

# CDM - Landfill Gas Projects

Introduction to discussion

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# Data for landfills

	Sao Paulo	Buenos A	Monterey	Maldonado	Liepaja	Olavarria
Total size (Ha.)	150	505	105	12,5	3	8
Size w. gas ex. (Ha.)	45	90	58	7	2.4	4
Av. Depth (m)	50	10	20	13	8	8
Waste (Mio. Tons)	30	48	18.44	0.473	0.095	0.238
Waste w. gas ex. (Mio. Tons)	20	25	8.7	0.355	0.095	0.180
Total organic	60 %	50 %	66 %	70 %	29 %	19 %
Compactors/no.	Yes/8	Yes/2	Yes/2	Yes/2 doz.	Yes/ dozer	Yes/1
Cover	60 cm Clay	80 cm clay	30 cm clay	80 cm clay	50 cm clay	30 cm soil
Precipitation (mm/year)	1,370	1,200	470	1,400	693	1,028
Start year Landfill	1979	1978	1990	1997	2004	1999
Close year Landfill	2007	2004	2020	2011	2024	2034
Start year LFG Plant	2004	2005	2003	2005	2005	2006



# Gas Model

	Sao Paulo	Buenos A	Monterey	Maldonado	Liepaja	Olavarria
Model	IPCC First order	Rettenberger First order	US-EPA E-PLUS	US-EPA First order	Dutch Multiphase First order model	Canyon Scholl First order model
$L_0$ ( $m^3 CH_4/ton$ )	77		94	68		102
k	0.105	0,035	0.066	0.28/0.056		0.099



# Gas Production depends on:

- Temperature in the landfill
- Moisture content of the waste
- Waste composition
- Waste age
- Covering of the landfill
- Structure of the waste

Impossible to include correct in a model

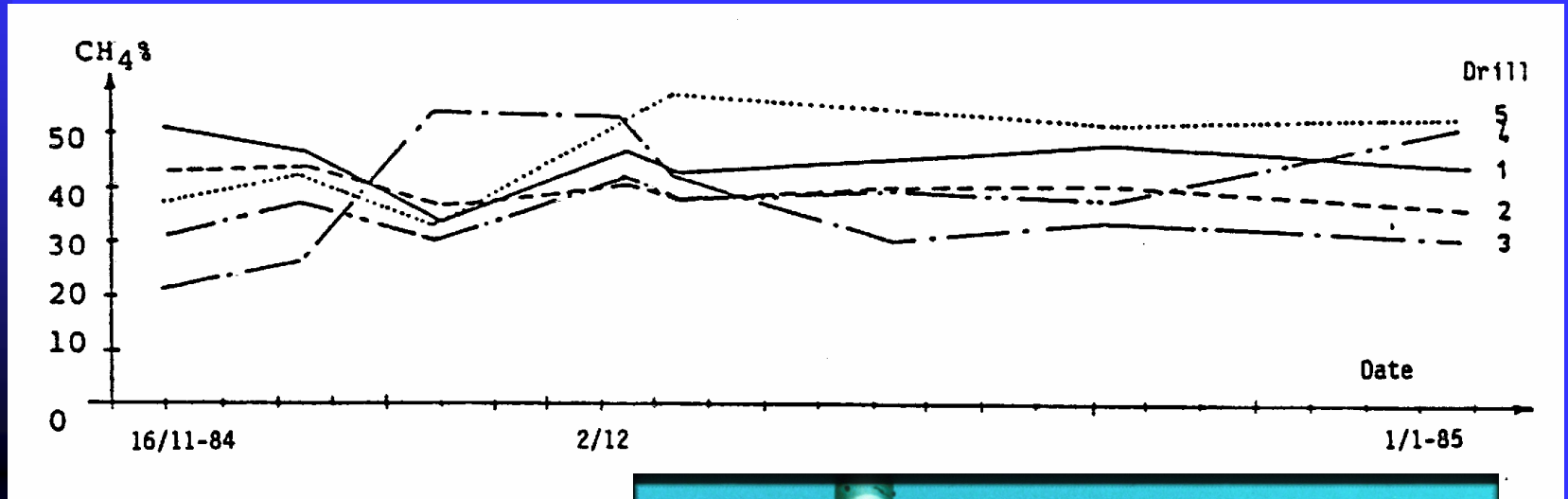


# Test Pumping - and real gas from each well

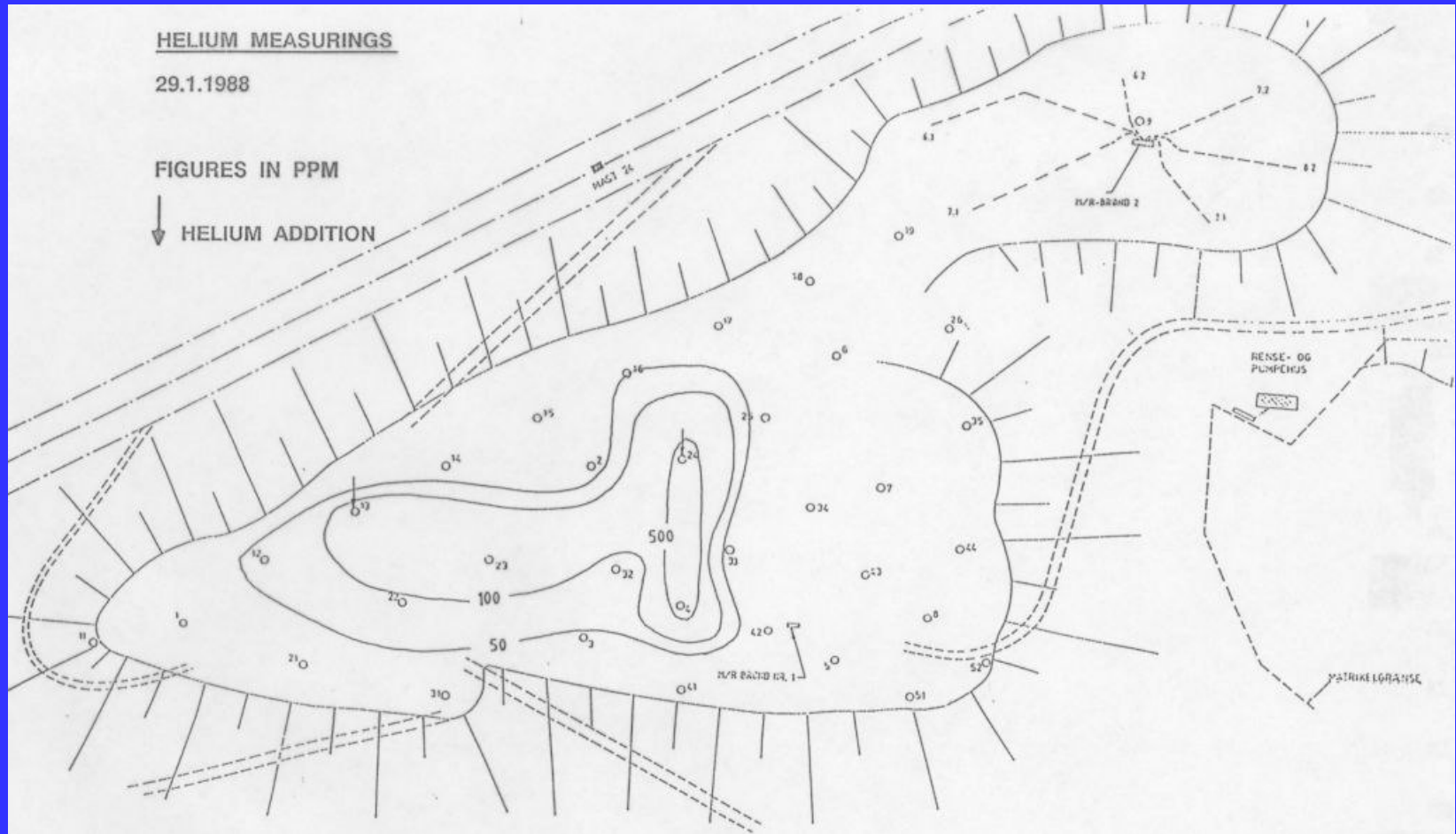
	Sao Paulo	Buenos A	Monterey	Maldonado	Liepaja	Olavarria
Number of wells	3	11	1	-	-	13
Extraction av. from test wells (m <sup>3</sup> /h)	109	60	10	-	-	13
Real extraction average from all wells or equivalent horizontal (m <sup>3</sup> /h)	52	2	17	-	-	6
Duration	8 weeks	6 weeks	7 days	-	-	1 day



# Test Pumping



# Test of the suction radius in the landfill



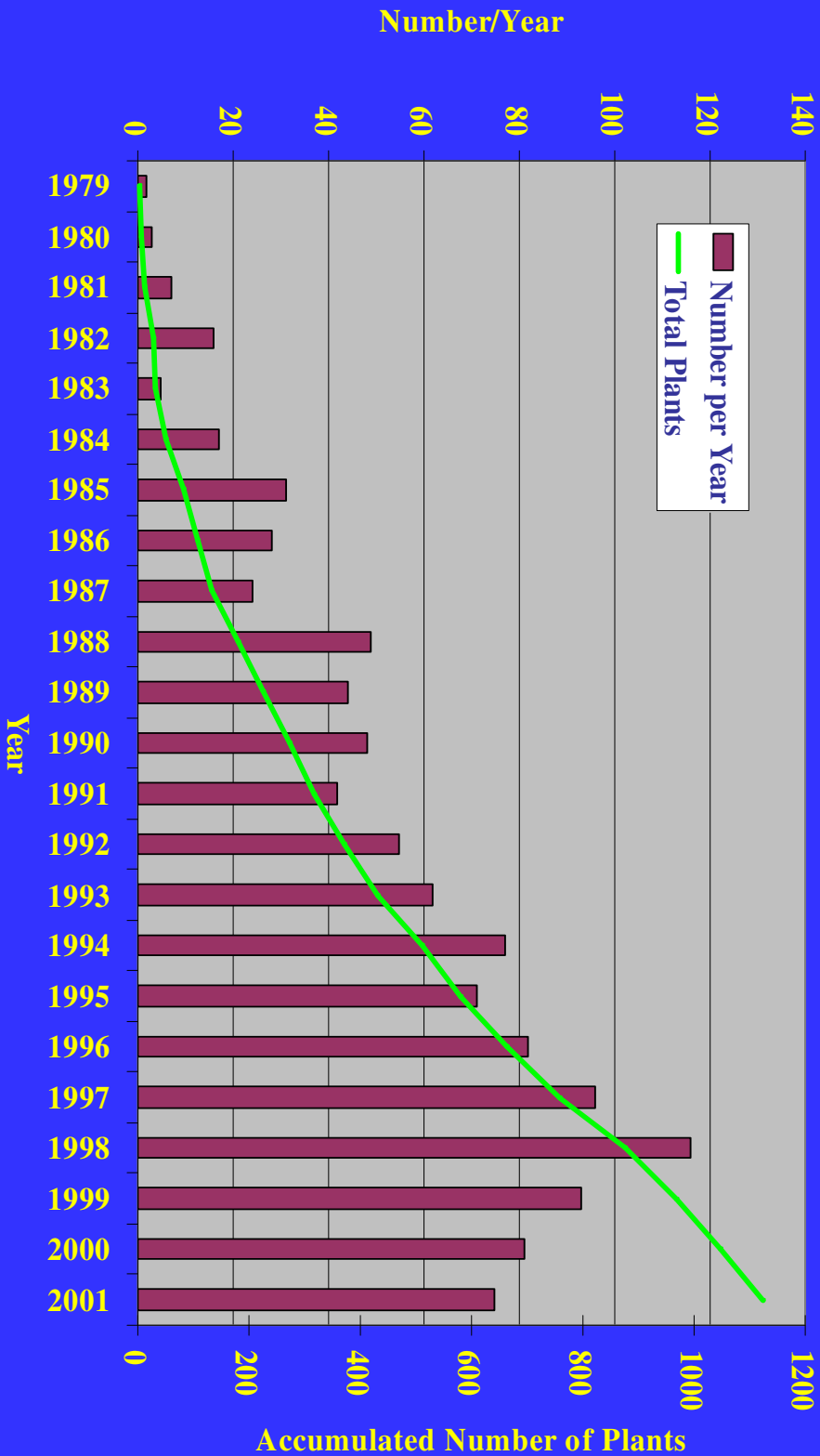
# Landfill Gas Extraction - year 2006

	Sao Paulo	Buenos A	Monterey	Maldonado	Liepaja	Olavarria
Estimated m <sup>3</sup> x 10 <sup>3</sup> LFG/year	215,000	116,500	15,340	1,963	696	3,408
Real m <sup>3</sup> x 10 <sup>3</sup> LFG/year	103,000	13,100	31,230	1,496	561	677
Difference m <sup>3</sup> x 10 <sup>3</sup> LFG/year	-112,000	-103,400	+15,890	-467	-135	-2,731
Difference in %	-48 %	-89 %	+104 %	-24 %	-20	-80 %
Hourly extraction (m <sup>3</sup> /h)	12,900	1,500	4,122	231	66	99 (58 at 50% CH <sub>4</sub> )
Real extracted m <sup>3</sup> /ton x year	5.15	0.52	3.59	4.21	5.90	3.76 (2.25 at 50% CH <sub>4</sub> )
Normal range m <sup>3</sup> /ton x year	3 – 6 m <sup>3</sup> /ton x year (at 50 % CH <sub>4</sub> )					
CH <sub>4</sub> %	53 %	50 %	52 %	53 %	52	30 %

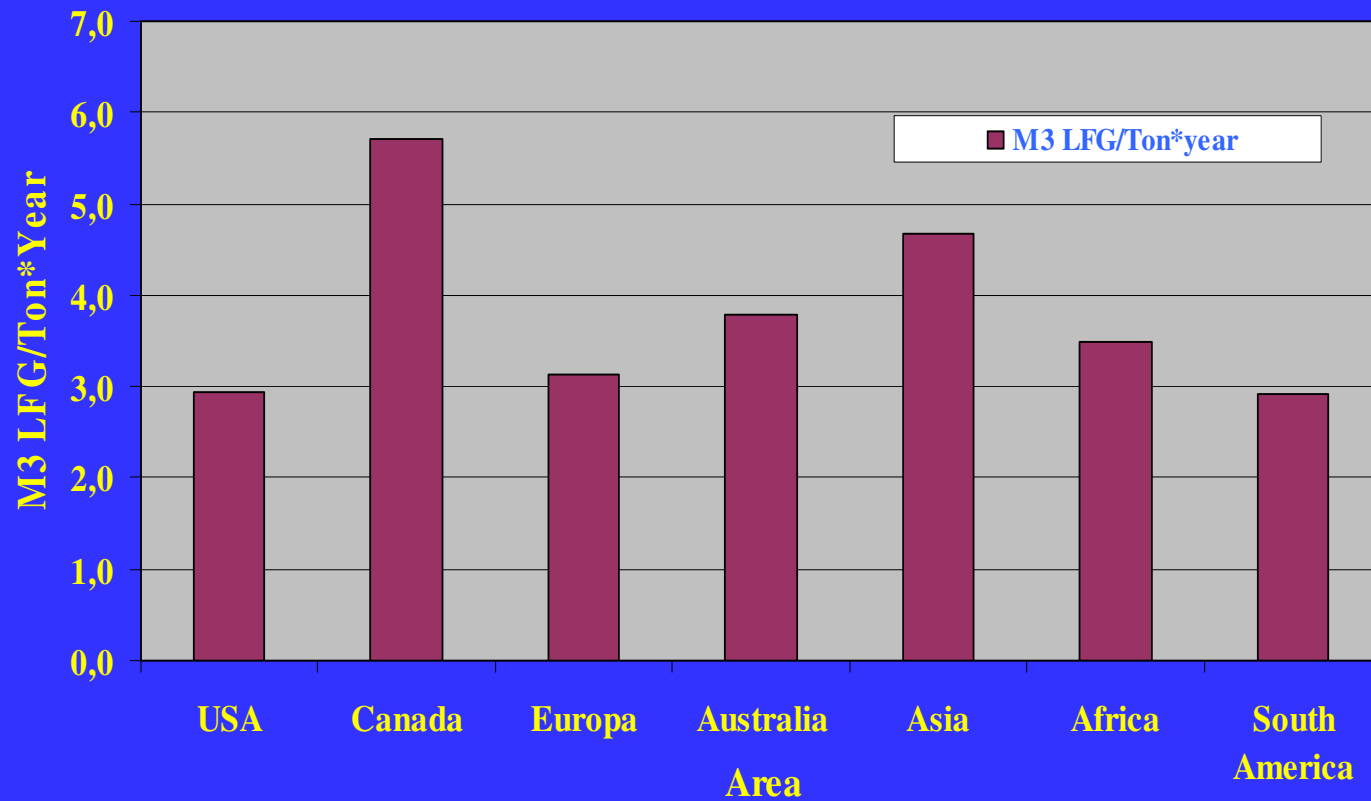




# Yearly and Total Number of LFG Plants Worldwide



# Landfill Gas Extraction Rate - Worldwide

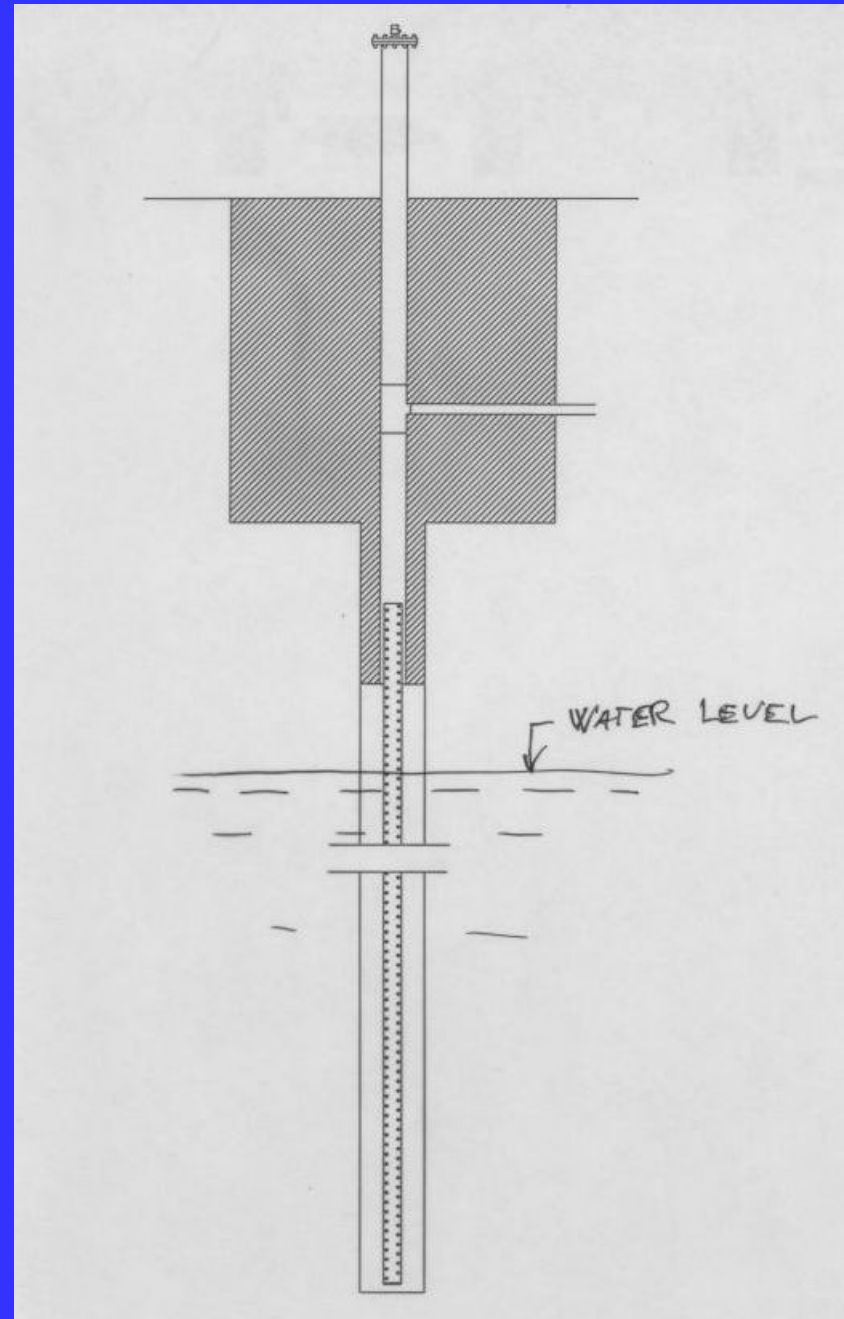


# Landfill Gas Extraction System

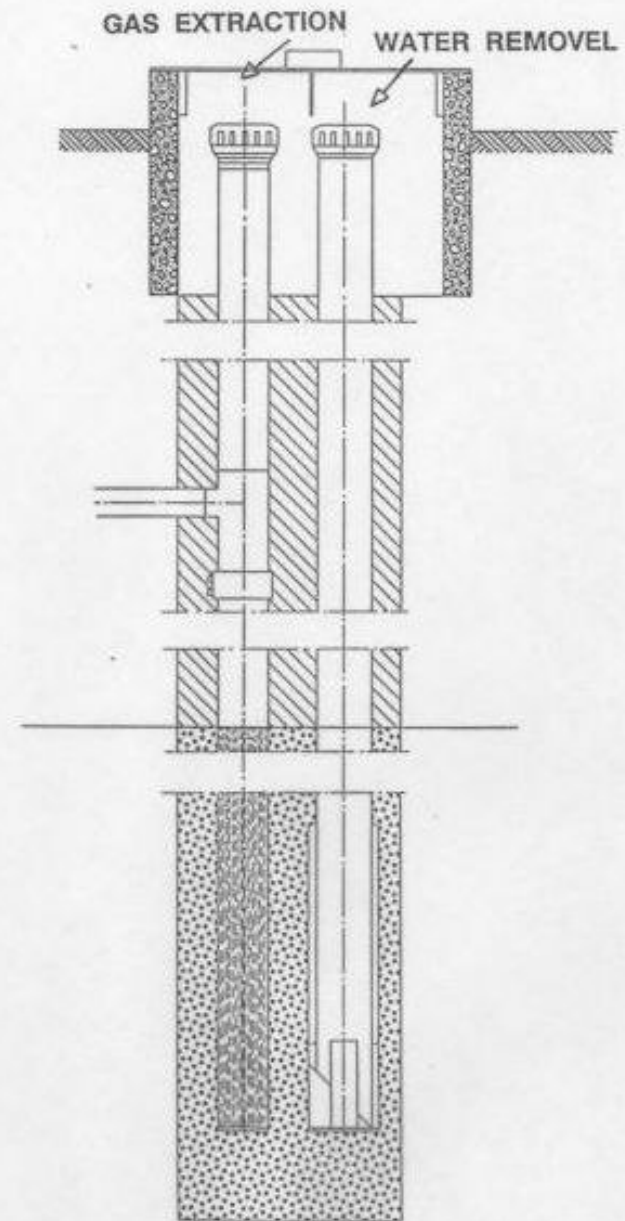
	Sao Paulo	Buenos A	Monterey	Maldonado	Liepaja	Olavarria
No. of wells	250	-	248	20	12	13
Distance between wells (m)	40	-	30	40 - 45	30 - 40	40
Horizontal extraction pipes (m)	-	7,500	-	85	-	-
Corresponding to no. of wells	-	750	-	2	-	-
Water in wells	Yes	-	Yes	Yes	No	Yes
Water pumps in wells	No	-	No	Yes	No	Yes
Water in horizontal pipes	Yes	Yes	Yes	Yes	-	-
Water removal	Yes	Yes	No	Yes	-	-
Suction pressure wellhead (mbar)	-5	-34	-50	0 - 65	-3	-8



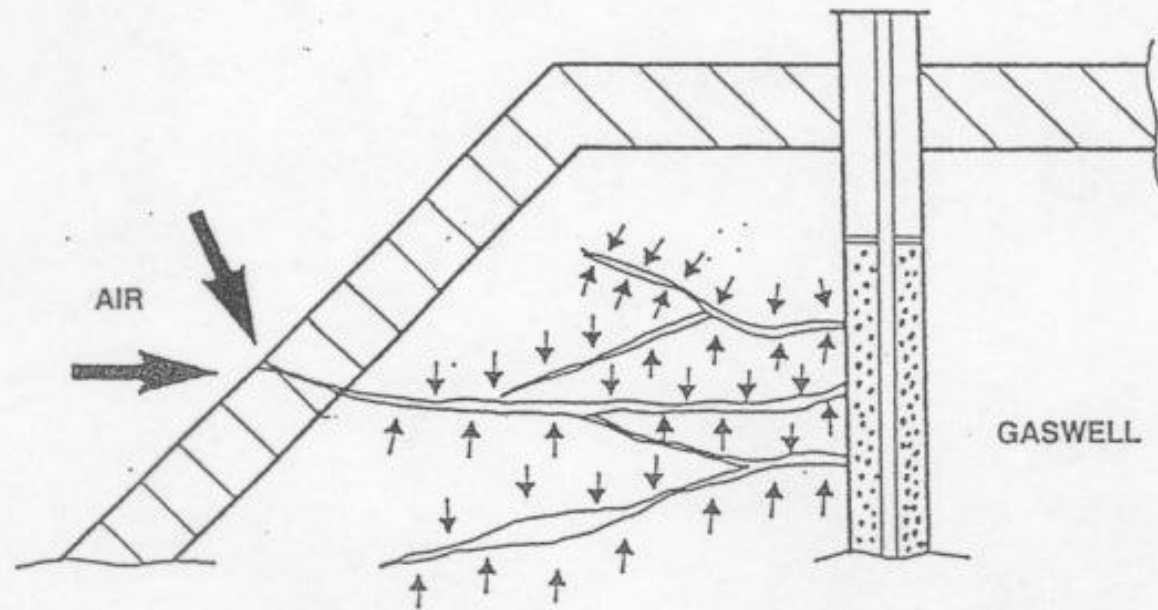
# Well with high water/ leachate level



Well with two  
pipes.  
Gas extraction  
and  
Water extraction



# Air intrusion into the Landfill



Example of Air Penetration in a Landfill



Important to analyze  $N_2$

# Settlement in the Landfill

- **Can damage the gas pipe in the wells by compression or torsion**
- **Horizontal pipes has to be installed with an adequate slope ~ downward gradient to a condensate trap. Even though settlement can cause cavity in the horizontal pipes**



# Landfill Gas Utilization System

	Sao Paulo	Buenos A	Monterey	Maldonado	Liepaja	Olavarria
Flare capacity (m3/h)	2,500	7,500	5,000	500	500	250
Number of gas engines	24	-	7	2	2	-
Power/engine (kW)	910	-	1,060	477	584	-
Tot. capacity (kW)	21,800	-	7,420	954	1,168	-
Actual production (kW)	18,000	-	7,420	250	0	0
Electric efficiency for gas engine /generator	0.28		0.32	0.26	-	

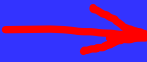


# Operation of LFG Plant

	Sao Paulo	Buenos A	Monterey	Maldonado	Liepaja	Olavarria
Individual flow regulation	Yes	Yes	Yes	Yes	Yes	Yes
Man./auto extraction system	Man.	Man.	Man.	Man./Aut	Man.	Man.
Operation staff working hours	24	24	24	24	24	8
Stationary analyzer	CH <sub>4</sub> , O <sub>2</sub>	CH <sub>4</sub> , CO <sub>2</sub> , O <sub>2</sub>	No	CH <sub>4</sub> , O <sub>2</sub>	Yes	No
Portable analyzer	CH <sub>4</sub> , CO <sub>2</sub> , O <sub>2</sub>	CH <sub>4</sub> , CO <sub>2</sub> , O <sub>2</sub>	CH <sub>4</sub> , CO <sub>2</sub> , O <sub>2</sub>	CH <sub>4</sub> , O <sub>2</sub>	CH <sub>4</sub> , CO <sub>2</sub> , O <sub>2</sub>	CH <sub>4</sub> , CO <sub>2</sub> , O <sub>2</sub> , CO, H <sub>2</sub> S
Analyzing frequency	Weekly	Monthly	Daily	Daily	Weekly	Weekly
Working hours/year	8,580	8,600	7,577	8,500	8,560	6,817



# Overall Economy

	Sao Paulo	Buenos A	Monterey	Maldonado	Liepaja	Olavarria
Investment 10 <sup>3</sup> x. US\$	23,000	n.a.	10,800	1,280	4,105	125
Income (2006) 10 <sup>3</sup> x. US\$	18,500	n.a.	4,537	0	13	5.8
O&M costs 10 <sup>3</sup> x. US\$	2,000	n.a.	1,342	120	556	18.5
O&M in % of investment	11.5 %	n.a.	7.45 %	10 %	13.5 %	14.8 %
Tot. capacity (kW)	21,800	n.a.	7,420	954	1,168	-
Investment costs US\$/ kW <sub>el-installed</sub>	1,053	n.a.	1,455	1,341	3,514	-
Investment costs Per kW <sub>el-installed</sub>	 Average worldwide: 1,550 – 2,250 US\$/ kW <sub>el-installed</sub>					



# Bandeirantes – Sao Paulo

## Comments/Questions/Suggestions:

1. Large extraction from the test. Probably suction from a larger area than expected.
2. - 48 % of the expected gas.  
Still: - extraction/ton of waste =  $5.15 \text{ m}^3/\text{t} \times \text{year}$   
It looks like the model have shown a very high extraction rate.
3. Water in wells maybe a problem: install pumps.
4. Possible damage of wells and pipes from settlement.
5. Suction pressure is very low at -5 mbar, especially for such a deep landfill. Higher suction pressure can probably give higher gas extraction.

Be aware:  $1 \text{ m}^3/\text{h}$  more extracted = 1,280 US\$/year



# Villa Dominico, Buenos Aires

## Comments/Questions/Suggestions:

1. Test pumping from 4 wells showed problems with water (still: 60 m<sup>3</sup>/h x well – but only 3 days – too short period)  
Then test from wells and 5 horizontal pipes – also water problems (still: 30 – 100 m<sup>3</sup>/h x well)  
Finally test from 2 horizontal pipes/drain of 40 m long – gave 80 m<sup>3</sup>/h ~2 m<sup>3</sup>/m
2. Decide to make 7,500 m of horizontal extraction pipe assuming 1 m<sup>3</sup>/m pipe ~ total 7,500 m<sup>3</sup>/h  
(original calculation was in 2006: 13,340 m<sup>3</sup>/h).
3. - 88 % of the expected gas.
4. Extraction/ton of waste = 0.52 m<sup>3</sup>/t x year, which is very low.  
If the extraction was as estimated, the rate was 2.42 m<sup>3</sup>/t x year ~ also low
5. Extraordinary problems with high water/leachate level in this landfill.
6. The leachate has to be pumped out to allow the extraction system to work efficiently



# Monterey

## Comments/Questions/Suggestions:

1. Short test pumping period - 7 days.
2. + 104 % of the expected gas.  
Still: - extraction/ton of waste is normal:  $3.6 \text{ m}^3/\text{t} \times \text{year}$ .  
The gas from model:  $1.8 \text{ m}^3/\text{t} \times \text{year}$  is low – why?
3. Water in wells and pipe a problem – solutions should be made.
4. What is the reason for not extracting gas from the remaining 11 mio. tons?



# Las Rosas, Maldonado

## Comments/Questions/Suggestions:

1. - 24 % of the expected gas.  
Still: - extraction/ton of waste =  $4.21 \text{ m}^3/\text{t} \times \text{year}$  .
2. 85 m long horizontal pipe deliver  $45 \text{ m}^3/\text{h}$  (25 % of the total gas)
3. No gas analyzer in 2006! Very unfavorable situation, there makes it difficult to regulate for optimizing the gas extraction.
4. Analyzer can not measure  $\text{CO}_2$ :  $\text{N}_2$  can not be calculated, which is important for optimizing the extraction.
5. Water in wells and pipe a problem – solutions is made (homemade!).



# Liepaja - Grobina, Latvia

## Comments/Questions/Suggestions:

1. - 20 % of the expected gas.

Still: - extraction/ton of waste =  $5.90 \text{ m}^3/\text{t} \times \text{year}$

2. In 2006 the  $\text{N}_2$  was high: 22%; were the cover material not sufficient?
3. Suction pressure is very low: -5 mbar



# Olavarria, Argentina

## Comments/Questions/Suggestions:

1. Test pumping only 1 day – will not give the right picture.
2. Very poor gas quality do to air intrusion/leakiness in the system:  
30 % CH<sub>4</sub>.
3. O<sub>2</sub> and CO<sub>2</sub> should be analyzed, when possible. This will indicate if it is intrusion of atmospheric air and/or leakiness.
4. A plastic membrane is used around the wells.
5. It seems that the cover material is insufficient.
6. Investigate the whole system for leakiness.
7. Make a better final cover with clay.
8. - 80 % of the expected gas.  
Low extraction rate – 2.25 m<sup>3</sup>/t x year



# General Problems discovered:

1. Estimation from Model and real gas extraction can vary +/- 100 %
2. Pumping tests period is often too short;
3. Pumping tests often gives higher gas volume per well than real wells in the LFG plant;
4. Water in wells prevent gas extraction if not removed efficient. Consider water pumps;
5. Water in horizontal prevent gas extraction if not removed efficient. Consider a better water removal system and use return blowing for removal of condensate if possible;
6. Settlement damage the connection between well pipe and suction pipe. Repair;
7. Poor final cover material allow atmospheric air intrusion. Improve the cover;
8. Suction pressure not adequate. Change it;
9. Regulation of individual wells or horizontal pipes not possible. Install valves;
10. Incorrect size of flare, gas engines, causing difficulties to run the LFG plant properly; Consider expanding the extraction area, another engine or a gas storage so the engine can partly run on full load.
11. **ATTENTION:** LFG has been a favorite CDM project category until now. But the LFG business will loose this status, if we don't enhance the accuracy of the gas estimation. Don't use a model in the dark and without practical LFG experience!



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