LANDFILL GAS TO ENERGY USES AND REGULATION IN BRAZIL

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This publication was developed under Assistance Agreement No. XA834446 01 0 awarded by the U.S. Environmental Protection Agency. It has not been formally reviewed by EPA. The views expressed in this document are solely those of the National Association of Regulatory Utility Commissioners grantee and EPA does not endorse any products or commercial services mentioned in this publication.

Table of Contents

ACKNOWLEDGEMENTS

The NARUC (National Association of Regulatory Utility Commissioners) is grateful to the many different individuals and agencies that supported this project. Foremost, NARUC is very grateful for the financial support provided by the United States Government through the United States Environmental Protection Agency. In particular, NARUC is grateful to the guidance and support provided throughout the life of the project by Mr. Christopher Godlove from EPA.

During the project NARUC collaborated with various Brazilian institutions, including the Brazilian Association of Regulatory Agencies (ABAR), the Brazilian Ministry of Environment (MMA) and a host of companies focused on Landfill to Gas-to-Energy projects in Brazil. In particular we would like thank Mr. Silvano Silvério da Costa, from the Brazilian MMA, for his support during the project and his important leadership in providing direct support for this collaborative report. MMA's decision to contract two consultants to help write the in-depth Brazil portions of this report were an invaluable in-kind contribution for which NARUC is very grateful.

Among the many people from ABAR that helped organize the workshops in Rio de Janeiro and Brasilia, we are articularly grateful for the support and the leadership provided by Mr. José Luiz Lins dos Santos (ABAR President), Mr. Ricardo Pinheiro (former ABAR President), Mr. Sergio Raposo (former ABAR Vice-President) and Mr. Marcos Fernandes Helano Montenegro (ADASA).

NARUC representatives, Ms. Anne Goodge (Public Utilities Commission of Ohio) and Mr. John Rogness (Public Service Commission of Kentucky) played vital roles throughout the project, through their voluntary participation in the workshops, sharing experiences from the U.S. and developing short case studies in this report on Ohio and Kentucky. NARUC would also like to thank Mr. Jeff Davis, former member of the Public Service Commission of Missouri, and Mr. Craig Johnson (East Kentucky Power Cooperative) for their support, sharing their perspectives at the workshops organized by NARUC and ABAR.

This report could not have been accomplished without the insights and tremendous amount of collaborative work done by the aforementioned individuals. NARUC hopes that government and industry entities in Brazil will find this report useful as Brazil seeks to create a solid enabling environment that will encourage further developments of Landfill Gas-to-Energy projects. In Additionally, NARUC hopes that the lessons learned and shared by Brazil through this project will help other country members of the Global Methane Initiative as policy and regulations evolve, hopefully leading to a more conducive environment for the capture and efficient use of methane gas.

ACRONYMS

ABAR	Brazilian Association of Regulatory Agencies Associação Brasileira de Agências de Regulação
ABRELPE	Brazilian Association of of Special Waste and Public Cleaning Companies Associação Brasileira de Empresas de Limpeza Pública e de Resíduos Especiais
ADASA	Regulatory Agency for Water, Energy and Sanitation for the Federal District Agência Reguladora de Águas, Energia e Saneamento Básico do Distrito Federal
AGENERSA	State Regulatory Agency for Energy and Sanitation of Rio de Janeiro Agência Reguladora de Energia e Saneamento Básico do Estado do Rio
MSW-LF	Municipal Solid Waste Landfill Aterro Sanitário de Resíduos Sólidos Urbanos
IDB	Inter-American Development Bank Banco Interamericano de Desenvolvimento
CONM	Non Methane Volatile Organic Compounds Compostos Orgânicos Voláteis Não Metano
DSIRE	Database of State Incentives for Renewables and Efficiency Banco de Dados de Incentivos Estaduais para Eficiência Energética e Energia Renovável
EG	EPA Emission Guidelines Diretrizes de Emissões da EPA
FEAM	State Environmental Foundation of Minas Gerais Fundação Estadual do Meio Ambiente de Minas Gerais
GHG	Greenhouse Gases Gases do Efeito Estufa
GMI	Global Methane Initiative Iniciativa Global para o Metano
LFG	Landfill Gas Gás de Aterro Sanitário
LFGTE	Landfill Gas to Energy Aproveitamento Energético do Gás de Aterro Sanitário
LMOP	Landfill Methane Outreach Program Programa de Extensão do Metano de Aterros Sanitários
M2M	Methane to Markets, organization that preceeded the GMI Parceria de Metano para os Mercados

MST	Ministry of Science and Technology Ministério da Ciência e Tecnologia
Mg	Megagrams Megagramas
MMA	Ministry of the Environment Ministério do Meio Ambiente
CDM	Clean Development Mechanism Mecanismo de Desenvolvimento Limpo
BDT	Best Developed Technology Melhor Tecnologia Demonstrada
NARUC	National Association of Regulatory Utility Commissioners Associação Nacional de Comissários de Regulação de Serviços Públicos
NESHAP	National Emission Standards for Hazardous Air Pollutants) Padrões Nacionais de Emissão de Poluidores Perigosos no Ar
NSPS	New Source Performance Standards Padrões de Desempenho para Novas Fontes
MSW	Municipal Solid Waste Resíduos Sólidos Urbanos
RCRA	U.S. Resource Conservation and Recovery Act Lei de Recuperação e Conservação de Recursos, EUA
RPS	Renewable Portfolio Standard Norma de Portfólio Renovável
SEA	State Secretariat of the Environmental of Rio de Janeiro Secretaria de Estado do Ambiente do Rio de Janeiro
SWANA	Solid Waste Association of North America Associação de Resíduos Sólidos da América do Norte
US EPA	United States Environmental Protection Agency Agência de Proteção Ambiental dos Estados Unidos

CHAPTER 1: BACKGROUND

NARUC Regulatory Partnership to Promote Landfill Gas-to-Energy (LFGTE) projects in Brazil

In 2009, as part of the larger Global Methane Initiative (formerly known as "Methane to Markets") the United States Environmental Protection Agency awarded NARUC with a grant to help create a regulatory dialogue in Brazil to explore methods and approaches in optimizing the use of Landfill Gas (LFG). NARUC, with the grant, created a platform so that regulators in the U.S. and in Brazil could exchange information and collaborate in promoting best practices encouraging the uptake and use of LFG.

Under the grant NARUC created a platform for regulators from the U.S. and Brazil to exchange information and collaborate on promoting best practices that encourage LFG recovery and use. These fora to promote Landfill Gas to Energy (LFGTE) in Brazil successfully gathered more than one hundred leaders and project developers who discussed the opportunities and challenges related to regulation and policies. This report is the direct result of a collaborative effort between NARUC and its regulatory and governmental counterparts in Brazil.

The Global Methane Initiative (GMI) [1]

The following excerpt was taken from the GMI website.
http://www.globalmethane.org/about/index.aspx

About the Initiative

Recognizing the important role of methane in global warming and its potential use as a clean energy source, 14 countries came together in 2004 to launch the Methane to Markets Partnership. On 1. October 2010, thirty-seven governments and the European Commission - plus the Asian Development Bank and the Interamerican Development Bank (IDB) - launched the Global Methane Initiative to urge stronger international action to fight climate change while developing clean energy and stronger economies.

GMI builds on the existing structure and success of the Methane to Markets Partnership to reduce emissions of methane, while enhancing and expanding these efforts and encouraging new resource commitments from country partners. By engaging partner governments and private sector entities, the GMI brings together the technical and market expertise, financing and technology necessary for methane capture and use project development around the world. Together, the Initiative is accelerating deployment of methane emission-reducing technologies and practices, stimulating economic growth and energy security in Member Countries, improving local environmental quality and leading the fight against global warming. Since the

[1] http://www.globalmethane.org/about/index.aspx

2004 launch, the number of Members has more than doubled.

Purpose

GMI is an international public-private initiative that advances cost-effective, near-term methane recovery and use as a clean energy source in four sectors: agriculture, coal mines, landfills and oil and gas systems. These projects reduce greenhouse gas emissions in the near term and provide a number of environmental and economic benefits, such as: • Stimulating local economic growth; • Creating new sources of affordable alternative energy; • Improving local air and water quality, with the associated public health benefits; • Increasing industrial worker safety.

Landfill Gas and Energy in Brazil

The Global Methane Initiative in Brazil is very active. According to the GMI website:

> "Brazil's estimated anthropogenic methane emissions ranked 4th in the world. While cattle are the country's largest source of methane emissions, approximately 7 percent of its anthropogenic methane emissions—28.91 MMTCO2E—come from agriculture (manure management), municipal solid waste, and natural gas and oil systems." [2]

The project database on the GMI website includes (as of December 2011) three Oil and Gas projects and twenty two landfill gas projects. The types of landfill projects include: methane recovery projects, creation og a Brazilian landfill database, thirteen landfill assessment reports combined with capacity building, and the aforementioned regulatory partnership lead by the National Association of Regulatory Utility Commissioners (NARUC). For more information, please visit the GMI website where each of this projects are listed with additional details. http://www.globalmethane.org/partners/brazil.aspx

Summary of the activities organized during the NARUC Regulatory Partnership

The NARUC/Brazil partnership featured two technical workshops that were designed in colsultation with Brazilian regulators and other key stakeholders. NARUC also organized a study tour for key individuals to the United States. Details regarding each of these activities are described below.

Workshop 1 : (For more information on this workshop, please visit NARUC's website): http://www.naruc.org/International/ProgramActivity.cfm?page=122

[2] http://globalmethaneinitiative.org/partners/brazil.aspx

NARUC and ABAR held the first workshop in Rio de Janeiro, Brazil, on May 27 and 28, 2010. Approximately 31 participants attended representing both state and federal regulatory agencies and project developers. Workshop objectives were:

- Launch the NARUC/Brazil project and introduce the partners to each other;
- Present background information of the overall Methane to Markets global partnership;
- Discuss environmental, societal and economic value of reducing methane emissions and using it as a viable clean energy source;
- Discuss regulatory framework and legislation in Brazil that promotes Landfill Gas (LFG) capture and incentivizes its commercial use;
- Analyze one or more successful Brazilian case studies;
- Present several U.S. regulatory models, approaches and practices that encourage and promote LFG use.

Workshop 2 : (For more information on this workshop, please visit NARUC's website below):

http://www.naruc.org/International/ProgramActivity.cfm?page=127

The second NARUC/Brazil workshop was held in Brasilia, on November 10 and 11, 2010. The objectives of this workshop included:

- Engage regulatory and other stakeholders (environmental regulators, government officials, the utility representatives, landfill managers and the private sector) in discussing specific opportunities and barriers related to Landfill Gas to Energy (LFGTE) including regulatory oversight, legislation, commercial deployment, financing opportunities and availability of innovative technologies.
- Discuss the current Brazilian legislation and regulatory framework and receive feedback from the non-regulatory stakeholders regarding potential reforms leading to a stronger enabling environment for Landfill Gas (LFG) and its use.
- Address posible areas of harmonization of policy and cooperation within Brazil to promote more robust direct use of Landfill Gas. Discuss State vs. Federal jurisdiction and responsibilities.
- Learn more about issues and concerns from both investor owned and public utilitites.

Study Tour to Washington, D.C. .: (For more information on this workshop, please visit NARUC's website below): http://www.naruc.org/International/ProgramActivity.cfm?page=150

NARUC organized a study tour to Washington, D.C., on February 12 to 16, 2011. The study tour gave participants the opportunity to: 1) See actual projects in the U.S., 2) Meet with the Inter-American Development Bank to discuss financing for LFG projects; 3) Meet with various other organizations, broadening the view on LFG potential in Brazil, including the Embassy of Brazil in Washington, D.C., and the Solid Waste Association of North America (SWANA). Participants included:

- Mr. José Luiz Lins dos Santos (President of ABAR)
- Mr. Marcos Montenegro (Representative from ABAR and ADASA)
- Mr. Alceu de Castro Galvão (Representative from ABAR and the Agência Reguladora de Ceará, ARCE (Ceará Regulatory Agency)
- Mr. Tiago Abdom Melo (State Foundation for the Environment (Fundação Estadual do Meio Ambiente, FEAM), Minas Gerais
- Mr. Adailton Ferreira Trindade (Representative of the Caixa Econômica Federal, CEF)
- Mr. Silvano Silvério da Costa (Secretary, Ministry of Environment -MMA)

- Mr. Osmar de Oliveira Dias Filho (Solid Waste Coordinator, Secretariat of State for the Environment of Rio de Janeiro)
- Ms. Luciana Serrão Sampaio (Embassy of Brazil in Washington, D.C.)
- Mr. John Rogness, (NARUC Volunteer, Kentucky Public Service Commission)
- Ms. Anne Goodge (NARUC Volunteer, Public Utilities Commission of Ohio)

The study tour organized meetings with the following organizations: The NARUC Executive Committee, NARUC Subcommittee on Gas, the Embassy of Brazil (met with Minister Ernesto Araujo), Solid Waste Association of North America (SWANA), the Interamerican Development Bank (IDB) and the EPA's Landfill Methane Outreach Program. Additionally, the group visited two LFG projects (the I-95 Landfill and Frederick County LFG Project).

Highlights from the study tour included:

- Increased interest in LFG by high-level government officials at the Brazilian Embassy. The group suggested the creation of an inter-agency body consisting of organizations such as ABRELPE, ABAR, MMA and others.

- SWANA presented on various LFG training programs they offer every year in the U.S. The participants were interested in conducting similar training programs in Brazil, for landfill operators and other stakeholders.
- The IDB discussed meeting with participants in Brasilia and in the state of Ceará following the sudy tour to discuss possible cooperation.

Common Themes from the Workshops and Study Tour

- Consortia Law: the management and regulation of landfills in Brazil is rapidly changing. It appears that legislation will create a financial incentive for municipalities to relinquish regulatory oversight to to state regulatory commissions (such as ADERASA in the State of Rio de Janeiro) to regulate landfills. The current small size of many garbage dumps/landfills limits the number of projects that are financially viable. The potential cost of consolidating landfills needs to be addressed as does the need to build technical capacities of the municipalities to run the new regional consortia.
- Interest in hearing about the history of U.S. landfill development which encouraged change in landfill management and created incentives for methane capture. Factors that influenced these changes included:
    - economic development;
    - creation of new landfill spaces further away from urban centers;
    - regionalization of landfills.
- Discussion whether LFG-to-energy or waste-to-energy (via combustion) should be a priority. It was noted that waste-to-energy via burning can be quite expensive and that it is important to carry out sufficient cost/benefit analyses.
- The Clean Development Mechanism (CDM) is a key financial incentive for LFGTE development, but there is uncertainty regarding how long this incentive will be available. Also, methane use in energy projects is not required for CDM carbon credits, since these can be achieved by flaring the captured methane, meeting the reduction in emission requirements.
- Developers stated that there is a need for stronger financial incentives, including the removal of certain fees, and discounts on transmission taxes and a circulation.
- There is a need to more clearly define the roles of various institutions involved in both waste management and in the generation of electricity from methane.
- Other barriers that limit implementation of landfill projects are:
    - Cost of operating a landfill;
    - Financial challenges facing municipalities;
    - Combination of temperature and rainfall that affects the quality and speed of methane generation;

    - The cost of importing generation equipment.
- One developer believes that it would help the market if the government would treat methane as it treats biodiesel (apparently there is a program that began in January 2011, where biodiesel must be added to diesel). This requirement to buy biodiesel creates certainty for that market. Similar requirements for the purchase of methane directly or electricity produced from methane could create more certainty for the LFGTE sector.
- There is strong interest in Brazil in operating landfills in an environmentally appropriate manner and rehabilitating garbage dumps that are not being operated appropriately. This will be necessary for further development of LFGTE.
- Due to the abundance of water resources, generating electricity from LFG is not considered a viable use for LFG. This may be an area where U.S. utility regulation/cost of service/ratemaking ideas might be helpful.
- Producer taxes appear to be a disincentive to producing electricity and the removal of these taxes would help spur landfill rehabilitation projects.
- Brazilian landfills seem to produce methane faster and in greater intensity than in the U.S., implying that the economic life of the engine may outlast the landfill methane production and could be moved to another site.
- Continued discussion on how Brazil's taxes affect landfill projects, natural gas (LFG) pipelines and electricty production, transmission and distribution could prove to be useful. How much revenue do the federal and state governments derive from taxes? Could the elimination of these tax revenues be offset by spending less on environmental, waste treatment and landfill rehabilitation?

As a result of the two workshops in Brazil and the study tour to the U.S., the Brazilian Ministry of the Environment agreed to work in collaboration with NARUC to develop this report. The primary goal of this collaborative report is to:

- Briefly describe major laws and regulations in the U.S. that affect the LFGTE sector;
- Provide examples of LFGTE development in the U.S.;
- Analyse Review in detail the Brazilian legal and regulatory framework;
- Review various Brazilian case studies;
- Provide preliminary recommendations for further analysis that will endeavor to improve the LFGTE sector in Brazil.

CHAPTER 2: LEGAL AND REGULATORY CONSIDERATIONS IN THE UNITED STATES

Introduction

Chapter 2 is designed to give a brief overview of laws and regulations in the United States that play a key role in the development of Landfill Gas to Energy projects. Much of the information in this chapter is found at the EPA's website under the Landfill Methane Outreach Program (http://www.epa.gov/lmop/). The section does not attempt to give a detailed explanation of each provision found in the laws or regulations. Links to the different laws and regulations are provided when available.

Federal Laws

There are two primary federal laws in the U.S. that relate to landfill management and the capture of methane gas. The first one is the Resource Conservation and Recovery Act (RCRA) of 1976. The second important law related to landfill gas is the Clean Air Act. The Environmental Protection Agency provides brief histories on their website for each of these Acts. Summary points applicable to this report are consolidated in the text boxes below. Although there is no current national policy on energy in the U.S., numerous states have adopted individual Renewable Portfolio Standards (RPS), which require that a certain percentage of energy be derived from renewable resources.

RCRA Act

1976 RCRA (Excerpts taken from the EPA website):

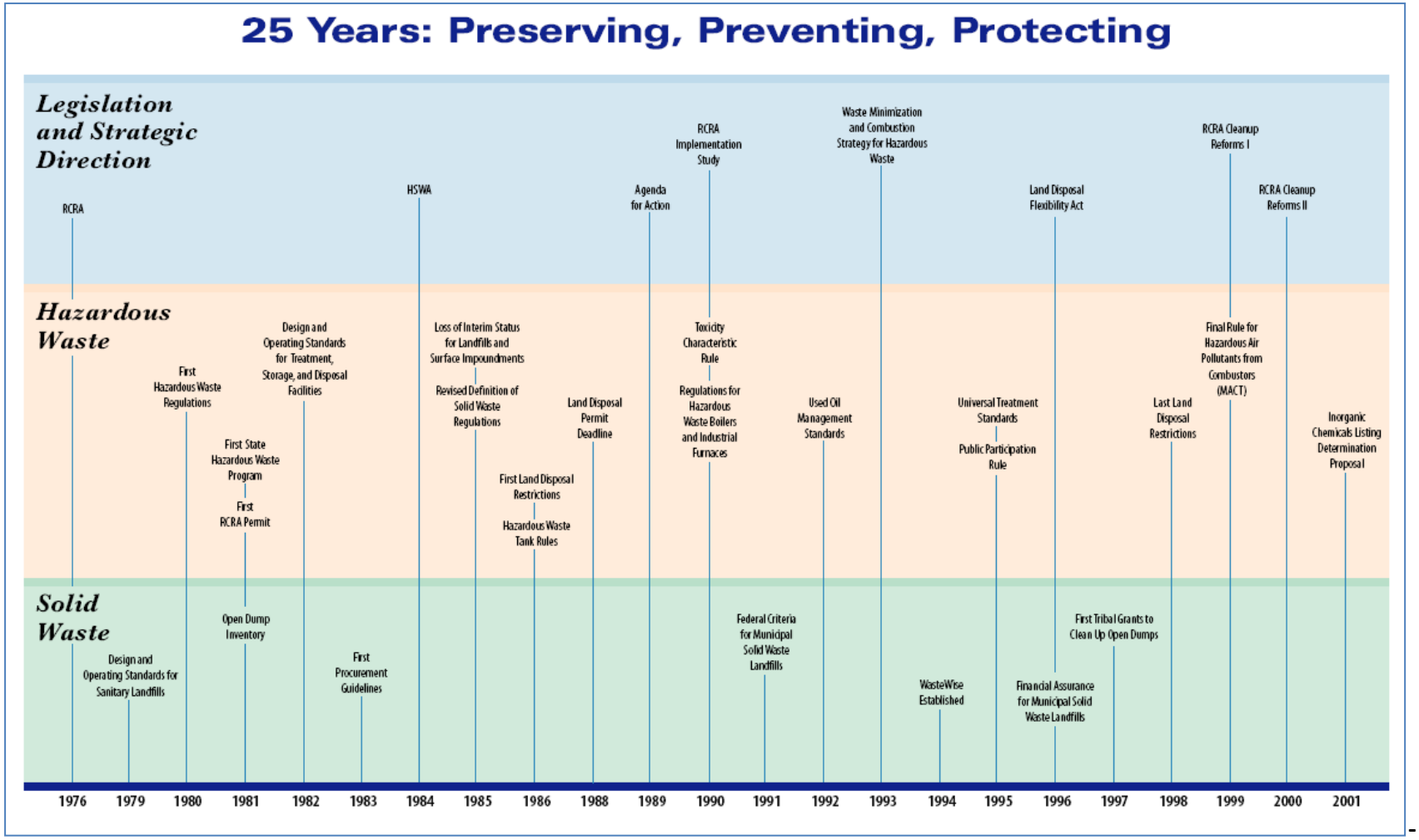
http://www.epa.gov/wastes/laws-regs/rcrahistory.htm

Congress passed RCRA on October 21, 1976 to address the increasing problems the nation faced from our growing volume of municipal and industrial waste. RCRA, which amended the Solid Waste Disposal Act of 1965, set national goals for:

- Protecting human health and the environment from the potential hazards of waste disposal;
- Conserving energy and natural resources;
- Reducing the amount of waste generated;
- Ensuring that wastes are managed in an environmentally-sound manner.

RCRA banned all open dumping of waste, encouraged source reduction and recycling, and promoted the safe disposal of municipal waste. RCRA also mandated strict controls over the treatment, storage, and disposal of hazardous waste.

RCRA Timeline [3]



1976 to 2001

[3] http://www.epa.gov/osw/inforesources/pubs/k02027.pdf (25 Years of RCRA: Protecting Our Future From Our Past, April 2002)

Some of the reasons for the adoption of RCRA in 1976 are interesting to note. A selection of findings by the U.S. Congress "highlights these reasons". [4]

- SEC 1002 (a) (4) "that while the collection and disposal of solid wastes should continue to be primarily the function of State, regional and local agencies, the problems of waste disposal as set forth above have became a matter national in scope and in concern and necessitate Federal action ... "
- SEC 1002 (b) (2) "disposal of solid waste and hazardous waste in or on the land, without careful planning and management can present a danger to human health and the environment"
- SEC 1002 (b) (8) "alternatives to existing methods of land disposal must be developed since many of the cities in the United States will be running out of suitable solid waste disposal sites within five years unless immediate action is taken."
- SEC 1002 (d) Energy - The Congress finds with respect to energy that - (1) solid waste represents a potential source of solid fuel, oil or gas, which can be converted into energy, (2) the need exists to develop alternative energy sources for public and private consumption in order to reduce our dependence on such sources as petroleum products, natural gas, nuclear and hydroelectric generation, and (3) technology exists to produce usable energy from solid waste.

In recognition of these findings, Congress outlined key objectives of the Act. A selection of these include:

(SEC 1003)

"The objectives of this Act are to promote the protection of health and the environment and to conserve valuable material and energy resources by:

- (1) providing technical and financial assistance to State and local governments and interstate agencies for the development of solid waste management plans...
- (3) prohibiting future open dumping on the land and requiring the conversion of existing open dumps to facilities which do not pose a danger to the environment or to health
- (7) establishing a viable Federal-State partnership ... five a high priority to assisting and cooperating with States in obtaining full authorization of state programs ...
- (8) promoting a national research and development program...
- (11) establishing a cooperative effort among Federal, State and local governments and private enterprise in order to recover valuable materials and energy from solid waste.

[4] http://epw.senate.gov/rcra.pdf pgs. 5 6

The Clean Air Act

Clean Air Act (Excerpts from the EPA website - "History of the Clean Air Act"):

http://www.epa.gov/airquality/peg_caa/understand.html

Several federal and state laws were enacted, including the original 1963 Clean Air Act, which allocated funding for studies and cleanup of air pollution. But there was no comprehensive response from the federal government that dealt with air pollution, until the Congress approved the stricter 1970 Clean Air Act. That same year, Congress created the EPA giving it the lead law enforcement role. Since 1970, the EPA is responsible for several Clean Air Act related programs to decrease air pollution across the country.

In 1990, Congress radically revised and expanded the Clean Air Act, giving the EPA more authority to implement and enforce air pollution emission reducing regulations. The 1990 Amendments also gave greater emphasis to more cost-effective approaches to reduce air pollution.

Roles and Responsibilities of the Clean Air Act

The Clean Air Act is a federal law covering the entire country. However, the states, tribes and local governments do much of the work to meet the demands of the Act.

The Role of EPA

The EPA sets limits for certain air pollutants and is the regulatory agency that sets limits to air pollutant emissions from sources such as chemical plants, power plants and steel mills. States or tribes may have stricter air pollution laws, but can not have pollution limits under those set by the EPA.

If a plan does not meet the necessary requirements, EPA may impose sanctions against the state and, if necessary, enforce the Clean Air Act in that area.

Role of State and Local Governments

It makes sense that state and local agencies responsible for air pollution take the lead in meeting the Clean Air Act. These agencies can come up with solutions to the pollution problems that require special attention from local industries, beyond those related to geography, housing and travel patterns, as well as other factors.

State, local and district governments also monitor air quality, inspect facilities in their jurisdiction and enforce Clean Air regulations.

The states must develop State Implementation Plans that show how each state will control air pollution and comply with the Clean Air Act. The State Implementation Plan is a collection of regulations, programs and policies that the state will use to clean up polluted areas. States should encourage public and industry involvement through hearings and opportunities to comment on the development of each state plan.

The Clean Air Act gives the EPA Administrator the responsibility to revise the list of categories of "stationary sources" (any building, facility or instalation that emits or may emit air pollutants). In 1991, Municipal Solid Waste Landfills (MSW-LF) were added as a stationary source. Within one year of being added as a category, the EPA was required to publish regulations in the Federal Standards for MSW Landfills, referred to as a "New Source Performance Standards" (NSPS). During the year after the release of the NSPS the public is given the opportunity to

comment, and the EPA considers whether or not to make changes to the regulations, based on those comments. Each State is given the opportunity to present a procedure/plan for implementation and enforcing standards of performance. If necessary, the EPA has the authority to prescribe a plan for a given State.

In the regulation for MSW Landfills, it is interesting to note some of the modifications that the EPA carried out following the period of public omment. As Brazil continues to establish and amend their laws, the changes made by the EPA may prove to be interesting. The EPA stated in the final rule (40 CFR Parts 51, 52 and 60):

> "In keeping with the EPA's common sense initiative, several of the changes were made to streamline the rule and to provide flexibility. Examples of this streamlining and increased flexibility include focusing control on the largest landfills, removing the gas collection system prescriptive design specifications, and more reasonable timing for the installation of collection wells." [5]

Standards in the regulation include (bold added): The Program

. **requires to reduction of MSW landfill emissions from new an existing MSW landfills, emitting 50 mg/year of NMOC (Not Methane Organic Compounds) or more with: (1) a well designed and well operated gas collection system and (2) a control device capable of reducing NMOC in the collected gas by 98 weight-percent.** A well designed and well operated gas collection system , would, at a minimum:

(1) Be capable of **handling the maximum expected gas generation rate** , (2) **have a design capable of monitoring and adjusting the operation of the system;** and (3) **be able to collect gas effectively from all areas of the landfill that warrant control** . Over time, new areas of the landfill will require control, so collection systems should be designed to allow expansion by the addition of further collection system components to collect gas, or separate collection systems will need to be installed as the new areas require control.

The BDT (Best Developed Technology) control device is a combustion device capable of reducing NMOC emissions by 98 wight-percent. **While energy recovery is strongly recommended, the cost analysis is based on open flares because they are applicable to all affected and designated facilities regulated by the standards and GE (Emission Guidelines) ...**

Alternatively, the collected gas may be treated for subsequent sale or use, provided that all emissions from all atmospheric vent from the treatment systems are routed to a control device meeting either specification above. The standards and EG require that three conditions be met to capping or removing the collection and control system: (1) The landfill must be permanently closed pursuant to 40 CFR 258.60, (2) **the collection and control system must have been in continuous operation a minimum of 15 years and** (3) the annual NMOC emission rate routed to the control device must be less than the emission rate cutoff on three successive dates, between 90 and 180 days apart, based upon the site-specific LFG flow rate and average NMOC concentration.

The EPA's Landfill Methane Outreach Program provided the following summary of current regulations that affect Landfill Gas and Energy.[6] .

[5] CFR Parts 51, 52, 60. p. 9907 (III) (C) (http://www.epa.gov/ttn/atw/landfill/fr12mr96.pdf) Pg. 9907
[6] http://epa.gov/lmop/documents/pdfs/LMOPQuickReference.pdf

LMOP Quick Reference Sheet:
Regulations and Proposals Affecting Landfills and LFG Energy Projects

LANDFILL METHANE OUTREACH PROGRAM

January 2012

GHG Reporting Rule (final rule published 10/30/09) –

MSW landfills are required to report if annual CH_4 generation ≥ 25,000 metric tons CO_2e. Subject landfills report CH_4 generation, emissions, and associated data. For the final rule, a landfill information sheet, FAQs, an applicability tool, and data reported by subject landfills: **http://www.epa.gov/climatechange/emissions/ghgrulemaking.html**.

GHG Endangerment Finding (published 12/15/09) –

EPA determined that the current and projected concentrations of the six key well-mixed GHGs, including CH_4, in the atmosphere threaten the public health and welfare of current and future generations. For the full findings, background information, and other resources: **http://www.epa.gov/climatechange/endangerment.html**.

PSD and Title V GHG Tailoring Rule (final rule published 6/3/10) –

Set thresholds for GHG emissions that define when CAA permits under Title V and NSR permit programs would be required. There are two initial phases:

Step 1 (Jan '11 – Jun '11): no sources were subject due solely to emissions of regulated GHGs, rather something else must have triggered the new requirements.

- PSD sources already subject: net GHG emissions increase of ≥ 75,000 tons CO_2e.
- Title V sources already subject: when applying for, renewing, or revising permit.

Step 2 (Jul '11 – Jun '13): regulated GHGs do affect applicability.

- PSD sources: ≥ 100,000 tons/yr CO_2e for New;
  increase of ≥ 75,000 tons/yr CO_2e for Existing sources with ≥ 100,000 tons/yr CO_2e.
- Title V sources: ≥ 100,000 tons/yr CO_2e.

Biogenic CO_2 was not exempted in the promulgated rule, however, on July 20, 2011, EPA finalized a three-year deferral of CO_2 emissions from biogenic sources, which means these emissions do not need to be included when determining if a stationary source meets applicability thresholds.

For the rule, proposed deferral, guidance document, and other information: **http://www.epa.gov/nsr/ghgpermitting.html.**

Internal Combustion Engines NESHAP (final rules 8/20/10, 3/9/11) **and NSPS** (final rule 6/28/11) – The NESHAP established emission standards, monitoring, recordkeeping, and reporting requirements for LFG-fired internal combustion engines at major and area sources of HAP. Existing, non-emergency, spark ignition, LFG-fired engines:

- ≥ 100 HP and ≤ 500 HP at major sources: limit of 177 ppmvd CO at 15% O_2.
- any size at area sources: management practice standards in lieu of a CO limit.

Previous NESHAP in 2004 and 2008 set standards for other LFG-fired engines.

The final Spark Ignition NSPS contains emission standards, monitoring, recordkeeping, and reporting requirements for new spark ignition engines (including LFG-fired).

For the final rules and other information: **http://www.epa.gov/ttn/atw/rice/ricepg.html ,**

http://www.epa.gov/ttn/atw/nsps/sinsps/sinspspg.html.

Major Source Boiler and Process Heater NESHAP (final rule published 3/21/11; stay to delay effective date of rule 5/18/11; reconsideration proposal 12/23/11) –

EPA is reconsidering this standard and has issued a stay to delay its effective date, allowing additional time to review public comments and input submitted. Owners/ operators of LFG-fired boilers/process heaters at major sources can submit comments on the proposal or additional data and information about their sources and emissions for EPA's consideration by March 21, 2012. EPA expects to finalize this rule in 2012 after reviewing data and comments received on the proposal.

Per the 12/23/11 proposal, LFG-fired units that operate no more than 876 hr/yr, have a design heat input capacity < 10 MMBtu/hr, or fire a gas stream that either meets a minimum CH_4 content or heating value or does not exceed the maximum Hg concentration will be subject to tune-up work practices. The proposal also exempts a unit used as a control device to comply with another MACT standard if ≥ 50% of its heat input is from the gas stream regulated under that standard. Units not meeting the above criteria would be subject to emission limits for PM, HCl, Hg, and CO.

For the reconsideration proposal and other information:
http://www.epa.gov/ttn/atw/boiler/boilerpg.html.

NSPS and EG for MSW Landfills (final rule published 3/12/96) –

Landfills that are greater than or equal to 2.5 million Mg and 2.5 million cubic meters in design capacity and have estimated emissions of non-methane organic compounds (NMOCs) of at least 50 Mg per year must reduce their emissions of LFG. For landfills that commenced construction, reconstruction, or modification on or after May 30, 1991, the NSPS apply. For older landfills that received waste after November 8, 1987, the EG apply. For the final rule and other information: **http://www.epa.gov/ttn/atw/landfill/landflpg.html.** Amendments have been proposed but are not yet final.

NESHAP for MSW Landfills (final rule published 1/16/03) –

Landfills with design capacities of at least 2.5 million Mg and 2.5 million cubic meters and estimated uncontrolled emissions of NMOCs of at least 50 Mg per year are required to collect and treat or control emissions of LFG. Subject landfills that operate part or all of the landfill as a bioreactor must install collection and control systems for the bioreactor earlier than would be required by the NSPS. The NESHAP also require semi-annual compliance reporting, instead of the annual reporting required by the NSPS.
For the final rule and other information: **http://www.epa.gov/ttn/atw/landfill/lndfillpg.html.**

For More Information:

EPA Climate Change site
http://www.epa.gov/climatechange/

LMOP LFG Energy Project Development Handbook, Chapter 5. Landfill Gas Contracts and Permitting
http://www.epa.gov/lmop/documents/pdfs/pdh_chapter5.pdf

Clean Air Act
http://www.epa.gov/lawsregs/laws/caa.html

EPA Rulemaking Gateway
http://yosemite.epa.gov/opei/RuleGate.nsf/

Renewable Energy Portfolio Standards

According to the Database of State Incentives for Renewables and Efficiency (DSIRE), 29 states in the U.S. have set a Renewable Portfolio Standard (RPS). The same database defines RPS as follows:

> Renewable portfolio standards (RPSs) require utilities to use or procure renewable energy or renewable energy credits (RECs) to account for a certain percentage of their retail electricity sales -- or a certain amount of generating capacity -- according to a specified schedule. (Renewable portfolio goals are similar to RPS policies, but renewable portfolio goals are not legally binding). Most U.S. states have established an RPS. The term “set-aside” or “carve-out” refers to a provision within an RPS that requires utilities to use a specific renewable resource (usually solar energy) to account for a certain percentage of their retail electricity sales (or a certain amount of generating capacity) according to a set schedule.

The Landfill Methane Outreach Program website states the following regarding the Renewable Energy Portfolio Standards in the U.S.:

> As of July 25, 2011, 37 states plus the District of Columbia and Puerto Rico have enacted an RPS or a Renewable Portfolio Goal (RPG), where LFG is potentially an eligible source of renewable energy.[7]

(For more information and updates regarding RPS/RPG programs and requirements, see the Database of State Incentives for Renewables and Efficiency (DSIRE), managed by the LMOP State Partner North Carolina Solar Center.) LMOP recommends selecting "Biomass" and "Landfill Gas") on the "Search a Technology" for a full list of LFG related RPS/RPG updates.

Other U.S. laws and regulations to be considered include:

- The National Pollutant Discharge Elimination (NPDES)
- Clean Water Act (CWA) Section 401

[7] http://www.epa.gov/lmop/publications tools/funding guide/renewable.html

DSIRE™
Database of State Incentives for Renewables & Efficiency

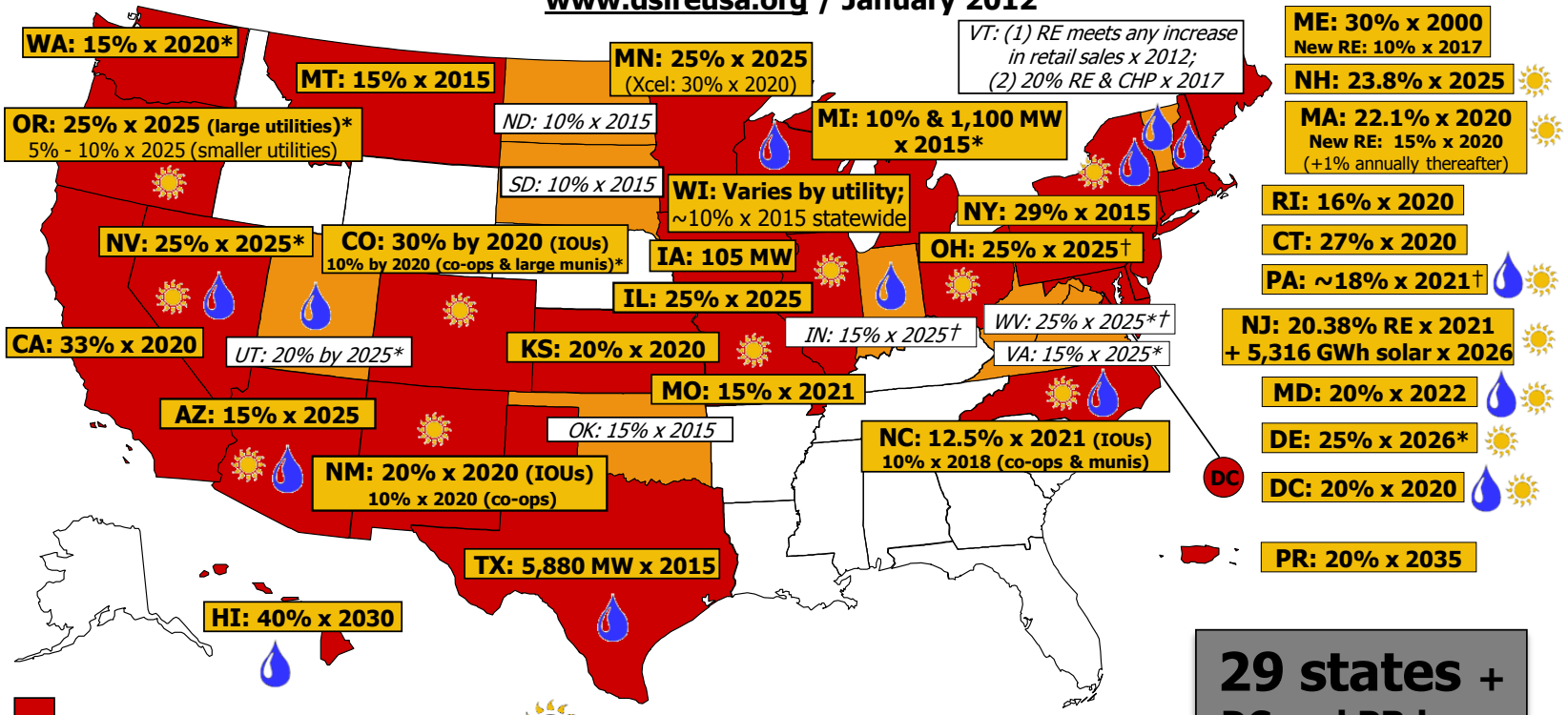
U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

IREC Interstate Renewable Energy Council

North Carolina Solar Center

RPS Policies

www.dsireusa.org / January 2012



Renewable portfolio standard

Renewable portfolio goal

Solar water heating eligible

Minimum solar or customer-sited requirement

* Extra credit for solar or customer-sited renewables

† Includes non-renewable alternative resources

29 states + DC and PR have an RPS
(8 states have goals)

CHAPTER 3: LEGAL AND REGULATORY CONSIDERATIONS IN BRAZIL [8]

* Note: The following is the executive summary of a report prepared by the Brazilian MMA. The original report has some minor editing by MMA.

Landfill Gas to Energy Use in Brazil and Regulations - Executive Summary

Introduction [9]

Human activity of all types has always produced many materials. The steady growth of urban populations, robust industrialization, increased purchasing power by the population in general have lead to an increasing volumes of solid waste, especially in large cities (BIDONE, 1999).

This paper compares public utilities management and the management of municipal solid waste in Brazil from 2008 to 2010. It discusses the relevant laws regarding this public utility, the National Policy on Solid Waste, and describes landfill gas to energy production from MSW, and identifies industry issues and concerns.

The methodology included a study of the bibliography and case studies carried out at the Bandeirantes landfill, in São Paulo, SP; at the Metropolitano do Centro (AMC) landfill, in Salvador, BA; at the CTRS - BR 040 landfill, in Belo Horizonte, MG; and at the CTR Nova Gerar landfill, in Nova Iguaçu, RJ.

According to IBGE and ABRELPE data, Brazil generated approximately 61 million tons of municipal solid waste in 2010, and approximately 54 million tons were collected. Of the MSW collected (ton/day): 18.1% was sent to open dumps, 24.3% to controlled landfills and 57.6% to landfills. The final disposal of MSW is currently one of the most serious issues because it is directly related to environmental quality and public health.

The companies above had already identified, in 2010, the number of municipalities in Brazil and how each of them disposed of their MSW: 1641 municipalities sent their MSW to dumps, 1760 to controled landfills, and 2164 to landfills. Landfills are specially designed spaces based on engineering technology and criteria that allows capturing the gas produced to generate power. Mention must be made that very few municipalities are using consortium solutions.

Urban sanitation services include MSW disposal, street cleaning, weeding, cleaning of streams and parks and gardens maintenance. With a population of 160,879,708 inhabitants (IBGE, 2010) in Brazil, the country spent R$ 70.30/person per year in 2009 and R$ 74.88/person per year in 2010 in sanitation services.

[8] The contents of this chapter were prepared by consultants at the Brazilian Ministry of the Environment (MMA).
[9] Section headings were added by NARUC.

Financial sustainability of sanitation services is an important factor to guarantee good quality of service. In almost all municipalities, full or partial sanitation services are paid through fees collected in conjunction with real estate taxes (Imposto Predial e Territorial Urbano, IPTU), but these are inadequate plus, the funds are often redirected elsewhere.

Waste Management

Management of solid waste should be comprehensive, that is, it should include all interconnected stages, from no waste generation to final disposal. It shoud include activities that are compatible with other environmental sanitation systems, and active participation from the government, the private sector and civil society.

Many of the key issues in environmental policy, such as sanitation, especially regarding waste collection and treatment, transportation systems and land use and regulation, are under the responsibility of unconnected agencies, which have their own proceedures and ways of doing things. The issue is not limited to mere lack of interconnectedness, it mainly involves contradictory goals and proceedures in the policies that are made and implemented within government.

The local government is responsible for residencial solid waste since it is a local issue, of local interest and so it is a public work related to basic sanitation that is paramount for public health. Currently, services are directly provided by local governments or their agencies, or contracted to private companies that perform this type of service following the technical specifications issued by the local government.

It is not customary in Brazil to delegate management to private companies, where management decisions regarding the system would be made by contractors. The contracts with private companies must follow management standards set by the local governments (PHILIPPI JR., 2005).

Management of urban sanitation services in medium and large cities of Brazil has seen an increasing shift towards outsourcing services that used to be performed by the local administration. These services are executed by private companies that are contracted by the local government, that run their own refuse collection, clean public spaces, treat and dispose of waste.

Cost of waste to the population

One of the most significant parts of Law 11,445/07 is that it addresses factors that may be taken into consideration when establishing the fee structure or cost of sanitation services. Art. 35 specifies that "charges or fees for the public work of urban sanitation services and MSW management (...) services may consider the following: I - income level of the population in the area; II - features of land use and areas that may be developed; III - average waste by weight or by volume collected per capita or per household. "

Although it is not yet feasible in most Brazilian cities, the law includes a criteria to define remuneration which has great practical and environmental importance. It refers to the average weight or volume of refuse collected per capita or per household. The figure itself is not necessarily a specific measurement of the service (for example, by actual weight, or by trash bag or by standardized bins), but a statistical figure for certain areas within the city.

This statistical criterion fails to fully achieve the goal of the "polluter-pays" principle (or "generator pays"), but brings the fee close to the cost of the service itself, which, if well managed, can raise awareness about generating trash and encourages decreasing the waste generated.

Outsourcing services

Several municipalities have begun contracting private companies to provide basic sanitation services, and these private companies make the necessary capital investments to expand their services. The lawful contracting arrangement that allows private companies to have exclusive rights to provide public services is a basic concession agreement for public services, covered under Laws No. 8987/95, No. 9074/95 and No. 11,445/07.

By way of this basic concession agreement, the city administration grants the private company the right to provide basic sanitation services but retains responsibility for the service itself. The concessionaire will then make and pay for all the necessary investments to expand and improve operations.

In a common concession agreement, the city is not required to contribute resources towards the operations. On the contrary, where the local market be financially promissing or viable, Art. 15 of Law No. 8,987/95 - the Law on Concessions - allows the local government to select the concessionaire according to factors such as the best technique, the lowest rates, or the most favorable agreement for the Administration.

The winning bidder may also, in addition to making investments to expand services and depending on the bidding datasheet, pay an amount to the local government to be selected as the winner. The city benefits with the investments made to expand services and the additional revenue can be applied to other areas.

Law 8,987/95, Article 2, Section II, defines concessions as "the Grantor delegating the provision of services for a specific term to the concessionaire after being selected in a competitive bidding process in which the company or the consortium of companies with the capacity to execute said operations at their own risk, compete." However, it does not describe exactly how remuneration will take place.

All investments are made by the concessionaire and the administration, as a rule, does not contribute with funds or personnel. The concessionaire uses its own resources, employees and technology and, therefore, the profit (JURUENA, 2004).

If a fee is to be assessed, it will be set by the price of the winning bid, and in some cases, the Grantor may set the fee (decision making criteria, Art. 15 of the law). In this case, the fairness of

the fee is calculated according to the utility provided and the user's income level since the fee must be affordable. The other sources of revenue can be: an interest rate that ensures the concessionaire return on his investment or income from executing other work that runs parallel to the services that are the object of the contract.

The term of the concession agreement is also necessary and it is a deciding factor in deciding the rates that will be charged to consumers. It is also encumbent upon the concessionaire to assess the responsibilities it is undertaking and it generates expectations of stability. Should there be an unjustified breach of this stability on the part of the Administration, the concessionaire is entitled to that monetary compensation.

According to the goals of the National Policy on Solid Waste, Law No. 12,305, of August 2, 2010, there is an incentive towards developing environmental and business management systems focused on improving production processes and recycling solid waste which includes recovery and energy use.

Landfills and power generation

LFGTE and landfill implementation, operation and monitoring in Brazil are good examples of public-private partnership that make it possible for an enterprise such as this one, one that requires significant investment, to take place. And it is done through concession contracts for periods ranging from 10 to 20 years, which are obtained through bidding processes.

The average cost of the investment to recover gas from waste was estimated by WILLUMSEN (2001) to be: collection system, USD 200-400/kWe; suction system USD 200-300/kWe, utilization system USD 850-1200/kWe, and planning and design USD 250-350/kWe.

In addition to the environmental and social benefits and the revenue received from the sale of electricity, the energy yield from MSW can collect revenue from the carbon credits it obtains. Carbon credits can become an additional source of income towards the financial viability of the MSW energy use (MME, 2008).

Landfills can generate close to 125 cubic meters of methane per ton of trash in a 10 to 40 year period. According to CETESB (1999), methane generation in Brazil is 677 Gg/year, which may mean close to 945 million cubic meters per year. Methane is produced after some time has passed after the waste gas been placed in the landfill and organic matter comes under anaerobic conditions.

Just the capture and flaring of methane in itself, even without using the heat it generates, reduces the impact on global warming. If the heat is used to generate power, depending on the technology used, each MSW generated MWh can compensate emitting 3 to 15 MWh generated from natural gas in a combined cycle (OLIVEIRA & ROSA, 2003). According to CETESB (2001), 8% of the world's methane emission originate in landfills and dumps.

To use energy from MSW, a gas capture system must be installed involving a network of uniformly perforated pipes where biogas travels and is transported to a main collector. According to Rosa et al. (2003), two collection system configurations are used: vertical wells

and horizontal trenches. The gas capture system has to be designed to allow for monitoring and adjusting the flow of biogas, thus facilitating the operation.

Liquid waste that is collected through gutters located at the base of the landfill, can be routed to the landfill, to increase decomposition and increase the production of gas. Landfills with 20 MW generation capacity produces 12,000 Nm^3 biogas/hour (PROINFA, 2005). This figure can range between 45% and 65%, since the volume of available biogas is not the same in all drains, so meters are needed to assess the pressure flow of methane over oxygen, to determine where capture will be collected.

The suction pressure exerted by compressors, as a result o the demand on the power plant, will determine the calibration of the flow valve in the selected drains, and only the necessary volume of gas will be routed to the central collector. Before biogas is used, it undergoes a treatment phase and then is converted into energy. At that stage, all particulates, impurities and condensate present in the gas, are removed. The treatment depends on the final use for biogas.

The treated gas is directed towards the steam generation systems (boilers, furnaces) or electric energy generation systems (stationary engines), where the rejected heat can be used to heat water. The use of gas as fuel to generate power is the most common use for gas.

There are several mathematical models that offer theoretical estimates of the power generation potential in landfills such as LandGEM Model, model used by the the World Bank and the model used by the IPCC (first order models).

According HENRIQUES (2004), annual electricity generation estimates can be calculated by multiplying the net power generation potential by the number of hours operated per year, defined as the capacity factor (CF). This factor includes the number of hours that power generation equipment is producing electricity at full capacity. The capacity factor may be obtained with the following formula:
FC = energy produced (kWh/year)/(peak capacity (kW) x 8760 (h/year))

The CDM was structured under the principle that the polluter pays, which means that a fee is charged to those who generate pollution and the income derived from those fees are used towards corrective action initiatives for that pollution. It is a mechanism that allows for the certification of emission reduction projects and ensuing marketing of these certificates to developed countries as an additional manner in which those countres can meet their goals of reducing greenhouse gas emissions.

The last information disclosed by the Ministry of Science and Technology (MST), compiled in June 2011, reports that there are currently 7,742 projects in some stage of the CDM project cycle, with 3,214 projects that have already been registered by the CDM's Executive Board and 4,528 other projects in other phases of the cycle. Brazil remains in 3rd place in terms of the number of project activities, with 499 projects (6.4%). The first place is occupied by China, with 3,056 (39.5%), and second place by India, with 2,098 projects (27.1%).

In terms of potential emission reductions associated with projects in the CDM cycle, China is still in first place with 4,038,261,099 ton CO2e to be reduced (47%), followed by India with

2,135,304,522 tons CO2e (25%) and Brazil in third position, registering the reduction of 412,197,677 tCO2e, which corresponds to 5% of the world total for the first period in which credits were granted.

Activities that will have the most CO2e emission reductions are renewable energy, landfill and and N2O reduction project, for a total of 71% of total CO2e emissions reduction during the first crediting period. These three activities have an emission reduction potential of of 293,004,348 tCO2e for the period in question.

Bandeirantes Landfill - São Paulo, SP

The Bandeirantes landfill is located at km 26 of the Bandeirantes Highway, in the Perus neighborhood, in São Paulo, 20 km from the urban center. In operation since 1979, the Bandeirantes landfill covers a 140 hectares area, with a maximum height of 110 meters. It only received household waste and inert material (refuse from street sweeping and construction) until 2007.

The Bandeirantes Thermoelectric Power Plant was located within the Bandeirantes landfill, to use the energy potential from the biochemical gas generated at the landfill, reducing pollution emissions into the environment. LFGTE use began in January 2004. The 15-year concession agreement for gas operations was granted by the City of São Paulo, through a bidding process in 2001, to the winning company Biogas Energia Ambiental SA.

The landfill gas flow began a few months after covering the waste in landfill and will continue for approximately 15 years after the landfill is closed. The gas flow is currently close to 5,000Nm3/h and is all used to generate electricity. Gas is routed to the flares to burn excess gas only when energy production has to stop, or to maintain the flow of gas.

The Thermal Power Plant has a 20 MW generation capacity that provides over 170,000 MWh of energy per year, enough to supply a city with a population of 400,000. The cost of the plant was estimated at USD 30 million which includes design, implementation, equipment (4 blowers, 2 burners, 2 coolers, 24 engines), 40 km of polyethylene piping, 280 gas collection wells whose peak flow in 2008 reached 16,000 m3/h biogas, and operation.

Registered at the UN as a Clean Development Mechanism project, the Bandeirantes Thermoelectric Plant (UTEB) has recorded and certified approximately 4 million tons of Certified Emission Reductions (CER's) pursuant with the Kyoto Protocol. Seventeen audits have been carried out for purposes of accountability and certification, the first one was in 2006 and the ensuing payments began in 2007.

In the bidding process for the concession agreement, the winning company had a proposal giving the city 50% of the carbon credits which can be traded in auctions, where approximately 51 million dollars have already been raised. The company responsible for capturing gas and generating power has a contract with a German bank that sets a baseline price for the sale of credits at € 10, and when the price increases, credits are sold at market price.

Among the main difficulties encountered for LFGTE use in the Bandeirantes Landfill are: gas quality management based on the daily and seasonal climate variations; monitoring collection wells that were set up when the landfill was still in operation, because of the repeated requests to change the plans where the wells would be installed; identifying the location of breaks in the HDPE pipes due to landfill movements and temperature fluctuations.

Metropolitano Centro Landfill, Salvador, Bahia

The Metropolitano Centro landfill (AMC) is located 6.5 km from the Estrada CIA/Aeroporto highway, in the São Cristovão neighborhood, city of Salvador, State of Bahia, in a rural area of 2,457,725.00 m2, at approximately 20 km NE of the city center of Salvador. Of the total area described, only 600,000 m2 are allocated for disposing of municipal waste from the cities of Salvador, Simões Filho and Lauro de Freitas.

The landfill was opened in October 1997. Its set up, operation and maintenance are the responsibility of the BATTRE (Bahia Transferência e Tratamento de Resíduos Ltda.), company pursuant to a concession agreement signed with the city of Salvador in 2000, for a 20 year term, in a competitive bidding process.

The Termoverde Salvador Plan is the first landfill biogas thermoelectric power plant in the Northeast region, built on the AMC landfill, in Salvador, over an area of approximately 7,000 m2. The gas collection system has been in operation since January 2004, and construction on the plant began in November 2008 and started operations in January 2011.

The initial project envisioned installing an enclosed flare to burn methane with capacity for 6,250 m3/h in 2000, which can expand to 46,250 m3/h. Total costs were estimated at USD 45 million dollars for 2003-2019 distributed in investment costs (for flares and biogas capture systems) and operating costs (electricity for pumping, deployment and maintenance of biogas grid, etc.).

The contract does not include additional remuneration for improvements in the capture of biogas or energy use. Because of this, all investments and/or operating costs required to burn more than the amount set forth in the contract will be considered "extra" and will have no other form of remuneration other than Emission Reduction Certificates (ERCs). The collecting and burning capacity of this system is being expanded and improved so that an estimated amount of 75-80% of the methane can be burned.

The thermoelectric plant produces 20 MW and is made up of a power plant with nineteen 1,038 kW generators, a moiture removal unit from the biogas, a step-up transmission substation and a 7.8 km transmission line linking the plant to the grid through COELBA (the Bahia electric power company) and generates clean energy from household waste placed in the landfill, producing 150,000 MWh per year, which means providing sustainable electricity to 50,000 households.

The landfill serves an average of 2,958,040 inhabitants, has a capacity of 18 million m3 and receives approximately 850,000 tons of household waste per year, with an organic composition between 55-60%.

The project estimates the average biogas per ton of waste placed in the landfill is 180 m3 biogas/ton of refuse. During the 2006-2010 period, the AMC received 4,508,646.24 tons of MSW which produced approximately 811,556,323 m3 of biogas during that time. Considering that biogas has a mean of 48% CH4, the CH4 output would be 389,547,035 m3 and the collected and burned biogas during that period was 238,850,156 m3, which corresponds to 61%.

Studies were undertaken to check the quality of biogas which at the beginning of the closing of cells is close to 60% CO2 and 10% CH4 changing after 30 to 40 days (and considered initial cells) to 40% CO2 and 60% CH4. For cells layered over other cells, the time required for this change to take place is two weeks after the cell is covered.

The biogas collection and treatment system has 300 gas extraction wells, five main lines, two of which are 400 mm and three are 315 mm, and all are approximately 1,200 m long, two valves per line responsible for stabilizing the vacuum pressure on the main lines, 2 capacitors, 3 blowers, 3 enclosed flares, where 2 of them are running, each with a capacity of 10,000 Nm3/h biogas at a temperature of 500-1000 °C.

The plant has 19 engines, 17 are active and 2 in maintenance (cold reserve), with a 6.1 MW capacity each, and uses the Miller cycle combustion principle (based on the Otto cycle, but since expansion is longer than compression, it allows an overexpansion of burnt gases) which has an approximate 41% efficiency in converting fuel to electrical power.

The AMC landfill has two chillers, a conventional electric one and a thermal absorption one, both with a 200 ton cooling capacity. The power consumption of an absorption chiller is typically about 10% of the consumption of electric chillers. Electric chillers consume about 230 KW/h, and are used only to start the process; thermal absorption chillers use the thermal energy rejected by the engine (heat) consuming only 2 KW/h allowing a gain of 228 KW/h.

The installed capacity of the power plant is 20 MW, but exports 16.4 MW due to domestic consumption (biogas plant), average energy sold during the year (energy delivered flat - discounted by maintenance downtime which is two to three days per year). The energy goes through a private grid to the concessionaire's substation which has granted access. This is the point in which energy is measured.

The thermoelectric power plant is an independent power producer registered with ANEEL with put option on the open market. The sale rate is above the average price established by PROINFA, the incentive program for alternative sources of energy. Alternative energy fully encouraged by the government and does not pay TUSD rates (fees for using the distribution system) or TUST (the fees for using the transmission grid).

The Termoverde plant has already recorded and certified approximately 4 million tons of CERs in accordance with the Kyoto Protocol, during the first crediting period. The concession agreement signed with the Municipality of Salvador and BATTRE requires that 5% of gains obtained with carbon credits are applied by the company in societal and environmental projects. The total projected emission reductions for the operational lifetime of the project is 13,958,155 tCO2e.

Among the main difficulties for the success of the endeavour are the certification procedures, which last an average of 6 months, and the PDD adjustment and analysis procedures which need to be more dynamic. The process must facilitate greater communication between the parties and should be less time consuming.

CTRS Landfill- Belo Horizonte, Minas Gerais

The Belo Horizonte landfill, CTRS, is located in the northwestern part of the city of Belo Horizonte, on the BR-040 highway, on the Jardim Filadélfia neighborhood. The gas capture plant received its licence to operate in November 2008, and was reviewed and reissued in May 2011 to include the exploration of biogas on behalf of the Horizon ASJA consorium, the company that had been awarded the concession by the City through a bidding process for a term of 15 years.

The City received from the company in the bidding process the amount of R$ 16 million to transfer carbon credits, and keeps 5%, that is approximately R$ 35,000/month, from the power generation revenues. The cost of setting up the power system will be borne by ASJA and was estimated at R$ 20 million. The cost of the project, operations and monitoring will also be added to the total cost that will be paid by the company.

The landfill began operating in 1975 and had a 32 year life cycle. In 1995, it began operating with landfill technology and equipment to capture and treat biogas. It has an area of 114.9 hectares, where 65 ha were allocated to receive 19,245,908 m3 of MSW from the city of Belo Horizonte. It has an average height of 65 m.

The Belo Horizonte landfill has 150 gas capturing wells, two main lines, a separator/coalescer filter for a first coarse separation of the condensate. It has two multi-stage turbo blowers/exhausters that can apply different pressures across all gas capturing lines while routing the treated biogas to power the engines and flares.

After the blower/exhauster and before the engines, the biogas passes through a series of heat exchangers with tube bundle with gas/water and glycol that can cool the LFG down to a temperature below 10 °C through a set of coolers. The condensate that is formed is then separated by a coalescer filter localed downstream from the tube bundle. Thus, a large portion of the impurities trapped in the actual condensate is removed from the LFG flow.

The gas that comes from the suction and treatment section is transmitted through a light pressure line to the modular type internal combustion engines. These type of engines can be installed step by step as the biogas flow increases. There are currently 3 engines installed and the total capacity of the plant is 4.5 MW.

The CEMIG (electric power company of Minas Gerais) encourages alternative energy generation and was interested in purchasing the biogas alternative power. The negotiations were bilateral with a sales contracts for set amounts of energy. The term of the agreement is from January 1st, 2011 to December 31st, 2014.

According to the PDD, some parameters were estimated for purposes of the project's financial analysis such as: average annual production of 17,479 MWh, with a total of 174,785 MWh of electricity delivered to the utility grid; sale of power at the expected value of € 52.87/MWh , average installed capacity of 4.04 MW and total investment of € 4,582,015; life cycle for the project is 10 years; annual operating costs for producing CERs amounting to € 149,200/year and 25 €/MWh as annual operation cost to produce power.

The depreciation rate was estimated at 10% per year and takes into account the amortization of the equipment until the end of the concession period when the ownership of all property involved in the project will be transferred to the city, which means that in 10 years there should be a 100% amortization of the investment. The price of electricity was estimated based on the results of the 1st Alternative Sources Auction, held in 2007, the only one until the presentation of the PDD.

The value of a carbon credit in the international market at the time the PDD was prepared was between € 12 and € 18 according to the Commodities & Funds Exchange (Bolsa de Mercadorias e Fundos)(PDD, 2009). To estimate the value of credits, the project worked with an average value of € 15, which would result in € 83 million. The PDD also said that without the CDM project it would be financially unfeasible to operate a thermoelectric power plant to use LFG from the Belo Horizonte landfill.

The main difficulties identified by the project investors were lack of skilled labor, high cost and time to import equipment. Plus, obtaining the environmental license for the LDGTE plant to capture and use biogas met with difficulties due to lack of knowledge on the part of the environmental agency's technical staff as well as regulations on this activity.

Nova Gerar Landfill - Nova Iguaçu, Rio de Janeiro

The Nova Gerar landfill is located in the Adrianópolis neighborhood, in the municipality of Nova Iguaçu, State of Rio de Janeiro, 10 km from the city center. In 2001, the city of Nova Iguaçu opened a bidding process for a 20 year concession to manage waste, conduct the environmental recovery of the former Marambaia Dumpsite and to design and execute the landfill project, including the environmental licensing, deployment, operation and monitoring for an additional 20 year period after the activities are closed.

The S.A. Paulista company, won the bidding valued at R$ 2.60/ton of waste and migrated to CTR Nova Iguaçu which operates the comprehensive waste treatment plant of Nova Iguaçu. The beginning of activities took place on February 13, 2003. The city receives 10% of all revenue generated, including the carbon credits, and gets a 20% discount for disposing of waste (deduction). The clean waste removal from construction and demolition sites is free of charge to the city of Nova Iguaçu.

CTR has a 1.2 million m2 area, consisting of a landfill (for waste class II and III according to NBR 10,004), a leachate treatment unit, a medical waste treatment unit and a debris recycling unit. It receives about 3,000 tons/day and since the beginning of the operation has recorded over 6,000,000 tons of waste, with a specific weight of 12.73 kN/m³.

To control stability, 127 superficial landmarks and 15 piezometers were installed. The project consists of a gas collection system with 60 active collection wells, six main lines, two gas suction engines, pretreatment system, and closed burning. A power generation system and a connection to the grid are planned.

A study by SOARES (2011) to analyze the gravimetric characterization of MSW received at CTR Nova Gerar, from the cities of Nova Iguaçu and Rio de Janeiro, studied 11 samples with the following results: 3.33% inorganic fraction (26.3% glass, and 73.69% metal) and 96.67% organic fraction.

The enclosed flare is designed to operate continuously with an automatic temperature control to safely destroy the biogas generated by the solid waste, and can process 3,000 Nm3/h biogas and can expand to 9,000 Nm3/h. A conservative estimate of emission reductions, burning efficiency was estimated at 90%. The average lifecycle for the equipment is between 15-20 years.

Enclosed flares have been used since the beginning of the operation and will continue to be used after the thermal power plant has been installed and the volume of gas exceeds the capacity of the power generation system or when the power generation is low (e.g., engine maintenance).

The Automated Extraction Monitoring System (AEMS) consists of three main components: a Field Analytical Unit (FAU), the Field Server Unit (FSU) and the Auto Calibration Package which are main system components. These products are designed specifically for use on landfills to monitor LFG extraction systems directly from the burning or combustion equipment.

The monthly methane flow that is captured and treated in the Nova Gerar LFG treatment unit in 2010 was approximately 765 m3/h for the first six months.

The power generation plant has not been installed yet and according to the PDD it should be operational from 2012-2026. The electric power transmission lines are less than 1 km from the Nova Gerar landfill.

According to the PDD, a modular unit made up of 3 generators, each with a 1,415 MW capacity (or total combined capacity of 4,245 MW) and 2 electricity transformers (3 phase, 60 Hz) will be installed to transform energy and transfer it to the grid (input voltage 380 V, output 13,8 KV, 12,500 KVA capacity).

At the time the project was approved, the PDD estimated that power generation and gas burning through flares would reduce GHG emissions by approximately 14.1 million MTCO2e for the period the landfill was operational. Because it was a pioneering project in Brazil, changes were made to the original plans and new emission reductions projections were developed.

The percentage of biogas loss produced was deemed variable as the landfill progressed, and would decrease over time, as cells are closed and sealed and no longer undergo any impacts or loss of operation. This improvement in the manner of anticipating captured biogas, together with more consistent inventory and dump figures, brought forth more realistic results, reducing the number of projected carbon credits that would be generated. The annual 2011 target is 132,000 tCO2e.

The main difficulty for LFGTE in medium-sized landfills is the large cost of investment required to set up the Thermal Power Plant.

Recommendation: a detailed budget for implementation, operation and monitoring LFG use; simplifying the environmental licensing system for landfills; adopting fiscal instruments benefitting cities that meet the criteria for environmental preservation, as is the case with LFGTE operations.

Municipalities should receive more technical information about the construction and operation of landfills with biogas utilization and about the technological options for power generation from MSW; and, about development banks establishing lines of credit with favorable rates for construction of landfills with biogas utilization systems, including for medium sized landfills.

Reducing import duties, price differential for renewable energy sale; incentive for industries to use LFG energy also key to minimizing the high risk investment required for LFG use.

* Note: The following is a report prepared by the Brazilian Ministry of the Environment (MMA).

Regulating Electric Power Production and Marketing by Independent Power Producers and Self-Generated Power Producers - The National Interconnected System

The Brazilian power generation and transmission system is unique in the world due to the country's size and characteristics. It is a large hydro-thermal system, where hydroelectric plants dominate under different ownership. In this national interconnected system (Sistema Interligado Nacional, SIN grid), the transmission lines (TLs), power transformers and substation equipment, at voltages equal to or greater than 230 kV, are designated as the Basic Network (ANEEL, 2004). Figure 2 shows the TLs and the power generation complexes in this SIN grid.

Figura 2. Horizonte 2012 Planejado pelo Operador Nacional do Sistema (ONS) para o SIN.

Figure 2. Horizon 2012 Planned by the National System Operator (Operador Nacional do Sistema, ONS) for the SIN grid.

Figure 2 shows that, in general, hydroelectric plants are positioned in the proximity of water to generate power, and they are miles away from the main load centers. Thus, the connection between the generation and distribution systems is done through transmission lines which, according to SMITH (2003), have higher energy losses the fartherst they reach. Thus, the operation of the SIN grid seeks to minimize both power generation and cost of transportation through the transmission lines.

In 2010, close to two hundred (200) of the over one thousand (1,000) generating units had a generation capacity over 30 MW each (CHIPP, 2010), while the reach of the transmission SIN grid measured about 95,464 km, with 811 (eight hundred and eleven) circuits and 401 (four hundred and one) substations. According to this reference, distribution agents and end users reached an average load of 50,618 MW, recorded in 2009.

Of the total installed capacity of approximately 125,246 MW, including the 8,170 MW imported, almost 66% is hydraulic, 18.5% thermal produced through fossil fuel and 7.18% through biomass, with 0.06% interest in biogas, and an additional 1.6% of nuclear source (ANEEL, 2012).

About 3.4% of the power generation capacity in Brazil is not connected to the SIN grid, rather, it is located in small isolated systems, especially in the Northern (ONS, 2012) region which represents approximately 45.3% of the Brazilian territory and 8.3% of the national population (IBGE, 2012). In these isolated systems, because there is a predominance of thermal generation, costs are higher than those of the SIN grid. Furthermore, access and supply difficulties in those localities exert pressure on cost and the logistics involved in supplying energy.

The Brazilian Market for Electricity

Brazil occupies a prominent position in the world scenario regarding the availability of natural resources for energy use. In 2009, the share of renewable sources in the global primary energy production was close to 13.3% and 7.6% for the countries of the Organization for Economic Cooperation and Development (OECD) (IEA, 2011). This year in Brazil this percentage reached 46.8% (BEN, 2011), as shown in Table 6.

Table 6. Comparison (%) of Primary Energy Production by Source.

	2009 World	OECD 2009	Brazil 2009
Petroleum	32,8	37,2	41,9
Coal	27,2	19,7	0,9
Gas	20,9	24,2	8,7
Nuclear	5,8	11,3	1,7
Hydroelectric power	2,3	2,1	13,9
Renewable Fuels and Waste	10,2	4,4	29,0
Other Renewable Sources	0,8	1,1	3,8
Renewable	13,3	7,6	46,8
Non Renewable	86,7	92,4	53,2

Source: IEA (2011) and BEN (2011).

Analyzing the BEN data for 2009, it is clear that the difference in renewable sources is due to the use of sugar cane products (18.8%) and hydroelectric power (13.9%.) However, as Table 7 shows, the share of firewood (10.2%) is almost three times higher than the use of other renewable sources (3.8%). Table 7 shows type of source in percentages of primary energy production in Brazil.

Table 7. Evolution of Primary Energy Production (%) by Source in Brazil.

Source:	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Oil	42,7	43,1	42,1	40,3	42,0	42,1	40,7	39,7	41,9	42,0
Gas	8,9	8,8	8,5	8,9	8,8	8,3	8,1	9,0	8,7	9,0
Steam Coal	1,4	1,1	1,0	1,1	1,2	1,0	1,0	1,1	0,9	0,9
Coking Coal	0,0	0,0	0,0	0,1	0,1	0,0	0,0	0,1	0,0	0,0
Uranium	0,4	1,9	1,5	1,9	0,7	1,1	1,6	1,7	1,7	0,7
Hydroelectric	14,7	14,1	14,3	14,5	14,5	14,2	14,4	13,4	13,9	13,7
Firewood	14,3	13,6	14,1	14,8	14,2	13,5	12,8	12,4	10,2	10,3
Sugar Cane	14,6	14,5	15,4	15,4	15,5	16,6	18,2	19,0	18,8	19,3
Other*	3,0	2,9	3,1	3,1	3,2	3,2	3,0	3,6	3,8	4,3
Renewable	46,6	45,0	46,9	47,8	47,3	47,4	48,5	48,4	46,8	47,5
Non renewable	53,4	55,0	53,1	52,2	52,7	52,6	51,5	51,6	53,2	52,5

Source: BEN (2010).
* Other renewable sources.

According to the 2010 to 2019 Ten-Year Plan for Energy Expansion (PDE), in order to meet the needs of an estimated annual average increase of 5% in GDP, which translates to an increase of approximately 5.9% in energy use, an approximate increase of 62% to the installed electricity generation capacity will be needed for this 10 year period.

As a way to signal the commitment to maintaining the high use of renewable sources in the Brazilian energy grid, in 2002 the incentive program for alternative sources of electric energy, PROINFA (Programa de Incentivo às Fontes Alternativas de Energia Elétrica), was created. This will be explained in detail in section 4.3.2, which includes energy sources such as wind, biomass and small hydroelectric plants (PCH). Table 8 shows the evolution of the percentages by source of energy generation in Brazil and the total use of renewable and non-renewable sources.

Table 8. Evolution of Electricity Production by Source (%) in Brazil.

Source:	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Gas	3,0	3,6	3,6	5,0	4,7	4,4	3,5	6,2	2,9	7,2
Coal	2,3	1,5	1,5	1,7	1,6	1,6	1,4	1,4	1,2	1,3
Firewood	0,2	0,2	0,2	0,2	0,2	0,2	0,2	0,3	0,2	0,4
Sugar Cane	1,4	1,6	1,9	1,8	1,9	2,0	2,5	2,6	3,0	3,1
Wind	0,0	0,0	0,0	0,0	0,0	0,1	0,1	0,3	0,3	0,4
Other recoveries	2,9	2,9	2,7	2,9	2,9	2,8	2,8	2,9	3,0	2,7
Diesel	1,8	1,6	1,7	1,9	1,9	1,6	1,4	1,8	1,6	1,7
Fuel oil	2,4	1,8	0,8	0,8	0,7	1,0	1,3	1,6	1,1	1,0
Nuclear	4,3	4,0	3,7	3,0	2,4	3,3	2,8	3,0	2,8	2,9
Hydro	81,5	82,8	83,9	82,8	83,7	83,2	84	79,8	83,9	79,2
Renewable	83,1	84,5	85,9	84,8	85,8	85,4	86,8	83,1	87,4	83,1
Non renewable	16,9	15,5	14,1	15,2	14,2	14,6	13,2	16,9	12,6	16,9

Source: Based on BEN (2011).

Other recoveries in Table 8 refer to the energy use of leach, coke oven gas, waste excluding sugar cane bagasse, etc. Thus, Table 8 shows that the highest percentage of renewable sources of energy generation in Brazil during the last decade refers to the hidroelectric power (average 82.5%). Followed by fossil fuel sources supplying thermal plants (average 8.9%), and then power generation from renewable thermal source recovered from heat and from various waste products (average 5.2%).

The energy use from alternative sources for electrical systems increased from approximately 4.5% in 2001 to a 6.6% in 2010, with focus on cane sugar products followed by wind energy. Looking at Table 7 and 8, it seems that both primary energy generation and power percentages remained virtually unchanged in terms of renewable and non-renewable sources.

Table 9 shows the number of thermal biomass plants in 2012, the installed power and percentage share by fuel type.

Table 9. Description of Biomass Thermal Projects in Operation.

Fuel	Quantity	Power	%
Sugar Cane	347	7,263,608	80.72
Black Liquor	14	1,245,198	13.84
Wood Waste	38	319,635	3.55
Biogas	18	76,308	0.85
Rice husk	8	32,608	0.36
Elephant grass	2	31,700	0.35
Charcoal	3	25,200	0.28
Palm Kernel Oil	2	4,350	0.05
Total	432	8,998,607	100

Source: ANEEL (2012).

The information in Table 9 shows that thermal biomass plants are predominantly operated with sugar cane bagasse, followed by a much smaller percentage of black liquor and then wood waste, leaving a very small contribution of biogas, almost 0, 9%.

Regulatory Framework of the Brazilian Power Sector

The 1988 Federal Constitution of Brazil, in its Articles 20 to 23, 49, 155, 175, 176, 187, 225, 231, made structural changes to the electricity market in Brazil, mainly from the 1990s onwards, in a reorganization process that was very similar to the English reform in an effort to attract private investment to ensure financial support for infrastructure in the sector; it did so through the following legislation:

- Law 7,990/1989 - establishes financial compensation for the results from using water resources for power generation (Article 21, XIX of the Constitution). The financial compensation will be an amount consistent with a percentage of the price of the energy recorded on the invoice minus taxes and [the bond-like figure of] "compulsory loans";
- Law 8,001/1990 - describes the percentages that will be distributed as the financial compensation described in Law No. 7,990/1989. It institutes the monthly distribution of said financial compensation in percentages that were modified by Law 9,993/2000;
- Law 8,631/1993 and Decree 774/1993 - sets the rate levels that will be charged for the public utility - electricity - and eliminates the guaranteed returns policy. It gives the Grantor the authority to approve proposals by the concessionaire regarding the electricity rates that will be charged to consumers in amounts that should cover the concessionaire's cost of distribution, as per its specific characteristics, to ensure appropriate public utility services;
- Law 8,666/1993 - regulates Art. 37, paragaraph XXI, of the Federal Constitution, establishing the rules that govern bids and contracts with the public sector;

- Law 8,987/1995 - defines concessions and permissions for providing the public services described in Art. 175 of the Federal Constitution. It gives the Union, the States, the Federal District and/or the Municipalities the power to enter into concession agreements for public services, for specific terms, through a bidding process, and to grant permission to a private company, or a group of companies, that shows to have the capacity to execute the public service, to provide the service at their own cost and risk;
- Law 9,074/1995 - describes the rules for granting and renewing concession agreements and authorizations to provide public services. This Law will be discussed further at the end of this section;
- Decree 1,717/1995 - establishes procedures to renew power utility concessions described in Law No. 9,074/1995. This Decree will be discussed further with Law 9,074/1995 at the end of this section;
- Law 9,427/1996 - creates the national electric energy agency (Agência Nacional de Energia Elétrica, ANEEL), which will be described in Section 4.3.1.1; it guides the economic and financial regulations for power utility concessions, and other provisions;
- Decree 2,410/1997 - addresses the assessment and collection of the electric energy services inspection fee (Taxa de Fiscalização de Serviços de Energia Elétrica, TFSEE) established by Law No. 9,427/1996. It provides the mathematical formula for calculating the TFSEE, and the annual fee, which differ according to modality and is proportional to the magnitude of the service privied under a concession, permission or authorization. It includes the case of independent power producers and self-power producers;
- Law 9,478/1997 and Decree 2,457/1998 - addresses the national energy policy, creates the national council for energy policy (Conselho Nacional de Política Energética, CNPE) - which will be discussed in section 4.3.1.6 - and establishes the operating structure;
- Law 9,648/1998 - authorizes the Executive Branch to encourage restructuring the Brazilian electric power plants (Centrais Elétricas Brasileiras, ELETROBRÁS) - described further in section 4.3.1.4 - and its subsidiaries, plus other provisions;
- Decree 2,655/1998 - regulates the wholesale electric energy market (Mercado Atacadista de Energia Elétrica, MAE), defines the organization rules for the national electric system operator (Operador Nacional do Sistema Elétrico, ONS), agency described in Law No. 9,648 of May 27, 1998, with the duties described in section 4.3.1.9;
- Law 9,991/2000 - addresses investments in research and development and in energy efficiency by concessionaires, pertmit holders and authorization holders in the electricity sector. This topic will be discussed at the end of this section;
- Law 9,984/200 - creates the national water agency (Agência Nacional de Águas, ANA), the federal agency in charge of implementing the National Water Resources Policy and coordinating the National Water Resources Management, and other provisions. Amends Law 8,001/1990 regarding the distribution percentages for the financial compensation, which will henceforth have the percentages described in Law 9,993/2000;

- Law 9,993/2000 - allocates the financial resources from the compensation for using water resources for power generation and for exploring mineral resources towards science and technology. Amends Law 8,001/1990 regarding the monthly allocation of the financial compensation in a percentage of 45% to the States and the Municipalities, 3% to the Ministry of the Environment and 3% to the Ministry of Mines and Energy, plus 4% to the National Fund for Scientific and Technological Development (Fundo Nacional de Desenvolvimento Científico e Tecnológico, FNDCT);
- Law 10,433/2002 - creates the Wholesale Energy Market (Mercado Atacadista de Energia Elétrica, MAE), a private legal entity and other provisions, that evolved into the CCEE, an entity that will be discussed in Section 4.3.1.3;
- Law 10,438/2002 - addresses increasing the power supply for emergencies, restructures special rates, creates the Incentive Program for Alternative Sources of Electric Energy (Programa de Incentivo às Fontes Alternativas de Energia Elétrica, PROINFA), the Energy Development Account (Conta de Desenvolvimento Energético, CDE), makes power utility universal, redrafts Laws 9,427/1996, 9,648/1998, 3,890-A/1961, 5,655/1971, 5,899/1973, 9,991/2000, and other provisions. These issues of the Law will be discussed at the end of this section;
- Law 10,604/2002 Act - allocates funding to subsidize electricity for low income consumers, rewrites Articles 27 and 28 of Law 10,438/2002, and other provisions. The law exempts residential low income consumers from rate increases due to higher PROINFA costs (which will be apportioned among the remaining consumers);
- Law 10,847/2004 and Decree 5,184/2004 - creates the energy research company (Empresa de Pesquisa Energética, EPE), which will be discussed further in section 4.3.1.7, and other provisions;
- Law 10,848/2004 - addresses the sale of electricity, both for the regulated contracting environment (Ambiente de Contratação Regulada, ACR) and for the unregulated contracting environment (Ambiente de Contratação Livre, ACL), which will be discussed in section 4.3.1.3, changes Laws 5,655/1971 , 8,631/1993, 9,074/1995, 9,427/1996, 9,478/1997, 9,648/1998, 9,991/2000, 10,438/2002, and other provisions that which be discussed at the end of the section;
- Decree 5,163/2004 - regulates the sale of electricity, the process of granting concessions and authorizations to generate power, and other provisions that will be discussed at the end of this section together with Law 10,848/2004;
- Decree 5,175/2004 - creates the Monitoring Committee for the Electricity Sector (Comitê de Monitoramento do Setor Elétrico, CMSE) described in Article 14 of Law 10,848/2004, and which will be discussed in section 4.3.1.5;
- Decree 5,177/2004 - regulates Articles 4 and 5 of Law 10,848/2004, and legislates the organization, responsibilities and the operations of the Chamber of Commerce for Electric Energy (Câmara de Comercialização de Energia Elétrica, CCEE), which will be discussed in section 4.3.1.3;

Decree 1,717/1995 and Article 40, Law 9,074/1995, set a 35-year (thirty five) amortization schedule from the signing of the agreement, for the investments related to the power generation concession prior to Dec 11, 2003, which may be extended for up to twenty (20) years. It also schedules an amortization period of thirty (30) years from the signing of the agreement, for investments related to the power transmission and distribution concession, with the possibility of extending the concession for equal time, at the discretion of the Grantor.

Since biogas energy use through electric systems takes place through thermal power plants (TPP), Article 50 of this Law stipulates that TPPs with power above 5,000 kW, allocated for public service, are subject to concession agreements obtained in a bidding process, while those allocated to self-producers for their exclusive use are subject to authorization agreements. TPPs with less than 5,000 kW capacity are exempt from concessions, permissions or authorizations, they must only communicate this to the Grantor.

Article 110 creates the figure of the independent power producer (IPP) (Produtor Independente de Energia Elétrica, PIE) - that can include the biogas TPP - as a company or group of companies working as a consortium to receive a concession or authorization from the Grantor (government) to produce and market all or part of the power produced at their own risk. The IPPs are guaranteed the right to access the grid of concessionaires and of authorization holders for distribution and the concessionaires for the transmission service.

Law 9,074/1995, Article 16, establishes the concept of independent consumer as one whose load is 3,000 kW or more, supplied at any voltage, and who is free to choose his utility provider.

Law 9,991/creates an important funding instrument for biogas energy used through electrical systems. It states that concessionaires and permit holders for power distribution utilities must allocate at least 0.75% (seventy five percent) of its net operating revenue for research and development (R&D) in the electricity sector, and at least 0.25% (twenty five percent) to end use energy efficiency programs.

Furthermore, it states that power generation concessionaires and independent power producers, and concessionaires for power transmission, must allocate annually at least 1% (one percent) of its net operating revenue in electric sector R&D, except companies that generate only wind, solar, or biomass power, small hidroelectric plants, and qualified co-generation companies.

Law 10,438/2002, Article 30 creates the PROINFA, and it will be discussed in section 4.3.2. Article 130 creates the Energy Development Account (Conta de Desenvolvimento Energético, CDE) to develop the state energy sectors, and to foster competition among the energy produced from wind sources, PCH, biomass, natural gas and domestic coal in the areas served by the interconnected systems, and promote the universality of the utility throughout the country.

Provided all connections and limits, described below, are observed, the CDE funds have to go towards paying power producers that generate electricity from wind, thermal, natural gas and biomass, and small hydroelectric plants, that begin operations starting on April 24, 2002. These payments consist of the difference in the cost of that alternative energy with a specific technology and the cost of the regular energy cost as purchased by the final consumer.

Article 80, Law 10,848/2004, in addition to establishing the ACR and ACL it also provides for the deverticalization of the Brazilian electricity sector, preventing concessionaires, permit holders and authorization holders for power distribution utilities that operate within the national interconnected system (Sistema Interligado Nacional, SIN) from operating in the power generation or transmission or in the sale of electricity to independent consumers, excluding those under their area of concession.

Furthermore, it specifies that power generation consessionaires and authorization holders that operate in SIN cannot be associated with or be parent companies of companies that distribute power through SIN. It also establishes that independent power producers using biogas for energy in TPP will be subject to regulated or independent marketing rules.

Organization of the Brazilian Energy Sector

The institutional organization allowed by this regulatory framework that culminated in the so-called New Industry Model held the regulatory agency (ANEEL) and the National System Operator (ONS), responsible for coordinating and overseeing the centralized operation of the Brazilian interconnected system. To monitor and constantly assess the continuity and safety of the power supply throughout the country and to suggest actions, the Power Sector Monitoring Comittee (Comitê de Monitoramento do Setor Elétrico, CMSE) was created, which is also connected to the Ministry of Mines and Energy (Ministério das Minas e Energia, MME).

Furthermore, the Federal Government, based on Laws No. 10,847/2004 and 10,848/2004, kept policymaking about the electricity sector as an Executive power in the hands of the Ministry of Mines and Energy (MME), and advice from the National Energy Policy Council (CNPE) and National Congress. The institutional structure of the electricity sector in this New Industry Model scenario is shown in Figure 3.

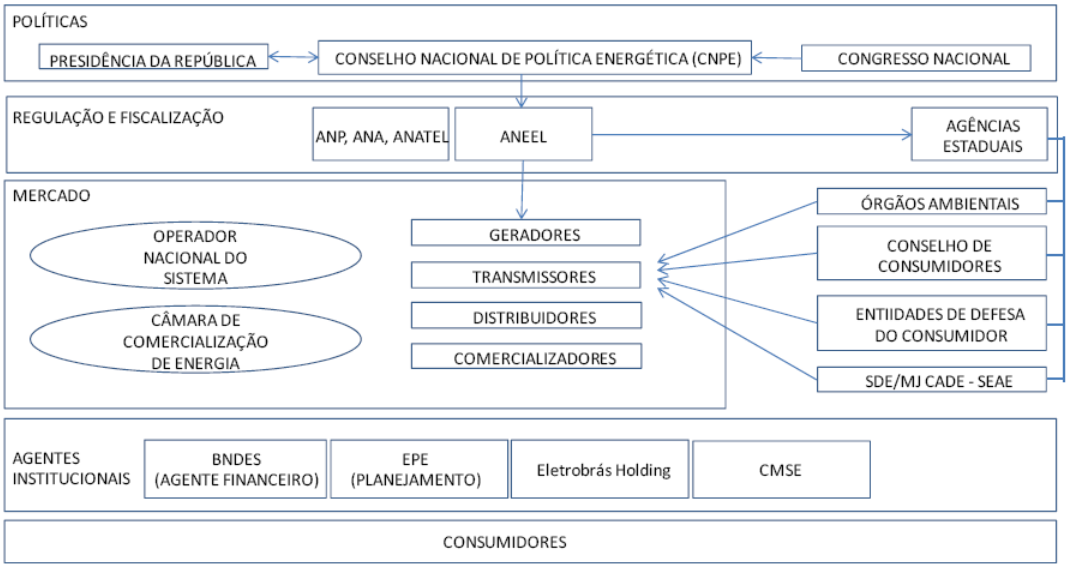


Figure 3. Institutional Structure of the Brazilian Power Sector
Updated by TOMASQUIM, M. et al. Strategies of Regulated Electric Utilities in Brazil. Rio de Janeiro.

The restructured electricity sector, a system that was almost totally controlled and operated by the government, changed to a more competitive system, where local and regional concessionaires were divided into separate independent generation, transmission and distribution companies. The generation and marketing sections followed market rules, while transmission and distribution remained as natural monopolies, all subject to the regulatory body.

Moreover, there are now those who market electricity in the free market, that is, the environment where power generators and consumers negotiate the terms, prices and conditions, for the utility contracts. Table 10 shows the evolution in the structure of the Brazilian electricity sector.

Table 10. Evolution of the Power Sector Structure in Brazil.

Old model (until 1995)	Free Market Model (1995-2003)	New Model (2004)
Financing from public funds.	Financing from public and private funds.	Financing from public and private funds
Vertical companies.	Companies classified by activity: generation, transmission, distribution and marketing.	Companies classified by activity: generation, transmission, distribution, marketing, importing and exporting.
Predominantly state-owned companies.	Decentralization and emphasis on privatization.	Coexistence between Private and State Companies.
Monopolies - nonexistent competition.	Competition in generation and marketing.	Competition in generation and marketing.
Captive Consumers.	Independent and captive consumers.	Independent and captive consumers.
Regulated rates in all segments.	Generation and marketing prices are independently negotiated.	In the independent environment: Generation and marketing prices are independently negotiated. In a regulated environment: auctions and bids look for the lowest rate.
Decisive Planning - Coordinating Group for Electrical System Planning (Grupo Coordenador do Planejamento Determinativo, GCPS).	Planning prescribed by the National Energy Policy Council (Conselho Nacional de Política Energética, CNPE).	Planning by the Energy Research Company (Empresa de Pesquisa Energética, EPE).
Hiring: 100% of the market.	Hiring: 85% of the market (until August 2003) and 95% market share (up dez./2004.	Hiring: 100% of the market + Reserve.
Surplus/deficit energy apportioned among buyers.	Energy surplus/deficits settled in the MAE.	Energy surplus/deficits settled in the CCEE. Surplus and Deficit Compensation Mechanism (MCSD) for distributors.

Prepared based on www.ccee.org.br.

The main objectives of the New Industry Model (GORINI, 2006) are:

- garantee electricity supply security;
- promote fair tariffs, through efficient energy procurement for regulated consumers;
- promoting social inclusion in the electricity sector, especially through universal service programs.

The key elements of this new model are (GORINI, 2006):

- restoring the role of the Executive as the Grantor;
- restructuring medium and long term planning;
- monitoring service conditions in the short term;
- redirecting energy contracts to long-term contracts, consistent with the depreciation of investments made;
- having a bidding competition for the lowest rate in energy generation;
- having both environments coexisting, the environment for regulated energy contracts (ACR) and the environment for independent contracting (ACL) described in Section 4.3.1.3;
- creating a regulated energy procurement pool where distribution concessionaires can purchase;
- unbundling the distribution service from the other activities;

Real conditions for financial feasibility were created from this new model in order to give access to agents of distributed generation, for the case of biogas use for electrical systems in TPPs. It also allowed brokers of energy to share transmission and distribution networks.

In this new model, the agents must follow a set of measures, such as the requirement for distributors and independent consumer to contract the entire demand. In addition, it anticipates contracting with hydroelectric and thermoelectric plants in figures that can ensure a better balance between supply assurance and cost, as well as the permanent monitoring of continuity and supply security, as a means to detect problematic imbalances between supply and demand.

In terms of fair rates, whereby the rate should not overburden consumers. The model provides for distributors in the regulated environment to purchase of electricity, observing the criteria of the lowest rate, aiming at reducing the purchase cost of electricity that will be passed on to the

rate of captive consumers, i.e., those who are subject to the regulated contracting environment (ACR).

Social inclusion seeks to promote universal access to electricity in a manner whereby electricity reaches all those who still do not receive the utility and ensuring that low-income consumers will receive a subsidy so they can afford the cost of electricity.

In the following section there is a description of the main actors of the institutional framework of the electricity sector in Brazil described in Figure 3.

National Electric Energy Agency (ANEEL)

Regulates and monitors production, transmission, distribution and sale of electricity pursuant to federal policies and guidelines. ANEEL, an agency under the Ministry of Mines and Energy (MME), was created by Law 9,427 of December 26, 1996.

Its responsibilities include regulating and monitoring generation, power transmission, distribution and sale, handling complaints by agents and consumers, balancing between the parties and to benefit the population; mediate conflict of interests between agents from the power sector and between these agents and consumers.

It is also responsible for granting, allowing and authorizing energy facilities and services; garantee fair rates, ensuring quality of service; demand investments; encourage competition among utilities and ensure universality of service. ANEEL's mission is to provide favorable conditions for the electric power market to develop a balance between the agents and to the benefit of society;

National Bank for Economic and Social Development (Banco Nacional de Desenvolvimento Econômico, BNDES)

BNDES, under the Ministry of Development, Industry and Foreign Trade (Ministério de Desenvolvimento, Indústria e Comércio Exterior, MDIC), is a federal public company that aims to invest in all segments of the economy to achieve economic development by financing industry, and social development, by giving support to social endeavours and/or financing projects including those to leverage regions and less favored regions or sectors. It has also began including sustainability projects.

Created in 1952, BNDES is the main financing instrument for long-term investments, including infrastructure, basic sanitation, urban transportation, energy efficiency, energy, specially renewable energy sources. The BNDES financing line, Finem, contributes over R$ 10 million to implementation, expansion and modernization projects to the following areas (BNDES, 2012):

- providing special support to environmental projects that encourage the country's sustainable development;

- forestry - focused on reforestation, forest conservation and forest restoration of degraded or converted areas, as well as the sustainable use of natural areas with forest management;
- support for Energy Efficiency Projects (Projetos de Eficiência Energética, PROESCO);
- environmental sanitation and water resources - targetting investment projects for universal access to basic sanitation and to rehabilitate environmentally degraded areas.

Chamber of Commerce for Electric Energy (Câmara de Comercialização de Energia Elétrica, CCEE)

CCEE, successor to the Wholesale Energy Market (MAE), was authorized by Law 10,848, of 15/03/2004, and created by Decree 5,177, of August 12, 2004, began operations on November 10, 2004 as a private non profit entity under ANEEL's regulation and supervision, looks to facilitate the sale of electricity within the National Interconnected System (SIN).

CCEE is a civil association made up of generation, distribution and marketing representatives that aim to facilitate the buying and selling of electricity, both in the environment for regulated energy contracts (ACR) and the independent energy contract (ACL) byt recording and managing contracts between generators, marketers, distributors and independent consumers. In addition, CCEE performs the accounting and settlement of transactions in the spot market.

The ACR is the market segment where the buying and selling of electricity between seller and distribution sellers takes place after the bidding process. This is the area that includes bilateral contracts regulated by ANEEL and signed between market agents before MAE was created, purchase agreements resulting from public energy auctions before CCEE was created, contracts resulting from auctions defined by Decree 5,163/2004 and PROINFA contracts.

ACL includes bilateral contracts signed between CCEE Agents that must register the energy amounts in the contracts to be settled by CCEE. Unlike the ACR, where energy supply prices and conditions are set through an auction, in the ACL, the parties, that is the seller and buyer, conduct the bilateral negotiations among themselves, but both are subject to review by the regulator (ANEEL).

Centrais Elétricas Brasileiras - Eletrobrás

Eletrobrás is a publicly traded company linked to the MME that operates in the areas of power generation, transmission and distribution. Eletrobrás also supports strategic government programs such as the Incentive Program for Alternative Sources of Electric Energy (PROINFA), the Light for All Program (Luz Para Todos) and the National Program for Electric Energy Conservation (Programa Nacional de Conservação de Energia Elétrica, PROCEL).

The main electric energy generation and transmission companies in this system are six (6) Eletrobrás holdings, namely CHESF Eletrobrás, Eletrobrás Furnas, Eletrobrás Eletrosul,

Eletrobrás Eletronorte, Eletrobrás CGTEE (thermal energy generation company) and Eletrobrás Eletronuclear.

As a representative of the Brazilian government, Eletrobrás holds half the capital of Itaipu Binacional. Eletrobrás also controls the Electric Energy Research Center (Eletrobrás Cepel-Centro de Pesquisas de Energia Elétrica) and Eletrobrás Participações S.A. (Eletrobrás Eletropar), and also opertates in the distribution sector through Eletrobrás Amazonas Energia, Eletrobrás Distribuição Acre, Eletrobrás Distribuição Roraima, Eletrobrás Distribuição Rondônia, Eletrobrás Distribution Piauí and Eletrobrás Distribuição Alagoas.

Eletrobrás's generating capacity, including half of the Itapu power belonging to Brazil, is 42,302 MW, currently accounting for about 36% of the national total, while its transmission lines (TLs) add 54,104.94 km long, representing about 56% LTs in Brazil (ELETROBRÁS, 2012).

Electricity Sector Monitoring Committee of the (Comitê de Monitoramento do Setor Elétrico, CMSE)

The CMSE is an entity created under the direct coordination of the MME tasked with monitoring and evaluating the continuity and security of the electricity supply throughout the country. Its main responsibilities include: monitoring power generation, transmission, distribution, marketing, import and export activities.

In addition, it also has the responsibility of assessing supply and service conditions, to conduct regular comprehensive analysis of the security of the supply and service, identify difficulties and obstacles that impact the reliability and security of supply and expansion of the sector and prepare proposals to adjust and execute preventive actions that can restore security in the power supply.

National Council for Energy Policy (Conselho Nacional de Política Energética, CNPE)

The CNPE is an advisory body to the Office of the President chaired by the Minister of Mines and Energy with the responsibility of formulating national policies, guidelines and specific measures (MME, 2012) to:

- promote the rational use of energy resources in the country, puirsuant to applicable law;
- ensure power supply to remote regions of the country or to those that are difficult to access; and when this involves creating subsidies, submit the specific measures to Congress;
- periodically review the energy matrices of the various regions in the country, assessing both conventional and alternative sources of energy as well as the technologies available;

- establish program guidelines for the use of natural gas, ethanol, other biomass, coal and thermonuclear energy, and others;
- establish import and export guidelines to meet domestic demand for oil and for oil products, natural gas and condensate, in addition to ensuring the proper functioning of the National System of Fuel Stocks and compliance.

Energy Research Company (Empresa de Pesquisa Energética, EPE)

EPE is a public company under the MME focused on providing services in the area of studies and research to support the planning of the energy sector, such as electricity, oil and natural gas and its derivatives, coal, renewable energy sources and energy efficiency, etc.

Among its main tasks is conducting studies and developing projections of the Brazilian energy matrix, conducting studies that allow the comprehensive planning for energy resources; studies that facilitate planning for the expansion of generation and transmission of electricity in the short, medium and long term; conducting analyzes of the technological, financial and environmental feasibility of power plants, in addition to obtaining the required environmental license for the use of hydroelectric and transmission of electricity.

These responsibilities are reflected in the planning guidelines for companies. Beginning in 2005, within the planning outlook, EPE took on the responsibility for conducting studies for exploring national and global energy scenarios.

Ministry of Mines and Energy (MME)

Created by Law 3,782/1960 and amended by Law 8,422/1992, it is an agency of the Executive Branch responsible for the geology sectors, energy and mineral resources, water resources and hydraulic energy, mining and metallurgy, in addition to the oil industry and electric energy, including nuclear energy.

National System Operator (Operador Nacional do Sistema, ONS)

The ONS is a nonprofit and private civil society organization association created in August 26, 1998, by Law 9,648/98, as amended by Law No. 10,848/04 and regulated by Decree No. 5,081/04. It is composed by generation, transmission and distribution agents, as well as energy importers and exporters.

Its responsibility is to coordinate and control generation and transmission operations that are part of the SIN, under ANEEL supervision and regulation. In order to accomplish this, it conducts studies and develops projections based on past, present and future data on electricity supply and the consumer market to decide which plants should be closed.

Incentive Program for Alternative Sources of Electric Energy (PROINFA)

The Incentive Program for Alternative Sources (PROINFA), the largest Brazilian program to promote alternative sources of energy, was established by Law 10,438/2002, Article 30 and regulated by Decree 4,541/2002. Its goals include increasing the share of renewable energy (wind, biomass and PCH) to meet 10% of the annual electricity demand within twenty (20) years, providing greater diversification to the Brazilian energy matrix.

Decree 5,025/2004, article 50, sole paragraph, provides, as a premise to PROINFA, increasing the share of wind, solar and small hydroelectric plants sources to reduce emissions of Greenhouse Gases (GHG), pursuant to the Kyoto Protocol of the United Nations Framework Convention On Climate Change (UNFCCC).

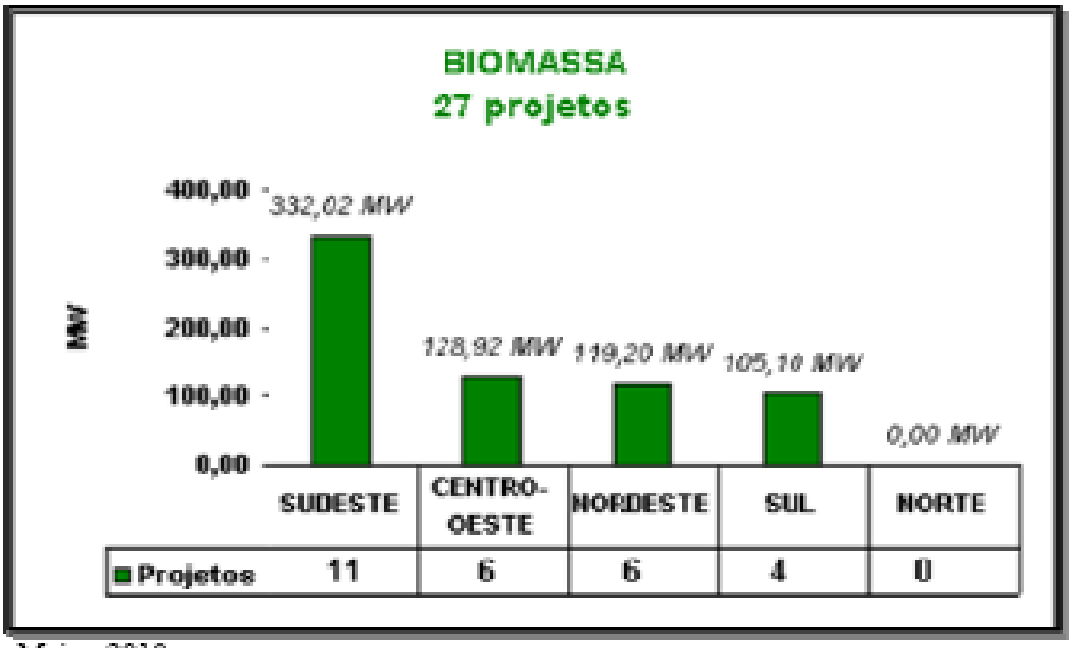
To implement PROINFA, bilateral contracts were signed between producers and the Brazilian power plants, Eletrobrás, guaranteeing purchase of electricity that will be produced for a fifteen (15) year period from the date of entry into operation defined in the contract.

In addition, PROINFA's goals are to increase security of supply and also, to give greater value to real and potenttial regional and local characteristics by creating employment, capacity building and training of skilled manpower. (* Figure 4 reference deleted) [10]

The first phase of PROINFA took place in 2004 through an auction of 3,300 MW, 1,100 MW for each energy source: wind, biomass and small hydroelectric plant (1,100 MW for each technology). Since wind energy in the first phase of PROINFA surpassed the expected 1,100 MW, it increased its share to 1,422 MW, by including the reapportionment of the unfilled share from biomass projects that was short of the inicial expectations.

Figure 5 highlights biomass projects under PROINFA divided by power and region, where the Southeastern region shows a larger venture concentration in Brazil (332 MW).

[10] Figure 4 was not provided in the original report prepared by MMA



Fonte: Meira, 2010.

Source: Meira, 2010.

Figure 5. Biomass PROINFA ventures by Region.

At the same time, when discussing biomass power generation in general, the analyzes focus on the potential the sugar cane bagasse, taking into account that the market by foreign demand, was structured to produce sugar and then ethanol, because at the time there was an international oil crisis during 70s/80s a significant government subsidy to expand the sector and increase productivity.

Moreover, power generation using solid waste is still in its first stages in Brazil. The 2011 passing of the National Solid Waste (PNRS) policy is a strong step forward for the the population. The PNRS allows us to envision building restrictive scenarios for municipal entities responsible for solid waste in charge of providing for an environmentally correct disposal, opening the way to introducing and expanding technologies that leverage such input to generate electricity.

During the initial phase of PROINFA there was no structured market for generating electricity from solar, wind biomass sources. Moreover, at the time the regulatory model has not yet established fair financial terms to access the transmission and/or distribution grid. The scale of projects did not allow the opportunity to reduce the cost of logistics or for purchasing materials and equipment to make it feasible or attractive to private entrepreneurs.

Finally, it should be noted that the national electric setor has its own dynamics, where large enterprises and lower cost technology are given priority and sometimes the short term option is given priority, without incorporating the social and environmental cost of the projects, which may thwart long term development and sustainability.

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CHAPTER 4: CASE STUDIES IN THE U.S. - OHIO AND KENTUCKY

Ohio Case Study

By Anne Goodge

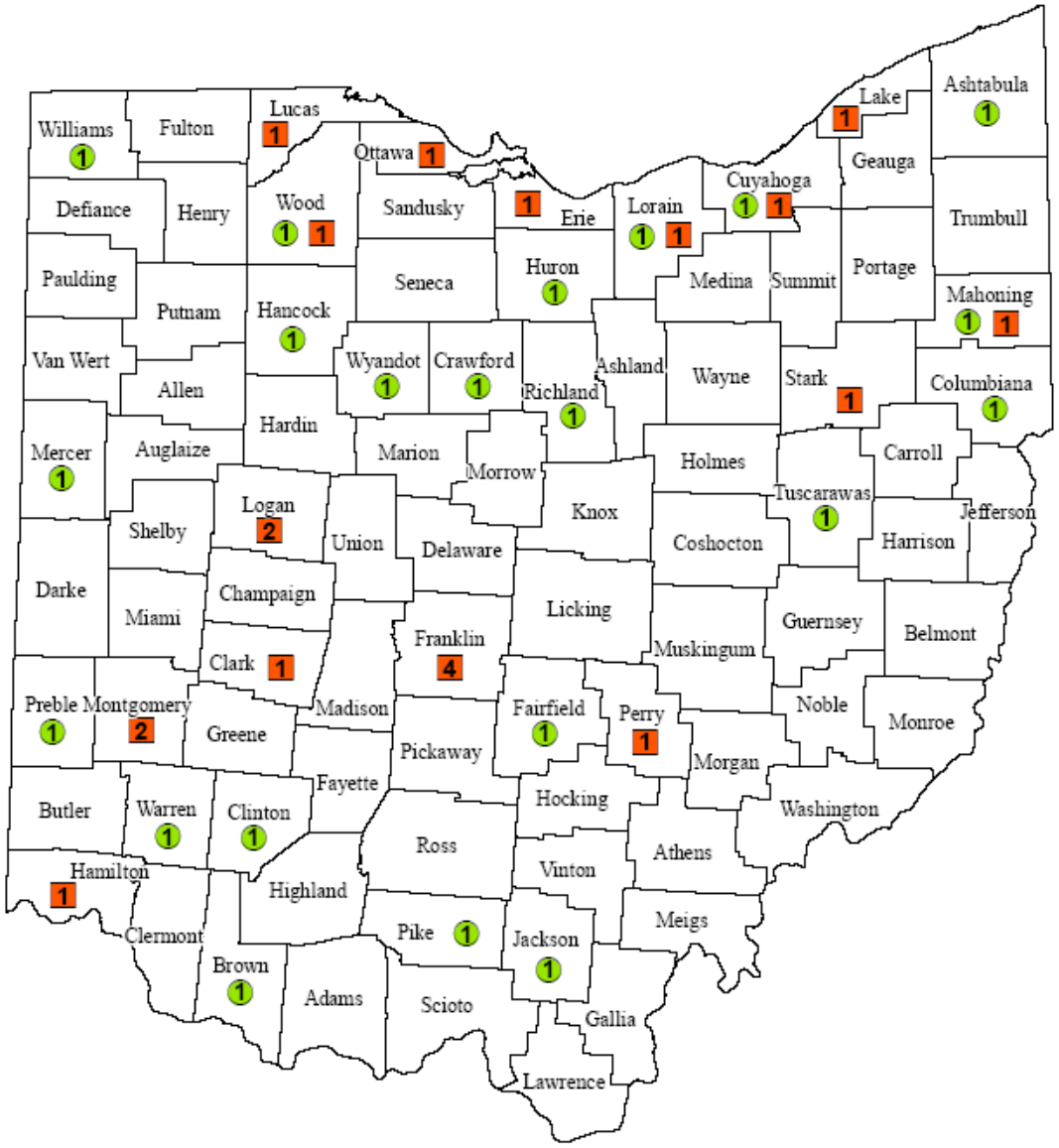
The Ohio Environmental Protection Agency (Ohio EPA), Division of Materials and Waste Management has primary responsibility for regulating solid waste disposal facilities in Ohio. The Division also oversees state and local planning for long-term solid waste management and promotes reuse and recycling of materials and waste generated in Ohio. Other divisions of the Ohio EPA which are responsible for enforcing facility compliance with specific environmental regulations include the Division of Drinking and Groundwater, Division of Surface Water, and Division of Air Pollution Control.

In 1988, the Ohio legislature passed a comprehensive solid waste management law which strengthened the regulations for solid waste disposal facilities and created solid waste management planning programs at both the state and local levels (see attached fact sheet in Appendix A). There are about 40 ? licensed municipal solid waste landfill facilities both publicly and privately operated in Ohio.

Ohio has about 20 operating landfill gas to energy facilities and about 20 landfills that the U.S. EPA Landfill Methane Outreach Program has identified as candidates for landfill gas to energy facilities. The use of the landfill methane gas began as early as 1986, and has included a variety of applications, both electricity generation and direct pipeline use (including three high BTU projects). More recently, a few facilities are creating and using alternative vehicle fuels.

Golf Course near Columbus, OH on closed landfill

The impetus for development of landfill energy facilities in Ohio has been derived from both environmental regulatory requirements for landfill gas collection systems and state and federal financial incentives when available, especially federal tax credits. At the state level, a recently enacted renewable portfolio standard for electricity generation provides a financial incentive for landfill gas to energy facilities that produce electricity.



Landfill Gas Facilities in Ohio

Number of Facilities by County

- **Candidate**
- **Operational**

The U.S. Environmental Protection Agency's Landfill Methane Outreach Program (LMOP) defines a candidate landfill as one that is accepting waste or has been closed for five years or less, has at least one million tons of waste, and does not have an operational or under-construction project; candidate landfills are also designated based on actual interest or planning.

This information is from the EPA's LMOP Landfill/Project database. Information in the database is compiled from a variety of sources by voluntary submittal, is updated periodically, and can change. LMOP can not guarantee the validity of the data.

The Ohio Alternative Energy Portfolio Standard

In 2008, the Ohio legislature adopted an alternative energy portfolio standard to diversify Ohio's generation resources. Ohio's overall electric generation mix has been dominated by a reliance on coal-fired generation (86%), with a relatively minor contribution of renewable sources. Under the standard, by 2025, at least 25 percent of electricity sold in the state by electric utilities must come from alternative energy resources. In addition to traditional renewable energy resources such as solar and wind, electricity generated from landfill methane gas or from solid wastes using advanced technologies, also qualify under the renewable portfolio standard.

By 2012, about 320 landfill gas generating facilities, 98 from Ohio and 232 from states contiguous to Ohio, have been certified in Ohio as renewable facilities, with a total capacity of over 3200 MW. Three solid waste to energy facilities have been certified to use tire, paper and computer plastic wastes. Four facilities generating power from paper manufacturing waste have also been certified. certified. Certification allows the facility owner to create renewable energy credits (RECs) for each megawatt hour of renewable generation produced. These RECs may be sold to Ohio utilities for compliance with the portfolio standard requirement, and thus serve as a revenue stream for the facilities using landfill gas or solid waste to generate electricity.

Rumpke Sanitary Landfill

The Rumpke Sanitary landfill located in the Cincinnati, Ohio area hosts one of the largest landfill gas to pipeline energy production facilities. Rumpke Consolidated Companies, based in Hamilton County, Ohio is one of the largest, privately-owned waste and recycling companies in the U.S. It is a family-owned and operated business that began in 1932. The landfill gas processing plant at the landfill was developed by another company, Montauk Energy Capital. The first of the three gas processing plants now operating at the landfill was installed in 1986 followed by an expansion in 1995. The newest plant was added in 2007, and increased production capacity by 60 percent.

The primary technology used to convert the landfill gas to pipeline quality high BTU gas is pressure swing adsorption which separates carbon dioxide from the landfill gas stream. The total processing capacity is 15 million cubic feet at the plant inlet, and provides the local gas utility, Duke Energy, with a local, renewable energy source, with enough volume to serve 25,000 area homes. In turn, the local University of Cincinnati entered into an agreement with Duke Energy not only to purchase some of the gas to produce campus heating and power, but also successfully applied to the Public Utilities Commission of Ohio to certify the generation as renewable energy for purposes of creating renewable energy credits.

Recently, the company has further expanded its use of the landfill methane resource into transportation fuel. Rumpke has partnered with an Ohio nonprofit organization, Clean Fuels Ohio, to obtain grant funding from the U.S. Department of Energy Clean Cities Ohio Program for a pilot program to run garbage trucks with compressed natural gas (CNG) as an alternative to conventional diesel. US$800,000 in federal grant funding and $2.3 million in matching funding by the company, are being used to purchase 10 CNG refuse collection trucks and to construct a CNG fueling station connected to the gas lines running from the landfill gas recovery system. The pilot project will provides an opportunity for the company to evaluate the use of CNG equipment and fuel in its operations.

Lessons learned

For many years, landfill gas to energy projects in Ohio have provided local, distributed energy using proven technologies, whether the project is a direct use project providing a lower BTU gas to an industrial customer; creating on-site, renewable power that can be used, sold into the electric grid, and certified for the creation and sale of REC's; or creating a cleaner burning, domestic transportation fuel.

The development of particular landfill gas to energy projects can be very site specific and based on a number of factors in addition to technical issues and capital costs, such as location, end use of the energy resource, access to grid or pipeline, on-site energy demand, gas or power purchase agreements, on-site maintenance and technical knowledge, having a local champion for the project, and availability of federal and state and local policy and financial incentives.

Landfill gas to energy resources are subject to changing energy market prices and conditions, especially with regard to pricing and availability of other competing fuel alternatives. The use of landfill methane resources has become a top renewable energy alternative in Ohio given the energy, environmental and economic benefits of using the resource.

OHIO CASE STUDY - Appendix A]

Ohio Environmental Protection Agency

March 2010
DSIWM — 0196

House Bill 592

House Bill 592 (HB 592), signed into law on June 24, 1988, dramatically revised Ohio's outdated solid waste regulatory program. The law also established a solid waste management planning program to be implemented at both the state and local government levels. The bill emphasized the need to reduce Ohio's reliance on landfills for the disposal of waste by increasing solid waste reuse, recycling and minimization efforts. This fact sheet is one in a series explaining the provisions of HB 592 that make up Ohio's solid waste management planning program.

Why was House Bill created?

Prior to House Bill 592 (HB 592), Ohio's solid waste regulatory program was based on a law adopted in 1967 and regulations adopted in 1976. While Ohio's existing law and regulations established a basic solid waste program, the overall scope of the program was limited.

In the mid- to late-80s, Ohio faced a number of problematic solid waste management issues, partly due to the lack of comprehensive regulations governing solid waste facilities and partly due to the lack of planning for how to manage Ohio's solid waste. These issues included:

- decreasing available landfill capacity and fewer operating landfill facilities;
- a lack of planning for new disposal facilities;
- increasing amounts of long-haul (out-of-state) waste being brought into Ohio;
- ground water contamination from poorly sited and designed landfill facilities;
- explosions due to methane gas migrating from landfill facilities;
- desire for increased local control over waste;
- a lack of consistent and effective enforcement of the solid waste regulations;
- limited public involvement in the landfill approval process; and,
- poor operating history of some Ohio landfills.

The seriousness of those issues greatly concerned Ohio's government, private, and public sectors. As a result, Ohio's General Assembly quickly wrote and passed HB 592. The bill made many needed changes to Ohio's solid waste program and created Ohio's current solid waste management planning and regulatory programs.

Requirements Established by HB 592

The new solid waste law instituted by HB 592 created a comprehensive solid waste regulatory program and, for the first time, required Ohio to minimize its reliance on landfills for managing solid waste by increasing efforts to reduce, reuse, and recycle. To accomplish this, HB 592:

- required the director of Ohio EPA to adopt comprehensive regulations governing solid waste disposal facilities.
- required the director of Ohio EPA to adopt a state solid waste management plan.
- created the Solid Waste Management Advisory Council to assist in the preparation and approval of the state solid waste management plan.
- required the board of county commissioners of each of Ohio's 88 counties to establish a solid waste management district, either individually or with other counties.
- required each solid waste management district, working through a policy committee, to prepare, adopt and submit a solid waste management plan to Ohio EPA.
- required the owner or operator of any solid waste facility that began operating prior to Jan. 1, 1980 to upgrade the facility by incorporating best available technology.

Since 1988, Ohio's General Assembly has made changes to the law originally established by HB 592. In some cases these changes have altered the original provisions covering the solid waste management planning program. Still, the basic intent of the program remains unchanged.

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House Bill 592

Related Documents

The Division of Solid and Infectious Waste Management (DSIWM) developed a series of fact sheets describing the requirements from HB 592 that apply to Ohio's solid waste management planning program. The document numbers and titles of other available fact sheets are:

- 0594 — *Ratification of Solid Waste Management District Disposal and Generation Fees*
- 0633 —*Local Solid Waste Management Planning Process*
- 0655 — *Ratification of Solid Waste Management District Solid Waste Management Plans*
- 0658 — *Solid Waste Management Advisory Council*
- *0659 — State Solid Waste Management Plan*
- 1004 — *Local Solid Waste Management Plans*
- 1005 — *Solid Waste Management Districts*

The documents listed above and the current state plan can all be found on the SWMD/Planning Page on DSIWM's Web site.

Interested parties can also contact DSIWM to obtain hard copies of the fact sheets and the current state plan.

For More Information

Ohio EPA
Division of Solid and Infectious Waste Management
P.O. Box 1049
Columbus, Ohio 43216-1049
(614) 644-2621 (phone)
(877) 372-2621 (toll free)
(614) 728-5315 (fax)
www.epa.ohio.gov/dsiwm/

For more information about the planning process and solid waste management in your area, contact your local SWMD. To determine what SWMD you live in, use the *Map of Ohio's Solid Waste Management Districts* that is available on the SWMD/Planning Page on DSIWM's Web site.

To contact your SWMD, call or e-mail the coordinator listed on the *SWMD Coordinators and Policy Committee Chairpersons List* that is available on the SWMD/Planning Page on DSIWM's Web site. You can also contact DSIWM to get information about your SWMD.

OHIOCASE STUDY - Appendix B][11]

OhioEPA

Municipal Solid Waste Landfill Program

Regulation of Municipal Solid Waste (MSW) landfills is under Ohio Administrative Code (OAC) Chapter 3745-27 rules 01 to 20 (Processing & Engineering Unit). Licensing requirements are addressed under OAC 3745-37. These rules are adopted pursuant to Ohio Revised Code (ORC) Chapter 3734. On the federal level, municipal solid waste is regulated pursuant to Subtitle D of the Resource Conservation and Recovery Act under 40 CFR Part 258.

MSW landfills can accept municipal solid waste as well as all other solid waste and exempt waste (e.g. spent nontoxic foundry sand, nontoxic ash, construction and demolition debris). Municipal solid waste is a type of solid waste generated from community, commercial, and agricultural operations. This includes wastes from households, offices, stores and other non manufacturing activities. MSW landfills cannot accept hazardous waste, regulated PCB wastes, bulk liquids or wastes containing free liquids, untreated infectious waste from a large generator, scrap tires or yard waste. An MSW landfill can accept regulated asbestos containing materials if a NESHAP air permit has been granted.

MSW landfills are required to meet design, siting, operating, closure, and post closure requirements. There are design standards for the composite liner system (consisting of recompacted soil overlain by a flexible membrane liner), a leachate management system (designed to limit the level of leachate on the liner system to one foot), a multilayer cap system, and surface water management. To

[11] Source: Ohio EPA's website http://www.epa.state.oh.us

accommodate advances in technology, the rules allow alternative materials and thicknesses. Every 10 years the facility undergoes a review of the landfill design to demonstrate it is consistent with current design standards.

Siting criteria provide for protection of ground water and drinking water wells, as well as setbacks from parks, surface waters, property lines and domiciles. Additionally, there are restrictions associated with airports, flood plains, earthquakes, and unstable areas.

Operating requirements include keeping records of waste loads accepted and rejected; activities at the working face, including the application of daily and intermediate cover; proper management of surface water and leachate; and prevention of nuisances or health hazards (e.g. managing noise, dust, odors, insects and rodents). The operator is also required to monitor the ground water for potential contamination and to monitor for explosive gas migration.

After an MSW landfill is closed, the facility is maintained and monitored for 30 years. Financial assurance is required. If at any time someone desires to disturb the landfill (e.g. build a road, install utility lines, put in ball fields), the director must first give his authorization to do so.

To construct and operate an MSW landfill, various authorizations are required. From the solid waste program, the owner or operator must obtain a permit to install (PTI) issued by Ohio EPA to construct the landfill. Every year the owner or operator must obtain a license issued by the licensing authority (either the health department or Ohio EPA). After a permit is issued, if the owner or operator desires to modify or alter the facility, they must obtain authorization from the director. A modification requires a permit. An alteration requires concurrence from the agency. The law allows an owner or operator to request a variance or exemption from a rule requirement. Often these requests are submitted with the application for a permit. There are fees for permits and licenses but not for alterations, variances or exemptions. Obtaining a permit is a very complex and lengthy process to resolve hydrogeologic issues (for siting and ground water monitoring) and design considerations. There are opportunities for public participation.

Kentucky Case Study

(By John Rogness and Craig Johnson)

Selected Kentucky Statistics

Kentucky Electric Generation 2008

	MWh	**Fuel percentage**
Coal	91,620,588	93.6
Oil	2,874,440	2.9
Natural Gas	978,692	1.0
Other Gas	3,835	*
Hydroelectric	1,917,470	2.0
Other renewable	459,619	.5
Other	8,697	*

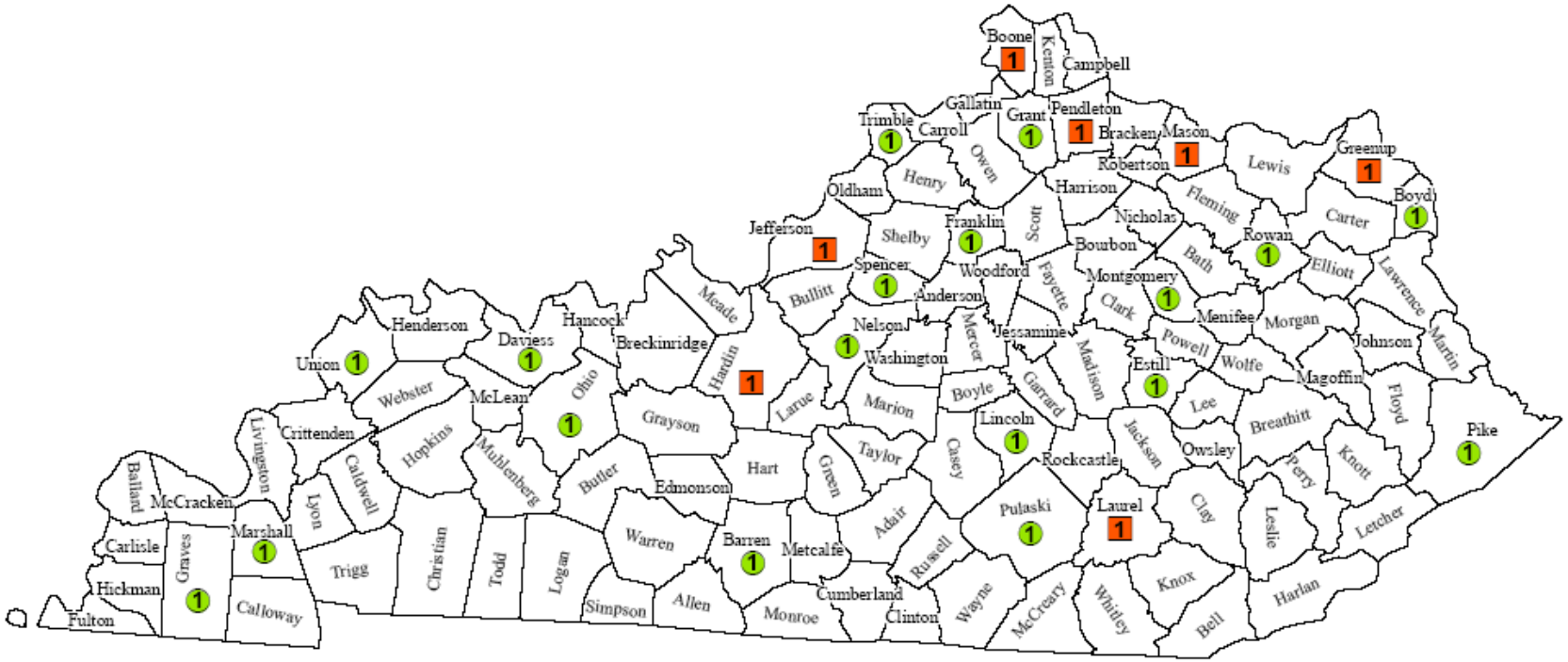
- About 4 million people
- 3rd largest coal producer in the U.S.
- 3rd largest automobile producer in the U.S.
- 40% of aluminum in the U.S. passes through Kentucky
- Average electricity prices consistently rank among the lowest in U.S.
- One of the highest per capita consumers of electricity in the U.S.
- 49% of electricity consumed is consumed by heavy industry and manufacturing

The Kentucky PSC is one of 51 utility regulatory commissions in the U.S. Some states have deregulated their electric utilities and introduced retail electric service competition. In those states, electric generation is separate from distribution and service functions. Retail electric consumers can choose their electric service supplier. However, Kentucky is a "traditional" regulation state. It is one of only two states that regulate electric cooperatives and all of the investor owned (private) electric utilities are vertically integrated from generation to distribution and retail service. All of the electric utilities are monopolies within defined service territories. Even though Kentucky has maintained its traditional regulation of electric utility monopolies, it uses a "least cost" paradigm to keep utility costs (including fuel costs) and electric prices low.

Landfill Gas Facilities in Kentucky

The U.S. Environmental Protection Agency's Landfill Methane Outreach Program (LMOP) defines a candidate landfill as one that is accepting waste or has been closed for five years or less, has at least one million tons of waste, and does not have an operational or under-construction project; candidate landfills are also designated based on actual interest or planning.

This information is from the EPA's LMOP Landfill/Project database. Information in the database is compiled from a variety of sources by voluntary submittal, is updated periodically, and can change. LMOP can not guarantee the validity of the data.



Many states in the U.S. have enacted legislation mandating a Renewable Energy Portfolio Standard (RPS). RPS rules are designed to force electric generators to substitute away from fossil fuels (coal, natural gas and petroleum) and toward renewable forms of energy including solar, wind, biomass and methane. Under a RPS law, an electric utility is required to have a certain percentage of its generation portfolio made up of renewable energy sources. However, because coal is abundant in Kentucky, the average price of electricity remains among the lowest in the U.S. In Kentucky, the price of renewable energy tends to be higher than that generated by fossil fuels. This price disparity has, in part, discouraged the adoption of utility scale renewable energy projects.

However, landfill methane gas has great potential for development in the near future. The EPA regulates landfills and once landfills achieve a certain size, requires the landfill operator to flare the methane. In Kentucky, the EPA has identified 39 landfills with sufficient potential for electric generation. There are 7 active landfill sites (estimated 21.68 million tons in place), 18 candidate sites (estimated 55,686 million tons in place) and 14 potential sites (estimated 19 million tons in place).

East Kentucky Power Cooperative Inc. (EKPC) is an electric generation and transmission cooperative in Kentucky and is the only utility operating landfill methane generators. EKPC currently generates approximately 17 MW of electricity from landfill methane. The landfill operator is responsible for maintaining, collecting and delivering methane (both volume and BTU content) to EKPC. EKPC takes possession of the methane and generates electricity onsite. In addition to the seven EKPC generation sites, there is one other landfill site delivering methane through a five mile pipe to an industrial site.

The following describes East Kentucky Power Cooperative's experience.

By Craig Johnson, East Kentucky Power Cooperative

About East Kentucky Power Cooperative
East Kentucky Power Cooperative (EKPC) was established nearly 70 years ago by its member cooperatives as a not-for-profit generation and transmission utility with headquarters in Winchester, KY. EKPC's purpose is to generate energy and ship it to co-ops that distribute it to retail customers. Today, EKPC provides wholesale energy and services to 16 distribution cooperatives through power plants, peaking units, hydro power and more than 2,800 miles of transmission lines. Together, EKPC and member cooperatives are known as Kentucky's Touchstone Energy Cooperatives.

From our humble beginnings, we have become one of Kentucky's fastest growing electric utilities. The distribution cooperatives supply energy to 519,000 Kentucky homes, farms, businesses and industries across 87 counties.

Kentucky's Touchstone Energy Cooperatives are owned, operated and governed by the people who use their energy and services. The 16 distribution cooperatives, which are called member systems, own EKPC. Each of them has representatives on EKPC's board.

In 2003, EKPC became the first utility in Kentucky to generate its own renewable power when it began operating its first plant fueled by methane gas from landfills. Today, EKPC has six landfill gas plants in operation.

EKPC's Generating Fleet

STATION	NUMBER OF UNITS	STATION CAPACITY, Megawatts Net	FUEL TYPE
COOPER	Two	341	Coal
DALE	Four	198	Coal
SMITH	Nine	1,042	Natural Gas/Fuel Oil
SPURLOCK	Four	1,346	Coal
BAVARIAN	Four	3.2	Landfill Gas
LAUREL RIDGE	Four	2.4	Landfill Gas
GREEN VALLEY	Three	2.4	Landfill Gas
HARDIN (Pearl Hollow)	Three	2.4	Landfill Gas
PENDLETON	Four	3.2	Landfill Gas
MASON	One	0.8	Landfill Gas

EKPC's Sources of Electricity

	Total MW Capacity	Percent of Capacity	MW Hours in 2009	Percent of MW Hours
Coal	1,885	64.6%	10,636,000	97.4%
Natural Gas	1,042 winter	34.8%	192,000	1.8%
Landfill Gas	14.4	0.6%	96,393	0.9%

Why Landfill Gas?

EKPC's landfill gas fleet gives EKPC a diverse source of carbon-neutral fuel. Methane is a powerful greenhouse gas produced when organic waste breaks down in landfills. In 2003, EKPC began generating its own renewable power by siphoning methane gas from landfills for use as fuel, preventing methane from reaching the atmosphere. EKPC was the first utility in Kentucky to build renewable power plants. Today, EKPC has six landfill gas plants, generating enough electricity to power more than 9,000 Kentucky homes. This clean, renewable power is marketed through the EnviroWatt Program. This gives members a choice of purchasing renewable power. With more than six landfill gas plants in operation, EKPC has shown that renewable power from this source can be produced reliably and affordably.

Since methane gas is used as a fuel in our power plants, it is not released into the atmosphere. In fact, EKPC's landfill gas plants eliminate 35,467 tons of methane each year and reduce carbon dioxide emissions by 85,063 tons, the equivalent to any one of the following annual benefits:

- Planting 152,398 acres of forest
- Offsetting the use of 3,732 railcars of coal or
- Removing emissions from using 80,399,192 gallons of gasoline

EKPC's Landfill Gas Stations

In the fall of 2003, EKPC opened three power plants that produce electric power from landfill gas. Each $4 million landfill gas-to-electric plant converts landfill methane into electricity. The projects have been applauded for being both environmentally responsible and cost efficient.

Of the 6,000 landfills across the U.S., there are about 340 with landfill gas-to-electric projects currently in operation. The Environmental Protection Agency estimates as many as 500 additional landfills could tap methane cost-effectively as an energy source, producing enough electricity to power one million homes across the country. EKPC now ranks as one of the leaders in renewable energy production in the Southeastern United States.

Operation and Maintenance

All of EKPC's landfill gas generation facilities are of similar design and layout. This standardizes operation and maintenance. EKPC has seven personnel dedicated to the operation and maintenance of the facilities. The engine/generator set of choice for EKPC has been the Caterpillar 3516 LE. This features a 16-cylinder reciprocating engine with a heat rate of 11,300 btu's per kw hour and a gas consumption of 275 SCFM of 550 btu's per cu.ft. EKPC has 19 of these engine/generator sets in our fleet. One engine is placed in rotation with all the facilities. This is done so that major engine overhauls can be performed on the fleet without the loss of generation.

The care and operation of these facilities is performed by our landfill gas generation group. This group is made up of one employee per station with the exception of Mason County. There is one floating employee and one supervisor. All of the maintenance is performed by this group with the exception of major engine overhauls. The group teams up to perform more involved maintenance activities such as engine top-end repairs. EKPC has found it best to remove an engine and return it to a rebuild center for major overhauls. The team typically works four ten-hour days during the work week. The control systems at each station have been configured to call in the designated operator if there are issues. The designated operator routinely has to attend to the station on their off days. Most of the after hour issues with our engines are due to changing gas quality from the landfill. The operator routinely has to adjust the amount of vacuum being pulled on the landfill collection wells to correct for oxygen content in the gas. The gas quality has been found to change with the seasons.

1 Generator Caterpillar 3516 LE

The annual operating and maintenance budget excluding the cost of fuel is approximately $300,000 per station. The fleet averages a capacity factor of 75%. The average bus bar cost for the fleet in 2009 was $45 per MW hour. EKPC's average operation and maintenance cost is $20 per MW hour. The maintenance cost of the fleet is increasing as more of the older engines require major overhauls.

Marketing Renewable Power

EKPC started its own marketing program to sell renewable energy produced by the landfill gas generating stations. The power is branded as EnviroWatts.

Through the fifteen participating distribution cooperatives, EnviroWatts are sold to members in 100 kWh blocks. Each block adds $2.75 to a member's monthly utility bill for one year. Each month, approximately 4,080 blocks are sold (total changes monthly). This number is equally split between commercial and residential participants. Co-op annual meetings are the primary source of residential sales for the program. Businesses can become Silver, Gold, or Platinum members of the EnviroWatts program. For interested businesses, EnviroWatts can fulfill requirements for LEED certification and the EPA's Green Power Partnership Program.

Promotional Efforts:

- Website, www.envirowattsky.com
- Facebook, www.facebook.com/envirowatts, 150 friends
- Twitter, www.twitter.com/envirowatts, 377 followers
- Programs available for community and school groups
- Tours of the six landfill-gas power plants are available

Sale of Renewable Energy Credits

EKPC also markets renewable energy credits (RECs) from the energy produced by the six landfill gas stations. The state of Kentucky does not have a Renewable Portfolio Standard (RPS), making the sale to in-state utilities difficult. Several states to the north of Kentucky, including Ohio, do have a state-imposed RPS. This is the primary source of the REC sales.

Project Development

According to EPA, Kentucky has approximately 18 landfills of sufficient size capable of supporting electric generation. EKPC's Board of Directors has approved the development of cost-effective, reliable renewable energy projects. EKPC has developed a list of candidate sites that can support electric generation. Typically, EKPC is approached by the landfill operator interested in establishing a plant. Or, in some cases, EKPC makes the initial contact. A gas supply study is the first step in the development of the business case for a new facility. EKPC has relied upon independent engineering firms specializing in municipal waste landfills for the estimate of potential gas production. It takes approximately a million tons of municipal solid waste to support 800 kilowatts of electricity. The facilities are designed to operate for 20 years. EKPC has found that the actual rate of gas produced from the wells can be 50% less than predicted. This is due to varying conditions found in the actual operations. Larger landfills which operate under the Federal EPA's Title V Air Permit are required to have a gas collection system with a flare. These facilities are easier to predict the rate of gas produced based upon the actual amount of gas being flared. Smaller landfills that only require passive gas collection are harder to predict. In all new prospects, EKPC will utilize only a portion of the gas predicted to develop new sites. The varying conditions found at EKPC's existing facilities include poorly designed gas collection systems, high levels of leachate in the landfill, poor well-field tuning, and poor leachate pump maintenance.

The business case is developed utilizing the number of engine/generators that can be operated at the landfill. The amount of money EKPC can pay to the landfill operator for gas supply is then negotiated. This is often the go, no-go point. If the initial negotiation for gas price is successful, a gas supply contract with the landfill operator is drafted. The contract should have a clear distinction on the responsibility of duties and include incentive provisions to the landfill operator for maintaining high gas production. EKPC has found it is advantageous to take an active role in the tuning of the well fields. The tuning requirement of the well field to support a landfill gas generating facility is critical to a high-performing operation.

The financing of EKPC's facilities typically has been done with Clean Renewable Energy Bonds (CREBS) through the Cooperative Financing Corporation (CFC.) The interest rate for this financing is one percent. The bus bar cost is offset by the Renewable Energy Production Incentive (REPI) and the sale of RECs. EKPC has received REPI payments from the federal program totally $1.1 million over the past six years. The REPI program has been underfunded by the federal government by 85% and should not be relied upon for justification of a new facility. Facilities qualify for the REPI program for only 10 years after their initial operation.

A justified project is then taken to EKPC's Board of Directors for their consideration. The Board's approval of the project results in the filing of necessary applications to Kentucky government agencies for regulatory approvals. EKPC is regulated by the Kentucky Public Service Commission. EKPC must file for an application to the PSC for the Certificate of Need and Necessity. A filing is made at the same time to the Kentucky Division of Air Quality for the air permit. Typically, the regulatory process takes six months to a year. The construction of the facility takes approximately eight months. EKPC uses a three-year planning cycle for justification of new projects.

CONCLUSION

EKPC's landfill gas generation program has proven to be a valuable addition to EKPC's generating portfolio. The facilities as a whole are reliable and cost-effective. The challenge remains in the development of the future facilities in an uncertain world. The value of gas in the landfill operator's opinion is more in some cases than economics can justify. Only a few large landfill operations remain undeveloped which can support multiple engine/generators. The smaller facilities are more difficult to justify. EKPC is evaluating the use of larger high-efficiency engine/generator sets to make the smaller landfills more economical to develop.

Kentucky Climate Action Plan Council

n early 2009, the Kentucky Energy and Environment Cabinet (KEEC) began a long range planning effort for the possibility of new federal legislation of or new U.S. Environmental Protection Agency (EPA) regulations for greenhouse gas (GHG) emissions released into the environment. This long range planning effort is unique among the large coal producing states and among the large coal burning states. The KEEC set out to identify opportunities for Kentucky to:

- Evaluate and understand the state's vulnerability to GHG constraints,
- Mitigate the impact of any federal legislation or regulations to address GHG emissions,
- Become more energy efficient and energy independent,
- Become more energy efficient and energy independent,

To ensure that Kentucky was well positioned to react to any new limits on GHG emissions, the Kentucky Climate Action Plan Council (KCAPC) was formed. The KCAPC is made of 30 voting members and five Technical Working Groups (TWGs) with an additional 49 members. KCAPC members were drawn from diverse and often competing stakeholder groups across the state. Members include leaders from private industry and manufacturing, coal mining, agriculture, non-profit organizations, electric generation and distribution utilities, universities, elected officials, and state and local governments. The five TWGs are responsible for developing recommendations based upon rigorous cost benefit and risk analysis for policy options with the purpose of reducing GHG emissions. The five TWG economic sectors of concentration include:

- Agriculture, Forestry and Waste Management (AFW)
- Transportation and Land Use (TLU)
- Energy Supply (ES)
- Residential, Commercial and Industrial (RCI)
- Sector Cross Cutting issues (CCI)

Technical advisors were hired to facilitate meetings and to provide unbiased assistance in quantifying the cost and impact of the various TWG recommendations. The final TWG policy

recommendations include an analysis of risks and feasibility and whether additional action by the Kentucky Legislature is required for implementation. The final report is expected in the fall 2011 and includes a policy recommendation specific to Landfill Methane Energy Programs. Programs. The goal of which is by 2025 to reduce uncontrolled methane emission by 50 percent. In conjunction with the reduction in landfill methane emissions, the goal contemplates increasing annual renewable energy production from landfill methane gas to 88 MW per year.

CHAPTER 5: CONCLUSIONS AND RECOMMENDATIONS FOR BRAZIL [12]

Note: the following conclusions and recommendations were provided by consultants of the MMA in Brazil. The original report has some minor editing by MMA.

Conclusion

Comparing the ABRELPE annual reports for 2008, 2009 and 2010 we can see that: MSW per capita has increased; almost 7 million tons of MSW per year are not being collected and is certainly disposed of inapporpiately; 6.4% municipalities in Brasil do not collect residential waste, especially in the Northeast region which contains 12.6% of the municipalities.

Household solid waste in Brazil consist of approximately 55% of organic matter that when placed in the soil, even when using the appropriate technology, such as in a landfill, generates leachate and greenhouse gases.

Of the MSW collected in 2010, 57.6% was properly disposed of by 2,164 municipalities, in landfills set up througout the country. However, that same year there was still a significant number of inappropriate waste disposals from 1,760 municipalities that send their waste to controlled landfills and 1,641 that send them to dumps that need to undergo remediation processes.

The Government is struggling to fund, implement and broaden the necessary infrastructure to provide sanitation services (including the suitable final destination for MSW). The average investment amount per year in 2010 for MSW collection was R$ 4.52/person and R$ 74.88/person for sanitation services. In almost all municipalities of Brazil, total or partial municipal sanitation services are paid through fees, but the amounts of the fees are inadequate.

Under these circumstantes trash collection through private companies is a viable option and has been increasingly adopted in Brazil. The municipalities contract with companies through a bidding process, regulated by Law 8,666/93. The companies become concessionaires or are granted permission to execute public services pursuant to Law 8,987/95. The responsibility for the service remains with the public administration.

The content of this chapter was prepared by consultants at the Brazilian Ministry of the Environment.

The alternative gas use to energy from the combustion of municipal solid waste associated with trading carbon credits contributes to the solution of sustainable MSW management. This mechanism may be used as strategic leverage to eradicate open dumps and encourage sustainable solutions to the MSW problem that is present mainly in underdeveloped countries.

[12] The content of this chapter was prepared by consultants at the Brazilian Ministry of the Environment.

According to Henriques (2004), in Brazil, biogas use to energy is the most simple use for solid waste and it is the most common use in the world. The calorific value of biogas is 14.9 to 20.5 MJ/m3, or approximately 5,800 kcal/m3. Biogas recovery has the advantage of reducing greenhouse gas emissions from landfills and generating energy.

The manner in which the process of recovering biogas is implemented can contribute to generating disadvantages, such as inefficiency in the biogas recovery process with rates of recovery of approximately 50% of the biogas produced, and the high cost of expanding the plant when the projected capacities are surpassed.

The most use given to biogas is as fuel for generating power, which is made available through the local concecionaire grid, where the electricity is sold to a nearby consumer. Power generation is advantageous because it produces an added value to biogas.

Case studies were developed to analyse the landfill gas use for energy produced at the Bandeirantes landfill, located in São Paulo, SP, at the Metropolitano do Centro (AMC) landfill, located in Salvador, BA, at the CTRS/BR 040 landfill, located in Belo Horizonte, MG and at the CTR Nova Gerar landfill, located in the city of Nova Iguaçu, RJ.

The Bandeirantes Thermoelectric Plant was built on the landfill in 2001 and began the operations to capture gas in 2004. It is managed by the Biogas Energia Ambiental SA company which was granted the concession by the Municipality for a 15 year period, through a bidding process. The estimated cost for the project design, implementation, equipment, tubing and building the 280 gas collection wells, and the operation of the plant was US$30 million.

Each ton of household waste placed in the landfill generates an average of 200 m3 of biogas. From August 2004 to October 2011, the landfill recorded a daily production average of 438,813,886 m3 of biogas with a CH4 percentage of approximately 48.21% resulting in an overall CH$ daily average production of about 212,425,827 m3.

The plant already obtained 3,663,368 reduced emission certificates (RECs) from a total of 17 inspections in the 2004 to 2010 period and is awaiting the 18th inspection to obtain 228,197 for carbon credits. According to the concession, 50% of the credits go to City Hall which trades through auctions. A total of approximately R$ 51 million has already been collected with the sale of carbon credits.

The total electricity exported by the plant from 2004 to 2011, was 714,403 MW available through the concessionaire grid which is sold to private companies.

The Termoverde Salvador Plant is the first landfill biogas thermoelectric power plant of the Northeast region, built on the AMC landfill, in Salvador, over an area of approximately 7,000 m2. The landfill was inaugurated in 1997, and gas collection system has been in operation since January 2004, but construction on the plant began in November 2008 and started operations in January 2011.

It is managed by BATTRE, the company that was granted the concession for 15 years by the Municipality through a bidding process. Total estimated cost was R$ 45 million for 2003-2019 distributed in investment costs (for flares and biogas capture systems) and operating costs (electricity for pumping, deployment and maintenance of biogas grid, etc.).

Not included in the contract is the additional remuneration for improving the biogas capture or biogas to energy use, and because of this, all investment or operating costs required to burn more than the amount stated in the contract is considered extra and will not be remunerated except through Reduced Emission Certificates.

The project estimates the average biogas per ton of waste placed in the landfill is 180 m3 biogas/ton of refuse. In the 2006-2010 period, the AMC has received 4,508,646.24 tons of MSW which would result in producing approximately 811,556,323 m3 of biogas. If the average value of CH4 is 48%, CH4 production would be 389,547,035 m3 where 61% of this value would have been collected and burned.

The thermoelectric's power capacity is 20 MW, it generates clean energy from household waste deposited in the landfill producing 150,000 MWh per year, exporting 16.4 MW to domestic use (biogas plant), average energy sold during the year (energy delivered in a flat scheme - discounting of maintenance downtime which is two to three days per year).

The Salvador Termoverde plant has already recorded and certified approximately 4 million tons of CERs pursuant to the Kyoto Protocol. The concession agreement signed with the Municipality of Salvador and BATTRE requires that 5% of gains obtained with carbon credits be applied by the company in social/environmental projects.

The projected emission reductions are 13,958,155 tCO2e throughout the operational lifetime of the project (16 years), a 664,674 tCO2e average per year, and 4,911,649 tCO2e during the first crediting period.

The ASJA Thermoelectric Plant obtained its operating license for biogas in May 2011. The concession was granted by the City government for 15 years through a bidding process in March 2008. The City received R$ 16 million in the bidding process to transfer the carbon credits rights to the company, and retaining 5%, (which amounts to approximately R$ 35,000/month) from the gains in power generation.

The cost of implementing the power system is ASJA's responsibility and was estimated at R$ 20 million. Added to that, the cost of design, operation and monitoring are also the company's responsibility.

The CEMIG (electric power company of Minas Gerais) encourages alternative energy generation and was interested in purchasing the biogas generated power. The negotiations were bilateral with a sales contracts for set amounts of energy. The term of the agreement is from January 1st, 2011 to December 31st, 2014. During the November 2010 to September 2011 period there have been 27,389.80 MWh of energy exported into the utility grid.

The gas use project estimates about 5,577,900 tCO2e emission reductions during the 10 years. Trading in carbon credits is in progress.

The CTR landfill, Nova Gerar, RJ is managed by the Nova Gerar company through a concession granted in a bidding process led by the Municipality of Nova Iguaçu, in 2001. In 2001, the city of Nova Iguaçu issued a request for The proposal included a waste management concession for 20 years, in addition to the environmental recovery of the old Marambaia Dumpsite and to design

and implement the landfill project, including the environmental licensing, deployment, operation and monitoring for an additional 20 year period after activities have ben closed.

The city receives 10% of all revenue generated in the project, including the carbon credits, and has a 20% discount for disposing of waste (deduction). The removal of clean waste from construction and demolition sites is free of charge to the city of Nova Iguaçu. Medical waste disposal is charged per kilo to individuals and per tons to the municipality county pursuant to the concession.

The beginning of the activities in the landfill began in 2003 and despite having the first CDM project approved in CIMCG in 2007, with estimated emission reductions in the amount of 14 million tCO2e, the company believes that the investment for construction, operation and maintenance of the thermal power plant aimed at using gas from midsize landfills is very high and presents great risk.

The landfill receives approximately 3,000 tons/day and since the beginning of the operations it has recorded over 6,000,000 tons of waste, with a specific weight of 12.73 kN/m³. It can collect, treat and flare biogas.

According to the PDD, a modular unit with three 1,415 MW generators (total combined capacity of 4,245 MW) and 2 transformers to transform the power and deliver to the grid (input voltage 380 V, output 13,8 KV, 12,500 KVA capacity). The power plant is estimated to operate from 2012 to 2026.

In all the landfills included in this study, CDM projects and carbon credits trade therof have produced gains that contribute or will contribute to implement and operate the plant that will use MSW gas to generate clean energy.

Industry Needs

The main needs identified by government agencies responsible for the collection and disposal of municipal solid waste:

1. increase actions to minimize the waste production;
2. conduct a technical assessment of the rates charged for urban sanitation services (which includes final destination of residential waste);
3. build capacity of technicians working in the area of municipal solid waste;
4. create landfills and remedy contaminated areas that are used as controlled landfills or dumps;

There is a need to encourage and promote development of equipment suitable for landfill gas projects in Brazil. Mainly, technology imported from countries such as Italy (flares), Germany (flow meters and gas analyzers), Switzerland (flares), United States (flares and engines) and the Netherlands (flow meters and gas analyzers).

The use of biogas generated in landfills is is technically and economically viable and an increasingly attractive proposition, especially for larger landfills. To increase this opportunity, however, it is important to formalize and transform dumps into landfills or at least control them.

Barriers and Difficulties to Success

The main difficulties identified by the companies operating the thermoelectric power plants set up at the Bandeirantes landfill (SP), the AMC landfill (BA), the CTRS-BR 0.40 Landfill (MG) and the CTR Nova Gerar landfill:

Bandeirantes Thermoelectric Plant (SP):

1. Manage gas quality in terms of daily and seasonal climate variations;
2. Monitoring the capture wells that were installed when the landfill was still in operation, because of the constant requests for changes in the plans to install wells;
3. Identifying the location of breaks in the HDPE pipes due to movements in the landfill and fluctuations of ambient temperature;
4. The condensate accumulation in the pipes, especially secondary pipes with smaller diameter, often prevents biogas from passing through the pipes;
5. LFG operation and collection should not be carried out by different companies;
6. Renewal of the environmental license, has been in progress for two years, and has bot been issued yet.

Salvador Termoverde Plant (BA)

1. Certification procedures that last an average of 6 months;
2. Procedures to adjust and analyse PDD are slow;

CTRS-BR 0.40 Thermoelectric Plant (MG)

1. Lack of skilled labor;
2. High cost and deadline to import equipment;
3. Environmental licensing for the capture and use of biogas has difficulties due to lack of knowledge on the part of the technical staff of the environmental agency and standardizing the activity plan;

CTR Nova Gerar Landfill

1. High investment cost for installing the Thermal Power Plant at a midsize landfill according to investors.

Recommendations

The Brazilian government, through the Incentive Program for Alternative Sources of Electric Energy-PROINFA, established in 2002, aims to reduce greenhouse gas emissions, increase the use os organic waste as an energy source (SALOMON, 2007).

With ANEEL Resolution No. 390, adopted on December 15, 2009, authorizing the sale of surplus power from all self-power producers in Brazil (ANEEL, 2009), the use of landfill biogas in internal combustion engines to generate power, is a promising demand potential and its sourse is present in all landfills.

A specific study to conduct a detailed survey of landfill and thermolelectric plant implementation and operation costs is recommended. The budgets of the companies visited were not made available to see deployment costs or operational costs. Costs were estimated in a comprehensive manner to include deployment, all the necessary equipment, and operation by investors.

The literature provides superficial costs such as, estimated cost of motor generators, but taking into account that many other devices are used, such as blowers, condensers, flare, meters, gas collection wells, construction of power house, private power network deployment to the local utility grid, qualified staff, etc., it becomes necessary to inquire and research and obtain the cost for each specific case.

Additional recomendations:

1) Offering tax incentives for municipalities that meet the criteria of environmental preservation, such as the deployment of landfills with energy recovery;
2) Disseminating technical information to the municipalities about the construction and operation of landfills with biogas utilization and the technology options for generating energy from municipal solid waste;
3) Establishing of lines of credit by development banks with preferencial rates for building landfills with biogas recovery systems, including midsize landfills;
4) Assessing penalties to municipalities that maintain dumps, without any environmental control or energy recovery;
5) Reducing import duties;
6) Setting price differentials for sale of renewable energy source;
7) Encouraging industries to purchase energy from landfill gas;
8) Studying the possibility of reducing state value added tax to generate power from biogas, which is 30% and which is hindering investment in the sector, and
9) Simplifying and streamlining the procedures to approve and obtain carbon credits.

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