DRAFT "MODEL"

FOR

CASE STUDIES

OF

CDM - LANDFILL GAS PROJECTS

PRESENTED AT A

WORKSHOP

IN

THE WORLD BANK

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1. BACKGROUND

1.1. General background

The Liepaja Solid waste management Project comprises several components, including LFG collection at two different sites, namely:

1. the old landfill "Skede";
2. the newly constructed Grobina plant (landfill) with energy cell technology and a disposal area for inert waste.

This particular Case Study presents information on the LFG collection from the energy cells at Grobina plant called Grobina Polygon.

Description of the situation at GROBINA POLYGON

The Grobina Polygon Energy Cells have been constructed in 2004 and 2005. Operations of the (first part of the) site started in September 2004 and the monitoring information on the LFG extraction system is available from November 2005 until present.

The amount, quality and continuity of the extracted LFG flow have not yet been sufficient to start up the first gas engine and to start the foreseen electricity production. Due to the lack of proper gas production, the agreed greenhouse gas (GHG) emission reductions under the prototype carbon fund (PCF) have not been reached.

Design

The design of the Grobina Polygon landfill has specific elements related to energy recovery from land filled waste. The concept of energy cells as constructed and currently in operation, requires certain technical parameters from the waste itself and the way of waste handling prior and after it has been put to the landfill cells. In the design and more specifically in the LFG part of the design (2001), the following conditions were incorporated while determining the design parameters:

- Operations of the site will start from the year 2002.
- The yearly foreseen amount of waste to be received was approximately 31,000 tons in 2002, growing to 47,500 tons in 2021.
- Before putting the waste to the energy cells, separation of waste streams shall take place, thus increasing the organic matter content of the waste in the energy cells. The assumed dry organic compound of the waste was set at 36.8% for the major waste stream to be received.
- Each energy cell is equipped with 3 vertical LFG extraction wells, from which LFG extraction was foreseen after reaching a minimum waste height of 2 meters.
- After reaching the maximum waste height of 10 meters, a cover construction of clay (0.5 meters) and top soil (0.5 meter) shall be applied.
- Leachate that is collected via the underlying drainage system is foreseen to be recirculated into the waste body, thus creating more ideal circumstances for biodegradable components in the waste to be converted into LFG.
- With one blower and one gas engine, the production of electricity was foreseen to start after two years of operations of the site.
- The second gas engine was foreseen to start electricity production from the 4th year of operations of the site.

Current situation

The site was visited by the Designer (Royal Haskoning) to analyze the practice of landfill operations and of the management of the LFG extraction system. The main findings of the site visit and the meetings with the involved employees of Liepajas RAS are:

- By December 2006 the first 4 energy cells have been filled with mixed municipal waste.
- The total amount of land filled waste is approximately 90,000 ton (in the period September 2004 – December 2006).
- Cell 1 and 2 have been covered according the design with clay and top soil. Cell 3 and 4 are still being filled up till their designed capacity (to be reached around the end of 2006).
- The LFG-extraction wells are installed according the design. At present, twelve wells of Cells 1 - 4 are connected to the extraction system
- Out of the twelve connected extraction wells, one well is practically not functioning. This well is situated in the part of the waste body where old waste, coming from an old excavated dumpsite in the Liepaja region has been put.
- A brief check of the wells, collectors, siphons and other visible parts of the LFG extraction system showed a high water level in the gas collector pit of Cell 1. It is not clear whether this water level was caused by the heavy rain during the visit, or whether the water level inside of Cell 1 is connected to the level observed in the pit. Other elements of the extraction system did not show considerable shortcomings that might cause problems.
- The LFG extraction is working on a continuous basis. The system produces LFG with acceptable CH4 contents.
- Since September 2004, the hourly rate of LFG extraction has not been enough to start the first gas engine. Therefore, all the extracted LFG is combusted in the flare.
- The foreseen recirculation of leachate is not currently being applied.

2. SITE INFORMATION

2.1. Data for Area

City	Liepaja
Name of the landfills	Polygon ”Kivites”
Site geology (sand, clay, etc.)	loam
Groundwater over/beneath bottom	1.2-2.0 m
Precipitation (mm rain water)	693
Normal range of temp. Win./Sum. (^{0}C)	- 4^{0}C / + 20^{0}C

Table 1: Site area information

The plan drawing of Grobina polygon

2.2. Landfill construction

Start of landfill (Year)	2004
Closing of landfill (Year/year expected)	2024
Area designated for landfilling (ha)	29
Site capacity at closure (Mio. tons)	0,704
Area used in 2006 (ha)	2.42
Max./min. depth of landfill 2006 (m.)	8
Average depth of landfill 2006 (m.)	8
Waste in place 2006 (Mio. tons)	0.095
Gas extraction in 2006 from (Mio. Nm^3)	0.561
Annual waste quantity (1,000 tons)	40-50
Leachate drainage system (yes/no)	yes
Type of membrane in the bottom (if any)	Geotextile and HDPE membrane 2 mm

Table 2: Site construction data

2.3. Waste data

Year	MSW (ton)	Industrial/ commercial (ton)	Other (ton)*	Total (ton)
2004	11 706	198	1 336	13 240
2005	34 175	452	6 473	41 100
2006	34 021	620	5 526	40 167
Total:	79 902	1 270	13 335	94 507

Table 3: Amount of waste disposed of.

* Construction; Garden waste; Sludge

Type of waste	Waste composition (% by weight)
Domestic	85
Industrial, Commercial & Institutional	1.5
Construction	2.6
Garden waste	5.2
Sludge	5.7
Other	-
Total:	100
Total organic (if this is available)	29

Table 4: Waste composition

2.4. Landfill operation

Usage of compactor (yes/no)	n/a
Number of compactors	n/a
Is temporary cover used (yes/no)	n/a
Frequency of temporary cover	n/a
Existence of final cover (yes/no)	yes
Type and thickness of final cover	Clay 50 cm; soil 20 cm
Leachate collection from the bottom (yes/no)	yes
Leachate collection from trenches (yes/no)	no

Table 5: Landfill operation

3. ESTIMATION OF LANDFILL GAS

3.0. Assessment of gas extraction system by "SWECO" in feasibility study in 1999.

Calculations were based on the population and waste prognosis. Table A shows the amount of waste to the energy cells and Table B - the gas production.

Year	Serviced Inhab.	Amount of waste*) tonnes/year	Waste increase 2 %/year	Total amount of waste Tonnes/year	Reduction for recycling/ recovery, %	Waste to energy cells Tonnes/year
1998	100378	22000	0	22000		
1999	99775	21950	1,02	22389		
2000	99106	21800	1,0404	22680		
2001	102667	22587	1,0612	23969	5	22770
2002	109613	24115	1,0824	26102	10	23490
2003	116632	25659	1,1041	28330	15	24080
2004	123851	27247	1,1262	30685	20	24550
2005	131142	28851	1,1487	33141	25	24850
2006	131750	28985	1,1717	33961	25	25470
2007	132360	29119	1,1951	34800	25	26100
2008	133010	29262	1,219	35670	25	26750
2009	133778	29431	1,2434	36595	25	27450
2010	134574	29606	1,2682	37546	25	28160
2011	135384	29784	1,2936	38529	25	28900
2012	136213	29967	1,3195	39541	25	29660
2013	137172	30178	1,3459	40617	25	30460
2014	138151	30393	1,3728	41724	25	31290
2015	139151	30613	1,4002	42556	25	31920
2016	140164	30836	1,4282	44040	25	33030
2017	140597	30931	1,4568	45060	25	33800
2018	142250	31295	1,4859	46501	25	34880
2019	143434	31555	1,5157	47828	25	35870
2020	144643	31821	1,546	49195	25	36900

Table A: Waste to energy cells

Year	Waste to energy cells	Gas for utilisation
	Tonnes/year	MWh/ year
2001	22770	-
2002	23490	9600
2003	24080	14600
2004	24550	19700
2005	24850	22100
2006	25470	23400
2007	26100	24000
2008	26750	24400
2009	27450	25000
2010	28160	25500
2011	28900	26100
2012	29660	26700
2013	30460	27400
2014	31290	28000
2015	31920	28500
2016	33030	29400
2017	33800	30000
2018	34880	30900
2019	35870	31700
2020	36900	32500

Table B: Generated gas energy

As stated by SWECO, for the first year the production of gas from the energy cells is calculated to zero, for the second year to 35 per cent, for the third year to 60 per cent, for the fourth year to 85 per cent and the fifth year and thereafter to 100 % of the total potential gas energy.

3.1. Gas Model by "Royal Haskoning" detailed design report of Grobina landfill

For the estimate of the total gas collected by the gas collection system the Multi-phase model (produced by the Landfill Gas Advisory Centre - the Netherlands in 1994) was used. The used model is based on experience in the Netherlands and has been validated (TNO 1994). The following input is required:

- waste quantity per year;
- type of waste;
- division per type of waste which percentage of the carbon content decomposes fast, medium and slow.

The model calculates for the waste deposited in a certain year the gas production in following years. The total gas production in one year is the accumulation of contributions from gas produced by waste deposited in previous years. Of the produced gas only a certain percentage is collected.

3.2. LFG estimation

Year	Estimation of LFG production / Total LFG generation from disposed waste (1.000 Nm^3/year) SWECO	Estimation of LFG extraction (1.000 Nm^3/year) ROYAL HASKONING	Estimation of LFG extraction (Nm^3/hour) ROYAL HASKONING
2002	510		
2003	970		
2004	1380		
2005	1750	174	60
2006	2080	696	80
2007	2380	1281	148
2008	2650	1786	206
2009	2900	2236	258
2010	3140	2648	306
2011	3370	2993	346
2012	3590	3290	380
2013	3800	3549	410
2014		3781	437
2015		3992	462
2016		4188	484
2017		4372	506
2018		4548	526
2019		4697	543
2020		4825	558
2021		4917	569
2022		4988	577
2023		5046	584
2024		5097	589
2025		3330	385

Table 6: Estimation of LFG production and extraction

*Total LFG generation from disposed waste (1.000 Nm^3/year) binding for 12 Years - THE PROTOTYPE CARBON FUND Baseline Study for the Greenhouse Gas Component of the Liepaja Regional Solid Waste Management Project Revision May 15, 2000

**From “Royal Haskoning” detailed design report of Grobina landfill

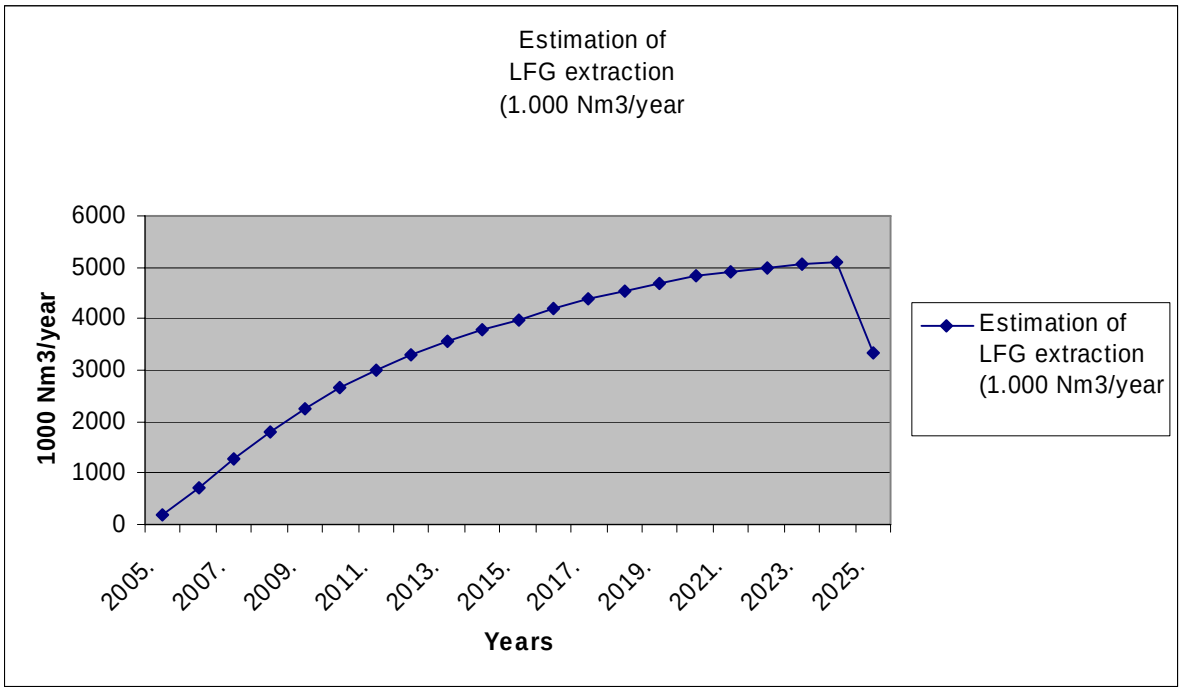

Figure 1: Estimation for gas extraction

LFG prognosis used in design stage in 2001

Basic parameters incorporated in the original LFG prognosis were:

- The operations of the landfill will start in 2002.
- The major waste stream will be separated prior to land filling, thus containing a higher amount of biodegradable matter (36.8%).
- The recovering factor, presenting the percentage of biodegradable waste that actually will be converted into LFG, was set on minimum 60% - maximum 70%. This is higher then in common LFG prognosis, due to the foreseen recirculation of leachate into the waste body.
- The recovery rate, presenting the percentage of LFG that will be captured by the installed LFG extraction system, was set on 85%. This is a common used rate, used for landfill cells with a cover construction of clay/top soil.
- The LFG extraction and utilization equipment will contain one blower with a maximum capacity of 750 Nm3/hr and two gas engine with a capacity of 300Nm3/hr each. The above waste figures and basic parameters resulted in the following estimate of LFG extraction and utilization for the full projection period.

4. TEST PUMPING

Pump capacity (m^3/h)	n/a
Number of test wells	n/a
Duration of the test pumping	n/a
Gas extraction from well no.1 (m^3/h)	n/a
Gas extraction from well no.2 (m^3/h)	n/a

Gas extraction from well no.3 (m^3/h)	n/a
Gas extraction from well no.4 (m^3/h)	n/a
Total gas extraction (m^3/h)	n/a

Table 7: Data and results from the test pumping

5. REAL LFG EXTRACTION

5.1. Estimated LFG extracted compared with real extracted

Year	Estimation of LFG extraction (1.000 Nm^3/year)	Real LFG extraction (1.000 Nm^3/year)	Difference (+/- 1.000 Nm^3/year)	Difference (+/- %)
2005	174	163	-11	-7
2006	696	561	-135	-20

Table 9: Estimation of LFG production and extraction

5.2. Estimated LFG composition compared with real composition

Year	Estimated gas quality				Real gas quality			
	CH_4 %	CO_2 %	O_2 %	N_2 %	CH_4 %	CO_2 %	O_2 %	N_2 %
2005	50-60	35-40	0-2	0-10	52.6	42	0.1	5.0
2006	50-60	35-40	0-2	0-10	42	35	0.1	22
Actual	50-60	35-40	0-2	0-10	52.3	37	0.1	10

Table 10: Estimation of LFG production and extraction

6. LANDFILL GAS PLANT

6.1. LFG Collection System

Wells	
Number of wells	12 (3 wells per cell)
Depth of wells/average depth (m)	6
Diameter of well (mm)	700
Diameter of gas extraction pipe (mm)	100
Distance between wells (m)	30 and 40
Presence of water/condensate in wells (yes/no)	no
Water/condensate pump in wells (yes/no)	no
Horizontal gas extraction pipes	
Horizontal gas extraction pipes (total m)	n/a
Diameter of horizontal gas extraction pipe (mm)	n/a
Presence of water/condensate in pipes (yes/no)	n/a
Water/condensate removal system for pipes (yes/no)	yes
Horizontal gas collection system (from wells to gas pump)	
Diameter of horizontal collection system (mm)	100
Condensate trap at low points (yes/no)	yes

Table 11: LFG Collection system

6.2. Gas Compressor/Pump System

Type of gas compressor/pump	RBS 65/F
Capacity of gas compressor/pump (m^3/hour)	1000
Suction pressure at the pump (mbar)	10
Suction pressure at the wells (mbar)	0.3-3.0

Table 12: Gas compressor/pump system

6.3. Utilization System

Flare	
Type of Flare (open or closed)	closed
Number of flares	1
Total capacity of flares (m^3/h)	500
Actual gas used in flare (m^3/h)	65
Gas Engine/generator unit(s)	
Fabricate and type of gas engine	TEDOM Quanto D550SPCON
Number of engines	2
Power production/generator (kW)	584
Actual total electricity production (kW)	0
Boiler or other utilization system	
Total boiler capacity (kW)	n/a
Actual total heat production (kW)	n/a

Table 13: LFG utilization system

6.4. Energy Production

Year	Electricity production (MWh/year)	Heat production (MW/year)
2005	0	0
2006	0	0

Table 14: Annual Energy production

6.5. Operation of the LFG Plant

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)	no
Is water/condensate from gas wells and/or	no

horizontal extraction pipes removed (yes/no)	
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)	8560 (8760-200)*

Table 15: Operation of the LFG Plant

* Maintenance, power interruptions, occasional low t^{o}

6.6. Measuring and analyzing system

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	LMSxi Type G 2.18
Which gases are analysed (CH_4, CO_2, O_2, H_2S, ?)	CH_4, CO_2, O_2, N_2
How often is the gas analysed from the individual wells (daily, weekly, or ?)	weekly
Are pressure, temperature, etc. measured automatically or manual (a/m)	a

Table 16: Measuring and analyzing system

6.7. Consultant, Contractor and O&M employees

Consultant for implementation (good/poor	Good by the Twinning Partner Carl Bro
Did the consultant have good references and long experience in LFG plants (approx. years)	25 years
Contractor for implementation (good/poor)	Good by the Supplier LNV Energy
Did the contractor have good references and long experience in LFG plants (approx. number of plants)	20 years with 15 projects of similar nature
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

6.8. Economy

Year	Investment costs US$	Annual income from energy US$	Annual income from CO_2 credit US$	O&M costs US$
2003	432 600			
2004	1 752 251	0		212 526
2005	1 638 203	0	4 467.8	476 522

2006	281 886	0	13 025.6	556 814

Table 18: Economy

*including capping of cells 3 and 4