

# Doña Juana Landfill Gas-to-Energy

Bogotá, Colombia 



## Bogotá's landfill project transforming waste-emitted gas to energy

The Doña Juana Landfill in the District Capital of Bogotá is the biggest sanitary landfill in Colombia, and one of the largest projects under the UN Clean Development Mechanism (CDM) in South America [13]. The project involves landfill gas capture (LFG), flaring treatment and use for thermal energy production on-site or in nearby industries [17]. The landfill provides a solution for the disposal of around 2 million tons of household solid waste generated by the almost 8 million inhabitants of Bogotá city each year [12]. The technology applied in the project activity is the combustion of the landfill gas captured at the landfill gas network, using different processes like direct flare in burners or gas-to-energy reciprocating engine use for electricity production [13].

### Country/ City Profile



Country		City	
Population (2014)	48.93 million [1]	Population (2014)	8 million (city) [2] 10.7 million (metropolitan) [4]
Land area (km <sup>2</sup> )	1.109 million	Land area (km <sup>2</sup> )	1,587 (city) 4,321 (metropolitan)
GDP per capita (2014, current international \$, at purchasing power parity)	13,046 [19]	GDP per capita (2014, US\$, at purchasing power parity)	n/a (city) 17,497 (metropolitan)[4]
Region	South America	Region	Inland (4°36'N, 74°5'W)

### City's physical geography

Location	<ul style="list-style-type: none"> <li>✓ In the center of the country, in the eastern part of the Andes Mountains (<b>occasional seismic activity</b>)</li> <li>✓ Set in a mountainous plateau area with a great variety of climates, soil types, water bodies and natural formations</li> <li>✓ Placed between mountains that act as a natural barrier, the city is restrained from humidity flow = it influences rain regimes [7]</li> <li>✓ Relatively high altitude (2,640m) = lower atmospheric oxygen levels</li> </ul>
Climate	<ul style="list-style-type: none"> <li>✓ subtropical highland climate zone (average temperatures: 15-20°C) = varied and unpredictable weather [5]</li> <li>✓ 799 mm of average annual rainfall [8], two rain seasons, one from March to May, and one from September to November</li> </ul>

### Initiating context

Landfills produce methane when organic matter decays under natural anaerobic conditions. Landfill gas (LFG) is normally composed of almost 50% methane, and can be a source of clean energy. LFG can be used as a direct substitute for fossil fuel consumption to generate electricity, or refined and injected into the natural gas pipeline [15].

Although Bogotá does not have a selective waste collection system, nearly 100% of the solid waste in Bogotá is collected, with 96% going to the landfill. The city performs poorly when it comes to recycling, only about 5% of solid waste in the city was recycled in 2011 (around 357 tons per day). Recycling is done informally by scavengers who get paid by the City according to the amount of solid waste sorted. Higher-income groups subsidize the waste collection tariffs for low-income communities. The solid waste sector in Bogotá is operated by both private and public concessionaires, and it is overseen by the city Unidad Administrativa Especial de Servicios Públicos (UAESP), a special unit within the municipal government in charge of public services [9].

## Project description

Located in Usme, around 20 kilometers south of Bogotá, the Doña Juana landfill includes a leachate treatment plant and a number of biogas collection facilities managed by private companies under concession agreements. The project involves landfill gas capture, flaring treatment, use in reciprocating engines and use for thermal energy production in nearby industries at the landfill site [12, 13].

The landfill is owned by the City of Bogotá, and has been operating since 1988 [8]. The City had launched an ambitious program called “Basura Cero” (Zero Waste), [11] with the goal of reducing the amount of landfilled solid waste by 2025. This framework encourages people and private entities to increase recycling activities and selective collection. In 2007, the Bogotá local government conceded to “Biogas Doña Juana S.A. E.S.P.” [16] to build and operate the landfill project for a period of 23 years and one month [12, 17].

UAESP reported that the amount of waste dumped at the landfill between 1998 and 2012 amounted to more than 28 million tons, and it has increased every year. In 2012, 2.28 million tons of solid waste entered the landfill, approximately 190,000 tons per month, or 6,300 tons per day [9].

## Implementation process

In 2009, the landfill gas network implementation started; followed by the blowers and flares plant, gas engines, and the treatment and distribution plant (all 100% operational by the end of 2010) [14]. The landfill consists of several zones and phases of waste disposal operation, LFG extraction having started in the newer areas, Zone 8 and Zone 2 Area 3 (150 hectares), which contain 16.320,895 and 465,807 tons of waste, respectively [17]. The estimated gas extraction rate from these areas is 13,000 m<sup>3</sup>/h (Zone 8) and 1,100 m<sup>3</sup>/h (Zone 2), [10] representing almost 60-70% of the total potential gas that can be produced; future extraction will include other zones [14].

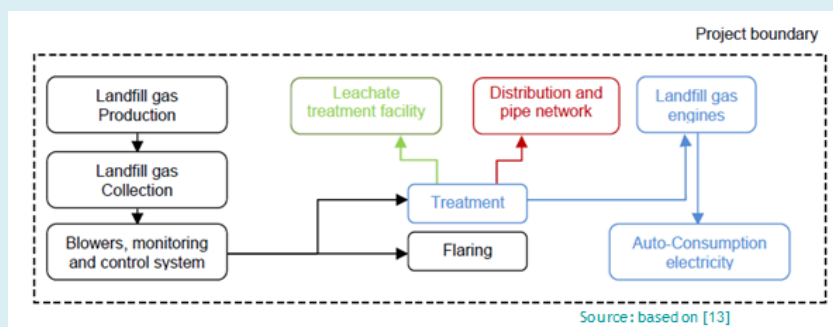
## Projects implementation details

<b>Process</b>	Being conceded in 2007 to “Biogas Doña Juana S.A. E.S.P.”, the landfill operators have installed a flaring system that began operating in early 2009. The waste disposal area is divided in eight cells (zones). Cell 8 (currently in operation) started receiving waste in June 2002, covers a 41 ha area, and has a 13 million tons capacity [8, 16].	
<b>Financing</b>	The project has been developed by a private consortium under a concession contract; the investment is coming from private loans totaling €13 million (US\$18.6 million), which are expected to be repaid through the revenues obtained from the sale of CERs (Certified Emissions Reductions credits) [10, 16, 17]. In 2014, the Nordic Environment Finance Corporation bought 5.39 million CERs to give a lifeline to the project since the near zero carbon price exposed the landfill to discontinuation risks. After securing the long term CER purchase, Biogas Doña Juana S.A. E.S.P. is seeking to invest further in on-site renewable energy production, thus improving the sustainability of the project [18].	
<b>The technology and equipment installed on site</b>	<ul style="list-style-type: none"> <li>✓ A gas collection pipe network and vertical gas wells</li> <li>✓ A pumping system and high temperature enclosed flares</li> <li>✓ A gas analyzer room</li> <li>✓ A supervisory control and data acquisition system</li> <li>✓ A treatment and compression plant</li> <li>✓ A reciprocating engine for auto-consumption electricity generation</li> </ul>	<b>Involved stakeholders</b> <b>Current project participants</b> <ul style="list-style-type: none"> <li>✓ Biogás Doña Juana S.A. ESP (Colombia - host)</li> <li>✓ Biogás Doña Juana S.A. ESP (Switzerland)</li> <li>✓ Nordic Environment Finance Corporation (Norway)</li> </ul>

### Four main phases of project development:

1. The landfill gas network (“LFG Network”), blowers and flares plant (“LFG Plant”).
2. The landfill gas engines.
3. The treatment and distribution plant and pipe network for delivering landfill gas to the nearby brick factories.
4. The leachate treatment facility.

As of 2014, phase 1 and 2 are fully operational, while phase 3 has not been commissioned yet. The technology needed for phase 4 has not been implemented yet [14].



## Results

Doña Juana Landfill Gas-to-Energy project is considerably reducing GHG emissions from the landfill by flaring LFG, generating electricity for its own consumption and using thermal energy production in nearby industries. The CDM monitors the emission reduction progress of the project and publishes a report every 6 months; over the 9th monitoring period (July-December 2014), the emission reduction amounted to 437,044 tCO<sub>2eq</sub> and resulted in credits that industrial countries can use for meeting their emissions reduction targets. [14] Total GHG emission reduction is estimated to 14.8 million tons of CO<sub>2</sub> equivalent over the entire 22-year-life of the project. This figure could be increased by future waste disposal areas equipped with biogas extraction infrastructure [10].

### Project benefits

<b>Direct benefits [13, 17]</b>	<ul style="list-style-type: none"> <li>✓ Increased support for industrial development in Colombia</li> <li>✓ Increased geotechnical stability of the waste mass</li> <li>✓ Increased technology know-how and skilled labor</li> <li>✓ Reduced LFG and odor emissions</li> <li>✓ Improved environmental conditions of the neighboring communities</li> <li>✓ Development and implementation of new technologies</li> <li>✓ Integrate stakeholders in the project</li> <li>✓ Improving landfill management</li> </ul>	<b>Technology transfer [12]</b>	<ul style="list-style-type: none"> <li>✓ “First of its kind” project in Colombia</li> <li>✓ The thermal use of landfill gas by brick factories or any other application has never been developed before in Colombia</li> <li>✓ The project will support efforts aimed at facilitating the dissemination of design and operational experience gained at Doña Juana landfill for possible use throughout the region or country</li> <li>✓ The generation of RE from the landfill gas for the site needs will allow transferring technology and knowledge on a small scale</li> </ul>
<b>Environmental benefits [14]</b>	<ul style="list-style-type: none"> <li>✓ Reducing GHG emissions by 14.8 million tons of CO<sub>2</sub> equivalent</li> <li>✓ The combustion of landfill gas oxidizes the methane into CO<sub>2</sub>, a gas with lower global warming potential</li> <li>✓ Flaring (with a retention time above 0.3 seconds) of the collected landfill gas not only destroys methane, but also destroys compounds in the landfill gas such as volatile organic compounds and ammonia</li> <li>✓ Minimize the accumulation of landfill gas by creating a dynamic and controlled collection system, thereby reducing the risk of explosion or the potential threat to human health</li> </ul>	<b>Financial benefits [10]</b>	<ul style="list-style-type: none"> <li>✓ The city will keep more than 24 % of the CERs and more than 2 % of the energy sold by the LFG concessionaire during the project life.</li> <li>✓ This income is invested in social projects agreed upon by the communities surrounding the landfill, such as parks, water and wastewater projects, recreation and sports centers. In 2011 investments in these social projects exceeded US\$1.2 million</li> </ul>

### Lessons learned

Having the Doña Juana Landfill Gas-to-Energy project registered to the CDM enables the payment of the initial private investment through the sales of Certified Emission Reductions (CERs). Also, the securing of long term CER purchase by the Nordic Environment Finance Corporation improved the sustainability of the project [18]. Capturing and using LFG can produce substantial energy, economic, environmental, air quality, and public health benefits. Local authorities and solid waste operators can benefit from engaging citizens in waste recycling. Public awareness campaigns could be organized to educate the city inhabitants on selective waste collection and also to promote the city’s programs to reduce landfill solid waste [9, 15].

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