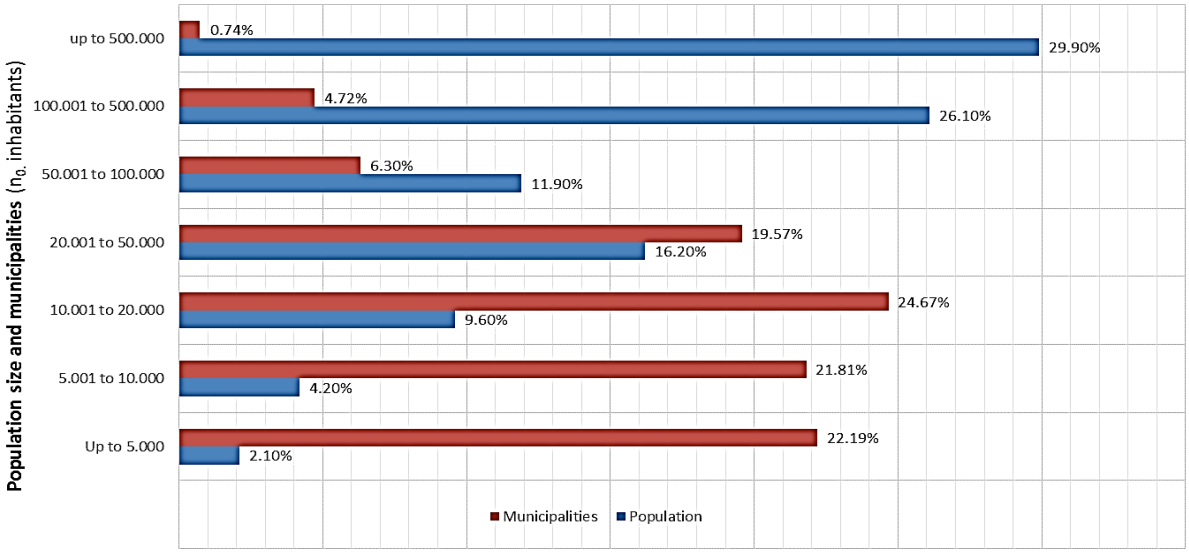


Figure 2 – Population / Brazilian municipalities' distribution grouped by populacional size of municipalities
Source – adapted from IBGE, 2015

The total amount of urban solid waste generated in Brazil in 2014 was about 78.6 million tons (215,297 t/day or 1.062 kg/inhabit/day; Associação Brasileira de Empresas de Limpeza Pública e Resíduos Especiais, Abrelpe, 2015, p. 41). The volume collected was about 71.3 million (90.7%) in 2014, and its distribution over Brazil's five "macro regions" is shown in Figure 3.

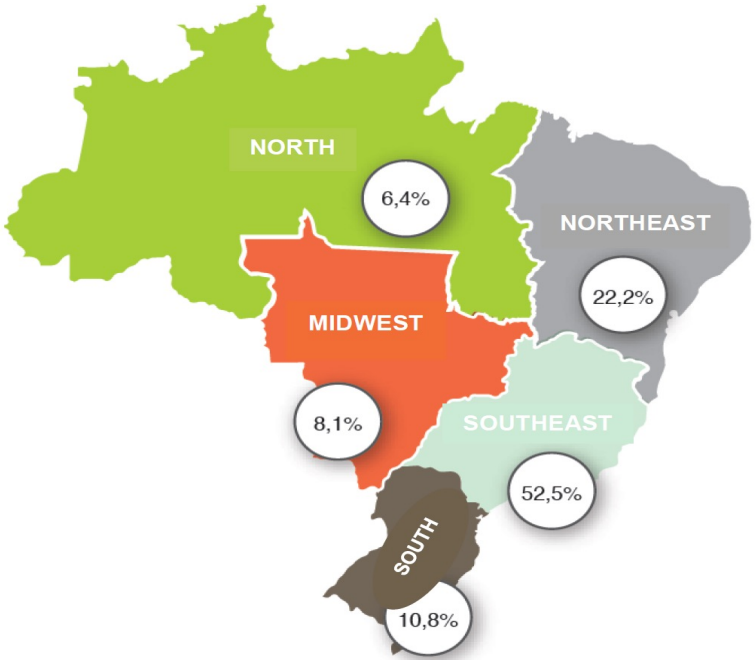


Figure 3 – Distribution of the total solid waste collected over Brazil's 5 macro regions (%)
Source – adapted from Abrelpe, 2015, p. 29

In Brazil, 927 municipalities (17% of the total) operated a solid waste selective collection program, covering 13% of the waste generated by 28 million people (13% of the total population in Brazil) in 2014; 81% of these municipalities is concentrated at both southeast (45%; 416 municipalities) and south (36%; 337 municipalities) regions (Compromisso Empresarial para Reciclagem, CEMPRE, 2014). The majority of selective waste collection program (43%) is done directly by municipalities and 37% by private organizations contracted by municipalities.

The gravimetric composition of the solid waste collected through the selective waste collection program in the country is shown in Table 2.

Table 2 - The gravimetric composition of the solid waste collected by selective collection program in Brazil

Plastic	24%	PET	34%
		PEAD	20%
		PEBD	19%
		MIXED	16%
		PP	6%
		PS	3%

		PVC	2%
Paper			36%
Glass			9%
Tetra pack			3%
Aluminum			1%
Ferrous metals			4%
Electronics			2%
Others			1%
Refused waste			20%

Source – CEMPRE, 2014

The Southeast region, which includes the tate of Sao Paulo, is the most populated in the country (10.32% of the total). It accounted for 49% of the total urban solid waste generated (Abrelpe, 2015, p. 41) and for more than half (52.5%) of the total solid waste collected in Brazil. However, 29.7 million tons of solid waste collected in the country (41.6% of the total collected), covering 3,334 municipalities, were disposed at open dumpsites (17.4%; 1,559 municipalities) or controlled landfills (24.2%; 1,755 municipalities) (Abrelpe, 2015, p. 39); 58.4% went to sanitary landfills (2,236 municipalities) in 2014 (Abrelpe, 2015, p. 38).

This region covers 1,668 municipalities that generated a total of 105,431 t/day of urban solid waste and collected 97.3% of this amount. Of this,,, 27.4% (28,086 t/day) went to open dumps and non-sanitary landfills (Abrelpe, 2015, p. 71). The average cost for the collection of this waste in the Southeast region by municipalities was US$1.20 inhabit/month (1.00 US$ = R$ 4.00) and US$1.65 inhabit/month (1.00 US$ = R$ 4.00) for other urban cleaning services (Abrelpe, 2015, p. 71). These services cost a total of US$ 3.65 billion (R$ 14.6 billion) in 2014.

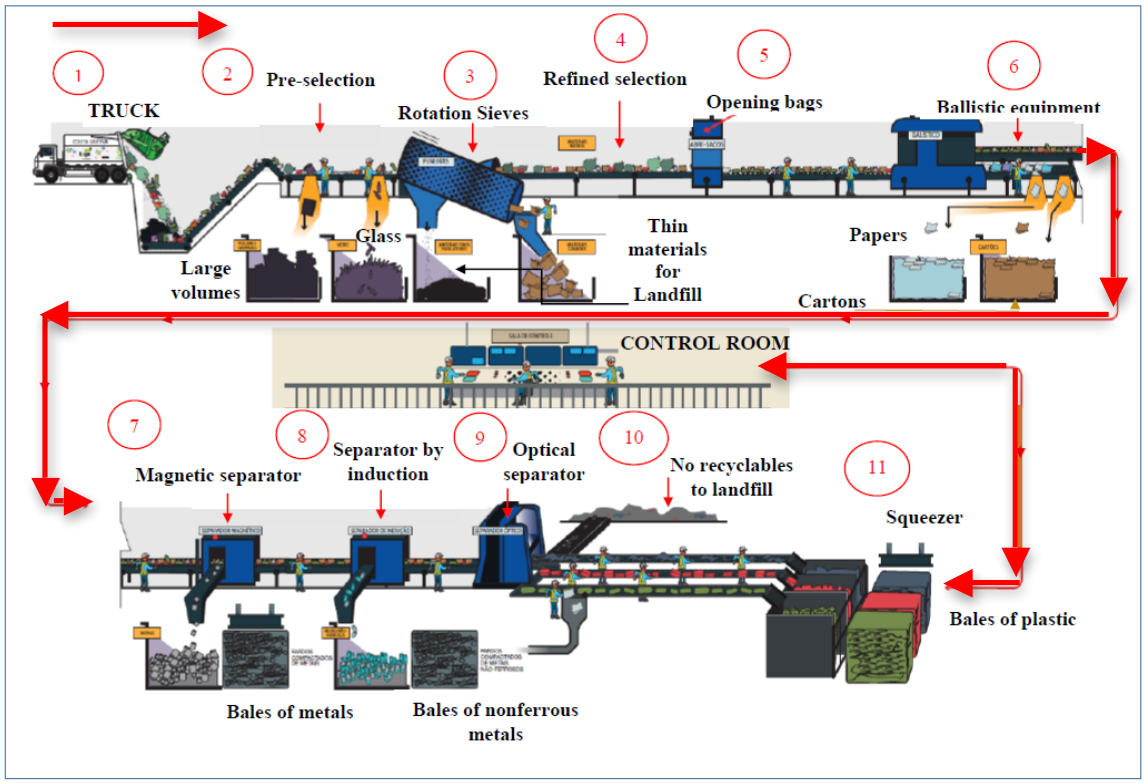
In the state of Sao Paulo, 61,340 t/day of solid waste were generated and collected 60,810 t/day (99.13%), i.e., 1.381 kg/inhabit/day in 2014 (Abrelpe, 2015, p. 77). It is estimated that 12,277 t/day of recyclables is generated in the State but only 245 t/day is recycled (Urban Solid Waste Plan of the State of Sao Paulo, 2014, p. 53).

The megacity of Sao Paulo is located in the State of Sao Paulo and it was the fifth among those 28 global megacities in 2014 (United Nations, 2014). The metropolitan region of Sao Paulo has a population of 20.3 million, making up for 19% of Brazil's GDP, and 57% of São Paulo State (Empresa de Planejamento do Estado de Sao Paulo, Emplasa, 2014, p.13). The city of Sao Paulo accounts for a population of about 12 million in a geographical area of 1,521 Km^2 (IBGE, 2015).

The city of Sao Paulo generates 20,000 tons of MSW per day (about 7,000 million tons per year. i.e., about 0.59 tons per capita), 50% organic, 35% dry and 15% tailings. There are 3 sanitary landfills operating in the city, Caieiras, Pedreira and the Center of waste treatment of East, and 3 inert landfills. There are also 2 unsanitary landfills closed but under monitoring phase (Sao Joao and Bandeirantes).

Only 3% of this amount is recycled, according to the Secretary of Services of the city of Sao Paulo (SMS, 2016). Municipal selective waste collection is something relatively new in Sao Paulo and it has been officially estimated by the Secretary of Services that only 60% of MSW is collected (Secretary of Service of the city of Sao Paulo, SMS, 2016).

However, the recyclability capacity in the city increased to 7% of the total solid waste generated in Sao Paulo, due to the 2 new central mechanized for sorting of recyclable waste inaugurated in 2014. One is located in the neighborhood of Ponte Pequena, which has the capacity to process 250 tons per day of recyclables (SMS, 2016) (see Figure 4).



Photos: Cesar Ogata, SECOM

Figure 4 – Central mechanized for sorting of recyclable waste Ponte Pequena – the process
Source – Municipality of Sao Paulo, Subprefeitura da Lapa, 2014, p. 54

The other one is located in in the neighborhood of Santo Amaro, which has the capacity to process 250 tons per day of recyclables (SMS, 2016) (see Figure 5).

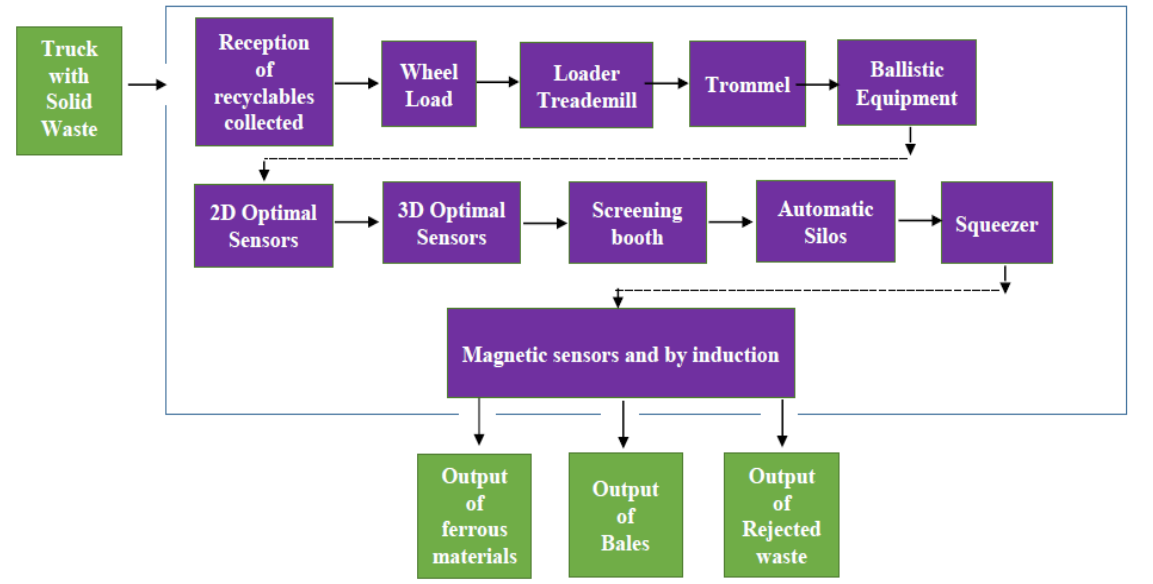


Foto: Fábio Arantes/ Secom
Figure 5 – Central mechanized for sorting of recyclable waste Santo Amaro – the process
Source – adapted from SMS, 2016

The city of Sao Paulo has 3 solid waste transshipment points, Ponte Pequena, Santo Amaro and Vergueiro. They process tighter the volume of 11,000 t/day of solid waste (AMLURB, 2016).

In the period 2002 - 2014, the selective waste collection in the city of Sao Paulo increased from 120 t/month to 5,000 t/month (an increase of more than 4,100%), as shown in Figure 6 (CEMPRE, 2014). In the period 2004 - 2014, the population covered by this program increased from 30% to 42% of the total population in the city (see Figure 7).

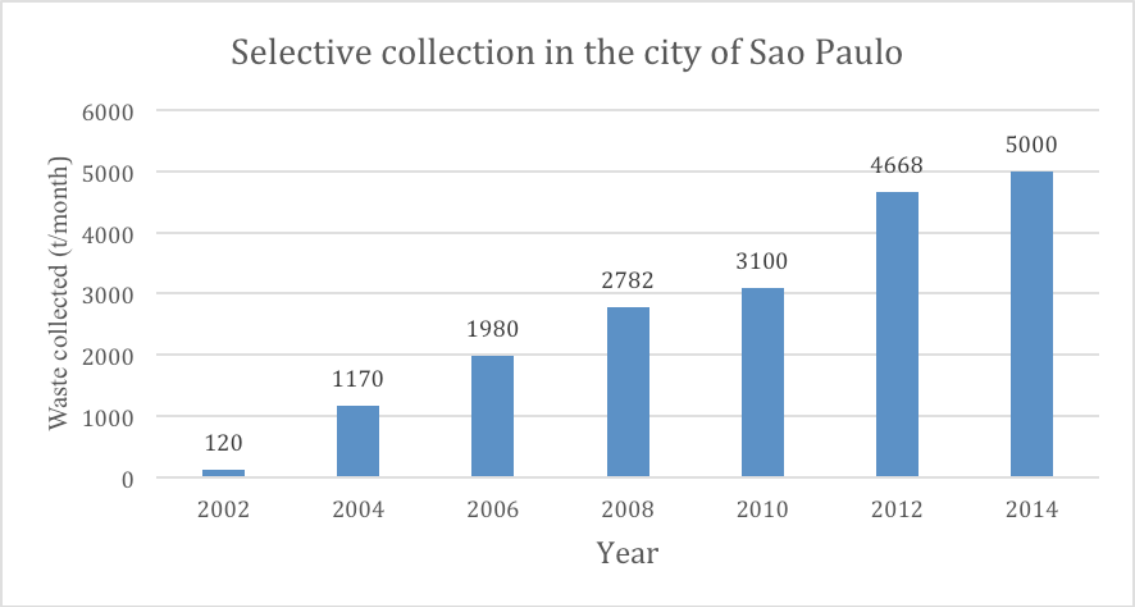


Figure 6 – Selective collection in the city of Sao Paulo (t/month), 2002, 2004, 2006, 2008, 2010, 2012, 2014
Source – adapted from CEMPRE, 2014

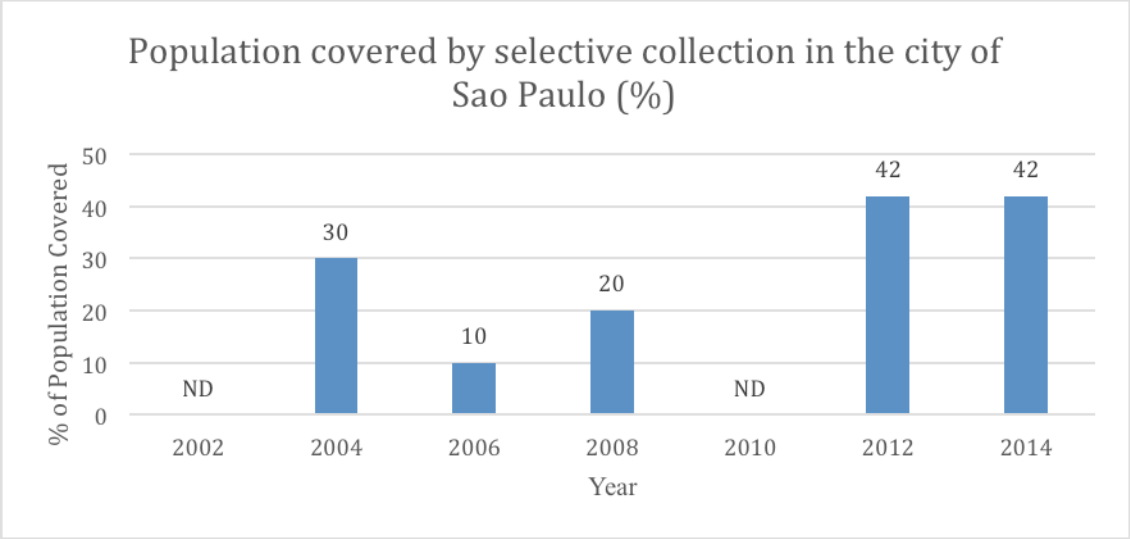


Figure 7 – Population covered by selective collection in the city of Sao Paulo (%), 2004, 2006, 2008, 2010, 2012, and 2014
Source – adapted from CEMPRE, 2014

It is estimated that there are nearly 4,500 clandestine discharge points, or waste dumpsites, in the city, impacting negatively the environment and human health. For example, it is estimated that,

for an annual rate of solid waste generation per capita of 4.4%, the emission of greenhouse gases (GHG) from solid waste in Sao Paulo can increase by 150%, from 3 million tons of CO2e to 7.5 million by 2039 (Sao Paulo Town Hall, Secretary of Environment, 2013, p. 18, 21). The gravimetric composition of the solid waste collected through the solid waste measured in landfill in the city is shown in the Table 3.

Table 3 - The gravimetric composition of the solid waste measured in landfill, in the city of Sao Paulo

Organic matter	52.47%	**PET**	0.78%
Plastic soft	7.99%	**Rubber**	0.75%
Plastic hard	6.54%	**Soil/rock**	3.34%
Paper	9.84%	**Wood**	2.05%
Glass	1.95%	**Foam**	1.19%
Tetra pack	1.00%	**Diapers**	5.07%
Aluminum	0.43%	**Rags and cloths**	2.31%
Ferrous metals	2.00%	**Others**	2.08%
Electronics	0.01%	**Styrofoam**	0.25%

Source – Integrated Solid Waste Management Plan, city of Sao Paulo, 2012, p. 162

The existing situation can change by the adoption of modern technologies for recovery of materials (recycling and composting) and recovery of energy, by using the MSW as a fuel in properly designed and operated WTE power plants that recover energy, in the form of electricity and/or heat.

The urbanization phenomena are associated with energy supply/demand, since, in the production-consumption context of the occidental economic system, when urban population size increases, energy supply/demand tends to increase too, increasing emissions of greenhouse gases as well.

2. Energy, waste and circular economy

Energy generation is an inevitable requirement for assuring consumption purposes. The production of goods and provision of services rely on energy supply to attend the energy demand and more production demanded, more energy demanded. However, to increase the energy supply, either the generation of energy must increase or more efficient must become the energy grid.
Primary energy has to be transformed into secondary energy and then delivered at the end-use. This process of production, conversion, delivery, and use of energy is barely completed in real time, and there are losses of energy in the entire process.

The production-consumption system primarily extracts the energy embodied in natural resources like natural gas, animal and vegetable residues, sun and wind, in order to transform these energy

fuels found in nature on other products expected to be consumed by individuals, families, corporations, countries etc.
However, according to the first law of thermodynamics, energy can be transformed from one to another form but it can't be created or destroyed. Furthermore, according to the second law of thermodynamics, if this transformation process occurs spontaneously, energy will change from a concentrated form to a disperse form, and a certain amount of energy will be lost (entropy = measure of disorder) (Odum, E. P., Barret, Gary W, 2011, p. 78).

The global growth of energy consumption between 1973 and 2013 almost doubled, from 4,667 Mtoe to 9,301 Mtoe. In this period, the consumption of electricity increased from 9.4% to 18.1% of the total, while the consumption of oil decreased from 48.3% to 39.9%; the share of renewables (geothermal, solar, wind, heat etc.) had an increase from 1.6% to 3.3% of the total but remaining with little share of the total (International Energy Agency, IEA, 2015).

With respect to electricity, however, the generation almost quadrupled, from 6,131 TWh to 23,322 TWh, in the same period. There was an increase in fuel share of natural gas (from 12.1% to 21.3%), nuclear power (from 3.3% to 10.3%) and renewables (from 0.6% to 5.7%), and a decrease in fuel share of oil (24.8% to 4.4%) and hydropower (20.9% to 16.3%) (IEA, 2015).

The domestic energy supply in Brazil (the amount of domestic energy available for transformation and/or final consumption) was 305.6 x 10^6 toe (2014 baseline year), an increase of 40.25% from 2005 baseline year (Ministry of Energy of Brazil, MME; Energy Research Company, EPE, 2015), as shown in the Table 4. The total losses were about 15.2% (MME, EPE, 2015).

Table 4 – Domestic energy supply in Brazil, 2005 (baseline year) and 2014

YEAR	**SOURCES** (10^6 toe)											
	Petroleum, oil, products, natural gas		Coal and coal products		Hydraulic and Electricity		Firewood and charcoal		Sugar cane products		Others	
2005	105.1	*48.2%*	12.9	*6.0%*	32.4	*14.9%*	28.5	*13.1%*	30.1	*13.8%*	8.9	*4.1%*
	TOTAL DOMESTIC SUPPLY											
	217.9						**-**					
2014	161.7	*52.9%*	17.5	*5.7%*	35.0	*35.2%*	24.7	*8.1%*	48.1	*15.7%*	18.5	*6.0%*
	TOTAL DOMESTIC SUPPLY											
	305.6						**+ 40.25%**					

Source – adapted from MME, EPE, 2015

The final consumption of electricity in the country registered an increase of 2.9% in 2014, supplied from the expansion of thermal generation, especially from plants fueled by coal (+ 24.7%), natural gas (+ 17.5%), biomass (+ 14.1%), whose participation in the energy matrix in 2014 compared to 2013, increased from 2.6% to 3.2%, from 11.3% to 13.0% and 6.6% to 7.4%, respectively.

The sectors that contributed most to the growth of electricity demand were residential (+ 5.7%) and commercial (+ 7.4%) (EPE, 2015). As a consequence of unfavorable hydrologic conditions, there was a decrease of 5.6% in hydro energy supply (EPE, 2015). The total emission of GHG was 485.2 Mt CO2-eq, of which 45.7% from transportation sector of Brazilian economy (EPE 2015, p. 11) (see Figure 8).

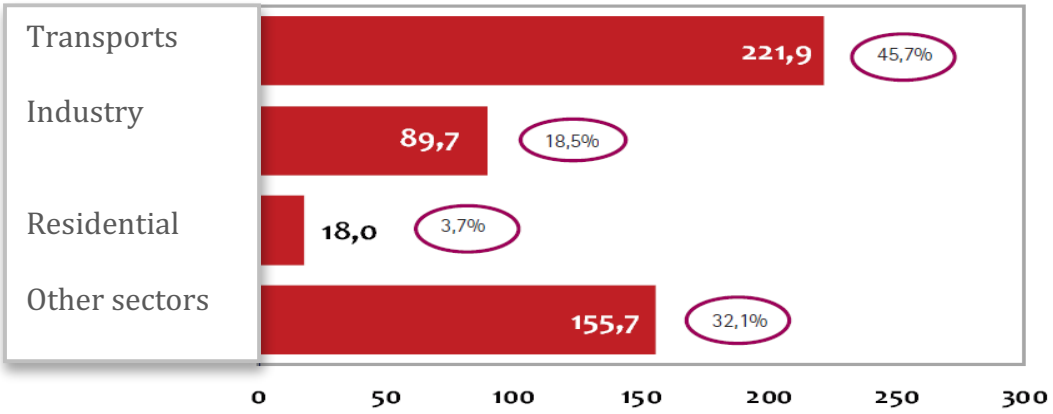


Figure 8 - Total emissions of Mt CO2eq from energy matrix per sector, Brazil, 2014
Source – EPE, 2015, p. 44

The total increasingly emissions of GHG from energy generation, transformation and consumption in Brazil – 2017, 2020 and 2023 - is estimated as in Figure 9.

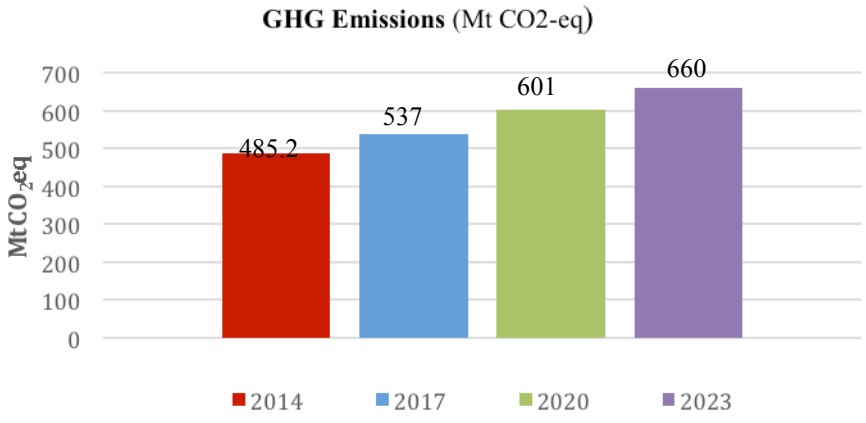


Figure 9 – Estimated emissions of GHG from energy generation, transformation and consumption, Brazil, 2014, 2017, 2020, 2023
Source – adapted from EPE, 2015, p. 359

The State of Sao Paulo consumed 44.47 x 10^6 toe of energy in 2014, of which 20.15% was consumed in the city of Sao Paulo (8.96 x 10^6 toe) (State of Sao Paulo, 2015); the 15 largest municipalities' consumers of energy in the State are shown in Table 5 (Appendix 1).

Five of the 15 largest municipalities' consumers of energy in the State of Sao Paulo are part of the metropolitan region of Sao Paulo (Sao Paulo, Guarulhos, Sao Bernardo do Campo, Santo Andre e Osasco.

The State of Sao Paulo consumed 137,076,905.86 KWH of electric energy in 2014, of which 21.9% was consumed in the city of Sao Paulo (State of Sao Paulo, 2015); the 15 largest municipalities' consumers of electric power in the State are shown in Table 6 (Appendix 2).

The Metropolitan Region includes 39 municipalities, with a geographical area of 7,947 km2 and an urbanization rate of 98%, making up for 19% of Brazil's GDP, and 57% of São Paulo State's GDP (EMPLASA, 2014) (see Appendix 3, Table 7).

The data of energy consumption (toe) and solid waste generated/year for each of the 39 municipalities of the Metropolitan Region of Sao Paulo is plotted in Figure 10 (Appendix 4).

In the period between 2003 and 2009, the total emissions of GHG from the energy sector in the city of Sao Paulo is shown in Figure 11, while the total emissions from the energy sector by type of GHG is shown in Figure 12.

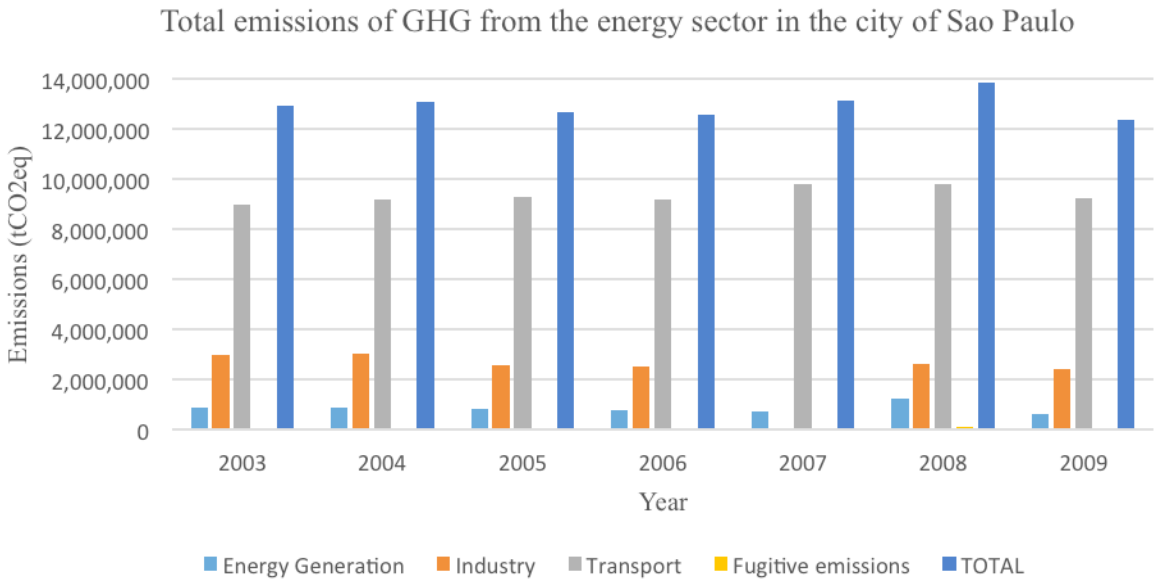


Figure 11 – Total emissions of GHG from the energy sector in the city of Sao Paulo, for fuel burn
Source – Sao Paulo Town Hall, 2012

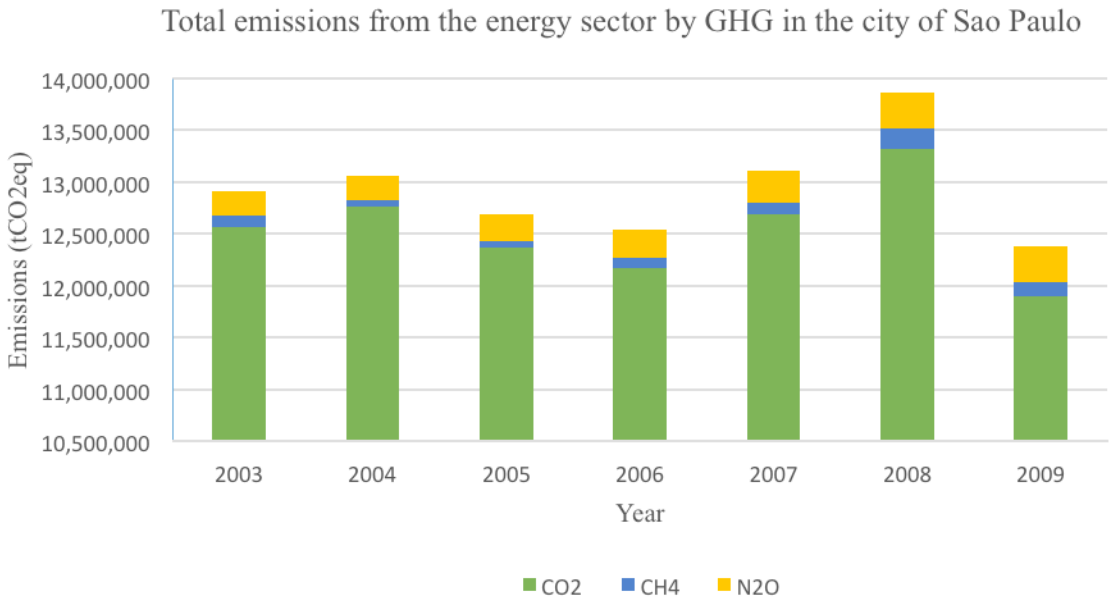


Figure 12 – Total emissions from the energy sector by type of GHG (CO_2, CH_4 and N_2O) in city of Sao Paulo
Source - Sao Paulo Town Hall, 2012

The main source of GHG from fuel burn was the transport sector (72%), followed by industry (23%) and energy generation (7%). The emissions of CO_2 were the most representative of GHG emissions in the city of Sao Paulo, more than 90% in the period (Sao Paulo Town Hall, 2012).

It means that the fuel combustion by vehicles were the main sources of GHG emissions in the city during this period.

The metropolitan region of Sao Paulo and the city of Sao Paulo itself are the center of a vibrant economy in Brazil and, as production-consumption is high there, it is expected a high volume of waste generation.

As explained in chapter I, although some important paths are being held in the city of Sao Paulo towards the improvement of waste management, the scenario is still fragile and call for urgent city upgrade of the strategy related to waste. This strategy must be linked to the Brazilian legislation and the best techniques to deal with waste creation and waste prevention.

In the traditional way, when the natural resources were abundant, the direction of the production and use of a product followed a linear direction, from the extraction of raw materials, its

transformation into another product, its consumption and disposal[1]. However, this one-way system incurred in several leaks or unconsidered factors:

- Waste in the production chain;
- End-of-life waste (almost 60% of waste could be recycled, reused or composted);
- Residual energy lost by disposal of products in landfills;
- Erosion of ecosystem services;
- High level and volatility of real commodity prices;
- Unable to deal with demographic trends;
- Unable to deal with infrastructure needs;
- Political risks affecting the system;
- Globalized markets;
- Climate change. (Ellen Macarthur Foundation, 2013, p. 14-20)

The world is more complex and the high scale of anthropogenic negative actions towards environment impact not only on economic but also social and intergenerational aspects. The idea of reuse and recycling is a result of the extension of this one-way conception to a "cycle-way", in which the product would be refurbished or converted into another product (Manahan, 2013, p 382); aluminum, for example, is 100% recyclable and allows 95% savings of energy spent in its first production (Mansor et al, 2010, p. 71).

Commonly, the waste is generated from an identifiable source, like households, construction or hospitals, and it becomes part of an identifiable waste stream, like paper, plastic, e-waste and/or sewage sludge stream (UNEP, 2013, p. 16, 17). In order to adequately manage the waste generated, all sort of materials shall be collected and separated for its proper utilization as a source for the best technical, economic and social solution, before the final disposal at landfills.

The higher is the amount of waste collected and then separated at source, the better tends to be the waste management, because these operations enable the re-use of goods and the recovery of recyclable materials; also, as the composition is less mixed, it is easier and less expensive to deal with these goods and materials than if it happens downstream (UNEP, 2013, p. 50).

The management of a product during its entire lifecycle, in order to optimize the use of energy and to reduce the negative impacts on environment and human health, is represented by the set of priorities for waste policy. The waste hierarchy is a valuable guideline for waste policy design, since it sets priorities (when it is possible in the context) for decision making related to waste management, as presented in Figure 13 (Earth Engineering Center ,Columbia University) Hierarchy (in English and in Portuguese version).

[1] "The premise of this model is simple: companies extract materials, apply energy to them to manufacture a product, and sell the product to an end consumer, who then discards it when it no longer works or no longer serves the user's purpose". Ellen MacArthur Foundation, Towards Circular Economy, 2013, p. 15.

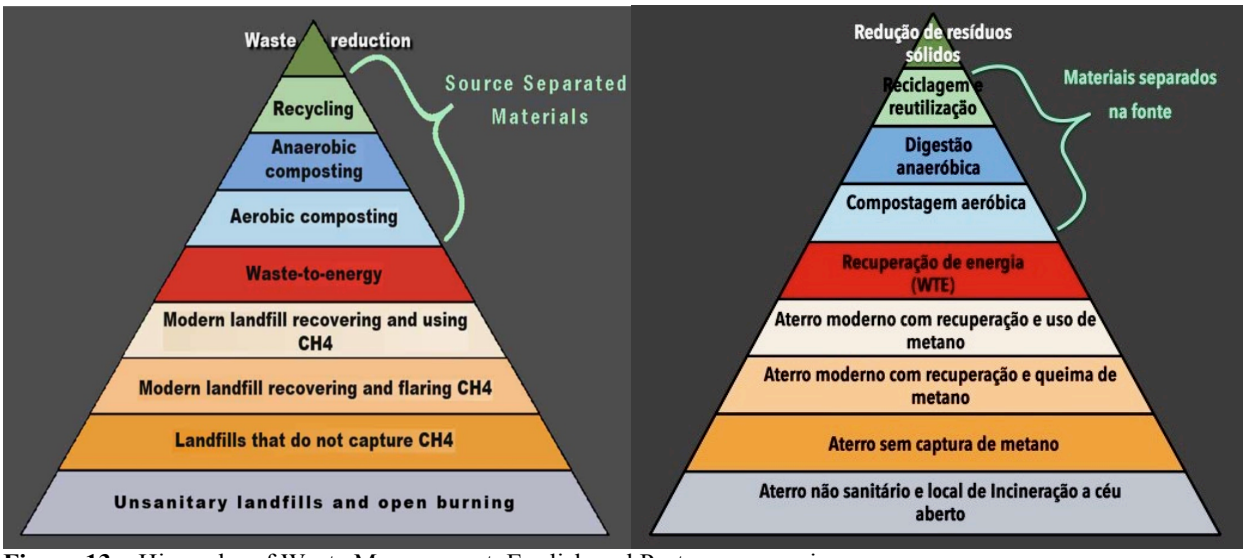
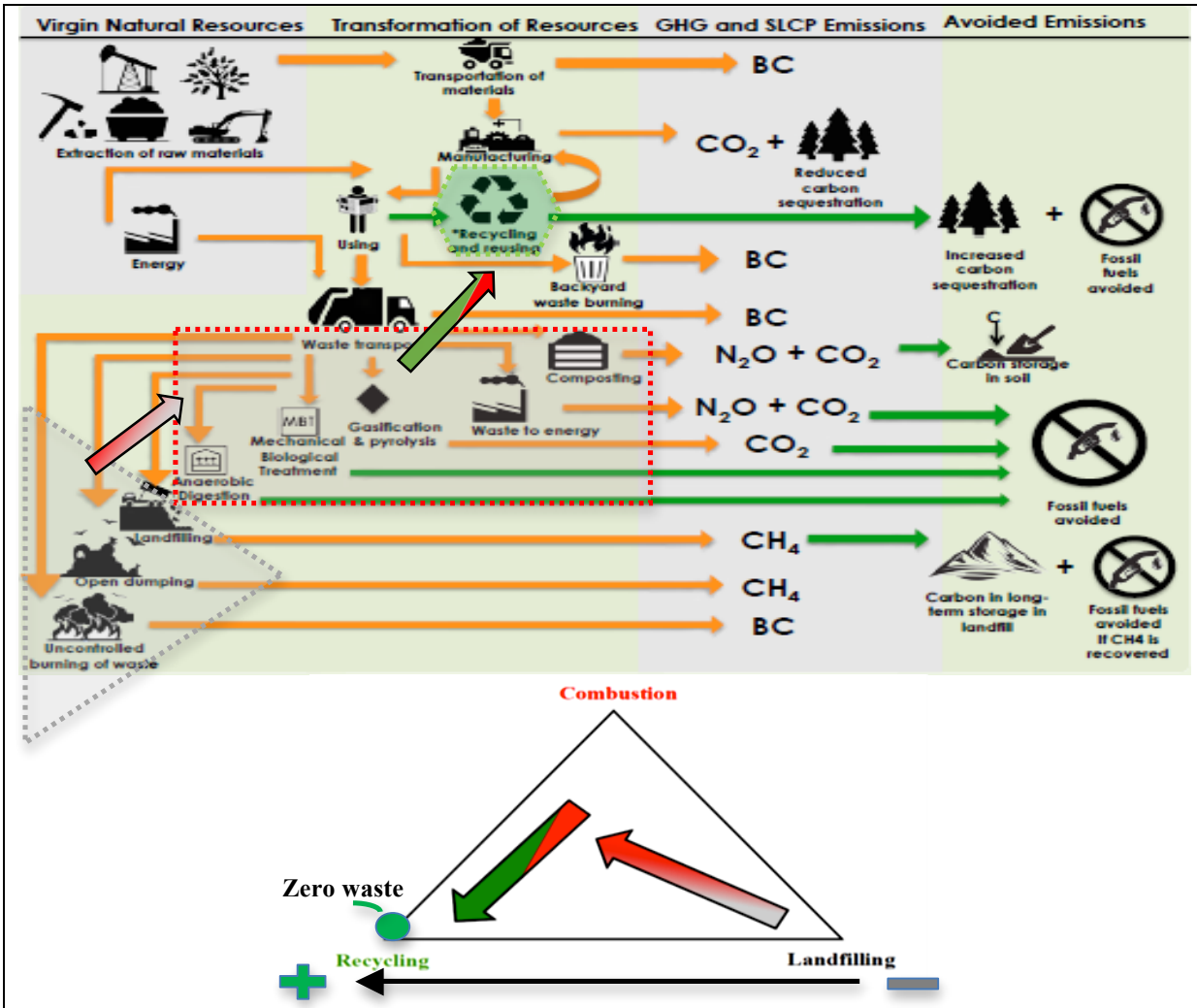


Figure 13 – Hierarchy of Waste Management, English and Portuguese version
Source – Themelis et al, 2013, p. 27

The engagement with stakeholders is essential for the Hierarchy of Waste Management success. For instance, the waste prevention is related to product design, choice of materials, and production, therefore, companies and professionals of these sectors need to be aligned with waste prevention guidelines; reuse involves engagement with collectors and dealers, and recycling with waste pickers, producers and designers (UNEP, 2013, p. 50). Also, the engagement of operators of waste collection, transport, composting and anaerobic digestion, waste-to-energy and landfill facilities and the public in general.

The waste prevention and waste management points out to two major rules to be followed by solid waste policy design: prevention of waste generation (product, non-waste) and management of waste generated (waste), including waste reduction. It is part of that cycle-way of thinking and for what is called “circular economy”, in which the idea is to optimize the whole system towards recycling increase and landfilling decrease (see Figure 14).



WASTE MANAGEMENT	**Recycling**	Any recovery operation by which waste materials are reprocessed into products, materials or substances whether for the original or other purposes. Product recycling: Any process in which the chemical and physical constitution of a product is maintained but the product is not used for the original purpose (e.g. using tires or glass bottles as building material). Material recycling: Any process in which the physical but not the chemical constitution is destroyed (e.g. melting and reprocessing of metals, or recycling of fertilizers from food-waste to the farming land by digestion or composting). Feedstock recycling (also raw material recycling or chemical recycling): Any process in which the physical as well as the chemical constitution of a material is reprocessed into its original constituants (e.g. de-polymerisation,). Downcycling: Any recycling process as mentioned above which results in a considerable lower product quality (e.g. recycled polymers).
	Other Recovery	Any operation by which waste is serving a useful purpose by replacing other materials. Thermal recovery: combustion with a sufficient high energy recovery rate, gasification, pyrolysis. Digestion: Production of biogas from food-waste.
	Disposal	Any operation which is not recovery. Incineration without or with low efficient energy recovery rate. Landfill (under controlled conditions)

Figure 14 – Evolution of waste management from landfilling towards recycling
Source – adapted from Directive 2008/98/EC; UNEP/ISWA, 2015.

Along with the sustainable development approach, and based on the waste management hierarchy, several factors have to be considered, like stakeholders (government, stakeholders, pollution, diseases, Laws, regulations, production standards etc), the waste system elements and other aspects (technical, economic, environmental, socio-cultural, institutional, policy-legal-political) (Van de Klundert, Anschütz, 2001) (see Figure 15).

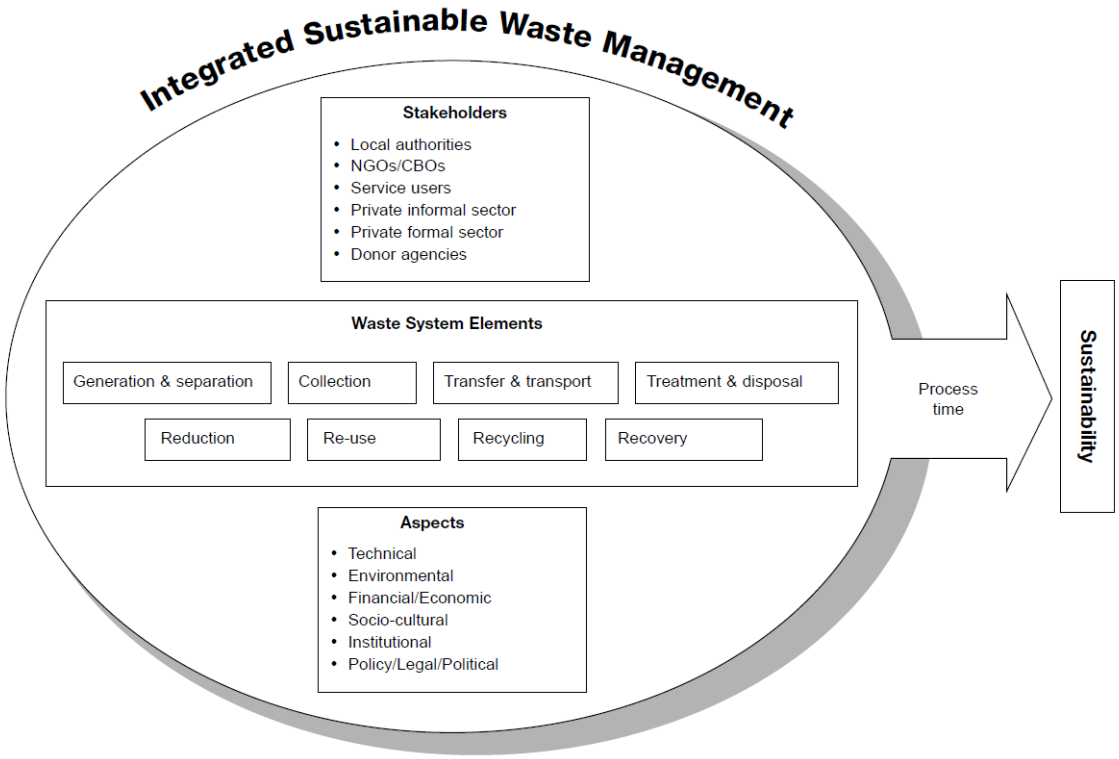


Figure 15 – The Integrated Sustainable Waste Management framework
Source – Van de Klundert, Anschütz, 2001, p. 14

These are the three dimensions of ISWM: the stakeholders, the elements of the waste system and the aspects of the local context. The stakeholder is a **"**person or an organization that has a legitimate interest in a project or entity, or would be affected by a particular action or policy" (UNEP, 2013), and in this case, those who have interest in the waste management or are affected by it.

The policy arena is one of the elements of the policy process called "policy cycle", a model where the political process is separated into three main stages: the development phase (design stage of political decision makers), the implementation (putting policy into action) and evaluation (comparing planned results and actually achieved). It is schematically represented by Figure 16 and Table 8.

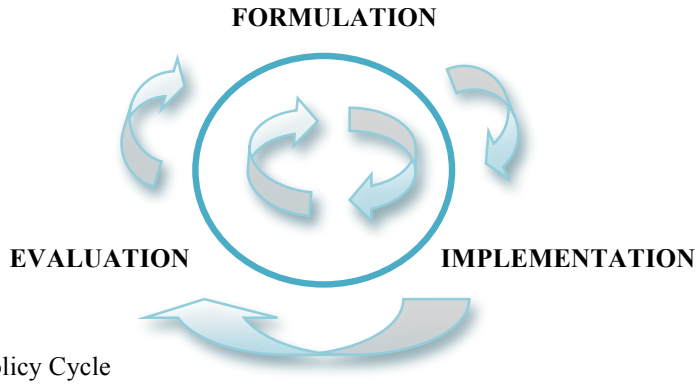


Figura 16 – The Policy Cycle
Source: Adapted from UNEP, 2009, 17.

The reasons for the choice of the policy cycle model to waste policy process are at least two: the way it separates the different tasks of the policy process, allowing the isolated study of the stages and sub-stages; and it shows the various roles played by the actors, institutions and ideas in the arena of political decision (Howlett, Ramesh, Perl, 2013).

Table 8 – Stages and sub-stages of the policy cycle

STAGE	STAKEHOLDERS	SUB-STAGES	PROCESS
Formulation	- Government - Bureaucracy - Waste pickers - Political parties - Private sector associations - Civil society (households) - Media - Wholesalers - Recyclers - End-user industries - NGOs - Donors - Consumer associations	**Problem identification**	Identification of a problem on demand of individuals or groups
		Agenda setting	Bring particular problem of public nature to the government agenda
		Formulation	Develop viable options to solve this problem
		Decision-making	Adopt one of the options according to established criter
Implementation	- Operators / waste system - Civil society - NGOs - Government - Bureaucracy - Private Sectors; donors	**Implementation**	Turning the option chosen in action
		Monitoring	Supervision of activity implementation
Evaluation	- Government - Bureaucracy - Civil society - Private sector - Donors		Evaluate the implementation of the adopted option according to the defined objectives of public policy

Source – Adapted from UNEP, 2009, 17;

The elements of the waste system of ISWM are the flow of energy, materials and services, and the closest scope of the integrated waste management strategy. In all stages of a product lifecycle, from extraction to final disposal, waste is generated along with pollution and emissions of GHG. The avoidance of natural resources degradation, high losses of energy, and negative impacts on human health, rising from the way society has been producing and consuming goods and services, are the main goals of the waste system management.

Therefore, it is from the integrated management of the elements of the waste system that the principles of ISWM can be achieved. All citizens have the right to the best waste management (equity**)** that lead to safe removal of all waste (effectiveness). On the other hand, along to optimum benefits and use of resources, at lowest cost possible (efficiency), under the local conditions and feasible from a technical, environmental, social, economic, financial, institutional and political perspective (sustainability) (van de Klundert, Anschutz, 2001, p. 11). It integrates the cycle-vision and the hierarchy of waste management, all elements in equilibrium. Even the waste hierarchy is relative, depending on the local, on the cost-benefits analysis, for example.

The third dimension are the aspects of the local context and how these aspects influence the waste management. The technical aspect, for example, will define the best formulation and implementation solutions, and how to reduce or avoid negative effects on environment (environmental aspect), based on the legal and regulatory framework (legal aspect), how some goals are set (political), and at the financial costs established. Also, it will be necessary institutional structure for the waste management, the pollution control and planning.

In the circular economy, the one-way system of the past is substituted by the cycle-way system, in which the connection of the waste system with the social, technical, financial and legal context becomes essential for the adequate waste management.

3. Waste to energy technologies

As energy is becoming short to face the high rates of population growth, urbanization and production-consumption supply/demand around the world, it is wise to recover energy from Municipal Solid Waste (MSW) before landfilling. Besides the energy generation, the volume of waste before landfilling can be reduced by 80-90% and by 60-70% in mass after waste to energy (WTE) treatment (Lomabardi, Carnevale, Corti, 2015), which reduces the area needed to waste final disposal; also, the WTE technology destroys pathogens and reduces GHG emissions (Themelis, 2015).

The WTE technology doesn't compete with recycling, since the prior deals with recovery of materials, while WTE with energy recovery. Also, the recyclability of materials/products are limited and not all materials can be recycled (cosmetics, soap), but some of these materials/products can still generate energy by WTE technology.

The estimated disposition of post-recycling urban solid waste in 2012 was about 1,200 billion tons (WTE = 200 billion tons, sanitary landfill with CH4 recovery = 200 billion tons, and landfilled without recovery of CH4 = 800 billion tons) and these numbers tend to increase (Themelis, 2015). In the Table 9, it is shown some advantages/ disadvantages between landfilling, composting and waste to energy technologies.

Table 9 – Comparison between landfilling, composting, and waste to energy

Technology	Advantages	Disadvantages
Landfilling	An universal solution that provides ultimate waste disposal	Requires large area of land
	Relatively low cost and easy to implement	Does not achieve the objectives of reducing volume of MSW and converting MSW into reusable resources
	Can derive landfill gas as a byproduct for household and industrial uses	May result in secondary pollution problems, including groundwater pollution, air pollution, and soil contamination
Composting	Converts decomposable organic materials into an organic fertilizer	There are issues with public perception, such as odor and bioaerosol emissions during the composting process
	Reduces the amount of waste to be landfilled	Can be costly to implement and maintain, and has no environmental or economic advantages compared to waste to energy
	Integrates well with landfilling and materials recovery/recycling	Compost product may cause soil pollution by heavy metals and pathogens
Waste to energy	Heat used as energy source for generation of steam and/or electricity	High capital and operational and maintenance costs
	WTE Facilities can be located near residential areas	Air pollution control equipment is required to treat the flue gas
	More optimal land use and more efficient integration of resources than landfilling	Public perception is sometimes negative, primarily with dioxins emission
	Air emissions can be well controlled	The fly ash needs to be disposed in hazardous waste landfills
	Provides substantial reduction (by 90%) in the total volume of waste requiring disposal in landfill	Significant operator expertise is required

Source – adapted from Cheng, Hu, 2010

There are more than 800 waste to energy plants in the world, and China had almost 200 WTE plants in 2014 (total capacity of more than 60 million annual tons) (ecoprog GmbH, 2015). In United States, there are 84 WTE power plants, 76.2% employing mass burn technology (64 unities), 15.5% refuse derived fuel (13 unities) and 8.3% utilize modular combustion (7 facilities); on the other hand, out of those 84 units, 73.8% produce electricity (62), 4.8% export steam (4 units) and 21.4% cogeneration—or combined heat and power (18) (Energy Recovery Council, ERC, 2014).

The MSW is rich in energy and the waste to energy plant releases this energy in the form of heat and electricity by a thermochemical conversion process, like combustion, gasification or pyrolysis (Lomabardi, Carnevale, Corti, 2015).

There are mainly two WTE technologies: the mass burn and the refused-derived fuel (RDF). The "mass burn" technology is the combustion ofas received MSW in a single combustion chamber, while the RDF receives the pre-processed MSW, after removing ferrous materials, glass, grit, and other materials that are not combustible (EPA, 2016). In Figure 17, it is shown the WTE plant process of generating electricity and heat.

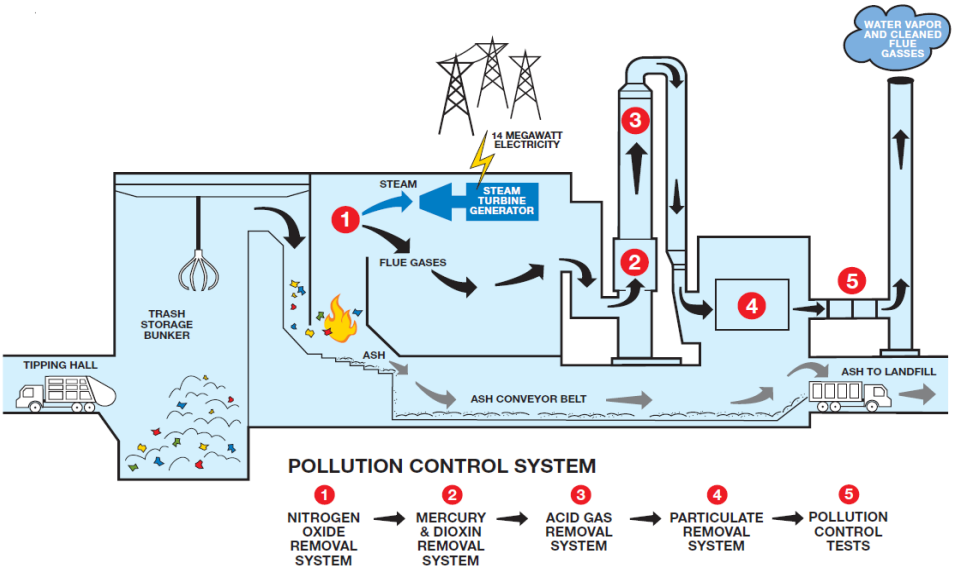


Figure 17 – A schematic representation of a WTE plant generating both electricity and heat
Fonte – EPA/Ecomaine, 2015, p. 133

MSW is stored in a trash storage bunker and then it is lifted it into a combustion chamber and then combusted, releasing heat (used to convert water to steam). While the steam is generating electricity through a steam turbine generator, the ash generated in this process is collected and taken to a landfill (EPA, 2016).

The amount of ashes generated ranges from 15-25 percent by weight of the MSW processed and from 5-15 percent of the volume of the MSW processed. Fly ash typically amounts to 10-20 percent by weight of the total ash while the bottom ash amounts to 80-90 percent by weight. The flue gases filtering process removes NOx, Mercury and dioxins, acid gas, particulate matter and then the Air Pollution Control process is tested. The cleaned fuel gases are then released to the air through a stack (EPA, 2016). The RDF technology input material are plastic packaging, paper industry rejects, high-caloric plastics, mixed waste from households, industry, construction business, and wood. The processing of RDF begins with pre-shredding operation, in order to

obtain homogeneous RDF with high calorific value. Then, the next steps are the separation, granulation line process, Fe – and NF – separation, and the outputs (NF – fraction, 10-30 mm; heavy fraction and RDF size between 10-90mm) (MeWa, 2016).

One of the most attractive characteristic of the waste to energy plant is related to reduction of GHG emissions.

Among the various issues related to sustainability is the climate change resulting from increased greenhouse gas emissions from the production process, consumption and waste generated by mankind.

It is estimated that these emissions over the next 100 years will be responsible for a rise of 5 ° C in the temperature of the planet in relation to the pre-industrial period (World Bank, 2010) – an increase equivalent to the difference between today's climate and the last glacial era - resulting in undesirable effects such as, for example, the greatest difficulty in producing enough food for entire world population, the lower availability and quality of water resources, and the increase of poverty.

Anthropogenic activities such as burning fossil fuels and releasing carbon dioxide, methane and nitrous dioxide in the atmosphere have been increasingly interfering with natural balance of Nature and its ecosystems, by rising the temperature of the troposphere, with huge consequences to present and future generations, and to the whole Planet.

For instance, as WTE is an intermediary process between recycling and landfilling, its comparative performance with GHG emissions from landfill is of high relevance. Landfilling is a definitive disposal of waste, while waste to energy is often classified by nationals' regulatory framework as a process prior to the definitive disposal[2]. So, if it reduces more the waste volume and GHG emissions than landfills, its utilization becomes essential for a healthier environmental.

The WTE GHG reductions are quantified by GHG reductions from avoided methane emissions from landfills, WTE electrical generation that offsets or displaces fossil-fuel based electrical generation, and the recovery of metals for recycling. A comparison of carbon dioxide equivalents, sulfur oxide emissions and nitrogen oxide emissions for landfill-gas-to-energy (LFGTE), WTE, and conventional electricity-generating technologies is shown in Figure 18 (Kaplan, Decapolis, Thorneloe, 2009).

The waste to energy reduction of CO_2, NO_x and SO_x emissions are higher than emissions from landfill-gas-to-energy and electricity-generating technologies. It shows the best performance of all other sources of GHG emissions considered in this study, except the nuclear power, which, however, has some well-known weakness.

[2] The European Union Directive 2008/98/EC, for example, classifies a waste to energy plant as "recovery" or "disposal", depending on the level of the Energy Recovery Indicator (R1).

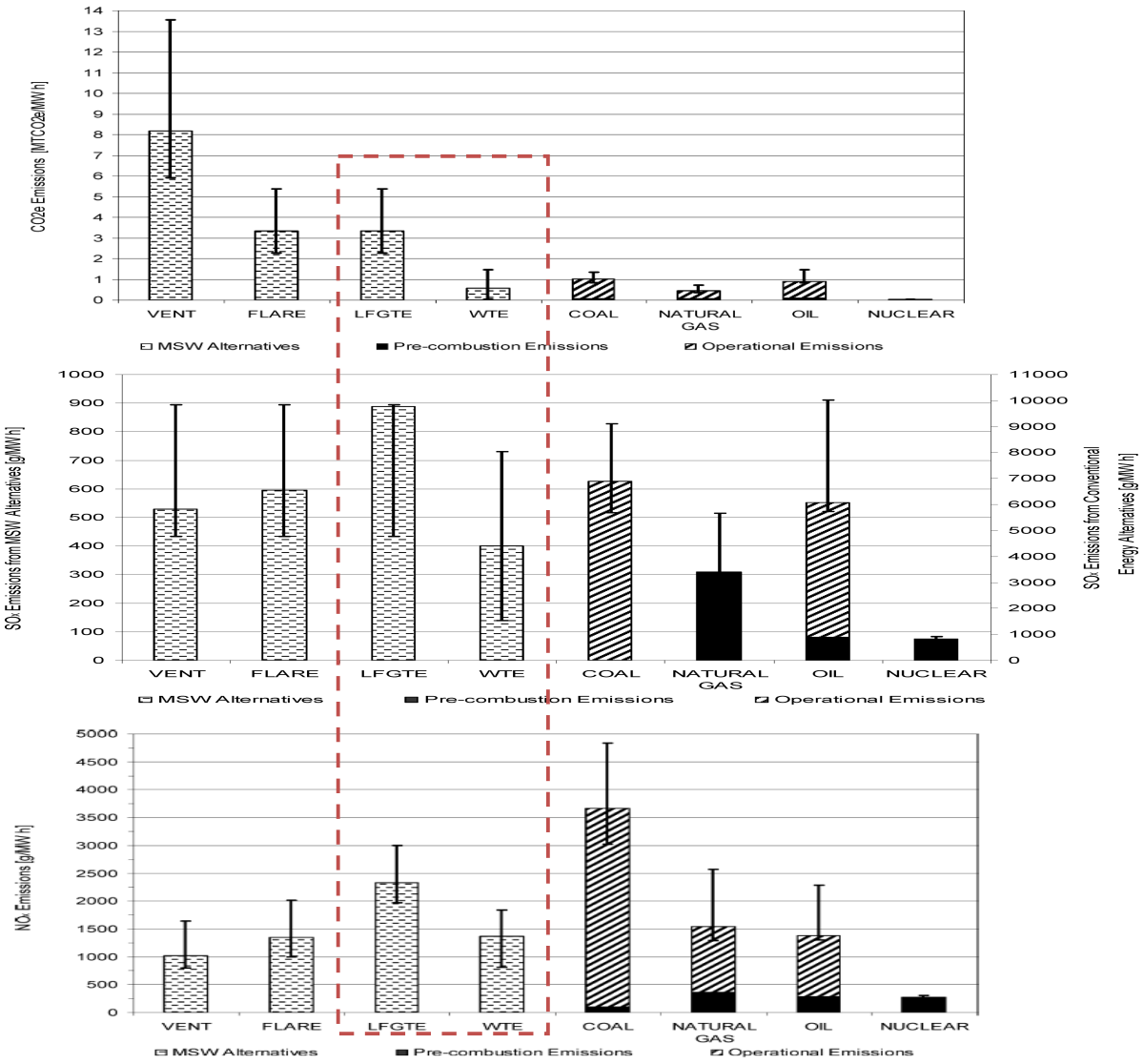


Figure 18 - Comparison of carbon dioxide equivalents, sulfur oxide emissions and nitrogen oxide emissions for landfill-gas-to-energy (LFGTE), WTE, and conventional electricity-generating technologies
Source – Kaplan, Decapolis, Thorneloe, 2009

These technical aspects are extremely useful for any decision making on urban solid waste policies but the implementation of a technological alternative depends on other factors, like the legal apparatus of the country, at local, regional and/or national levels. If there is a National Law that doesn't accept certain kind of technology, even being the best technology at the moment, it will not be feasible in this place.

That's the reason for focusing on legal aspects at national, regional (States) and local (municipalities) levels in Brazil in the next chapters, in order to demonstrate the feasibility of Waste to energy technology in the country.

4. Legal aspects related to waste to energy plant in Brazil

The heart of Brazilian's legal system is the Constitution enacted in 1988. Among several principles and mandates, there are some key points that must be taken into account, since they are the basis of legislative and executive competencies assigned to public entities like the Union, the Federal government, states and municipalities, related to environment and urban policies.

While only the Union and the states have both competencies to legislate about urban law, forests, hunting, fishing, fauna, nature conservation, soil and natural resources defense, environmental protection and pollution control, the Union, the states and municipalities have together the managerial competency to protect the environment and fight pollution in any of its form. The municipalities have also the competency to legislate about local issues and to supplement the federal and states' legislation where applicable. Also, it is up to municipalities to organize and provide for, directly or by means of concession or permission, the public services of local interest.

In the Constitution, the general rules of urban policy for municipalities are already designed and the most important for the purpose of this study is the master plan, approved by the City Council, compulsory for cities of over twenty thousand inhabitants that is the basic tool of development policy and urban sprawl.

Concerning the environment, the Constitution establishes that every person has the right to an ecologically balanced environment, for common use and essential to a healthy quality of life, imposing to the government and society the duty to defend it and preserved it for present and future generations.

These key points lead to the understanding that municipalities have less legislative power over issues that are of their concern and, on the other hand, more managerial obligations, since it has to deal with all subjects that were previous regulated by the Union and the states. This context remains the same in the solid waste management. At the end of the line, the municipalities have the responsibility to manage the solid waste flux.

Finally, the Constitution assures an ecologically balanced environment, for common use and essential to a healthy quality of life, basic principles to be followed in the integrated municipal solid waste management.

4.1 The Brazilian National Solid Waste Policy

In August 2, 2010, the Brazilian National Solid Waste Policy (hereinafter referred to as BNSWP) was established in Brazil, by the enactment of Law 12,305. This Law was regulated by the Decree n^{o} 7,404, December 23, 2010.

Besides its intrinsic legal power as a law approved by the Brazilian Parliament, the whole legislative process of this law initiated in 1989 with the Federal Senate Bill no. 354/1989, and after nearly hundred amendments and joined projects, the bill entered into force in 2010. However, this policy was barely discussed by Brazilian society during this period, since there was only one public hearing, which occurred few months before its enactment by the President of Brazil.

The only public hearing held during the legislative process of BNSWP occurred in May, 2010, and it was attended by the Ministry of Environment (MMA), the Ministry of Cities, the National Confederation of Municipalities, the Brazilian Association of Infrastructure and Basic Industries, the Brazilian Public Cleaning and Special Waste Association, the National Confederation of Industry and the National Movement of Recyclable Materials (Villac, 2014, p. 153).

So, despite its importance as an attempt to give a systematic approach to the waste management in the country, the law is practically unknown by most Brazilians and civil society in general. The law was intended to benefit few powerful actors from domestic industry and commercial sectors, but as soon as it became a law, its interpretation and applicability escaped the hands of legislators and entered in the legal system.

The BNSWP has to be interpreted together, for instance, with Brazilian Constitution, International agreements, the Brazilian National Environmental Policy, the National Basic Sanitary Policy, the Brazilian National Policy for Climate Change, the National Policy on Environmental Education, and in accordance with the National Sanitary Surveillance System (hereinafter referred to as SNVS), the Unified System of Animal and Plant Health (hereinafter referred to as Suasa) and the National System of Metrology, Standardization and Industrial Quality (hereinafter referred to as Sinmetro).

The Brazilian National Solid Waste Policy adopted the solid waste integrated management, the share responsibility for the lifecycle of the product, reverse logistic, and waste hierarchy (non-generation, reduction, reutilization, recycling and treatment of solid waste, as well as final environmentally-adequate waste disposal), public cleaning and solid waste management services, and sustainable consumption and production standards as well.

It establishes its harmonization with States Solid Waste Policies and Municipalities' Solid Waste Policies, regarding to the solid waste hierarchy and the use of technologies for energetic recovery of urban solid waste, provided that technical and environmental feasibility are proven, and a toxic-gas-emissions-monitoring program approved by the relevant environmental body, imbalance with other guidelines established in the National Policy.

The National Policy distinguishes solid waste destination and solid waste disposal. While final environmentally-adequate destination is the "waste discarding that comprises reuse, recycling, composting, energy recovery and utilization, or other forms of disposal permitted by Sisnama, SNVS and Suasa competent bodies, including final destination, observing specific operational

norms in a way to avoid damage or risks to public health and minimize adverse environmental impacts", final environmentally-adequate disposal is "refuses discarding in landfills, observing specific operational norms in a way to avoid damage or risks to public health and minimize adverse environmental impacts".

As refuses are defined in the law as "solid residues that, after all available and economically-feasible technological treatment and recovery attempts, present no possibility other than final environmentally-adequate disposal", i. e, landfilling, the Law clearly links energy recovery to final environmentally-adequate destination, including, therefore, waste to energy technologies.

Also, as the objectives of BNSWP are the "adoption, development and improvement of clean technologies as a way to minimize environmental impacts", "reduction of volume and danger potential of hazardous waste", and "incentive to recycling, aiming at fostering the use of raw material and supplies derived from recyclable and recycled material", the waste to energy technology is included in these objectives, since it is a clean technology (when properly used), it reduces 90% the volume of waste, and it can be fueled by recycled material. Another objective of BNSWP includes the incentive to energetic recovery, and waste to energy technology is one way to recover energy from solid waste.

According to the BNSWP, the waste plans are: National Solid Waste Plan, States Solid Waste Plans, Micro regions Solid Waste Plans, Metropolitan Urban Regions Solid Waste Plans, Inter-municipal Solid Waste Plans, Integrated Solid Waste Management, and waste management plans (see Figure 19). However, these plans aren't laws.

Figure 19 – Solid Waste Plans in the Brazilian National Solid Waste Policy
Fonte – Brazilian Ministry of Environment, MME, 2010

The Federal District and municipalities are responsible for the integrated management of the solid waste generated in their respective territories, and the states, for promoting the integration

of organization, planning and execution stages of public functions of common interest related to solid waste management in metropolitan regions, urban agglomerations and micro regions, under the terms of the state supplementary law anticipated in Para. 3. of Art. 25 of the Federal Constitution (environmental crimes and penalties).

4.2 The Brazilian National Environmental Policy

The Brazilian National Environmental Policy (BNEP) was established in August, 1981 but it is still contemporary. Some of its rules ideas were adopted by Brazilian Constitution, and it has implications for solid waste management and waste to energy technology.

In the BNEO, the degradation of the quality of the environment is defined as the adverse alteration of the characteristics of the environment and pollution as the degradation of the environmental quality resulting from activities that directly or indirectly: a) harm society's health, security and well-being; b) result in unfavourable conditions to social and economic activities; c) adversely affect the environment; d) affect sanitary and aesthetic environmental conditions; e) release substances or energy that does not comply with the established environmental standards.

As environment is there defined as the group of conditions, principles, influences and interactions of a physical, chemical and biological nature that enables, shelters and rules all forms of life, and environmental resources as including the atmosphere, the inland, superficial and ground water, the estuaries, the territorial sea, the soil, the subsoil and the components of the biosphere, the BNEO and solid waste management are straight linked.

The inadequate waste management is one of the ways that leads to the degradation of the quality of the environment and a form of pollution itself, when this degradation harm society's health, and adversely affect the environment and sanitary and aesthetic environmental conditions. The controlled landfilling and open dumpsites cause degradation and pollution, and of course all activities related to solid waste creation and waste management can be a potential source of pollution, if it is not aligned with the standards for the preservation of an adequate and healthy quality of the environment.

Thus, there are some aspects of the BNEO that have to be accomplished by any enterprise related to solid waste, including waste to energy plant: the environmental quality standards established by the policy, the adequation of the enterprise for the environmental zoning defined by law, the access to the assessment of environmental impacts of the enterprise and the licensing and revision of its polluting activities. One of the instruments of the National Environmental Policy is the incentive to the production and installation of equipment and the development or incorporation of technologies for the improvement of the environment, what can be achieved by waste to energy technology, when feasible.

The National Environmental Council (CONAMA) established in this policy has the responsibility of establishing norms and criteria for the licensing of polluting activities, to be conceded by the states, and norms, criteria and standards related to the control and maintenance of the environmental quality with a view to the rational utilisation of the environmental resources, in particular the water resources.

The Decree 99,274 of June, 1990, regulated the BNEP and it assigned to CONAMA the competency to decide, in the form of resolution, proposals, recommendations and motions aimed at meeting the objectives of the National Environmental Policy. Also, the Decree established that the institutional public power (States) is authorized to issue the following licenses: I - Preliminary License (LP) in the preliminary phase of activity planning, containing basic requirements to be met in stages of location, installation and operation, subject to the municipal plans, state or federal land use; II - Installation License (LI), authorizing the start of implementation, according to the specifications of the approved Executive Project; and III - Operating License (LO), authorizing, after the necessary verifications, the start of the licensed activity and operation of its pollution control equipment, as provided for Preliminary and Installation Licenses.

In the State of Sao Paulo, the analysis about these licenses is made by the Environmental Company of the State of Sao Paulo (CETESB). Depending on the enterprise, additional studies can be required (see Figure 20).

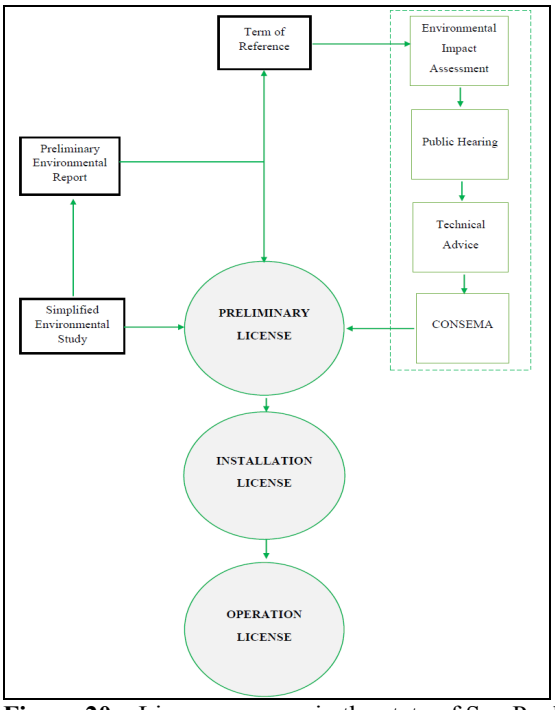


Figure 20 – License process in the state of Sao Paulo
Source – CETESB, 2014.

The Resolution CONAMA nº 316/02 regulates procedures and criteria for the operation of thermal treatment systems, as well as the toxicity equivalency factors for dioxins and furans (see Table 10). This resolution sets maximum and minimum standards limits of air pollution originated from external emission of combustion processes in new sources of stationary pollution with total nominal power of 70 MW and higher.

Also, each municipality has its own regulations to issue the proper license to authorize the project, the implementation and operation of the enterprise, according to local regulations.

4.3 The Brazilian National Basic Sanitary Policy

Both the Brazilian National Solid Waste Policy and the Brazilian National Environmental Policy mentioned directly or indirectly the Brazilian National Basic Sanitary Policy (BNBSP). The healthy sanitary environment depends on how the waste is managed and the better is the waste management, the better is the sanitary environment.

Basic Sanitation for the BNBSP is a set of services, infrastructures and operating installations of potable water supply; sanitation / sewage; urban waste collection and solid waste management; and urban rainwater drainage and management. The urban waste collection and solid waste management is the set of activities, infrastructure and operational installations for the collection, transportation, transfer and final disposal of domestic waste and of the waste generated by the sweeping and cleaning of public sites and roads.

For the purpose of BNBSP, the public urban waste collection and urban solid waste management services are made up by the following activities: collection, transfer and transportation of waste related to urban waste collection and solid waste management; sorting for reuse or recycling, treatment and composting purposes, and for the final disposition of waste associated to urban waste collection and solid waste management; and sweeping, weeding and pruning of trees on public roads and sites and other eventual services associated to public urban cleaning.

4.4 The Brazilian National Policy on Climate Change

The National Policy on Climate Change – BNCCP - was established by Law nº 12,817, December, 2007, and one of its objectives is the reduction of anthropogenic greenhouse gas emissions with regard to their different sources.

Among its directives, the BNCCP assure the commitments Brazil has undertaken under the United Nations Framework Convention on Climate Change (UNFCCC), the Kyoto Protocol and other documents on climate change the country may come to sign.

The National Policy on Climate Change lists several instruments to stimulate the achievement of its goals like: existing financial and economic mechanisms referring to climate change mitigation and adaptation to the effects of climate change under the United Nations Framework Convention on Climate Change and the Kyoto Protocol; fiscal and tax measures destined to stimulate emissions reduction and removals of greenhouse gases, including differentiated tax rates, breaks, exemptions, compensations and incentives, to be established by specific law; specific lines of credit and financing from public and private financial agents; and development of lines of research by development agencies.

4.4.1 The Kyoto Protocol and the Clean Development Mechanism

The urbanization growth aligned with the increase of energy demand, waste generation, emissions of CO2eq and global warming require urgent actions from all nations, at national and local levels. It requires not only energy efficiency but also a change in the global energy matrix actually linked to fossil fuels combustion. The energy recovery and renewable energy, for example, are incorporated in this change, aligned with Kyoto Protocol and the Clean Development Mechanism (CDM).

The Kyoto Protocol establishes incineration among the sources of emission of greenhouse gases (Appendix A), and there are several projects of waste to energy approved by the Executive Board of United Nations Framework Convention on Climate Change (UNFCCC), including the URE Barueri, in the State of Sao Paulo, about what it will be given more details in chapter 5.

At the UNFCCC, the project developer has to send the project ideas to the Designated National Authority (in the Ministry of Science and Technology, in Brazil), which subscribe a letter of no objection to the same developer. The next step is to elaborate the project design document and send it to the Designated Operational Entity that will send a validation report to the Designated National Authority (DNA); the DNA send a letter of approval and then a request for registration to CDM Board of Directors (see Figure 21).

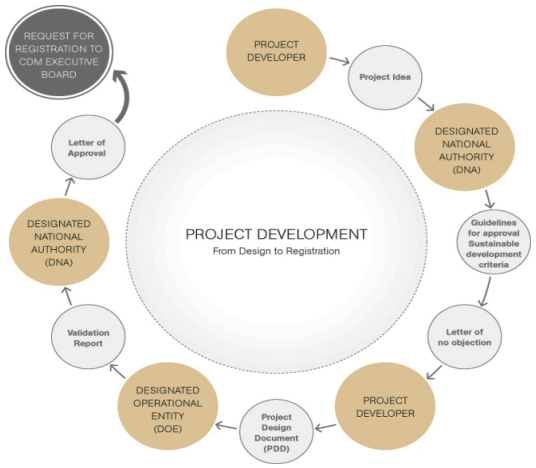


Figura 21 – The CDM project development
Fonte - CDM, 2016

The CDM projects earn tradable, saleable certified emission reduction (CER) credits that can be used by industrialized countries, in order to achieve its emission reduction targets under the Kyoto Protocol. Also, developing countries with CDM project can benefit by funding and transfer or diffusion of technology (CDM, 2016). Although registering the project as a CDM project is not mandatory, those benefits from CDM can support the project.

In Brazil, the Brazilian National Solid Waste Policy, the State of Sao Paulo Solid Waste Policy and regulations from the National Council of Environment (CONAMA) and from Secretariat of Environment of the State of Sao Paulo, connected with other rules about environment, and energy, aligned with the local laws, are the legal support for a waste to energy plant approval in the State of Sao Paulo.

4.5 Rules related to energy recovery plant in the State of Sao Paulo

The State of Sao Paulo of Sao Paulo has its own solid waste policy since 2006 and its solid waste plan since 2014. The Solid Waste Policy of the State of São Paulo (SWPSSP) was established by the Law 12,300, of March 16, 2006, and regulated by State Decree 54,645 of August 5, 2009. One of its principle is waste minimization through incentives for environmentally sound practices of reuse, recycling, reduction and recovery.

The Resolution SMA n^{o} 79/2009 of the Secretariat of Environment of the State of Sao Paulo established guidelines and conditions for the operation and licensing of the heat treatment of solid waste in energy recovery plants – URE, while the Environment Policy of the State of Sao Paulo established three environment licenses: the Primary License (related to the preliminary phase of planning), the Installation License (authorize the implementation) and the Operation License (authorize the operation). Notice that this policy just repeated the BNEP regulation on licenses.

A comparative scenario of emission limits for Energy Recovery Plants is listed in Table 11.

Table 11 – Comparative emissions limits for Energy Recovery Plant

Parameter	Unity	EPA (i)	EU (ii)	SMA (III)	CONAMA (iv)
MP	mg/Nm^3	20	10	10	70
NOx	mg/Nm^3	210	200	200	560
Sox	mg/Nm^3	90	50	50	280
HCL	mg/Nm^3	20	10	10	80
CO	mg/Nm^3	130	50	50	125
Hg	mg/Nm^3	0.05	0.05	0.05	-
Cd+Ti	mg/Nm^3	0.01	0.05	0.05	-
HF	mg/Nm^3	-	1	1	5
Dioxins and Furans	mg/Nm^3	0.26	0.1	0.1	0.5

Source – (i) EPA 40 CFR Part 40; (ii) EU 2007/07/CE; (iii) SMA 079/2009; (iv) CONAMA 316/2002

In the study elaborated by the Metropolitan Company of Water and Energy (Empresa Metropolitana de Águas e Energia - EMAE) in Sao Paulo, Brazil, it was compared the annual quantities of emissions and impacts between Energy Recovery Plant and Landfill, both with 1,200 t/day of waste capacity (see Appendix, Table 12).

For the Brazilian point of view, the results surprisingly showed the emission of dioxins and furans in energy recovery plant (WTE) was almost 25 times lower than in a landfill (flare) and 5 times lower when in Otto cycle engine, burning the same amount of waste. Dioxins and furans are the worst substances to human health, with huge environmental cost and health impact.

The recovery plant energy produced around 208 tons of greenhouse gases per year and the landfill with burning gases in the air or in engines, it produced about 465,000 tonnes of greenhouse gases per year, more than double of the production of greenhouse gases by incineration (Bolognesi, 2012).

5. Case study: URE Barueri

The city of Barueri is 26.5 kilometers from the city of São Paulo, has about 246,000 inhabitants and a floating population of about 170,000 (IBGE, 2012). The city is among the ten municipalities with the highest population growth in the state of São Paulo and its geographical area is 64 km^2 (population density of 3,838 inhabitants per square kilometer). Its GDP/capita is US$ 32,500 (IS THIS NUMBER RIGHT???) while Brazil's GDP is US$ 4,400. In Barueri, 99% of its avenues are paved. According to the city of Barueri website, 100% of the solid waste generated in the city is collected and sorted.

In 2010, in view of the fact that the final destination of the solid waste of the city of Barueri was the Solid Waste Treatment Center, located at 20 km distance from the city, Barueri launched a public contest for a Public Private Partnership (PPP) contract for the implementation and operation of an Energy Recovery Unity for 30 years' period. The PPP would be responsible for the implementation and operation licenses, for the thermal processing of the solid waste and its adequate final destination (Grynwald, 2014).

The winner was the FOXX consortium, which would aggregate the solid waste from other two municipalities to the Energy Recovery Unit, the cities of Carapicuiba and Santana de Parnaiba, for combusting 825 t/day of MSW (272,000 tons MSW/year), using moving grate technology with electricity generation of 17 MW over 8,000 hours per year (136,000 MWh/year), and projected reduction of 272,000 tons of $CO_{2\ per\ year}$ (URE Barueri, 2012).

The site of the URE Barueri is close to a Sewage Treatment Station and an Electric Substation (Figure 22).

Figure 22 – Aerial photo of site of URE Barueri
Source - URE Barueri, 2012

In December, 2012, the preliminary license for the URE Barueri was issued by the Environmental Company of the State of Sao Paulo (CETESB License n^{o} 2183), indicating the feasibility of Waste to Energy plant in the State of Sao Paulo, Brazil. The next step is to obtain the installation license that have not been issued yet.

The URE Barueri is registered at UNFCCC – CDM as Project n^{o} 8128 (Barueri Energy CDM Project), i.e., a project that complies with the CDM scope of *energy industries (renewable - /*

non-renewable sources), due to electricity generation, and *waste handling and disposal (*Incineration of Municipal Solid Waste, as specified in the CDM list of accepted technologies).

The analysis of the entire process of the licensing of URE Barueri demonstrates that knowledge of all laws and types of rules relating somehow to the approval of a proposed enterprise is essential before choosing the site for the waste to energy plant (URE). The consortium waged a successful media campaign which resulted in the fast expedition of the CETESB license but, after three years, they still do not have all licenses to implement the URE.

6. Case study: City of Sao Paulo

This section discusses some legal aspects related to a potential waste to energy plant in the city of Sao Paulo. The objective is to show that waste to energy plant implementation and operation is allowed in the city.

At the local level, the Organic Municipal Law is the equivalent of a Constitution that, however, cannot conflict with the Brazilian Constitution or the Constitution of the State of Sao Paulo. The Organic Municipal Law of the city of Sao Paulo, in accordance with the Brazilian Constitution, is the master plan of the city. This law was approved by the City Council in 2002, revised in 2014 and is the so called "Strategic Master Plan" of the city of Sao Paulo.

One of the objectives of the Strategic Master Plan is the reduction of solid waste volume. The Plan determines that the Integrated Management of Solid Waste must follow the guidelines and decisions of the National Solid Waste Policy, and also ensure adequate destination of the solid waste. In conclusion, the city of Sao Paulo, as all other cities in Brazil, must follow the Brazilian National Solid Waste Policy law and its mandates.

The Brazilian National Solid Waste Policy establishes that the solid waste policies of all States and all municipalities must be compatible with its provisions which allow that technologies for the energetic recovery of urban solid waste may be used, provided that technical and environmental feasibility are proven, and a toxic-gas-emissions-monitoring program, approved by the relevant environmental body, has been implemented.

The Municipal Policy for Climate Change (Law 14,933, June, 2009) establishes among its goals the minimization of the amount of waste generated, the reuse and recycling of urban waste, its harmfulness reduction and the environmentally appropriate treatment and disposal of the remaining waste. Also, this law states that waste management projects will be subject to joint implementation between organs of the municipal government and there will be measures and incentives to minimize the generation of municipal waste and to stimulate the treatment and disposal of waste, preserving health conditions and promoting the reduction of emissions of greenhouse gases.

An objective of the law is to ensure the contribution of São Paulo in the fulfillment of the United Nations Framework Convention purposes on Climate Change, and to achieve stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system. Therefore, this law is aligned with the implementation of waste to energy technologies, since they are accepted to be a type of waste treatment that reduces GHG emissions.

Also, the waste to energy plants are accepted by Clean Development Mechanism, which is linked to the United Nations Framework Convention, as one of the enterprises that can benefit from CDM instruments to stimulate the reduction of GHG emissions.

However, one of the Integrated Solid Waste Management Plan (2014) main guidelines for the management of MSW in the city of Sao Paulo is “no for incineration” (PGRIS, 2014). This guideline was approved by the 800 representatives of the 4th Environmental Conference of the municipality of Sao Paulo in WHAT YEAR?? . This is a proof that there is a lack of public information about the technological advances of waste to energy plant during this century and confusion of “incineraton” of the past with the modern WTE plants used throughout the world. Also, the Sao Paolo Plan cannot conflict with the Brazilian National Solid Waste Policy and the Solid Waste Policy of the State of Sao Paulo, so the above guideline of the city of Sao Paolo must be reviewed.

Considering this legal scenario, some data about waste collection, selective waste collection (Figure 23) and gravimetric composition of urban solid waste in the city of Sao Paulo are shown in Table 13. A feasibility study of waste to energy power plant in the city can be subject of future studies.

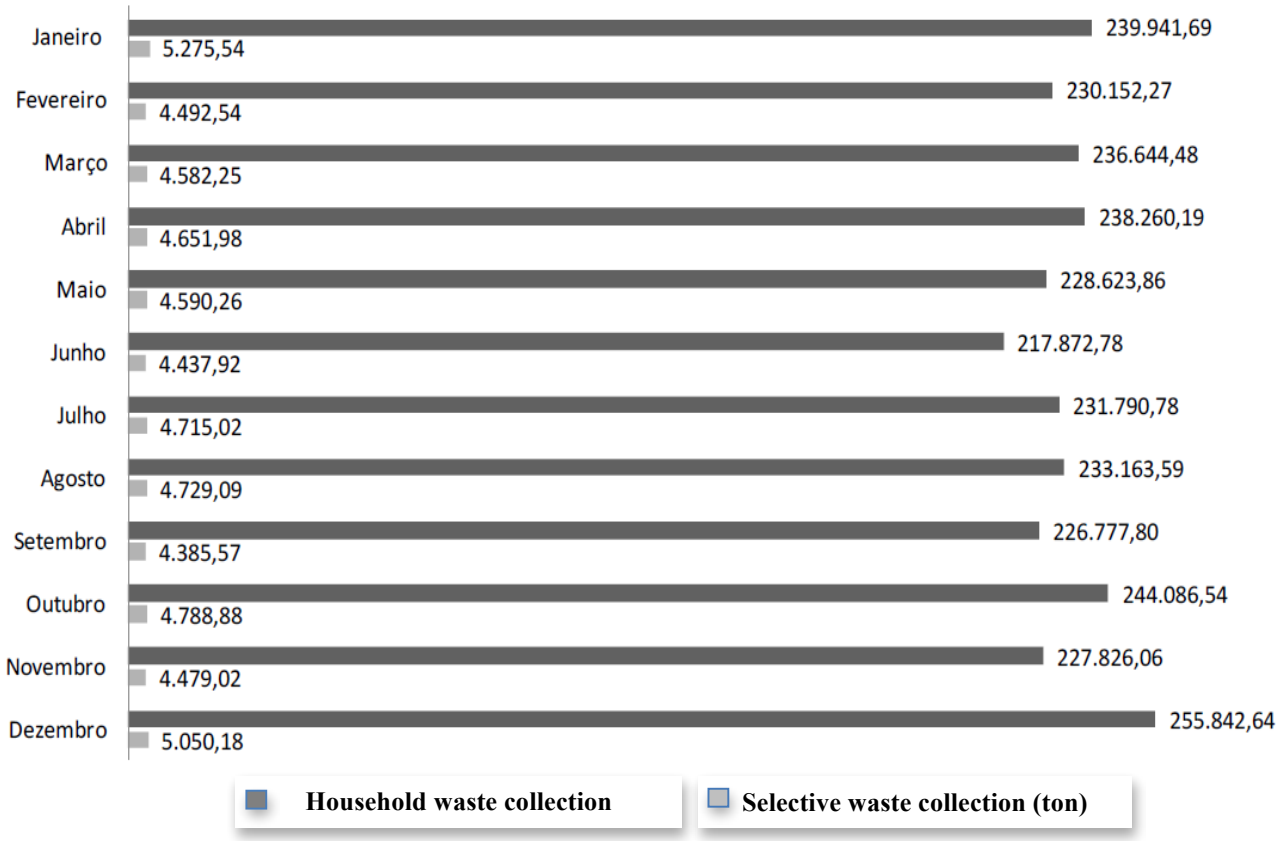


Figure 23 – Comparison between residential waste collection and selective waste collection in Brazil
Source – AMLURB *apud* Paschoalin Filho et al, 2014

The data shows that only 1.9% of the total mass of waste was collected by selective waste collection. This scenario has to improve significantly in order to make recycling and the energy recovery plant in the city feasible.

Another fact to be considered for the definition of the location of a recycling and WTE power plant is the destination of this volume, what is shown in the Figure 24. The highest amount of waste from selective waste collection goes to the solid waste transshipment Ponte Pequena.

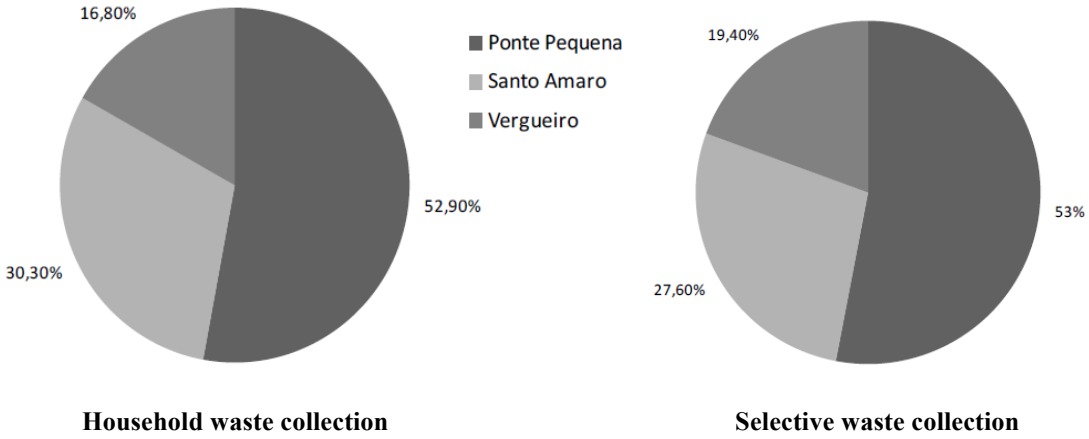


Figure 24 – Share of each of the three solid waste transshipment points in the city of Sao Paulo
Source – AMLURB *apud* Paschoalim Filho et al, 2014

Table 13 – Gravimetric composition of urban solid waste in the city of Sao Paulo, 2013

Waste	%
Metals	2.2
Plastics	15.9
Paper, Tetra Pack	11.1
Glass	1.8
Organic matter	57.5
Others	11.5

Source – Agostinho et al *apud* Paschoalin Filho et al, 2014

7. Conclusion

Brazil has been improving its solid waste management since the enactment of the Brazilian National Solid Waste Law (2010) but, as shown in this study, there is a long way to go. The decision making on waste management in Sao Paulo seems to be influenced more by the interests of the domestic industry on MSW collection and landfilling, rather on scientific evidence as to what constitutes sustainable waste management. The Integrated Solid Waste Management Plan of the city of Sao Paulo and its main guideline against incineration reveal how the lack of scientific knowledge can negatively impact citizens' life and the environment.

However, the national legislation of Brazil is ahead of this scenario and is aligned with the modern goals on environment and public health protection. The existing legal framework ensures the feasibility of waste to energy implementation and operation of high standards WTE facilities, as the URE Barueri preliminary license and registration at the Clean Development Mechanism demonstrate.

The recycling rates in Brazil, in the state of Sao Paulo, and the city of Sao Paulo are low in comparison with other countries at the same economic level. Therefore, there is an opportunity for increased recycling and also waste to energy activities in the country, both of which are supported by the National Solid Waste Policy, the National Environmental Policy and the Brazilian National Policy on Climate Change. As it has been shown in many developed countries, recycling and WTE complement each other and can be implemented to work together.

8. Future studies

A detailed feasibility analysis of the economic and environmental incentives of building a WTE plant to serve the City of Sao Paulo should be conducted, in order to entice investment on a waste to energy plant.

Also, the symbiosis model of Kalundborg industrial park should be considered for several areas in the country, since Brazil is one of the largest countries in the world and there is a lot of room for a combination of WTE, recycling, and other technologies, in order to improve the quality of life of its population and also protect the environment.

9. References

The references to this report were cited throughout the body of the report.

Appendix 1 – Energy consumption: municipalities of Sao Paulo State

Table 5 – The 15 largest municipalities' consumers of energy in the State of Sao Paulo, 2014

MUNICIPALITY	ELECTRICITY (toe)	NATURAL GAS (toe)	COMPRESSED GAS (toe)	ETHANOL (toe)	OIL DERIVED (toe)	TOTAL (toe)	PARTICIPAÇÃO (%)
São Paulo	2.586.350	1.273.972	0	830.385	4.270.082	8.960.789	20,15
Guarulhos	293.213	90.202	0	76.989	2.500.242	2.960.646	6,66
Campinas	293.785	39.728	0	120.941	772.317	1.226.770	2,76
Cubatão	315.174	267.928	4.458,5	2.626	555.200	1.145.385	2,58
Santo André	261.235	233.064	0	50.367	217.568	762.235	1,71
São Bernardo do Campo	265.663	79.154	0	58.370	337.171	740.358	1,66
Sorocaba	190.666	45.694	0	79.899	369.886	686.145	1,54
Paulínia	86.505	184.280	0	9.332	355.090	635.208	1,43
Ribeirão Preto	163.873	13.776	0	72.003	369.699	619.352	1,39
Piracicaba	196.991	129.303	0	50.567	218.002	594.863	1,34
São José dos Campos	162.212	48.548	0	50.029	329.766	590.555	1,33
Jundiaí	181.087	60.689	0	50.310	258.071	550.158	1,24
São José do Rio Preto	102.646	0	0	61.098	327.616	491.359	1,10
Osasco	137.370	18.167	0	50.462	277.027	483.025	1,09
Jacareí	97.379	210.178	0	12.248	153.470	473.275	1,06
Total dos 15 Maiores	5.334.149	2.694.682	4458,467	1.575.626	11.311.207	20.920.123	47,04
ESTADO SÃO PAULO	11.788.614	5.014.074	15.045	3.647.364	24.003.814	44.468.911	100

Source – State of Sao Paulo, SEE, 2015

Appendix 2 - Electricity consumption: municipalities of Sao Paulo State

Table 6 –The 15 largest municipalities' consumers of electric power in the State of Sao Paulo, 2014

MUNICIPALITY	RESIDENTIAL		COMERCIAL		RURAL		INDUSTRIAL		PUBLIC LIGHTINING		PUBLIC SECTOR		PUBLIC SECTOR		OWN CONSUMPTION		TOTAL		PART. (%)
	N.C.*	kWh	N.C.	kWh	N.C.	kWh	N.C.	kWh	N.C.	kWh	N.C.	kWh	N.C.	kWh	N.C.	kWh	N.C.	kWh	
São Paulo	4.417.507	11.350.365.690	291.715	11.743.717.284	94	3.146.461	18.196	3.644.803.198	21	578.686.241	8.453	1.040.324.624	711	1.681.667.346	187	31.128.413	4.736.884	30.073.839.257	21,9
Alumínio	5.099	12.391.761	240	7.324.803	6	54.708	15	3.659.458.688	9	1.388.795	49	1.307.784	12	1.025.882	1	884	5.431	3.682.953.305	2,7
Cubatão	37.037	100.111.159	2.228	89.755.167	1	0	76	3.378.912.428	64	10.472.043	311	16.398.517	46	69.043.069	5	117.489	39.768	3.664.809.872	2,7
Campinas	423.166	1.115.439.023	35.752	1.172.459.348	839	137.955.333	2.094	667.641.363	82	77.366.885	1.939	147.343.773	189	88.889.218	26	9.007.836	464.087	3.416.102.779	2,5
Guarulhos	387.822	884.825.224	26.540	822.279.341	56	903.595	2.670	1.534.575.527	800	48.694.729	1.594	76.260.979	158	40.417.245	35	1.491.956	419.675	3.409.448.595	2,5
São Bernardo do Campo	289.140	733.462.921	14.286	563.418.212	7	213.804	1.246	1.575.853.244	349	51.008.376	1.143	51.430.071	96	112.631.449	14	1.089.642	306.281	3.089.107.719	2,3
Santo André	270.093	704.259.536	13.831	618.795.927	1	929	990	1.590.358.815	287	53.990.416	882	50.281.254	74	18.947.431	9	987.223	286.167	3.037.621.531	2,2
Piracicaba	146.196	396.480.307	10.368	261.415.089	1.056	13.458.616	1.526	1.464.813.037	458	37.042.271	1.066	38.187.088	115	78.685.139	13	509.906	160.798	2.290.591.453	1,7
Sorocaba	248.888	665.044.921	12.019	405.092.015	268	5.820.894	1.221	999.358.380	364	52.994.766	1.037	34.713.319	125	53.219.464	32	801.810	263.954	2.217.045.569	1,6
Jundiaí	155.721	421.161.399	10.536	376.038.934	1.041	9.477.985	742	1.183.620.455	110	41.119.291	803	21.297.373	68	52.358.577	8	589.896	169.029	2.105.663.910	1,5
Ribeirão Preto	247.168	733.055.750	22.632	672.422.350	633	5.914.413	1.683	204.806.299	255	57.543.174	1.388	90.988.194	151	139.742.594	17	1.030.363	273.927	1.905.503.137	1,4
São José dos Campos	238.319	558.366.750	21.357	437.085.518	596	4.905.839	2.269	693.295.113	606	49.287.534	1.211	83.810.641	220	58.430.508	22	1.009.580	264.600	1.886.191.483	1,4
Osasco	251.204	644.798.411	9.398	517.521.302	0	0	650	338.056.885	370	31.085.328	724	29.768.362	44	35.338.673	9	754.006	262.399	1.597.322.967	1,2
Mogi das Cruzes	136.785	317.602.620	11.031	201.386.454	1.231	17.493.184	541	772.595.181	174	32.264.538	730	21.498.852	98	77.313.313	21	1.574.860	150.611	1.441.729.002	1,1
Santos	191.156	639.746.048	16.683	572.004.989	0	0	434	137.353.945	225	34.237.255	1.322	39.633.187	75	13.971.783	7	730.817	209.902	1.437.678.024	1,0
Total dos 15 Maiores	7.445.301	19.277.111.520	498.616	18.460.716.733	5.829	199.345.761	34.353	21.845.502.558	4.174	1.157.181.642	22.652	1.743.244.018	2.182	2.521.681.691	406	50.824.680	8.013.513	65.255.608.603	47,6
Estado São Paulo	15.994.203	39.459.404.369	1.084.228	29.749.946.262	267.368	3.309.301.356	124.805	52.694.428.524	19.825	3.169.818.512	86.811	3.226.841.921	13.002	5.384.952.592	1.528	82.212.320	17.591.770	137.076.905.856	100,0

Source – State of Sao Paulo, SEE, 2015

Appendix 3 – Data: energy, solid waste – Sao Paulo Metropolitan Region

Table 7 – Estimates of Energy consumption and Municipal Solid Waste (MSW) generation in all Municipalities of the Metropolitan Region of Sao Paulo, 2014

MUNICIPALITY	ENERGY (10^6 toe)	%	MSW (t/day)	%	MSW (t/year)
Arujá	618	0.00	63.48	0.31	23,170.2
Barueri	319,506	1.81	233.60	1.15	85,264
Biritiba-Mirim	14,097	0.08	21.17	0.10	7,727.05
Caieiras	120,605	0.68	73.74	0.36	26,915.1
Cajamar	95,852	0.54	55.43	0.27	20,231.95
Carapicuíba	213,752	1.21	351.07	1.72	128,140.55
Cotia	165,673	0.94	202.78	1.00	74,014.7
Diadema	266,823	1.51	368.65	1.81	134,557.25
Embu das Artes	171,671	0.97	233.15	1.14	85,099.75
Embu-Guaçu	23,635	0.13	52.01	0.26	18,983.65
Ferraz de Vasconcelos	55,941	0.32	156.92	0.77	57,275.8
Francisco Morato	37,412	0.21	149.55	0.73	54,585.75
Franco da Rocha	47,337	0.27	119.25	0.59	43,526.25
Guararema	30,149	0.17	16.88	0.08	6,161.2
Guarulhos	2,960,646	16.74	1,443.42	7.09	526,848.3
Itapecerica da Serra	114,233	0.65	147.56	0.72	53,859.4
Itapevi	89,065	0.50	198.23	0.97	72,353.95
Itaquaquecetuba	143,254	0.81	313.67	1.54	114,489.55
Jandira	61,399	0.35	105.71	0.52	38,584.15
Juquitiba	45,358	0.26	16.49	0.08	6,018.85
Mairiporã	73,704	0.42	63.36	0.31	23,126.4
Mauá	287,652	1.63	403.90	1.98	147,423.5
Mogi das Cruzes	357,586	2.02	348.17	1.71	127,082.05
Osasco	483,025	2.73	762.60	3.74	278,349
Pirapora do Bom Jesus	8,324	0.05	12.16	0.06	4,438.4
Poá	72,035	0.41	100.02	0.49	36,507.3
Ribeirão Pires	70,701	0.40	107.68	0.53	39,303.2
Rio Grande da Serra	10,408	0.06	38.18	0.19	13,935.7
Salesópolis	6,721	0.04	7.39	0.04	2,697.35
Santa Isabel	37,892	0.21	34.13	0.17	12,457.45
Santana de Parnaíba	93,398	0.53	111.44	0.55	40,675.6
Santo André	762,235	4.31	778.38	3.82	284,108.7
São Bernardo do Campo	740,358	4.19	877.71	4.31	320,364.15
São Caetano do Sul	182,569	1.03	141.48	0.69	51,640.2
São Lourenço da Serra	18,137	0.10	9.58	0.05	3,496.7
São Paulo	8,960,790	50.66	11,720.00	57.55	4,277,800
Suzano	373,722	2.11	245.25	1.20	89,516.25
Taboão da Serra	134,106	0.76	241.49	1.19	88,143.85
Vargem Grande Paulista	38,600	0.22	38.3	0.19	13,979.5
TOTAL	**17,688,989**	**100**	**20,363.98**	**100**	**7,432,852.7**

Source – adapted from State of Sao Paulo, SEE, 2015; SABESP, 2015

Appendix 4 - Graph: energy, solid waste – Sao Paulo Metropolitan Region

PAULO EITHER REMOVE THIS APPENDIX 4 OR USE A SMALLER SCALE OF Y-AXIS. RIGHT NOW ONW CAN SEE NOTHING EITHER FOR ENERGY OR MSW GENERATION

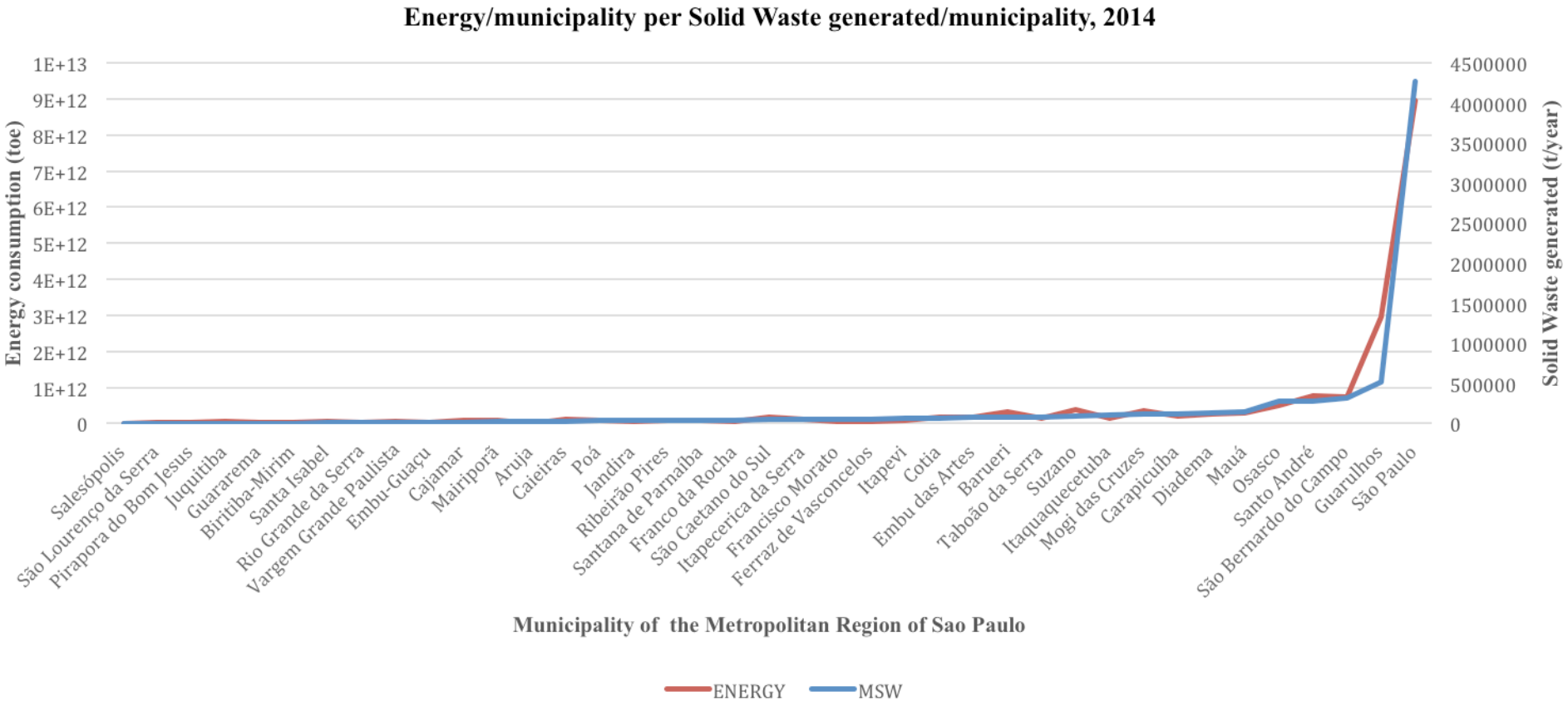


Figure 10 – Energy consumption (toe) and solid waste generated/year for each of the 39 municipalities of the Metropolitan Region of Sao Paulo
Source – elaborated by the author

Appendix 5 - Toxicity equivalency factors for dioxins and furans

Table 10 – Toxicity equivalency factors for dioxins and furans

Toxicity equivalency factors for dioxins and furans	
Dioxins	**TEF**
Mono-, di-, e tri-CDDs (mono-di – e tri-cloro-dibenzo-p-dioxins)	0
2,3,7,8 – TCDD (tetraclhorine -dibenzo-p-dioxin)	1
outros TCDDs (tetraclhorine-dibenzo-p-dioxins)	0
1,2,3,7,8 – PeCdd (penta tetraclhorine-dibenzo-p-dioxin)	0.5
outros PeCDDs (penta tetraclhorine-dibenzo-p-dioxins)	0
1,2,3,4,7,8 – HxCDD (hexa tetraclhorine-dibenzo-p-dioxin)	0.1
1,2,3,7,8,9 – HxCDD (hexa tetraclhorine-dibenzo-p-dioxin)	0.1
Outros HxCDDs (hexa tetraclhorine-dibenzo-p-dioxins)	0
1,2,3,4,6,7,8 – HpCDD (hepta tetraclhorine-dibenzo-p-dioxin)	0.01
Outros HpCDDs (hepta tetraclhorine-dibenzo-p-dioxins)	0
OCDD (octa tetraclhorine-dibenzo-p-dioxin)	0.001
Furans	**TEF**
Mono-, di-, tri-CDFs (mono-, di- e tri- tetraclhorines-dibenzofuranos)	0
2,3,7,8 – TCDF (tetra tetraclhorine-dibenzofurano)	0.1
outros TCDFs (tetra tetraclhorine-dibenzofuranos)	0
Dioxins	**TEF**
1,2,3,7,8 – PeCDF (penta tetraclhorine-dibenzofurano)	0.05
2,3,4,7,8 – PeCDF (penta tetraclhorine-dibenzofurano)	0.5
outros PeCDDs (penta tetraclhorine-dibenzofuranos)	0
1,2,3,4,7,8 – HxCDF (hexa tetraclhorine-dibenzofurano)	0.1
1,2,3,6,7,8 – HxCDF (hexa tetraclhorine-dibenzofurano)	0.1
1,2,3,7,8,9 – HxCDF (hexa tetraclhorine-dibenzofurano)	0.1
2,3,4,6,7,8 – HxCDF (hexa tetraclhorine-dibenzofurano)	0.1
outros HxCDFs (hexa tetraclhorine-dibenzofuranos)	0
1,2,3,4,6,7,8 – HpCDF (hepta tetraclhorine-dibenzofurano)	0.01
1,2,3,4,7,8,9 – HpCDF (hepta tetraclhorine-dibenzofurano)	0.01
outros HpCDFs (hepta tetraclhorines-dibenzofuranos)	0
OCDF (octa tetraclhorine-dibenzofurano)	0.001

Source - Resolução CONAMA nº 316/02

Appendix 6 - Quantification of annual emissions of energy recovery plant and landfill

Table 12 – Quantification of annual emissions of energy recovery plant and landfill – capacity 1,200 t/day

Quantification of annual emissions of energy recovery plant and landfill – capacity 1,200 t/day				
Compounds	**Unity**	**UTR**	**Landfill**	
			Biogas burn (flare)	**Biogas burn (Otto)**
CO_2	t/year	207.966	135,732	135,732
CH_4	t/year	4	15,707	15,707
NOx	t/year	259	121	361
CO	t/year	20.8	16.1	185
MP	t/year	2	7.6	7.5
Dioxins and Furans	t/year	0.006	0.15	0.03
SO_2	t/year	17.1	13.8	13.8
HCL	t/year	5.1	2.5	2.5
COV	t/year	0.9	87.5	87.5
Chorume	t/year	No applicable	105,850	105,850
HF	t/year	0.36	0.57	0.57
Cd+Ti	t/year	0.004	No available	No available
Hg and compounds	t/year	0.007	0.18	0.18
Pb+As+Co+Ni+Cr+Mn+Sb+Cu+V and compounds	t/year	0.044	No available	No available
Light ashes	t/year	17,500.00	No applicable	No applicable
Refuse	t/year	80,000.00	No applicable	No applicable

Source – EMAE, 2011

Appendix 7 – Brazilian National Policy on Solid Waste

Unofficial Translation by the Ministry of the Environment of Brazil
LAW 12,305, OF 2 AUGUST 2010
Institutes the National Policy on Solid Waste; alters Law
No. 9,605 of 12 February 1998; and makes other provisions.
I, THE PRESIDENT OF THE REPUBLIC, hereby inform that the National Congress has enacted and I sanction the following Law:
TITLE I
GENERAL PROVISIONS
CHAPTER I
OBJECT AND SCOPE
Art. 1. This Law institutes the National Policy on Solid Waste, its principles, objectives and instruments, and sets forth guidelines in relation to integrated management and solid waste management (including hazardous ones), generators' responsibilities and applicable economic instruments. Para. 1. This Law shall apply to all individuals and legal entities, ruled by Private or Public Law, which are either directly or indirectly responsible for the generation of solid waste, and develop actions related to integrated management or solid waste management.
Para. 2. This Law does not apply to radioactive waste, which shall be regulated by specific legislation. Art. 2. In addition to the provisions outlined herein, provisions of Laws No. 11,445, of 5 January 2007, 9,974, of 6 June 2000, and 9,966, of 28 April 2000, and the norms established by bodies of the National Environment System (hereinafter referred to as Sisnama), the National Sanitary Surveillance System (hereinafter referred to as SNVS), the Unified System of Animal and Plant Health (hereinafter referred to as Suasa) and the National System of Metrology, Standardization and Industrial Quality (hereinafter referred to as Sinmetro) also apply to solid waste.
CHAPTER II
DEFINITIONS
Art. 3. For the purposes of this Law, the following definitions apply:
I – sectorial agreement: act of contractual nature entered into between the Public Authority and manufacturers, importers, distributors or sellers, aiming at implementing shared responsibility for certain product's life cycle;
II – contaminated area: place where there is contamination caused by the regular or irregular disposal of any substances or waste;
III – contaminated orphan site: sites where the responsible parties cannot be identified or personalized;
IV – product's life cycle: series of stages involving a product's development, collection of raw material and supplies, productive process, consumption and final disposal;
V – selective waste collection: collection of solid wastes identified by their constitution and composition;
VI – social control: set of mechanisms and procedures that guarantee society's access to information and participation in the formulation, implementation and assessment processes of public policies related to solid waste;

VII – final environmentally-adequate destination: waste discarding that comprises reuse, recycling, composting, energy recovery and utilization, or other forms of disposal permitted by Sisnama, SNVS and Suasa competent bodies, including final destination, observing specific operational norms in a way to avoid damage or risks to public health and minimize adverse environmental impacts;
VIII – final environmentally-adequate disposal: orderly waste discarding in landfills, observing specific operational norms in a way to avoid damage or risks to public health and minimize adverse environmental impacts;
IX – solid waste generators: individuals or legal entities, ruled by Private or Public Law, whose activities – including consumption standards – generate solid waste;
X – solid waste management: set of actions carried out, either directly or indirectly, during collection, transport, transshipment, treatment and final environmentally-adequate destination of waste, in accordance with a municipal integrated-management plan or a solid waste management plan, as required herein;
XI – solid waste integrated management: set of actions aimed at finding solutions for solid waste, considering political, economic, environmental, cultural and social dimensions, with social control and under the premise of sustainable development;
XII – reverse logistics: a social-economic development instrument defined by a set of actions, procedures and means intended for the feasibility of collection and restitution of solid waste to the entrepreneurial sector, or other final environmentally-adequate destination;
XIII – sustainable consumption and production standards: production and consumption of goods and services to meet the needs of current generations and allow for better life standards without compromising environmental quality and care for future generations;
XIV - recycling: transformation of solid waste, involving the alteration of physical, physical-chemical or biological properties into supplies or new products, in compliance with conditions and standards established by the Sisnama competent bodies, and also SNVS and Suasa if applicable;
XV - waste: solid residues that, after all available and economically-feasible technological treatment and recovery attempts, present no possibility other than final environmentally-adequate disposal;
XVI – solid waste: material, substance, object or goods discarded as a result of human activities in society, whose final disposal is carried out, supposed to be carried out, or must be carried out in solid or semi-solid states, also including gas-contained recipients and liquids whose particularities make it impracticable for them to be discharged in public sewage dumps or water bodies, or require technically or economically unfeasible solutions in light of the best technology available;
XVII – shared responsibility over products' life cycle: set of individualized and connected duties from manufacturers, importers, distributors and sellers, consumers and holders of public cleaning and solid waste management services in order to reduce impacts on human health and environmental quality resulting from products' life cycle under the terms herein;
XVIII - re-utilization: process of using solid waste without their biological, physical or physical-chemical transformation, in compliance with the conditions and standards established by Sisnama competent bodies, and also SNVS and SUASA if applicable;

XIX - public cleaning and solid waste management services: set of activities outlined in Art. 7 of Law No. 11,445, of 2007.

TITLE II

NATIONAL POLICY ON SOLID WASTE

CHAPTER I

GENERAL PROVISIONS

Art. 4. The National Policy on Solid Waste encompasses the set of principles, objectives, instruments, guidelines, goals and actions adopted by the Federal Government, either individually or in cooperation with Unofficial Translation by the Ministry of the Environment of Brazil the states, the Federal District, municipalities or private third parties aiming at the integrated and environmentally-adequate management of solid waste.

Art. 5. The National Policy on Solid Waste is part of the National Environmental Policy and is coordinated with the National Policy on Environmental Education, regulated by Law No. 9,795, of 27 April 1999, with the Federal Policy on Basic Sanitation, regulated by Law No. 11,445, of 2007, and with Law No. 11,107, of 6 April 2005.

CHAPTER II

PRINCIPLES AND OBJECTIVES

Art. 6. The principles of the National Policy on Solid Waste are as follows:

I – prevention and precaution;

II – polluter-pays principle and protector-receiver principle;

III - a systemic view of solid waste management, considering environmental, social, cultural, economic, technological and public health variables;

IV – sustainable development;

V – eco-efficiency, through conciliation between the supply of qualified goods and services that satisfy human needs and bring about better standards of living at competitive prices and the reduction of the environmental impact and consumption of natural resources at a level equivalent to the planet's estimated support capacity, at least;

VI – cooperation among the different levels of the Public Authority, the entrepreneurial sector and other segments of society;

VII – shared responsibility over products' life cycle;

VIII – recognition of recyclable and reusable solid waste as an economic asset with social value that generates jobs and income and promotes active citizenship;

IX – respect to local and regional diversities;

X – society's right to information and social control;

XI – reasonability and proportionality.

Art. 7. The objectives of the National Policy on Solid Waste are as follows:

I – protection of public health and environmental quality;

II – non-generation, reduction, reutilization, recycling and treatment of solid waste, as well as final environmentally-adequate waste disposal;

III – incentive to the adoption of sustainable standards of production and consumption of goods and services;

IV – adoption, development and improvement of clean technologies as a way to minimize environmental impacts;

V – reduction of volume and danger potential of hazardous waste;

VI – incentive to recycling, aiming at fostering the use of raw material and supplies derived from recyclable and recycled material;
Unofficial Translation by the Ministry of the Environment of Brazil
VII – integrated management of solid waste;
VIII – coordination among different levels of government and the entrepreneurial sector with the purpose of establishing technical and financial cooperation for the integrated management of solid waste;
IX – continued technical capacity in solid management;
X – regularity, continuity, functionality and universalization of urban cleaning and solid waste management services with the adoption of managerial and economic mechanisms that ensure cost recovery of the services rendered as a way to guarantee its operational and financial sustainability, in compliance with Law No. 11,445, of 2007;
XI – governmental purchases and hiring should prioritize:
a) recyclable and recycled products;
b) goods, services, and works that consider criteria which are compatible with socially and environmentally sustainable consumption standards;
XII – engagement of waste-pickers collecting reusable and recyclable material in actions that involve shared responsibility over products' life cycle;
XIII – incentive to the implementation of a product's life cycle assessment;
XIV – incentive to the development of environmental and entrepreneurial management systems intended for the improvement of productive processes and reuse of solid waste, including energetic recovery and use;
XV – incentive to environmental labels and sustainable consumption.
CHAPTER III
INSTRUMENTS
Art. 8. The instruments of the National Policy on Solid Waste are described below:
I – solid waste plans;
II – annual solid waste inventories and declaratory system;
III – selective collection, reverse logistics and other tools related to the implementation of shared responsibility over products' life cycle;
IV – incentive to the creation and development of cooperatives or other forms of association of waste-pickers collecting reusable and recyclable material;
V – environmental, sanitary and agricultural monitoring and enforcement;
VI – technical and financial cooperation between public and private sectors for research and development of new products, methods, processes and management technologies, recycling, reuse, waste treatment and final environmentally-adequate disposal;
VII – scientific and technological research;
VIII – environmental education;
IX – fiscal, financial and credit incentive;
X – the National Environmental Fund and the National Scientific-Technological Fund;
XI – the National Solid Waste Management Information System (hereinafter referred to as Sinir);
XII – the National Basic Sanitation Information System (hereinafter referred to as Sinisa);
XIII – environmental councils and health councils, if applicable;

XIV – municipal collegiate deliberative bodies intended for the social control of urban solid waste services;
XV – the National Record of Hazardous Waste Operators;
XVI – sectorial agreements;
XVII – instruments of the National Environmental Policy, when applicable:
a) environmental quality standards;
b) the Federal Technical Record of Potentially Polluting Activities or Activities Using Natural Resources;
c) the Federal Technical Record of Environmental Defense Instruments;
d) environmental impact assessments;
e) the National Environmental Information System (hereinafter referred to as Sinima);
f) licensing and review of potentially or effectively polluting activities;
XVIII – terms of commitment and conduct adjustment;
XIX – incentive to the adoption of consortia or other forms of cooperation among federated entities aiming at increasing utilization and reducing the costs involved.

TITLE III

GUIDELINES APPLICABLE TO SOLID WASTE

CHAPTER I

PRELIMINARY PROVISIONS

Art. 9. When managing solid waste, the following priority shall be observed: non-generation, reduction, reutilization, recycling, solid waste treatment and final environmentally-adequate waste disposal.

Para. 1. Technologies for the energetic recovery of urban solid waste may be used, provided that technical and environmental feasibility are proven, and a toxic-gas-emissions-monitoring program approved by the relevant environmental body had been implemented.

Para. 2. The National Policy on Solid Waste and local Policies on Solid Waste in the states, the Federal District and municipalities shall be compatible with provisions outlined in this Article's introduction and Para. 1, as well as with other guidelines established herein.

Art. 10. The Federal District and municipalities are responsible for the integrated management of the solid waste generated in their respective territories, with no prejudice to control and enforcement attributions of Sisnama, SNVS and Suasa's federal and state bodies, and notwithstanding the generator's responsibility for waste management, as outlined herein.

Art. 11. The states, in compliance with guidelines and other determinations set forth herein, shall be responsible for:

I – promoting the integration of organization, planning and execution stages of public functions of common interest related to solid waste management in metropolitan regions, urban agglomerations and microregions, under the terms of the state supplementary law anticipated in Para. 3. of Art. 25 of the Federal Constitution;

II – controlling and inspecting the activities of pollution generators subject to environmental licensing by the SISNAMA environmental body.

Sole Paragraph. The state shall support and prioritize municipal initiatives of associated and shared solutions between 2 (two) or more municipalities.

Art. 12. The Federal Government, the states, the Federal District and municipalities shall jointly organize and keep the National Solid Waste Management Information System (Sinir) coordinated with Sinisa and Sinima.
Sole Paragraph. The states, the Federal District and municipalities are responsible for providing all information about waste under their scope of competence to Sinir at such a time and in such a manner as the regulation may determine.
Art. 13. For the purposes of this Law, solid waste is identified as follows:
I – sources:
a) domestic waste: generated from domestic activities in urban residences;
b) waste resulting from urban cleaning services: generated from sweeping, cleaning of public areas and streets, and other public cleaning services;
c) urban solid waste: listed in topics "a" and "b";
d) waste from commercial establishments and service providers: waste generated by those activities, except for the ones referred to in topics "b", "e", "g", "h" and "j";
e) waste resulting from public sanitation services: waste generated by those activities, except for those referred to in topic "c";
f) industrial waste: waste generated in productive processes and industrial facilities;
g) medical waste: waste generated by health services, as defined by regulations or in norms established by Sisnama or SNVS bodies;
h) civil construction waste: waste generated in construction sites, refurbishments, reforms and demolitions in the civil construction industry, including the ones resulting from site preparation and excavation for civil construction;
i) agricultural waste: waste generated in agroforestry and cattle-raising activities, including supplies used in those activities;
j) transport waste: waste generated in ports, airports, customs, bus stops, railways and borders;
k) mining waste: waste generated in research, extraction or processing in mining activities;
II – hazard potential:
a) hazardous waste: is waste that, according to a law, regulation or technical norm, poses substantial risks to public health or environmental quality due to their inflammability, corrosivity, reactivity, toxicity, pathogenicity, carcinogenicity, teratogenicity and mutagenicity;
b) non-hazardous waste: those not included in topic "a" above.
Sole Paragraph. In conformity with the provisions on Art. 20, waste referred to in topic "d" of item I of this Article's introduction, if characterized as non-hazardous, may, due to its nature, composition or volume, be compared to domestic waste by the municipal public authority.
CHAPTER II
SOLID WASTE PLANS
Section I
General Provisions
Art. 14. The following are solid waste plans:
I – the National Plan on Solid Waste;
II – the state plans on solid waste;
III – micro-regional, metropolitan and urban plans on solid waste;
IV – inter-municipal plans on solid waste;
V – municipal plans on integrated management of solid waste;

VI – solid waste management plans.
Sole Paragraph. Broad publicity of solid waste plans as well as social control of its formulation, implementation and operationalization is guaranteed in compliance with provisions set forth in Law No. 10,650, of 16 April 2003, and Art. 47 of Law No. 11,445, of 2007.
Section II
The National Plan on Solid Waste
Art. 15. The Federal Government shall formulate the National Plan on Solid Waste under the coordination of the Ministry of the Environment, to be valid for an undetermined time frame, with a 20 (twenty)-year horizon, to be updated every 4 (four) years, with the following minimum content:
I – definition of the current situation of solid waste;
II – proposition of scenarios, including international and macroeconomic trends;
III – reduction, reuse, recycling and other targets aiming at reducing the quantity of waste and residues subject to final environmentally-adequate disposal;
IV – targets for the energetic use of gases generated in final solid waste disposal units;
V – targets for the elimination and recovery of dump yards, associated to the social inclusion and economic emancipation of waste-pickers collecting reusable and recyclable material;
VI – programs, projects and actions to accomplish expected targets;
VII – norms and technical conditions for access to Federal Government's funds, for obtaining permission or to access funds that are, either directly or indirectly, managed by a federal entity, when they are intended for actions or programs of interest of the solid waste area;
VIII – measures to encourage and permit the regionalized management of solid waste;
IX – guidelines for planning and other activities regarding solid waste management in integrated development regions established by a supplementary law, as well as for areas with special tourist interest;
X – norms and guidelines for the final disposal of waste and, when applicable, residues;
XI – means to be used for control and inspection, at the national level, of implementation and operationalization, with social control guaranteed.
Sole Paragraph. The National Plan on Solid Waste shall be prepared through a process of social mobilization and participation, which shall include public hearings and consultations.
Section III
State Plans on Solid Waste
Art. 16. The formulation of state plans on solid waste, under the terms outlined herein, is conditional for states to be entitled to Federal Government's funds, or funds controlled thereby, which are intended for undertakings and services related to the management of solid waste, or to be incremented by incentives or financing from federal credit entities or support for this purpose.
Para. 1. Access to funds referred to in this Article's introduction shall be prioritized to states considered as micro-regions as per Art. 25 Para. 3 of the Federal Constitution, to integrate organization, planning and execution stages of actions under the responsibility of adjacent municipalities in the management of solid waste.
Para. 2. Supplementary rules on the access to the Federal Government's funds under the terms of this Article shall be established by a regulation.
Para. 3. In conformity with the responsibility of generators under the terms herein, micro-regions instituted under the terms of Para. 1 shall comprise activities such as selective collection,

recovery, recycling, final treatment and destination of urban solid waste, management of civil construction waste, transportation, health and agrosilvopastoral services waste, or other waste, according to micro-regional peculiarities.

Art. 17. State plans on solid waste shall be formulated to be valid for an undetermined time frame, with a 20 (twenty)-year horizon, to be updated every 4 (four) years, with the following minimum content:

I – definition, including the identification of the main waste flows in the state and its socioeconomic and environmental impacts;

II – proposition of scenarios;

III – reduction, reuse, recycling and other targets aiming at reducing the quantity of waste and residues subject to final environmentally-adequate disposal;

IV – targets for the energetic use of gases generated in solid waste final disposal units;

V – targets for the elimination and recovery of dump yards, associated to the social inclusion and economic emancipation of waste-pickers collecting reusable and recyclable material;

VI – programs, projects and actions to accomplish expected targets;

VII – norms and technical conditions of access to state funds, for obtaining permission or to access funds that are, either directly or indirectly, managed by a federal entity, when they are intended for actions or programs of interest of the solid waste area;

VIII – measures to encourage and permit the associated or shared management of solid waste;

IX – guidelines for planning and other activities regarding solid waste management in metropolitan regions, urban agglomerations and micro-regions;

X – norms and guidelines for the final disposal of waste and, when applicable, residues, under the terms of provisions established at national level;

XI – forecast, according to other territorial planning instruments, especially economic-ecological zoning and coastal zoning of:

a) favorable zones for the location of solid waste treatment units or final waste disposal units;

b) degraded areas due to inadequate disposal of solid waste or waste to be used for environmental recovery;

XII – means to be used for control and inspection, at the national level, of its implementation and operationalization, with social control guaranteed.

Para. 1. In addition to the state plans, states can draft micro-regional solid waste plans, as well as specific plans intended for metropolitan regions or urban agglomerations.

Para. 2. The formulation and implementation, by the states, of solid waste micro-regional plans, or plans by metropolitan regions or urban agglomerations according to Para. 1 must compulsorily have the participation of the municipalities involved and do not exclude any of the municipalities' prerogatives outlined in this Law.

Para. 3. In conformity with the responsibility of generators under the terms herein, the solid waste microregional plan shall meet state-plan requirements and establish integrated solutions for selective collection, recovery and recycling, treatment and final destination of urban solid waste and, all micro-regional peculiarities considered, other types of waste.

Section IV

Municipal Plans on Integrated Management of Solid Waste

Art. 18. The formulation of the municipal integrated plan on solid waste, under the terms outlined herein, is conditional for the Federal District and municipalities to be entitled to Federal

Government's funds, or funds controlled thereby, which are intended for undertakings and services related to urban cleaning and the management of solid waste, or to be incremented by incentives or financing from federal credit entities or support for this purpose.
Para. 1. Access to Federal Government's funds referred to in the Article's introduction shall be prioritized to municipalities that:
I – opt for associated inter-municipal solutions for the issue of solid waste management, including the formulation and implementation of an inter-municipal plan; or voluntarily participate in micro-regional plans on solid waste referred to in Art. 16, Para. 1;
II – implement selective collection with the participation of cooperatives or other forms of association of waste-pickers collecting reusable and recyclable material, set up by low-income people.
Para. 2. Supplementary rules on the access to the Federal Government's funds under the terms of this Article shall be established by a regulation.
Art. 19. The municipal plan on integrated management of solid waste shall have the following minimum contents:
I – definition of the status of solid waste generated within the respective territory, including the origin, volume, waste characterization and final destination and disposal adopted;
II – identification of favorable areas for the final environmentally-adequate waste disposal, in compliance with the master plan referred to in Art. 182, Para. 1 of the Brazilian Constitution, and environmental zoning, if any;
III – identification of possibilities for the implementation of associated or shared solutions with other municipalities, considering, under the criteria of economy of scale, proximity with established locations and ways to prevent environmental risks;
IV – identification of solid waste and generators subject to a specific management plan under the terms of Art. 20 or a reverse logistics system under the terms of Art. 33, in compliance with the provisions herein and enforcement regulation, as well as norms established by SISNAMA and SNVS bodies;
V – operational procedures and minimum specifications to be adopted in public urban cleaning and solid waste management services, including final environmentally-adequate waste disposal and in compliance with Law No. 11,445, of 2007;
VI – operational and environmental performance indicators of public urban cleaning and solid waste management services;
VII – rules for transportation and other stages of solid waste management outlined in Art. 20, in accordance with norms established by Sisnama and SNVS bodies and other pertinent provisions outlined in federal and state legislation;
VIII – definitions of responsibilities for implementation and operationalization, including stages of solid waste management planning referred to in Art. 20 under the control of the public authority;
IX – capacity-building programs and actions towards implementation and operationalization;
X – environmental education programs and actions that promote the non-generation, reduction, reuse, and recycling of solid waste;
XI – programs and actions for the participation of interested groups, particularly cooperatives or other forms of association of waste-pickers collecting reusable and recyclable material, set up by low-income people, if any;

XII – mechanisms for the creation of business, job and income sources by valuing solid waste;
XIII – a system to calculate the costs of urban cleaning and solid waste management, as well as the method of collection for these services, in compliance with Law No. 11,445, of 2007;
XIV – targets for the reduction, reuse, selective collection and recycling, among others, aiming at reducing the quantity of waste subject to final environmentally-adequate disposal;
XV – description of ways and limits of participation by the Public Authority in selective collection and reverse logistics, in compliance with provisions in Art. 33, and other actions related to shared responsibility by products' life cycle;
XVI – means to be used for control and enforcement, at local level, of implementation and operationalization of solid waste management plans referred to in Art. 20 and reverse logistics systems anticipated in Art. 33;
XVII – preventive and corrective actions to be practiced, including monitoring programs;
XVIII – identification of environmental liabilities related to solid waste, including contaminated areas and respective correction measures;
XIX – periodicity of reviews, in compliance with the validity of the municipal multi-year plan.
Para. 1. The municipal plan on integrated management of solid waste may be inserted in the basic sanitation plan outlined in Art. 19 of Law No. 11,445, of 2007, in compliance with the minimum established under the items of this Article's introduction and provisions of Para. 2.
Para. 2. The municipal plan on integrated management of solid waste shall have a simplified content, under the terms of the regulation, for municipalities with less than 20,000 (twenty thousand) inhabitants.
Para. 3. The provision set forth in Para. 2. does not apply to the following municipalities:
I – those in areas of especial tourist interest;
II – those in areas with undertakings or activities with significant environmental impact at regional or national levels;
III – those covering Protected Areas, either total or partially.
Para. 4. The existence of a municipal plan on integrated management of solid waste does not exempt the municipality or the Federal District of issuing environmental licensing for landfills or other operational infrastructure or facilities that are part of public urban cleaning and solid waste management services by the Sisnama competent body.
Para. 5. In defining responsibilities under the terms of item VIII of this Article's introduction, it is forbidden to assign the waste management stages referred to in Art. 20 to the public urban cleaning and solid waste management service, contrary to the respective environmental license or norms established by Sisnama bodies, and, SNVS bodies if applicable.
Para. 6. In addition to the provisions outlined in items I to XIX of this Article's introduction, the municipal plan on integrated management of solid waste shall consider specific actions aiming at the rational use of environmental resources, the struggle to avoid squandering and the reduction in the generation of solid waste, to be developed within the scope of the public administration bodies.
Para. 7. The contents of the municipal plan on integrated management of solid waste shall be made available for Sinir under the terms of the regulation.
Para. 8. The lack of a municipal plan on integrated management of solid waste cannot be used to stop the installation or operationalization of undertakings or activities which are duly licensed by the competent bodies.

Para. 9. The municipality that opts for associated inter-municipal solutions for solid waste management under the terms of the regulation, provided that the inter-municipal plan meets the requirements set forth in items I to XIX of this Article's introduction, may be exempt from formulating a municipal plan on integrated management of solid waste.

Section V

Solid Waste Management Plan

Art. 20. The following are subject to the formulation of a solid waste management plan:

I – solid waste generators outlined in clauses “e”, “f”, “g” and “k” of Art. 13 item I;

II – commercial or service-rendering establishments that:

a) generate hazardous waste;

b) generate waste which, even if not classified as hazardous due to its nature, composition or volume, is not compared to domestic waste by the municipal public authority;

III – civil construction companies, under the terms of the regulation or norms established by Sisnama bodies;

IV – those responsible for terminals and other facilities referred to in Art. 13 item I clause “j” and transport companies, under the terms of a regulation or norms established by Sisnama bodies, and SNVS, if applicable;

V – those responsible for agrosilvopastoral activities, if required by a competent Sisnama, SNVS or Suasa body.

Sole Paragraph. In accordance with the provision set forth in Chapter IV of this Title, specific requirements in relation to the hazardous waste management plan shall be established by a regulation.

Art. 21. The solid waste management plan shall have the following minimum content:

I – description of the undertaking or activity;

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II – definition of generated or managed solid waste, with waste source, volume and characterization, including related environmental liability;

III - in compliance with norms established by Sisnama, SNVS and Suasa bodies, and the municipal plan on integrated management of solid waste, if any:

a) a description of the ones responsible for each stage of solid waste management;

b) definition of operational procedures related to stages of solid waste management under the generator's responsibility;

IV – identification of associated or shared solutions with other generators;

V – preventive or corrective actions to be executed in incorrect management situations or accidents;

VI – goals and procedures related to minimizing solid waste management, and, in compliance with norms set forth by Sisnama, SNVS and Suasa bodies, goals and procedures related to reutilization and recycling;

VII – actions related to shared responsibility for products' life cycle, if applicable, under the terms of Art. 31;

VIII – corrective measures for environmental liabilities related to solid waste;

IX – periodicity of reviews, in compliance, if applicable, with the validity of the respective operation license under the responsibility of Sisnama bodies.

Para. 1. The solid waste management plan shall comply with the provision of the municipal plan on integrated management of solid waste of the respective municipality, without prejudice of the norms set forth by Sisnama, SNVS and Suasa bodies.
Para. 2. The lack of a municipal plan on integrated management of solid waste does not exempt the formulation, implementation or operationalization of the solid waste management plan.
Para. 3. The following shall be established by a regulation:
I – norms on the enforceability and contents of the solid waste management plan in relation to the performance of cooperatives or other forms of association of waste-pickers collecting reusable and recyclable material;
II – simplified criteria and procedures for the presentation of solid waste management plans for microenterprise and small-sized enterprise, according to definitions of Supplementary Law No. 123, of 14 December 2006, Art. 3, items I and II, provided that the activities developed thereby do not generate hazardous waste.
Art. 22. A duly qualified technician shall be appointed for the formulation, implementation, operationalization and monitoring of all stages of the solid waste management plan, including control of final environmentally adequate waste disposal.
Art. 23. Those responsible for solid waste management plans shall keep complete and updated information on the implementation and operationalization of the plan under their responsibility available to the competent municipal body, the Sisnama licensing body and other authorities.
Para. 1. Without prejudice to other applicable requirements, a declaratory system shall be implemented in order to achieve the provision outlined in this Article's introduction, on an annual basis, according to the regulation.
Para. 2. The information referred to in this Article's introduction shall be passed on by public bodies to Sinir under the terms of a regulation.
Art. 24. The solid waste management plan is part of the environmental licensing process of the undertaking or activity by the competent body of Sisnama.
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Para. 1. Approval of the solid waste management plan of undertakings and activities that do not require an environmental license is subject to the competent municipal authority.
Para. 2. During the environmental licensing process subject to approval by a Sisnama federal or state body, as referred to in Para. 1 above, the competent municipal body shall be assured the opportunity to be heard, particularly in relation to final environmentally-adequate waste disposal.
CHAPTER III
GENERATORS AND PUBLIC AUTHORITY'S RESPONSIBILITIES
Section I
General Provisions
Art. 25. The Public Authority, the business sector and the society are responsible for the effectiveness of actions taken towards assuring compliance with the National Policy on Solid Waste, guidelines and other determinations established herein and in the regulation.
Art. 26. The holder of public urban cleaning and solid waste management services is responsible for organizing and rendering those services in compliance with the respective municipal plan on integrated management of solid waste, Law No. 11,445, of 2007, the provisions herein and the regulation.

Art. 27. Individuals or corporate bodies referred to in Art. 20 are responsible for the complete implementation and operationalization of the solid waste management plan approved by the competent body under the terms of Art. 24.
Para. 1. The hiring of services such as collection, storage, transport, transshipment, treatment and final environmentally-adequate waste disposal does not exempt individuals or corporate bodies referred to in Art. 20 from accountability over damages caused by the inadequate management of respective waste or debris.
Para. 2. In the cases covered by Art. 20, the stages under the responsibility of the generator which are eventually carried out by the Public Authority shall be duly compensated by the relevant individuals or corporate bodies, in compliance with the provision of Art. 19 Para. 5.
Art. 28. The responsibility of domestic solid waste generators shall cease with the adequate waste disposal for collection or, in the cases covered by Art. 33, with restitution.
Art. 29. The Public Authority shall act subsidiarily with a view to minimize or cease damages immediately after having taken notice of a deleterious event for the environment or public health related to the management of solid waste.
Sole Paragraph. Those who cause the damages shall fully compensate the Public Authority for expenses resulting from measures outlined in this Article's introduction.
Section II
Shared Responsibility
Art. 30. It is hereby instituted shared responsibility for products' life cycle, to be implemented in an individualized and integrated manner, involving manufacturers, importers, distributors and sellers, consumers and holders of public urban cleaning and solid waste management services, in accordance with duties and procedures outlined herein.
Sole Paragraph. Shared responsibility for products' life cycle aims at:
I – making the interests of social and economic agents, entrepreneurial, market and environmental management processes compatible by developing sustainable strategies;
Unofficial Translation by the Ministry of the Environment of Brazil
II – promoting the use of solid waste, directing them to their productive chain or other productive chains;
III – reducing the generation of solid waste, squandering, pollution and environmental damages;
IV – fostering the use of less aggressive and more sustainable supplies;
V – fostering market development, production and consumption of by-products from recycled and recycling material;
VI – providing for the efficiency and sustainability of productive activities;
VII – fostering good practices of socio-environmental responsibility.
Art. 31. Notwithstanding the obligations outlined in the solid waste management plan and aiming at strengthening shared responsibility and its objectives, manufacturers, importers, distributors and sales people's responsibilities include:
I – investment in the development, manufacturing and market placing of products which:
a) are able, after being used by the consumer, to be reused, recycled, or disposed in an environmentally adequate form;
b) are manufactured in a way that generate less solid waste;
II – promote awareness on ways to avoid, recycle and eliminate their products' solid waste and respective by-products;

III – collection of leftovers and debris after use, as well as subsequent final environmentally-adequate disposal for products which are object of reverse logistics under the terms of Art. 33;
IV – commitment to, whenever agreements are entered into with municipalities, participate in actions outlined in the municipal plan on integrated management of solid waste, for products not included in the reverse logistics system.
Art. 32. Packaging shall be manufactured with material that can be reused or recycled.
Para. 1. The relevant parties shall ensure that packaging:
I – follows the required dimensions in terms of volume and weight in order to protect the contents and product marketability;
II – is projected in a way that allows for reuse in a technical and viable way, compatible with the requirements applicable to the products contained therein;
III – is recycled, if reuse is not possible.
Para. 2. A regulation shall provide on cases which, for technical or economic reasons, do not allow the application of provisions set forth in this Article's introduction.
Para. 3. This Article applies to those who:
I – manufacture packaging or provide material for packaging manufacturing;
II – puts packaging and packaging material into circulation, regardless of their stage in the commerce chain.
Art. 33.Manufacturers, importers, distributors and sellers of the products below are compulsorily required to frame and implement reverse logistics systems upon receiving products from consumers not using public urban cleaning and solid waste management services:
I – pesticides, their residues and packaging, as well as other products whose packaging constitute hazardous waste, in compliance with solid waste management rules outlined by law or regulation, norms established by Sisnama, SNVS or Suasa bodies or technical norms;
II – cells and batteries;
III - tires;
IV – lubricant oils, their residues and packaging;
V – fluorescent, sodium and mercury vapor, and mixed light lamps;
VI – electric-electronic appliances and their components.
Para. 1. Under the provisions of a regulation or sectorial agreements entered into by the Public Authority and the entrepreneurial sector, the systems outlined in this Article's introduction shall be applied to products sold in plastic, metallic or glass packaging, and to other products and packaging, considering the degree and extension of their impact on public health and the environment.
Para. 2. The definition of products and packaging referred to in Para. 1 above shall take into consideration technical and economic feasibility of reverse logistics, as well as the degree and extension of the impact of waste they generate on public health and the environment.
Para. 3. Without prejudice to specific requirements established by law or regulation, norms established by Sisnama and SNVS bodies or sectorial agreements and terms of commitment entered into between the Public Authority and the entrepreneurial sector, manufacturers, importers, distributors and sellers of products referred to in items II, III, V and VI or products and packaging referred to in items I and IV of this Article's introduction and Para. 1. are in charge of taking all necessary steps to ensure the implementation and operationalization of the

reverse logistics system under their responsibility, in accordance with the terms of this Article, and may, among other actions:
I – implement purchasing procedures of used products or packaging;
II – establish drop-off points for reused and recyclable waste;
III – work together in partnerships with cooperatives or other forms of association of waste-pickers collecting reusable and recyclable material, in cases outlined in Para. 1. Para. 4. Consumers shall return products and packaging referred to in items I to VI of the Article's introduction, and other products or packaging subject to reverse logistics to sellers or distributors, as per Para. 1. Para. 5. Sellers and distributors shall return products and packaging delivered to them under the terms of Para. 3 and 4 to manufacturers or importers.
Para. 6. Manufacturers or importers shall arrange for the final environmentally-adequate disposal of products and packaging collected or delivered, with final environmentally-adequate waste disposal under the terms established by Sisnama's competent body, and the municipal plan on integrated management of solid waste, if any.
Para. 7. If the holder of public urban cleaning or solid waste management services, by a sectorial agreement or term of commitment entered into with the entrepreneurial sector, takes charge of activities under the responsibility of manufacturers, importers, distributors and sellers in reverse logistics of products and packaging referred to in the Article, actions by the Public Authority shall be duly compensated in accordance with the form agreed previously between the parties.
Para. 8. Except for consumers, all participants of reverse logistics shall keep updated, complete information of projects under their responsibility available to the competent municipal body and other authorities.
Art. 34. Sectorial agreements or terms of commitment referred to in item IV of the introduction of Art. 31 and in Para. 1 of Art. 33 may have scope at national, regional, state or municipal levels.
Para. 1. Sectorial agreements or terms of commitment entered into at national level prevail over those Unofficial Translation by the Ministry of the Environment of Brazil entered into at regional or state level, which, in turn, prevail over those entered into at municipal level.
Para. 2. When competing rules apply, under the terms of Para. 1, agreements with lesser geographical scope may broaden, but never soften, environmental-protection measures outlined in sectorial agreements and terms of commitment with higher geographical scope.
Art. 35. Whenever a selective collection system is established by the municipal plan on integrated management of solid waste and in the application of Art. 33, consumers are compulsorily required to:
I – pack solid waste adequately and in a differentiated way;
II – adequately separate reusable and recyclable waste for collection and delivery.
Sole Paragraph. The municipal Public Authority may establish economic incentives to consumers who participate in the selective collection system referred to in this Article's caput, under the terms of a municipal law.
Art. 36. Within the scope of shared responsibility on products' life cycle and in compliance with the municipal plan on integrated management of solid waste, if any, the holder of public urban cleaning and solid waste management services is responsible for:
I – adopting procedures to re-utilize reusable and recyclable solid waste generated from public urban cleaning and solid waste management services;

II – establishing a selective collection system;
III – coordinating measures with economic and social agents towards reincorporating reusable and recyclable solid waste generated from public urban cleaning and solid waste management services to the productive cycle;
IV – carrying out activities defined by a sectorial agreement or term of commitment under the terms of Art. 33 Para. 7, by means of compensation by the entrepreneurial sector;
V – implementing a composting system for organic solid waste and coordinating with economic and social agents ways to use the end result;
VI – provide for the final environmentally-adequate disposal of waste and debris generated from public urban cleaning services and solid waste management services.
Para. 1. In order to comply with the provisions in items I to IV of this Article's introduction, the holder of public urban cleaning and solid waste management services shall prioritize the creation and operation of cooperatives or other forms of association of waste-pickers collecting reusable and recyclable material formed by low-income people, and engage their service.
Para. 2. Hiring individuals as per Para. 1. above does not require a bidding process, under the terms of item XXVII of Art. 24 of Law No. 8,666, of 21 June 1993.
CHAPTER IV
HAZARDOUS WASTE
Art. 37. The installation and operation of undertakings or activities that generate or operate with hazardous waste can only be authorized or licensed by the competent authorities if the holder proves to have technical and economic capacity to provide the necessary management to those kinds of waste.
Art. 38. Legal entities operating hazardous waste at any management stage are compulsorily required to register in the National Registering of Hazardous Waste Managers.
Para. 1. The registering referred to in this Article's introduction shall be coordinated by the federal Sisnama's competent body and implemented jointly by federal, state and municipal authorities.
Para. 2. For registering purposes, legal entities referred to in this Article's introduction shall have a technical person responsible for managing hazardous waste, either from their own staff or otherwise hired, with proper qualification, whose personal details shall be updated in the registering.
Para. 3. The registering referred to in this Article's introduction is part of the Federal Technical Registering of Potentially Polluting Activities and Activities Using Natural Resources and the information system mentioned in Art. 12.
Art. 39. The legal entities referred to in Art. 38 are required to formulate a hazardous solid waste management plan and submit it to the Sisnama's competent body and, if applicable, the SNVS, in compliance with the minimum established in Art. 21 and other requirements provided by in a regulation or technical norms.
Para. 1. The hazardous solid waste management plan referred to in this Article's introduction may be inserted in the waste management plan referred to in Art. 20.
Para. 2. The legal entities referred to in Art. 38 are required to:
I – keep an updated and easily available record of all procedures related to the implementation and operationalization of the plan referred to in this Article's introduction;

II – inform, on an annual basis, the Sisnama's competent body, and if applicable, the SNVS, on the quantity, nature and temporary or final destination of waste under their responsibility;
III – adopt measures intended to reduce the volume and hazard of waste under their responsibility, as well as improve their management;
IV – immediately inform the relevant bodies on accidents or other occurrences related to hazardous waste.
Para. 3. Whenever requested by Sisnama and SNVS's competent bodies, access shall be granted for facilities inspection and procedures related to the implementation and operationalization of the hazardous waste management plan.
Para. 4. In case control is exercised by Sisnama and SNVS's federal or state bodies, information on the content, implementation and operationalization of the plan referred to in this Article's introduction shall be passed on to the Public Municipal Authority, under the terms of a regulation.
Art. 40. In licensing undertakings or activities which operate with hazardous waste, the Sisnama licensing body may request a public liability insurance cover damages caused to the environment or public health, in compliance with coverage rules and maximum limits established by regulation.
Sole Paragraph. The provisions of this Article's introduction shall consider enterprise size, under the terms of a regulation.
Art. 41. Notwithstanding the initiatives of other government levels, the Federal Government must structure and keep instruments and activities intended for the promotion of the decontamination of contaminated orphan sites.
Sole Paragraph. If, after the decontamination of an orphan site, carried out with Federal Government funds or other funds, those responsible for contamination are identified, they shall fully refund the Public Authority.
CHAPTER V
ECONOMIC INSTRUMENT
Art. 42. The Public Authority may introduce inductive measures and credit lines to meet, on a priority basis, the following initiatives:
I – prevention and reduction of solid waste generation in the productive process;
II – development of products with less impacts on human health and environmental quality during their life cycle;
III – implementation of physical infrastructure and purchase of equipment for cooperatives or other forms of association of waste-pickers collecting reusable and recyclable material created by low-income individuals;
IV – development of solid waste management projects with an inter-municipal nature, or, under the terms of item I of the introduction of Article 11, regional nature;
V – constitution of selective collection systems and reverse logistics;
VI – decontamination of contaminated areas, including orphan sites;
VII – development of research towards achieving clean technologies applicable to solid waste;
VIII – development of environmental management and entrepreneurial systems intended for the improvement of productive processes and waste reuse.

Art. 43. In supporting or granting incentives to meet the guidelines herein, official credit institutions may establish different access criteria for recipients of the National Financial System for productive investments.
Art. 44. The Federal Government, the states, the Federal District and municipalities, within the scope of their competences, might institute norms aiming at granting fiscal, financial or credit incentives, in compliance with the limitations of Supplementary Law No. 101, of 4 May 2000 (Fiscal Responsibility Law) to:
I – industries and entities dedicated to reuse, treatment and recycling of solid waste produced within the national territory;
II – projects related to responsibility over products' life cycles, particularly those in partnership with cooperatives or other forms of association of waste-pickers collecting reusable and recyclable material formed by low-income individuals;
III – companies working with urban cleaning and related activities.
Art. 45. Public consortia constituted under the terms of Law No. 11,107, of 2005, aiming at decentralization and rendering of public services involving solid waste have priority in obtaining incentives from the Federal Government.
Art. 46. Compliance with the terms herein shall be taken into effect in accordance with Supplementary Law No. 101, of 2000 (also known as Fiscal Responsibility Law), as well as guidelines and objectives of the respective multi-year plan, goals and priorities established by laws on budget guidelines and within the limit of annual budgetary laws.
CHAPTER VI
PROHIBITIONS
Art. 47. The following final destination or disposal of solid wastes are prohibited:
I – casting solid waste in beaches, oceans or any bodies of water;
II – casting in natura solid waste outdoors, except for mining waste;
III – incinerating solid waste outdoors or in recipients, facilities and equipment not licensed for this purpose;
IV – other forms prohibited by the Public Authority.
Para. 1. In case of sanitary emergencies, outdoor solid waste incineration may be carried out, provided that it is authorized and accompanied by competent bodies of Sisnama, SNVS, and, if applicable, Suasa.
Para. 2. Basins for the decantation of industrial or mining waste, provided that they are impermeable and licensed by the Sisnama relevant body, shall not be considered as bodies of water for the purposes of the provisions of item I of this Article's introduction.
Art. 48. The following activities are prohibited in areas of final solid waste disposal:
I – use of disposed waste as feedstock;
II – material separation and collection, in compliance with the provision of Art. 17 item V;
III – pet breeding;
IV – construction of temporary or permanent housing;
V – other activities prohibited by the Public Authority.
Art. 49. The importation of hazardous solid waste, as well as waste whose characteristics cause damages to the environment, public, animal and vegetation health, is prohibited, even if waste is used for treatment, reform, reuse or recovery.
TITLE IV

FINAL AND TEMPORARY PROVISIONS

Art. 50. The lack of the regulation outlined in Para. 3 Art. 21 does not prevent the performance of cooperatives or other forms of association of waste-pickers collecting reusable and recyclable material under the terms herein.

Art. 51. Notwithstanding the obligation of compensating damages regardless of fault, actions or omissions by individuals or corporate bodies that lead to insubordination of the provisions herein or its enforcement regulation, subject offenders to sanctions defined by Law, particularly Law No. 9,605, of 12 February 1998, which "provides on criminal and administrative sanctions applicable to conducts and activities harmful to the environment, and makes other provisions", and by its enforcement regulation.

Art. 52. Compliance with the provisions outlined in the introduction of Article 23 and Art 39 Para. 2 herein is considered an obligation of relevant environmental interest for the purposes of Art. 68 of Law No. 9,605, of 1998, without prejudice of the enforcement of other applicable sanctions at criminal and administrative levels.

Art. 53. Art. 56 Para. 1 of Law No. 9,605, of 12 February 1998, shall hereinafter read as follows:

" Art. 56. .....

Para. 1. The same penalties shall apply to:

I – whoever abandons products or substances referred to in the introduction or uses them in disagreement with environmental and safety norms;

II – whoever deals with, packs, stocks, collects, transports, reuses, recycles or provides for the final disposal of hazardous waste in disagreement with norms established by law or regulation.

....." (NR)

Art. 54. In compliance with the provisions of Art. 9 Para. 1, final environmentally-adequate waste disposal shall be implemented within up to 4 (four) years after the date of publication hereof.

Art. 55. Provisions of Arts. 16 and 18 shall enter into force 2 (two) years after the publication hereof.

Art. 56. Reverse logistics related to products outlined in the introduction of Art. 33 items V and VI shall be implemented progressively, according to a schedule established by a regulation.

Art. 57. This Law shall enter into force on the day of its publication.

Brasília, 2 August 2010; 189th year of the Independence and 122th year of the Proclamation of the Republic.

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The text above does not substitute the one published in the Official Gazette on 3.8.2010

Glossary

Biogases – "Gases arising from the anaerobic fermentation of biomass and the gasification of solid biomass (including biomass in wastes). (United Nations International Recommendations on Energy Statistics UN, 2013)".

Biofuels – **"**Fuels derived directly or indirectly from biomass. *Remark*: Fuels produced from animal fats, by-products and residues obtain their calorific value indirectly from the plants eaten by the animals". (United Nations International Recommendations on Energy Statistics UN, 2013).

Climate change – "Climate change refers to a change in the state of the climate that can be identified (e. g., by using statistical tests) by changes in the mean and / or the variability of its properties, and that persists for an extended period, typically decades or longer. Climate change may be due to natural internal processes or external forcings such as modulations of the solar cycles, volcanic eruptions and persistent anthropogenic changes in the composition of the atmosphere or in land use. Note that the United Nations Framework Convention on Climate Change (UNFCCC), in its Article 1, defines climate change as: 'a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods'. The UNFCCC thus makes a distinction between climate change attributable to human activities altering the atmospheric composition, and climate variability attributable to natural causes". (IPCC, 2015)

CO2-equivalent emission – "The amount of carbon dioxide (CO2) emission that would cause the same integrated radiative forcing, over a given time horizon, as an emitted amount of a greenhouse gas (GHG) or a mixture of GHGs. The CO2-equivalent emission is obtained by multiplying the emission of a GHG by its Global Warming Potential (GWP) for the given time horizon (see Appendix II.9.1 and WGI AR5 Table 8.A.1 for GWP values of the different GHGs). For a mix of GHGs it is obtained by summing the CO2-equivalent emissions of each gas. CO2-

equivalent emission is a common scale for comparing emissions of different GHGs but does not imply equivalence of the corresponding climate change responses". (IPCC, 2015).

Cogeneration – "is the simultaneous generation and useful application of electricity and useful heat". (IPCC, 2015).

Combined-cycle gas turbine (CCGT) – **"**A power plant that combines two processes for generating electricity. First, gas or light fuel oil feeds a gas turbine that exhausts hot flue gases (> 600°C). Second, heat recovered from these gases, with additional fi ring, is the source for producing steam that drives a steam turbine. The turbines rotate separate alternators. It becomes an **integrated CCGT** when the fuel is syngas from a coal or biomass gasification reactor with exchange of energy flows between the gasification and CCGT plants". (IPCC, 2015).

Compliance – **"**Compliance is whether and to what extent countries adhere to the provisions of an accord or individuals or firms adhere to regulations. Compliance depends on implementing policies ordered, and on whether measures follow up the policies. **Conversion:** Energy shows itself in numerous ways, with transformations from one type to another called energy conversions. For example, kinetic energy in wind flows is captured as rotating shaft work further converted to electricity; solar light is converted into electricity by photovoltaic cells. Also, electric currents of given characteristics (e.g., direct/alternating, voltage level) are converted to currents with other characteristics. A **converter** is the equipment used to realize the conversion". (IPCC, 2015).

Decarbonization – "The process by which countries or other entities aim to achieve a low-carbon economy, or by which individuals aim to reduce their carbon consumption". (IPCC, 2015).

Disposal - **"**The discharge, deposit, dumping, spilling, leaking or placing of any solid waste into or in any land.132 – The final handling of solid waste, following collection, processing or incineration. Disposal most often means placement of wastes in a dump or a landfill". (UNEP, 2013)

Disposal site - **"**A site where solid waste is finally discharged and deposited". (UNEP, 2013)

Eco-efficiency – "It is a management strategy that combines environmental and economic performance. It enables more efficient production processes and the creation of better products and services while reducing resource use, waste, and pollution along the entire value chain. It creates more value with less impact by unlinking goods and services from the use of nature. Not only can it save production costs but can also open up new sources of revenue for companies" (World Business Council of Sustainable Development, Learning Module, p. 16).

Electricity (1) **–** **"**the transfer of energy through the physical phenomena involving electric charges and their effects when at rest and in motion. *Remark:* Electricity can be generated through different processes such as: the conversion of energy contained in falling or streaming water, wind or waves; the direct conversion of solar radiation through photovoltaic processes in

semiconductor devices (solar cells); or by the combustion of fuels". (United Nations International Recommendations on Energy Statistics UN, 2013).

Electricity (2) - **"**The flow of passing charge through a conductor, driven by a difference in voltage between the ends of the conductor. Electrical power is generated by work from heat in a gas or steam turbine or from wind, oceans or falling water, or produced directly from sunlight using a photovoltaic device or chemically in a fuel cell. Being a current, electricity cannot be stored and requires wires and cables for its transmission (see grid). Because electric current flows immediately, the demand for electricity must be matched by production in real time". (IPCC, 2015).

Emission:

- Anthropogenic emissions - Emissions of greenhouse gases (GHGs), aerosols, and precursors of a GHG or aerosol caused by human activities. These activities include the burning of fossil fuels, deforestation, land use changes (LUC), livestock production, fertilization, waste management, and industrial processes. (IPCC, 2015).

- Direct emissions - Emissions that physically arise from activities within well-defined boundaries of, for instance, a region, an economic sector, a company, or a process. (IPCC, 2015)

- Embodied emissions: Emissions that arise from the production and delivery of a good or service or the build-up of infrastructure. Depending on the chosen system boundaries, upstream emissions are often included (e. g., emissions resulting from the extraction of raw materials). (IPCC, 2015)

- Indirect emissions: Emissions that are a consequence of the activities within well-defined boundaries of, for instance, a region, an economic sector, a company or process, but which occur outside the specified boundaries. For example, emissions are described as indirect if they relate to the use of heat but physically arise outside the boundaries of the heat user, or to electricity production but physically arise outside of the boundaries of the power supply sector. (IPCC, 2015)

- Territorial emissions: Emissions that take place within the territories of a particular jurisdiction. (IPCC, 2015)

Emissions Reduction Unit (ERU) - Equal to one metric tonne of CO2-equivalent emissions reduced or of carbon dioxide (CO2) removed from the atmosphere through a Joint Implementation (JI) (defined in Article 6 of the Kyoto Protocol) project, calculated using Global Warming Potentials (GWPs). (IPCC, 2015)

Emission standard - An emission level that, by law or by voluntary agreement, may not be exceeded. (IPCC, 2015)

Energy – **"**The amount of work or heat delivered. Energy is classified in a variety of types and becomes available to human ends when it flows from one place to another or is converted from one type into another. Daily, the sun supplies large flows of radiation energy. Part of that energy is used directly, while part undergoes several conversions creating water evaporation, winds, etc. Some share is stored in biomass or rivers that can be harvested. Some share is directly usable such as daylight, ventilation or ambient heat.
Primary energy (also referred to as energy sources) is the energy embodied in natural resources (e.g., coal, crude oil, natural gas, uranium, and renewable sources). It is defined in several alternative ways. The International Energy Agency utilizes the physical energy content method, which defines primary energy as energy that has not undergone any anthropogenic conversion. The method used in this report is the direct equivalent method (see Appendix II), which counts one unit of secondary energy provided from non-combustible sources as one unit of primary energy, but treats combustion energy as the energy potential contained in fuels prior to treatment or combustion. Primary energy is transformed into **secondary energy** by cleaning (natural gas), refining (crude oil to oil products) or by conversion into electricity or heat. When the secondary energy is delivered at the end-use facilities it is called **final energy** (e.g., electricity at the wall outlet), where it becomes **usable energy** in supplying services (e.g., light)". (IPCC, 2015).

Energy efficiency (EE) – "The ratio of useful energy output of a system, conversion process, or activity to its energy input. In economics, the term may describe the ratio of economic output to energy input". (IPCC, 2015).

Energy flows – "In general, energy flows describe various activities of energy industries and energy consumers undertaken on national territory of a compiling country such as production of energy products, their import, export, and use". (United Nations International Recommendations on Energy Statistics UN, 2015).

Energy intensity **- "**The ratio of energy inputs (in Joules) to the economic output (in dollars) that absorbed the energy input. Energy intensity is the reciprocal of energy productivity. At the national level, energy intensity is the ratio of total domestic primary (or final) energy use to gross domestic product (GDP). The energy intensity of an economy is the weighted sum of the energy intensities of particular activities with the activities' shares in GDP as weights. Energy intensities are obtained from available statistics (International Energy Agency, International Monetary Fund) and published annually for most countries in the world". (IPCC, 2015).

Energy intensity – "is also used as a name for the ratio of energy inputs to output or performance in physical terms (e.g., tonnes of steel output, tonne-km transported, etc.) and in such cases, is the reciprocal of energy efficiency". (IPCC, 2015).

Energy productivity – **"**The reciprocal of energy intensity". (IPCC, 2015).

Energy recovery - **"**The process of extracting useful energy from waste, typically from the heat produced by incineration or via methane gas from landfills". (UNEP, 2013)

Energy system – "The energy system comprises all components related to the production, conversion, delivery, and use of energy". (IPCC, 2015)

Energy transfer – **"**Energy is transferred as work, light or heat. **Heat transfer** spontaneously occurs from objects at higher temperature to objects at lower temperature and is classified as conduction (when the objects have contact), convection (when a fluid like air or water takes the heat from the warmer object and is moved to the colder object to deliver the heat) and radiation (when heat travels through space in the form of electromagnetic waves)". (IPCC, 2015)

Extended producer responsibility – **"**Making producers responsible for their products at the end of the use phase in their life-cycle". (UNEP, 2013).

Fossil fuels - Carbon-based fuels from fossil hydrocarbon deposits, including coal, peat, oil, and natural gas. (IPCC, 2015).

Fuel – "refers to energy sources, whether primary or secondary, that must be subjected to combustion or fission in order to release for use the energy stored up in them". (United Nations International Recommendations on Energy Statistics UN, 2013).

Global warming - Global warming refers to the gradual increase, observed or projected, in global surface temperature, as one of the consequences of radiative forcing caused by anthropogenic emissions. (IPCC, 2015)

Global Warming Potential (GWP) - An index, based on radiative properties of greenhouse gases (GHGs), measuring the radiative forcing following a pulse emission of a unit mass of a given GHG in the present-day atmosphere integrated over a chosen time horizon, relative to that of carbon dioxide (CO_2). The GWP represents the combined effect of the differing times these gases remain in the atmosphere and their relative effectiveness in causing radiative forcing. (IPCC, 2015).

Green product - "A green product is one that uses smaller amounts of materials that are less hazardous to produce and that has a lower potential to expose people or the environment to hazardous substances, pollutants, and wastes in its use and disposal" (Manahan, 2007, p. 11, 12, 16).

Green Technology - "Technology applied in a manner that minimizes environmental impact and resource consumption and maximizes economic output relative to materials and energy input" (Manahan, 2007, p. 11, 12, 16).

Greenhouse gas (GHG) - Greenhouse gases are those gaseous constituents of the atmosphere, both natural and anthropogenic, that absorb and emit radiation at specific wavelengths within the spectrum of terrestrial radiation emitted by the earth's surface, the atmosphere itself, and by clouds. This property causes the greenhouse effect. Water vapour (H2O), carbon dioxide (CO*2*), nitrous oxide (N*2*O), methane (CH*4*) and ozone (O*3*) are the primary GHGs in the earth's atmosphere. Moreover, there are a number of entirely human-made GHGs in the atmosphere, such as the halocarbons and other chlorine- and brominecontaining substances, dealt with under the Montreal Protocol. Beside CO2, N2O and CH4, the Kyoto Protocol deals with the GHGs sulphur hexafluoride (SF*6*), hydrofluorocarbons (HFCs) and perfluorocarbons (PFCs). (IPCC, 2015).

Grid (electric grid, electricity grid, power grid) – **"**A network consisting of wires, switches and transformers to transmit electricity from power sources to power users. A large network is layered from low-voltage (110-240 V) distribution, over intermediate voltage (1-50 kV) to high-voltage (above 50 kV to MV) transport subsystems. Interconnected grids cover large areas up to continents. The grid is a power exchange platform enhancing supply reliability and economies of scale". (IPCC, 2015).

Gross domestic product (GDP) - The sum of gross value added, at purchasers' prices, by all resident and non-resident producers in the economy, plus any taxes and minus any subsidies not included in the value of the products in a country or a geographic region for a given period, normally one year. GDP is calculated without deducting for depreciation of fabricated assets or depletion and degradation of natural resources. (IPCC, 2015).

Heat (1) – **"**the energy obtained from the translational, rotational and vibrational motion of the constituents of matter, as well as changes in its physical state. *Remark:* Heat can be produced by different production processes". (United Nations International Recommendations on Energy Statistics UN, 2013).

Heat (2) – "A form of energy transfer between systems due to a temperature difference. Heat is a flow quantity, i.e., energy in transit. By convention in analysis, heat input to a system is considered positive while heat exiting is negative".

Heat capacity Ratio of the heat absorbed in a substance to the resulting increase in temperature. The change in temperature depends on the heating process, with the most common being constant volume or constant pressure.

Hydropower - Power harnessed from the flow of water. (IPCC, 2015).

Household - "a group of persons who share the same living accommodation, who pool some, or all, of their income and wealth, and who consume certain types of goods and services collectively, mainly housing and food" (United Nations International Recommendations on Energy Statistics UN, 2013).

ICLEI – “is a leading association of cities and local governments dedicated to sustainable development. ICLEI represents a movement of over 1,000 cities and towns in 88 countries. ICLEI promotes local action for global sustainability and supports cities to become sustainable, resilient, resource-efficient, biodiverse, and low-carbon”.

Industrial Ecology – “Industrial Ecology is simply a comprehensive approach to production, distribution, utilization, and termination of goods and services in a manner that maximizes mutually beneficial utilization of materials and energy along enterprises thereby minimizing consumption of nonrenewable raw materials and energy while preventing the production of wastes and pollutants” (Manahan, 2007, p. 530).

Kinetic energy – “is contained in moving objects”. Manahan, p. 566

Landfill - **“**A solid waste disposal site where waste is deposited below, at or above ground level. Limited to engineered sites with cover materials, controlled placement of waste and management of liquids and gases. It excludes uncontrolled waste disposal. Landfills often release methane, CO2 and other gases as organic materials decay”. (IPCC, 2015).

Material recovery – **“**Utilization of all or parts of waste as a replacement for a component material”. (UNEP, 2013).

Measures – “In climate policy, measures are technologies, processes or practices that contribute to mitigation, for example renewable energy (RE) technologies, waste minimization processes, public transport commuting practices”. (IPCC, 2015).

Mitigation (of climate change) – “A human intervention to reduce the sources or enhance the sinks of greenhouse gases (GHGs). This report also assesses human interventions to reduce the sources of other substances which may contribute directly or indirectly to limiting climate change, including, for example, the reduction of particulate matter (PM) emissions that can directly alter the radiation balance (e. g., black carbon) or measures that control emissions of carbon monoxide, nitrogen oxides (NOx), Volatile Organic Compounds (VOCs) and other pollutants that can alter the concentration of tropospheric ozone (O3) which has an indirect effect on the climate”. (IPCC, 2015).

Municipal solid waste – **“**All solid waste generated in an area except industrial and agricultural wastes. It sometimes includes construction and demolition debris and other special wastes that may enter the municipal waste stream, and generally excludes hazardous wastes, except to the extent that they enter the municipal waste stream. It is sometimes defined to mean all solid wastes that a city authority accepts responsibility for managing in some way”. (UNEP, 2013)

Open dumpsite - **“**A disposal area wherein the solid wastes are indiscriminately thrown or disposed of without due planning and consideration and health standards”. (UNEP, 2013)

Policies – **"**Policies are taken and/or mandated by a government—often in conjunction with business and industry within a single country, or collectively with other countries—to accelerate mitigation and adaptation measures. Examples of policies are support mechanisms for renewable energy supplies, carbon or energy taxes, and fuel efficiency standards for automobiles, etc". (IPCC, 2015).

Potential energy – "is stored energy, such as in an elevated reservoir of water used as a means of storing hydroelectric energy for later use that can be run through a hydroelectric turbine to generate electricity as needed. A very important form of potential energy is chemical energy stored in the bonds of molecules and released, usually as heat, when chemical reactions occur". (Manahan, 2007, p. 566).

Power – "is the rate at which work is done (or heat released, or energy converted). The rate of one joule per second is called a *watt*. As an example, a light bulb might draw 100 joules of electricity per second to emit light and heat (both forms of energy). This light bulb would then draw the power of 100 watts. The above definition of watts leads to another commonly used measure of energy, the *kilowatt hour* (kWh), which refers to the energy equivalent of 1000 watts (joules per second) over a one- hour period. Thus, 1 kilowatt-hour equals 3.6x106 joules". (United Nations International Recommendations on Energy Statistics UN, 2013).

Prevention – "prevention' means measures taken before a substance, material or product has become waste, that reduce: (a) the quantity of waste, including through the re-use of products or the extension of the life span of products; (b) the adverse impacts of the generated waste on the environment and human health; or (c) the content of harmful substances in materials and products" (Directive 2008/98/EC).

Product Life Cycle – "The life of a product in a market with respect to business sales and profits over time. There are five stages to the product life cycle: product development, introduction, growth, maturity and decline" (Council of Supply Chain Management, CSMP, 2013).

Product Life Cycle Management –"The process of managing the entire lifecycle of a product from its conception, design, development and manufacture, to management of its introduction, growth and decline" (Council of Supply Chain Management, CSMP, 2013).
Renewable energy (RE) - Any form of energy from solar, geophysical, or biological sources that is replenished by natural processes at a rate that equals or exceeds its rate of use. For a more detailed description see Bioenergy, Solar energy, Hydropower, Ocean, Geothermal, and Wind energy. (IPCC, 2015)

Regulation – **"**A rule or order issued by governmental executive authorities or regulatory agencies and having the force of law. Regulations implement policies and are mostly specific for particular groups of people, legal entities or targeted activities. Regulation is also the act of designing and imposing rules or orders. Informational, transactional, administrative and political constraints in practice limit the regulator's capability for implementing preferred policies". (IPCC, 2015).

Sanitary landfill – "An engineered disposal facility designed, constructed, operated in a manner that minimizes impacts to public health and the environment.167 – An engineered method of disposing of solid waste on land, in a manner that meets most of the standard specifications, including sound siting, extensive site preparation, proper leachate and gas management and monitoring, compaction, daily and final cover, complete access control and recordkeeping". (UNEP, 2013)

Solid waste – "Any of a wide variety of solid materials, as well as some liquids in containers, which are discarded or rejected as being spent, useless, worthless or in excess.171 Solid wastes, as defined in Agenda 21, include all domestic refuse and non-hazardous wastes such as commercial and institutional wastes, street sweepings and construction debris. In some countries, the solid waste management system also handles human wastes such as night-soil, ashes from incinerators, septic tank sludge and sludge from sewage treatment plants. If these wastes manifest hazardous characteristics they should be treated as hazardous wastes". (UNEP, 2013)

Source separation - **"**Setting aside of compostable and recyclable materials from the waste stream before they are collected with other municipal solid waste, to facilitate reuse, recycling, and composting". (UNEP, 2013).

Stakeholder – **"**A person or an organization that has a legitimate interest in a project or entity, or would be affected by a particular action or policy". (UNEP, 2013).

Standards – **"**Set of rules or codes mandating or defining product performance (e.g., grades, dimensions, characteristics, test methods and rules for use). ***Product***, ***technology*** or ***performance standards*** establish minimum requirements for affected products or technologies". (IPCC, 2015).

Technology – **"**The practical application of knowledge to achieve particular tasks that employs both technical artefacts (hardware, equipment) and (social) information ('software', know-how for production and use of artefacts)". (IPCC, 2015).

TOE – "In the past, when coal was the principal commercial fuel, the *ton of coal equivalent* (tce) was commonly used as an energy unit. However, with the increasing importance of oil, it has been replaced by the *ton of oil equivalent* (toe). The toe is now defined as 41.868 gigajoules, whereas the tce equals 29.3076 gigajoules. Generally, it should *not* be assumed that one ton of coal contains one tce or that one ton of oil contains one toe of energy content since there is a wide spread in calorific values among various types of coals, crude oils and petroleum products". (United Nations International Recommendations on Energy Statistics UN, 2013).

Transmission and distribution (electricity) - **"**The network that transmits electricity through wires from where it is generated to where it is used. The distribution system refers to the lower-voltage system that actually delivers the electricity to the end user". (IPCC, 2015).

Waste - “Substances or objects which are disposed of or are intended to be disposed of or are required to be disposed of by the provisions of national law”. (UNEP, 2013)

Waste collection – “The act of picking up wastes at homes, businesses, commercial and industrial plants and other locations; loading them into a collection vehicle (usually enclosed); and hauling them to a facility for further processing or transfer or to a disposal site)”. (UNEP, 2013)

Waste management (1) - **“**Collection, transport, recovery and disposal of waste including the supervision of such operations and the aftercare of disposal sites, including actions taken as a dealer or broker”. (UNEP, 2013)

Waste management (2) – “means the collection, transport, recovery and disposal of waste, including the supervision of such operations and the after-care of disposal sites, and including actions taken as a dealer or broker;”.

Waste management hierarchy – **“**The hierarchy indicates an order of preference for action to reduce and manage waste. The waste hierarchy is presented as a pyramid that specifies that preventing the generation of waste is the preferred action, followed by reduction (e.g. through re-use), recycling, recovery and as the least preferred action, disposal. Different versions of the hierarchy have been adopted by different countries”. (UNEP, 2013)

Waste picker – **“**Person or family who salvages recyclable materials from streets, public places or disposal sites”. (UNEP, 2013)

Waste prevention – **“**Programs, strategies and activities that prevent materials from entering the waste stream”. (UNEP, 2013)

Waste sources – “Agricultural, residential, commercial and industrial facilities, open areas and treatment plants where solid waste are generated”. (UNEP, 2013)

Waste stream – “The total flow of waste from a community, region or facility”. (UNEP, 2013)

Waste-to-energy (WTE) plant – **“**A facility that uses solid waste materials (processed or raw) to produce energy. WTE plants include incinerators that produce steam for district heating or industrial use, or that generate electricity; they also include facilities that convert landfill gas to electricity”. (UNEP, 2013).