

Landfill gas development in Ukraine

Hennadiy Zhuk¹, Dr.

¹ The Gas Institute of National Academy of Sciences of Ukraine, Kyiv, UKRAINE

1. Introduction

At present, waste disposal at landfills is the main way to dispose of solid municipal waste all over the world. The amount of solid waste annually increases by 3-6%. In Ukraine, there are about 4,500 landfills with total area of more than 7.5 thousand hectares. The amount of solid waste 11-13 million tons, which is annually putted to Ukrainian landfills, pollutes about 800 thousand tons of methane in the process of anaerobic digestion of the whole organic mass. Since methane has a 25 times greater greenhouse effect than carbon dioxide, its amount is equivalent to 16 million tons of carbon dioxide. The technical potential of landfill gas production in Ukraine was estimated by the Ministry is 0.5 million tons of standard fuel.

Requirements for collecting and utilizing landfill gas were introduced in 2005 with the approval of the construction standard DBN V.2.4-2-2005 "Polygons of municipal solid waste. Basic Design Provisions". But only setting in 2011 of "green tariff" on electricity produced from biogas in the law of Ukraine "On electric power" pushed the landfill gas utilization and power stations development.

2. Current situation

According to Government data (Table 1), number of Landfill gas facilities is 21, it is more than Biogas ones, but total capacity is nearly the same – 18.845 MW, effectiveness is about 40%. Here we have two big players – LNK and Clear Energy Companies.

Table 1. Landfill gas power plants in Ukraine (2018).

	Facility	Region	Since	Power, kW	Average Power 2018, kW
1	AEU Energo Ltd.	Vinnitsa region	2015	0,999	0,687
2	Biogas Energy LLC	Khmelnysky city	2017	0,659	0,312
3	Clear Energy LLC	Ivano-Frankivsk region	2016	0,660	2,372
4		Kharkiv region		1,063	
5		Kharkiv region		0,845	
6		Dnipropetrovsk region		1,063	
7		Volyn region		0,659	
8		Dnipropetrovsk region		1,318	
9	Clear Energy-Kremenchuk LLC	Poltava region	2017	0,845	0,428
10		Poltava region		1,003	
11	Clear Energy Chernihiv LLC	Chernihiv region	2017	1,131	0,536
12	PE "MPP" Latex "	Transcarpathian region	2014	0,600	0,091
13	LLC "LNK"	Kiev region	2011	1,063	2,833
14		Kiev region		2,126	
15		Kiev region		0,885	
16		Zhytomyr region		1,063	
17		Mykolaiv region		1,063	
18		Cherkasy region		0,600	
19	"Masterenergo Invest" Ltd	Rivne region	2017	0,500	0,047
20	"International Center of Gas Technologies" Ltd	Khmelnysky region	2018	0,500	0,060
21	TIS Eco Ltd.	Mariupol, Donetsk region.	2011	0,200	0,036
Total				18,845	7,402

Last technical regulation for biogas and landfill gas supplied to the gas pipe in Ukraine (version 2019) set the following requirements: higher Wobbe number (under standard conditions 25/20) – min 44.9, max 53.7 MJ/m³; higher heat of combustion (under standard conditions 25/20) – min 35.4 MJ/m³; min methane content – 90%, quality limits – H₂S - 3.5 ppm, CO₂ - 2.5%. Actually, it is not special standard for biogas - it is standard for any gas adopted to pipelines.

Law of Ukraine № 555-15 of 2017 "On alternative energy sources" sets the "green tariff" and its premium value for electricity received by landfill gas processing, and now it is about 13 Euro cents per one kWh.

3. Technology practices

The Gas Institute have leading position in Ukraine in research of biogas and its using technologies. Firstly, we had explored more than two tens of landfills, determinate gas potential and its chemistry.

Landfills exploration

Inspected landfills of different degree of development and terms of operation in Kyiv, Odesa, Sumy, Kharkiv, Ivano-Frankivsk, L'viv, Mykolaiv and others. Among the landfills, in particular, the research was conducted on existing and closed areas, open and reclaimed (covered with soil) sites from the beginning of storage of solid waste up to 50 years. Averaged results of chemical analysis indicate a high content of methane (more than 50%) in gas, which corresponds to a net calorific value of 20-25 MJ / Nm³. The content of carbon dioxide is 20-40% volumetric. We have own explored trend in landfill gas chemistry in time: carbon dioxide contention will the same, methane will drop, and nitrogen will rise (Fig.1). The high fossil fuel potential of landfill gas

biogas allows it to be used efficiently instead of natural gas in power plants. The extensive experience in the field of the use of combustible gases allowed the development of various technological processes for the use of landfill gas.

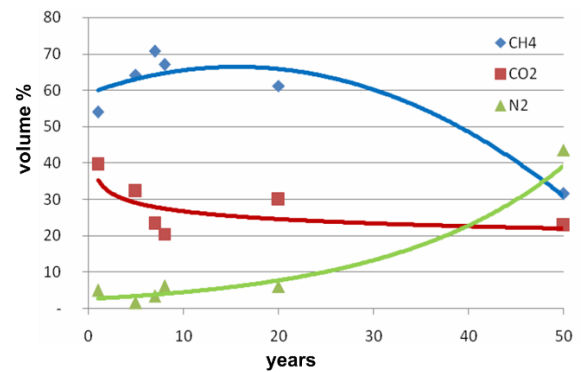


Figure 1. The trend in the content of the LFG

Carbon dioxide removing

The authors carried out computational studies on the recovery of CO₂ from landfill gas [1], which made it possible to combine the strengths of MDEA and MEA: the low corrosion activity of MDEA, and increased reactivity of MEA to CO₂. The resulting composition of the optimum absorbent is as follows: 40 % MDEA + 10 % MEA + 50 % H₂O.

Using this absorbent reduces heat costs for regeneration of saturated solution by 1.5 ÷ 2.5 times compared to 18 % of MEA and reduces by 15–30% the consumption of the absorbent and, accordingly, the power of the circulation pump. If compared with water absorption method has more specific energy cost, but it compensated by higher biomethane yield.

Power generation

The system for collection and gathering of landfill gas using modern methods of calculating, techniques and materials was developed [2]. The system is adapted to the conditions of typical landfill and includes utilization of 600...800 m³/hr LFG

to generate of an approximately 1MW of electricity. Original technical solutions allowed us to develop the system at several operational landfills.

Mathematical modelling of the system was carried out with a software GasCondOil based on thermodynamic dependencies, using the massive of experimental data and the programming phase transitions, properties and processes. The calculations obtain the basic characteristics of the system: the material balance of LFG in the system, the pressure difference (input-output) in all sections of pipelines, the gas flow rate, phase composition, flow.

Technological developments has been successfully implemented at the biggest in Ukraine landfill No 5 (Kiev region) by LNK Company in 2012 and now works at power of 2 MW. Since that, similar projects 1MW are developed and implemented in Zhytomyr, Mykolaiv, Brovary and other cities. The last one (0.63 MW) was implemented at Kamyanets-Podilsky, Khmelnytsky region by ICGT Company. This project firstly used domestic gas piston engine generator manufactured by Pervomaiskdiselmash.



Figure 2. 0.63 MW power station at Kamyanets-Podilsky landfill

4. Conclusions

Ukraine has significant potential of landfill methane producing estimated as 0.5 million tons of standard fuel. There are at

least 21 objects of electricity producing from landfill gas in Ukraine, stimulated by “green tariff”. The complex technology of gathering, preparing and using of landfill gas to generate electricity was designed at the Gas Institute. The original absorption processing with 40MDEA+10MEA+50H₂O amines solution was developed. Several industrial scale complexes for the atmosphere protection of greenhouse gases and their utilization were developed and implemented.

5. References

- [1] Yu.Ivanov, O.Pyatnichko, H.Zhuk, L.Onopa, M.Soltanibereshne. Extraction of carbon dioxide from gas mixtures with amines absorbing process // Energy Procedia 128 (2017) p. 240–247.
- [2] O. Pyatnichko, H. Zhuk, V. Bannov, S. Kubenko. System of Landfill Gas Collection and Utilization // International Journal of Energy for a Clean Environment 14(2–3), p.191–199 (2013).