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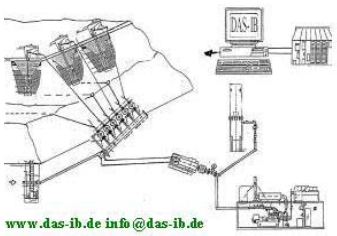

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"LFG projects between Old Europe (Germany) and the Old Eastern Bloc (L., R. and B.)"

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Due to the current political situation, the co-authors, companies and states wish to remain anonymous

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Summary:

LFG projects in the old Eastern Bloc parties. Optimisation of gas collection systems, utilisation, boosters and gensets in W2E (waste to energy) projects.

Index words:

Landfill gas, optimisation, gas collection system, hazardous waste, abandoned waste disposal sites, landfill, gas extraction system, gas wells, methane emissions, climate change, CO_2 potential, reduction of global warming, GWP, LFG, methane, flaring, CHP, W2E, waste to energy project, old Europe, Eastern Bloc, fake news.

General remarks

Methane emissions that escape from landfills (landfill gas) are highly relevant to the climate. According to the IPPC, methane is in these years 28 (25, 21 in older papers) times more harmful (higher negative effect) than carbon dioxide (CO_2).

About the author of this report:

Wolfgang H. Stachowitz started his professional career in 1987 in the function of a Project Manager for landfill gas extraction facilities at Haase Energietechnik GmbH, Neumünster, Germany. Sales and planning activities made him travel to numerous landfill sites throughout Europe. Until spring 2001, Wolfgang H. Stachowitz was responsible for the planning, implementation, and commissioning of a total of approx. 450 gas engineering plants in the world. He was an Authorised Signatory in these years and in charge of the entire Gas Engineering Department.

In 2002, he created his own company: DAS – IB GmbH in Kiel, Germany, which operates in the fields of biogas, digester gas and landfill gas technology. Planning, projecting, training of operating personnel and the issue of independent expertises are the company's main activities. Major projects have been carried out in Morocco, Finland, Hungary, Turkey, Lithuania and Germany in recent years.

1 Landfills: V., O., N. and G. I and II from B. (no fake news – but short cuts)

We checked the landfills and the extraction system as seen in the photos here and the presentation at Sardinia and on our website www.das-ib.de/english.htm

V. and O.:

Regarding the request for LFG prognosis and possible LFG utilisation:

Sardinia 2017

It did not seem to be useful to make a prognosis for both sites, since no data were available.

This primarily results from the deficits of the gas extraction systems, namely the very simple design, such as the small diameter of the pipes that are used to control the suction. In such a manner, it is nearly impossible for the operator to determine the amount of gas that is sucked from the landfill and to define the vacuum in certain sections of the landfill.

Another reason can be found in the operations. It cannot be detected how much gas is sucked to operate the engine. That is at their lowest point of performance.

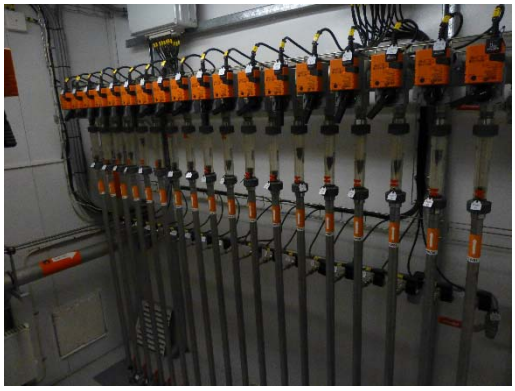
It could also be stated on site that operation less than 18 or 24 month methane content dropped from > 50 vol.-% to > 30 vol.-% and CO_2 from approx. 30 vol. % to > 60 vol. %.

This means that the process of composting started due to:

- aeration
- over suction

CH_4 (from the landfill) + 2 O_2 (from the air) transfer to CO_2 + 2 H_20 + energy

However, the temperature of the landfill gas was so low that the energy is also low, and the air so cold that the temperature of the landfill gas even decreased instead of increasing (getting higher): approx. 10°C instead of 30°C to 40°C.



N.:

The illustration shows an old landfill with an existing poor extraction system. It would not have been useful to analyse it.

However, there is a new site near by.

The dimensions amount to approx. 40 to 60 % of the existing one.

I suggested building a new and better extraction system at the new site, with a suitable extraction system and to use the old one for approx. 18 to 12 months with a decrease of the LFG to zero. The reasons why the LFG production would drop and is currently dropping are the same:

- Aeration
- Oversuction

The last but not least one in B.:

G. I from B.

At min. another 1 MW_{el} engine is possible to install and to operate but with a new and better extraction system – but taken into account the challenges on site that can be seen in the video in the presentation on site, lots of water emerges from the site along with the gas and H_2 (!) as well as a high H_2S content. Someone is needed to invest in the extension and upgrade of the extraction system.

Currently, no H_2S filters (e.g. active carbon) are installed at the site. The available cooler was inactive.

The landfill is not compacted as are the other ones and, therefore, it is exposed to aeration, when the suction is not effectuated properly, which is the case in the landfills that are currently operated.

The equipment at the site is adequate, if used properly, such as CHPs and gas booster stations.

At all the sites, no technical details (flow, delta pressure etc.) of the installed boosters are available / installed.

At all the sites, gas leakages can be found at the engines (turbo charger and cylinder):



The maintenance of the engines was poorly implemented.

O&M reports of the installed technical equipment were not available at any of the sites.

We have seen worse oil analysis reports without any changes regarding the operation of the technical equipment.

2 Landfill: K. from L.

The K. landfill is one of the biggest landfills in L.. The construction of the landfill started in 2006, and its operation started in 2007. The landfill is situated at two km south of K. village in the E. district. It is used by eight different districts of the V. region, where around 500,000 people live. The entire surface area of the landfill amounts to approximately 27 ha, and is subdivided into two sections. The first section has been operated since 2013. An estimated amount of approximately 1,4 million tons of waste are stored here. After the first section had been closed, the second section was opened. It is planned to store around 1 million tons of waste.

In 2013, after the cogeneration plant was opened in V. city, which is situated at approximately 5,5 kilometers from the landfill, the gas suction system was installed. In the first section of the K. landfill, a total of 34 gas pipes were installed. In 2015, another 16 pipes were added to the existing gas suction system. In total, there are five manifold stations with approx. 50 pipes that are extracting landfill gas (LFG) from both sections of the landfill. All the collected gases are compressed in a booster station that is also integrated into the landfill area, and then supplied to cogeneration plants in V. city.

This presentation is based on our yearly site visits from 2013 to 2016

DAS – IB GmbH hereby confirms that, according to the aforementioned visits and documents that are provided by our customer, the waste deposition plan of the land filling is sufficient and suitable to reach the following gas production levels:

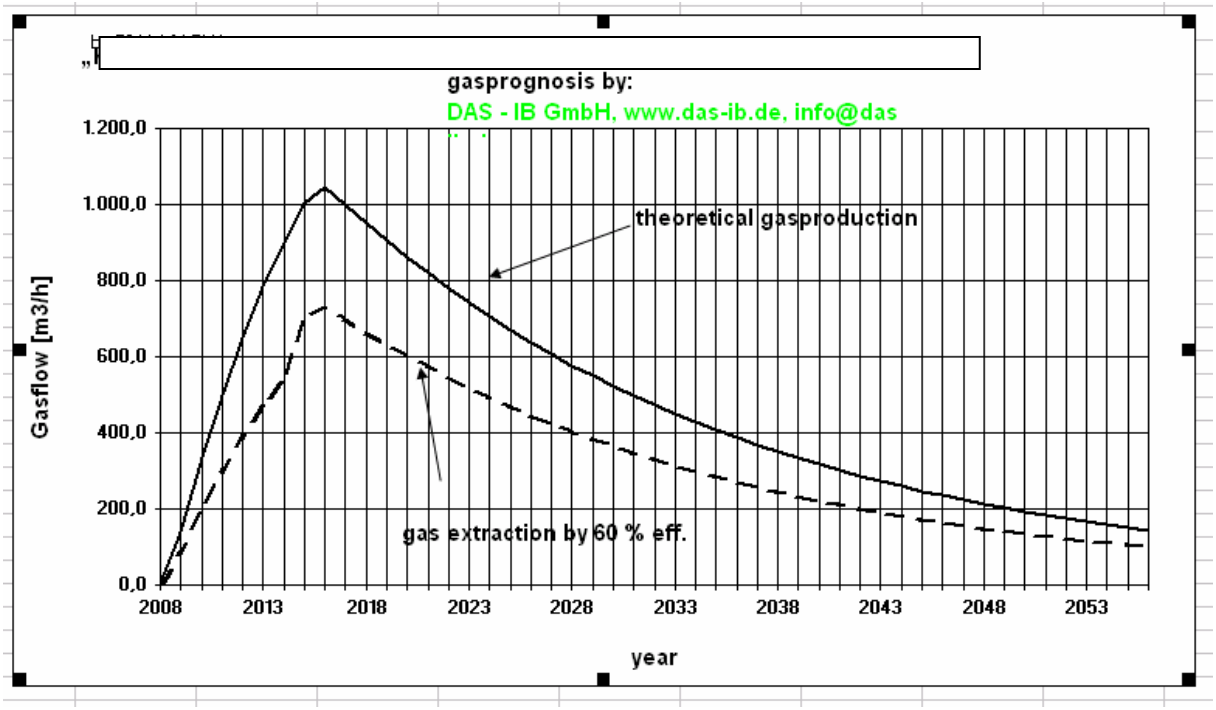
Gasprognosis
Landfill

az

k (Zeitbeiwert):	0,05
fa0 (Anfangszeitfaktor):	0,80
fa (Abbaufaktor):	0,70
f0 (Optimierungsfaktor):	0,70

Jahr year a	Abfallmenge waste Mg/a	TOC average kg/t Mf	efficiency %	Gasprod. Qt m³/h	Gasextrac. Qa m³/h
2007	4.600	120	0,6	0,0	0,0
2008	224.315	150	0,6	2,3	1,4
2009	260.768	189	0,6	139,3	83,6
2010	267.816	165	0,6	333,4	200,0
2011	262.993	164	0,6	497,3	298,4
2012	247.625	164	0,6	648,8	389,3
2013	230.812	164	0,6	782,7	469,6
2014	224.315	161	0,6	898,9	539,3
2015	200.565	110	0,6	1.002,2	701,6
2016	120.000	17	0,6	1.043,3	730,3
2017		160	0,6	1.000,7	700,5
2018		160	0,7	951,9	666,3
2019		160	0,7	905,5	633,9
2020		160	0,7	861,3	602,9
2021		160	0,7	819,3	573,5
2022		100	0,7	779,4	545,6
2023		100	0,7	741,4	519,0
2024		100	0,7	705,2	493,6
2025		100	0,7	670,8	469,6
2026		100	0,7	638,1	446,7
2027		100	0,7	607,0	424,9
2028		100	0,7	577,4	404,2
2029		100	0,7	549,2	384,5
2030		100	0,7	522,4	365,7
2031		100	0,7	496,9	347,9
2032		100	0,7	472,7	330,9
2033		100	0,7	449,7	314,8
2034		100	0,7	427,7	299,4
2035		100	0,7	406,9	284,8
2036		100	0,7	387,0	270,9
2037		100	0,7	368,1	257,7
2038		100	0,7	350,2	245,1
2039		100	0,7	333,1	233,2
2040		100	0,7	316,9	221,8

All the values are approximate values and are based on theoretical values for the landfill gas production and practical gas production in landfills with similar conditions. The values may vary, depending on changes in the deposited waste (TOC), changes in the structure of the landfill (water, plastic, compactor etc.) and the operator's work procedures (required measurements, optimization and O&M on the technical equipment). Other issues that may have an impact on the landfill gas production are, therefore, subject to change.



The approximate average theoretical gas production from 2014 to 2016 is as follows:

600 m^3/h * 8,760 oph pa = approx. 5,256,000 m^3 pa with a methane content of 50 vol. %, one will receive an approximate firing capacity of the landfill gas of:

5,256,000 m^3 * 5 kWh / m^3 = approx. 26,000,000 kWh of thermal energy with the efficiency of approx. 0,4 gas engines, one will obtain approx.

26,000000 kWh * 0,4 = approx. 10,500,000 kW electric energy

Our costumer has operated the site in 2013 and 2014 as follows:

2013: 2,510,500 m^3

2014: 3,358,000 m^3 with 5,970,028 kW electric energy

It can, therefore, be said that there is still potential regarding the operation of the LFG plant.

The data from our costumer dated autumn 2016 after our double check:

Year	LFG m3 / year	Electric power kWh/y	Heat kWh/y	kWh / m3	kW		LFG m3/h
2013	2,510,500	5,970,028	4,314,710	2,4	682		287
2014	3,336,948	6,471,961	4,590,030	1,9	739	1 engine	381
2014	2,732,389	5,479,773	4,980,970	2,0	1,268	2 engine	632
2015	6,737,588	14,012,183		2,1	1,600		769
2016							

Trends and processing in the years 2015 to 2016:

- Operation of the manifold stations / gas wells:

Manifold station	Number of pipes / gas wells		Number of pipes / gas wells in operation	Number of pipes / gas wells in operation with water	Number of pipes / gas wells closed or not installed
K – 4	11: (2015)	2016	1 (5)	4 (4)	6 (2)
K – 2	12: (2015)	2016	0 (4)	3 (6)	12 (2)
K – 3	11: (2015)	2016	1 (0)	4 (9)	6 (2)

K – new	22: 2016 with new booster 18: (2015)	10 (8)	9 (10)	3 (0)
K – brand new	32 only 2016	10	2	13 not installed + 7
∑	88 (52)	22 (17)	22 (29)	34 + 13 not installed (6)

Conclusion: 2016: 22 out of 88 performed well 25 %
22 out of 88 are infiltrated with water 25 %

50 % are worse and not in operation

2015: 17 of 52 performed well 33 %
22 of 52 are infiltrated with water 42 %
29 % were worse and not in operation

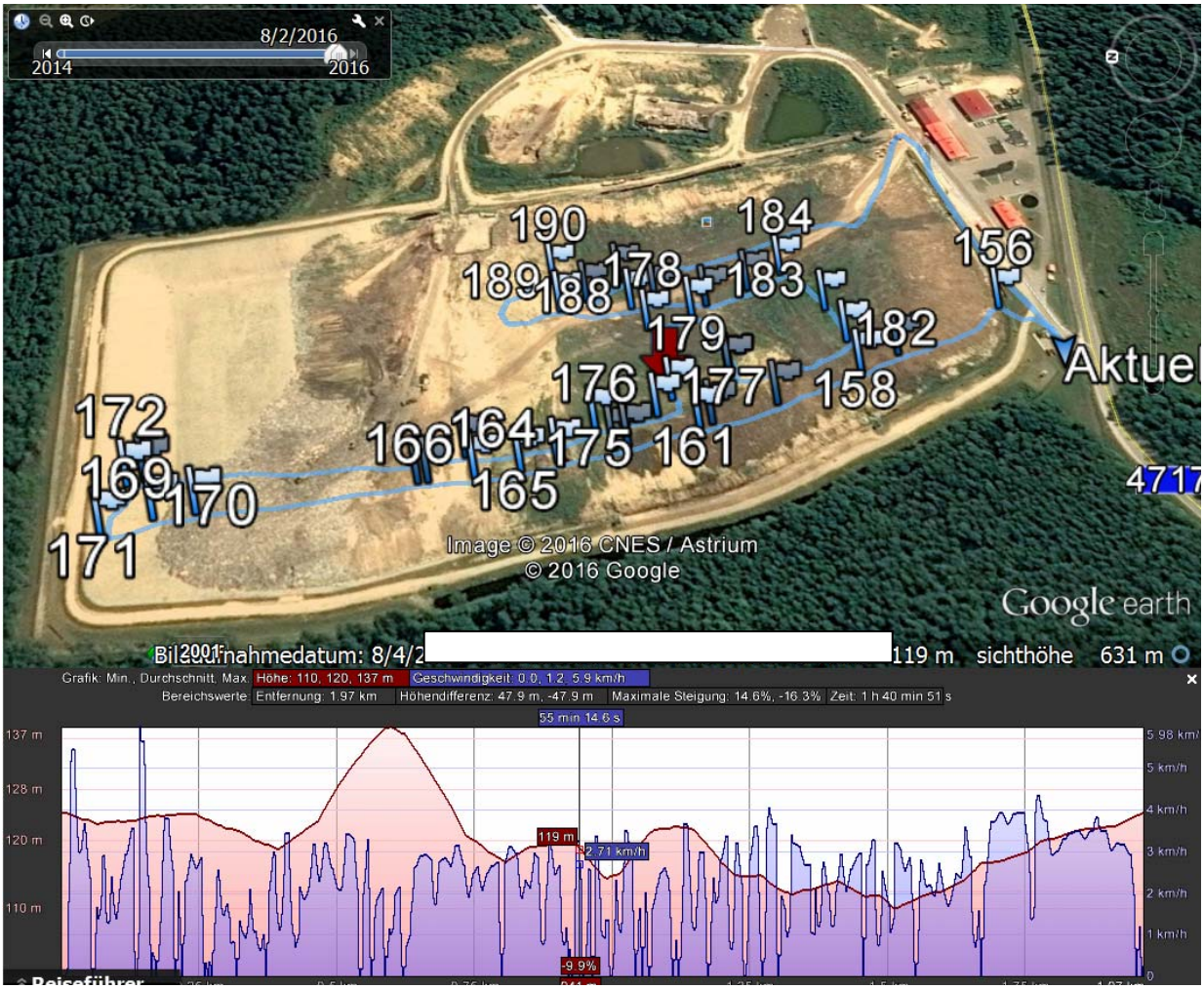
- Leachate ponds/lagoons – slide of the landfill
  In 2016, we found three big leachate ponds / lagoons on the surface area of the landfill. This type of operation is absolutely unusual. Normally, leachate ponds / lagoons can be found in a separate area of the landfill but not on the waste (at the landfill). For such a landfill size, a technical leachate system is used in “Old” Europe, like an RO, dryer etc. . At least, the water content of the leachate will be evaporated by the sun via black HPDE liners. The sizes of the ponds / lagoons are presented in-between waypoints 177–180, 181–183 and 183–186.
  Photos of the three leachate ponds / lagoons dated 2016.

Normal pond / lagoon near to a landfill site:

- TOC and waste input

  As a result of the starting-up of an MBT / MBP plant in V., the TOC of the waste decreased extremely in 2016. Furthermore, the waste input at the site also decreased due to the old Europe nations.

- Emissions over the surface



GPS waypoints of emissions and track of the emission control, 2016

Waypoint	Emission over the surface (Sewerin HS 680) in ppm / vol. % of methane	Emissions in a height of approx. 1m, measured in ppm with Sewerin ExTec PM 4

156	100 – 500	10
157	40 – 50	
158	30 – 60	
159	10 – 30	
160	0.2 vol.-%	10 – 50
Until 161		
162	5	0
163	30	10
164	< 10	0
From 165	50 – 100	> 10
Until 166	< 10	< 3
From 167	> 30	> 10
Until 168	< 10	0
169 (open dump)	> 30	> 10
From 170	660 ppm – 0.1 vol. %	10 – 20
Until 171	240 – 0,1 vol. %	4 – 20

Until 172	200 – 600	7 – 30
From 173	> 10	0
Until 174	10 – 30	0
From 175	> 10	> 10
Until 176	> 10	0
From 187	> 10	10 – 20
Until 188	> 10	0
From 189	10 – 0,1 vol. %	10 – 20
Until 190	0	< 3
From 191	60 – 0,1 vol. %	> 10
Until 190	3	< 5

Conclusion: The gas extraction system needs to be optimised and improved.

- leachate treatment / storage

The K. landfill site needs a leachate treatment system, or at least the storage of leachate water in this range and the accumulation of leachate on the landfill surface area must be stopped. Otherwise, the gas extraction system will be filled with water

and the slope of the landfill will slide towards the ring road. The first movements can already be discerned.

. 2016

2015