



Biogas Emissions and Renewable Energy Potential of Municipal Solid Waste Landfills: A Case Study in Kashan, Iran

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ABSTRACT

Landfill gas from municipal solid waste is a climate liability and a renewable energy opportunity. In this study, methane (CH₄), carbon dioxide (CO₂), and non-methane organic compound (NMOC) emissions from Kashan landfill, located in a semi-arid region of Iran, were estimated and simulated, and its electricity potential was determined. LandGEM, a U.S. EPA first-order model, was applied with data from Kashan landfill, taking into account waste characteristics and decay rate constant ($k = 0.0268 \text{ yr}^{-1}$), decay L ($L_0 = 191 \text{ m}^3 \text{ CH}_4 \text{ Mg}^{-1} \text{ waste}$). Peak methane emission occurred one year after closing (2036), with a rate of 9.85 Gg.yr^{-1} ($\sim 14.8 \times 10^6 \text{ m}^3 \text{ yr}^{-1}$). Total landfill gas generated is $3.50 \times 10^4 \text{ Mg.yr}^{-1}$ at the end of filling (2035). Assuming a gas collection efficiency of 60% and electricity efficiency of 33%, total electricity produced peaks at $\sim 27.1 \text{ GWh.yr}^{-1}$ ($\sim 27,091 \text{ MWh.yr}^{-1}$). These results show that LFG collection and use should be a priority for semi-arid region MSW landfills with large percentages of organic waste.

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INTRODUCTION

Urbanization and changing consumption patterns have caused an acceleration in municipal solid waste (MSW) accumulation with high environmental impacts attributed to landfilling activities within developing countries. For Iran, it is noted that there is an adherence to landfilling practices within these countries, and emissions caused by uncontrolled activities within these sites may account for a large component of local greenhouse emissions (GHG). For global circumstances, landfills have been noted as a significant source of methane (CH₄) emissions (Du et al., 2017; Zhang et al., 2019). Natural greenhouse gases emit a high amount of greenhouse gases compared to carbon dioxide (CO₂) on a 20 and 100 year time scale (Masson-Delmotte et al., 2021; Moghadam et al., 2021). As a consequence of methanogenesis occurring over long periods, there will be long-lasting impacts on mitigation beyond waste management and disposal operations (Pazoki et al., 2015; Yaashikaa et al., 2022).

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Landfill gas (LFG) is generated during anaerobic decomposition of biodegradable wastes, generally consists of mainly CH₄ (about 45% to 60%) and CO₂ (about 40% to 60%), while trace constituents include nitrogen, oxygen, ammonia, hydrogen sulfide, and non-methane organic compounds (NMOCs) (Gavrila et al., 2025; Przydatek et al., 2024; Un, 2023). Another concern with CH₄, as reported by (Zhang et al., 2025), is when there exists an explosion risk since methane accumulates, and as such, there exists an explosive hazard for gases with such potential. Hence, there exists an important need for effectively quantifying gases generated as a result of degradation.

In parallel, there is an increasing focus on waste valorisation, particularly in arid or resource-constrained environments, such as integrated water, energy, and food planning strategies, as well as the potential for waste-derived materials in construction applications (Goh et al., 2025; Mashaal et al., 2025). However, in many semi-arid cities the dominant and unavoidable near-term pathway remains landfilling, and methane emissions from MSW landfills continue to be one of the most consequential and under mitigated components of the waste sector. Therefore, landfill specific methane projection and utilization assessment remain critical for practical climate mitigation and for evaluating realistic energy recovery potential.

In terms of energy generation, CH₄ produced from landfills can be used to power internal combustion engines or turbines to produce electricity and heat, or even be upgraded and used in transportation or pipelines (Paolini et al., 2018; Yaashikaa et al., 2022). Case studies of successful projects where flaring was replaced with CH₄ use have demonstrated that this can offer advantages in terms of emissions reduction and energy usage in Southeast Asia and North Africa (Elsebaay et al., 2024; Pheakdey et al., 2023). However, the feasibility and timing of energy recovery depend strongly on site specific conditions, especially waste composition, operational practices and climate driven moisture availability, which control decay kinetics and thus the magnitude and temporal profile of gas generation.

A range of modeling approaches has been developed to estimate landfill gas generation, including zero-order and first-order models recommended by the IPCC and other tools such as GasSim and mechanistic or data-driven variants (Krause et al., 2016; Ramprasad et al., 2022; Wangyao et al., 2010). Among these, the U.S. EPA LandGEM is widely applied because it is transparent, computationally simple, and requires a limited set of inputs, primarily annual waste acceptance and two key parameters: methane generation potential (L_0) and methane generation rate constant (k) (Nematollahi et al., 2024). LandGEM has been used across diverse climates to estimate emissions and energy recovery potential. In India, estimation of methane yield was carried out to be 233 million m³ in Kanpur and 16.6 million m³ per annum in Tirupati by 2042 (Chandra & Ganguly, 2023; Ramprasad et al., 2022). In Iran, (Amirmahani et al., 2020) showed a rise in methane from 72 m³/h in 2015 to over 5,000 m³/h by 2033 in modeling the Kerman landfill. Meanwhile, (Moghadam et al., 2021) projected that by 2032 Iran's overall GHG emissions from sanitary landfills will be 3.84 million Mg.yr⁻¹, mostly made of carbon dioxide and methane. Despite this growing literature, there remains a need for case studies in semi-arid regions that parameterize LandGEM using locally measured waste composition and climate relevant decay assumptions, report emissions in unit-consistent form, and translate modeled methane generation into transparent electricity recovery estimates that are directly interpretable for municipal planning.

This study addresses these needs using the Abuzeydabad landfill serving Kashan and surrounding settlements in central Iran, where the MSW stream contains a high biodegradable fraction and the climate is semi-arid. The objectives of this study are to quantify annual emissions of CH₄, CO₂, and NMOCs using LandGEM parameterized with local waste characterization and site specific decay parameters, to evaluate the temporal evolution of gas generation during operation and post-closure, and to estimate the electricity recovery potential under practical assumptions for collection and conversion efficiency, thereby providing decision relevant

evidence for methane mitigation and waste to energy planning in semi-arid urban contexts.

MATERIALS AND METHODS

This study focuses on the Kashan and Aran & Bidgol region in Isfahan Province, central Iran. The zone covers an area of about 10,493 km², with the Kashan extending between 49°51'–54°50' E and 27°34'–30°33' N and Aran & Bidgol situated between 51°18'–52°27' E and 33°25'–34°47' N. Currently, six major agglomerations form the area, which includes the towns of Nushabad, Sefidshahr, Abuzeydabad, and Qamsar. MSW produced in these settlements is transported to a central disposal facility (Fig. 1) located on Abuzeydabad Road.

From a climatological point of view, this region can be classified as arid desert under the de Martonne classification scheme; the summers are hot, and the winters are cold. This region has average monthly temperatures ranging from -0.3°C in January to 40.8°C in July, with the average annual temperature being 19.8°C. This region receives an average annual precipitation of 138 mm, with relative humidity ranging from 16% in summer and 78% in winter; the prevailing winds are from the southwest.

The waste disposal site covers 130 hectares of land and receives 200 Mg of waste daily. The site operates using a semi-engineered facility with a trench method, where trenches are dug to 200-300m in length and 4-8m in depth. A layer of clay is used to cover the surface of the site to minimize emissions and surface run-off. The site operates above a groundwater table 45m deep, which acts as a geological barrier.

The amount of MSW collected annually increased over the same period in Kashan, from 65,295 Mg to 113,362 Mg between 2006 and 2019. The population size being 521,537, as estimated for 2019, has allowed calculation of the rate of MSW collection as kg person⁻¹ day⁻¹,

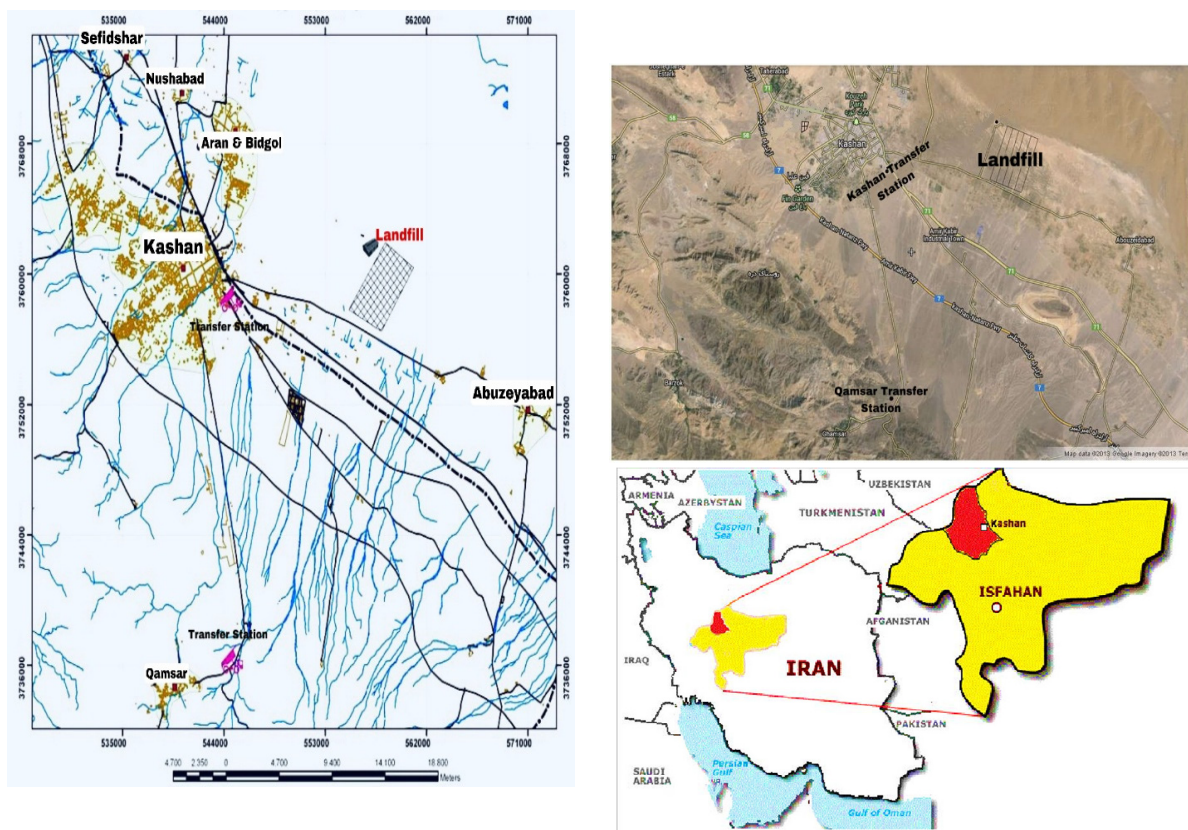


Fig. 1. Case Study location in Iran and landfill site

Table 1. Estimated Rates of Urban Landfill Gas Production in Kashan Based on Physical Waste Composition and Annual Rainfall (133.7 mm) (Ghasemzade, 2017; Rezaee et al., 2014).

Waste Components	Mass Fraction (%) (W_i)	Low Speed Decomposition	Average Speed Decomposition	High Speed Decomposition
Food Waste	67.99	-	-	67.99
Paper & Cardboard	5.20	-	5.20	-
Textiles	3.51	3.51	-	-
Wood	7.56	7.56	-	-
Plastic	8.90	-	-	-
Glass	2.50	-	-	-
Metal	2.02	-	-	-
Other	2.32	-	-	-
Total	100	11.07	5.20	67.99
Gas production rates for each group (yr^{-1})	-	0.01	0.02	0.03
Weighted Decay Product ($W_i \times k$)	-	0.1107	0.1040	2.0397
Final gas production rate (yr^{-1})	-	-	-	0.0268

which is on par with the national Iranian standards at around 310 Mg day^{-1} .

To determine the physical composition of the waste, a comprehensive field analysis was conducted using a stratified random sampling methodology. To capture seasonal variations in waste generation and composition, sampling was performed across all four seasons of the year. During these campaigns, samples were collected from the accumulated waste pile at a ratio of 5 kg of sample per 5 Mg of incoming waste. The material was selected from at least four distinct points within the waste mass to ensure representativeness and mixed well on a thick plastic sheet to homogenize the sample. The homogenized samples were manually segregated into four key categories, namely: wet/organic waste, including putrescible materials, food scraps, and green waste; dry recyclables, such as paper, plastics, metals, and glass; hazardous household waste, like batteries, electronics, and medical waste; and construction and demolition debris. After segregation, each fraction was weighed separately using calibrated scales to show percentage composition.

The analysis reveals that the waste stream has a high potential for biogas generation, with the organic fraction constituting 67.99% of the total mass. The remaining composition includes plastics (8.9%), wood (7.56%), paper (5.2%), textiles (3.51%), glass (2.5%), metals (2.02%), and other materials (2.32%) (Table 1). The high proportion of rapidly biodegradable organic matter suggests that the Kashan landfill is highly suitable for methane projection analysis using the LandGEM model.

LandGEM Model

The Landfill Gas Emissions Model (LandGEM, v3.02), developed by the U.S. EPA, was employed to estimate the generation of methane and co-pollutants. The model is based on a first-order decay equation (Eq. 1), which assumes that gas generation peaks shortly after waste placement and then decreases exponentially as degradable organic matter is depleted:

$$Q_{CH_4} = \sum_{i=1}^n \sum_{j=0.1}^1 KL_0 \left[\frac{M_i}{10} \right] e^{-K_{ij}} \quad (1)$$

Where:

n: Duration of the modeling period (years)

j = 0.1 year time increment

M_i : Mass of waste disposed in year *i* (Mg)

- t_j : Age of the j^{th} section of waste mass M_j (years)
 $Q_{\text{CH}_4}^j$: Annual methane generation (m^3yr^{-1})
 K : Methane generation rate constant (yr^{-1})
 L_0 : Methane generation potential (m^3Mg^{-1})

The methane generation rate constant (k) determines the rate of waste decomposition and is sensitive to moisture availability, temperature, and waste composition. The EPA recommends a default of $k=0.02 \text{ yr}^{-1}$ for arid climates defined here as having annual precipitation under 635 mm but the use of one default value can bring in uncertainty when local waste composition is different from national-average conditions that were assumed. Therefore, to better represent Kashan's waste stream, a site-specific weighted k was calculated based on the biodegradability of the main waste fractions.

As shown in Table 1, the waste fractions were grouped into low-, moderate-, and high-decay categories ($k=0.01, 0.02, \text{ and } 0.03 \text{ yr}^{-1}$, respectively (ESMAP, 2004) according to their cellulose/lignin characteristics and degradability. Using the relative mass fractions of degradable waste (total degradable mass = 84.26%), a weighted average decay rate constant was derived:

$$k_{\text{weighted}} = \frac{\sum(W_i \times k_i)}{\sum W_{\text{degradable}}} = 0.0268 \text{ yr}^{-1} \quad (2)$$

The potential methane generation capacity (L_0) represents the total methane that can be generated per unit mass of waste and is strongly dependent on the organic content and degradability of the disposed materials. Based on the decomposition based approach summarized in Table 2, the estimated L_0 for the studied landfill falls within a range of approximately 190.85–257.7 $\text{m}^3 \text{Mg}^{-1}$. However, in the absence of long term site specific landfill gas monitoring data (e.g., measured methane recovery, field emission measurements, or biochemical methane potential tests), selecting the upper-bound L_0 may overestimate methane generation and bias subsequent energy recovery estimates. Consistent with conservative practice reported in comparable studies, the lower-bound estimate was adopted to improve reliability and avoid inflating projections when local calibration data are limited. Accordingly, L_0 was set to 191 $\text{m}^3 \text{Mg}^{-1}$ in the LandGEM model inputs (Table 3).

Table 2. Estimation of methane production potential (L_0) based on waste decomposition

Decomposition rate	Lowest rate (L_0) (m^3Mg^{-1})	Highest rate (L_0) (m^3Mg^{-1})
Low speed decomposition	5	25
Average speed decomposition	140	200
High speed decomposition	225	300
The lowest estimated rate of L_0 at the studied landfill	190.85	

Table 3. LandGEM Model Inputs

Landfill Characteristics	Value	Unit
Landfill Open Year	2006	-
Landfill Closure Year	2035	-
Actual Closure Year	2035	-
Have Model Calculate Closure Year?	NO	-
Methane Generation Rate, k	0.027	yr^{-1}
Potential Methane Generation Capacity, L_0	191	$\text{m}^3 \text{Mg}^{-1}$
NMOC Concentration	4,000	ppmv as hexane
Methane Content	50	% by volume

RESULTS AND DISCUSSION

The amount of gas emitted, specifically methane, is mostly affected by the volume of waste entering a landfill site. In the case of Kashan, data on the growth of the human population is significant in projecting the future growth of waste production. Based on the results from the census conducted from 1966 to 2006, the average annual growth rate was calculated as 2.37%. This study, however, uses the results from 2006 up to 2019, due to the lack of exact information prior to 1996.

Population projection was done using Equation 1, which determines projected population based on exponential growth:

$$P = P_0(1+r)^n \quad (3)$$

Where:

- P is the projected population in the target year
- P_0 is the population in the base year
- r is the annual growth rate
- n is the number of years between the base year and the target year

Using this formula, the population of Kashan was estimated for the years 2006 to 2035. At the beginning of the planning period in 2006, the population was 362,615 and the annual municipal solid waste generation was estimated at 65,295 tons. By 2035, the population is expected to reach 835,478 with an annual waste generation of approximately 220,355 tons. Over the 30 year period, the total amount of municipal solid waste produced is projected to be 3,853,644.1 tons.

LFG Emissions

The various coexisting processes regulating the generation of landfill gases (LFG) encompass anaerobic degradation of organic matter, characteristics of the waste, moisture content, temperature, and operational practices such as compaction and covering. The pattern and rate of emitted methane depend on climate conditions, among other landfill practices (Kabir et al., 2022; Malmir et al., 2023). In the LandGEM model, two chief controlling factors dictate emission behavior, namely, the methane generation potential constant k and the methane generation potential L0, which depend on characteristics and moisture content in wastes (Njoku et al., 2020). Because methane has a relatively high heating value, it can also be considered a valuable renewable energy carrier if captured and utilized properly (Rasi et al., 2007).

In this study, LandGEM was applied to the Kashan landfill starting from the opening year (2006), assuming waste acceptance continues through 2035. The model combines annual waste input data with first-order decay kinetics to estimate methane and co-pollutant generation over time. As expected, methane generation increased from the early operational years due to the accumulation of disposed waste and the high biodegradable fraction of MSW (food waste alone constitutes 67.99%).

Total LFG emissions in 2035 were 3.501×10^4 Mg yr⁻¹ and included 9.351×10^3 Mg yr⁻¹ of methane and 2.566×10^4 Mg yr⁻¹ of CO₂. NMOC emissions from the same year totaled to 4.019×10^2 Mg yr⁻¹ \approx 4.30% of methane mass, which once again demonstrates the importance of gas management and collection during the late operational stage.

At the same time, methane and carbon dioxide emissions remained high in 2036, 9.851×10^3 Mg and 2.703×10^4 Mg, respectively; methane reached a maximum in that year. It reaches its peak in 2036 because the LandGEM sums age-dependent emissions from all waste “cohorts”; after the final disposal year (2035), the landfill contains its maximum cumulative waste mass

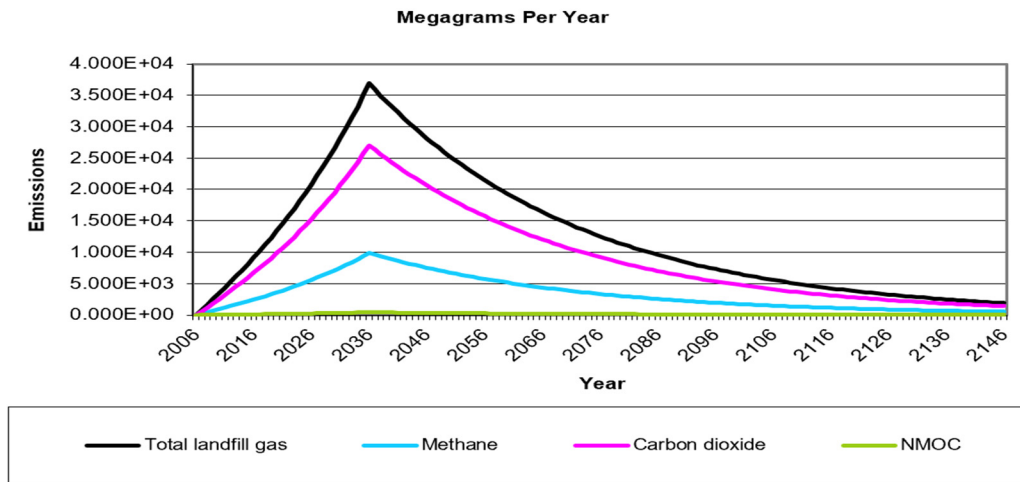


Fig. 2. Mass of produced gas emissions in landfill from 2006 to 2146

and the youngest waste fractions are still in a high-generation phase, creating a short lag before decay dominates. After this point, with no new waste inputs, total emissions decline as the degradable organic fraction becomes progressively depleted.

Modeled early emissions in 2007 were 221.94 Mg yr⁻¹ of methane, 608.95 Mg yr⁻¹ of CO₂, and 9.54 Mg yr⁻¹ of NMOCs, reflecting the rapid onset of biodegradation in the first years of operation. The average yearly generation of methane was approximately 3,356 Mg (σ = 2,641 Mg), whereas average yearly CO₂ emissions were approximately 9,209 Mg yr⁻¹ and average NMOC emissions were approximately 144.27 Mg yr⁻¹. Figure 2 illustrates yearly emissions of total LFG, methane, carbon dioxide, and NMOCs from 2006 to 2146.

It is noteworthy that overall, the emission trend here displays a bell curve characteristic, characterized by a gradual rise up to 2020, a plateau effect from 2020 to 2035, and a decline in emission post-closure. The plateau effect here may be seen as a balance between two phenomena: (i) fresh waste addition, which will enhance emissions in a short time frame, and (ii) old wastes whose effect will decrease over time.

Once disposal ends, the input term becomes zero and the decay term controls the profile, which explains the post-closure decrease. From a practical viewpoint, this means the most favorable window for energy recovery and mitigation occurs in the late operational stage and the early post-closure years, when gas flows are high enough for efficient collection and utilization.

Carbon dioxide is generated in parallel with methane during anaerobic decomposition and can be represented stoichiometrically as:

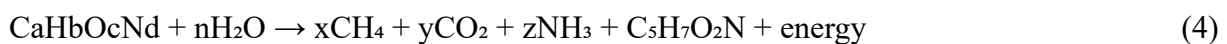


Figure 3 illustrates the annual profiles of total LFG, methane, carbon dioxide, and NMOCs. In addition to mass-based emissions, the annual gas volumes were also evaluated in cubic meters (Fig. 4).

Energy generation potential from methane

The potential for generating electrical energy from methane (CH₄) in landfill gas can be estimated using a standard analytical model. This method quantifies the annual electricity production (MWh.yr⁻¹) based on the quantity of methane generated and successfully captured from landfill operations. The following equation is used:

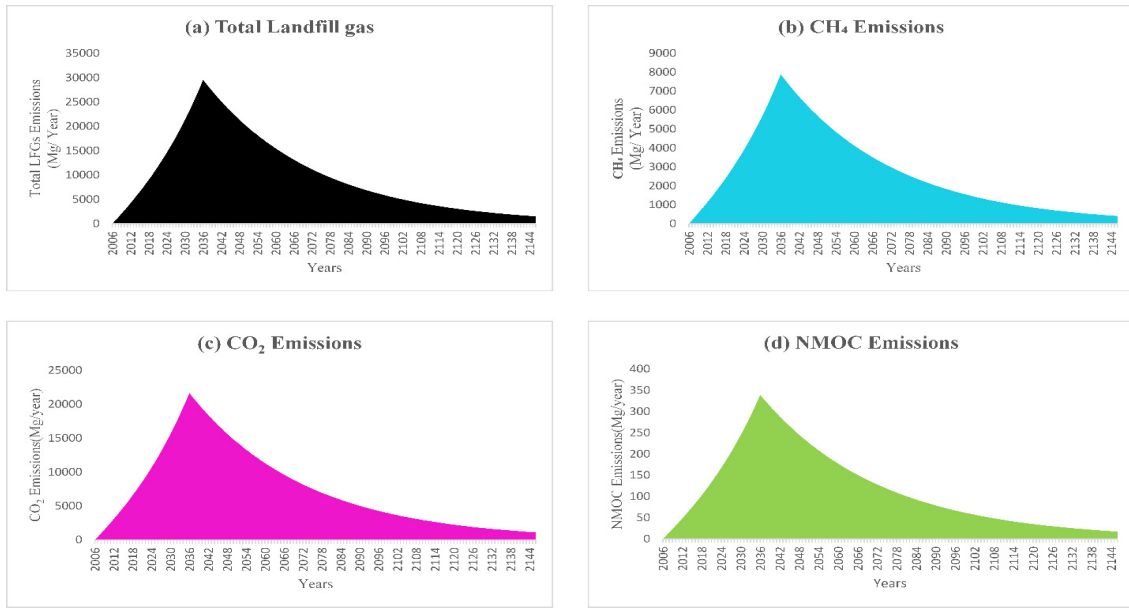


Fig. 3. (a) Annual total landfill gas emissions, (b) Methane (CH₄) emissions in megagrams per year, (c) Carbon dioxide (CO₂) emissions, and (d) Non-methane organic compound (NMOC) emissions.

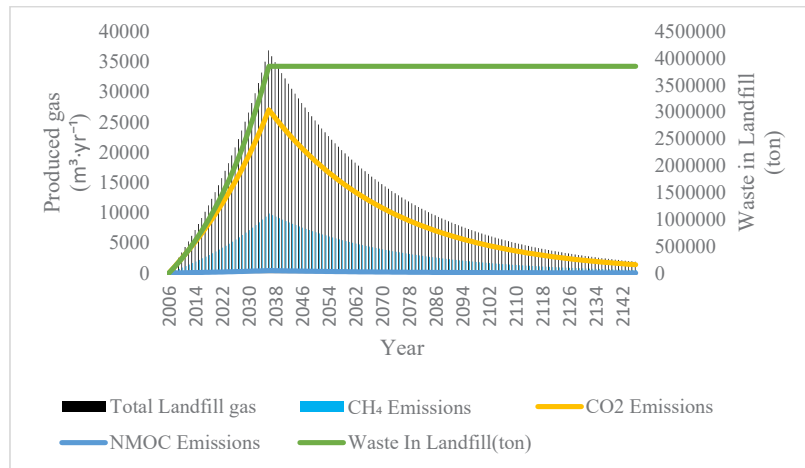


Fig. 4. Annual gas emissions from the Abuzeydabad landfill (in cubic meters) from 2006 to 2146, as estimated using the Land-GEM model.

$$E = \frac{LHV_{CH_4} \times Q_{CH_4} \times 1000 \times \eta \times \lambda}{3600} \quad (5)$$

Where:

LHV_{CH_4} = 50 MJ/kg, Lower Heating Value of methane (energy released during combustion)

Q_{CH_4} = Annual methane production (Mg yr⁻¹)

λ = Methane collection efficiency, taken as 60% or 0.60

η = Electrical conversion efficiency, taken as 33% or 0.33

3600 = Conversion factor from MJ to MWh

According to this model, methane is burned in an internal combustion engine or other generator system. The values for gas capture efficiency and performance are in line with what

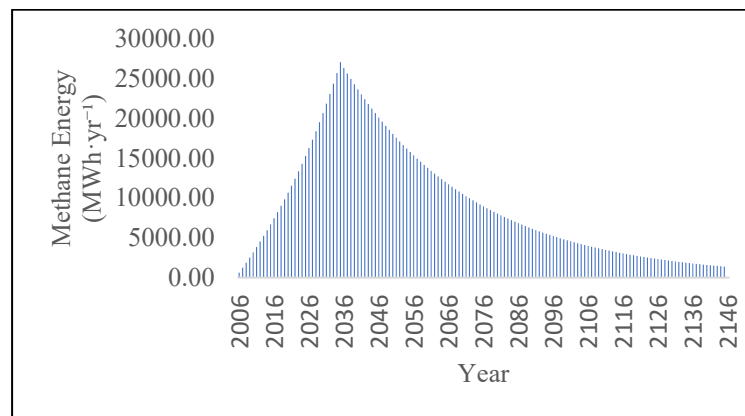


Fig. 5. Projected electrical energy generation potential from landfill methane (2006–2146).

is currently done to recover landfill gas.

Based on Eq. (5), the estimated electrical energy output from landfill methane increases steadily over time. It is about 610 MWh.yr⁻¹ in 2007 and rises to approximately 14,310 MWh.yr⁻¹ by 2025.

Because methane generation reaches its peak shortly after closure, the highest energy recovery potential, assuming 60% gas collection efficiency and 33% electrical conversion efficiency, occurs in 2036 at about 27,091 MWh.yr⁻¹. Following 2036, methane generation follows a typical post-closure decay trend, whereas electricity generation potential remains substantial, e.g., ~20,681 MWh.yr⁻¹ in 2046, supporting methane recovery's strategic value for long-term renewable energy planning (Fig. 5).

This study clearly indicates the realistic and long-term feasibility of landfill methane as one promising source of renewable energy. Energy generation from methane is especially significant in the high-yield phase, running from approximately 2015 up to 2045. The peak comes in the year 2036, one year after closure, during which time methane-derived energy production is at its highest. Energy recovery efforts are thus most successful within this 30-year period.

APPLICATIONS AND BENEFITS

Landfill methane quantification is a fundamental requirement to move away from waste disposal and towards waste resource recovery strategies. As discussed in the International Energy Agency's Global Methane Tracker 2025, waste is a major contributor to global anthropogenic methane emissions. However, it also presents some of the most attractive mitigation options currently in existence (Agency, 2025). In Iran, where sanitation landfill is the most common waste disposal technique, LSG modeling and techno-economic evaluation is a vital step to convert this waste menace to a clean and renewable energy resource.

Energy Recovery Potential

This potential is clearly demonstrated in the case study of the Kashan landfill (2006–2035). Projections indicate that methane emissions will peak one year post-closure (2036) at 9,851 Mg yr⁻¹. Under standard collection and conversion efficiencies (60% capture, 33% electrical efficiency), this corresponds to a recoverable electricity output of ~27,091 MWh.yr⁻¹ (~27.1 GWh.yr⁻¹). During the 140-year post-closure period (2006–2146), these emissions represent a substantial reserve of lost energy if left unmanaged. Recovered methane has numerous engineering uses:

- **Electricity Production:** LFG with methane content of 45-60% is ready for utilization in

internal combustion engines or gas turbines. A medium-sized facility like Kashan can support local baseload power demand, hence stabilizing the regional grid.

- **Thermal Energy:** Where natural gas networks remain limited, purified biogas can serve industries requiring process heat or district heating.

- **Biomethane Upgrading:** This process would upgrade the LFG to pipeline-quality biomethane (>95% CH₄) through CO₂ separation and dehydration, usable as Compressed Natural Gas (CNG). Though expensive in terms of purification costs, it offers a great pathway for energy security.

Economic Feasibility and National Context

While the technical potential is evident, economic viability in Iran is often challenged by heavily subsidized domestic fuel prices. However, recent comparative studies suggest that landfilling with gas recovery remains the most prudent fiscal path.

An analysis by (Maghmoumi et al., 2020) indicates that shifting from incineration to sanitary landfilling can reduce total capital costs by up to 62%. When combined with potential revenue from carbon credits (CDM) or guaranteed feed-in tariffs, biodegradable waste to energy projects become economically attractive.

This conclusion is supported by recent modeling across the region. A 2024 study of the Aradkooh landfill in Tehran emphasized that accurate parameter calibration is key to designing viable recovery systems (Zare Shahne et al., 2025). Similarly, research conducted in Baft County indicated a potential to harness 27 GWh·yr⁻¹ by 2054 (Goushki et al., 2023). Moreover, analysis conducted in Kish Island indicated a production potential of 5,400 Mg·yr⁻¹ by 2043 (Nematollahi et al., 2024). In this regard, it is evident that not only is methane harvesting eco-friendly but also has the potential to provide the needed energy in Iran.

CONCLUSION

This study examined the renewable energy potential associated with the biogas emissions from the Kashan landfill using the LandGEM model. This has confirmed that although the amount of greenhouse gas emissions from this landfill has considerable potential, there has been considerable potential for using the landfill as a source of renewable energy. The analysis projects a peak methane generation of 9.85 Gg yr⁻¹ in 2036, one year post-closure, corresponding to a recoverable electricity potential of approximately 27.1 GWh·yr⁻¹.

Implications for Theory and Practice

The findings have direct implications for waste management policy and energy planning in semi-arid urban contexts. From a practical standpoint, the modeled electricity potential, totaling approximately 310.47 GWh over the 2006–2146 period, demonstrates that LFG recovery can contribute meaningfully to the local baseload power supply.

Economically, while advanced capture systems require significant capital investment, landfilling remains the most cost-effective waste management strategy for the region. Indicative comparative studies demonstrate that a transformation of the waste disposal system from incineration to sanitary landfill disposal could result in total capital costs being decreased by as much as 62%. Furthermore, the optimal way forward for the city of Kashan would not be the immediate desistance from landfilling practices; rather, it would be the upgrading of the existing infrastructure to include gas collection systems. It is, therefore, imperative to build a new policy that would penalize the aforementioned emissions while offering incentives to offset the initial capital costs of the new “gas to energy” projects.

Limitations and Challenges

However, the accuracy of these projections is conditional upon the limitations of first-order decay models. The accuracy of the output generated using the LandGEM model is greatly influenced by the k and L_0 parameters used in the input data. Without the availability of data from long-term field observations, such as a pump test or historical decay rates, these data still have an element of uncertainty attached. Heterogeneity in the waste mass and seasonality in the moisture content might cause the actual decay rate to differ from the assumed constant decay rate.

Technological and infrastructural challenges are also identified as major barriers. The gas that the capturers in Kashan expect to capture consists of impurities like hydrogen sulfide and siloxanes, which are said to require expensive purification systems to be installed to prevent corrosion of the engines and quality of the gas in the pipelines. Future research should be directed at validating these predictions at the field level through gas flow measurement and biochemical methane potential (BMP) tests.

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CONFLICT OF INTEREST

The authors declare that there is not any conflict of interests regarding the publication of this manuscript. In addition, the ethical issues, including plagiarism, informed consent, misconduct, data fabrication and/ or falsification, double publication and/or submission, and redundancy has been completely observed by the authors.

LIFE SCIENCE REPORTING

No life science threat was practiced in this research.

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