













Design and Performance Evaluation of an Automated Biogas Combustion System for Emission Mitigation in Landfills





Diseño y evaluación del desempeño de un sistema automatizado de combustión de biogás para la mitigación de emisiones en rellenos sanitarios

Aguirre-Orozco, Mario Abelardo ^a, Portillo-García, Lizeth ^b, Salinas-Pérez, Martin Alejandro ^c and Baray-Guerrero, Maria del Rosario^{^*} ^d

^a  Tecnológico Nacional de México - Instituto Tecnológico de Delicias •  KDO-9073-2024 •  0000-0002-6899-5230 •  813343

^b  Tecnológico Nacional de México - Instituto Tecnológico de Delicias •  LFS-6873-2024 •  0009-0008-1474-2925 •  732411

^c  Tecnológico Nacional de México - Instituto Tecnológico de Delicias •  LFS-4652-2024 •  0000-0003-2420-9909 •  286299

^d  Tecnológico Nacional de México - Instituto Tecnológico de Delicias •  OTI-5082-2025 •  0000-0002-0289-9000 •  201384

Classification:

Area: Engineering and Technological Development

Field: Engineering

Discipline: Waste Management

Subdiscipline: Biogas Utilization

 <https://doi.org/10.35429/EJE.2026.13.23.4.1.9>

History of the article:

Received: April 01, 2026

Accepted: May 31, 2026

*  [\[rbaray@uach.mx\]](mailto:rbaray@uach.mx)



Abstract

Sustainable development requires the implementation of technologies aimed at reducing the environmental impact of human activities, particularly those related to solid waste management and greenhouse gas emissions. In this context, landfills represent a significant source of methane [CH₄], a greenhouse gas with a global warming potential substantially higher than that of carbon dioxide. This study aims to design, develop, and evaluate the performance of an automated biogas combustion system for emission mitigation in a landfill located in the central-southern region of the state of Chihuahua, Mexico. The methodology involved site analysis, design of the automated combustion system, component selection, integration of sensors and control elements, and operational testing to assess system performance. The results demonstrate that the proposed system enables stable and controlled combustion of the generated biogas, contributing to the reduction of direct methane emissions into the atmosphere and improving the environmental management of the landfill. The study concludes that automated biogas combustion systems represent a technically feasible, relatively low-cost technological alternative with high potential for application in developing regions, consistent with cleaner production strategies and climate change mitigation efforts.

Objectives	Methodology	Contribution
Evaluate the technical feasibility of an automated biogas combustion system for mitigating methane emissions in a landfill	Y8610U Turn Signal Retrofit Kit	to contribute to environmentally sound management of waste disposal and to the strengthening of integrated waste management strategies in the municipalities that make up the region

Biogas, Landfill, Emission Mitigation, Automated Combustion System, Environmental Engineering.

Resumen

El desarrollo sustentable exige la implementación de tecnologías que permitan reducir el impacto ambiental de las actividades humanas, particularmente aquellas asociadas a la gestión de residuos sólidos y a la emisión de gases de efecto invernadero. En este contexto, los rellenos sanitarios representan una fuente significativa de metano [CH₄], gas con un potencial de calentamiento global considerablemente mayor al del dióxido de carbono. El presente estudio tiene como objetivo el diseño, desarrollo y evaluación del desempeño de un sistema automatizado de combustión de biogás para la mitigación de emisiones en un relleno sanitario ubicado en la región centro-sur del estado de Chihuahua, México. La metodología incluyó el análisis del sitio, el diseño del sistema de combustión automatizado, la selección de componentes, la integración de sensores y elementos de control, así como pruebas operativas para evaluar su funcionamiento. Los resultados obtenidos muestran que el sistema permite una combustión estable y controlada del biogás generado, contribuyendo a la reducción de emisiones directas de metano a la atmósfera y mejorando la gestión ambiental del relleno sanitario. Se concluye que la implementación de sistemas automatizados de combustión de biogás constituye una alternativa tecnológica viable, de bajo costo relativo y con alto potencial de aplicación en regiones en desarrollo, alineada con los principios de producción más limpia y mitigación del cambio climático.

Objetivos	Metodología	Contribución
Evaluar la viabilidad técnica de un sistema automatizado de combustión de biogás para la mitigación de emisiones de metano en un relleno sanitario	Y8610U Juego de Modificación Retroactiva de Piloto Intermitente	contribuir a una gestión ambientalmente adecuada de la disposición final de los residuos y al fortalecimiento de estrategias de manejo integral de residuos en los municipios que conforman la región.

biogás, relleno sanitario, mitigación de emisiones, combustión automatizada, ingeniería ambiental.

Area: Promotion of frontier research and basic science in all fields of knowledge

Citation: Aguirre-Orozco, Mario Abelardo, Portillo-García, Lizeth, Salinas-Pérez, Martin Alejandro and Baray-Guerrero, Maria del Rosario. [2026]. Design and Performance Evaluation of an Automated Biogas Combustion System for Emission Mitigation in Landfills. ECORFAN Journal-Ecuador. 13[23]1-9: e41323109.



ISSN 1390-9959/© 2009 The Author[s]. Published by ECORFAN-Mexico, S.C. for its Holding Ecuador on behalf of ECORFAN Journal-Ecuador. This is an open access article under the CC BY-NC-ND license [<http://creativecommons.org/licenses/by-nc-nd/4.0/>]

Peer Review under the responsibility of the Scientific Committee MARVID®- in contribution to the scientific, technological and innovation Peer Review Process by training Human Resources for the continuity in the Critical Analysis of International Research.



Introduction

At present, all municipalities in the south-central region of the state dispose of their municipal solid waste in open dumps, which poses a serious pollution problem.

Faced with this problem and keen to offer the region's inhabitants a feasible, modern and efficient solution for solid waste management, the idea arose to create a regional landfill site, involving the municipalities of Delicias, Rosales, Meoqui, Julimes and Saucillo. In 2008, the Association of Municipalities of the South-Central Region was established, comprising the aforementioned municipalities, and this marked the start of work to commission a feasibility study for the construction of the landfill.

On 16 August 2010, Banobras granted a non-repayable grant of up to \$27,200,000 to support the five municipalities forming the association.

On 21 December 2010, Banobras granted an additional non-repayable grant of up to \$8,817,898 to the Municipality of Delicias, for the collection of solid waste from that municipality.

Once the study was completed and the project's feasibility confirmed, the land on which it would be located was identified and acquired, with an initial investment of \$13,760,904.

Box 1

Table 1

Waste generation in the participating municipalities

Municipality	Population	Daily Generation [tonnes]	%
Delicias	127,211	102	58.5%
Meoqui	41,389	33	19.0%
Saucillo	28,508	23	13.1%
Rosales	15,935	13	7.3%
Julimes	4,507	4	2.1%
Totals	217,550	174	100%

The information provided here is based on the 2005 General Population Census, which served as the basis for calculating the population percentages for each municipality; these figures, in turn, formed the basis for calculating the contributions.

To date, all infrastructure has been completed and the facilities include:

Internal roads. Perimeter fencing, lighting. Security hut. Weighbridge. Offices. Workshop area. Basic services.

The advantages of converting municipal rubbish dumps into a landfill site, amongst others, are as follows:

- ü Waste control.
- ü Reduction of environmental impact.
- ü No contamination of groundwater.
- ü Additional products.
- Ø Waste recycling.
- Ø Biogas.
- ü Generation of carbon credits.

On Wednesday 15 June 2010, the decree establishing the "Operating Body for the South Central Region Sanitary Landfill" was published in the State's official gazette. This Inter-municipal Decentralised Body [ODI] is responsible for administering the landfill and managing relations between the landfill operator and the municipal authorities.

The ODI will be responsible for supervising the services to be provided by the company awarded the landfill operation contract, which are:

- Waste collection.
- Transfer stations.
- Landfill operation.
- Negotiations and coordination with the recycling company.
- Surveillance and control of the landfill.

For the operation of the landfill, multi-year funding is required.

To resolve the issue of the final disposal of Municipal Solid Waste and Special Management Waste [MSW and SMW], the municipalities surrounding Delicias—which make up the region known as Centro Sur—met.

These are the municipalities of Delicias, Meoqui, Rosales, Saucillo and Julimes. This area is shown in Figure 1.

Box 2



Figure 1

Location of the Central-Southern Region of the State of Chihuahua.

To a large extent, in addition to the significant overall savings achieved by constructing a regional landfill rather than several local ones, the site complies with Mexican Official Standard 083-SEMARNAT-2003. This NOM requires final disposal sites to meet certain requirements based on the daily tonnage of waste they receive. This site is classified as Type A, meaning it will receive more than 100 tonnes daily.

One of the most important features of this type of landfill is that it must have a waterproofing system to ensure that the subsoil adjacent to the site is not contaminated by the infiltration of leachate [liquids produced by the decomposition of organic matter in the waste], either through the installation of a geomembrane or by adapting the existing material on site, provided this is feasible.

With the participation of representatives from the municipalities involved in this project, an agreement was reached on the best location for this project [Figure 2].

Box 3



Figure 2

Site locations

The five municipalities in the region therefore acquired the selected land, and work on the landfill began.

Currently, the regional landfill has a capacity of 18 years and 11 months of operation; however, its useful life will exceed 20 years.

There is a need to degrade or utilise the methane gas produced by the landfill waste, as methane gas and other greenhouse gases are released 24 hours a day, negatively impacting the environment as this is one of the causes of global climate change. For this reason, the ten existing wells emitting methane gas will be interconnected via an automated burner.

The importance of managing waste deposited in inter-municipal landfills lies in the fact that it decomposes through a series of complex chemical processes. The main products of decomposition are leachate and gases. [Monroy et al., 1990] Both liquids and gases can affect the health of surrounding communities.

The relevance of methane gas production stems from the activity of microorganisms such as bacteria, which, through biological processes, degrade the waste, emitting methane and other gases, Gunnerson et al., 1986; Varel et al., 1976 and releasing other chemical substances. The gases produced by the anaerobic fermentation of organic matter in the waste constitute a difficult problem to solve. [OLADE, n.d.; Pfeffer et al., 1973]. Depending on the amount of waste involved, gas production can be significant and prolonged.

Consequently, there is a need to degrade or utilise the methane gas produced by landfill waste, [Rodríguez et al., 1985; Cyted E. Roberto et al., pp.16–34]. as this greenhouse gas is released 24 hours a day, negatively impacting the environment as it is one of the causes of global climate change.

Methodology

Biogas can be released into the atmosphere, or it can be burned or used to generate energy. [Kispert et al., 1975; Wong-Chong, 1975] In this case, a burner will be designed for installation in the landfill's chimneys.

The model assumes certain simplifications of reality that must be taken into account for its correct application:

Aguirre-Orozco, Mario Abelardo, Portillo-García, Lizeth, Salinas-Pérez, Martín Alejandro and Baray-Guerrero, María del Rosario. [2026]. Design and Performance Evaluation of an Automated Biogas Combustion System for Emission Mitigation in Landfills. ECORFAN Journal-Ecuador. 13[23]1-9: e41323109. <https://doi.org/10.35429/EJE.2026.13.23.4.1.9>

Article

1. The landfill does not accumulate biogas; whatever is generated is emitted.
2. There are no significant quantities of industrial waste with physical and chemical characteristics very different from those of common municipal waste that could significantly alter methane generation, insofar as there are components that inhibit anaerobic methanogenesis. [E. Roberto et.al, pp 79 – 89].
3. The waste begins to degrade after the first year of disposal in the landfill.

Phase 1

Ten wells have been installed, spaced 30 metres apart, [Kroeker et al., 1975]. corresponding to a radius of influence of approximately 60 metres for a landfill depth of 11 metres. The wells have chimneys equipped with a non-automated gas burner and a ½-inch gate valve for manual ignition using a lighter.

Phase 2

Measurements were taken of the components of the biogas generated in the various chimneys, [Speyer, 1981]revealing percentages of 13% CH₄ [methane] and other types of gases.

Box 4



Figure 3

Process diagram of the biogas plant

All chimneys operate as open systems in which combustion takes place by mixing biogas with atmospheric air [in the presence of oxygen], producing carbon dioxide [CO₂] and, to a lesser extent, sulphur dioxide [SO₂], nitrogen oxides and other related gases. The incineration temperature is 70°C; the burner can only be ignited manually.

The requirements under the CDM [Clean Development Mechanism] are normally 1000 °C for a minimum of 0.3 seconds and a combustion efficiency of between 98% and 99.5%.

Phase 3.

Process diagram of the biogas burner. This is shown in Figure 5.

Box 5

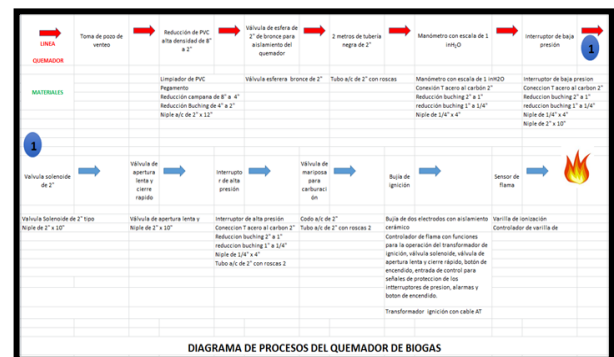


Figure 4

Process diagram of the biogas burner

Box 6

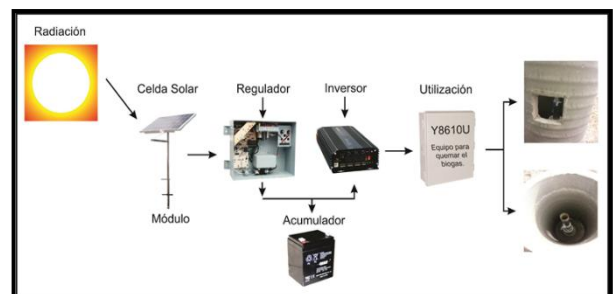


Figure 5

Process diagram of the biogas plant

Box 7

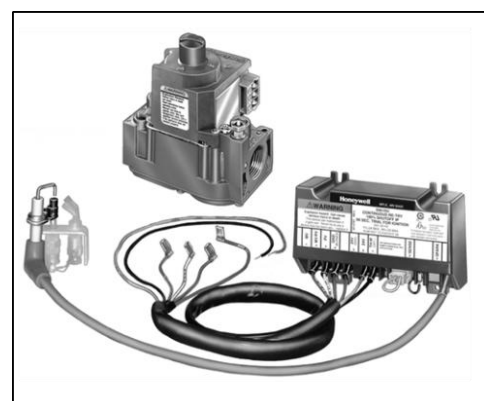


Figure 6

Y8610U Retrofit Kit for Flashing Pilot Light

Article

Product details

- 393691 Conversion Kit from Natural Gas to Propane
- Pre-wired
- 393690-14 Right-Hand Flange Kit [3/4 inch]
- Reducing adapters for gas control
- S8610 adhesive mounting option
- Installation hardware

Temperature rating:

- VR8304M: -40°F to +175°F [-40°C to +79°C].
- S8610U: -40°F to +165°F [-40°C to +74°C]. [If the main valve current is 1A or less, a maximum ambient temperature of +175°F [+79°C] applies.]

Module

Uses the rectification principle for flame detection.

Provides 13 kV peak capacitive discharge spark output [at a 25 pF load].

Applications

The Y8610U is a complete kit for converting conventional continuous-pilot systems to intermittent-pilot systems. It is used in atmospheric air heaters, boilers, and gas-fired heating appliances. It is not used in direct-vent equipment or power burners. It complies with the ANSI Z21.71 standard for automatic intermittent pilot ignition systems for field installations.

Features

- Y8610U kits can be used with natural gas or propane.
- The Y8610U provides a maximum ignition attempt of 90 seconds, shuts off, waits for a nominal six minutes, then restarts the pilot ignition sequence. The ignition attempt-shut-off-wait cycle repeats until the pilot flame ignites or the heating demand signal ends.
- Y8610U kits can be used with natural gas or propane; they provide timed ignition attempts and 100 per cent total pilot shut-off in the event of flame loss.

Each kit includes:

- S8610U Intermittent Pilot Module
- VR8304M Gas Control with Dual Valve Combination
- 392431 Igniter-Sensor
- 394800-30 Ignition Cable

Gas control

- Straight-through body pattern
- VR8304M capacity at 1 inch wc pressure drop [0.25 kPa pressure drop is 270 ft³/hr [7.6 m³/hr].
- Manual ON-OFF valve blocks gas flow within the gas control in the OFF position.
- Two main automatic valves—one solenoid-operated, the other a servo-operated diaphragm system.

Igniter/Sensor

- Single electrode made of Kanthal provides both ignition and flame detection.
- Rated for 1775°F [968°C] at the electrode tip, 1250°F [677°C] at the ceramic insulator.

Specifications

Important

The specifications given in this publication do not include normal manufacturing tolerances. Consequently, the units will not necessarily conform to the stated specifications.

Furthermore, the units are tested and calibrated under strictly controlled conditions; if these conditions are altered, subtle differences in performance may occur [Pfeffer, J. et. al 1973]

SUPER TRADELINE® Models

SUPER TRADELINE models are selected and packaged for easy handling and stock control, and maximum replacement value. The specifications of SUPER TRADELINE models are the same as regular models except for the noted differences.

Available SUPER TRADELINE Models:

Y8610U Intermittent Pilot Retrofit Kit

:

- Complies with ANSI Z21.71 Automatic Intermittent Pilot Ignition Systems for Field Installation.
- For natural gas or propane gas applications
- 90-second maximum ignition attempt, shuts off, waits for a nominal six minutes, then restarts the pilot ignition sequence. The ignition attempt-shutdown-wait cycle repeats until the pilot flame ignites or the preheat signal ends. 100 per cent total pilot shutdown on flame loss.
- S8610U Intermittent Pilot Module.
- VR8304M Gas Control with Dual Valve

Combination.

Ambient Temperature Rating:

VR8304M: -40°F to +175°F [-40°C to +79°C].
S8610U: -40°F to +165°F [-40°C to +74°C]. [If the main valve current is 1A or less, the maximum ambient temperature of +175°F [+79°C] applies.]

Also refer to the Igniter-Sensor specifications.

Electrical Ratings:

- Voltage and Frequencies: 20.5 to 28.5 Vac [24 Vac nominal], 60 Hz.
- Current Capacity: 0.7A [includes both module and gas control].
- Thermostat Lead-in Setting: 0.7A plus the current ratings of other devices in the thermostat control circuit.

Relative Humidity Rating:

5 to 90 per cent at 95°F [35°C].

Thermostat Compatibility:

Compatible with any 24V Honeywell thermostat and with competitive 24V thermostats that are powered independently of the module. [Pigg, D. L, 1977].

Determining Transformer Capacity: Add together the current ratings of the Y8610U, the damper actuator, and any other components in the control system. Multiply this total by 24V to determine the required VA rating of the transformer.

ISSN: 1390-9959.

RENIECYT: 1702902

ECORFAN® All rights reserved.

Wiring Connections:

Between the module and the gas control: 30-inch [762 mm] pre-wired cable with 1/4-inch quick-connect terminals.

Between the module and the igniter-sensor: 30-inch [762 mm] ignition cable with a contact terminal and a 1/4-inch quick-connect terminal.

Intermittent Pilot Module Specifications: S8610U Intermittent Pilot Module, for natural gas or propane gas applications only.

Dimensions: Refer to Figure 11.

Flame Failure Response Time:

0.8 seconds maximum at 1.0 μ A flame current

Box 8



Figure 7

Components of the Y8610U retrofit kit.

Installing the S8610U Pilot Light Module

Choose a location near the pilot burner to allow the ignition wire to be routed to the igniter-sensor. Ambient temperature and other conditions must match those specified in the Specifications. We recommend mounting the module with the terminals facing downwards to protect them from dripping water and dust. Alternatively, the module can be mounted with the terminals on either side. Do not mount the module with the terminals facing upwards. Secure it firmly with four No. 6-32 machine screws or No. 8 self-tapping screws of appropriate length.

Wiring the System

Aguirre-Orozco, Mario Abelardo, Portillo-García, Lizeth, Salinas-Pérez, Martín Alejandro and Baray-Guerrero, María del Rosario. [2026]. Design and Performance Evaluation of an Automated Biogas Combustion System for Emission Mitigation in Landfills. ECORFAN Journal-Ecuador. 13[23]1-9: e41323109.

<https://doi.org/10.35429/EJE.2026.13.23.4.1.9>

WARNING

Disconnect the power supply before connecting the cables to prevent electric shock or damage to the equipment.

Connecting the Ignition Cable

Connect one end of the ignition cable to the SPARK quick-connect male terminal on the S8610 Module. Connect the other end of the ignition cable to the 392431 Ignition Sensor.

Connecting the Vent Damper

The D80D Vent Damper can be used with all ignition modules, although the Molex connector provided on some modules simplifies wiring connections when used with the D80D Plug-in Vent Damper. Once a module with a vent damper connector has powered a vent damper circuit, it cannot be used in a gas system without a vent damper. A fuse, which cannot be replaced, in the module blows during initial power-up. Once this fuse has blown, the module will not function unless the vent damper is connected.

To connect the plug-in vent damper: Remove and discard the vent damper plug from the module's terminal strip. Using the pre-formed wiring provided, insert the male adapter plug into the socket on the module and connect the other end to the vent damper.

To connect the D80D Vent Damper, follow the wiring diagrams provided with the vent damper.

Connecting the S8610 Module Connect the gas control and all other system components to the terminals on the ignition module as shown in Figure 8 shows a basic circuit for a single-burner atmospheric heating system.

Connecting the Control System Ground

The igniter, flame sensor, and ignition module must share a common ground with the main burner. Connect the ground wire with the 1/4-inch female quick-connect terminal to the male quick-connect terminal, GND [BURNER], on the ignition module. [Speyer, Philippe, 1981].

Strip the other end of the wire and tie it under the mounting screw of the igniter bracket.

If necessary, use a heat shield to protect the ground wire from radiant heat.

The burner serves as the common ground area. If there is no good metal-to-metal contact between the burner and ground, run a wire from the burner to ground.

Note: a physical ground is not required standard operating procedure.

Box 9

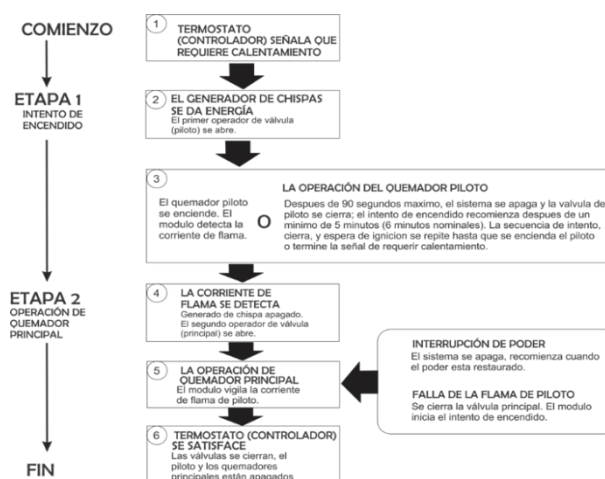


Figure 8

Box 10

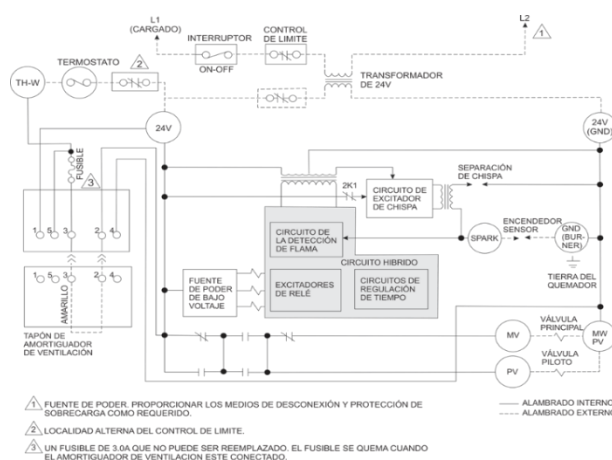


Figure 9

Results

A prototype automated biogas burner has been designed for use in connecting the ten existing wells that emit methane gas at the regional landfill in the south-central part of the state of Chihuahua, thereby establishing better waste management, reducing environmental impact, preventing groundwater contamination, and facilitating the recycling of solid waste whilst producing biogas.

Aguirre-Orozco, Mario Abelardo, Portillo-García, Lizeth, Salinas-Pérez, Martín Alejandro and Baray-Guerrero, María del Rosario. [2026]. Design and Performance Evaluation of an Automated Biogas Combustion System for Emission Mitigation in Landfills. *ECORFAN Journal-Ecuador*. 13[23]1-9: e41323109. <https://doi.org/10.35429/EJE.2026.13.23.4.1.9>

Converting the methane gas emitted by the waste deposited in the regional landfill will contribute to the proper final disposal of municipal solid waste and support specialised waste management for the five municipalities comprising this region.

Discussion of results:

Thus, capturing gas from the landfill to generate alternative energy provides environmental benefits and can offer economic advantages; the gas produced at the landfill would be sufficient to operate this plant, considering these alternatives for the management and utilisation of these collection centres in a more cost-effective manner through these energy sources.

Given the potency of methane gas in contributing to the greenhouse effect—as it is more than 23 times more potent than carbon dioxide and has an atmospheric lifetime of 10 years—this alternative of burning it and breaking it down into carbon dioxide constitutes an effective way of achieving a positive short-term effect to mitigate global climate change.

It also helps to reduce the impact of the landfill on the health of the population living near the site, as methane gas can pose a public health risk.

The risks of explosion and odour arising from methane generation will be reduced; if it escapes uncontrollably, it can accumulate [because its specific gravity is lower than that of air] in enclosed structures, basements, underground service facilities, nearby facilities or other enclosed spaces, both near and within or outside the site. A potential explosion exists when the gas accumulates in enclosed spaces at explosive concentrations [5 to 15% methane by volume] and if an ignition source is present.

With this project, the South Central Region Landfill in the State of Chihuahua fulfils its responsibility to develop strategies and implement programmes related to climate change, incorporating global best practices into its environmental conservation programmes.

Declarations

Conflict of interest

The authors declare that they have no conflict of interest.

ISSN: 1390-9959.

RENIECYT: 1702902

ECORFAN® All rights reserved.

They have no known competing financial interests or personal relationships that could have influenced the publication of the article reported in this paper.

Contributions of the authors

Aguirre-Orozco, Mario: Main concept of the article

Baray-Guerrero, Maria: Contributed to the main concept. Authors recognised by the SNI Level I CONAHCYT

Salinas-Pérez, Martin: Methodological design

Portillo-García, Lizeth: Table layout and design

Availability of data and materials

The information was obtained from various sources and from the project carried out as part of the postgraduate course in environmental sustainability at the Delicias Institute of Technology by Mario Aguirre Orozco.

Funding

No budget was allocated to the production of this article; all expenses were borne by the authors.

Acknowledgements

Acknowledgement to the Technological Institute of Delicias

Conclusions

The results of the study indicate that landfill gas, when used to generate alternative energy, provides environmental benefits and can offer economic advantages. The gas produced at the landfill would be sufficient to operate this plant, making these alternatives a more cost-effective way to manage and utilise such waste collection sites through these energy sources.

Given the potency of methane gas in contributing to the greenhouse effect—as it is more than 23 times more potent than carbon dioxide and has an atmospheric lifetime of 10 years—this alternative of burning it and breaking it down into carbon dioxide constitutes an effective way of achieving a positive short-term effect to mitigate global climate change.

Abbreviations.

CONAHCYT National Council for Science and Technology

Aguirre-Orozco, Mario Abelardo, Portillo-García, Lizeth, Salinas-Pérez, Martín Alejandro and Baray-Guerrero, María del Rosario. [2026]. Design and Performance Evaluation of an Automated Biogas Combustion System for Emission Mitigation in Landfills. *ECORFAN Journal-Ecuador*. 13[23]1-9: e41323109.

<https://doi.org/10.35429/EJE.2026.13.23.4.1.9>

Article

RSUyME Municipal and Special-
Management Solid Waste
SEMARNAT Ministry of the Environment
and Natural Resources

References

Basic

E. Roberto et. al,[pp 16 – 34.]. [Programa Iberoamericano de Ciencia y Tecnología para el Desarrollo. Energía – Biomasa – Ibero América \[Reservas, recursos, ecosistemas, tecnologías, mercados, impacto socioeconómico, calidad de vida, desarrollo sustentable, perspectivas\]. México.](#)

E. Roberto et.al, [pp 79 – 89]. [Programa Iberoamericano de Ciencia y Tecnología para el Desarrollo. Perfiles de país; América Central y el Caribe. Subprograma IV: Biomasa como Fuentes de Productos Químicos y Energía. México.](#)

Gunnerson et.al [1986. 156 pp.]. [Integrated Resource Recovery, Anaerobic digestion, Principles and practices for biogas systems. World Bank Technical paper number 49. UNPD project managment report number 5. E.U.A. The Worl Bank.](#)

Kispart, R. G. et. al. [1975]. [Fuel gas production from solid waste. Informe final en NSF contract C-927. Dynatech R/D Co. Disponible en U. S. NTIS.](#)

Krocker, E. J. et. al. [1975]. [Energy, Agriculture and waste management. W. J. Jewell. Ed. An Arbor Science, Ann Arbor, Mich. E.U.A.](#)

Monroy et. al [1990. 223 pp.]. [Biotecnología para el aprovechamiento de los desperdicios orgánicos. Ed. AGT Editor.](#)

OLADE. [41 pp.] [Biogás, energía y fertilizantes a partir de desechos orgánicos, manual para el promotor de la tecnología. Instituto de Investigaciones Eléctricas, división fuentes de energía, departamento de fuentes no convencionales de energía. Organización Latinoamericana de Energía](#)

Pfeffer, J. et. al [1973]. [Fuel gas production from municipal solid astw. Infoeme semestral, University of Illinois at Champaign-Urbana, Informes disponibles en U. S. NTIS.](#)

Pigg, D. L. [1977]. [Commercial Size Anaerobic Digester performance with dairy manure. Presentado por la Am. Soc. Ag. Eng. Meeting Raleigh, N.C., E.U.A. Disponible a través de American Society of Agricultural Engineers, st. Joseph, Mich. 49085, E.U.A.](#)

Rodríguez, et al., [1985]. 583pp.] [Alternativas Energéticas. UNAM. México. Ed. Fondo de Cultura Económica.](#)

Speyer, Philippe.[1981]. [Le Biogaz a la Ferme Aux U. S. A. Francia. Ed. Groupe de Recherche et d' Echanges Technologies.](#)

Varel, V. H. et al.[1976] [Termophilic anaerobic digestion of cattle manure. Artículo presentado en la tercera conferencia de energía Inter – Universitaria. Springfield.](#)

W. J. Jewell. Ed. [Ann Arbor Science, Ann Arbor, Mich., E.U.A.](#)

Wong-Chong, G. M. [1975]. [Energy, agriculture and waste management.](#)

www.ambientum.com

www.cne.cl/fuentesenergeticas/e.renovables.php

www.cps.unizar.es

www.geocities.com/venergia/

www.panoramaenergetico.com/biomasa

www.ingenieriaquimica.org/usuario/wagner