LANDFILL GAS AVOIDANCE PROJECTS AS AN ALTERNATIVE SOLUTION IN THE URBAN SOLID WASTE MANAGEMENT

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Abstract: *This contribution refers to the potential environmental impacts caused by municipal solid waste landfills due mainly to the release of methane gas. It proposes alternative uses for the landfill gas taking into consideration the current opportunities for investments on landfill gas projects through the Kyoto Protocol and its Clean Development Mechanism. Benefits for the local economy resulting from landfill gas avoidance projects are also highlighted.*

Keywords: waste management, landfills, methane gas, Kyoto Protocol, Clean Development Mechanism

1 Introduction

A large number of urban and rural localities all over the world are currently facing harmful environmental transformations due to the population growth and to an increase of the industrial activities. Consequently, it has been observed a significant increase in the amount of disposable consumption goods offered, generating garbage and several kinds of wastes which required larger disposal sites. In fact, to find the appropriate location to dispose of the solid urban waste generated by one or more towns have became a great challenge due to the environmental and health impacts[1] which may occur in the surrounding zone during the operation of the landfill site and after its operation if its enclosure is not properly managed. Additionally, the construction of a landfill site and its operational costs may be too high for some communities which deal with a large amount of solid urban waste. This problem has been observed in most of developing countries and in all under development countries where still exist a large amount of dump sites with improvised solutions for the urban waste disposal.

Although the environmental impacts of dump sites are more evident, there are several aspects of landfill operations that may have a significant impact upon the environment if not well managed, such as: water pollution (groundwater and surface water), air pollution, changes in the landscape and visual discomfort, soil contamination, dust, litter, noise, mud and pests.

It the following section are presented in more detail the main potential environmental impacts caused by the operation of a landfill site. The probability of each impact to occur and the severity of each impact will depend mostly on the safety and efficiency level of the operations in the site.

On further sections, all attention is focused on the environmental impacts caused by the release of methane gas from landfill sites and the alternative solutions for its avoidance through energy recovery projects. These projects are being efficiently implemented in a worldwide level and this trend has been observed boosted by the possibility of acquisition of carbon credits through the Clean Development Mechanism of Kyoto Protocol. An example of landfill gas avoidance project will be briefly presented.

[1] "Insects which are in contact with dump sites may spread endemic and infect-parasitic diseases in a range up to 12 Km". LIXO (s.d Available in: www.asaep.hpg.ig.com.br/lixo.html. Acessed in: 11/11/2006.

2 Potential environmental impacts caused by landfill sites

In the Table 1 are presented the most remarkable potential environmental impacts caused by landfill operations and possible ways how to prevent them:

Table 1: The most remarkable environmental impacts caused by landfill operations

Potential Impacts	How impacts may occur	How impacts may be prevented
Soil and Water Pollution (ground water and surface water) on the surroundings of the landfill site by nitrates, nitrites and other pollutants.	As rain falls on the landfill site the water comes into contact with the waste and is contaminated. This contaminated water is called leachate and can affect adversely even the adjoining soils which bring along consequential effects to their utilization.	Installation of liners to prevent movement of liquids into water supplies and leachate recovery and treatment systems.
Air Pollution (landfill gas) and intensification of the Greenhouse Effect	Landfill gas and unpleasant odors are produced from decomposition of organic waste disposed of in landfill	Installation of methane gas recovery system and energy recovery system to burn the methane.
Litter	On windy days there is the potential for waste on the site to be blown away.	Litter control fences must be in place around the tipping area to minimize this problem.
Dust	In very dry weather the site can become dusty.	A water bowser shall be deployed to dampen all dusty areas as and when necessary.
Mud	In very wet weather there is the danger that mud from the site could be carried out on to the road.	The site shall contain a wheel wash and all vehicles shall be required to use this before leaving the site.
Noise	Noise from the landfill site can be an issue for nearby residents.	Installation of sound barrier moveable walls and use of vegetation to reduce noise.
Dissemination of pathogenic agents	The collection, transport and storage of urban waste facilitate the multiplication and dissemination of the pathogenic agents and their accompanying breed: insects, rats, crows, stray dogs.	The pathogenic agents shall be dealt effectively and regularly by a local pest control company.

3 Methane gas and its environmental impacts

Methane gas is considered the second largest contributor to the global warming due to the drastic increase of its concentration in the atmosphere in the last two centuries. Scientists created a parameter to measure the contribution of each greenhouse gas on the global warming which is called Global Warming Potential (GWP). The GWP is the ratio of heat trapped by one unit mass of the greenhouse gas to that of one unit mass of CO2 over a specified time period.2 The references values of GWPs published by the Intergovernmental Panel of Climate Change (IPCC) consider a 100 year time horizon. Taking these premises into account, it was estimated that methane gas has a global warming potential 21 times bigger than carbon dioxide.

[2] http://www.epa.gov/highgwp/scientific.html

Because methane has a fairly short atmospheric lifetime (from 9 to 15 years), and because it is so effective in trapping heat, efforts to reduce methane emissions will have a rapid impact on mitigating global warming. Methane gas can also contribute on the formation of Volatile Organic Compounds (VOC) and ozone in the troposphere which together with other air pollutants contribute on the creation of photochemical smog, a serious concern for human health in major urban centers once it can cause breathing problems, eye and nose irritation and decrease the immunity capacity of organism. Hospital admissions and respiratory deaths often increase during periods when ozone levels are high in the troposphere.3

Methane is emitted from a variety of both human-related (anthropogenic) and natural sources. Human-related activities include fossil fuel production, animal husbandry (enteric fermentation in livestock and manure management), rice cultivation, biomass burning, and waste management. These activities release significant quantities of methane to the atmosphere. It is estimated that 60% of global methane emissions are related to human-related activities (IPCC, 2001c). Natural sources of methane include wetlands, gas hydrates, permafrost, termites, oceans, freshwater bodies, non-wetland soils, and other sources such as wildfires.4

Municipal solid waste landfills are the largest source of human-related methane emissions in the United States, accounting for about 25 percent of these emissions in 2004.5 This problem is similar in most of developed countries where there is a high per capita generation of solid waste and is becoming a topic of importance in many developing countries where a significant increase on consumption rate has been observed in the last decades.

Methane is generated in landfills and open dumps as waste decomposes under anaerobic (without oxygen) conditions. The amount of methane created depends on the quantity and moisture content of the waste and the design and management practices at the site.

Unlike other greenhouse gases, methane can be used to produce energy since it is the major component (95 percent) of natural gas. Consequently, for many methane sources, opportunities exist to reduce emissions cost-effectively or at low cost by capturing the methane and using it as fuel.

At the same time, methane emissions from landfills represent a lost opportunity to capture and use a significant energy resource. Landfill gas (LFG) consists of about 50 percent methane (CH4), the primary component of natural gas, about 50 percent carbon dioxide (CO2), and a small amount of non-methane organic compounds.

The use of LFG helps to reduce odors and other hazards associated with its emissions, and it helps prevent methane from migrating into the atmosphere and contributing to local smog and global climate change.

4 Extraction of landfill gas and its alternative uses

Landfill gas is extracted from landfills using a series of wells and a blower/flare (or vacuum) system. This system directs the collected gas to a central point where it can be processed and treated depending upon the ultimate use for the gas. From this point, the gas can be simply flared or used to generate electricity, replace fossil fuels in industrial and manufacturing operations, fuel greenhouse operations, or be upgraded to pipeline quality gas. Within all possible destinations from the recovery of LFG, the generation of electricity is the most used one. There are a varied number of available technologies for for this purpose,

[3] http://en.wikipedia.org/wiki/Photochemical_smog
[4] http://www.epa.gov/methane/sources.html
[5] http://www.epa.gov/lmop/

including internal combustion engines, turbines, microturbines, Stirling engines (external combustion engine), Organic Rankine Cycle engines, and fuel cells. The vast majority of projects use internal combustion (reciprocating) engines or turbines, with microturbine technology being used at smaller landfills and in niche applications. Certain technologies such as the Stirling and Organic Rankine Cycle engines and fuel cells are still in the development phase.6

It is estimated that a LFG project can capture roughly 60-90% of the methane emitted from the landfill, depending on system design and effectiveness. The captured methane is destroyed (converted to water and the much less potent CO2) when the gas is burned to produce electricity7.

Producing energy from LFG avoids the need to use non-renewable resources such as coal, oil, or natural gas to produce the same amount of energy. This can avoid gas end-user and power plant emissions of CO2 and pollutants such as sulfur dioxide (which is a major contributor to acid rain), particulate matter (a respiratory health concern), nitrogen oxides (NOx), and trace hazardous air pollutants.

It should be noted that LFG electricity generation devices, like all combustion devices, generate some emissions of NOx, which can contribute to local ozone and smog formation. Depending on the fuels and technologies used by the power plant and the landfill project, the NOx emission reductions from the power plant may not completely offset the NOx emitted from the LFG electricity project. However, the overall environmental improvement from LFG electricity generation projects is significant because of the large methane reductions, hazardous air pollutant reductions, and avoidance of the use of limited non-renewable resources such as coal and oil that are more polluting than LFG.

5 Benefits to the local economy derived from landfill gas projects

Every landfill gas project generates revenue from the sale of the gas and can also create jobs associated with the design, construction, and operation of energy recovery systems. Landfill gas projects involve engineers, construction firms, equipment vendors, and utilities or end-users of the power produced. Much of this cost is spent locally for drilling, piping, construction, and operational personnel, helping communities to realize economic benefits from increased employment and local sales. Businesses are also realizing the cost savings associated with using LFG as a replacement for more expensive fossil fuels, such as natural gas. Some companies will save millions of dollars over the life of their LFG energy projects. For example, the Ecology Club at Pattonville High School in Maryland Heights, Missouri, came up with the idea to use gas from the nearby landfill to heat their school. The school paid $175,000 to run a 3,600-foot pipeline between the landfill and the school's two basement boilers. In turn, the landfill owner donated the methane to the school as a way of "giving back to the community." The school anticipates that it will save $40,000 a year, and recapture its investment within five years.8

6 Opportunities on the landfill gas projects through the Kyoto Protocol

Besides all the benefits previously mentioned as a result of the recovery of methane gas from landfill sites for the generation of electricity and heat, it is noteworthy to remind the possibility to have these projects accredited by the Executive Board of the United Nations on

[6] http://www.epa.gov/lmop/overview.htm#methane

[7] http://www.epa.gov/lmop/benefits.htm - CO_2 emissions from MSW landfills are not considered to contribute to global climate change because the carbon was contained in recently living biomass. The same CO_2 would be emitted as a result of the natural decomposition of the organic waste materials outside the landfill environment.

[8] http://www.epa.gov/lmop/benefits.htm

Climate Convention (UNCCC) as a Clean Development Project in one of the developing countries.

The CDM is one of the flexibility mechanisms established by the Kyoto Protocol with the purpose of facilitating attainment of the targets for greenhouse gas (GHG) emission reduction that were defined for each of the ratifying countries. In short, the CDM proposal (described in Article 12 of the Protocol) states that each tonne of CO2 equivalents1 (tCO2e) which is not emitted or which is removed from the atmosphere by a developing country (non-Annex I) may be traded in the form of carbon credits in world markets, thereby providing an additional incentive to further the reduction of global GHG emissions.

The Kyoto Protocol determines that all Annex I parties (industrialized countries with emission reduction targets) must establish the emission reduction targets of the main GHG emitters that reside within their territories, in accordance with the national target set for them by the Protocol. With the introduction of the CDM, companies which are not able or do not wish to reduce their emissions according to their government established targets may as an alternative purchase **Certified Emission Reductions (CERs)** from developing countries which have implemented GHG emission reduction projects, and use those purchased CERs to help them comply with their obligations. However, it should be noted that the use of this mechanism is limited to only a part of their reduction commitments. In order to benefit from the incoming revenues obtained from CER sales to industrialized countries, developing countries, in turn, must create CDM projects to foster sustainable development.

In order to obtain CDM project validation a proposed GHG emission reduction project must first comply with a series of legal procedures at which time it will receive authorization from the UN through its **CDM Executive Board**, which is the ultimate instance for evaluating CDM projects.

Within the CDM framework there are currently a higher concentration on projects related to energy industries (renewable and non-renewable sources) followed by waste handling and disposal projects as the graphic 1 below may represent:

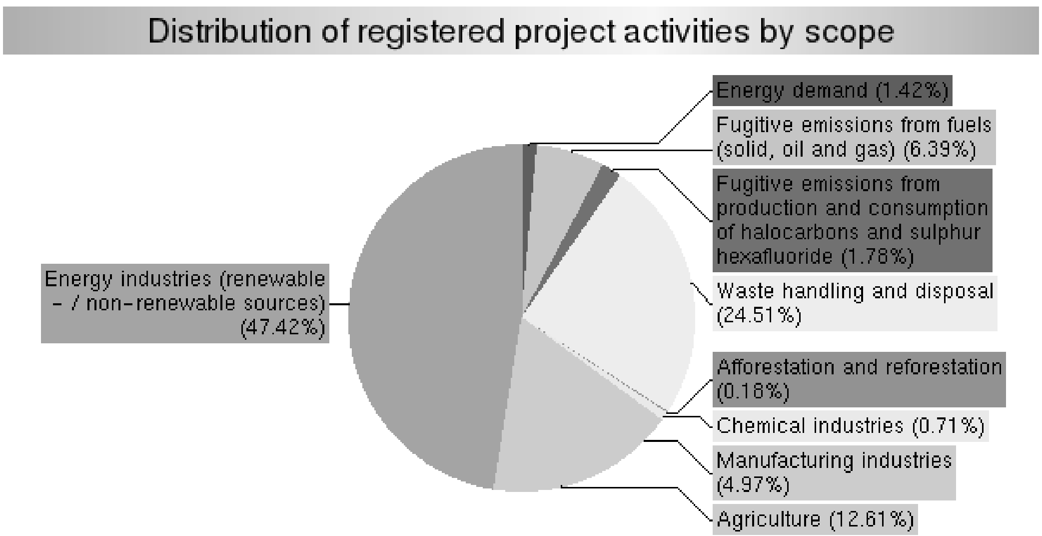

Fig. 1

There are currently 29 landfill gas projects registered by Executive Board under the CDM framework and most of them (about 30%) are implemented in Brazil. The first LFG project ever implemented under the CDM framework was registered on November 2004 and is called Nova Gerar.

Nova Gerar is a joint venture between EcoSecurities, an environmental finance company which specializes in greenhouse gas mitigation issues and S.A. Paulista a Brazilian civil engineering and construction firm based in the city of Sao Paulo, Brazil.

In 2001, S.A. Paulista was granted a 20-year concessional licence by the Empresa Municipal de Limpeza Urbana (EMLURB – Municipal Waste Collection Company, a government agency responsible for waste collection and disposal) to manage the Marambaia and Adrianopolis landfills in the State of Rio de Janeiro, and to explore the landfill gas potential of these sites.

The objective of Nova Gerar joint venture is to explore the landfill gas collection and utilization activities of the landfills managed by SA Paulista. This include the investment in a gas collection system, leachate drainage system and a modular electricity generation plant at each landfill site (with expected final capacity of 12 MW), as well as generator compound at each site. The generators combust the methane in the landfill gas to produce electricity for exporting to the grid. Excess landfill gas, and all gas collected during periods when electricity is not produced, shall be flared.

It is expected that the capture and combustion of the landfill gas methane to generate electricity will effectively result in the avoidance of 14.072 million tones of CO_2 emissions over 21 years.

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