DRAFT "MODEL"

FOR

CASE STUDIES

OF

CDM - LANDFILL GAS PROJECTS

PRESENTED AT A

WORKSHOP

IN

THE WORLD BANK

19TH APRIL 2007

CONTENT

1. BACKGROUND

1.1. General background

Present a brief description of the landfill site, the landfill gas plant (LFG Plant) and its present operations. ½-1 page

The Villa Domínico sanitary landfill is located in the Avellaneda and Quilmes municipalities, Province of Buenos Aires, at approximately 15 kilometers from the Capital City. It was built on a low terrain which is part of the marginal forest of the coast of Buenos Aires province. CEAMSE put out to national and international public tender the design, building, and operation of such landfill in 1978. Techint SA was awarded the bid and created SYUSA as part of the contract. SYUSA appointed the consultant Brown and Cadwell for the sanitary landfill technical design. Said company used state-of-the-art techniques for the design of the landfill. The project anticipated the reception and disposal of urban solid waste generated in the City of Buenos Aires and the municipalities of the South area for the term of 20 years. Such project consisted of the implementation of a sanitary landfill by means of the trench method and using the surface extensively since there were approximately 500 hectares available. In those days, the isolation of the bottom and slopes of the modules was performed by using only the existing geological barrier which consisted of a variable clay stratum (layer) of between 1.5 and 5 meters thick with a permeability of 1×10^{-7} cm/sec. Initially, and up to January 2001, according to the final project, the leachate generated was confined within the modules; as from January 2001, a leachate treatment plant which treated part of the leachate generated and accumulated in the modules started working. The final waste coverage and subsequent module closure were performed with a layer of between 0.60 and 1 m. of low permeability clay properly distributed and compacted.
As from 1995, due to the limited remaining surface, it was decided to carry out a vertical expansion project by which a second floor over the landfilled modules would be made so that it would be possible to continue with the waste reception for its final disposal at the same sanitary landfill thus avoiding the search and building of a new one. Therefore, the modules having an average height of 18 mtr. The coverage was made in the same way as the one above described.
The sanitary landfill was closed down in 2004.

1.2. Data for Area

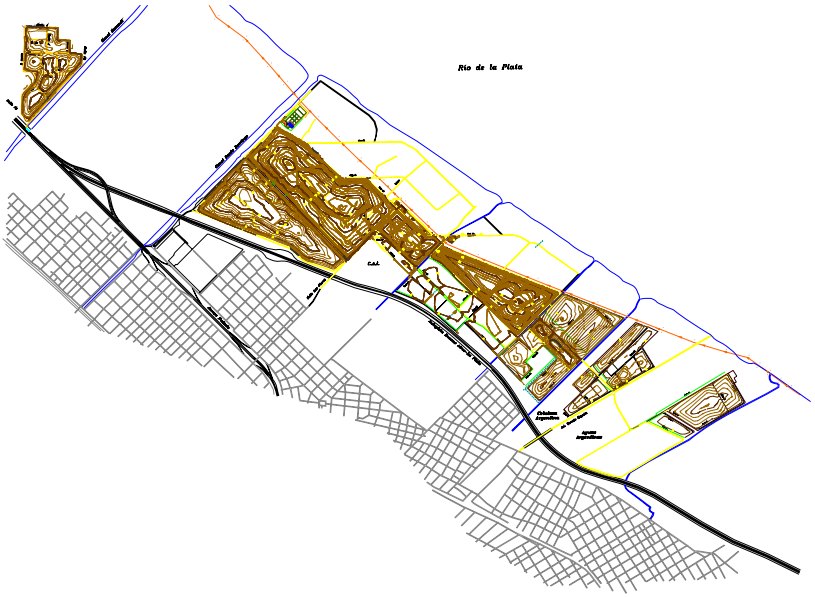
Please, fill out table 1 below. If necessary give a short description or comments to the site information.

City	Almirante Brown, Avellaneda, Berazategui, Esteban Echeverría, Florencio Varela, Lanús, Lomas de Zamora, Quilmes, Ciudad Autónoma de Buenos Aires

Name of the landfills	Centro de Disposición Final Villa Domínico
Site geology (sand, clay, etc.)	Clay
Groundwater over/beneath bottom	Beneath
Precipitation (mm rain water)	1.200 mm/year
Normal range of temp. Win./Sum. (^{0}C)	15o/24o

Table 1: Site area information

Place a plan drawing over the landfill if possible



Example on a plan drawing over a landfill

1.3. Landfill construction

Please, fill out table 2 below. If necessary give a short description or comments to the site information.

Start of landfill (Year)	1978
Closing of landfill (Year/year expected)	2004
Area designated for landfilling (ha)	487
Site capacity at closure (Mio. tons)	48
Area used in 2006 (ha)	73 ha.
Max./min. depth of landfill 2006 (m.)	20,38m – 2,88m
Average depth of landfill 2006 (m.)	6 m

Waste in place 2006 (Mio. tons)	-
Gas extraction in 2006 from (Mio. Tons)	**138.690**
Annual waste quantity (1,000 tons)	Landfill is closed
Leachate drainage system (yes/no)	Yes
Type of membrane in the bottom (if any)	No

Table 2: Site construction data

1.4. Waste data

Please, describe the possibility for having good or bad historical information about the waste quantity and quality (we know this in many cases is difficult topic). Try to fill out table 3 as shown below with actual data and actual years for your landfill.

Year	MSW (ton)	Industrial/ commercial (ton)	Other (ton)	Total (ton)
…….				
1990	1,257,829	87,658		1,345,486
1991	1,518,132	104,896		1,623,028
1992	1,898,887	128,979		2,027,865
1993	2,136,551	136,762		2,273,313
1994	2,330,631	145,204		2,475,836
1995	2,207,356	131,377		2,338,733
1996	2,276,502	151,405		2,427,907
1997	2,401,729	175,767		2,577,497
1998	2,644,560	217,093		2,861,653
1999	2,828,728	211,795		3,040,523
2000	2,811,518	165,311		2,976,829
2001	2,682,405	141,218		2,823,623
2002	2,142,101	93,215		2,235,315
2003	884,712	45,665		930,376
2004	8,874			8,874
2005				
2006				
…….				
…….				
Total:				

Table 3: Amount of waste disposed of.

In table 3 the overall waste composition is divided. If more detail is available please, describe this by filling out table 4 below (with more or less breakdown, depending on the availability)

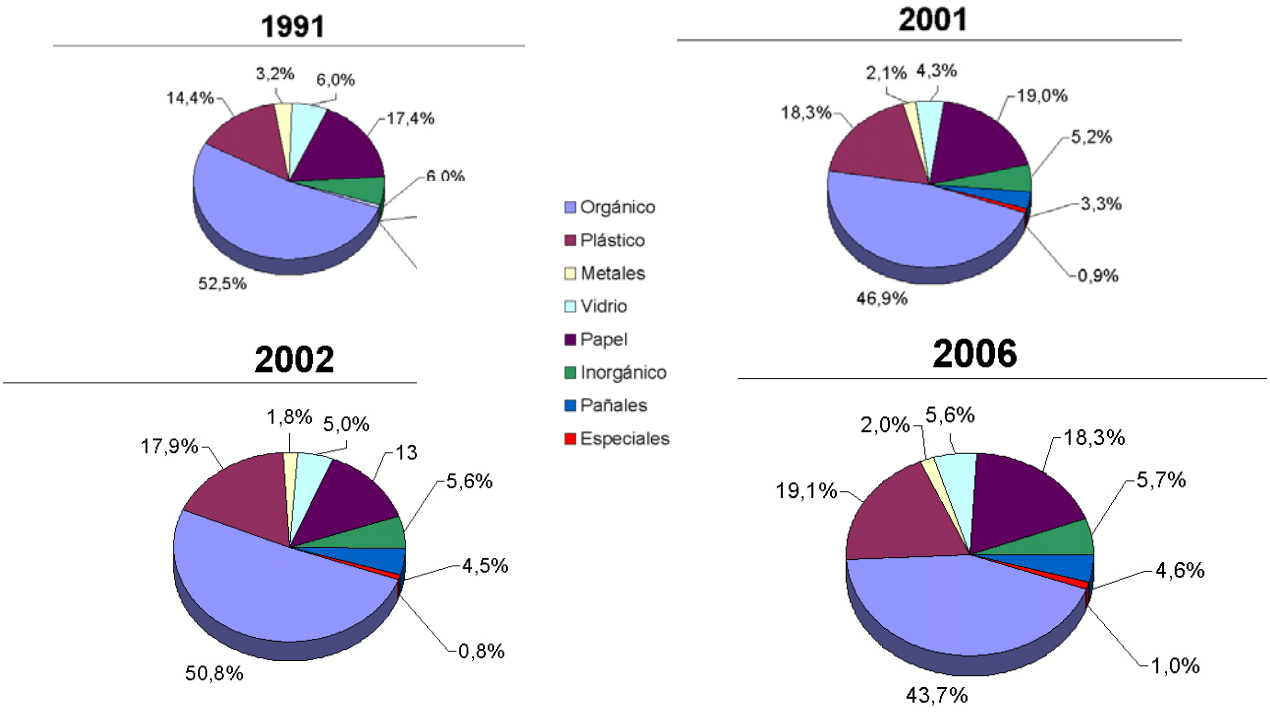
Type of waste	Waste composition (% by weight)
Domestic	86,7%
Industrial, Commercial & Institutional	6%
Construction	7,3%
Garden waste	
……	

Other	
Total:	100
Total organic (if this is available)	57%(1991) – 40,3%(2001)

Table 4: Waste composition

Ingreso de Residuos a CEAMSE
Residuos Domiciliarios
Composición Ciudad de Buenos Aires

ítem	AÑO			
	1991	2001	2002	2006
Orgánico	52,5	46,9	50,8	43,7
Plástico	14,4	18,3	17,9	19,1
Metales	3,2	2,1	1,8	2,0
Vidrio	6,0	4,3	5,0	5,6
Papel	17,4	19,0	13,6	18,3
Inorgánico	6,0	5,2	5,6	5,7
Pañales	0,0	3,3	4,5	4,6
Especiales	0,5	0,9	0,8	1,0
kg/hab.día	0,727	1,090	0,860	0,930



Please, describe further information on landfill operation and fill out table 5. Explain very brief the leachate collection system.

Usage of compactor (yes/no)	Yes
Number of compactors	Two (2)
Is temporary cover used (yes/no)	No
Frequency of temporary cover	-
Existence of final cover (yes/no)	Yes
Type and thickness of final cover	Clay, 0,60m
Leachate collection from the bottom (yes/no)	No
Leachate collection from trenches (yes/no)	Yes

Table 5: Landfill operation

2. ESTIMATION OF LANDFILL GAS

2.1. Gas Model

Inform about the model used for estimation of gas production and extraction potential.
Which model?

The model used is the Rettenberger model. For this project a K-value of 0.035 is used. The model uses a K-value of 0.025-0.05. The data used in as input for the model is the data mentioned above in table 3.

2.2. LFG estimation

Please, inform about the result of the estimation by filling out table 6

Year	Estimation of LFG production (1.000 Nm^3/year)	Estimation of LFG extraction (1.000 Nm^3/year)	Estimation of LFG extraction (Nm^3/hour)
…….			
2005	180.430		20.500
2006	166.431		18.900
2007	153.545		17.500
2008	141.657		16.100
2009	130.690		14.900
2010	120.572		13.700
2011	111.234		12.900

Table 6: Estimation of LFG production and extraction

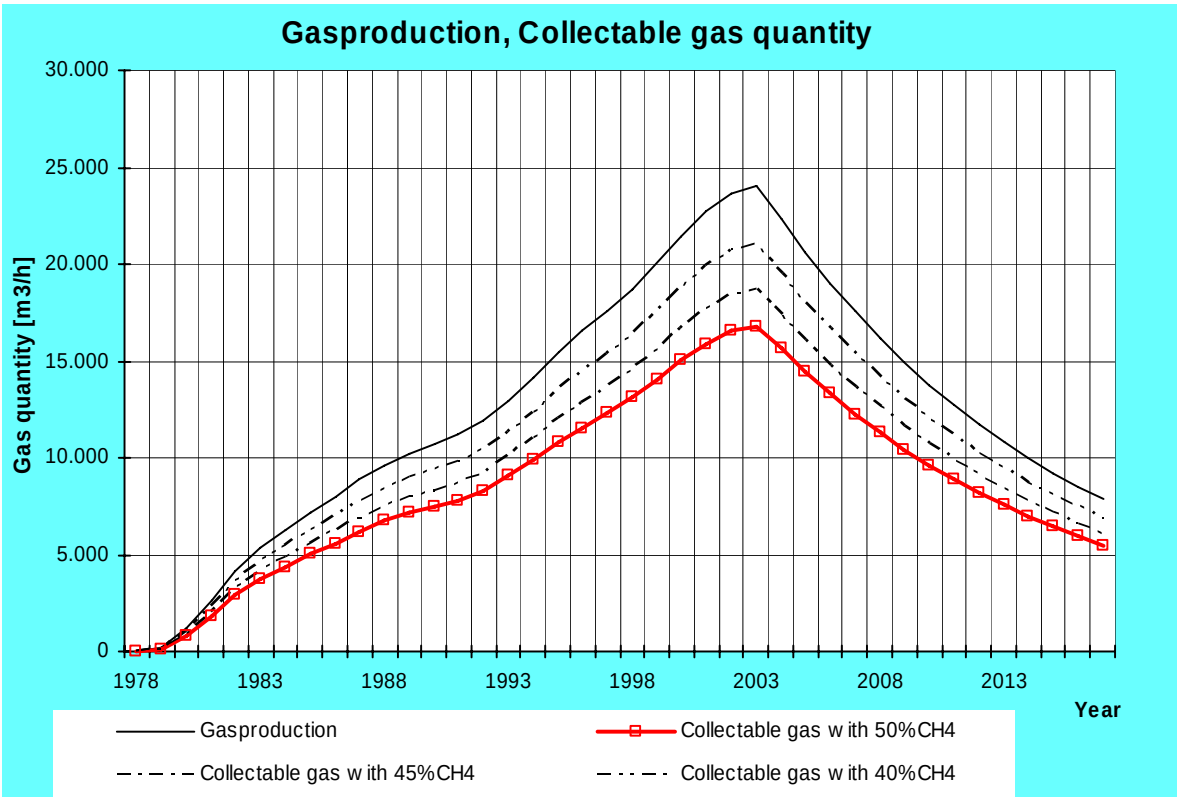


Figure 1: Estimation for gas extraction

3. TEST PUMPING

If a test pumping is carried out, please give some information about thisand fill out table 7

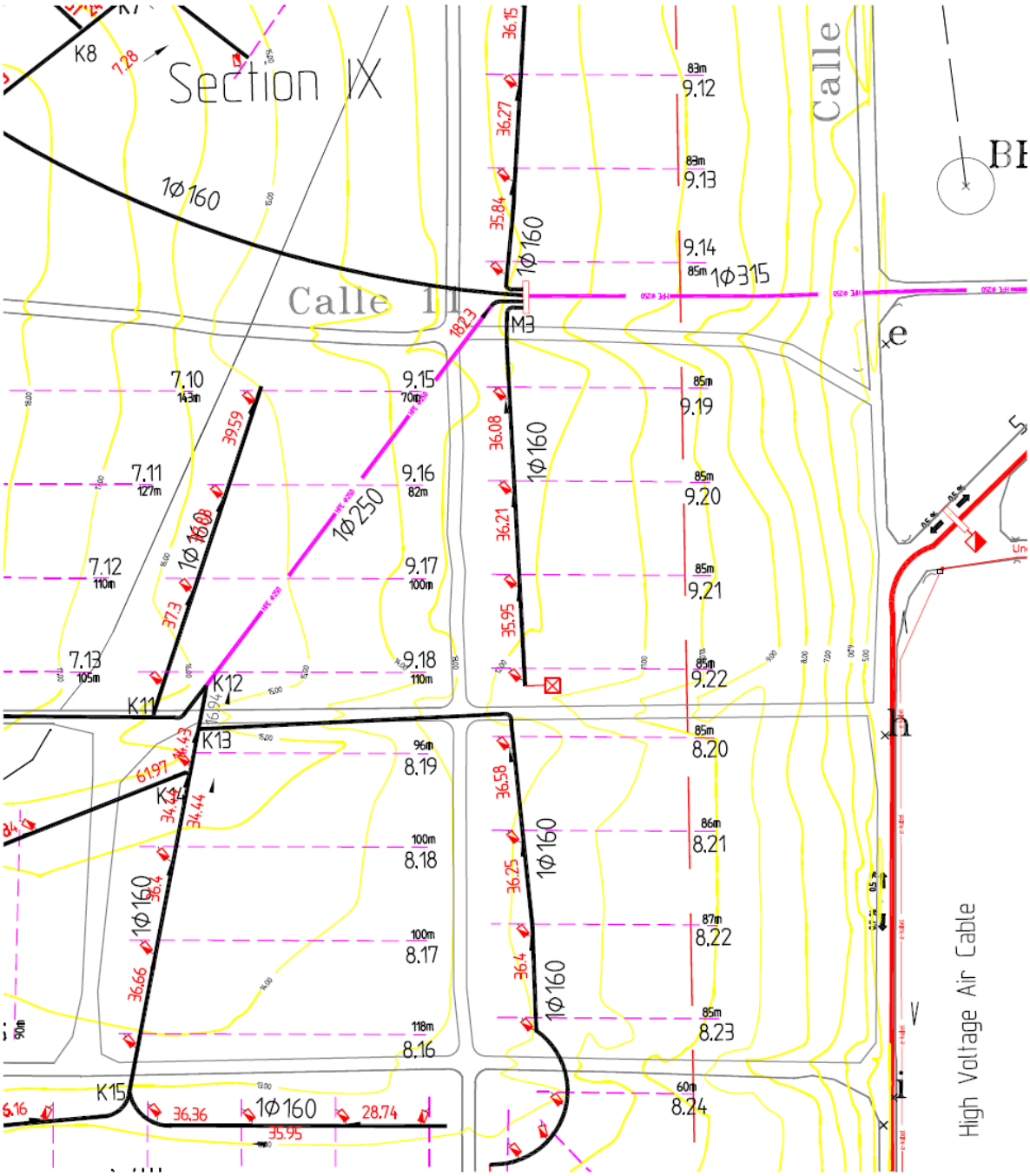
Pump capacity (m^3/h)	350
Number of test wells	11
Duration of the test pumping	12/03 to 3/05
Gas extraction from **well no.39** (m^3/h)	60
Gas extraction from **well no.40**(m^3/h)	17
Gas extraction from **well no.43** (m^3/h)	61
Gas extraction from **well no.44** (m^3/h)	62
Gas extraction from **combi well 1** (m^3/h)	58
Gas extraction from **combi well 2** (m^3/h)	58
Gas extraction from **combi well 3** (m^3/h)	60
Gas extraction from **combi well 4** (m^3/h)	100
Gas extraction from **combi well 5** (m^3/h)	30
Gas extraction from **Horizontal drain 1**(m^3/h)	75
Gas extraction from **Horizontal drain 2**(m^3/h)	80
Total gas extraction (m^3/h)	198.9

Table 7: Data and results from the test pumping

The available gas composition can be filled in to table 8 below

Well No	CH_4 %	CO_2 %	O_2 %	N_2 %
39	59.8	40	0.08	0.12
40	44	37	1.2	17.80
43	59	40	0.2	2.45
44	58	41	0.196	0.80
Combi 1	55.6	38.4	0.02	5.98
Combi 2	58.4	39.1	0.05	2.44
Combi 3	52	34.7	2.4	10.9
Combi 4	56	38	0.7	5.3
Combi 5	56.1	26.7	1.20	6
Hor. Drain 1	48.5	34.7	2.8	14
Hor. Drain 2	50	33.55	2.74	13.7
Total				

Table 8: LFG composition from test pumping



Example of plan drawing with test wells

Inform if the results from the test pumping were valuable, when the size of the LFG plant was decided. Was the result comparable with the result from the model?

4. REAL LFG EXTRACTION

4.1. Estimated LFG extracted compared with real extracted

Compare the estimated gas extraction from table 6 with the real extraction in table 9 below:

Year	Estimation of	Real	Difference	Difference

	LFG extraction (1.000 Nm^3/hour)	**LFG extraction (1.000 Nm^3/hour)**	**(+/- 1.000 Nm^3/hour)**	**(+/- %)**
…….				
2005	20.5	1.4	-19.1	-93.1
2006	18.9	1.5	-17.4	-92
2007	17.5			
2008	16.1			
2009	14.9			
2010	13.7			
2011	12.9			

Table 9: Estimation of LFG production and extraction

4.2. Estimated LFG composition compared with real composition

Compare the estimated gas quality used in the original calculation with the real annual average quality in table 10 below (if all the mentioned gasses are not available, the important is of course the methane concentration):

Year	**Estimated gas quality**				**Real gas quality**			
	CH_4 %	**CO_2 %**	**O_2 %**	**N_2 %**	**CH_4 %**	**CO_2 %**	**O_2 %**	**N_2 %**
……								
2005	50				53.3			
2006	50				50.0			
2007	50							
2008	50							
2009	50							
2010	50							
2011	50							
Actual	50							

Table 10: Estimation of LFG production and extraction

5. LANDFILL GAS PLANT

5.1. LFG Collection System

Please, indicate the drilling system, how the wells are constructed and/or (if carried out) the horizontal collection system. Fill out table 11 below

Wells	
Number of wells	**NA**
Depth of wells/average depth (m)	**NA**
Diameter of well (mm)	**NA**
Diameter of gas extraction pipe (mm)	**NA**
Distance between wells (m)	**NA**
Presence of water/condensate in wells (yes/no)	**NA**
Water/condensate pump in wells (yes/no)	**NA**
Horizontal gas extraction pipes	
Horizontal gas extraction pipes (total m) aprox.	7.500 m

Diameter of horizontal gas extraction pipe (mm)	160
Presence of water/condensate in pipes (yes/no)	Yes
Water/condensate removal system for pipes (yes/no)	Yes
Horizontal gas collection system (from wells to gas pump)	
Diameter of horizontal collection system (mm)	160/200/315
Condensate trap at low points (yes/no)	Yes

Table 11: LFG Collection system

5.2. Gas Compressor/Pump System

Please, fill in table 12 below

Type of gas compressor/pump	Centrifugal
Capacity of gas compressor/pump (m^3/hour)	3*2500
Suction pressure at the pump (mbar)	-40
Suction pressure at the wells (mbar)	-34

Table 12: Gas compressor/pump system

5.3. Utilization System

Please, inform very brief about the utilization system and fill in table 13 below

Flare	
Type of Flare (open or closed)	Closed
Number of flares	3
Total capacity of flares (m^3/h)	7500
Actual gas used in flare (m^3/h) approx.	1600
Gas Engine/generator unit(s)	
Fabricate and type of gas engine	NA
Number of engines	
Power production/generator (kW)	
Actual total electricity production (kW)	
Boiler or other utilization system	
Total boiler capacity (kW)	NA
Actual total heat production (kW)	

Table 13: LFG utilization system

5.4. Energy Production

Please, fill in table 14 with the yearly energy production

Year	Electricity production (MWh/year)	Heat production (MW/year)
…….	NA	NA
2000		
2001		
2002		
2003		
2004		
2005		
2006		

Table 14: Annual Energy production

5.5. Operation of the LFG Plant

Please, describe briefly the operation of the plant, especially the problems. If there is any automatic regulation for the gas extraction system, please describe that too. Then fill out table 14 below.

As mentioned above two pumping trials have been executed. First a trial had been done with vertical drains. This option turned out to be unattractive because of the high leachate level. A second pumping trial was performed after this using vertical "Combi" wells. A high quantity of leachate was pumped away to the leachate plant of CEAMSE. Because of the lack of treatment capacity of mentioned plant we had to stop this test after 3 days. After this we did a third test with horizontal drains. These drains produced an amount of circa $2m^3$ LFG per meter of drain. After this third pumping trial it was decided to install a degassing installation with a total capacity of 7.500 m^3/h. This decision was based on 7.500 meters of horizontal drain.

The actual situation shows that there is an extreme high leachate level which varies a lot from place to place but is in fact on average higher then it was in the area used for the pumping trial. This means that the gas production is much lower than assumed after the pumping trial.

Is it possible to regulate the suction/flow from the individual wells and/or horizontal extraction pipes (yes/no)	Yes
Are there any automatic regulation for the gas extraction (yes/no)	Yes
Is water/condensate from gas wells and/or horizontal extraction pipes removed (yes/no)	Yes
Are there operation staff at the plant 24 hours/day	Yes
Do the alarm system call for attention 24 hours/day to the operator (yes/no)	Yes
What is the plant efficiency (working hours/year)	>8500

Table 15: Operation of the LFG Plant

5.6. Measuring and analyzing system

Please, inform briefly about the measuring and analyzing system and fill in table 16below.

Are there stationary gas analyser in the plant (yes/no)	Yes
Which gases are analysed (CH_4, CO_2, O_2, H_2S, ?)	CH_4, CO_2, O_2
Type of portable gas analyser used	GA94
Which gases are analysed (CH_4, CO_2, O_2, H_2S, ?)	CH_4, CO_2, O_2
How often is the gas analysed from the individual wells (daily, weekly, or ?)	monthly
Are pressure, temperature, etc. measured automatically or manual (a/m)	Pressure only. Automaticly

Table 16: Measuring and analyzing system

5.7. Consultant, Contractor and O&M employees

Please, inform briefly about the establishment of the LFG plant, the commissioning, start-up and running-in; was it satisfactory? Was the training of the Operation and Maintenance (O&M) employees satisfactory? Fill in table 17 below

Consultant for implementation (good/poor)	
Did the consultant have good references and long experience in LFG plants (approx. years)	Yes, >10 years
Contractor for implementation (good/poor)	Good
Did the contractor have good references and long experience in LFG plants (approx. number of plants)	>10
Did the team for start-up and running-in have expertise (yes/no)	Yes
Good training of O&M employees (yes/no)	Yes
Good O&M manuals (yes/no)	Yes

Table 17: Consultant, contractors and O&M employees

5.8. Economy

Please, fill in to table 18 the investment costs and the annual income as well as the annual O&M costs

Year	Investment costs US$	Annual income from energy US$	Annual income from CO_2 credit US$	O&M costs US$
…….				
2000				
2001				
2002				
2003				
2004				
2005				
2006				

Table 18: Economy