A new, effective solution for landfill gas extraction

Ing. Eugène Timmermans
Ing. Tristan Hillebregt

1. Introduction

A small test field was built to compare the LFG (Land Fill Gas) extraction performance of a new vertically and horizontally applied LFG drainage system called ‘Multriwell’ with a conventionally used vertical gas extraction well.

The test field is located on the Solid Waste Deposit Site ‘Afvalverwerking Vink’ in the city of Barneveld in the Netherlands.

The primary test objective was to compare the performance of standard vertical LFG wells with the new Multriwell system. The secondary objective was to gain knowledge about the installation performance, such as effectiveness, equipment and material consumption.

The particularly test site was chosen because:

- the waste composition is typical of the Netherland;
- single vertical wells were already installed
- the LFG extraction system was in operation
- therefore the test results can beconsidered as being realistic

The area to be served by the single well was designed at approximately 4,500 m^2, (distance between the wells 70 m) whereas the area of the installed Multriwell system was calculated at approximately 2,000 m^2. The Multriwell system was installed on an area of 1,600 m^2 (40 x 40 m), but the actual influence area is assumed to be 30 % more. (based on test results and flow calculations with SV-flow model). The gas well 26 has a depth of 18 m and is perforated from a depth of 3 to 18 m below surface. The Multriwell drains are placed in a grid of 2 by 2 m and the average depth is 11 m below surface.

The installation depth of the Multriwell system is 7 m less than the single well. Due to the decreased LFG production of the older and deeper situated waste no significant influence is assumed (a production decrease of maximum 3 m^3 per hour is calculated based on 2,000 m^2).

The potential LFG production was calculated based on available Dutch Standard Data, using standard calculating models. The fraction of biological degradable carbon which was available for degradation varied between 3 and 7 % depending on the year of depositing.

It was concluded that the potential gas production for the years 2009 and 2010 on average was:

- LFG 83 m^3/hour,upper boundary 98 m^3/hour, lower boundary 69 m^3/hour;
- CH_4 50 m^3/hour,upper boundary 58 m^3/hour, lower boundary 41 m^3/hour.

When other data for organic content are used - for example 30 and 60 % with all other assumptions unchanged, the potential LFG production increases to 200 and 400 m^3/hour for 2010 (CH_4 120 and 240 m^3/hour) respectively.

The maximum extractable LFG production of the single gas well with an under pressure of 6 mbar was approximately 80 m^3/hour. Under the same circumstances the maximum gas production of the installed Multriwell system was about 250 m^3/hour.

The performance of the Multriwell system, with the control valves adjusted to provide a constant CH_4 content, was farbetter than theoretically expected (produced average 84 m^3/hour, expected 35 m^3/hour, a factor 2.4, see Table 5).

Conclusion about installation:

The installation of the Multriwell system appeared to be easy. A detailed description is given in 2.

Conclusions test results:

Based on the measurements the following can be concluded:

- Due to the installation of Multriwell and partly in combination with the Trisopalst cape the productivity of the extraction system increased from 48 m^3/h to 60 m^3/h.
- In comparison with the conventional well the performance is a factor 1.4 more effective. When taking the different influence area into consideration the performance of the Multriwell system becomes a factor 2.5 to 3.0 times more effective, neglecting the fact that the lower 7 m of waster are not made use of. (see also chapter 4.3)The better performance is plausible due tothehigher perforation rate causinga better relocation of the existing water within the waste as a result of the vertical drains. The chemical conversion of dried out organic waste is therefore restarted, resulting in an increase in flux of LFG. The general increase in extractable Gas volumes is also partly due to the partial capping of the field trial area with Trisoplast.
- The Multriwells have a significant potential overcapacity compared with a single well. This overcapacity is believed to be caused by a nearly complete perforation of the waste, less entrance resistance and the greater surface area.
  Traditional well with a diameter of 300 mm gives 706.5 cm^2/1m (over a length of 15 meters (18 – 3 m)) in comparison to the total Multriwell type V; 1,900 cm^2/1 m (4 mm x 95 x 500 wells for 1,600 m^2)) over a length of 11 meters.
- The vast extraction potential can lead to a decrease of the LFG quality, if the potential is fully used without control because more Gas can be withdrawn than LFG is produced by the waste. On the other hand the extraction can be optimised to best meet the LFG production, whereas the conventional gas well system reaches its limitation at a lower level.

When CO_2 reduction is the main objective, the Multriwell system is capable of extracting the gas far easier and in a shorter time frame than the traditional vertical wells. This in combination with flares offers a significantly better environmental protection as well as economic advantages.

It is recommended to limit the influence area of the Multriwell system, same as for single gas well solutions, to approximately 2,500 m^2 per regulation unit in order to be in a position to optimise the gas extraction

2. Installation of the Multriwell system

The Multriwell type V was installed with a standard 60 tons CAT excavator. A special sticher was mounted to the excavator (see Picture 1)

Picture 1: Excavator with Sticher.

After pressing in the Multriwell type V with a maximum speed of 4 m/s and in this case a maximum depth of 11 meters (the maximum depth can normally be chosen of up to 30 meters) the Multriwell was cut off ata length of 0.5 meters above the waste level. (see Picture 2)

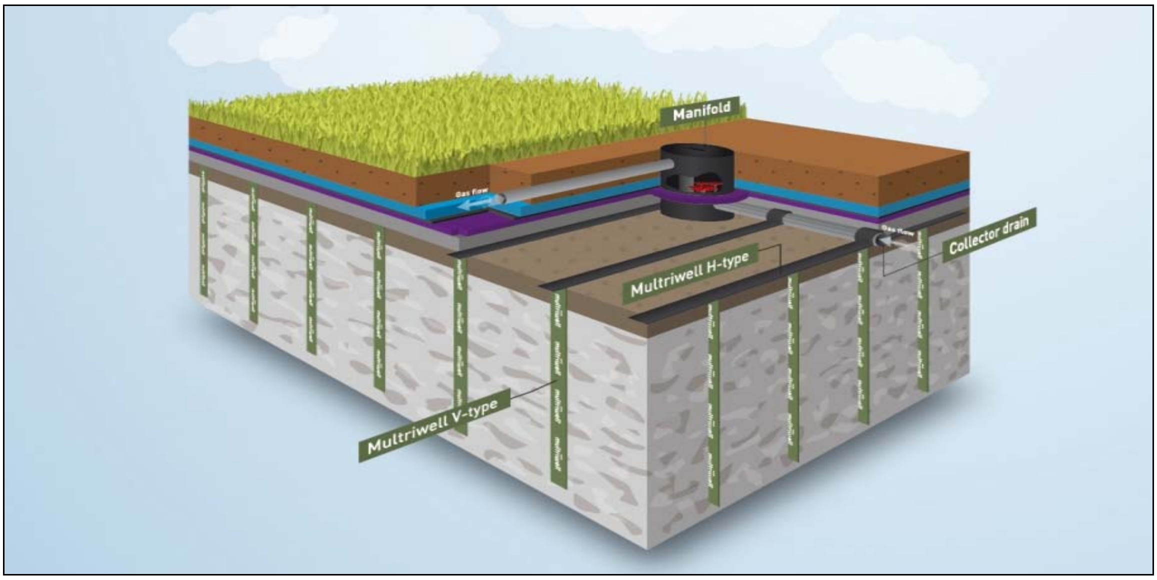
Picture 2: Cutting of the Multriwell type V

After installingall Multriwell type V, the Multriwell type V were connected with the Multriwell type H by stapling them together. (See Picture 3)

Picture 3: stapling the Multriwell type V to the type H

Before covering the Multriwell system with the gas and liquid impermeable Trisoplast layer the Multriwell type H was connected to the collector drain which goes to the manifold. (See Picture 4).

Picture 4: connecting the Multriwell Type H to the collector drain and covering it with a Trisoplast mineral liner



Picture 5: illustration of the Multriwell system

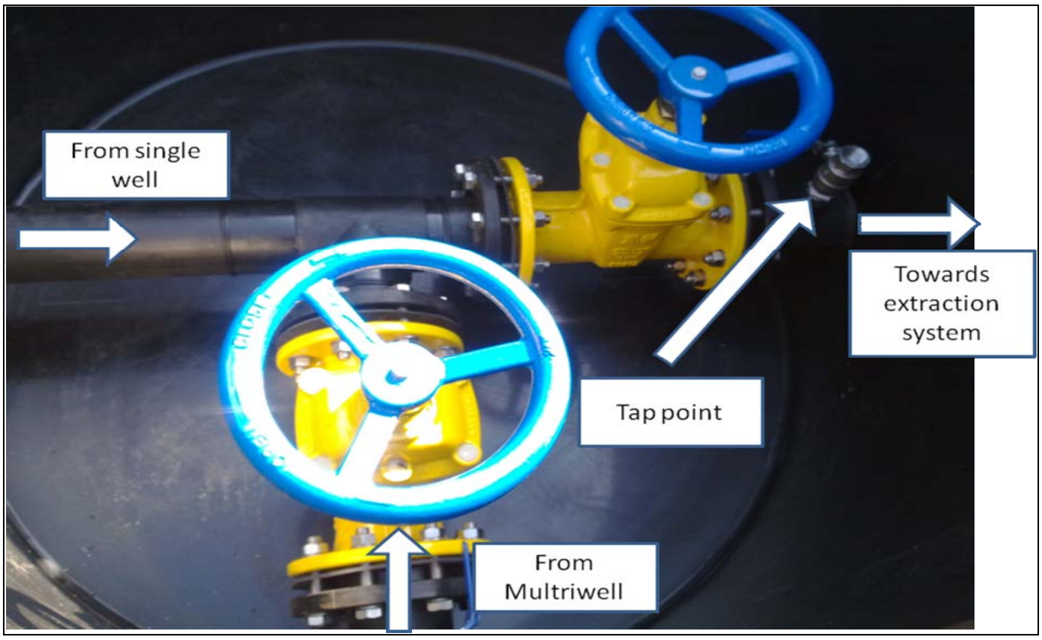
3. Test Elaboration

The test field configuration exists of one single vertical well, around which the vertical and horizontal components of the Multriwell system, combined with the Trisoplast cover, were installed. Through a completely adjustable manifold both the single well and Multriwell system were connected to the LFG extraction system.

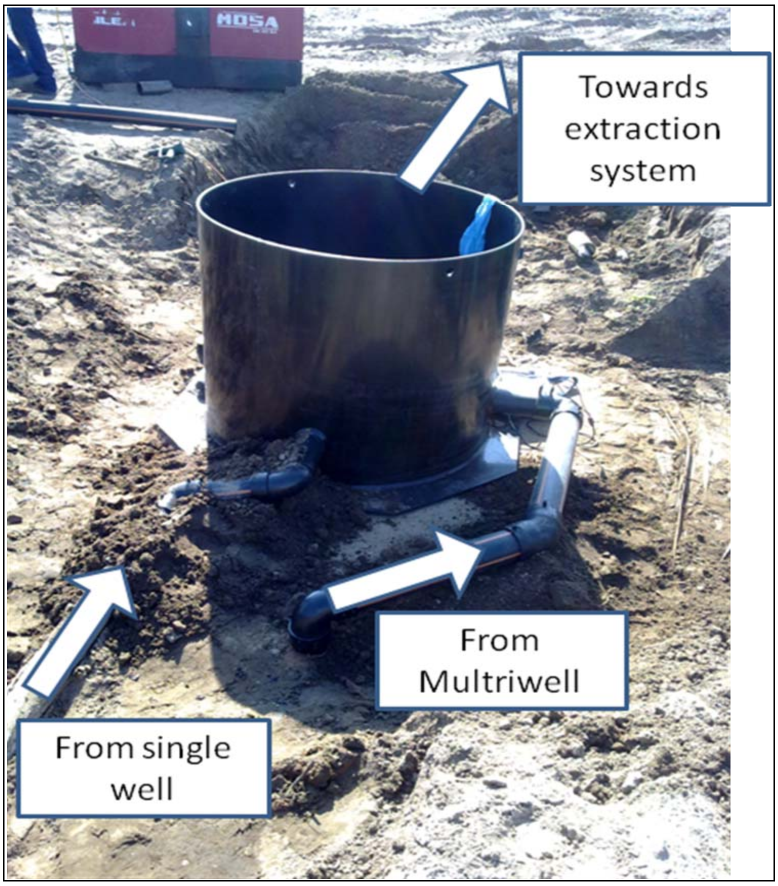
The performance of both single well and Multriwell system was measured on the same tap point. The test elaboration waschosen as followed:

- Measuring LFG flux single well before installing Multriwell (maximum and optimum)
- Measuring LFG flux single well after installing Multriwell and Trisoplast cover (maximum and optimum)
- Measuring LFG flux Multriwell (maximum flux) after completely closing the single well (manifold is on the well itself)
- Adjusting the flux from Multriwell to optimum for constant CH_4 content (duration 6 months)
- Closing Multriwell system and adjusting single well to optimum and maximum flux
- Closing single well and adjusting Multriwell system to optimum and maximum flux

The figures below show the manifold as built.



Picture 6: Manifold test field configuration



Picture 7: Manifold configuration

4. Layout and Influence Areas

4.1 Layout

Figure 1 shows the layout of the test field and its traditional well location within the existing Landfill

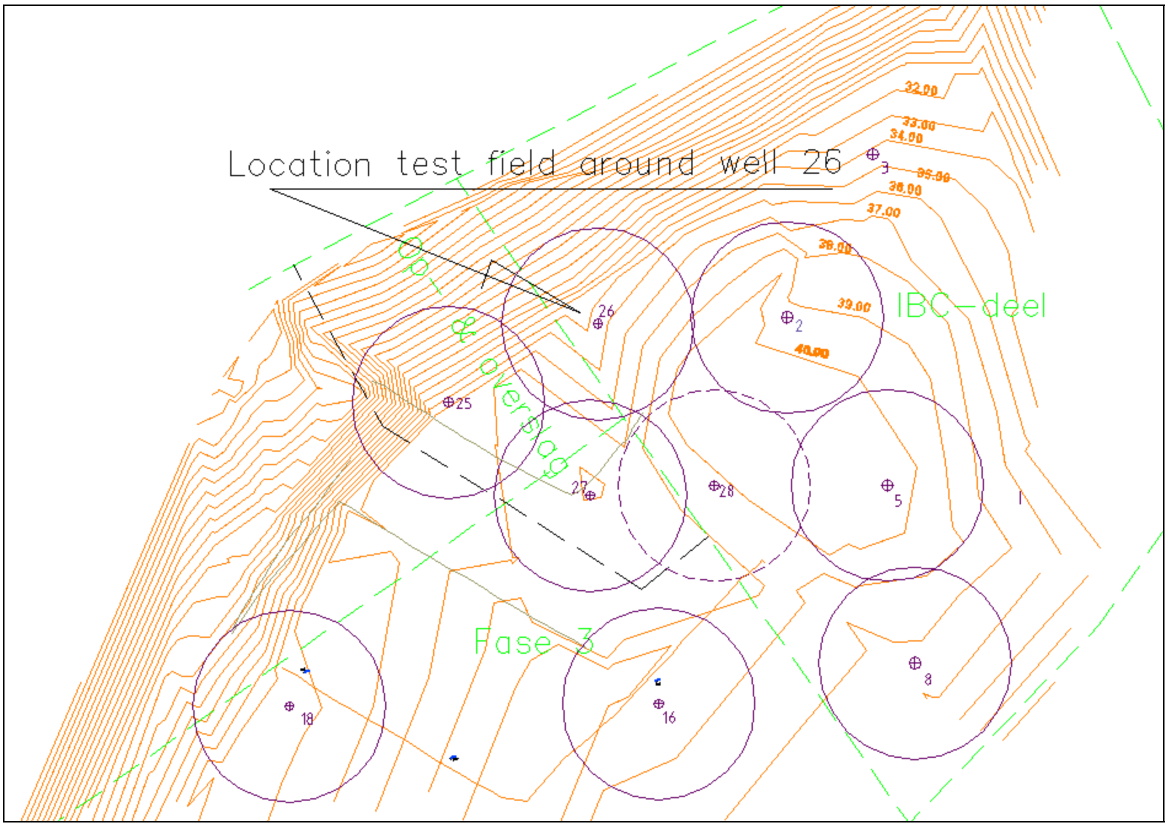


Figure 1: Layout test field

Test field with the existing wells

4.2 Influence Area

The designed influence area of the traditional gas well is 75 m in diameter around the gas well 26 resulting in approx. 4,500 m^2.

The surface area of the Multriwell system is 1,600 m^2 and the surface area of the mineral cap is approx. 2,800 m^2.Figure 2 shows the test field as built.
(See appendix 1)

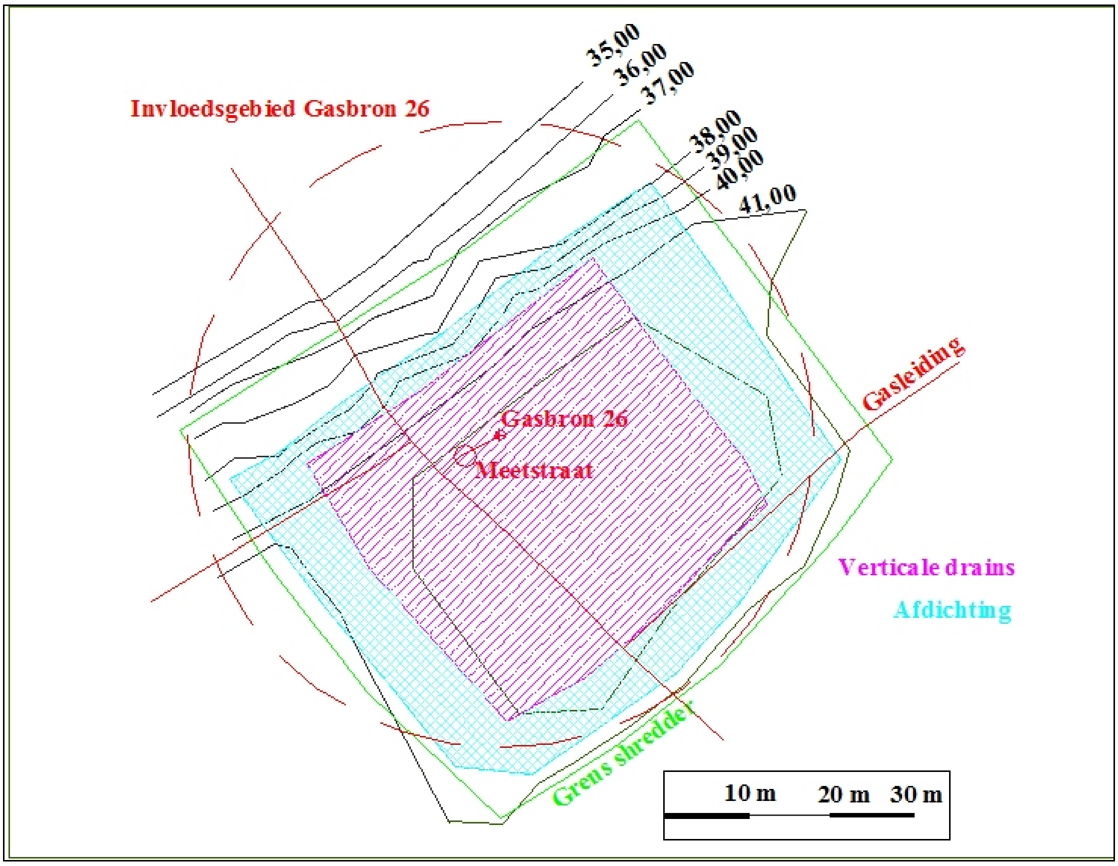


Figure 2: Test field

Translation:

- Invloedsgebied gasbron 26: Influence area well 26
- Meetstraat: Manifold
- Gasleiding: LFG pipe
- Verticale drains: Multriwell system
- Afdichting: Trisoplast cover
- Grens shredder: Boundary of the supporting layer for Trisoplast

The gas well 26 has a depth of 18 m and is perforated over a depth of 3 to 18 m below surface. The Multriwell drains are placed in a grid of about 2 by 2 m and the average depth is 11 m below surface. Bottom of waste core is situated at 15 m + NAP, thus thickness of waste is 25 m on average.

5. Theoretical calculation LFG production

5.1 Waste and Quantity

A clear recording of the nature and quantity of the waste products has become common practice in the Netherlands since 1989. In the period between 1973 - 1989 and 1989 - 1995 municipal waste and industrial waste products were disposed on this site. In the period between 1995 and 2007 industrial waste products were more common than municipal waste.

The test field is located on the sections ‘IBC’ and ‘op- and overslagterrein’of the landfill site.

These areas have been in operation since 1985 and November 2007 respectively.

The influence area of the test field is divided between these two landfill areas by approx. 1.500 $m^2$of ‘op- en overslagterrein’ and 3.000 m^2 of ‘IBC’.

Table 1 shows the historical yearly waste disposal for the test site.

Table 1: Waste disposal test site

Year	ton/year	Year	ton/year
1980	2700	1995	2700
1981	1350	1996	3300
1982	1350	1997	3300
1983	1350	1998	3300
1984	1350	1999	3300
1985	1350	2000	3300
1986	2700	2001	0
1987	2700	2002	0
1988	2700	2003	0
1989	2700	2004	3300
1990	2700	2005	3300
1991	2700	2006	3300
1992	2700	2007	6600
1993	2700	2008	29700
1994	2700	2009	19800
Total			120.000

5.2 Prognosis of Gas Production

The potential gas production was calculated applying three methods:

- EPA landgem version 3.02
- Protocol 9084 Waste Deposit Sites NIR 2009 April 2009
- Specifically calibrated model according to Scholl Canyon

The Landgem version 3.02 model is based on the Scholl Canyon calculation for the potential gas production:

$$Q_{CH4} = \sum_{i=1}^{n} \sum_{j=0,1}^{1} k\, L_o \left(M_i / 10\right) e_{ij}^{-kt}$$

In which:

Q_{CH4} : annual methane generation in the year of the calculation (m^3/year)
i: 1 year time increment
n: (year of the calculation)-(initial year of waste acceptance)
j: 0.1 year time increment
k: methane generation rate (year-1)
L_0: potential methane generation capacity (m3/ton)
M_i: mass of waste accepted in the i^{th} year (ton)
t_{ij}: age of the j^{th} section of waste mass M_i accepted in the i^{th} year

De NIR uses the following definition:

$$\mathrm{Pr}od_{x(t)} = M_x * DOC_x * f * k_x * e^{-k_x*(t-x)} * F * 16/12 * MCF$$

In which:

t:	report year
x:	year of accepted waste
$Prod_x(t)$:	methane production (ton) in year t of in year x disposed waste
M_x :	mass of waste in year x
DOC_x :	fraction biological degradable carbon in waste year x
f :	fraction biological degradable carbon which is available for degradation
k_x :	reaction constant
F :	fraction methane in landfill gas (according NIR 0,6)
16/12 :	molecular weight ratio CH4 / C
MCF:	methane correction factor; in the Netherlands =1

The specifically calibrated model according to Scholl Canyon is formulated as:

$$Q_i = k * Lo * m_i * (e^{-k(i-x)})$$

In which:

Q_i = methane produced in year "i" (m^3 CH_4/year)
k = methane generation constant (default 0,05)
Lo= methane generation potential (CH_4/ton waste)
m_i = waste disposal in year "i" (ton)
i = current year
x = years of waste input

According to the specifications all model calculations do have an uncertainty of approx. 35 % (±17.5 %). Reliability intervals are not specified. A more secure input gives a more accurate calculation.

The organic content of the waste as deposited varies between 12 and 13.2 %. National data varies from 7 up to 13.2 % depending on the year of disposal. Not all the organic content is available for biological degradation. The fraction of biological degradable carbon which is available for degradation varies between 3 and 7 %.

The EPA Langdem model results in more conservative values than the NIR and Scholl Canyon model due to the objective (emission reduction) and scale size. The EPA model was therefore chosen as reference.

Figure 3 shows the potential gas production of the test field. This report does not include the validation of the calculation methods on other production wells. This validation shows a reliability of ±15 % in comparison with long year measurements of gas production.

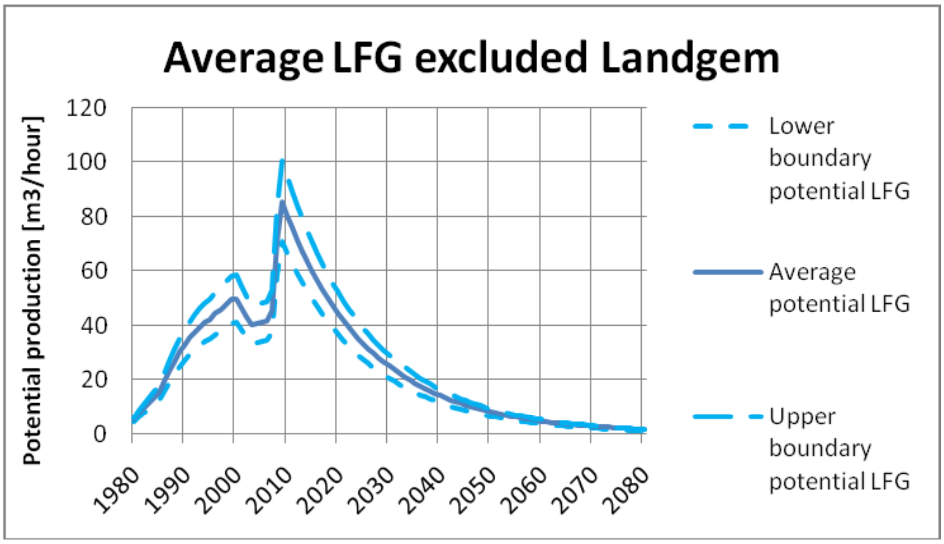
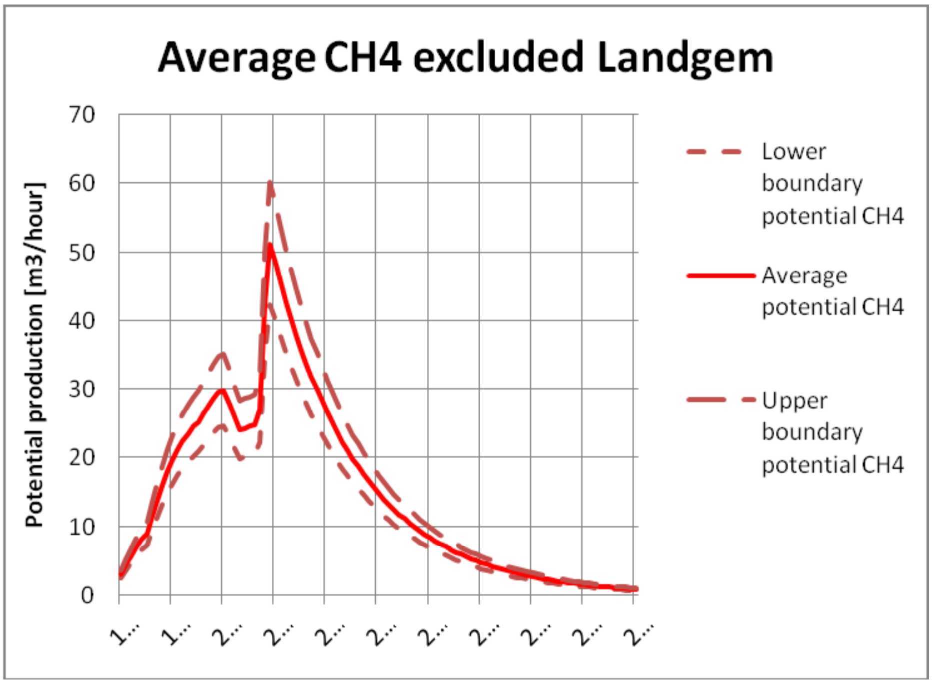


Figure 3: potential gas production of waste for location 26



It can be concluded that the potential gas production for the years 2009 and 2010 on average were:

- LFG 83 m^3/hour upper boundary 98 m^3/hour, lower boundary 69 m^3/hour;
- CH_4 50 m^3/hour upper boundary 58 m^3/hour, lower boundary 41 m^3/hour.

If a different organic content were used, e. g. 30 % and 60 % with the other data being equal, the potential LFG production would increase to 200 and 400 m^3/hour in 2010 (CH_4 120 and 240 m3/hour) respectively.

5.3 Influence Area: Horizontally and Vertically

It is assumed that the influence area of the vertical traditional gas well includes the theoretical boundary and complete thickness of the waste. So the horizontal influence area is 4.500 m^2 and the thickness is 18 m.

The average installation depth of the Multriwell system was11 m below surface. The vertical influence of the Multriwell gas drains was considered 30 % deeper than the installed depth. The older deposited waste produces a relative small amount of LFG. It was calculated that the waste at larger depth actually produces 2 to 3 m^3/hour of LFG. Therefore, seen from the gas productions point of view, the difference in vertical influence area between the Multriwell and the single gas well is not that significant and thus could be neglected for the calculations.

The horizontal influence area of the Multriwell system as installed is smaller than that of the single gas well. The designed horizontal influence area of the single well is approximately 4,500 m^2. The installed area of the Multriwell system is 1,600 m^2. The horizontal influence area was assumed to be 30 % larger, so approximately 2,000 m^2.

5.4 Prognoses of the Extractable Gas Production

The maximum quantity of extractable landfill gas depends on the way the landfill is covered. With none or insufficient covering 55 to 60 % of the potential landfill gas is generally extractable. After effective capping of the landfill this percentage increases to almost 100 %.

The test field was covered with a Trisoplast mineral liner providing an effective gas sealing layer. From the theoretical surface of 4.500 m^2 only 2.800 m^2 were covered so it was assumed that about 85 % of the potential gas production was extractable in the test configuration.

In Table 2 below the prognosis of the extractable amount of landfill gas is given for the test field.

Table 2: Prognosis extractable LFG test field in m^3/hour

	Non covered	reliability	Covered with Trisoplast	reliability
LFG	46 tot 50	± 7	71	± 11
CH_4	27 tot 30	± 4	42	± 7

5.5 Conclusion theoretical gas production

Applying the mentioned boundaries, the theoretical extractable prognosis for both the single well and the Multriwell system are shownin Table 3.

Table 3: Prognosis extractable LFG Single well and Multriwell system for the test field in m^3/hour

	Horizontal influence area (m^2)	Vertical influence area (m^1)	Potential extractable LFG after partly covering with Trisoplast (m^3/hour)
Multriwell system	2.000	± 14	32***** ± 11
Single well	4.500	± 18	70 ± 11

***Note:** only due to the smaller installation area and the resulting smaller theoretical influence area, the total extractable amount of LFG for Multriwell system should be smaller than the calculated potential amount for the single well.

6. Test results and Performance

6.1 Testing Properties

LFG flux is measured by a calibrated velocity meter. Knowing the inside diameter of the tube the exact flux in m^3/hour could be determined. CH_4 and CO_2 content were measured with calibrated instruments.

All measurements on both the single well and the Multriwell system were carried out at the same measurement tap point and were carried out by anadequately qualified and certified independent party.

6.2 Maximum gas production

The maximum gas production was measured directly after installation (September 18th) as well as two weeks later. In the same time a comparison with the maximum gas production of the gas well was made.

The maximum gas production of the single gas well with an under pressure of 6 mbar was approximately 80 m^3/hour. Under the same circumstances the maximum gas production of the installed Multriwell system was 250 m^3/hour.

In case of a single well preferential flow paths and lock-ups will decrease the maximum flow towards the well, due to the high perforation rate of the Multriwell system there is almost no block age for the LFG.

Because the entrance surface of the Multriwell system is much larger than of a single well the LFG is extracted with less resistance.

Given the smaller influence area of the installed Multriwell system the maximum capacity compared with a single well should be even greater.

But this maximum capacity exceeds the potential production of LFG in the waste. In case the Multriwell system is not equalled to the potential gas production of the waste a decrease in the methane percentage of the LFG will occur whenever more methane is extracted than is produced by the waste.

During testing a decrease of methane percentage from originally 52 % to 38 % was measured at the maximum extraction rate of 250 m^3/hour. The total amount of $CH_4$was, in comparison with the single well, still greater, but the decrease of the CH_4 percentage suggests an over extraction of the gas field.

The extraction overcapacity of the Multriwell system is much higher than in case of a single gas well. In the case of the Multriwell system this enables the gas extraction to be optimised in a much wider range in order to ensure a constant and ideal CH_4content, whereas a single well is limited by its comparably smaller maximum extraction potential. Any how too high extraction amounts should however be avoided due to the aimed optimum CH_4 rate required for combustion.

Based on this particular test field the most fundamental conclusions are:

- Multriwell has a significantly higher extraction potential than the single gas well.
- By using the Multriwell system the extractable gas production and CH_4 content can be easily optimised, whereas a single well is limited by its relatively small maximum extraction limit.
- By maximum use of the vast extraction potential of the Multriwell drains a decrease of the CH_4 percentage is obvious because the extraction exceeds the gas potential of the waste.

It is recommended that the gas extraction is coordinated to the potential gas production and the intended use of the extracted LFG.

6.3 Measurements Gas Production Single Gas Well 26

The measurements of the gas production of the traditional single gas well are given in Table 4. Longer term measurements are not available because the well was only placed in July 2009.

Table 4: Measurement gas well 26

	P pipe (mbar)	Flow LFG (m^3/h)	CH_4 (%)	Flow CH_4 (m^3/h)	O_2 (%)	Remarks
Not covered	- 5,7	48	54	25	0	(average of 3 measurements)
Covered with Trisoplast and Multriwells installed	- 6,0	60	53	32	0	(average of 2 measurements)

With regards to the prognosis for the non-covered situation the measurements correspond remarkably well and within the reliability intervals.

The increase of the production performance due to the capping and the positive influence of the Multriwells with regards to the LFG production and accessibility is not as good as expected. The production level is at the lower end of the reliability interval.

6.4 Measurements Gas Production Multriwell

The measurements of the gas production of the Multriwell system are shown in Table 5.

Table 5: Measurements Multriwell system 2009/2010

	P pipe (mbar)	Flow LFG (m^3/h)	CH_4 (%)	Flow CH_4 (m^3/h)	O_2 (%)	Remarks
100 % open	- 6,0	250	42	63	0	18. September 2009
100 % open	- 6,2	275	38	105	0	25. September
Extraction regulated	- 5,9	80	51	41	0	1. October
Extraction regulated	- 6,1	85	53	45	0	6. October
Extraction regulated	- 5,8	75	50	41	0	16. October
Extraction regulated	- 5,9	83	51	42	0	29. October
Extraction regulated	-6,1	81	54	44	0	18. November
Extraction regulated	-6,4	90	54	46	0	13. January 2010
Extraction regulated	-7,5	95	57	54	0	3. February
Extraction regulated	-6,0	83	55	46	0	19. march

After regulation of the extraction quantity the methane value in the LFG is stable.

Table 6 shows the average and 95 % reliability interval of the measurements.

Table 6: Average regulated extraction Multriwells after 6 months

	P pipe (mbar)	Flow LFG (m^3/h)	CH_4 (%)	Flow CH_4 (m^3/h)
Upper boundary 95 % reliability interval		88	55	48
Average	-6	84	53	45
Lower boundary 95 % reliability interval		80	51	42

The performance of the Multriwell system is much better than theoretically expected (produced 84 m^3/hour, a factor of 2.4 more than the 35 m^3/hour that was expected,).

Partly this difference can be explained by the assumption that the theoretical influence area is not fully correct and should be further adjusted. When a bigger influence area (e. g. 2,500 instead of 2,000 m^2) is taken into account the performance is a factor 2.2 better than expected. It is however unrealistic to take no correction factor at all.

A more plausible explanation is the perforation rate of the waste. Common features are local drying out of the waste and perched water levels within the waste. Due to these features a decrease of potential LFG production is not unusual. The intensive perforation can diminish these negative effects by relocating the present water, and by doing so partly restarting the chemical conversion of organic material into CH_4.

In comparison with the single well the performance is a factor 1.4 times better bearing in mind that the influence area was smaller. When corrected for the different influence areas the performance of the Multriwell system is a factor 2,5 to 3,0 better.

The justification of the assumed influence areas can be theoretical be proven, but a practical prove is given by the configuration of the test field itself. The Multriwell system is sensitive for air entrance as it is a horizontal sub surface built up extraction system. As there is a open connection between the non covered waste and air it is just to assume any extraction outside the covered waste will increase the air concentration.

As during testing no or only very few air has entered the system of the test field the influence area of 1.600 m2 Multriwell is certainly smaller than the covered (Trisoplast) area (2.800 m2).

It can be estimated that the influence area of one V drain is small due to the relatively small amount of LFG extracted per drain. It is therefore assumed that the influence area horizontally is bounded.

6.5 Measurements in2010

Due to a complete overhaul of the western part of the gas extraction piping system on the landfill, a revised extraction configuration was necessary. The Multriwell system was shut down during a period from 31st April until 15th July and the extraction was taken over by the single gas well again. Duringthis period the extraction volume of gas well 26 was regulated to amaximumof 65 m^3/hour with a constant CH4 content of 52 %. The main reason for the adjustment was due to the CH4 content which had decreased from 55 % to 52 %. All surrounding gas wells showed the same decrease of the CH4 content, so the most plausible explanation can be foundin the condition changes during the summer period. The same behaviour can be seen in the historical overview of the gas performance of all the gas wells at Afvalverwerking Vink BV.

From 15th July 2010 onwards the production on the test site was taken over by the Multriwell system again and the volume was also restricted to 65 m^3/hour.

Table 7: Update Measurements Multriwell system and gas well 26 in the year 2010

	P pipe (mbar)	Flow LFG (m^3/h)	CH_4 (%)	Flow CH_4 (m^3/h)	O_2 (%)	Remarks
100 % open Multriwell	- 6,0	220	48	105	0	21 July 2010
100 % open gas well 26	- 6,0	85	51	43	0	21 July 2010
Extraction regulated Multriwell	- 6,0	65	50	33	0	21 July 2010
Extraction regulated Gaswell 26	- 6,0	65	52	34	0	21 July 2010

It should be notated that with maximum flow a decrease of CH4 content caninstantly be seen. To achievea constant and sufficient CH4 content it is necessarily to regulate the LFG flow in accordance with the maximum potential gas production of the waste.

The difference between the CH4 content of the gas well 26 and the Multriwell system is plausible and most likely caused by the different size of the influence areas and the infiltration of rainwater. The Multriwell system is installed on a smaller part of the influence area of the gas well 26. The moisture content of the deposited waste under influence of the Multriwell system was not maximized to field capacity and cannot reach its field capacity due to the capping. Because the influence area of gas well 26 is only partly capped, rainwater can still partly infiltrate and reaches deeper waste layers. This phenomenon was expected right from the start of the tests because the Multriwell site is built on ‘new’ deposited waste with insufficient moisture content. Initiallyan increase of the gas production was recognized due to the positive effect of relocating water through the drains, but then the insufficient moisture content of the waste overruled this process, causing a slight decrease of the CH4 content.

6.6 Measurements in 2011

Two test periods were realised in 2011:

- January until June 2011 : Multriwell system off, gas well 26 regulated;
- July until November 2011 : Multriwell system regulated, gas well 26 off.

Table 8: Update Measurements Multriwell system and gas well 26

	P pipe (mbar)	Flow LFG (m^3/h)	CH_4 (%)	Flow CH_4 (m^3/h)	O_2 (%)	Remarks
100 % open Multriwell	- 6.8	210	49	103	0.6	24. June 2011
100 % open gas well 26	- 6.6	75	52	32	0.1	24. June 2011

The extraction is regulated as obliged by landfill owner at 65 m3/h.

Table 9: Update Measurements Multriwell system and gas well 26

	P pipe (mbar)	Flow LFG (m^3/h)	CH_4 (%)	Flow CH_4 (m^3/h)	O_2 (%)	Remarks
100 % open Multriwell	- 7.3	225	51	115	0.3	22. November 2011
100 % open gas well 26	- 7.2	78	53	41	0.1	22. November 2011

The extraction is regulated as obliged by landfill owner at 65 m3/h

Conclusion after 2 years testing:

- The Multriwell test field is deemed stable.

As extension of the elaboration it is recommended to infiltrate water through the Multriwell system into the waste body. The Multriwell system is thought to be more capable of infiltrating water than the traditional gas wells. Main goal should be to measure an increase of LFG production due to water infiltration and to research the possibility and effect of water infiltration through the Multriwell system.

Irrespective the use of Multriwell or a traditional well system it is recommended to infiltrate a sufficient amount of water to reach the maximum field capacity of the waste before capping.

7. Provisional Conclusions and Recommendations

Installation:

The installation of Multriwell system appeared to be fast, safety and easy.

Measurements:

Based on the measurements the following can be concluded:

- In comparison with the single well the performance of the Multriwell system is a factor 1,4 better whilst noting that the influence area of the Multriwell system as built was smaller. When corrected for the different influence areas the Multriwells performance is a factor 2,5 to 3,0 better. The better performance is most likely caused by a higher perforation rate and a relocating of the existing water in the waste through the vertical drains. The chemical conversion of dried out organic waste is therefore restarted, causing a flux of LFG.
- All the Multriwells together have a significant potential overcapacity compared with a single well. This overcapacity is believed to be caused by a nearly complete perforation of the waste, a lower entrance resistance and the greater surface area of the Multriwells.
- The vast extraction potential can lead to, in case this potential is completely used, a decrease of the LFG quality, because more LFG is withdrawn than is produced by the waste.
- The potential extraction quantity allows optimising the LFG gas production as them maximum extraction rate is no boundary, where the single well is limited in quantity performance.

When CO2 reduction is the main objective, the Multriwell system is capable to drain the potential gas easier and faster than the single vertical wells. This in combination with a flare is a high potential environment and economical advantage.

It is recommended to limit the influence area of the Multriwells (the same applies to the traditional well system) to approximately 2,500 m^2 per regulation unit to optimize the gas extraction.

Literatur

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Appendix 1.

Air Permeability waste

Correlation to soil's physical properties. Soil air permeability is estimated from soil characteristics such as grain size distribution or hydraulic conductivity by assuming a linear correlation. This is a quick estimation method and provides only an order of magnitude estimate. This relationship is expressed by the following equation:

$$k_a = k_w \left(\frac{\rho_a \mu_w}{\rho_w \mu_a}\right)$$

where Ka = air permeability

Kw = hydraulic conductivity
ra = density of LFG = 1,163 kg/m3
rw = density of water = 1000 kg/m3
ma = viscosity of air = 126 µP
mw = viscosity of water = 10000 µP
Thus, $k_a = 0,092 * k_w$

Water permeability of waste is regarded to be within 1 to 5 m/day, air permeability is 0,01 - 0,5 m/day.

Modelling

With computer model SC office a estimation is made of influence area based on the next assumptions:

Air pressure 101 kPa
Overpressure due to LFG generation: 103 kPa
under pressure wells 6 mbar
Open connection to air, Trisoplast air tide over 40 m diameter
ka = 0,09 m/day, porosity 35 %, volumetric water content 0,05
vertical anisotropy: 0,1
model width: 100 x 25 m

Following figures shows the pressure partitioning in both system traditional well and Trisoplast/Multriwell system.

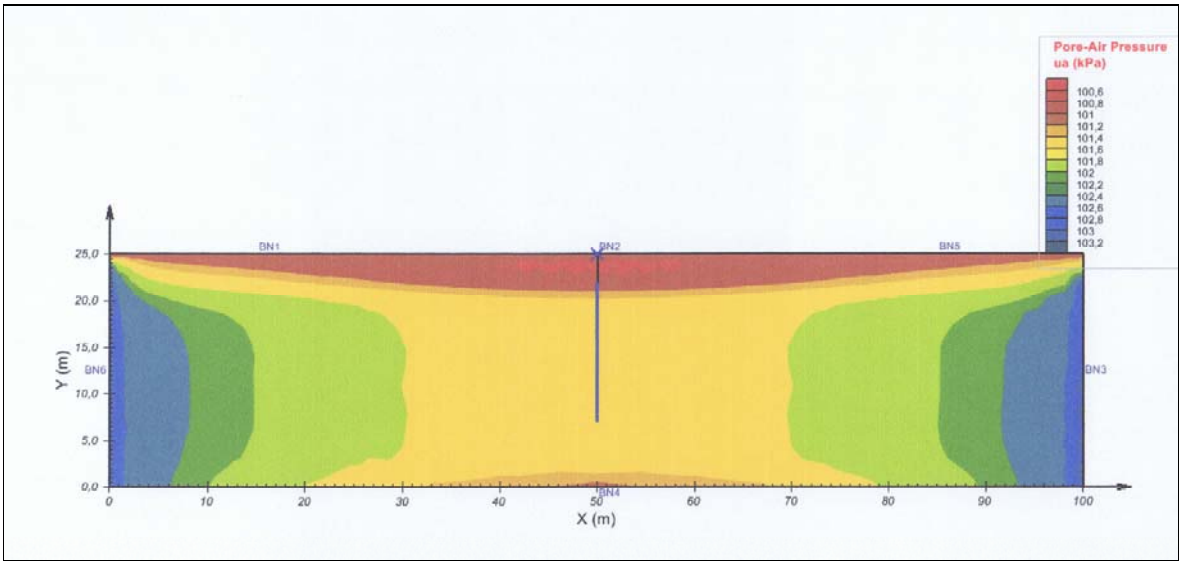

Figure 1: Pressure partitioning traditional well

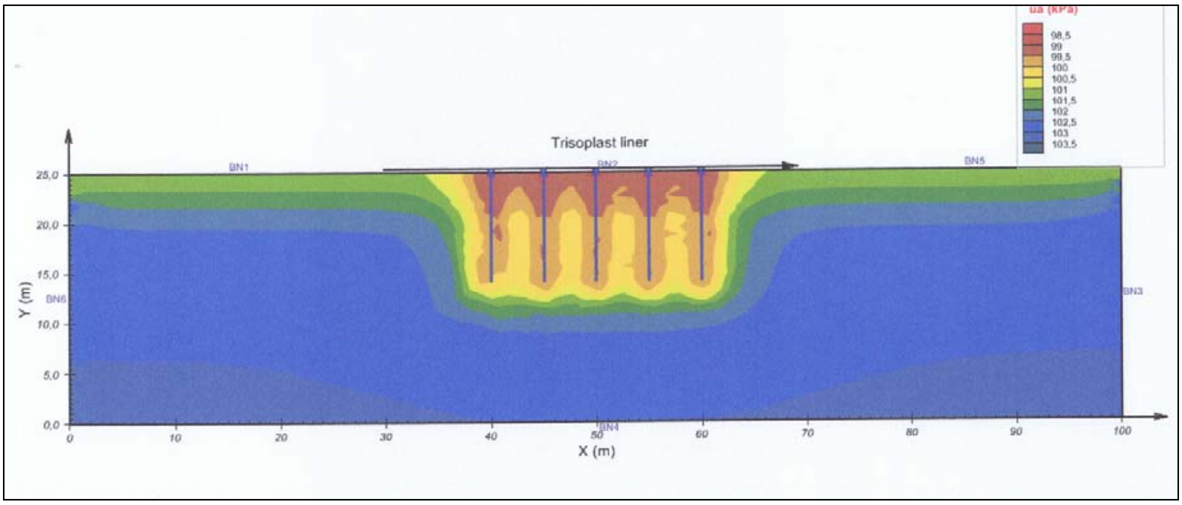

Figure 2: Pressure partitioning Multriwell/Trisoplast