Mazurskie
Landfill Gas Package,
Poland

Project Design Document
ANNEXES

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2 Information regarding public funding

There is no Official Development Assistance in this project.

3 Baseline information

3.1 Identification of methodology

3.1.1 Proposed methodology title

For the landfill gas plants the approved consolidated baseline methodology ACM0001/Version 1, 3rd September 2004, titled: "Consolidated baseline methodology for landfill gas project activities" has been applied.

3.1.2 List of categories of project activity to which the methodology may apply

For all of the activities within the project boundaries described in section B.5 this methodology is applicable.

3.1.3 Condition under which the methodology is applicable

This section includes explanation to the conditions under which the methodology is applicable to the project activity.

It is a fact that environmental policy in general have high priority in Poland and that a large amount of money and manpower has been on the national budget for to implement guidelines for environmental goals to be accomplished. However, lack of funds gives natural boundaries for the speed of environmental improvements. Considering the financial situation in Poland no major changes in the environmental policy are expected within the next 10 years as condition for the applied methodology. As example no sudden national requirements for establishment and funds for construction of landfill gas plants with gas utilization are expected implemented in Poland.

However, legislation in connection with Poland as member of the EU requires that from 2012 facilities must be implemented as a minimum to collect/ventilate and flare the landfill methane gas. This has been taken into consideration in the baseline.

3.1.4 Potential strengths and weaknesses of the proposed methodology

Some of the major potential strengths of the proposed methodology are listed below:

Simplification	Only one potential scenario are expected to be considered as described in section B. Several scenarios would have made the comparison to the calculated baseline emission reduction more complex.
Measurements	The proposed baseline scenario only includes calculations of given registered amounts of waste as well as single measured content of methane.

Some of the major potential weaknesses of the proposed new methodology are listed below:

Biogas production	Biogas production itself is a complicated procedure to be foreseen or calculated in advance as described in this application. Since the emission reduction anyway is calculated from the baseline situation and JI-funds will be paid according to these calculations, some corrections to the payment can be anticipated.
Future planning	There will always be some degree of uncertainty connected to how the future planning locally will be. However, considering the situation described in section H.3.1.3 no major changes can be expected.

3.2 Overall summary description

The methodology is a financial test and the methodology is applied in the following steps:

1. Draw up a list of possible baseline scenarios.
2. Reduce the list of possible scenarios by eliminating those that are not possible because not permissible under applicable law or not possible from practical and/or technical point of view.
3. For all possible alternatives, calculate a conservative (with the interpretation of conservative being defined below) project economy, not taking carbon finance into account. The calculation must include the incremental investment costs, the O&M costs and all other costs of implementing the technology of alternative. It must include all revenues generated by the implementation of the technology except carbon revenues.
   The project economy is calculated conservatively if the assumptions made tend to increase the payback time of the project scenario instead of decreasing it. To ensure this, values that tend to lead to a increased payback time should be used for all assumptions and for all alternatives, i.e. costs of low estimate and revenues a high estimate. Conservatism of these assumptions should be ensured by obtaining expert opinions and by the Operational Entity validating the project.
4. Determine that the project payback time for all calculated scenarios is clearly and significantly shorter than a conservatively expected and acceptable payback time for a comparable investment project in the country in question.
5. Conclude that the other possible scenarios are economically unattractive and that the BAU is the most likely baseline scenario.
6. Calculate baseline emissions. Describe assumptions and parameters used.

3.3 Choice of and justification as of baseline approach

This section includes choice of and justification as to why one of the baseline approaches listed in paragraph 48 of CDM modalities and procedures is considered to be the most appropriate.

3.3.1 General baseline approach

Paragraph 48 of the CDM modalities and procedures is shown below:

"48. In choosing a baseline methodology for a project activity, project participants shall select from among the following approaches the one deemed most appropriate for the project activity, taking into account any guidance by the executive board, and justify the appropriateness of their choice:

a) Existing actual or historical emissions, as applicable; or
b) Emission from a technology that represents an economically attractive course of action, taking into account barriers to investment; or
c) The average emissions of similar project activities undertaken in the previous five years, in similar social, economic, environmental and technological circumstances, and whose performance is among the top 20 per cent of their category."

Approach b) is chosen and has been referred to as "a financial test" as written in section 3.2. Approach b) has been chosen because the used technology for the gas utilization plants represents an economically attractive course of action since there is a potential income related to the selling of the produced heat and electricity. However, there is a major barrier in relation to the investment. The plants are expensive to establish, but the project economy can be feasible if grants are obtained. In this case the grants are expected for the Danish Ministry in relation to the emission reduction, but also grants from Polish national funds will be needed before the economy is feasible. Furthermore, please refer to Chapter B.3.3 concerning the project economy.

3.3.2 Justification of the approach chosen

The approach chosen in section 3.2 is considered the most appropriate since the landfill gas utilization plant are modern technologies representing an economically attractive course of action, taking into account barriers to investment such as the need for additional funding for the project to be feasible.

3.4 Explanation and justification of the proposed new baseline methodology

3.4.1 Explanation of how the methodology determines the baseline scenario

This section includes indication of the scenario that reasonably (most likely) represents the anthropogenic emission by sources of GHG's that would occur in the absence of the proposed project activity.

Below are comments concerning likelihood listed for the in section B.3.1 mentioned potential numbers of technical treatment possibilities (scenarios).

Possible baseline scenarios for the waste treatment are listed below.

a) Landfilling: The collected waste is brought to a landfill site for deposit. The organic fractions of the waste will decompose and generate methane.
b) Incineration: An incineration plant has a very high establishment cost. The environmental demands for the exhaust gas and waste from the incineration plants also result in high establishment for treatment of the exhaust gas (cleaning) and the remaining waste from the combustion processes. It will therefore only be feasible to operate such a plant if a high enough amount of waste will be available, which is way beyond the waste amount in the Zakopane area.
c) Recycling: Only between 5-10% of the total amount of collected waste are recycled in Poland at present. More and more recyclable waste is being collected, but the progress is going slowly and the possible scenario has no influence on the already deposited amount of waste.
d) Methane recovery: Methane recovery and flaring is the cheapest solution investment vice, but this solution itself does not provide any potential revenue to the landfill site. However, methane recovery with an electricity and/or heat production will provide source of revenue and could potentially make the solution economically attractive (the proposed project).

3.4.2 Criteria used in developing the proposed baseline methodology

Conditions and assumptions given under section B concerning the baseline are used to elaborate the proposed methodology.

3.4.3 Project activities as additional scenario

This section includes explanation of how, through the methodology, it can be demonstrated that a project activity is additional and therefore not the baseline scenario as indicated in section B.3 of the CDM-PDD. Section B.3 of the CDM-PDD is shown below:

"B.3. Description of how the anthropogenic emissions of GHG by sources are reduced below those that would have occurred in the absence of the registered CDM project activity.
Explanation of how and why this project is additional and therefore not the baseline scenario in accordance with the selected baseline methodology. Include 1) a description of the baseline scenario determined by applying the methodology, 2) a description of the project scenario, and 3) an analysis showing why the emissions in the baseline scenario would likely exceed emissions in the project scenario."

1) Baseline scenario:
The baseline scenario can be described as follows:

"There will be no treatment of the landfill site produced methane gas, thus the unimpeded release of methane to the atmosphere will continue until the time when treatment of landfill gas becomes required by the national law or becomes an economically attractive course of action."

2) Project scenario:
The project scenario can be described as indicated in the project title:
"Mazurskie Landfill Gas Package, Poland"

3) Analysis:
All of the produced methane gas will be released to the atmosphere in the baseline scenario and all of the produced methane gas will be utilized in the project scenario. Thereby the emissions in the baseline scenario will exceed emissions in the project scenario.

3.4.4 National and/or sector policies and circumstances

This section includes descriptions to how the national and/or sector policies and circumstances can be taken into account by the methodology.

See section H.3.1.3.

3.4.5 Project boundary

This section includes description of the project boundaries concerning gasses and sources included as well as physical delineation.

Only the methane gas is considered from the sources of waste. In section B.5 graphical delineations of the physical project boundaries are shown.

The table below illustrates the emissions identified related to the project boundaries and indicates which of these are included in the calculations of emissions in the baseline and the project scenario. Only the direct and indirect on-site emissions are included. Other possible emissions not included are assessed as insignificant or not attributable to the project.

Summary of system and project boundaries	Emissions within the Project scenario	Emissions within the Baseline scenario	GHG reduction
Direct, on-site	Fugitive emissions and Emission reduction from combustion of methane	Uncontrolled release of gas	Calculated/included
Direct, off-site	Transport of project equipment to project site	None	Excluded
Indirect, on-site	a) Emission from the use of electricity at the plants. b) Emission reduction due to electricity production from biogas c) Emission from construction of the project	a) Emission from the use of electricity at the plants.	a) Assumed unchanged (excluded) b) Calculated/included c) Excluded

Indirect, off-site	Transport of sludge to- and from wastewater treatment plant	Transport of sludge to- and from wastewater treatment plant	Assumed unchanged (excluded)

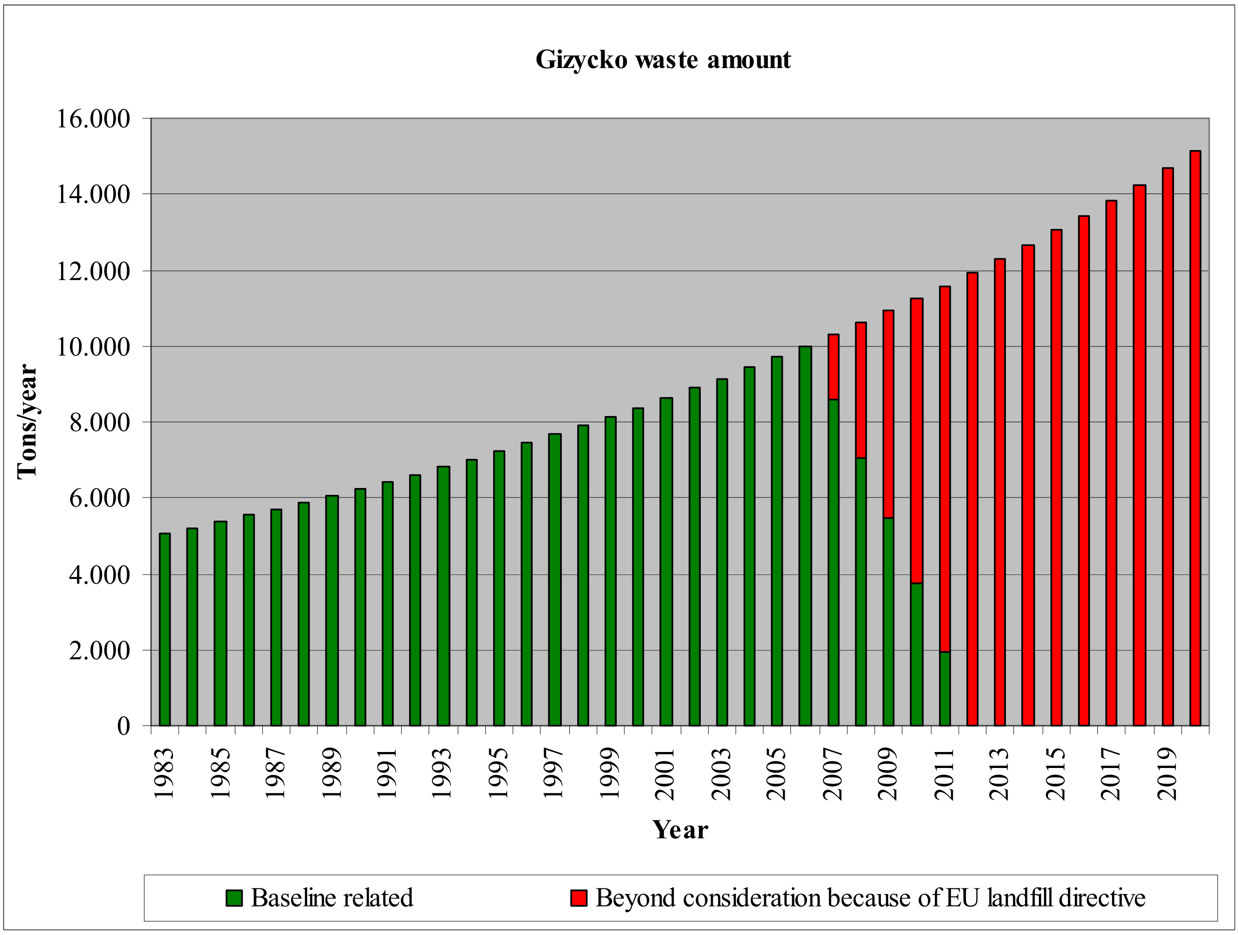
3.4.6 Formulae/algorithms used to determine the baseline scenario

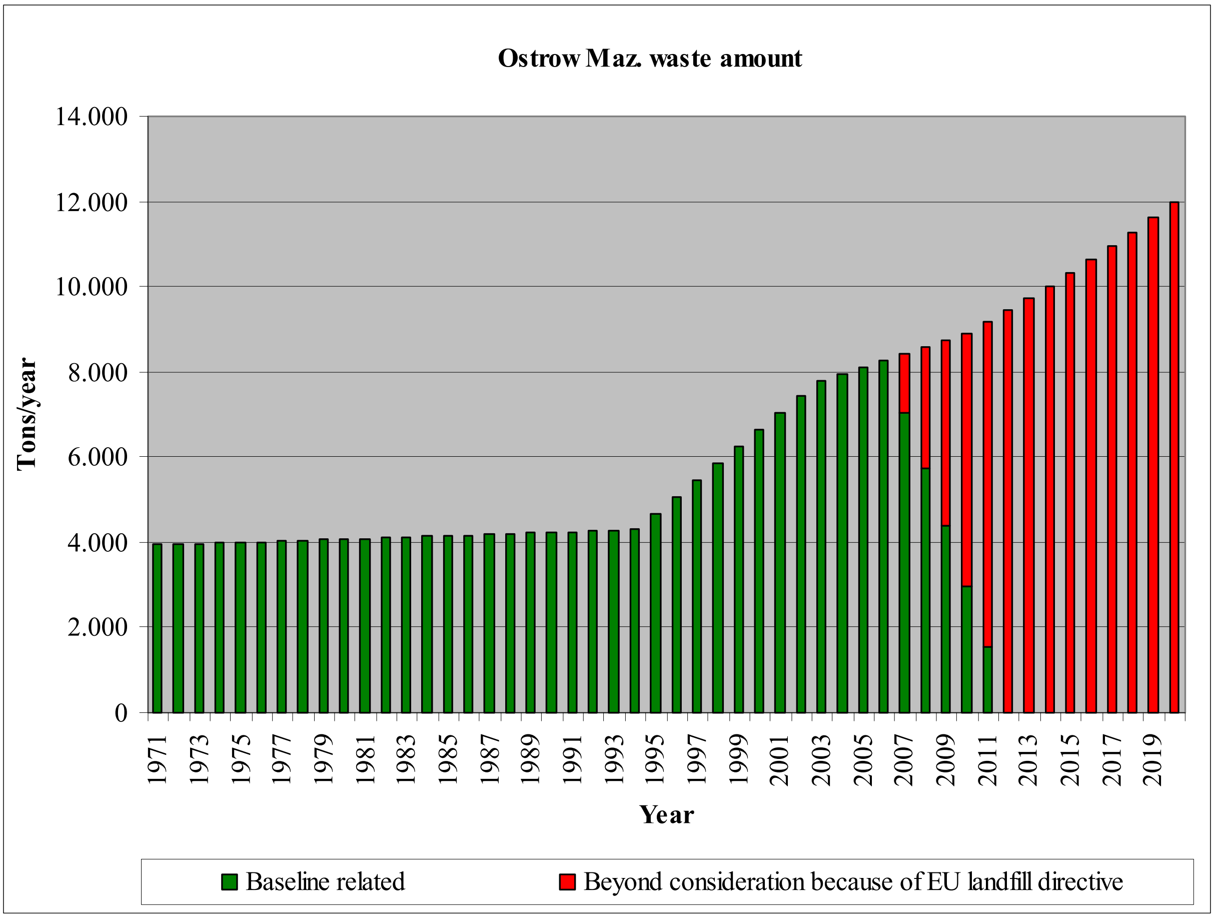
This section includes descriptions for to elaborate and justify formulae/algorithms used to determine the baseline scenario such as variables, fixed parameters and values to be reported as for example fuels used and fuel consumption rates.

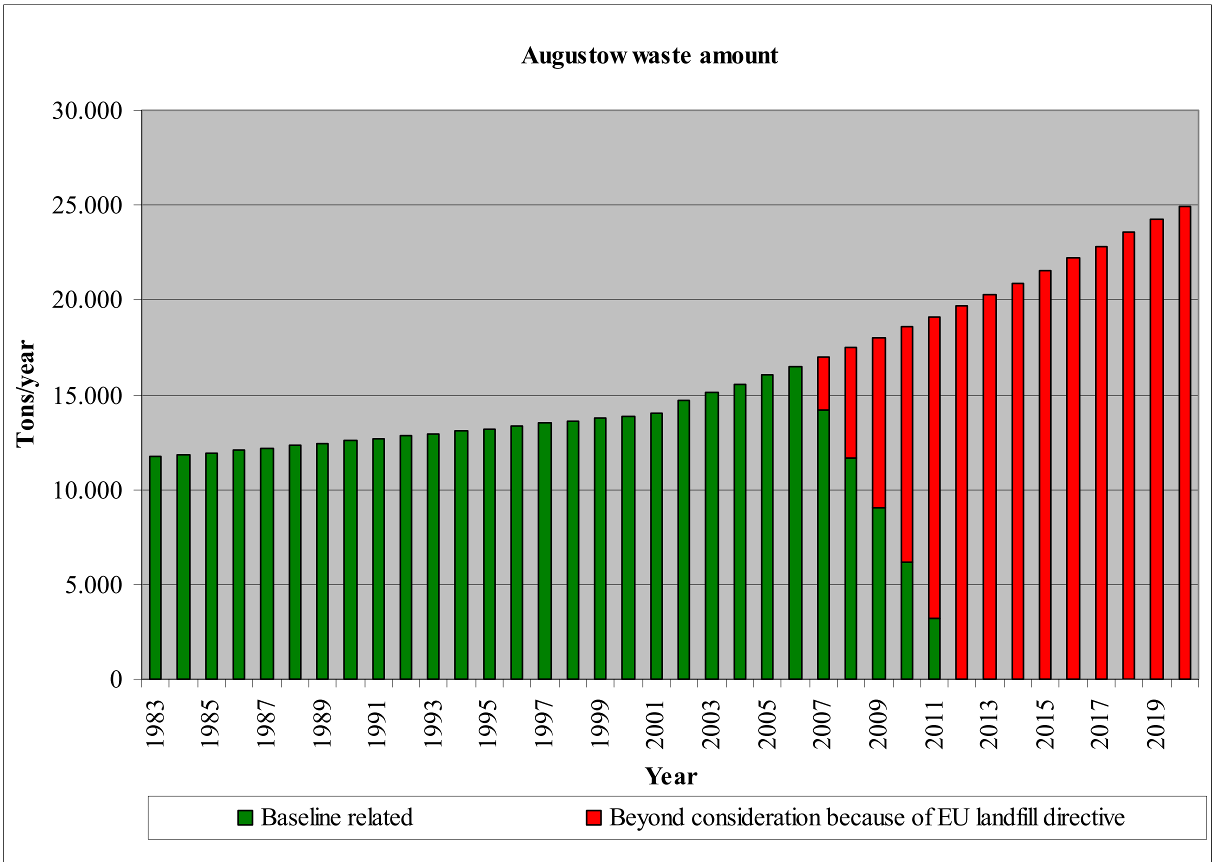
Given the special conditions of the project there is no need for to determine the baseline scenario beyond the description shown below and the ones specified in chapter 3.7 since the emission reduction is given directly as described in chapter E.5 and 3.4.9.

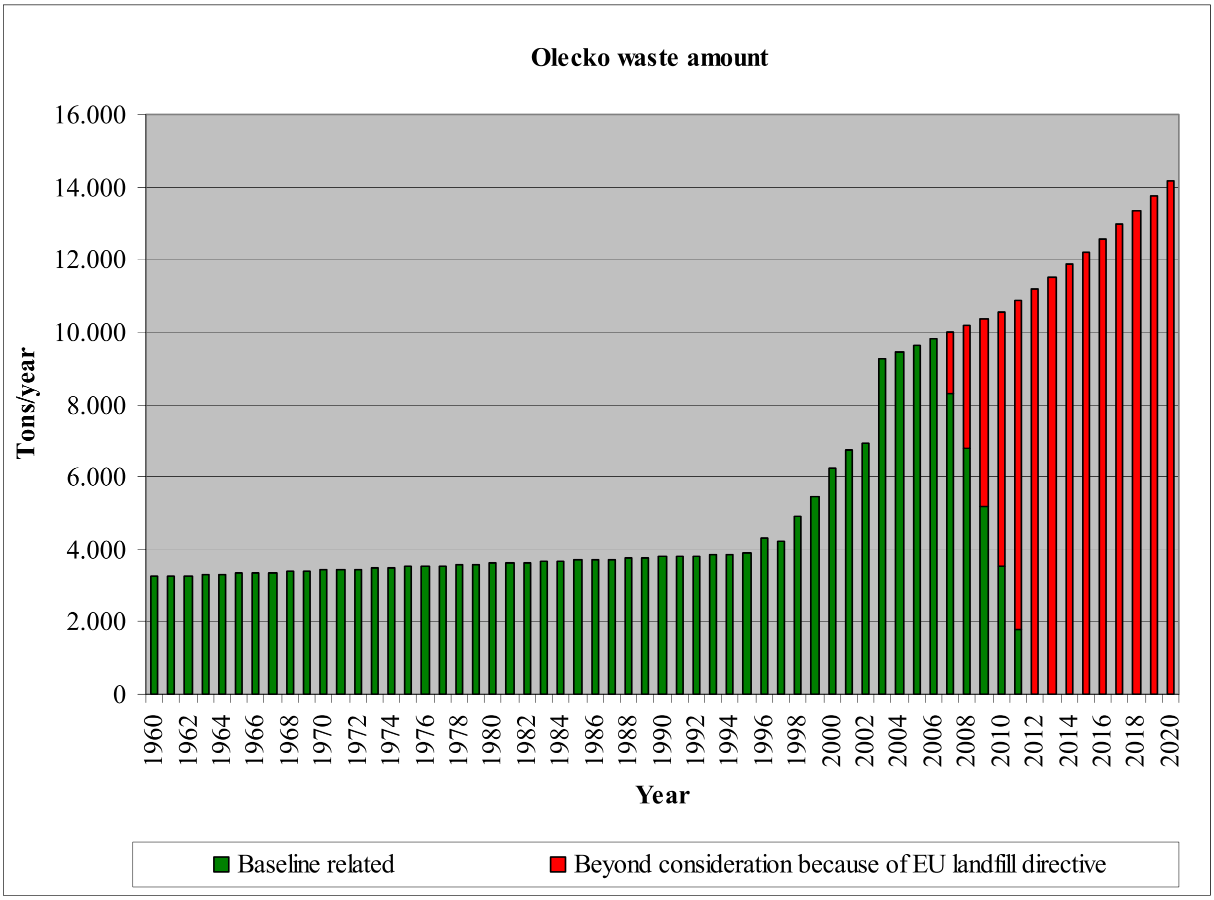
3.4.6.1 Step 1: Waste amount

Below is shown the anticipated amount of waste deposited on Landfill Sites.

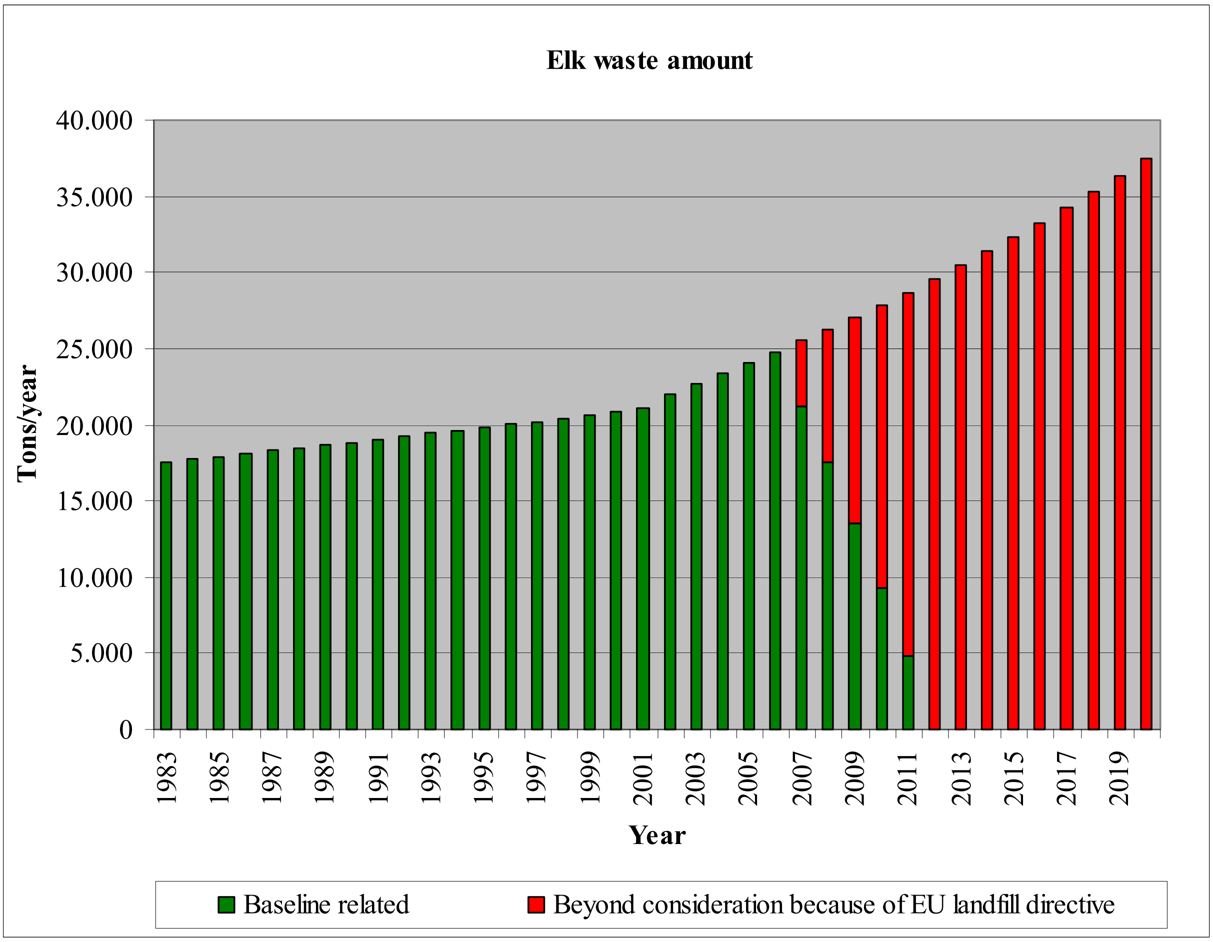



Ostrow Maz. waste amount
Tons/year
14.000
12.000
10.000
8.000
6.000
4.000
2.000
0
1971
1973
1975
1977
1979
1981
1983
1985
1987
1989
1991
1993
1995
1997
1999
2001
2003
2005
2007
2009
2011
2013
2015
2017
2019
Year
Baseline related
Beyond consideration because of EU landfill directive

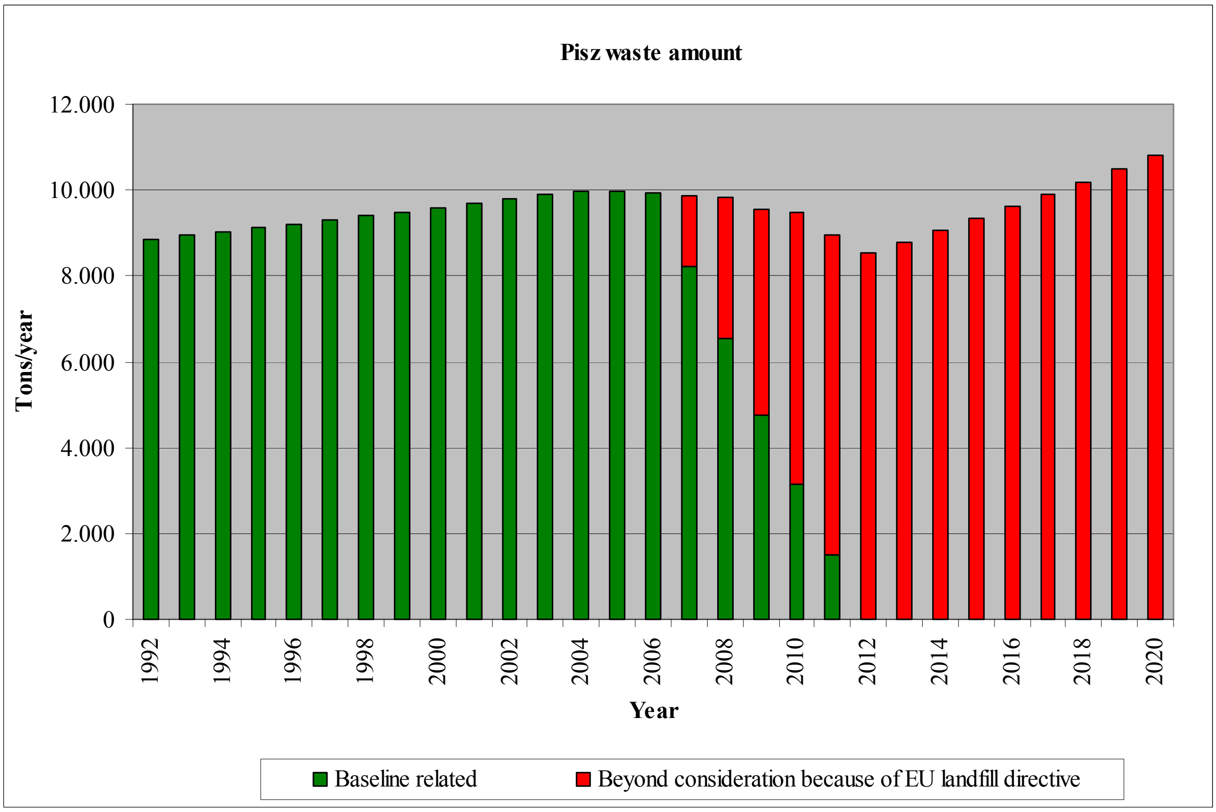

Augustow waste amount
Tons/year
30.000
25.000
20.000
15.000
10.000
5.000
0
1983
1985
1987
1989
1991
1993
1995
1997
1999
2001
2003
2005
2007
2009
2011
2013
2015
2017
2019
Year
Baseline related
Beyond consideration because of EU landfill directive

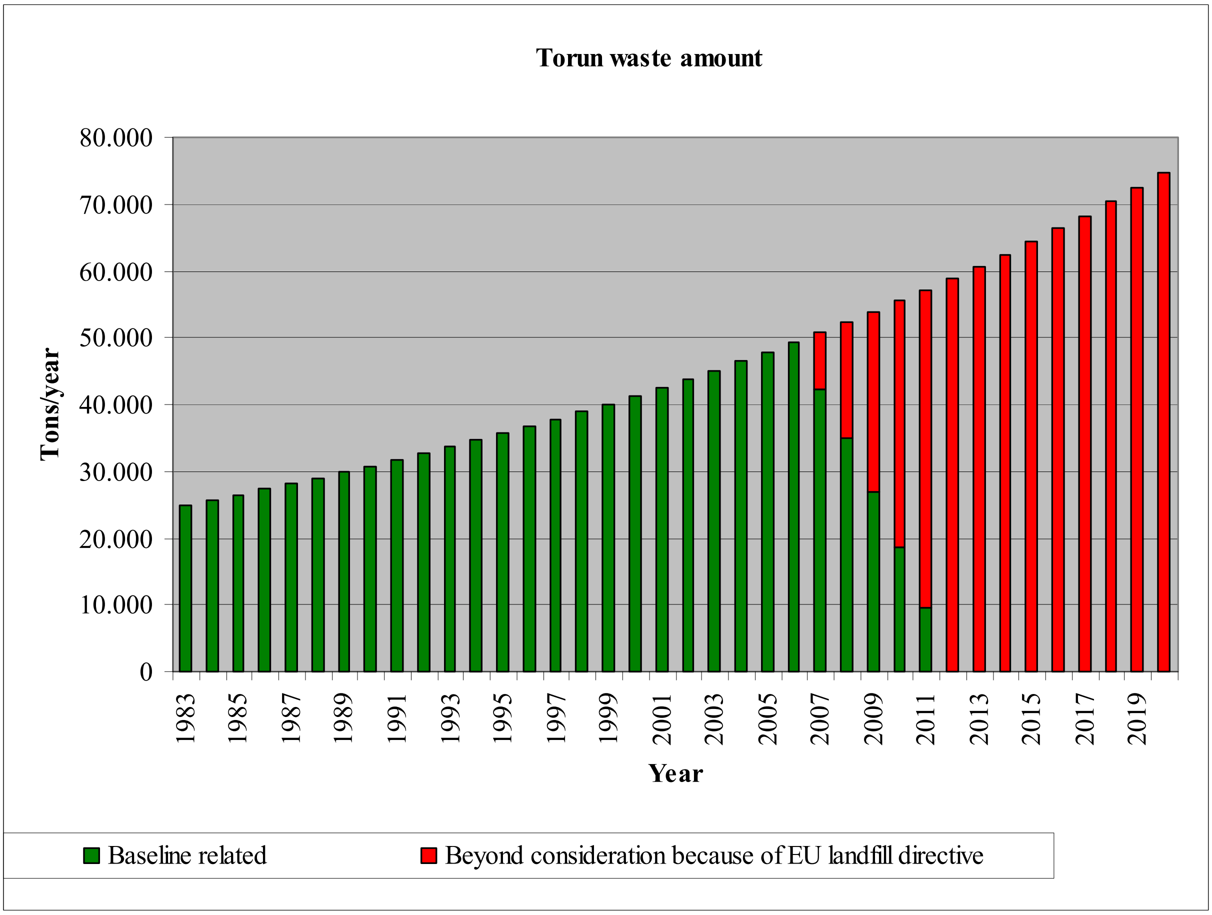


Olecko waste amount
Tons/year
16.000
14.000
12.000
10.000
8.000
6.000
4.000
2.000
0
Year
Baseline related
Beyond consideration because of EU landfill directive



Elk waste amount
Tons/year
40.000
35.000
30.000
25.000
20.000
15.000
10.000
5.000
0
Year
Baseline related
Beyond consideration because of EU landfill directive


Pisz waste amount
Tons/year
12.000
10.000
8.000
6.000
4.000
2.000
0
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
Year
Baseline related
Beyond consideration because of EU landfill directive


Torun waste amount
Tons/year
80.000
70.000
60.000
50.000
40.000
30.000
20.000
10.000
0
1983
1985
1987
1989
1991
1993
1995
1997
1999
2001
2003
2005
2007
2009
2011
2013
2015
2017
2019
Year
Baseline related
Beyond consideration because of EU landfill directive

The EU landfill directive specifies combustion of landfill gas generated from waste deposited after 2012 and that an adjustment phase must be considered from 2006 until 2012. That is the reason for the phasing out of the ”considered amount of waste” in the above graphs according to the below fractions.

Year	Waste deposit considered in %
>=2006	100
2007	83
2008	67
2009	50
2010	33
2011	17
2012=<	0

Only emission reductions related to the landfill gas plant up until and including 2012 have been considered. Furthermore, the Torun landfill site already have a landfill gas plant on part of the landfill site and therefore only waste deposited on new areas without landfill gas plant has been considered.

The EU Landfill Directive specifies targets and not final national legislation. However, Polish legislation specifies that by 2012 all landfill sites should be equipped with facilities for combustion of generated landfill gas, which is the same goal as the EU Landfill Directive. The EU Landfill Directive has been taken into consideration for these specific landfill sites by reducing the amount of waste considered from 2006 till 2012, as shown in the above table. The Polish Ministry will by their Letter of Approval specify that the project is in accordance with this. However, the Polish Ministry can not submit their Letter of Approval before they receive the Determination report for this PDD.

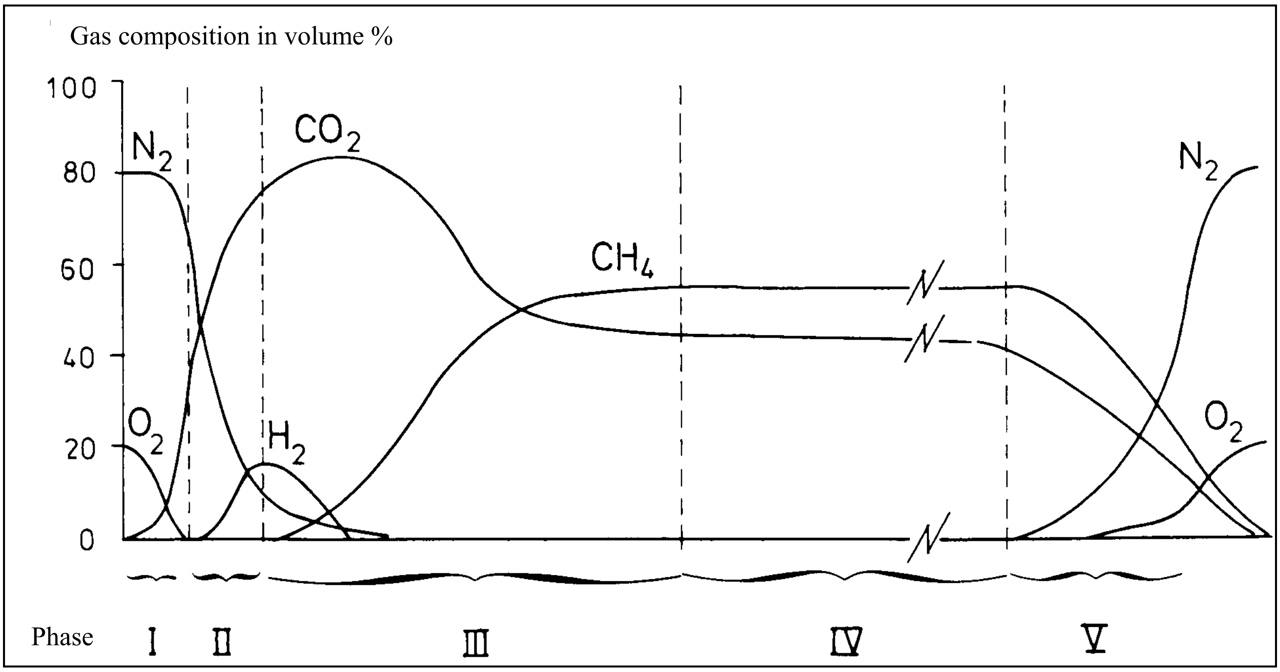
Further descriptions to the above graph have been included in chapter E.6.2.

3.4.6.2 Step 2: Organic amount of waste

All needed calculations and results are shown in chapter E.6.2.

3.4.6.3 Step 3: Gas production

To evaluate the gas production one have to consider the biological processes, which will start as soon as the waste is deposited. In short the initial process will be an aerobe decomposition whereby the present oxygen will be used. When the oxygen is used an anaerobe decomposition will commence from which biogas will be developed. Below is shown in a graph how the gas composition varies during time. Base on the processes of decomposition the time has been split into 5 phases described below the graph.



Phase I: In this phase the easiest transformable organic fraction decomposed primarily based on the available oxygen present in the waste when it is deposited. The oxygen will be transformed and the temperature will increase. The duration is relatively short, normally between few days and few weeks.

Phase II – Anaerobe acid phase: After the aerobe phase follow a transfer phase, during a strong anaerobe condition develop. A heavy production of organic acid and carbon dioxide, from the fermentative bacteria, will occur caused by the acid phase.

Phase III – Anaerobe methane production phase, unstable: In this phase the methane production starts and the concentration will build up. This develops in the same time as the carbon dioxide concentration falls down and the organic acids are transformed.

Phase IV – Methane phase. After some time the methane phase will be more stable and result in methane concentrations between 40 and 60 % volume. This phase normally continues for many years and even after 30 till 50 years anaerobe transformation of difficult transformable organic materials can be measured. The long duration can also be because of not optimal conditions regarding parameters as moisture, temperature etc.

Phase V – Stable phase: At a certain time the methane production activity will fall to such a low level that atmospheric nitrogen will occur in the landfill gas. Aerobe zones can be produced in the upper part of the landfill, and the landfill will now be stable.

Beside methane and carbon dioxide the landfill gas in the methane phase also contain a number of other gasses and traces of components. Below is shown the gasses that normally will occur in the largest concentrations.

Gas component	Chemical name	Variation	Average
Methane	CH_4	30-65%	48%
Carbon dioxide	CO_2	25-50%	40%
Nitrogen	N_2	5-30%	10%
Oxygen	O_2	0-5%	1%
Hydrogen	H_2	0-1%	0,5%
Argon	Ar	0-0,4%	0,1%
Hydrogen Sulfide	H_2S	0-100 ppm	20 ppm
Total Chlorine	Cl	0-200 ppm	20 ppm
Total Flour	F	0-100 ppm	20 ppm

Furthermore, the landfill gas contain other components as aroma hydro carbons as benzene, toluene, methyl benzene, styrene, halogens as chlorine methane, chlorine double flour methane, triple chlorine flour methane. The mentioned trace components will normally be decomposed when the gas is used for energy purposes by combustion in a boiler or as fuel to a gas engine.

The gas production varies significantly from plant to plant, which is because of different conditions depending on the situation in the single landfill site. The rate of production, meaning the produced amount of gas per time unit from a given amount of waste (Nm3 landfill gas / tons of waste / year) will depend on the following parameters:

- Temperature in the landfill site depending on the depth of the deposited waste.
- The waste content of moisture depending on the composition of the waste.
- The waste composition can vary significantly from landfill site to landfill site.
- Age of the waste. The maximum yearly gas production will normally occur in 3-8 years and after 15-25 years the gas production will in most cases decrease so much, that it alone from a financially point of view no longer will be feasible to extract the gas for energy production.
- Landfill site coverage is important to avoid atmospheric air to penetrate. This is why coverage by clay normally will be a god solution since it sufficient prevents air slipping into the waste and in the same time allows rain water to penetrate down through the landfill site as the needed moisture to the waste.
- The waste structure since particles will give a larger surface for bacteria's to live in, compared to one large compact lump of waste.
- Components which will slow down the bacteria culture.

By a normal mixture of waste, including household waste, the total gas potential in 1 tons of waste will normally be between 150 and 250 m3 landfill gas. The decomposition speed and transfer percentage (meaning part of potential transformed) will vary significantly depending on the parameters mentioned above.

From above knowledge, general experiences, several types of formulas and actual test pumping results from existing landfill sites. The maximum gas production is estimated taking into consideration how large a part of the deposited waste will generate methane gas as described in step 2. Finally the calculated result is compared with actual test pumping results. The result of calculations is shown in step 4. In the calculations the maximum yearly gas production has been estimated to occur 5 years after deposit and after 25 years after deposit the gas production has been set to be close to zero.

Below are specified, as examples of landfill gas qualities, data from 1 Danish and 2 Polish landfill gas plants all established by technical assistance from AAEN Consulting Engineers A/S personal.

Landfill gas plant	Landfill gas quality as % methane
Viborg, Denmark	50-58
Olztyn, Poland	50-60
Torun, Poland	54-58

A conservatively landfill gas quality of 50 % methane has been used in the PDD.

The total GHG production for each year waste deposit (* in the below schemes) has been calculated according to the IPCC Guidelines with the parameters shown below. Result of * is shown in step 7.

A	B	C	D	E	F	G
Waste disposed (MSW)	Methane Correction Factor	Fraction of DOC in MSW	Fraction of DOC which actually degrades	Fraction of Carbon released as Methane	Conversion Ratio	Potential Mehane Generation Rate per Unit of Waste
Tons/year	Default value	Poland	Default value	Default value	Default value	Tons CH4/tons MSW
						= C*D*E*F
*	0,6	0,15	0,77	0,5	1,33	0,077

Factors for B: ”Methane Correction factor” and C: ”Fraction of DOC in MSW” in the above table could have been chosen from the Appendix B of the simplified modalities and procedures for small-scale CDM project (B = 0,4 and C = 0,3). However, if these factors had been chosen the emission reduction from the landfill gas plant would have been 3 times higher than calculated in the PDD. However, by the chosen factors (B = 0,6 and C = 0,15) the amount of generated landfill gas, compared with other ways of calculating the methane generation and actual measurements from existing landfill gas plants in Poland and Denmark, is closer to the amount that can be expected.
As result of the above it is our opinion that we have chosen a conservative way of calculating.

H	J	K	L	M	N
Released (Country specific) Methane Generation Rate per Unit of Waste	Gross Annual Methane Generation	Recovered Methane per Year	Net Annual Methane Generation	One Minus Methane Oxidation Correction Factor	Net Annual Methane Emissions
Tons CH4/tons MSW	Tons CH4	Tons CH4	Tons CH4	Default value	Tons CH4
=B*G	=H*A		=J-K		=L*M
0,0462	*	0	0	1	*

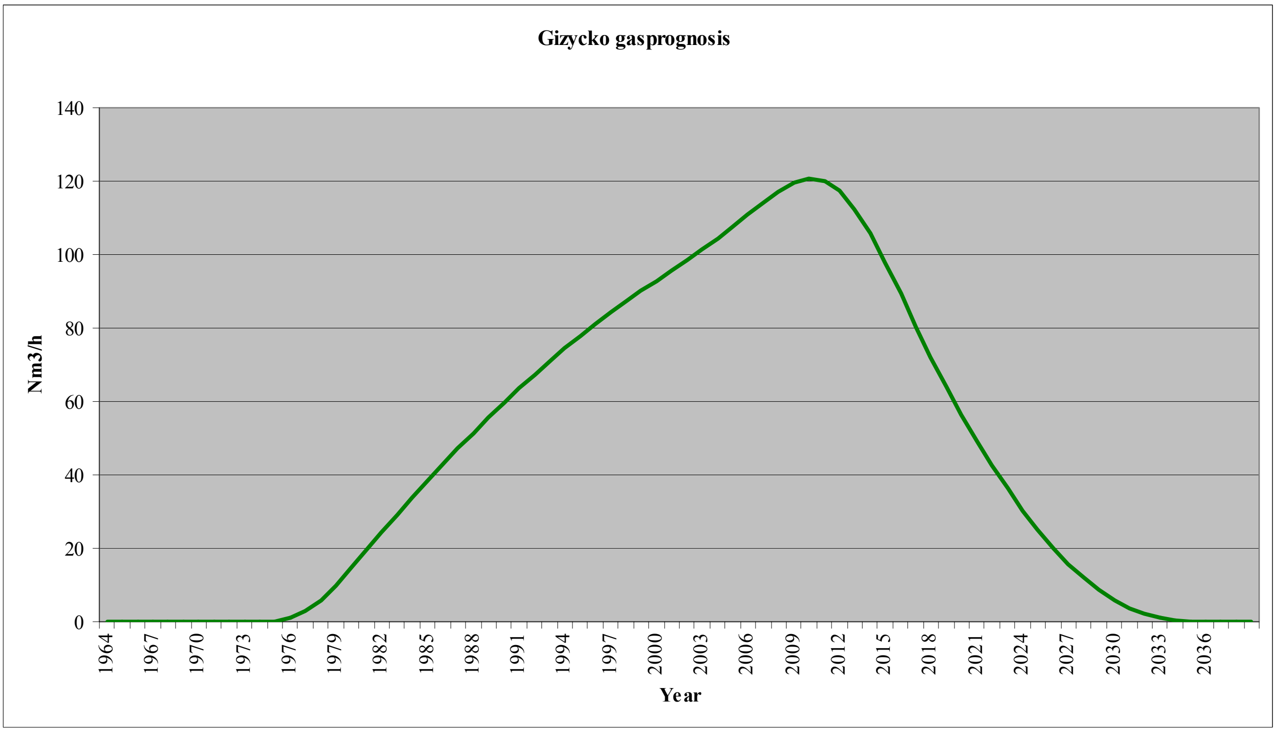
Each year Net annual Methane Emissions (N in the above scheme) has been calculated into total LFG gas amount as actual fuel input to an engine or flare as shown below. Result of * is shown in step 7.

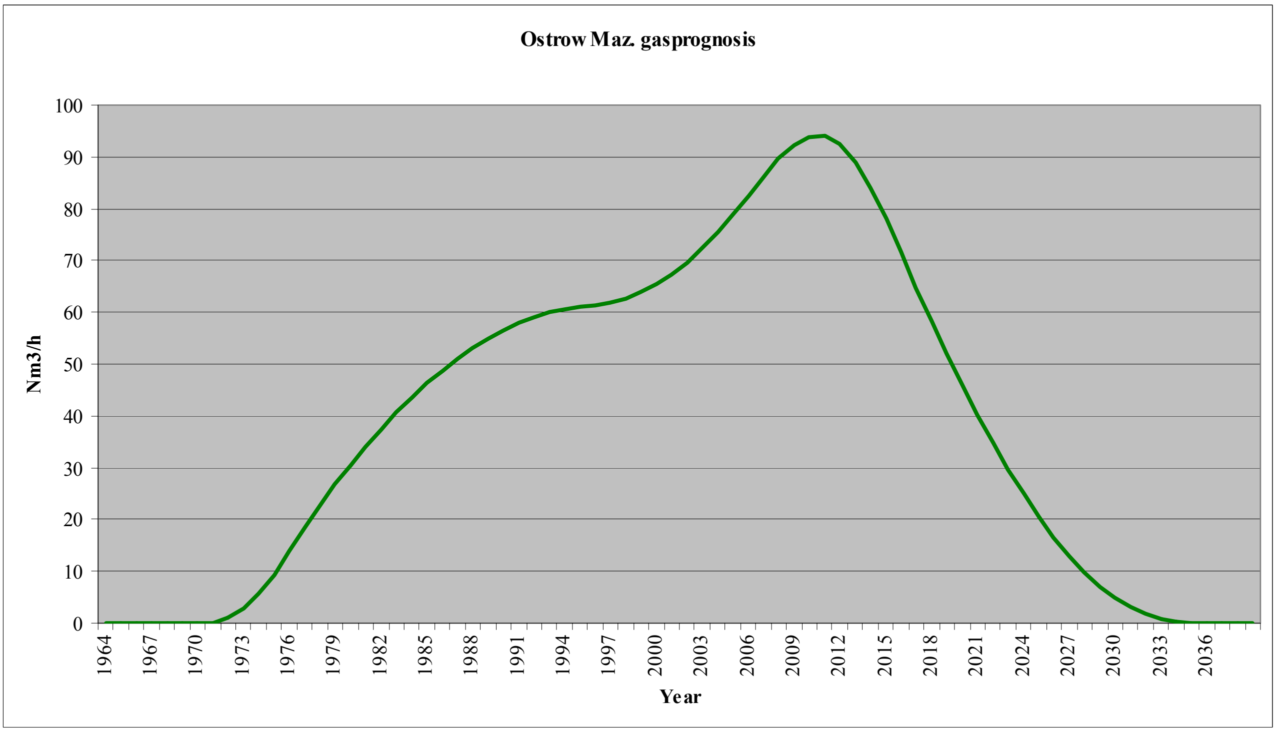
O	P	Q	R
Dch4	LFG quality	LFG gas amount for engine or flare	LFG gas amount for engine or flare
Tons CH4 / m3 CH4	m3 CH4 / m3 LFG	m3 LFG /Year	m3 LFG / hour
Default value		=N/O/P	=Q/365/24
0,0007168	0,5	*	*

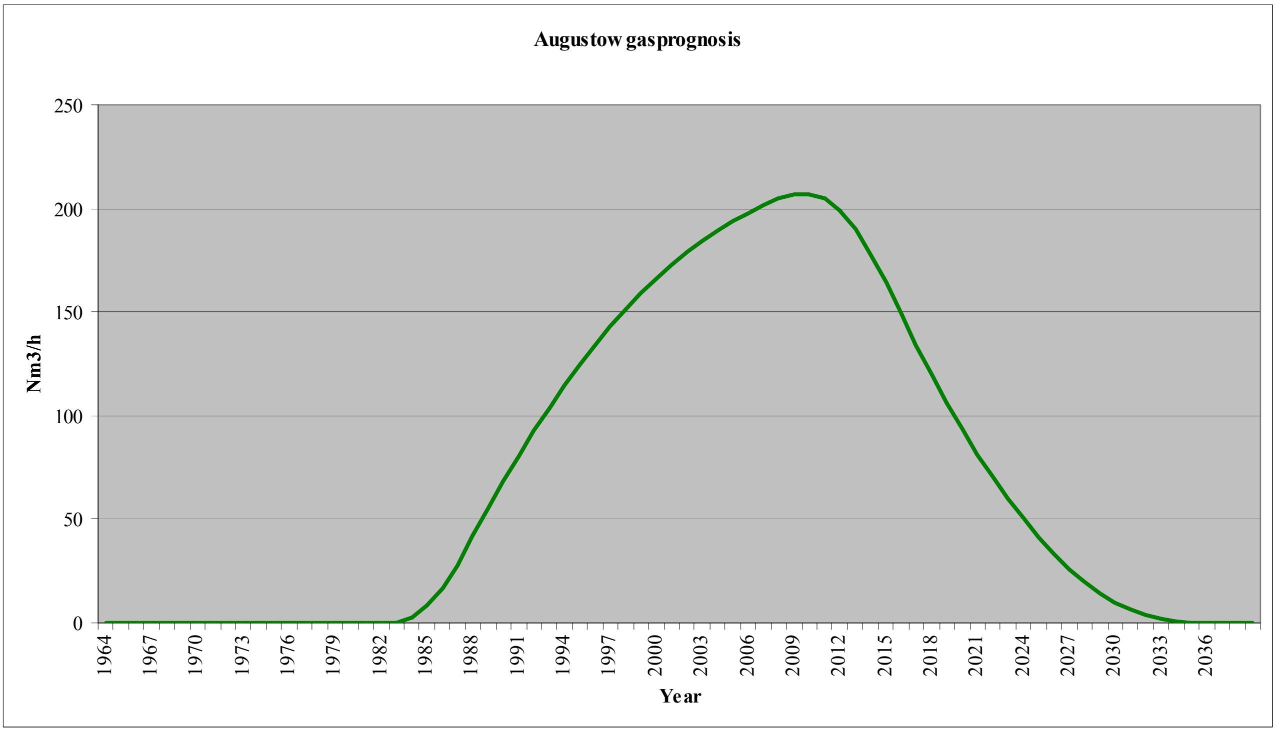
Actual development of each year LFG gas amount for engine or flare (R in the above scheme) has been calculated according to the assumption that the maximum yearly gas production from one year waste deposit will occur 5 years after deposit and after 25 years after deposit the gas production has been set to be close to zero.

3.4.6.4 Step 4: Gas utilization

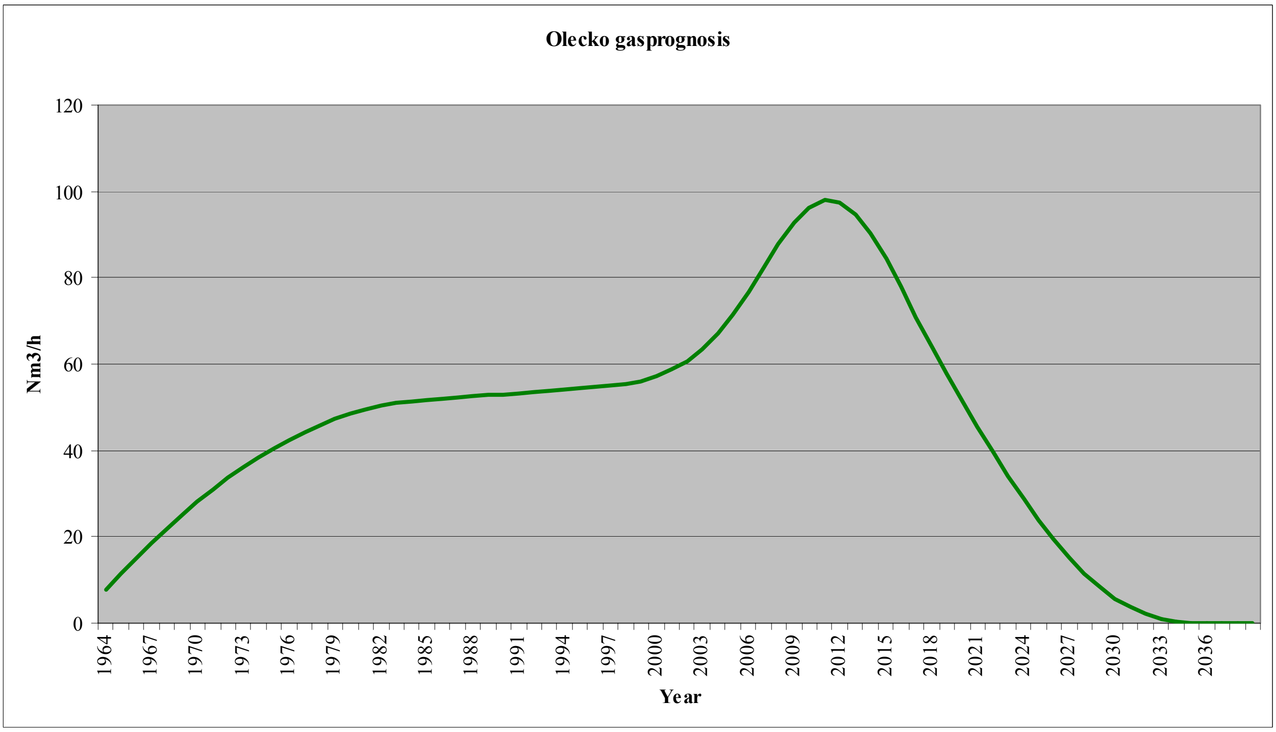
Below is shown results of gas production calculations and thereby potential amount of gas for the gas utilization.



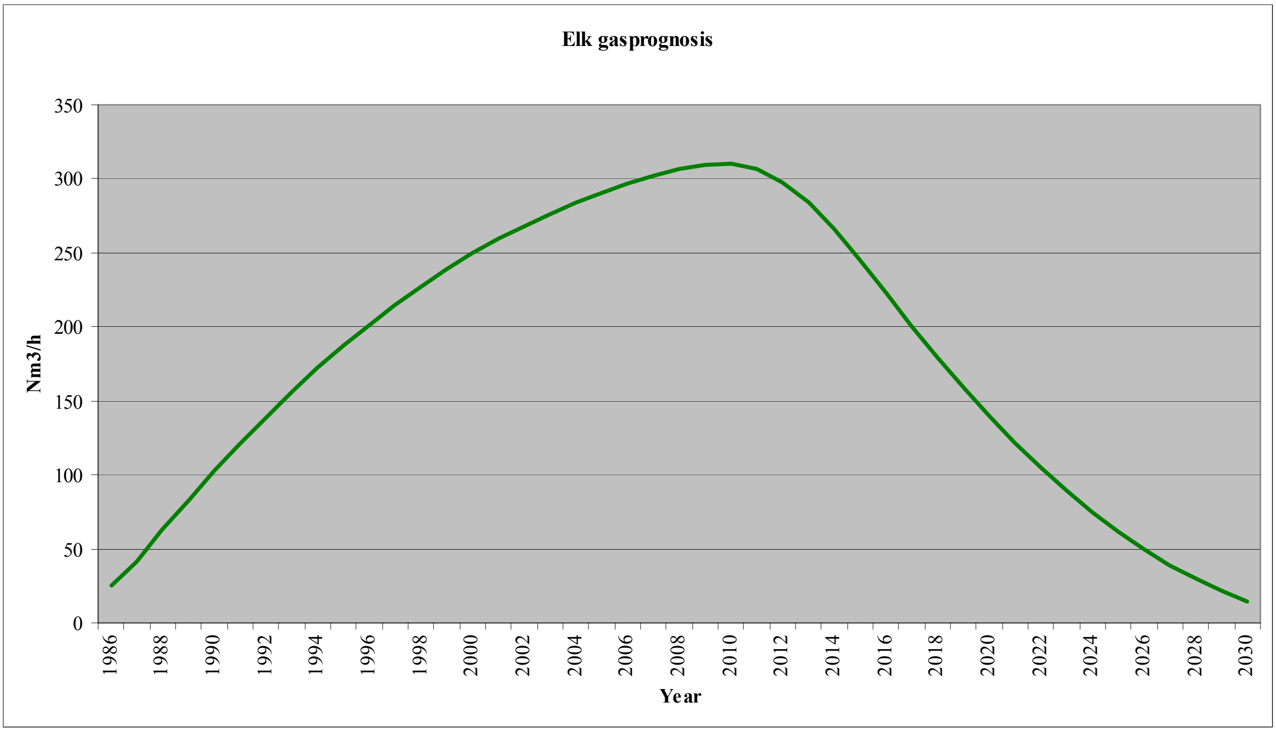


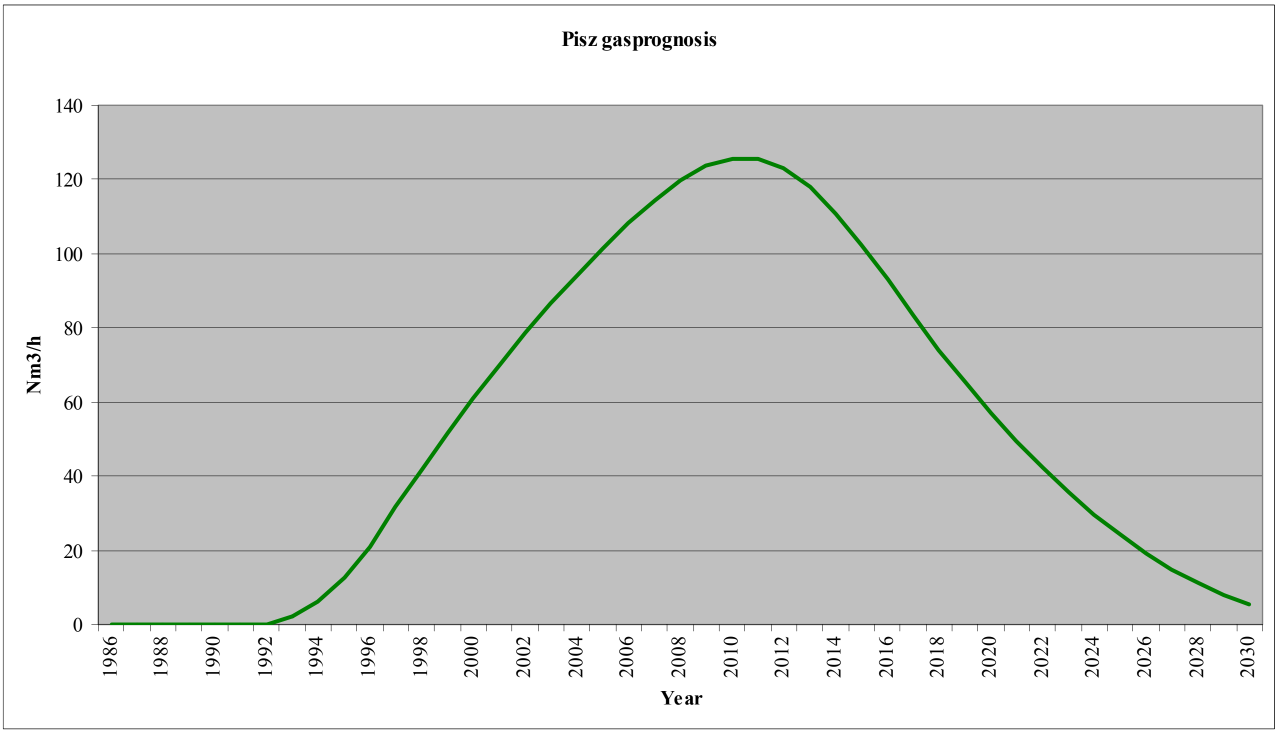


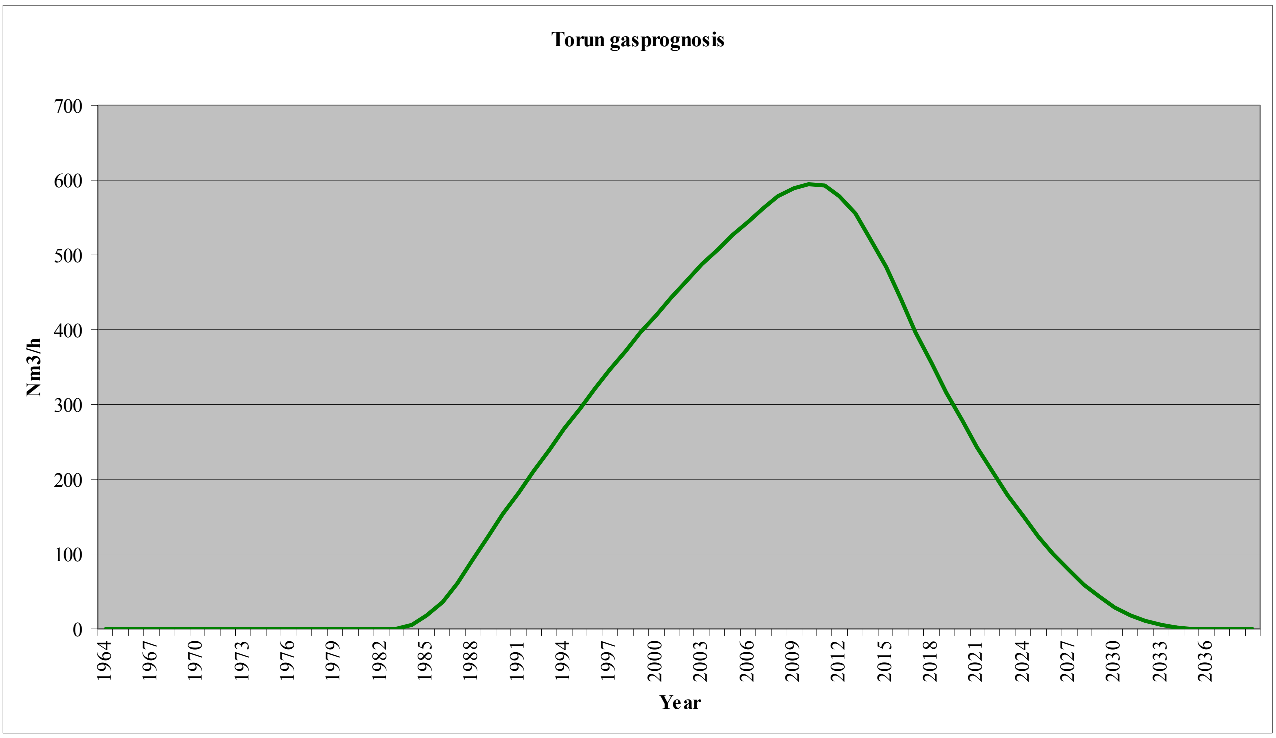
Augustow gasprognosis
250
200
150
100
50
0
Nm3/h
1964
1967
1970
1973
1976
1979
1982
1985
1988
1991
1994
1997
2000
2003
2006
2009
2012
2015
2018
2021
2024
2027
2030
2033
2036
Year



Olecko gasprognosis
120
100
80
60
40
20
0
Nm3/h
1964
1967
1970
1973
1976
1979
1982
1985
1988
1991
1994
1997
2000
2003
2006
2009
2012
2015
2018
2021
2024
2027
2030
2033
2036
Year


Elk gasprognosis
Nm3/h
Year
0
50
100
150
200
250
300
350
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
2024
2026
2028
2030


Pisz gasprognosis
Nm3/h
Year
0
20
40
60
80
100
120
140
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
2024
2026
2028
2030



Only deposited waste as described in step 1 has been considered. However, the continuous gas production after year 2012 is visible in the above graphs.

Furthermore, the calculated gas production will be compared with measured potential gas amount and quality from test wells wherever they are available. Test pumping has been performed in Olecko with 2 test wells and Elk also with 2 test wells. Results are shown below.

Elk test pumping took place from 14th December 2004 till 25th of April 2005 (approximately 4 months). However, there was a brake from the 27th January till 24th of March because of bad weather conditions.
Average gas quality over the period: Approximately 55 % methane
Average gas amount per well over the period: Approximately 10 m^3/h
Expected numbers of wells: 35 pieces
Estimated gas amount based on the above: 350 m^3/h
Calculated gas amount total: 300 m^3/h
As can be seen from the above the calculations are conservative compared with actual test pumping results.

Olecko test pumping took place from 17th December 2004 till 21st of April 2005 (approximately 4 months). However, there was a brake from the 27th January till 24th of March because of bad weather conditions.
Average gas quality over the period: Approximately 40 % methane
Average gas amount per well over the period: Approximately 12 m^3/h
Expected numbers of wells: 10 pieces
Estimated gas amount based on the above: 120 m^3/h
Calculated gas amount total: 100 m^3/h
As can be seen from the above the calculations are conservative compared with actual test pumping results.

Test pumping at the other landfill sites are expected to take place according to the below time schedule.

Elk	14th December 2004 till 25th April 2005	Completed
Olecko	17th December 2005 till 21st April 2005	Completed
Gizycko	October till December 2005	Planned
Torun	October till December 2005	Planned
Pisz	April till June 2006	Planned
Ostrow Maz.	April till June 2006	Planned
Augustow	April till June 2006	Planned

Final number and placement of wells and pipes will be determinated during the tender phase of each of the landfill gas plant.

3.4.6.5 Step 5: Electricity and heat production

Based on the calculated amount of landfill gas from each of the landfill sites and on the assumption that approximately 250 m^3/h landfill gas will be sufficient as fuel for a 1 MW_{input} engine each landfill site is expected equipped with the below engine sizes.

Elk	1200 kW_{input}
Olecko	320 kW_{input}
Gizycko	1200 kW_{input}
Torun	2300 kW_{input}
Pisz	450 kW_{input}
Ostrow Maz.	350 kW_{input}
Augustow	800 kW_{input}

Final size of engines will be determinated when second test pumping results are available from all installed wells.

All needed calculations and results of the above are shown in chapter E.6.2.

3.4.6.6 Step 6: Substituted coal based electricity and heat production

All needed calculations and results are shown in chapter E.6.2.

3.4.6.7 Step 7: Equivalent emission reduction

The equivalent emission reduction can be calculated based on figures below.

Formula:

$$ER_y = (MD_{project,y} - MD_{reg,y}) * GWP_{ch4} + EG_y * CEF_{electricity,y} + ET_y * CEF_{thermal,y}$$

$$MD_{project,y} = MD_{flared,y} + MD_{electrictiy,y} + MD_{thermal,y}$$

$$Md_{flared,y} = LFG_{flare,y} * W_{ch4,y} * D_{ch4} * FE$$

$$MD_{electricity,y} = LFG_{electricity} * W_{ch4,y} * D_{ch4} = LFG_{engine} * W_{ch4,y} * D_{ch4} * E_{electricity}$$

$$MD_{thermal,y} = LFG_{thermal} * W_{ch4,y} * D_{ch4} = LFG_{engine} * W_{ch4,y} * D_{ch4} * E_{heat}$$

Name	Value	Unit	Unit text	Text
ERy	-	tCO2e	Tonnes of CO2 equivalents	The greenhouse gas emission reduction achieved by the project activity during af given year "y"
MDproject,y	-	tCH4	Tonnes of methane	Amount of methane actually destroyed/combusted during the year
MDreg,y	-	tCH4	Tonnes of methane	Amount of methane that would have been destroyed/combusted during the year in the absence of the project activity
GWPch4	21	tCO2e/tCH4	-	Approved Global Warming Potential value for methane. The approved Global Warming Potential value for methane for the first comitments period is 21.
EGy	-	MWh	Mega Watt hours	Net quantity of electrictiy displaced during the year
CEFelectricity,y	0,342	tCO2e/MWh	Tonnes of CO2 equivalents per megawatt hour	The CO2 emission intensity of the electricity displaced
ETy	-	TJ	TeraJoules	The quantity of thermal energy displaced during the year. The unit of MWh has been used in the calculations.
CEFthermal,y	-	tCO2e/TJ	Tonnes of CO2 equivalents per TJ	The CO2 emissions intensity of the thermal energy displaced. The unit of tCO2e/MWh equal to CEFelectricity has been used in the calculations.
MDflared,y	-	tCH4	Tonnes of methane	The quantity of methane destroyed by flaring
LFGflare,y	-	m3	cubic meters	The quantity of landfill gas flared during the year
Wch4,y	0,5	m3CH4/m3LFG	Fraction	The average methane fraction of the landfill gas as measured druing the year equal to a gas quality of 50 % methane.

FE	0,95	-	Fraction	The flare efficiency equal to the fraction of the methane destroyed
Dch4	0,0007168	tCH4/m3CH4	Tonnes of methane per cubic meter of methane	The methane density
MDelectricity,y	-	tCH4	Tonnes of methane	The quantity of methane destroyed by generation of electricity
LFGelectricity,y	-	m3	cubic meters	The quantity of landfill gas fed into electricity generator. 1)
MDthermal,y	-	tCH4	Tonnes of methane	The quantity of methane destroyed for the generation of thermal energy
LFGthermal,y	-	m3	cubic meters	The quantity of landfill gas fed into the boiler. 1)
LFGengine	-	m3	cubic meters	The quantity of landfill gas fed into the engine
Eelectricity	35	%	Percentage	The fraction of the landfill gas fed into the engine for electricity production
Eheat	27,5	%	Percentage	The fraction of the landfill gas fed into the engine for heat production. Normally 55 % can be expected. But since only half of the produced heat are expected utilized Eheat = 27,5 % has been used in the formulas.

The part of GHG emission, which are not utilized in the engine are expected flared.

Baseline scenario for the local heat and power consumers expected connected to the engines included in the project are at present receiving heat and power produced on coal. Thereby the 0,342 tCO_2e/MWh as given in the above table for the heat and electricity displaced can be used.

Below are specified the formula’s used for calculation of the energy production from the sludge engines.

EGy = Iengine*Einput/Einputkapacity*FPP*Eelectricity/100
ETy = Iengine*Einput/Einputkapacity*FPP*Ethermal/100

Where:

EGy	The net quantity of electricity displaced during the year in MWh
ETy	The quantity of thermal energy displaced during the year in MWh
Iengine	The actual gas input to the engine in m^3/hour.
Iinputkapacity	The maximum gas input available in the beginning in m^3/hour.
FPP	The hours of full power production, which in this case is 8000 hours/year
Einput	The engine size in MWinput
Eelectricity	The engine electricity production efficiency in %, which in this case is 35 %
Ethermal	The engine heat production efficiency in %, which in this case is 55 %

The above conservative formula’s are chosen since they gives same or lower amount of replaced energy production. Below are shown result of the above formula’s and steps.

Gizycko	A	J	L	N	Q	R
	Waste disposed (MSW)	Gross Annual Methane Generation	Net Annual Methane Generation	Net Annual Methane Emissions	LFG gas amount for engine or flare	LFG gas amount for engine or flare
Year	Tons/year	Tons CH4	Tons CH4	Tons CH4	m3 LFG /Year	m3 LFG / hour
1974	0	0	0	0	0	0
1975	4.000	185	185	185	515625	59
1976	4.120	190	190	190	531094	61
1977	4.244	196	196	196	547027	62
1978	4.371	202	202	202	563437	64
1979	4.502	208	208	208	580340	66
1980	4.637	214	214	214	597751	68
1981	4.776	221	221	221	615683	70
1982	4.919	227	227	227	634154	72
1983	5.067	234	234	234	653178	75
1984	5.219	241	241	241	672774	77
1985	5.376	248	248	248	692957	79
1986	5.537	256	256	256	713746	81
1987	5.703	263	263	263	735158	84
1988	5.874	271	271	271	757213	86
1989	6.050	280	280	280	779929	89
1990	6.232	288	288	288	803327	92
1991	6.419	297	297	297	827427	94
1992	6.611	305	305	305	852250	97
1993	6.810	315	315	315	877817	100
1994	7.014	324	324	324	904152	103
1995	7.224	334	334	334	931276	106
1996	7.441	344	344	344	959214	109
1997	7.664	354	354	354	987991	113
1998	7.894	365	365	365	1017631	116
1999	8.131	376	376	376	1048159	120
2000	8.375	387	387	387	1079604	123
2001	8.626	399	399	399	1111992	127
2002	8.885	410	410	410	1145352	131
2003	9.152	423	423	423	1179713	135
2004	9.426	435	435	435	1215104	139
2005	9.709	449	449	449	1251557	143
2006	10.000	462	462	462	1289104	147
2007	8.584	397	397	397	1106481	126
2008	7.073	327	327	327	911740	104
2009	5.464	252	252	252	704319	80
2010	3.752	173	173	173	483633	55
2011	1.932	89	89	89	249071	28
2012	0	0	0	0	0	0

Ostrow Maz.	A	J	L	N	Q	R
	Waste disposed (MSW)	Gross Annual Methane Generation	Net Annual Methane Generation	Net Annual Methane Emissions	LFG gas amount for engine or flare	LFG gas amount for engine or flare
Year	Tons/year	Tons CH4	Tons CH4	Tons CH4	m3 LFG /Year	m3 LFG / hour
1970	0	0	0	0	0	0
1971	3.936	182	182	182	507333	58
1972	3.951	183	183	183	509346	58
1973	3.967	183	183	183	511360	58
1974	3.983	184	184	184	513373	59
1975	3.998	185	185	185	515386	59
1976	4.014	185	185	185	517399	59
1977	4.029	186	186	186	519413	59
1978	4.045	187	187	187	521426	60
1979	4.061	188	188	188	523439	60
1980	4.076	188	188	188	525452	60
1981	4.092	189	189	189	527465	60
1982	4.107	190	190	190	529479	60
1983	4.123	190	190	190	531492	61
1984	4.139	191	191	191	533505	61
1985	4.154	192	192	192	535518	61
1986	4.170	193	193	193	537532	61
1987	4.186	193	193	193	539545	62
1988	4.201	194	194	194	541558	62
1989	4.217	195	195	195	543571	62
1990	4.232	196	196	196	545584	62
1991	4.248	196	196	196	547598	63
1992	4.264	197	197	197	549611	63
1993	4.279	198	198	198	551624	63
1994	4.295	198	198	198	553637	63
1995	4.685	216	216	216	603968	69
1996	5.076	235	235	235	654299	75
1997	5.466	253	253	253	704629	80
1998	5.857	271	271	271	754960	86
1999	6.247	289	289	289	805291	92
2000	6.638	307	307	307	855621	98
2001	7.028	325	325	325	905952	103
2002	7.418	343	343	343	956283	109
2003	7.809	361	361	361	1006613	115
2004	7.965	368	368	368	1026746	117
2005	8.121	375	375	375	1046878	120
2006	8.277	382	382	382	1067010	122
2007	7.028	325	325	325	905952	103
2008	5.727	265	265	265	738183	84
2009	4.373	202	202	202	563704	64
2010	2.967	137	137	137	382513	44
2011	1.528	71	71	71	196994	22
2012	0	0	0	0	0	0

Augustow	A	J	L	N	Q	R
	Waste disposed (MSW)	Gross Annual Methane Generation	Net Annual Methane Generation	Net Annual Methane Emissions	LFG gas amount for engine or flare	LFG gas amount for engine or flare
Year	Tons/year	Tons CH4	Tons CH4	Tons CH4	m3 LFG /Year	m3 LFG / hour
1982	0	0	0	0	0	0
1983	11.714	541	541	541	1510053	172
1984	11.833	547	547	547	1525306	174
1985	11.952	552	552	552	1540713	176
1986	12.073	558	558	558	1556276	178
1987	12.195	563	563	563	1571996	179
1988	12.318	569	569	569	1587874	181
1989	12.442	575	575	575	1603913	183
1990	12.568	581	581	581	1620115	185
1991	12.695	587	587	587	1636479	187
1992	12.823	592	592	592	1653009	189
1993	12.953	598	598	598	1669707	191
1994	13.084	604	604	604	1686572	193
1995	13.216	611	611	611	1703608	194
1996	13.349	617	617	617	1720816	196
1997	13.484	623	623	623	1738198	198
1998	13.620	629	629	629	1755756	200
1999	13.758	636	636	636	1773491	202
2000	13.897	642	642	642	1791405	204
2001	14.037	649	649	649	1809500	207
2002	14.667	678	678	678	1890625	216
2003	15.107	698	698	698	1947344	222
2004	15.560	719	719	719	2005764	229
2005	16.027	740	740	740	2065937	236
2006	16.507	763	763	763	2127915	243
2007	14.169	655	655	655	1826460	209
2008	11.675	539	539	539	1505003	172
2009	9.019	417	417	417	1162615	133
2010	6.193	286	286	286	798329	91
2011	3.189	147	147	147	411139,5	47
2012	0	0	0	0	0	0

Olecko	A	J	L	N	Q	R
	Waste disposed (MSW)	Gross Annual Methane Generation	Net Annual Methane Generation	Net Annual Methane Emissions	LFG gas amount for engine or flare	LFG gas amount for engine or flare
Year	Tons/year	Tons CH4	Tons CH4	Tons CH4	m3 LFG /Year	m3 LFG / hour
1960	3.232	149	149	149	416689	48
1961	3.251	150	150	150	419072	48
1962	3.269	151	151	151	421454	48
1963	3.288	152	152	152	423836	48
1964	3.306	153	153	153	426218	49
1965	3.325	154	154	154	428600	49
1966	3.343	154	154	154	430983	49
1967	3.362	155	155	155	433365	49
1968	3.380	156	156	156	435747	50
1969	3.399	157	157	157	438129	50
1970	3.417	158	158	158	440511	50
1971	3.436	159	159	159	442894	51
1972	3.454	160	160	160	445276	51
1973	3.473	160	160	160	447658	51
1974	3.491	161	161	161	450040	51
1975	3.510	162	162	162	452422	52
1976	3.528	163	163	163	454804	52
1977	3.547	164	164	164	457187	52
1978	3.565	165	165	165	459569	52
1979	3.584	166	166	166	461951	53
1980	3.602	166	166	166	464333	53
1981	3.621	167	167	167	466715	53
1982	3.639	168	168	168	469098	54
1983	3.658	169	169	169	471480	54
1984	3.676	170	170	170	473862	54
1985	3.695	171	171	171	476244	54
1986	3.713	172	172	172	478626	55
1987	3.731	172	172	172	481009	55
1988	3.750	173	173	173	483391	55
1989	3.768	174	174	174	485773	55
1990	3.787	175	175	175	488155	56
1991	3.805	176	176	176	490537	56
1992	3.824	177	177	177	492919	56
1993	3.842	178	178	178	495302	57
1994	3.861	178	178	178	497684	57
1995	3.879	179	179	179	500066	57
1996	4.287	198	198	198	552660	63
1997	4.200	194	194	194	541406	62
1998	4.911	227	227	227	633097	72
1999	5.436	251	251	251	700696	80
2000	6.258	289	289	289	806657	92
2001	6.740	311	311	311	868802	99
2002	6.900	319	319	319	889453	102
2003	9.240	427	427	427	1191094	136
2004	9.425	435	435	435	1214916	139
2005	9.610	444	444	444	1238738	141
2006	9.794	453	453	453	1262559	144
2007	8.316	384	384	384	1071984	122
2008	6.776	313	313	313	873469	100
2009	5.174	239	239	239	667013	76
2010	3.511	162	162	162	452616	52
2011	1.808	84	84	84	233097	27
2012	0	0	0	0	0	0

Elk	A	J	L	N	Q	R
	Waste disposed (MSW)	Gross Annual Methane Generation	Net Annual Methane Generation	Net Annual Methane Emissions	LFG gas amount for engine or flare	LFG gas amount for engine or flare
Year	Tons/year	Tons CH4	Tons CH4	Tons CH4	m3 LFG /Year	m3 LFG / hour
1982	0	0	0	0	0	0
1983	17.572	812	812	812	2265079	259
1984	17.749	820	820	820	2287959	261
1985	17.928	828	828	828	2311069	264
1986	18.109	837	837	837	2334413	266
1987	18.292	845	845	845	2357993	269
1988	18.477	854	854	854	2381811	272
1989	18.664	862	862	862	2405870	275
1990	18.852	871	871	871	2430172	277
1991	19.043	880	880	880	2454719	280
1992	19.235	889	889	889	2479514	283
1993	19.429	898	898	898	2504560	286
1994	19.626	907	907	907	2529858	289
1995	19.824	916	916	916	2555412	292
1996	20.024	925	925	925	2581225	295
1997	20.226	934	934	934	2607298	298
1998	20.431	944	944	944	2633634	301
1999	20.637	953	953	953	2660236	304
2000	20.845	963	963	963	2687108	307
2001	21.056	973	973	973	2714250	310
2002	22.000	1016	1016	1016	2835938	324
2003	22.660	1047	1047	1047	2921016	333
2004	23.340	1078	1078	1078	3008646	343
2005	24.040	1111	1111	1111	3098905	354
2006	24.761	1144	1144	1144	3191873	364
2007	21.253	982	982	982	2739691	313
2008	17.513	809	809	809	2257505	258
2009	13.529	625	625	625	1743923	199
2010	9.290	429	429	429	1197494	137
2011	4.784	221	221	221	616709	70
2012	0	0	0	0	0	0

Pisz	A	J	L	N	Q	R
	Waste disposed (MSW)	Gross Annual Methane Generation	Net Annual Methane Generation	Net Annual Methane Emissions	LFG gas amount for engine or flare	LFG gas amount for engine or flare
Year	Tons/year	Tons CH4	Tons CH4	Tons CH4	m3 LFG /Year	m3 LFG / hour
1991	0	0	0	0	0	0
1992	8.852	409	409	409	1141052	130
1993	8.941	413	413	413	1152577	132
1994	9.032	417	417	417	1164220	133
1995	9.123	421	421	421	1175979	134
1996	9.215	426	426	426	1187858	136
1997	9.308	430	430	430	1199856	137
1998	9.402	434	434	434	1211976	138
1999	9.497	439	439	439	1224218	140
2000	9.593	443	443	443	1236584	141
2001	9.690	448	448	448	1249075	143
2002	9.788	452	452	452	1261692	144
2003	9.887	457	457	457	1274436	145
2004	9.986	461	461	461	1287309	147
2005	9.962	460	460	460	1284133	147
2006	9.925	459	459	459	1279431	146
2007	8.233	380	380	380	1061330	121
2008	6.547	302	302	302	843954	96
2009	4.767	220	220	220	614478	70
2010	3.160	146	146	146	407288	46
2011	1.492	69	69	69	192323	22
2012	0	0	0	0	0	0

Torun	A	J	L	N	Q	R
	Waste disposed (MSW)	Gross Annual Methane Generation	Net Annual Methane Generation	Net Annual Methane Emissions	LFG gas amount for engine or flare	LFG gas amount for engine or flare
Year	Tons/year	Tons CH4	Tons CH4	Tons CH4	m3 LFG /Year	m3 LFG / hour
1982	0	0	0	0	0	0
1983	25.000	1155	1155	1155	3222656	368
1984	25.750	1190	1190	1190	3319336	379
1985	26.523	1225	1225	1225	3418916	390
1986	27.318	1262	1262	1262	3521483	402
1987	28.138	1300	1300	1300	3627128	414
1988	28.982	1339	1339	1339	3735942	426
1989	29.851	1379	1379	1379	3848020	439
1990	30.747	1421	1421	1421	3963461	452
1991	31.669	1463	1463	1463	4082365	466
1992	32.619	1507	1507	1507	4204835	480
1993	33.598	1552	1552	1552	4330981	494
1994	34.606	1599	1599	1599	4460910	509
1995	35.644	1647	1647	1647	4594737	525
1996	36.713	1696	1696	1696	4732579	540
1997	37.815	1747	1747	1747	4874557	556
1998	38.949	1799	1799	1799	5020793	573
1999	40.118	1853	1853	1853	5171417	590
2000	41.321	1909	1909	1909	5326560	608
2001	42.561	1966	1966	1966	5486357	626
2002	43.838	2025	2025	2025	5650947	645
2003	45.153	2086	2086	2086	5820476	664
2004	46.507	2149	2149	2149	5995090	684
2005	47.903	2213	2213	2213	6174943	705
2006	49.340	2279	2279	2279	6360191	726
2007	42.350	1957	1957	1957	5459164	623
2008	34.896	1612	1612	1612	4498351	514
2009	26.957	1245	1245	1245	3474976	397
2010	18.511	855	855	855	2386150	272
2011	9.533	440	440	440	1228867	140
2012	0	0	0	0	0	0

The waste deposited for the years 2004 and onwards includes a 3 % yearly increase of inhabitants and tourists and only includes the considered amount of waste as can be seen on the graph in step 1.

For comparison and regarding the approach towards the EU landfill directive is below shown the calculations for Elk for the years 2004-2012 as an example.

Year	Waste disposed including increase factor	Increase factor	Waste deposit considered	A = Waste deposit considered
	Tons/year		%	Tons/year
2004	23340	1,03	=100	23340
2005	24040	1,03	=100	24040
2006	24761	1,03	=100	24761
2007	25504	1,03	=100/3+50	21253
2008	26269	1,03	=100/6+50	17513
2009	27057	1,03	=50,00	13529
2010	27869	1,03	=100/3	9290
2011	28705	1,03	=100/6	4784
2012	29566	1,03	0	0

Each year waste deposit total gas production is however distributed over several years as specified in Step 3. The gas production takes 5 years to reach a maximum and after 25 years the gas production has faded out. This can also be simplified by the below tables.

Year	1	2	3	4	5	6
Gas production %	0,0	1,6	3,2	4,8	6,4	8,0

Year	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	Total
Gas production %	7,6	7,2	6,8	6,4	6,0	5,6	5,2	4,8	4,4	4,0	3,6	3,2	2,8	2,4	2,0	1,6	1,2	0,8	0,4	0,0	100,0

By taking each year waste deposits total gas production and spreading it out on the next 25 years according to the above table it gives a gas production curve for each year waste deposit. By adding these curves it gives the graph shown in step 4. The curve is a sum of all years waste deposit curves for the waste deposited. This method of calculation gives result equal to or below actual gas production from compared existing landfill sites.

Using the set of formulas specified in this step 7 the results are shown below.

Pisz								
Y	Year	2006	2007	2008	2009	2010	2011	2012
LFGengine	m3/year	865856	915622	957851	989135	1005885	1005131	983734
LFGflare	m3/year	82256	86984	90996	93968	95559	95487	93455
MDthermal,y	tCH4	85	90	94	97	99	99	97
MDelectricity,y	tCH4	109	115	120	124	126	126	123
MDflared,y	tCH4	28	30	31	32	33	33	32
MDproject,y	tCH4	222	235	246	254	258	258	252
MDreg,y	tCH4	0	0	0	0	0	0	0
EGy	MWh	1212	1282	1341	1385	1408	1407	1377
ETy	MWh	952	1007	1054	1088	1106	1106	1082
Baseline emission	**tCO2e**	**5401**	**5712**	**5975**	**6170**	**6275**	**6270**	**6137**
ERy	**tCO2e**	**0**	**2465**	**5975**	**6170**	**6275**	**6270**	**6137**

Flare in operation by 1st of January 2007 and engine in operation by 1st of January 2008.

Elk								
Y	Year	2006	2007	2008	2009	2010	2011	2012
LFGengine	m3/year	2374843	2421131	2455654	2478085	2479404	2450061	2381656
LFGflare	m3/year	225610	230007	233287	235418	235543	232756	226257
MDthermal,y	tCH4	234	239	242	244	244	241	235
MDelectricity,y	tCH4	298	304	308	311	311	307	299
MDflared,y	tCH4	77	78	79	80	80	79	77
MDproject,y	tCH4	609	621	629	635	636	628	611
MDreg,y	tCH4	0	0	0	0	0	0	0
EGy	MWh	3325	3390	3438	3469	3471	3430	3334
ETy	MWh	2612	2663	2701	2726	2727	2695	2620
Baseline emission	**tCO2e**	**14815**	**15104**	**15319**	**15459**	**15467**	**15284**	**14857**
ERy	**tCO2e**	**6392**	**15104**	**15319**	**15459**	**15467**	**15284**	**14857**

Flare in operation by 1st of January 2006 and engine in operation by 1st of January 2007.

Olecko								
Y	Year	2006	2007	2008	2009	2010	2011	2012
LFGengine	m3/year	612427	657357	703418	742210	770289	784095	779996
LFGflare	m3/year	58181	62449	66825	70510	73177	74489	74100
MDthermal,y	tCH4	60	65	69	73	76	77	77
MDelectricity,y	tCH4	77	82	88	93	97	98	98
MDflared,y	tCH4	20	21	23	24	25	25	25
MDproject,y	tCH4	157	169	180	190	197	201	200
MDreg,y	tCH4	0	0	0	0	0	0	0
EGy	MWh	857	920	985	1039	1078	1098	1092
ETy	MWh	674	723	774	816	847	863	858
Baseline emission	**tCO2e**	**3820**	**4101**	**4388**	**4630**	**4805**	**4891**	**4866**
ERy	**tCO2e**	**1648**	**4101**	**4388**	**4630**	**4805**	**4891**	**4866**

Flare in operation by 1st of January 2006 and engine in operation by 1st of January 2007.

Augustow								
Y	Year	2006	2007	2008	2009	2010	2011	2012
LFGengine	m3/year	1583229	1614993	1638914	1654774	1656558	1637902	1592073
LFGflare	m3/year	150407	153424	155697	157203	157373	155601	151247
MDthermal,y	tCH4	156	159	162	163	163	161	157
MDelectricity,y	tCH4	199	203	206	208	208	205	200
MDflared,y	tCH4	51	52	53	54	54	53	51
MDproject,y	tCH4	406	414	420	424	425	420	408
MDreg,y	tCH4	0	0	0	0	0	0	0
EGy	MWh	2217	2261	2294	2317	2319	2293	2229
ETy	MWh	1742	1776	1803	1820	1822	1802	1751
Baseline emission	**tCO2e**	**9877**	**10075**	**10224**	**10323**	**10334**	**10218**	**9932**
ERy	**tCO2e**	**0**	**4347**	**10224**	**10323**	**10334**	**10218**	**9932**

Flare in operation by 1st of January 2007 and engine in operation by 1st of January 2008.

Ostrow Maz.								
Y	Year	2006	2007	2008	2009	2010	2011	2012
LFGengine	m3/year	660015	689564	716819	738416	751445	752899	739706
LFGflare	m3/year	62701	65509	68098	70150	71387	71525	70272
MDthermal,y	tCH4	65	68	71	73	74	74	73
MDelectricity,y	tCH4	83	86	90	93	94	94	93
MDflared,y	tCH4	21	22	23	24	24	24	24
MDproject,y	tCH4	169	177	184	189	193	193	190
MDreg,y	tCH4	0	0	0	0	0	0	0
EGy	MWh	924	965	1004	1034	1052	1054	1036
ETy	MWh	726	759	789	812	827	828	814
Baseline emission	**tCO2e**	**4117**	**4302**	**4472**	**4606**	**4688**	**4697**	**4614**
ERy	**tCO2e**	**0**	**1856**	**4472**	**4606**	**4688**	**4697**	**4614**

Flare in operation by 1st of January 2007 and engine in operation by 1st of January 2008.

Torun								
Y	Year	2006	2007	2008	2009	2010	2011	2012
LFGengine	m3/year	4364188	4506886	4626139	4716583	4760430	4738847	4631917
LFGflare	m3/year	414598	428154	439483	448075	452241	450190	440032
MDthermal,y	tCH4	430	444	456	465	469	467	457
MDelectricity,y	tCH4	547	565	580	592	597	594	581
MDflared,y	tCH4	141	146	150	153	154	153	150
MDproject,y	tCH4	1119	1155	1186	1209	1220	1215	1187
MDreg,y	tCH4	0	0	0	0	0	0	0
EGy	MWh	6110	6310	6477	6603	6665	6634	6485
ETy	MWh	4801	4958	5089	5188	5236	5213	5095
Baseline emission	**tCO2e**	**27225**	**28115**	**28859**	**29423**	**29697**	**29562**	**28895**
ERy	**tCO2e**	**11747**	**28115**	**28859**	**29423**	**29697**	**29562**	**28895**

Flare in operation by 1st of January 2006 and engine in operation by 1st of January 2007.

Gizycko								
Y	Year	2006	2007	2008	2009	2010	2011	2012
LFGengine	m3/year	886864	913470	937641	955972	964859	960485	938812
LFGflare	m3/year	84252	86780	89076	90817	91662	91246	89187
MDthermal,y	tCH4	87	90	92	94	95	95	93
MDelectricity,y	tCH4	111	115	118	120	121	120	118
MDflared,y	tCH4	29	30	30	31	31	31	30
MDproject,y	tCH4	227	234	240	245	247	246	241
MDreg,y	tCH4	0	0	0	0	0	0	0
EGy	MWh	1242	1279	1313	1338	1351	1345	1314
ETy	MWh	976	1005	1031	1052	1061	1057	1033
Baseline emission	**tCO2e**	**5532**	**5698**	**5849**	**5964**	**6019**	**5992**	**5857**
ERy	**tCO2e**	**2387**	**5698**	**5849**	**5964**	**6019**	**5992**	**5857**

Flare in operation by 1st of January 2006 and engine in operation by 1st of January 2007.

Engine: The part for the engine is the yearly gas amount / 8760 hours * 8000 hours
Flare: The part for the flare is the yearly gas amount / 8760 hours * (8760 hours – 8000 hours)

Total CO2 reduction is specified below.

Total	**Year**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**
Baseline emission	tCO2e	70.788	73.106	75.086	76.576	77.285	76.914	75.158
Project related emission reduction	tCO2e	22.175	61.686	75.086	76.576	77.285	76.914	75.158

The input for the landfill gas engines has been calculated by the amount of the gas in m3/h (as shown in step 4 and as specified in the above) multiplied with the amount of hours where the engine is running full power (in this case 8000 hours/year). As example are shown below the figures for Elk.

Year		2006	2007	2008	2009	2010	2011	2012
Gas amount	m3/h	297	303	307	310	310	306	298
Engine	1000 m3/year	0	2421	2456	2478	2479	2450	2382

Differences in the last decimal of the above table (as for example 2007: 303*8000/1000 = 2424 ≠ 2421) is caused by extra decimals beyond the ones specified above (as for example 2007: 302,64*8000/1000 = 2421,12 thousand m3/hour).

A graphic illustration of the above calculations is shown in chapter E.6.2.

3.4.7 Formulae/algorithms used to determine the emissions from the project activity

This section includes descriptions for to elaborate and justify formulae/algorithms used to determine the emissions from the project activity such as variables, fixed parameters and values to be reported as for example fuels used and fuel consumption rates.

In general potential emission from project activity could for example be increased emission from increased energy production. But in this project the significant values has been taken into consideration in the formulas and others are of no significant and therefore the emission from the project activity is not applicable.

Given the special conditions of the project no significant emission from the project activity are expected.

3.4.8 Potential leakage of the project activity

As defined in section B "Glossary of the CDM-terms" of the CDM-PDD:

"Leakage is defined as the net change of anthropogenic emission by sources of greenhouse gasses (GHG) which occurs outside the project boundary, and which is measurable and attributable to the CDM project activity."

No considerable leakage is expected either measurable or attributable to the JI project activity and the baseline methodology do therefore not addresses to the potential leakage of the project activity.

3.4.9 Formulae/algorithms used to determine the emissions reductions

This section includes descriptions for to elaborate and justify formulae/algorithms used to determine the emissions reductions from the project activity such as variables, fixed parameters and values to be reported as for example fuels used and fuel consumption rates.

Given the special conditions of the project the emissions reductions can be calculated directly and all formulas and algorithms used to determine the emission reduction are elaborated and justified in section E.6.

3.5 Data sources and assumptions

3.5.1 Parameters and assumptions

Below is a list of parameters which have no additional comments in the main section of this application including assumptions described, emission factors and activity levels.

Parameter	Figure given	Unit	Comments
Coal based power production	342	kg CO2/MWh	Given in several literatures concerning general assumptions, which can be taken when comparing with a coal based power production.
Methane content in landfill gas	50	%	Measured and compared with experiences from other landfill gas plants.
Methane density tons/m3	0,0007168	tons/m3	Mass density of methane given by the molecule structure of CH_4 (methane).
CO2 factor	21	CO2/methane	The value given is used as specified in the PIN.
General electrical efficiency	35	%	Value used as experiences from existing and running landfill gas plants.
General heat efficiency	55	%	Value used as experiences from existing and running landfill gas plants.
Overall CHP efficiency	90	%	Sum of the two figures above. Chosen figures are conservatively used since the efficiency can be even higher in new engines.
Utilization of the produced heat	50	%	Of the produced heat from the landfill gas engine.
Full power production	8000	Hours/year	The value is chosen conservatively a little lower than experiences from existing and running landfill gas plants, which can be more than 8000 hours/year.
Given timetable for the commissioning of the landfill gas plants	-	Years	Estimation which can defer significant, however given figures are evaluated conservatively.
Increase of the inhabitants and tourists	3	% per year	Estimated based on the last 10 years development in the area.

3.5.2 List of data used indicating sources and precise references

This section includes list of data used indicating sources and precise references and justify the appropriateness of the choice of such data as for example official statistics, expert judgment, proprietary data, IPCC, commercial and scientific literature.

Please refer to section H.3.5.1, which also includes the above mentioned examples when ever they have been used.

3.5.3 Vintage of data

This section includes explanations concerning vintage of data for example relative to the starting date of the project activity.

Below are listed data used for the calculation of the expected emission reduction including comments concerning vintage of the data relative to the starting date of the project activity:

- Waste amount are up until and including the year 2003 and no new data will be available prior to the expected starting date of the project activity.
- Test pumping results from the landfill sites are from the fall of 2004 and no new data will be available prior to the expected starting date of the project activity.

3.5.4 Spatial level of data

This section includes a description of the spatial level of data locally, regional and national.

Locally data has been collected from the waste management company concerning waste amounts and test measurements have been taken on the landfill site concerning amount and quality of the landfill gas.

Regional data has been collected concerning amount of inhabitants and tourists in the region.

National data has been collected to be able to compare with other landfill sites.

3.6 Assessment of uncertainties

This section includes assessment of uncertainties inclusive sensitivity to key factors and assumptions.

Please refer to section H.3.5.1, which also includes the above mentioned.

3.7 Development of baselines

This section includes explanation of how the baseline methodology allows for the development of baselines in a transparent and conservative manner.

The landfill gas plants are expected implemented by the end of 2005 and the baseline emission is calculated in Annex 3.4.6.7 from 2005 till 2012.

The basic formula for CO2 emission reduction projects is:

Emission reduction = Baseline emission – Project emission

However, as described in Annex 3.4.7 no significant emission from the project activity (leakages) are expected and thereby the Project emission can be considered as equal to zero. Thereby, the emission reduction equals the project related baseline emission during the operation of the project plant. The emission reduction from 2005 till 2017 is shown in chapter E.6.1. However, only ERU's in the crediting period up until and including 2012 has been considered.

4 Monitoring plan

4.1 Identification of methodology

4.1.1 Title of the proposed methodology

The following name is proposed for this methodology:

"Monitoring and calculation of ERU's in landfill gas utilization plants"

4.1.2 List of categories of project activities to which the methodology may apply

For all of the activities within the project boundaries described in section B.5 this methodology is applicable.

4.1.3 Conditions under which the methodology is applicable

This section includes explanation concerning conditions under which the methodology is applicable to the project activity.

Given the baseline situation described in section B this methodology is applicable.

4.1.4 Potential strengths and weaknesses of the proposed new methodology

Some of the major potential strengths of the proposed new methodology are listed below:

Simplification	Only comparison to the calculated baseline emission reduction is needed for to monitor the project results.
Measurements	Almost all of the proposed monitoring points needed for to calculate the emission reduction will be needed anyway in a normal operation of the plants for to optimize production.

Some of the major potential weaknesses of the proposed new methodology are listed below:

Amount of monitored data	A large amount of data must be monitored, reported and stored. But this will be no larger problem because of modern computer monitoring, reporting and backup facilities.
Continuously registration of data	A continuously registration of the monitored data will be needed. For the security of this continuation there will be need for power back-up systems for the modems transmitting the information in case of power failure. This is technical no problem but causes some establishment, operation and maintenance costs, which could have been lower in case of no continuous registration was needed.

4.2 Proposed new monitoring methodology

4.2.1 Brief description of the new methodology

The new methodology is based on a monitoring plan corresponding with the procedure described below and with result directly comparable with figures given in the baseline.

Emission reduction due to landfill gas collection

The emission reduction due to the landfill gas collection follows the below procedure for the methane utilized as well as for the substituted coal based CHP.

1. Waste amount
2. Organic amount of waste
3. Gas production
4. Gas utilization
5. Electricity and heat production
6. Substituted coal based electricity and heat production
7. Equivalent emission reduction

4.2.2 Option 1: Monitoring of the emissions in the project and baseline scenario

Option 1 has not been applied for this project. Therefore the following sections have been excluded in this application:

- Data to be collected in order to monitor emissions from the project activity, and how this data will be archived
- Description of formulae used to estimate project emissions (for each gas, source, formulae/algorithm, emissions units of CO_2 equ.)
- Relevant data necessary for determining the baseline of anthropogenic emissions by sources of GHGs within the project boundary and how such data will be collected and archived
- Description of formulae used to estimate baseline emissions (for each gas, source, formulae/algorithm, emissions units of CO_2 equ.)

Instead option 2 concerning direct monitoring of emission reductions has been applied as described in the following section.

4.2.3 Option 2: Direct monitoring of emission reductions

Below are listed those figures, which directly will be monitored for to calculate the emission reduction directly from the project activity. The values monitored and calculated from those are consistent and directly comparable with those in section E.

Data to be collected

Below are listed the data to be collected in order to monitor emissions from the project activity, and how this data will be archived.

ID number	Data variable	Source of data	Data unit	Measured (M), calculated (C) or estimated (E)	Recording frequency	Proportion of data to be monitored	How will the data be archived? (electronic/ paper)	For how long is archived data to be kept?	Comment
2.01	*Biogas*	*Methane, CO_2 and O_2 content*	*%*	*M*	*Continuous*	*100%*	*Electronic*	*	**
2.02	*Biogas*	*Total biogas production*	*m3/h*	*M*	*Continuous*	*100%*	*Electronic*	*	**
2.03	*Biogas*	*Flow to flare*	*m3/h*	*M*	*Continuous*	*100%*	*Electronic*	*	**
2.04	*Boolean*	*Ignition in flare*	*yes/no*	*M*	*Continuous*	*100%*	*Electronic*	*	**
2.05	*CHP*	*Electricity and heat production*	*kWh*	*M*	*Continuous*	*100%*	*Electronic*	*	**

* Data will be kept in 2 years and in duration of the project crediting period.
** Data will be aggregated monthly and yearly.

Description of formulae used to calculate project emissions

Since option 2 concerning direct monitoring of emission reductions from the project activity no monitoring or calculations will be performed concerning the project emissions. However, the emission reduction itself will be monitored and calculated. Therefore no comments has been implemented concerning description of formulae used to calculate project emissions for each gas, source, formulae/algorithm, emissions units of CO_2 equivalents.

4.2.4 Treatment of leakage in the monitoring plan

No leakage is anticipated in advance. However, if leakage is detected it will be monitored, recorded and considered in calculation of the total emission reduction. Because of this no comments has been implemented for this section and the following section has been excluded in this application:

- If applicable, please describe the data and information that will be collected in order to monitor leakage effects of the project activity
- Description of formulae used to estimate leakage (for each gas, source, formulae/algorithm, emissions units of CO2 equ.)

4.2.5 Description of formulae used to estimate emission reductions

Below are listed figures measured as well as figures calculated including formulae used to estimate emission reductions for the project activity for each gas (only methane is considered), source, formulae/algorithm, emission units of CO_2 equivalents.

Step 1: Waste amount

	Unit	Measured/calculated
Waste amount deposited	Tons/year	B4 = Measured

Step 2: Organic amount of waste

	Unit	Measured/calculated
Organic fraction	%	B5 = Estimated

Step 3: Gas production

	Unit	Measured/calculated
Gas production	m3/h	B6 = Measured
Gas quality (methane content)	%	B7 = Measured

Step 4: Gas utilization

	Unit	Measured/calculated
Gas utilization	%	B8 = Measured
Gas utilization	**m3/year**	B9 = B8*A6/100

Step 5: Electricity and heat production

	Unit	Measured/calculated
Electricity production	**MWh/year**	**B11 = Measured**
Heat production	**MWh/year**	**B12 = Measured**
Full power production	h/year	B13 = Measured

Step 6: Substituted coal based electricity and heat production

The substituted coal based electricity and heat production is equal to the in step 5 shown energy production.

Step 7: Equivalent emission reduction

	Unit	Measured/calculated
Coal based power production	kg CO2/MWh	B14 = Average figure
Substituted electricity production	Tons co2 eq./year	B15 = B14*B11/1000
Substituted heat production	Tons co2 eq./year	B16 = B14*B12/1000
Methane density tons/m3	tons/m3	B17 = Average figure
CO2 factor	CO2/methane	B18= Average figure
Reduction of methane emissions	Tons co2 eq./year	B19 = B9*B7*B17*B18
Total CO2 reduction	**Tons co2 eq./year**	**B20 = B15 + B16 + B19**

4.2.6 Assumption used in elaborating the new methodology

Conditions and assumptions given under section B concerning the baseline are used to elaborate the new methodology.

4.2.7 Quality control (QC) and quality assurance (QA) procedures being undertaken

The below table describes how the QC and QA procedures are expected being undertaken for the data monitored in section D.3.

Data *	Uncertainty level of data (High/Medium /Low)	Are QA/QC procedures planned for these data	Outline explanation why QA/QC procedures are or are not being planned.
D3.2.01	Low	Yes	Gas analyzer will be subject to a regular maintenance and testing regime to ensure accuracy. Expected accuracy for water flow meter is > 95 %.
D3.2.02, D3.2.03	Low	Yes	Gas flow meters will be subject to a regular maintenance and testing regime to ensure accuracy. Expected accuracy for water flow meter is > 95 %.
D3.2.04	Low	Yes	Ignition in flares can be registered accurately by several methods e.g. temperature, ion mobility etc.
D3.2.05	Low	Yes	The electricity production will be confirmed by the electricity company and the heat production by the district heating company

* Indicated table and ID numbers referring to the table in section D.3.

4.2.8 Methodology applied elsewhere

This section could include information if the methodology has been applied successfully elsewhere and, if so, in which circumstances. However, the methodology has not been applied elsewhere.

5 Glossary of terms

BAU	=	Business as Usual
CHP	=	Combined Heat and Power
DEPA	=	Danish Environmental Protection Agency
GHG	=	Green House Gasses
LFG	=	Landfill Gas
O&M	=	Operation and Management
PIN	=	Project Identification Note
QA	=	Quality Assurance
QC	=	Quality Control

6 Stakeholders' comments

6.1 Comments by local stakeholders

The several meetings held during 2004 and 2005 with all local stakeholders included the following representatives, companies and institutions:

- Mr. Adam Jan Puza, Starosta, Ełk Poviat
- Mr. Krzysztof Marcinczyk, Chairman of the Board, Ełk City council
- Mr. Krzysztof Wiloch, Vice Mayor, Ełk Municipality
- Ms. Maria Sokoll, Vice Mayor, Pisz Municipality
- Mr. Dariusz Zacharzewski, Director of Department of Investment, Pisz Municipality
- Mr. Zbigniew Wdowiarski, Director of Department of Agriculture and Environemtal Protection, Pisz Municipality
- Mr. Pawel Czacharowski, Vice Mayor, Gizycko Municipality
- Mr. Roman Czeberkus, General Manager, ZUK Gizycko (Gizycko Waste Management Company)
- Mr. Sebastian Hyzyk, Economy Manager, Miejskie Przedsiebiorstwo Oczyszczania Sp. z o.o. (Torun Landfill Site)
- Mr. Wacław Olszewski, Mayor, Olecko Municipality
- Mr. Mieczysław Scymalski, Mayor, Ostrow Maz. Municipality
- Mr. Jerzy Demianczuk, Vice Mayor, Augustow Municipality
- Ms. Agnieszka Galan, Senior Inspector, Polish Ministry of Environment
- Ms. Inge Gerhardt-Pedersen, Chief Programme Coordinator, DEPA
- Ms. Ms. Jolanta Kozakiewisz, Project Co-ordinator, The Polish National Fund for Environmental Protection and Water Management
- Mr. Sven Aaen, General Manager, AAEN Consulting Engineers A/S
- Mr. Mads Hagh, Project Manager, AAEN Consulting Engineers A/S

6.2 Stakeholders comments

On the following pages are included stakeholders comments as specified below:

- Letter of Intend from Olecko
- Letter of Intend from Pisz
- Letter of Intend from Gizycko
- Letter of Intend from Ełk
- Letter of Intend from Ostrow Maz.
- Letter of Intend from Torun
- Letter of Endorsement from the Polish Ministry

Comments are included in the following pages as included in the scanned in signed documents from the stakeholders.