JOINT IMPLEMENTATION PROJECT DESIGN DOCUMENT FORM
Version 01 - in effect as of: 15 June 2006

CONTENTS

Annexes

SECTION A. General description of the project

A.1. Title of the project:

Landfill Gas Capture Project in Kremenchuk
Ver1.6
Scope 13: Waste handling and disposal
17/11/2010

A.2. Description of the project:

Main objective of this project is to capture and collect landfill gas (LFG) generated from the solid waste disposal site (SWDS) in Kremenchuk Town, Ukraine. Methane gas, as a flammable LFG constituent and greenhouse gas (GHG), shall be converted to carbon dioxide through combustion in a flare system.

Kremenchuk landfill site, which is owned by Kremenchuk Town Municipality, is located approximately 5 km from the center of the town and not far from the settlement “Krykow” on the right bank of the “Dnipro river” on the “Deevskaja Hill”. The landfill territory is adjacent of the town cemetery and an area of drinking water wells. The apartment houses of the Krykov settlement are close to the landfill site. The site covers an area of 25,055 ha. It started waste disposal in 1965 and is scheduled to be operated for still 3 years. The site consists of 3 parts; two of them are not longer in service. The larger of the two bodies forms a parallelogram with a length of approximately 340 m and a width of 150 m. The smaller one is rectangular in shape, and approximately 280 m long and 140 m wide. The depth of those parts is 9 - 15 m. The body of the part, which is still in operation, forms an uneven quadrangle with the maximum length of the sides of 450 m and a maximal width of 400 m. The height of the waste dumped on an area of 150 m x 90 m is approximately 20 m.The amount of dumped waste on the already closed bodies is approximately 2,150,000 t and the amount of the dumped waste on the body in service is approximately 400.000 t. It is estimated, that the area at this disposal can still accept 1,500,000 m³, corresponding to 330,000 t of municipal solid waste.

From 1994 to 2009 the operating company « Kommunalnoe Awtotransportnoe Predprijatie 1628» carried approximately 6,700,000 m^3 (1,475,000 tons) of waste to the site. The solid waste disposal site accepts MSW from the town area of 25,036 km^2, with the population of 344,000 people (Kremenchuk Town - 230,000 people; Komsomolsk Town - 54,600 people; Swetlowodsk Town - 59,500 people). At present the quantity of the incoming waste is 104,880 tons per annum. The estimated quantity of the prospective incoming MSW is 108,027 tons in 2011, 111,268 tons in 2012 and 57,303 tons in 2013. It is scheduled a waste disposal on the site until the designated closure in 2013.

The project will contain the main activities at the site including:

- installation of wells and piping network for LFG collection and
- installation of a flaring system including gas booster, flare and monitoring system.

LFG will be combusted and destroyed via flare stacks. The greenhouse gas reduction is achieved due to the thermal conversion of methane to carbon dioxide. If amount and quality allow it, the LFG should be used for the power generation in the future. This is not part of the description here. In this case the project design will be changed and the PDD will be developed accordingly. The targeted commissioning date for the system is September 1st 2010.

The project crediting period is expected to be 2 years and 4 months and the total reduction of emissions during this period is estimated to be 73,344 tons CO_2.

In addition to the reduced emissions by flare stacks it is anticipated that the project in Kremenchuk will contribute to sustainable development in the following ways:

- environmental improvement through prevention of odor on the landfill site
- environmental improvement through prevention of fires on the landfill site
- creation of new employment through project realization (construction, equipment, maintenance, commissioning)

A.3. Project participants:

Party involved	Legal entity project participant	Please indicate if the Party involved wishes to be considered as project participant?
Ukraine (host country)	Kommunalnoe Awtotransportnoe Predprijatie 1628	no
Germany	Management Business Service GmbH	no
	Vattenfall Europe Generation AG & Co. KG	no
	HAASE Energietechnik AG	no

A.4. Technical description of the project:

A.4.1. Location of the project:

A.4.1.1. Host Party(ies):

Ukraine

A.4.1.2. Region/State/Province etc.:

Poltava region; Kremenchuk district

A.4.1.3. City/Town/Community etc.:

Kremenchuk town

A.4.1.4. Detail of physical location, including information allowing the unique identification of the project (maximum one page):

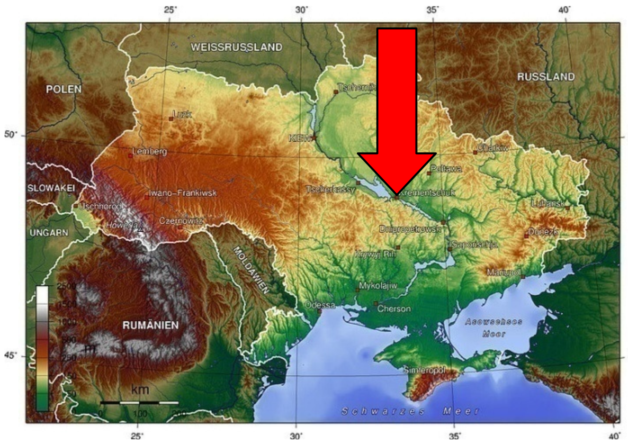


Figure 1 shows the location of Ukraine and Kremenchuk

Figure 2 Location map of the Kremenchuk Landfill Site

Figure 3 shows an arial shot of the site

The exact coordinates are: 49°00’07’’N and 33°25’39’’E.

A.4.2. Technology(ies) to be employed, or measures, operations or actions to be implemented by the project:

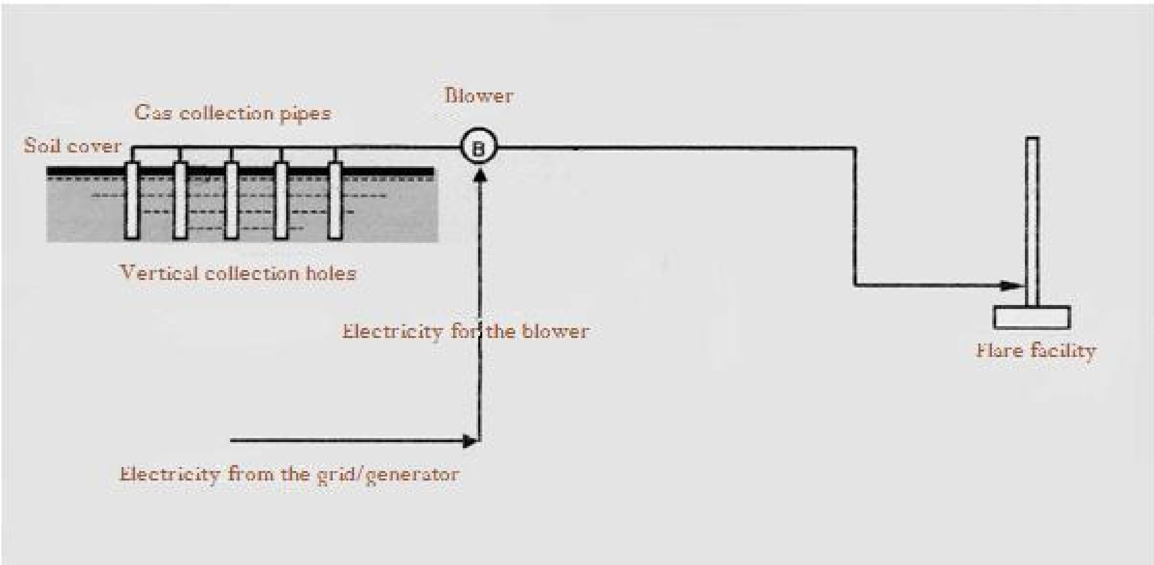
LFG collection system technology

The collection system is composed of vertical extraction wells, horizontal gas drains, gas collection pipes, airtight sheet, gasholders, measuring instruments and blowers. It is a high-efficiency system in which an LFG collection efficiency of 50% or more can be anticipated.

Flaring technology

The flare facilities combust and thereby destroy the LFG. In order to stably combust and destroy LFG, closed flare facilities are used.

Figure 3 shows the schematic of the overall project system.



The main equipments of the flare system are as follows:

- The flare elements consist of the flare itself, a demister with filter element, isolation and control valves, blower with a capacity of 500 m³ per hour and gas analyzers. The demister element protects the fan from moisture and particulates that flow with the gas from the waste deposit.
- Flame arrestor: to avoid flashback of the flame to the fuel feed pipe
- Burner: to provide controlled mixing of the fuel and air and ensure controlled combustion and LFG flow speed.
- Ignition system: to provide safe, controlled ignition of the landfill gas
- Air inlet dampers and thermocouples in the stack: flame temperature control.
- Combustion air system: to provide air for combustion support, depending on burner load. The additional air is drawn into the chamber by natural draught via control louvers or open vents.
- Stack: the stack height of the flares will is determined to provide sufficient residence time for destruction of compounds in the gas at height temperature and in a controlled environment to destroy extracted methane.
- Control panel: houses all of the flare controls, motor starters, alarms and interlocks that ensure safe operation of the flare.

The unit includes sophisticated monitoring equipment that will be comprehensively described in the following section (please refer to the section D) and is briefly listed below:

- flow meter to measure the volumetric gas flow through the system;
- LFG pressure and temperature transducers for calculation of the gas mass flow rate;
- gas analyzer (methane, CO_2, oxygen) that measures the quality of the gas delivered to the flare;
- sampling points for taking gas samples with portable instrumentation and for laboratory analysis;
- thermocouple that monitors the temperature of the flame in the stack and feeds back the signal to the automated air louver in order to maintain the temperature within the stack at desired level;
- data logging system
- electricity meter to measure the electricity consumption

The exhaust gas quality is in line with the legal requirements. The exhaust gas is discharged via the flue gas system to the atmosphere.

Origin of technology

Currently there are known 3 landfills applying active LFG collecting and flaring in Ukraine.

The table below shows where and when the active collecting and flaring were started.

Town	Starting year
Alushta, Yalta	2008
Mariapol	2010
Lviv	2008

Much of the flaring systems and controls, therefore, will come from abroad. Training to properly maintain and operate the equipment will be arranged for local operators and engineers.

In the table below is given the expected origin of the LFG collection and flaring system components.

COMPONENT	Imported or locally Manufactured	STANDARD
Gas collection system	imported from EU	according to EU standards
Flaring system	Flare- and Boosterstation NTF 500, imported from EU	according to EU regulation • “Machinery” 98/37/EC, annex II A • “Low voltage” 2006/95/EC • “Equipment and protective systems intended for use in potentially explosive atmospheres” 94/9/EC
Monitoring and control system	Flare- and Boosterstation NTF 500, imported from EU	according to EU regulation • “Machinery” 98/37/EC, annex II A • “Low voltage” 2006/95/EC • “Equipment and protective systems intended for use in potentially explosive atmospheres” 94/9/EC

A.4.3. Brief explanation of how the anthropogenic emissions of greenhouse gases by sources are to be reduced by the proposed JI project, including why the emission reductions would not occur in the absence of the proposed project, taking into account national and/or sectoral policies and circumstances:

Most Ukrainian landfills were operated as unauthorized dumps and are not in compliance with any environmental protection measures regarding LFG control. Before 2005 national standards on landfill operation did not envisage mandatory LFG control. In 2005 National Construction Standard DBN V.2.4-2-2005 Basics of Sites Design was introduced containing requirements on LFG collection and flaring/ utilization after the landfill closure. However, municipalities and municipal companies operating landfills are in a poor financial state and cannot invest in such projects.

The landfill site also generates methane gas, which has a high Global Warming Potential and all of this is discharged into the atmosphere. Moreover the methane gas will continue to be discharged if the project is not implemented. On the other hand, in case of the project implementation, the following additional GHG emissions reductions will be realized:

- Reduction of methane gas emissions through the capture of methane gas (GHG) in a LFG collector system, and destruction of the methane gas through GHG operation / flaring, i.e. combustion.

A.4.3.1. Estimated amount of emission reductions over the crediting period:

	Years
Length of the crediting period	2 years and 4 months
Year	Estimate of annual emission reductions in tonnes of CO_2 equivalent
2010 (4 months)	10,119
2011	31,184
2012	32,041
Total estimated emission reductions over the crediting period (tonnes of CO_2 equivalent)	73,344
Annual average of estimated emission reductions over the crediting period (tonnes of CO_2 equivalent)	24,448

A.5. Project approval by the Parties involved:

The Letters of Endorsement from the Ministry of Environmental Protection of Ukraine and from the German Designated Focal Point (Deutsche Emissionshandelstelle) are given. The Letter of Approval from the Ministry of Environmental Protection of Ukraine will be issued after the presentation of the PDD and the Final Determination Report, prepared by the AIE. The LoA of the German DFP will be issued after application in connection with the Final Verifiction Report of the AIE and the LoA of the Ukrainian Ministry before first-time credit of the certificates.

SECTION B. Baseline

B.1. Description and justification of the baseline chosen:

1. Referencing of the approved baseline and monitoring methodology applied to the project

According to paragraph 9(a) of the "Guidance on criteria for baseline setting and monitoring" the approach for baseline setting and monitoring was chosen in accordance with appendix B of the JI guidelines. The baseline will be established following an existing CDM methodology for baseline determination. The baseline scenario is the continuation of the situation prior to the start of the project meaning that under business as usual will be not capturing and flaring of landfill gas. LFG is freely released into the atmosphere.

In the project the approved consolidated baseline methodology ACM0001 "Consolidated baseline and monitoring methodology for landfill gas project activities - Version 11" will be applied.

The project will also apply the following tools as referred to in the methodology:

- "Tool for the demonstration and assessment of additionality", (Version05.2)
- "Tool to determine methane emissions avoided from disposal of waste at a solid waste disposal site", (Version 04)
- "Tool to determine project emissions from flaring gases containing methane"
- "Tool to calculate project or leakage CO_2 emissions from fossil fuel combustion"
- "Tool to calculate baseline, project and/or leakage emissions from electricity consumption"

2. Justification of the choice of the methodology and why it is applicable to the project

In the methodology ACM0001, the following conditions are stated on the page 2:

"This methodology is applicable to landfill gas capture project activities, where the baseline scenario is the partial or total atmospheric release of the gas and the project activities include situations such as:

a) The captured gas is flared; and/or
b) The captured gas is used to produce energy (e.g. electricity/thermal energy). Emission reductions can be claimed for thermal energy generation, only if the LFG displaces use of fossil fuel either in a boiler or in an air heater. For claiming emission reductions for other thermal energy equipment (e.g. kiln), project proponents may submit a revision to this methodology; or
c) The captured gas is used to supply consumers through natural gas distribution network. If emissions reductions are claimed for displacing natural gas, project activities may use approved methodology AM0053."

Conditions in the project are as follows:

1. Currently, LFG collection is not carried out on Kremenchuk Landfill Site and all LFG is released into the atmosphere.
2. The project proposes to collect LFG on Kremenchuk Site and to flare the captured gas.
3. Electricity for the project activities is sourced from the grid.
4. The captured gas is not used for the feed of natural gas distribution networks.

Therefore, since the project meets one of the criteria's of the above mentioned bullet points a, b or c for the approved consolidated baseline methodology ACM0001, this methodology is applicable.

"Tool to determine methane emissions avoided from disposal of waste at a solid waste disposal site" is applicable as outline below:

- The projekt is located at a solid waste disposal site which can be clearly identified, the Kremenchuk landfill;
- Hazardous waste is not disposed at the Kremenchuk landfill.

"Tool to calculate baseline, project and/or leakage emissions from electricity consumption" is applicable as outline below:

- The project will consume electricity from the Ukrainian grid for the operation of the LFG collection and flaring equipment.

"Tool to determine project emissions from flaring gases containing methane" is applicable as outline below:

- LFG that is going to be flared does not contain gases other than methane, carbone monoxide and hydrogen;
- LFG to be flared is a result of decomposition of organic materials.

"Tool to calculate project or leakage CO_2 emissions from fossil fuel combustion" is applicable as outline below:

- Up to the connection to the Ukrainian grid the project will consume electricity generated by afossil fuel used generator for the operation of the LFG collection and flaring equipment.

3. *Description of how the methodology is applied in the context of the project*

Based on ACM0001, the following expression is used to calculate the emission reductions.

(1) $BE_y = (MD_{project,y} - MD_{BLy}) * GWP_{CH4} + El_{LFG,y} * CEF_{elec,BL,y} + Et_{LFG,y} * CEF_{ther,BL,y}$

BE_y	Baseline emissions, in tons of CO_2 equivalents
$MD_{project,y}$	the amount of methane that would have been destroyed/combusted during the year in tons of methane (tCH_4) in project scenario
MD_{Bly}	The amount of methane that would have been destroyed/combusted during the year in the absence of the project, due to regulatory and/or contractual requirement, in ton MD_{BLy} s of methane (tCH_4),
GWP_{CH4}	Global Warming Potential value for methane for the first commitment period is 21t CO_2e/tCH_4
$El_{LFG,y}$	net quantity of electricity produced using LFG, which in the absence of the project activity would have been produced by power plants connected to the grid or by an on-site/off-site fossil fuel based captive power generation, during year y, in megawatt hours (MWh)
$CEF_{elec,BL,y}$	CO_2 emissions intensity of the baseline source of electricity displaced, in tCO_2e/MWh
$Et_{LFG,y}$	The quantity of thermal energy produced utilizing the landfill gas, which in the absence of the project activity would have been produced from on-site/off-site fossil fuel fired boiler, during the year y, in TJ
$CEF_{therm,BL,y}$	CO_2 emissions intensity of the fuel used by boiler to generate thermal energy, which is displaced by LFG based thermal energy generation in tCO_2e/TJ

Here, since the project does not include utilization of electricity and heat, equation (1) is modified in the manner shown in (1').

(1') $BE_y = (MD_{project,y} - MD_{BLy}) * GWP_{CH4}$

In cases where regulatory or contractual requirements do not specify $MD_{BL,y}$ or no historic data exists for LFG captured and destroyed an "Adjustment Factor" (AF) is used and justified, taking into account the project context.

(2) $MD_{BLy} = MD_{project,y} * AF$

AF	Adjustment factor

In cases where a **specific system for collection and destruction of methane** is mandated by regulatory or contractual requirements or is undertaken for other reasons, the ratio of the destruction efficiency of the baseline system to the destruction efficiency of the system used in the project activity shall be used. It follows the following stepwise proceeding:

Step 1 - ***Estimation of the destruction efficiency of the system***
Step 2 - ***Estimation of the destruction efficiency of the system used in the project activity***
Step 3 - ***Estimation of the adjustment factor (AF)***
Step 4 - ***Definition of*** $MD_{project,y}$

Step 1 - Estimation of the destruction efficiency of the system`

The destruction efficiency of the system is determined according to the equation (3) in situations where the baseline specific system for collection and destruction of methane installed and operating prior to implementation of the project activity and measurements of the amount of methane that is destroyed are available.

(**3**) $\varepsilon_{BL} = MD_{Hist} / MG_{Hist}$

Where:

ε_{BL} = Destruction efficiency of the baseline system fraction

MD_{Hist} = Amount of methane destroyed historically measured for the previous year before the start of project activity (tCH_4)

MG_{Hist} = Amount of methane generated historically for the previous year before the start of project activity, estimated using the actual amount of waste disposed in the landfill as per the latest version of the "Tool to determine methane emissions avoided from disposal of waste at a solid waste disposal site" (tCH_4, Version 04)

In our project relevant historical data are not recorded and the gas collecting and flaring system are not installed prior to implementation of the project activity.Therefore the determination of the destruction efficiency of the baseline system would have been not applicable ($\varepsilon_{BL} = 0$).

In cases, where the baseline system for collection and destruction of methane is **not** installed prior to project implementation and/or measurements of the amount of methane that is destroyed are **not** available then the destruction efficiency of the system mandated by regulatory or contractual requirements (ε_{BL}) should be assumed to be equal to the theoretical efficiency of the specific system for collection and destruction of methane that is defined in the regulation or contract. In other cases, an amount of landfill gas that would be captured in absence of the project activity shall be estimated.

In our project is estimated: $\varepsilon_{BL} = 0$

Step 2 - Estimation of the destruction efficiency of the system used in the project activity

The destruction efficiency of the system used in the project activity is estimated once and remains fixed for the whole crediting period and will be estimated according to Option 1 as follows:

(4) ε_{PR} = $MD_{project,1} / MG_{PR,1}$

Where:

ε_{PR}	=	Destruction efficiency of the system used in the project activity that will remain fixed for the whole crediting period (fraction)
$MD_{project,1}$	=	Amount of methane destroyed by the project activity during the first year of the project activity (tCH_4)
$MG_{PR,1}$	=	Amount of methane generated during the first year of the project activity estimated using the actual amount of waste disposed in the landfill as per the latest version of the “Tool to determine methane emissions avoided from disposal of waste at a solid waste disposal site”, see guidance in Step 1 (tCH_4).

In our case we assume that that we can achieve an efficiency of landfill recovery of approximately 60% of the whole amount emitted. Therefore the destruction efficiency of the system used in the project activity result to **ε_{PR} =0.6**.

Step 3 - Estimation of the adjustment factor (AF)

We have chosed option 1 in Step 2. Therefore "AF" is principally calculated as follows:

$AF = \varepsilon_{BL} / \varepsilon_{PR}$

However, since there are no regulatory or contractual requirements, "AF" = is 0.

Considering the determined adjustment factor AF the equation (2) can be modified to

$BE_y = (1-AF)*MD_{project,y} * GWP_{CH4} + El_{LFG,y} * CEF_{elec,BL,y}$

$BE_y = MD_{project,,y} * GWP_{CH4} + El_{LFG,y} * CEF_{elec,BL,y}$ (1´´) in case of AF = 0

Step 4 - Determination of $El_{LFG,y}$

This step is not applicable, because in absence of the project no energy is used on the site.

Step 5 - Determination of $CEF_{elec,BL,y}$

This step is not applicable, because in absence of the project no energy is used on the site.

Step 6 - Definition of $MD_{project,y}$

$MD_{project,y}$ will be determined *ex post* by metering the actual quantity of methane captured and destroyed once the project activity is operational. $MD_{project,y}$ is defined as

(6) $MD_{project,y} = MD_{flared,y} + MD_{electricity,y} + MD_{thermal,y} + MD_{PL,y}$

$MD_{flared,y}$	the quantity of methane destroyed by flaring, in tCH_4
$MD_{electricity,y}$	the quantity of methane destroyed by generation of electricity, in tCH_4
$MD_{thermal,y}$	the quantity of methane destroyed for the generation of thermal energy, in tCH_4
$MD_{PL,y}$	the quantity of methane sent to the pipeline for feeding to the natural gas distribution network, in tCH_4

Here, since the project does not include thermal and electrical utilization and a feed of the natural gas distribution network, equation (6) is modified in the manner shown in:

(6')

$MD_{project,y} = MD_{flared,y}$

Here, $MD_{flared,y}$ and $MD_{electricity,y}$ can be calculated using expressions (7) and (8) below.

(7)

$MD_{flared,y} = (LFG_{flare,y} * W_{CH4,y} * D_{CH4}) - (PE_{flare,y} / GWP_{CH4})$

Where:

$LFG_{flare,y}$ = Quantity of landfill gas fed to the flare(s) during the year measured in cubic meters (m^3)

$W_{CH4,y}$ = Average methane fraction of the landfill gas as measured during the year and expressed as a fraction (in m^3 CH_4 / m^3 LFG)

D_{CH4} = Methane density expressed in tons of methane per cubic meter of methane (tCH_4/m^3CH_4)

$PE_{flare,y}$ = Project emissions from flaring of the residual gas stream in year y (tCO_{2e}) determined following the procedure described in the "Tool to determine project emissions from flaring gases containing Methane". If methane is flared through more than one flare, the $PE_{flare,y}$ shall be determined for each flare using the following equation from the tool

$$PE_{flare,y} = \sum_{h=1}^{8,760} TMRG,h * (1 - \eta flare,h) * \frac{GWPCH4}{1,000}$$

B.2. Description of how the anthropogenic emissions of greenhouse gases by sources are reduced below those that would have occurred in the absence of the JI project:

Setting of the baseline scenario and demonstration of additionality carried out according to the "Tool for the demonstration and assessment of additionality (Version05.2)".

The baseline for the Kremenchuk landfill site is the atmospheric release of the gas with no capture and destruction.

Step 1: Identification of alternatives to the project activity consistent with current laws and regulations

Sub-step 1a. Define alternatives to the project activity

	Alternatives to project activity	Probability of scenario
1	The continuation of the current situation: no landfill gas extraction	*Most probable:* Current practice shows that the regulations on landfills across the Ukraine are either enforced or generally used. Technical expertise and financial investment to engage in LFG collection projects are not developed in Ukraine. Therefore, it is not expected that the regulation requiring the capture and destruction of landfill gas at the Ukraine sites will be followed.

2	Collection of the landfill gas and combustion of the gas in a flaring stack for methane reduction only (as n o n JI-project)	*Not probable:* The project activity requires funds as well as for the construction and the maintenance of the required equipment. Financial sources for the realization of the project are not known and the existing regulatory requirements regarding emissions control is not expected to be followed. Moreover, this alternative does not provide any potential revenue to the landfill by itself. Therefore it is not considered a plausible alternative.
3	Landfill owner invests in the landfill gas collection system and the equipment for generation of electricity from landfill gas in order to supply to the public network (as n o n JI-project)	*Not probable:* Connection to the power grid does not exist. Thus provision of electricity to potential consumers would require additional investments on electricity generation units, transformer and construction of transmission lines. Moreover, no licenses are issued presently in the Ukraine for the feed-in of electric energy which is produced of landfill gas. The corresponding law is unclear concerning this. Power generation is presently not an attractive option and so not probable.
4	A different utilization of biogas offsite is proposed	*Not probable:* *Heat off-take:* No significant off-takers for heat energy are within reasonable distance. Delivery of heat energy to a long-distance off takers will require installation of additional equipment and significant heat transportation pipelines. Thus deliveries of heat energy are economically unattractive. *Fuel production:* The fuel production is not the business of the landfill owner and it requires installation of additional equipment and execution of additional agreements with a fuel retail network. The fuel production adds very high cost, high risks and complication to the project. Consequently fuel production is not probable.

The analysis shows, that alternative 4 is not plausible. Alternatives 2 and 3 are plausible, but not probable. The only reasonable alternative to the project activity is the continued uncontrolled release of landfill gas to the atmosphere as a part of the “business-as-usual” scenario at the site.

Sub-step 1b. Consistency with mandatory laws and regulations

Before 2005, national standards on the operation of landfills did not envisage mandatory LFG control. In 2005, National Construction Standard DBN V 2.4-2-2005 “Basics of Sites Design” was introduced containing requirements on LFG collection and venting after the landfill closure. However, historically, the legal requirements on proper operation of landfills have not been enforced mainly due to financial barriers. Hence non-compliance with those requirements is widespread in Ukraine. Due to financial state and lack of technical knowledge, this is expected to continue. Presently, common practice shows that existing landfills in Ukraine do not capture and flare or utilize their landfill gas. In the Ukraine approx. 7,800 dumps and sites are known. Approx. 20%, i.e. approx. 1,100 pieces of them are approved by the authorities. Remaining approx. 6,700 dumps are illegal. Approx. 50% of them are closed. The others are in operation. [1] Presently no more than 2 landfill locations (Chernivtsi, Cherkassy) in which according to the abovementioned law the LFG is extracted are known. This amount is less than 0.05% of all dumps respectively sites. Thus, even if alternative 1 does not comply with the existing regulation it is considered a plausible baseline scenario. All other alternatives are consistent with aforementioned legislation.

Another laws, regulations and guidelines connected to Scenarios 1-4 above are as follows:

- law on the protection of the environment (June 1991)
- ukrainian law “On Municipal Waste” (March 5, 1998)
- ukrainian law “On Protection of Ambient Air” (June 21, 2001)

Step 2: Investment Analysis

Sub-step 2a. Determine appropriate analysis method

According to the “Tool for the demonstration and assessment of additionality”, one of three options must be applied for this step: (1) simple cost analysis (where no benefits other than JI income exist for the project), (2) investment comparison analysis (where comparable alternatives to the project exist), or (3) benchmark analysis.
As no benefits other than JI income exist for the project, the simple cost analysis will be applied.

Sub-step 2b. Option 1. Apply simple cost analysis

In order to implement and register the project under the Joint Implementation, investment needed to be made to the installation of project equipments and the inclusion of the feasibility study and pumping tests, which is estimated to be about 1,250,000 Euro. The German KfW-Entwicklungsbank has subsidized 557,000 EUR for pumping test and feasibility study in connection with a separate project. This project was finished. Some parts of the equipment can be used in our project again. Hence, approx. 692,000 EUR remains as an investment sum for the project developer.

The table below summarizes approximate values for the project developer regarding the project considering the subsidy from the German KfW-Entwicklungsbank:

Part of equipment/service	Total sum	Subsidy from KfW-Entwicklungsbank	Developers investment
Building site facilities/engineering	210,600 EUR	105,300 EUR	105,300 EUR
Gas collection wells and pipework system	506,300 EUR	222,200 EUR	284,100 EUR
Gas collection station and knock out station	59,000 EUR	59,000 EUR	0.00 EUR
Flare stack	184,900 EUR	0.00 EUR	184,900 EUR
Gas plant installation	289,200 EUR	170,800 EUR	118,400 EUR

The LFG system will also incur additional expense once it becomes operational (e.g. maintenance, management) of approximately 4.24% of the total capital cost or approximately 7.66% of the investment sum for the project developer annually. This value consists as follows:

[1] Country sheet Ukraine, by bifa Umweltinstitut Augsburg, 31.05.2009

Insurance	3,000 EUR/p.a.
Maintenance gas extraction	15,000 EUR/p.a.
Maintenance booster station / flare (gas plant)	10,000 EUR/p.a.
Operation staff for gas extraction system, booster station and flare	25,000 EUR/p.a.
Total sum	**53,000 EUR/p.a**

The table below shows the developers investment concerning the costs for project equipment, feasibility study and pumping test and the operational expense.

Investment	
Project equipment, feasibility study and pumping test	692,000 EUR
Operational Expense (maintenance, management)	
7.66% of the investment sum	53,000 EUR p.a.

Sub-step 2c. Calculation and comparison of financial indicators

Not applicable due to the selection of the simple cost analysis method.

Sub-step 2d. Sensitivity analysis

Not applicable due to the selection of the simple cost analysis method.

Step 3. Barrier Analysis

Since step 2 was implemented, step 3 can be skipped.

Step 4. Common Practice Analysis

In the Ukraine approx. 7,800 dumps with a total area of approx. 160,000 ha are known. Only approx. 1,100 of them have an official approval.[2] In spite of the 2005 regulation waste disposal is in many cases carried out improperly located, mainly in terms of hydro geological conditions and distance to water bodies, wells and aquifers.

Furthermore, the vast majority of the landfills and dumps, of a similar age to the Kremenchuk Site (20 - 40 years old), are not properly designed regarding surface water diversion, leachate collection and treatment and also landfill gas management. The operation of many landfills and dumps is not carried out with a view to minimize the adverse impacts on environment and human health. In many cases waste is disposed over large areas than rather in small well-defined sites and without proper soil cover. The result of it is: wind dispersal of waste, odor nuisances and enhanced leachate generation. Proper operation of leachate collection and treatment system as well as gas management system is uncommon.
The table below presents information regarding a representative sample of landfills throughout the Ukraine.[3] The sample represents 40% of the major landfill servicing large cities with number of inhabitants of more than 200,000 persons.

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[2] Country sheet Ukraine, by bifa Umweltinstitut Augsburg, 31.05.2009

[3] Identification and preparation of ProjectPreCheck (PPC) documents for LFG collection and utilization projects in Ukraine. Final report. For KfW Entwicklungsbank; by DECON GmbH, SEC "BIOMASS", June 2005

Landfill site / Aspects investigated	Number of inhabitants serviced by land-fill, in thousand	Annual waste amount, (un-compacted) 1000 m³ in 2004	Total amount of waste collected to 2007 (uncompacted), million m³	Starting year of operation	Total landfill area in ha	LFG-Control
Zhytomir	300	300	8.0	1957	18.7	None
Vinnitsa	385	340	5.1	1985	5	None
Khmelnitsky	250	490	14.8	1956	8.8	None
Chernivtsi	260	340	2.7	1995	25	Passive venting
Ivano-Frankivsk	230	260	3.0	1992	22.4	None
Lutsk	215	340	3.6	1991	9.9	None
Rivne	245	400	12.2	1959	24.5	None
Kirovohrad	280	260	10.9	1949	23	None
Cherkassy	310	360	4.8	1992	9	Passive venting
Kremenchuk	245	290	12.3	1965	28	None

As the table shows, landfills in Ukraine either have:

- no system for collecting, venting or flaring LFG, or
- passive system for venting LFG only

In both cases no methane is destroyed.

One demonstration project on LFG collection and flaring was implemented at the Lugansk landfill in 2002 supported by EcoLinks Subvention and USAID. The project was aimed at a demonstration of LFG control practice, thus promoting development of clean technologies and renewable energy sources.Three LFG extraction wells, collecting pipe and a flare were installed at the landfill and monitored for a year, however this work has not had any follow-up activities upon project completion.

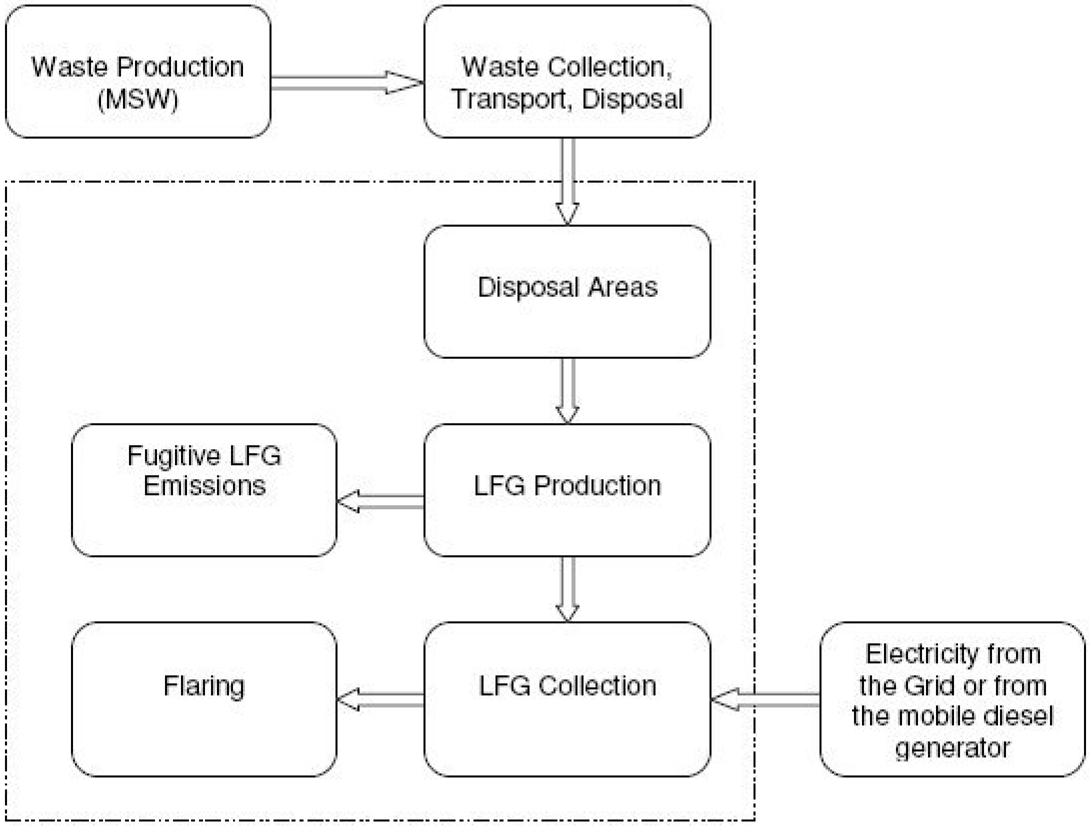
Other than this demonstration project, LFG collection and flaring or utilization systems have been implemented in Ukraine in Alushta and Yalta on the peninsula Crimea. The vast majority of landfills do not have a LFG control system at all. Development of LFG projects in Ukraine was started in the JI-framework only, specifically: PDDs for Kyiv, Donetsk and Kharkiv landfills were developed by Danish Environment Protection Agency 6 years ago and PDDs for Yalta and Alushta were developed by the English Carbon Capital Markets Ltd. 3 years ago. There are also LFG capture projects currently being developed as JI-projects at several other landfills (e.g. Belaya Tserkov, Vinnitsa, Dnipropetrovsk), that are at different stages of development. The letter of approval was obtained for the landfills in Kharkiv, Alushta and Yalta. However, currently realised projects either were subsidised by the EU (Lugansk) or they have developed within the JI process (Alushta, Yalta). The practical realisation for the other projects has not begun up to now due to the absence of a potential project investment company.

The above steps have been showed, that the project is additional.

B.3. Description of how the definition of the project boundary is applied to the project:

Project boundary includes Landfill site itself and equipment for collection, destruction and utilization of landfill gas, which are blower and flare.

The following figure shows the project and the project boundaries.



The generation sources and gases contained within the project boundary are as follows:

	Source	*Gas*	*Included?*	*Justification/ Explanation*
Baseline	Emissions from decomposition of waste at the landfill site	CH_4	yes	The major source of emissions in the baseline
		N_2O	no	N_2O-emissions are small compared to CH_4 emissions from landfills. Exclusion of this gas is conservative.
		CO_2	no	CO_2 -emissions from the decomposition of organic waste are not accounted.
	Emissions from electricity consumption	CO_2	yes	Nevertheless, electricity is not consumed in the baseline scenario.
		CH_4	no	Excluded for simplification. This is conservative.
		N_2O	no	Excluded for simplification. This is conservative.

	Emissions from thermal energy generation	CO_2	yes	not applicable
		CH_4	no	not applicable
		N_2O	no	not applicable
Project activity	On-site fossil fuel consumption due to the project activity other than for electricity generation	CO_2	yes	The CO_2-emissions as a result of the construction activity and the transport are small compared to CO_2 baseline emissions. Exclusion of this part is conservative. However, the emissions as a result of the electricity generation for the project activity on site by a mobile diesel generator are to be considered.
		CH_4	no	Excluded for simplification. This emission source is assumed to be very small.
		N_2O	no	Excluded for simplification. This emission source is assumed to be very small.
	Emissions from on-site electricity use	CO_2	yes	It is an important emission source.
		CH_4	no	Excluded for simplification. This emission source is assumed to be very small.
		N_2O	no	Excluded for simplification. This emission source is assumed to be very small.

B.4. Further baseline information, including the date of baseline setting and the name(s) of the person(s)/entity(ies) setting the baseline:

1 Oktober 2010

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SECTION C. Duration of the project / crediting period

C.1. Starting date of the project:

01/09/2010

The starting date was determined according to its definition in the JI glossary. Essential components of the gas collecting system and the flaring system are already installed at this date. And so the project can start after the receipt of the LoA from the Ukrainian DFP at the beginning of September.

C.2. Expected operational lifetime of the project:

15 years

C.3. Length of the crediting period:

The length of the crediting period amounts a total of 10 years, of it

- **During the first commitment period:**
  2 years and 4 months

- **Beyond the first commitment period:**
  In consideration of the decree No. 206 dated February 22, 2006 "On Approval of the Procedure of Drafting, Review, Approval and Implementation of Projects Aimed at Reduction of Anthropogenic Emissions of Greenhouse Gases" of the Cabinet of Ministers of Ukraine the project will request ERUs for the duration of 10 years. It reads as follows under paragraph 6 subparagraph 4: "Where JI project implementation period is longer than the first commitment period of the Kyoto Protocol, an installation owner shall be entitled to submit to the NEIA an application on depositing the assigned amount units (parts) with the purpose to carry over them to the next commitment period of the Kyoto Protocol to the extent not exceeding the planned emission reductions. The NEIA shall approve the requirements to grounding the implementation period of such project."

SECTION D. Monitoring plan

D.1. Description of monitoring plan chosen:

The approved monitoring methodology applied to this projct activity is the ACM0001 "Consolidated baseline and monitoring methodology for landfill gas project activities --- Version 11". The methodology also refers to "Tool to determine project emissions from flaring gases containing methane".

The monitoring methodology is based on direct measurement of the amount of methane captured and destroyed in the flare. The main variables that need to be determined are the quantity of methane actually captured and the quantity of methane flared.

The actual tonnage of methane emissions reduced by the project is calculated based on flow rate of the landfill gas, methane concentration and destruction/conversion efficiency of the combustion equpment. The monitoring plan provides for the continuous measurement of both quantity and quality of LFG captured and fed to the combustion equipment using a continuous flow meter and on-line LFG analyzer. Temperature and pressure of the LFG will also be measured.

The enclosed flare will be used for the LFG combustion and its efficiency is determined according to the "Tool to determine project emissions from flaring gases containing methane" (Vers01). This tool provides for a continuous monitoring of the residual and exhaust gas to determine flare efficiency. Should this not be possible, the tools 90% default value will be used provided that compliance with manufacturers specification of flare (temperature of the flare exhaust gas and others if applicable) proven through continuous monitoring of the specifications. Principally it is planned on the site in Kremenchuk to determine the flare efficiency per hour from the measuring results. As long as the necessary equipment is not installed, the tools 90% default value will be used.

Calibration of the equipment and training of the stuff will be conducted according to manufacturer's requirements.

The monitoring plan is attached the annex 3 as a flow sheet.

D.1.1. Option 1 – Monitoring of the emissions in the project scenario and the baseline scenario:

Because Option 2 is selected, this section is not filled in.

D.1.1.1. Data to be collected in order to monitor emissions from the project, and how these data will be archived:								
ID number *(Please use numbers to ease cross-referencing to D.2.)*	data variable	source of data	data unit	measured (m), calculated (c), estimated (e)	recording frequency	proportion of data to be monitored	how will the data be archived? (electronic/paper)	comment

D.1.1.2. Description of formulae used to estimate project emissions (for each gas, source etc.; emissions in units of CO_2 equivalent):

D.1.1.3. Relevant data necessary for determining the baseline of anthropogenic emissions of greenhouse gases by sources within the project boundary, and how such data will be collected and archived:								
ID number *(Please use numbers to ease cross-referencing to D.2.)*	data variable	source of data	data unit	measured (m), calculated (c), estimated (e)	recording frequency	proportion of data to be monitored	how will the data be archived? (electronic/paper)	comment

D.1.1.4. Description of formulae used to estimate baseline emissions (for each gas, source etc.; emissions in units of CO_2 equivalent):

D. 1.2. Option 2 – Direct monitoring of emission reductions from the project (values should be consistent with those in section E.):

D.1.2.1. Data to be collected in order to monitor emission reductions from the project, and how these data will be archived:								
ID number	data variable	source of data	data unit	measured (m), calculated (c), estimated (e)	recording frequency	proportion of data to be monitored	how will the data be archived?	comment

ID 1	*$LFG_{total,y}$* total amount of landfill gas captured at normal temperature and pressure	On-line LFG flow meter	m³	m	Measured continuously, interval for generation of average value: minutely and hourly, total value for every hour is recorded electronical and on hardcopy	100%	electronic	The values are to be kept 2 years after the crediting period. Because there are no other loads in our case, is $LFG_{total,y}= LFG_{flare,y}$. Calibration: 1 x per half-year
ID 2	*$PE_{flare,y}$* project emissions from flaring of the residual gas stream in year y		tCO_2e	c	See comments	100 %	electronic	A default of 90 % will be used w.t.r. the flare efficiency and the flare specifications of the manufacturer will be continuously monitored as long as the necessary measuring instruments are not installed. After the installation of them the exact flare efficiency will be determined.
ID 3	*W_{CH4}* methane fraction in the landfill gas	Continuous gas quality analyzer, infrared measuring method	% Vol.	m	Measured continuously, interval for generation of average value: minutely and hourly, average value per hour is recorded	100 %	electronic	The values are to be kept 2 years after the crediting period. Calibration: 1 x per week
ID 4	*T* temperature of the landfill gas	Thermocouple through thermoresistance	°C	m	Measured continuously, interval for generation of average value: minutely and hourly, average value per hour is recorded	100 %	electronic	The values are to be kept 2 years after the crediting period. Measured to determine the density of methane D_{CH4} Calibration: 1 x per year
ID 5	*P* Pressure of the landfill gas	Pressure gauge, piezoelectric method	hPa	m	Measured continuously, interval for generation of average value: minutely and hourly, average value per hour is recorded	100 %	electronic	The values are to be kept 2 years after the crediting period. Measured to determine the density of methane D_{CH4} Calibration: 1 x per half-year

ID 6	$EF_{grid,y}$ Carbon emission factor from electricity consumption from the grid		tCO_2/ MWh	c	Calculated as per the "Tool to calculate the baseline, project and/or leakage emissions from electricity consumption"			Principally the factor is estimated as describe in the "Tool to calculate the baseline, project and/or leakage emissions from electricity consumption". In our case a value of 1.104 is used in accordance with the abovementioned tool. The value is given by the European Bank of Reconstruction and Development. [4]
ID 7	$PE_{EC,y}$ project emissions from electricity consumption by the project activity during the year		tCO_2	c	Calculated as per the "Tool to calculate the baseline, project and/or leakage emissions from electricity consumption"			Because on the site in Kremenchuk the energy for the gas collection system is used from the grid, a value of 1,104 tCO_2/MWh for the emission factor for electricity generation $EF_{el,j,y}$ is used in accordance with the tool.
ID 8	$TDL_{j,y}$ Average technical transmission and distribution losses for providing electricity to source *j* in year *y*.			c	Calculated as per the "Tool to calculate the baseline, project and/or leakage emissions from electricity consumption"			This value will be not monitored. In accordance to the "Tool to calculate the baseline, project and/or leakage emissions from electricity consumption" a value of 13.5 is setting. The value is given by the European Bank of Reconstruction and Development. [5].

[4] Development of the electricity carbon emission factors for Ukraine Baseline Study for Ukraine - Final Report - by European Bank of Reconstruction and Development, 14.10.2010

[5] Development of the electricity carbon emission factors for Ukraine Baseline Study for Ukraine - Final Report - by European Bank of Reconstruction and Development, 14.10.2010

ID 9	$f_{Vi,h}$ Volumetric fraction of component *i* in the residual gas in the hour *h* where *i* = CH_4,CO_2,O_2	Continuos gas analyser, CH_4 and CO_2 - infrared measuring method, O_2 - paramagnetic measuring procedere	% Vol.	m	Measured continuously, interval for generation of average value: minutely and hourly, average value per hour is recorded	100%	electronic	If the temperature of the LFG exceeds 60°C, the measurements have to provide on the same basis (dry or wet) like the measurement of the volumetric flow rate for the residual gas $FV_{RG,h}$. The values are to be kept 2 years after the crediting period. Calibration: 1 x per week. A zero check and a typical value check will be performed with 2 types of testgas (1= 50% CH_4/50%CO_2, 2= synthetic air)
ID 10	$FV_{RG,h}$ Volumetric flow rate of the residual gas under process conditions and calculated to normal conditions in the hour *h*	Different pressure type flow meter	m³/h	m	Measured continuously, interval for generation of average value: minutely and hourly, average value per hour is recorded	100%	electronic	For temperatures of the LFG from more than 60°C see the comments under ID9. The values are to be kept 2 years after the crediting period. Calibration: 1 x per year.
ID 11	$t_{O2,h}$ volumetric fraction of O_2 in the exhaust gas of the flare in the hour h	Continuos gas analyser, paramagnetic measuring method	%Vol.	m	Measured continuously, interval for generation of average value: minutely and hourly, average value per hour is recorded	100%	electronic	The values are to be kept 2 years after the crediting period. Calibration: 1 x per month. A zero check and a typical value check will be performed with a testgas (synthetic air)
ID 12	$fv_{CH4,FG,h}$ Concentration of methane in the exhaust gas of the flare in dry basis at normal conditions in the hour *h*	Continuos gas analyser, infrared measuring method	% Vol.	m	Measured continuously, interval for generation of average value: minutely and hourly, average value per hour is recorded	100%	electronic	The values are to be kept 2 years after the crediting period. Calibration: 1 x per month. A zero check and a typical value check will be performed with a testgas (1% CH_4/99% N)
ID 13	T_{flare} Temperature in the exhaust gas	Thermocouple through thermoresistance	°C	m	Measured continuously, interval for generation of average value: minutely and hourly, average value per hour is recorded	100%	electronic	The values are to be kept 2 years after the crediting period. Calibration: 1 x per year.

ID 14	$TV_{n,FG,h}$ Volumetric flow rate of the exhaust gas in dry basis at normal conditions		m³/h	c	See comments	100%	electronic	Determined by calculation. It is based on a stoichiometric calculation of the combustion process. The values are to be kept 2 years after the crediting period.
ID 15	Regulary requirements relating to landfill gas project (AF)	Information received from the government of Ukraine.			Information received 1 x year, on regular basis	100 %	electronic	The values are to be kept 2 years after the crediting period; The information though recorded annually, is used for changes to the adjustment factor (AF) or directly $MD_{BL,y}$ of the credit period.
ID 16	Electricity consumption	kilowatt meter	kWh	m	Measured continuously and recorded 1x per day	100 %	electronic	The values are to be kept 2 years after the crediting period. This is monitored to determine CO_2 emission for the operation of the gas collection system. Calibration: 1 x per year.
ID 17	*FC* Quantity of fuel type *i* combusted in process *j* during the year	ruler gauge	l	m	Measured continuously and recorded 1x per day	100 %	electronic	The values are to be kept 2 years after the crediting period. This is monitored to determine CO_2 emission for the operation of the gas collection. Calibration: 1 x year
ID 18	NCV_{Diesel} Weighted average net calorific value of *Diesel* in year *y*	2006 IPCC Guidelines on National GHG Inventories	MJ/l	c	Information received 1 x for the project life time, on regular basis	100 %	electronic	The values are to be kept 2 years after the crediting period. This is monitored to determine CO_2 emission for the operation of the gas collection.
ID 19	Operational time of the collecting system	data logger	h	m	Measured continuously and recorded 1x per day	100 %	electronic	The values are to be kept 2 years after the crediting period. This is monitored to determine CO_2 emission for the operation of the gas collection system. Calibration: 1 x per year.

D.1.2.2. Description of formulae used to calculate emission reductions from the project (for each gas, source etc.; emissions/emission reductions in units of CO_2 equivalent):

According to the ACM0001 “Consolidated monitoring methodology for landfill gas project activities” the following formula for estimation of the GHG emissions reductions from the project is used:

Emission reductions

$ER_y = BE_y - PE_y$

ERy	Emissions reductions in year y (tCO_2e/yr)
BEy	Baseline emissions in year y (tCO_2e/yr)
PEy	Project emissions in year y (tCO_2e/yr)

Baseline emissions

From the results of the monitoring, the following method is used to calculate emission baseline in the project:
(Step 1)
$BE_y = (MD_{project,y} - MD_{BL,y}) * GWP_{CH4} + EL_{LFG,y} * CEF_{elec,BL,y} + ET_{LFG,y} * CEF_{ther,BL,y}$

BE_y	Baseline emissions in year y (tCO_2e)
$MD_{project,y}$	The amount of methane that would have been destroyed/combusted during the year, in tonnes of methane (tCH_4) in project scenario
$MD_{BL,y}$	The amount of methane that would have been destroyed/combusted during the year in the absence of the project due to regulatory and/or contractual requirement, in tonnes of methane (tCH_4)
GWP_{CH4}	Global Warming Potential value for the first commitment period is 21 t CO_2e/tCH_4
$EL_{LFG,y}$	Net quantity of electricity produced using LFG, which in the absence of the project activity would have been produced by power plants connected to the grid or by an on-site/off-site fossil fuel based captive power generation during year y, in MWh
$CEF_{elec,BL,y}$	CO_2 intensity of the baseline source of electricity displaced, in tCO_2/MWh
$ET_{LFG,y}$	The quantity of thermal energy produced utilizing the landfill gas, which in the absence of the project activity would have been produced from on-site/off-site fossil fuel fired boiler/air heater, during the year y in TJ
$CEF_{ther,BL,y}$	CO_2 intensity of the fuel used boiler/air heater to generate thermal energy which is displaced by LFG based thermal energy generation, in tCO_2e/TJ

Because in Kremenchuk neither electric energy nor warm energy is produced, the formula can be simplified as follows:

$BE_y = (MD_{project,y} - MD_{BL,y}) * GWP_{CH4}$

(Step 2)
$MD_{BL,y} = MD_{project,y} * AF$

With this equation the amount of methane that would have been destroyed/combusted during the year in the absence of the project activity is determined. The Adjustment factor ("AF") is defined as the ratio of the destruction efficiency of the collection and destruction system mandated by regulatory or contractual requirements to that of the collection and destruction system in the project activity. For this project, regulatory and contractual requirements are not considered and the baseline scenario chosen above is that the landfill gas would be released into the atmosphere. Therefore, the AF applied to the project activity is 0% and $MD_{BL,y}$ is 0.

(Step 3)

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

With this equation the amount of methane actually destroyed/combusted during the year is determined. Since in Kremenchuk neither electric energy nor warm energy is produced, the formula can be simplified as follows.

$$MD_{project,y} = MD_{flared,y}$$

(Step 4)

$$MD_{flared,y} = (LFG_{flare,y} * W_{CH4,y} * D_{CH4}) - (PE_{flare,y} / GWP_{CH4})$$

With this equation the quantity of methane destroyed by flaring of landfill gas is determined.

$LFG_{flare,y}$	The quantity of landfill gas fed to the flare during the year measured in cubic meters (m³).
W_{CH4}	The average methane fraction of the landfill gas measured* during the year and expressed as a fraction (in m³ CH_4 / m³ LFG)
D_{CH4}	The methane density expressed in tonnes of methane per cubic meter of methane (tCH_4/m^3CH_4)**
$PE_{flare,y}$	The project emissions from flaring of the residual gas stream in the year y (tCO_2).

(*) Methane fraction of the landfill gas to be measured on wet basis.

(**) At standard temperature and pressure (101.325 kPa and 273.15 K) the density of methane is 0.0007168 tCH_4/m^3CH_4

Formula for calculation of methane density D_{CH4} in every specific hour is:

$$D_{CH4} = P_{CH4} / ((R_U/MM_{CH4}) * T_{CH4})$$

D_{CH4}	The methane density expressed in tonnes of methane per cubic meter of methane (tCH_4/m^3CH_4)
P_{CH4}	Measured pressure of methane in the hour *h* (Pa)
R_U	Universal ideal gas constant (8.314 J/molK)
MM_{CH4}	Molecular mass of methane (kg/kmol)
T_{CH4}	Measured temperature of methane in the hour h (K)

Project emissions

From the results of the monitoring, the following equations are used to calculate project emissions:

The project emissions (PE) will be determined following the procedure described in the "Tool to determine project emissions from flaring gases containing Methane". The tool offers two options for enclosed flares. Where possible, option 2 will be used: continuous monitoring of the methane destruction efficiency of the flare as per the tool methodology. According to the methodology, when the recorded temperature of the exhaust gas of the flare is lower than 500°C for more than 20 minutes in an hour, the flare efficiency of the hour will be considered 0%. When option 2 is not possible, option 1 will be used: 90% default efficiency factor with continuous monitoring of manufacturers specifications (temperature and flow rate of residual gas at the inlet of the flare). Principally option 2 will be applied to the site in Kremenchuk. But a default of 90 % (option 1) will be used w.t.r. the flare efficiency and the flare specifications of the manufacturer will be continuously monitored as long as the necessary measuring equipment is not installed.

The methane emissions in the flare due to the flare efficiency can be estimated according to the following equation, thereby is $PE_{y2} = PE_{flare,y}$:

$$\mathbf{PE_{y2}} = \sum_{h=1}^{8,760} TM_{RG,h} * (1 - \eta_{flare,h}) * \frac{GWP_{CH4}}{1,000} \quad (tCO_2equivalent/year)$$

where:

- **PE_{y2}** are the estimated project emissions from non combusted methane (tonnes CO_2equivalent)
- **$TM_{RG,h}$** is the mass flow rate of methane in the residual gas in the hour *h*; in kg/h
- **$\eta_{flare,h}$** is the flare efficiency in the hour h
- **GWP_{CH4}** is the global warming potential of methane valid for the commitment period (**GWP = 21**)

In the case, when the efficiency of the flare is not identified by measurements, the default value for flare efficiency is fixed at the level of **η = 90%**. Up to the installation of the measuring instruments the flare efficiency $\eta_{flare,h}$ is determined as follows:

- 0% for every hour, in that the temperature in the exhaust gas of the flare is below 500°C for more than 20 minutes
- 50% for every hour, in that the temperature in the exhaust gas of the flare is above 500°C for more than 40 minutes and the manufacturers specifications on proper operation of the flare are not met at any point in time during the hour
- 90% for every hour, in that the temperature in the exhaust gas of the flare is above 500°C for more than 40 minutes and the manufacturers specifications on proper operation of the flare are met continuously during the hour

In cases, since the flare efficiency is calculated, the following steps are necessary according to the "Tool to determine project emissions from flaring gases containing methane"

Step 1Determination of the mass flow rate of the residual gas that is flared

$$FM_{RG,h} = \rho_{RG,n,h} * FV_{RG,h}$$

where:

$FM_{RG,h}$	is the mass flow rate of the residual gas in the hour *h*; in kg/h
$\rho_{RG,n,h}$	is the density of the residual gas at normal conditions in the hour *h*; in kg/m³
$FV_{RG,h}$	is the volumetric flow rate of the residual gas in dry basis at normal conditions in the hour *h*; in m³/h

and

$$\rho_{RG,n,h} = \frac{P_n}{\frac{R_u}{MM_{RG,h}} * T_n}$$

where:

$\rho_{RG,n,h}$	is the density of the residual gas at normal conditions in the hour *h*; in kg/m³
P_n	is the atmospheric pressure at normal conditions (101 325); in Pa
R_u	is the universal gas constant (8 314); in Pa.m³/kmol.K
$MM_{RG,h}$	is the molecular mass of the residual gas in the hour *h*; in kg/kmol
T_n	is the temperature at normal conditions (273.15); in K

and

$$MM_{RG,h} = \sum_i (fv_{i,h} * MM_i)$$

where:

$MM_{RG,h}$	is the molecular mass of the residual gas in the hour *h*; in kg/kmol
$fv_{i,h}$	is the volumetric fraction of the component *i* in the residual gas in the hour *h*
MM_i	is the molecular mass of the residual gas component *i*; in kg/kmol
i	are the components CH_4, CO, CO_2, O_2, H_2, N_2

As a simplified approach only the volumetric fraction of CH_4 will be measured in the project. The difference to 100% will be considered as being nitrogen (N_2).

Step 2Determination of the mass fraction of carbon, hydrogen, oxygen and nitrogen in the residual gas

$$fm_{j,h} = \frac{\sum_i fv_{i,h} * AM_j * NA_{j,i}}{MM_{RG,h}}$$

where:

$fm_{j,h}$	is the mass fraction of the element *j* in the residual gas in the hour *h*
$fv_{i,h}$	is the volumetric fraction of component *i* in the residual gas in the hour *h*
AM_j	is the atomic mass of element j; in kg/kmol
$NA_{j,I}$	is the number of atoms of element j in component i

$MM_{RG,h}$	is the molecular mass of the residual gas in the hour *h*; in kg/kmol
j	are the elements carbon, hydrogen, oxygen and nitrogen
i	are the components CH_4, CO, CO_2, O_2, H_2, N_2

Step 3Determination of the volumetric flow rate of the exhaust gas in a dry basis

$$TV_{n,FG,h} = V_{n,FG,h} * FM_{RG,h}$$

where:

$TV_{n,FG,h}$	is the volumetric flow rate of the exhaust gas in dry basis at normal conditions in the hour *h*; in m³/h
$V_{n,FG,h}$	is the volume of the exhaust gas of the flare in dry basis at normal conditions per kg of residual gas in the hour *h*; in m³/kg residual gas
$FM_{RG,h}$	is the mass flow rate of the residual gas in the hour *h*; in kg residual gas/h

$$V_{n,FG,h} = V_{n,CO2,h} + V_{n,O2,h} + V_{n,N2,h}$$

where:

$V_{n,FG,h}$	is the volume of the exhaust gas of the flare in dry basis at normal conditions per kg of residual gas in the hour *h*; in m³/kg residual gas
$V_{n,CO2,h}$	is the quantity of CO_2 volume free in the exhaust gas of the flare at normal conditions per kg residual gas in the hour *h*; in m³/kg residual gas
$V_{n,O2,h}$	is the quantity of O_2 volume free in the exhaust gas of the flare at normal conditions per kg residual gas in the hour *h*; in m³/kg residual gas
$V_{n,N2,h}$	is the quantity of N_2 volume free in the exhaust gas of the flare at normal conditions per kg residual gas in the hour *h*; in m³/kg residual gas

$$V_{n,O2,h} = n_{O2,h} * MV_n$$

where:

$V_{n,O2,h}$	is the quantity of O_2 volume free in the exhaust gas of the flare at normal conditions per kg residual gas in the hour *h*; in m³/kg residual gas
$n_{O2,h}$	is the quantity of moles O_2 in the exhaust gas of the flare per kg residual gas flared in the hour *h*; in kmol/kg residual gas
MV_n	is the volume of one mol of any ideal gas at normal temperature and pressure (22.4 L/mol); in m³/kmol

$$V_{n,N2,h} = MV_n * \left\{\frac{fm_{N,h}}{200AM_N} + \left(\frac{1-MF_{O2}}{MF_{O2}}\right) * \left[F_h + n_{O2,h}\right]\right\}$$

where:

$V_{n,N2,h}$	is the quantity of N_2 volume free in the exhaust gas of the flare at normal conditions per kg residual gas in the hour *h*; in m³/kg residual gas
MV_n	is the volume of one mol of any ideal gas at normal temperature and pressure (22.4 m³/kmol); in m³/kmol
$fm_{N,h}$	is the mass fraction of nitrogen in the residual gas in the hour *h*
AM_N	is the atomic mass of nitrogen; in kg/kmol

$\mathbf{MF_{O2}}$	is the O_2 volumetric fraction of air
$\mathbf{F_h}$	is the stochiometric quantity of moles of O_2 required for a complete oxidation of one kg residual gas in the hour *h*; in kmol/kg residual gas
$\mathbf{n_{O2,h}}$	is the quantity of moles O_2 in the exhaust gas of the flare per kg residual gas flared in the hour *h*; in kmol/kg residual gas

$$\mathbf{V_{n,CO2,h}} = \frac{\mathbf{fm_{C,h}}}{\mathbf{AM_C}} * \mathbf{MV_n}$$

where:

$\mathbf{V_{n,CO2,h}}$	is the quantity of CO_2 volume free in the exhaust gas of the flare at normal conditions per kg residual gas in the hour *h*; in m³/kg residual gas
$\mathbf{fm_{C,h}}$	is the mass fraction of carbon in the residual gas in the hour *h*
$\mathbf{AM_N}$	is the atomic mass of carbon; in kg/kmol
$\mathbf{MV_n}$	is the volume of one mol of any ideal gas at normal temperature and pressure (22.4 m³/kmol); in m³/kmol

$$\mathbf{n_{O2,h}} = \frac{\mathbf{t_{O2,h}}}{\left(1-\left(\mathbf{t_{O2,h}}/\mathbf{MF_{O2}}\right)\right)} * \left[\frac{\mathbf{fm_{C,h}}}{\mathbf{AM_C}} + \frac{\mathbf{fm_{N,h}}}{\mathbf{2AM_N}} + \left(\frac{1-\mathbf{MF_{O2}}}{\mathbf{MF_{O2}}}\right) * \mathbf{F_h}\right]$$

where:

$\mathbf{n_{O2,h}}$	is the quantity of moles O_2 in the exhaust gas of the flare per kg residual gas flared in the hour *h*; in kmol/kg residual gas
$\mathbf{t_{O2,h}}$	is the volumetric fraction of O_2 in the exhaust gas in the hour *h*
$\mathbf{MF_{O2}}$	is the volumetric fraction of O_2 in the air (0.2l)
$\mathbf{F_h}$	is the stochiometric quantity of moles of O_2 required for a complete oxidation of one kg residual gas in the hour *h*; in kmol/kg residual gas
$\mathbf{fm_{j,h}}$	is the mass fraction of element *j* in the residual gas in the hour *h*
$\mathbf{AM_j}$	is the atomic mass of element *j*; in kg/kmol
j	are the elements carbon (index C) and nitrogen (index N)

$$\mathbf{F_h} = \frac{\mathbf{fm_{C,h}}}{\mathbf{AM_C}} + \frac{\mathbf{fm_{H,h}}}{\mathbf{4\ AM_H}} + \frac{\mathbf{fm_{O,h}}}{\mathbf{2\ AM_O}}$$

where:

$\mathbf{F_h}$	is the stochiometric quantity of moles of O_2 required for a complete oxidation of one kg residual gas in the hour *h*; in kmol/kg residual gas
$\mathbf{fm_{j,h}}$	is the mass fraction of element *j* in the residual gas in the hour *h*
$\mathbf{AM_j}$	is the atomic mass of element *j*; in kg/kmol
j	are the elements carbon (index C), hydrogen (index H) and oxygen (index O)

Step 4Determination of methane mass flow rate in the exhaust gas on a dry basis

$$TM_{FG,h} = \frac{TV_{n,FG,h} * fv_{CH4,FG,h}}{1{,}000{,}000}$$

where:

$TM_{FG,h}$	is the mass flow rate of methane in the exhaust gas of the flare in dry basis at normal conditions in the hour *h*; in kg/h
$TV_{n,FG,h}$	is the volumetric flow rate of the exhaust gas in dry basis at normal conditions in the hour *h*, in m³/h exhaust gas
$fv_{CH4,FG,h}$	is the concentration of methane in the exhaust gas of the flare in dry basis at normal conditions in the hour *h*; in mg/m³

Step 5Determination of methane mass flow rate in the residual gas on a dry basis

$$TM_{RG,h} = FV_{RG,h} * fv_{CH4,RG,h} * \rho_{CH4,n}$$

where:

$TM_{RG,h}$	is the mass flow rate of methane in the residual gas in the hour *h*; in kg/h
$FV_{RG,h}$	is the volumetric flow rate of the residual gas in dry basis at normal conditions in the hour *h*; in m³/h
$fv_{CH4,RG,h}$	is the volumetric fraction of methane in the residual gas in dry basis in the hour *h*; (this corresponds to $fv_{i,RG,h}$ where i refers to methane)
$\rho_{CH4,n}$	is the density of methane at normal conditions (0.716); in kg/m³

Step 6Determination of the hourly flare efficiency

$$\eta_{flare,h} = 1 - \frac{TM_{FG,h}}{TM_{RG,h}}$$

where:

$\eta_{flare,h}$	is the flare efficiency in the hour *h*
$TM_{FG,h}$	is the methane mass flow rate in exhaust gas averaged in a period of time (hour, two months or year); in kg/h
$TM_{RG,h}$	is the mass flow rate of methane in the residual gas in the hour *h*; kg/h

The calculation procedure in this tool determines the flow rate of methane before and after the destruction in the flare, taking into account the amount of air supplied to the combustion reaction and the exhaust gas composition (oxygen and methane). The flare efficiency is calculated for each hour of a year based either on measurements or default values plus operational parameters. Project emissions are determined by multiplying the methane flow rate in the residual gas with the flare efficiency for each hour of the year. After the installation of the measuring instruments the above formulas are applicable in cases, where the temperature of the exhaust gas of the flare is above 500°C for more than 40 minutes during the hour h. If the temperature is below than 500°C for more than 20 minutes of an hour, than is the flare efficiency 0% in this hour.

With regard to the emissions resulting from electricity used by LFG pumping equipment we distinguish 2 options:

1. Electricity from the grid and
2. Electricity from the off-grid fossil fuel (diesel) using generator.

The supply from the generator occurs from the beginning of the project as long as, until the landfill site is connected to the public grid. Emissions from using the generator for energy requirement on site under project activity during the year y are determined according the following equation:

$$\mathbf{PE_{y3,FC,j,y} = \sum FC_{i,j,y} * COEF_{j,y}}$$

where:

$\mathbf{PE_{y3,FC,j,y}}$	CO_2 emissions from fossil fuel combustion in process *j* during the year *y*(tCO_2/yr)
$\mathbf{FC_{i,j,y}}$	quantity of fuel type *i* combusted in process *j* during the year *y* (mass or volume unit/yr)
$\mathbf{COEF_{j,y,i}}$	CO_2 emission coefficient of fuel type *i* in year *y* (tCO_2/mass or volume unit)
	fuel types combusted in process *j* during the year *y*

According the "Tool to calculate project or leakage CO_2 emissions from fossil fuel combustion" (Version 02) the CO_2 emission coefficient $COEF_{j,y}$ will be calculated using the following equation:

$$\mathbf{COEF_{j,y} = NCV_{i,y} * EF_{CO2,i,y}}$$

where:

$\mathbf{NCV_{i,y}}$	weighted average net calorific value of the fuel type *i* in the year *y* (in our case 43 MJ/l)[6]
$\mathbf{EF_{CO2,i,y}}$	weighted average CO_2 emission factor of fuel type *i* in year *y* (in our case 74.1 tCO_2/TJ)[7]

For calculation of the above emissions following parameters will be used:

Parameter	Value
Type of fossil fuel used by the generator	Diesel
Emissions factor for fossil fuel	$EF_{CO2,i,y}$ = 74.1 tCO_2/TJ
Heating value of fossil fuel (diesel)	$NCV_{i,y}$ = 43 MJ/l = 43 * 10^{-6} TJ/l

It is intended to supply the collecting system no longer as 6 months with electric energy generated from the generator. Mainly project emissions will arise as a result of the supply with electric energy from the grid. Emissions from electricity from the grid used during the project for energy requirement on site under project activity during the year y, in MWh are determined according the following equation, thereby is $PE_{y3,grid} = PE_{EC,y}$:

$$\mathbf{PE_{EC,y} = EC_{PJ,y} * EF_{EL,,y} * (1 + TDL_{,y})}$$

where:

$\mathbf{PE_{EC,y}}$	Project emissions from electricity consumption in year *y* (tCO_2/yr)

[6] IPCC Guidelines for National GHG Inventories, Volume 2 *Energy*, Chapter 1, Table 1.2

[7] IPCC Guidelines for National GHG Inventories, Volume 2 *Energy*, Chapter 1, Table 1.2

$EC_{PJ,y}$ Quantity of electricity consumed by the project electricity consumption from the grid in the year *y* (MWh)

$EF_{EL,,y}$ Emission factor for electricity generation for electricity from the grid in year *y* (tCO_2/MWh, in Ukraine 1.104 tCO_2equivalent/MWh[8])

$TDL_{,y}$ Average technical transmission and distribution losses in the grid in year y

D.1.3. Treatment of leakage in the monitoring plan:

According to ACM0001, there will be no leakage in this project.

D.1.3.1. If applicable, please describe the data and information that will be collected in order to monitor leakage effects of the project:

ID number	data variable	source of data	data unit	measured (m), calculated (c), estimated (e)	recording frequency	proportion of data to be monitored	how will the data be archived?	Comment

No leakage effects have to be accounted for under the applied methodology.

D.1.3.2. Description of formulae used to estimate leakage (for each gas, source etc.; emissions in units of CO_2 equivalent):

No leakage effects have to be accounted for under this methodology.

D.1.4. Description of formulae used to estimate emission reductions for the project (for each gas, source etc.; emissions/emission reductions in units of CO_2 equivalent):

Please see section D.1.2.2. for details.

D.1.5. Where applicable, in accordance with procedures as required by the host Party, information on the collection and archiving of information on the environmental impacts of the project:

Environmental impact legislation relating to the project is as follows:

[8] www.ukrstat.gov.ua

- Law on the protection of the environment (June,1991);
- Ukrainian law 'On Protection of Ambient Air' (June 21, 2001).

D.2. Quality control (QC) and quality assurance (QA) procedures undertaken for data monitored:		
Data *(Indicate table and ID number)*	Uncertainty level of data (high/medium/low)	Explain QA/QC procedures planned for these data, or why such procedures are not necessary.
D.1.2.1; ID 1 $LFG_{total,y}$	Low	Measuring signal: 4 mA to 20 mA; measurement range: 0-500 Pm³/h; manufacturer: HWFB maintenance/calibration of devices: min 1 x half-year by specially trained servicing staff; testing/calibration of devices: 1 x year by the laboratory "Kremenchuk Gas", Str. Prikhodko 60/18 in Kremenchuk (controller)
D.1.2.1; ID 3 W_{CH4y}	Low	Measuring signal: 4 mA to 20 mA; measurement range: 0-80 %Vol.; manufacturer: Emmerson maintenance/calibration of devices: 1 x week by specially trained servicing staff; testing/calibration of devices: 1 x year by the laboratory "Kremenchuk Gas", Str. Prikhodko 60/18 in Kremenchuk (controller)
D.1.2.1; ID 4 T	Low	Measuring signal: 4 mA to 20 mA; measurement range: 0-100 °C; manufacturer: HAASE maintenance/calibration of devices: min 1 x year by specially trained servicing staff; testing/calibration of devices: 1 x year by the laboratory "Kremenchuk Gas", Str. Prikhodko 60/18 in Kremenchuk (controller)
D.1.2.1; ID 5 P	Low	Measuring signal: 4 mA to 20 mA; measurement range: -250-0 hPa; manufacturer: WIKA maintenance/calibration of devices: min 1 x half-year by specially trained servicing staff; testing/calibration of devices: 1 x year by the laboratory "Kremenchuk Gas", Str. Prikhodko 60/18 in Kremenchuk (controller)
D.1.2.1; ID 9 $f_{Vi,h}$	Low	Measuring signal: 4 mA to 20 mA; measurement range: 0-25 %Vol. O_2; manufacturer: Emmerson maintenance/calibration of devices: 1 x week by specially trained servicing staff; testing/calibration of devices: 1 x year by the laboratory "Kremenchuk Gas", Str. Prikhodko 60/18 in Kremenchuk (controller)
D.1.2.1; ID 10 $FV_{RG,h}$	Low	Measuring signal: 4 mA to 20 mA; measurement range: 0-500 m³/h; manufacturer: HWFB; measuring temperature below 60°C maintenance/calibration of devices: min 1 x half-year by specially trained servicing staff; testing/calibration of devices: 1 x year by the laboratory "Kremenchuk Gas", Str. Prikhodko 60/18 in Kremenchuk (controller)

D.1.2.1; ID 11 $t_{O2,h}$	Low	Measuring signal: 4 mA to 20 mA; measurement range: 0-25 %Vol.; manufacturer: Emmerson maintenance/calibration of devices: 1 x week by specially trained servicing staff; testing/calibration of devices: 1 x year by the laboratory "Kremenchuk Gas", Str. Prikhodko 60/18 in Kremenchuk (controller)
D.1.2.1; ID 12 $fv_{CH4,FG,h}$	Low	Measuring signal: 4 mA to 20 mA; measurement range: 0-0.2 %Vol.; manufacturer: Emmerson maintenance/calibration of devices: 1 x week by specially trained servicing staff; testing/calibration of devices: 1 x year by the laboratory "Kremenchuk Gas", Str. Prikhodko 60/18 in Kremenchuk (controller)
D.1.2.1; ID 13 T_{flare}	Low	Measuring signal: 4 mA to 20 mA; measurement range: 0-1,600 °C; manufacturer: Plöger maintenance/calibration of devices: min 1 x half- year by specially trained servicing staff; testing/calibration of devices: 1 x year by the laboratory "Kremenchuk Gas", Str. Prikhodko 60/18 in Kremenchuk (controller)
D.1.2.1; ID 16 *Operational time*	Low	The kilowatt meter will be calibrated delivered from a local manufacturer in a sealed state and it will be exchanged according to manufacturer's data.
D.1.2.1; ID 17 *Quantity of diesel*	Low	The diesel gauge will be calibrated delivered from the manufacturer "FLEXBIMEC" and it will be calibrated 1 x year by the laboratory "Kremenchuk Gas", Str. Prikhodko 60/18 in Kremenchuk (controller).

D.3. Please describe the operational and management structure that the project operator will apply in implementing the monitoring plan:

MBS GmbH as project developer will organize and supervise the project operation and the management of the project. They will bear full responsibility for monitoring, ERU control, reporting and accounting. HAASE Energietechnik AG as equipment supplier is responsible for facilities operation and maintenance. HAASE Energietechnik AG and Kommunalnoe Awtotransportnoe Predprijatie 1628 will operate the plant in a joint operating company and so.Kommunalnoe Awtotransportnoe Predprijatie 1628 as the presently operator of the site explains the works according to the instructions of HAASE Energietechnik AG and MBS GmbH.

Operational procedures and responsibilities for monitoring and quality assurance of emissions reductions from the project activity are presented in the table below (E - executing data collection, R - responsible for overseeing and assuring quality, I - to be informed).

Task	Site Engineer/ Equipment supplier	Project developer	Manager from ERUs purchaser side
Collect data	E	R	
Enter data into spread sheet	E	R	
Make monthly and annual reports	E	R	I
Archieve data and reports	E	R	I
Calibration/Maintenance, rectify faults	E/R	I	I

In the project, quality control and quality assurance shall be carried out by the following methods:

- The project implementing organization will consist of operating personnel and management.
- Management will prepare written procedures for operating facilities.
- Written procedures, containing daily work contents, periodic maintenance methods and judgment criteria, etc., will be complied according to appropriate formats.
- Management will check reports from operating personnel and determinate there are no problems according to the procedures. If problems are found in such checks, management will implement the appropriate countermeasures with appropriate timing.
- Management will every month file and store reports from operating personnel according to the procedures.
- In the event of accidents (including the unforeseen release of GHG), management will ascertain the causes, implement and instruct countermeasures to the operating personnel.
- In case of emergency (including the unforeseen release of GHG), operating personnel will take stopgap measures and implement countermeasures according to instructions from management.
- Measuring instruments will be periodically and appropriately calibrated according to the procedures. Calibration timing and methods will be in accordance with "the monitoring plan".

D.4. Name of person(s)/entity(ies) establishing the monitoring plan:

1 April 2010
General Manager: Dirk Raedisch
Manager: Michael Donath
MBS GmbH
Industriestrasse Str. 3a
07546 Gera
tel.: +49-365-8001220
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e-mail: info@mbs-gera.de

SECTION E. Estimation of greenhouse gas emission reductions

The estimate of ex-ante emissions reductions is given in this section for reference purpose only, since direct monitoring of methane destroyed in the project scenario will be applied according to the ACM0001 methodology version 11.

E.1. Estimated project emissions:

The project emissions are potentially represented by three sources:

1. Fugitive methane emissions due to not captured LFG

One source of project emissions identified within the system boundary is fugitive methane emission from the landfill, i.e. methane not captured by the collection system. It is assumed that the gas collection system installed will capture approx. 50% of the total amount of gas released by the landfill in the baseline scenario. This figure is obtained from considering the percentage of the landfill covered by LFG extraction wells (70%), well efficiency (80%) and well availability (90%). Therefore the remaining 50% of fugitive emissions will be considered as project emissions.

The fugitive methane emissions from not captured LFG can be estimated from the following equation:

$$PE_{y1} = W_{CH4,y} * D_{CH4,y} * (1-CE) * GWP_{CH4} \quad (tCO_2equivalent/year)$$

2. Fugitive methane emissions in the flare due to the flare efficiency

Another relevant source of project emissions is methane not combusted in the flare. This source is covered through the parameter "flare efficiency" (FE in %), which enters the calculation of the emissions reductions. Depending on availability of the monitoring equipment, either a default value of flare efficiency of 90% will be used or continuous monitoring of flare efficiency will be used to claim more than 90% efficiency methane destruction. In the case of Kremenchuk site the more conservative option of default value of 90% flare efficiency for the calculation was chosen.

The methane emissions in the flare due to the flare efficiency can be estimated according to the following equation:

$$PE_{y2} = W_{CH4,y} * D_{CH4} * (1-CE) * (1-FE) * GWP_{CH4} \quad (tCO_2equivalent/year)$$

where:

PE_{y1}	estimated project emissions from non captured methane (tonnes CO_2equivalent)
PE_{y2}	estimated project emissions from non combusted methane (tonnes CO_2equivalent)
$W_{CH4,y}$	is the methane generated at the landfill (m³ of CH_4)
D_{CH4}	is the methane density (kg/m³ of CH_4)[9]
CE	is the LFG collection efficiency
FE	is the flare efficiency
GWP_{CH4}	is the global warming factor of methane (GWP = 21)

Landfill gas collection efficiency is estimated at the level of **CE = 50%**.
In the case, when the efficiency of the flare is not identified by measurements, the default value for flare efficiency is fixed at the level of **FE = 90%**.

[9] At standard temperature and pressure (0 degree Celsius and 1.013 bar) the density of methane is 0.0007168 tCH_4/m^3CH_4.

3. CO_2 emissions resulting from electricity used by LFG pumping equipment

For the calculation of these values it is referred to chapter D, paragraph D.1.2.2.

Since on the Kremenchuk site only LFG flaring is applied, emissions on the bounce using electric energy from the grid represent project emissions.

The sum of the project emission is equal to:

$$PE_y = PE_{y1} + PE_{y2} + PE_{y3}$$

4. Emissions from construction works on installation of LFG collection system

Since share of the construction emissions is less than 1% of the total baseline emissions, it can be neglected.

Results of calculation of the project emission from the Kremenchuk solid waste disposal site are given below:

Project emission Kremenchuk solid waste disposal site						
Year	PE_{y1}	PE_{y2}	$PE_{y3,grid}$	$PE_{y3,generator}$	$PE_{y,grid,total}$	$PE_{y,generator,total}$
2010	11,382.35	1,138.24	124.82	33.99	12,645.40	12,554.47
2011	35,065.02	3,506.50	374.45	101.96	38,945.97	38,673.48
2012	36,018.04	3,601.80	374.45	101.96	39,994.30	39,721.81
2013	34,679.29	3,467.93	374.45	101.96	38,521.66	38,249.18
2014	31,201.34	3,120.13	374.45	101.96	34,695.92	34,423.43
2015	28,173.94	2,817.39	374.45	101.96	31,365.76	31,093.27
2016	25,529.35	2,552.94	374.45	101.96	28,456.74	28,184.25
2017	23,210.84	2,321.08	374.45	101.96	25,906.37	25,633.89
2018	21,170.67	2,117.07	374.45	101.96	23,662.18	23,389.69
2019	19,368.70	1,936.87	374.45	101.96	21,680.02	21,407.53
2020	17,771.14	1,777.11	374.45	101.96	19,922.70	19,650.21
2010 - 2020	283,570.65	28,357.07	3,869.30	1,053.60	315,797.01	312,981.32

E.2. Estimated leakage:

According to ACM0001, there will be no leakage in this project.

E.3. The sum of E.1. and E.2.:

The sum of E.1. and E.2. is equal to:

$$PE_y = PE_{y1} + PE_{y2} + PE_{y3}$$

For the results of the calculation of the project emission please refer to the section E.1.

E.4. Estimated baseline emissions:

1. Estimation of baseline methane emissions into the atmosphere

The amount of methane release in the baseline scenario is estimated using **Methodological "Tool to determine methane emissions avoided from disposal of waste at a solid waste disposal site (Version 04)"**

In accordance to this methodology the amount of methane that would in absence of the project activity be generated from disposal of waste at the solid waste disposal site ($BE_{CH4,SWDS,y}$) is calculated with a multi-phase model. The calculation is based on a first order decay (FOD) model. The model differentiates between the different types of waste j with repectively different decay rates k_j and different fractions of degredable organic carbon (DOC_j).

The model calculates the methane generation based on the actual (or estimated) waste streams $W_{j,x}$ disposed in each year *x*, starting which the first year after the start of the project aktivity (the year 2010) until the end of the year *y* (the year 2020), for which baseline emissions are calculated (years x with x= 1 to x = y).

Since in our case no SWDS methane is captured and flared, combusted or used in another manner in the baseline scenario, the baseline emissions are not adjusted for the fraction of methane captured at the SWDW.

The amount of methane producedin the year *y* ($BE_{CH4,SWDS,y}$) is calculated as follows:

$$\mathbf{BE_{CH4,SWDS,y} = \varphi \cdot (1-f) \cdot GWP_{CH4} * (1-OX) \cdot 16/12 \cdot F \cdot DOC_f * MCF \cdot \sum_{X=1}^{y} \sum_{j} W_{j,x} * DOC_j * (e^{-k(y-x)} * (1-e^{-kj})}$$

where:

$\mathbf{BE_{CH4,SWDS,y}}$	methane emissions avoided during the year *y* preventing waste disposal at solid waste disposal site (SWDW) during the period from the start of the project activity to the end of the year (tCO_2e)
φ	model correction factor to account for model uncertainties (0.9)
f	fraction of methane captured at the SWDS and flared, combusted or used in another manner (0 in our case)
$\mathbf{GWP_{CH4}}$	Global Warming Potential (GWP) of methane, valid for the relevant commitment period (21)
OX	oxidation factor (reflecting the amount of methane from SWDS that is oxidised in the soil or other material covering the waste, 0 in our case)
F	fraction of methane in the SWDS gas (volume fraction, 0.5 in our case)
$\mathbf{DOC_f}$	fraction of degredable organic carbon (DOC) that can decompose (0.5)
MCF	methane correction factor (0.8 in our case)
$\mathbf{W_{j,x}}$	amount of organic waste type *j* prevented from disposal in the SWDS in the year x (t)
$\mathbf{DOC_j}$	fraction of degredable organic carbon (by weight) in the waste type *j*
$\mathbf{k_j}$	decay rate for the waste type *j*
j	waste type categorie (index)
x	year during the period: x runs from the first year of the period (x=1) to the year y for which avoided emissions are calculated
y	year for which methane emissions are calculated

Model correction factor to account for model uncertainties (*φ*)

Given the uncertainties associated with the model and in order to estimate emissions reductions in a conservative manner, a discount of 10% is applied to the model results, therefore **φ** =0.9.

Fraction of methane captured at the SWDS and flared , combusted or used in another mannet (*f*)

No methane capture is currently applied at the site, therefore f=O.

Oxidation factor (*OX*)

Oxidation factor reflects the amount of methane from SWDS that is oxidized in the soil or in other material covering waste. IPCC (2006 Guidelines for National Greenhouse Gas Inventories) recommends the following values for the different types of dumps:

Data / parameter	OX
Data unit:	-
Description:	Oxidation factor (reflecting the amount of methane from SWDS that is oxidized from the soil or other material covering the waste)
Source of data:	Conduct a site visit at the solid waste disposal site in order to assess the type of cover of the solid waste disposal site. Use the IPCC 2006 Guidelines for National Greenhouse Gas Inventories for the choice of the value to be applied.
Value to be applied:	Use 0.1 for managed solid waste disposal sites that are covered with oxidizing material such as soil or compost. Use 0 for other types of solid waste disposal sites.

Fraction of methane in the SWDS gas (*F*)
This factor reflects the fact that some degradable organic carbon does not degrade, or degrades very slowly, under anaerobic conditions in the SWDS. A default of 0.5 is recommended by IPCC.

Fraction of degradable organic carbon (DOC) that can decompose (DOC_f)
IPCC 2006 Guidelines for National Greenhouse Gas Inventories recommends 0.5 value to be applied.

Methane correction factor (*MCF*)
The methane correction factor (MCF) accounts for the fact, that unmanaged SWDS produce less methane from a given amount of waste than managed SWDS, because a larger fraction of waste decomposes aerobically in the top layers of unmanaged SWDS.

Data / parameter	**MCF**
Data unit:	-
Description:	Methane correction factor
Source of data:	IPCC 2006 Guidelines for National Greenhouse Gas Inventories
Value to be applied:	Use the following values for MCF: • for **anaerobic managed solid waste disposal sites**. These must have controlled placement of waste (i.e., waste directed to specific deposition areas, a degree of control of scavenging and a degree of control of fires) and will include at least one of the following: (i) cover material; (ii) mechanical compacting; or (iii) leveling of the waste • 0.5 for **semi-aerobic managed solid waste disposal sites**. These must have controlled placement of waste and will include all of the following structures for introducing air to waste layer: (i) permeable cover material; (ii) leachate drainage system; (iii) regulating poundage; and (iv) gas ventilation system • 0.8 for **unmanaged solid waste disposal sites - deep and/or with high water table.** This comprises all SWDS not meeting the critera of managed SWDS and which have depths of greater than or equal to 5 meters and/or high water table at near ground level. Latter situation corresponds to filling inland water, such as pond, river or wetland, by waste. • 0.4 for **unmanaged-shallow solid waste disposal sites.** This comprises all SWDS not meeting the critera of managed SWDS and which have depths of less than 5 meters.

For Kremenchuk the MCF value of 1.0 was used.

Fraction of degradable organic carbon (by weight) in the waste type *j* (DOC_j)
The values for fraction of degradable organic carbon (by weight) for different types of waste *j* recommended by IPCC are given in the table below.

Data / parameter	**DOC_j**
Data unit:	-
Description:	Fraction of degradable organic carbon (by weight)in the waste type *j*.
Source of data:	IPCC 2006 Guidelines for National Greenhouse Gas Inventories (adapted from Volume 5, Tables 2.4 and 2.5)
Value to be applied:	Apply the following values for the different waste types *j*:

Waste type *j*	**DOC_j (% wet waste)**	**DOC_j (% dry waste)**
Wood and wood products	43	50
Pulp, paper and cardboard (other than sludge)	40	44
Food, food waste, beverages and tobacco (other than sludge)	15	38
Textiles	24	30
Garden, yards and park waste	20	49
Glass, plastic, metall and other inert waste	0	0

Decay rate for the waste type k_j
The values for decay rates *k* for different types of waste *j* recommended by IPCC are given in the table below:

Data / parameter	**k_j**
Data unit:	-
Description:	**Decay rate for the waste type *j*.**
Source of data:	IPCC 2006 Guidelines for National Greenhouse Gas Inventories (adapted from Volume 5, Table 3.3)
Value to be applied:	Apply the following values for the different waste types *j*:

Waste type *j*		**Boreal and temperate (MAT<20°C)**		**Tropical (MAT>20°C)**	
		Dry (MAP/PET<1)	Wet (MAP/PET>1)	Dry (MAP< 1000mm)	Wet (MAP> 1000mm)
Slowly degrading	Pulp, paper, card-board, (other than sludge), textiles	0.04	0.06	0.045	0.07
	Wood, wood products and straw	0.02	0.03	0.025	0.035
Moderately degrading	Other (non food) organic putrescible garden and park waste	0.05	0.10	0.065	0.17
Rapidly degrading	Food, food waste, sewage sludge, beverages, tobacco	0.06	0.185	0.085	0.40

Kremenchuk is situated in an area with boreal character and average temperatures less 20 °C. Therefore, the suitable values were chosen for the types of waste.

The concrete values of the conditions in Kremenchuk are given in the table below:

Waste type j	DOC_j (% wet waste)	rate in Kremenchuk	k_j
Wood and wood products	43%	3%	0,03
Pulp, paper and cardboard	40%	14%	0,06
Food, food waste, beverages	15%	30%	0,185
Textiles	24%	5%	0,06
Garden, yards and park waste	20%	5%	0,1

Taking into account all abovementioned initial values the following values of the Baseline emission arise for the site in Kremenchuk according to FOD-model:

Baseline emissions from the Kremenchuk solid waste disposal site		
Year	Methane release in tones	Emission from CH_4 release, tCO_2e
2010	1,084.03	22,764.70
2011	3,339.53	70,130.04
2012	3,430.29	72,036.09
2013	3,302.79	69,358.57
2014	2,971.56	62,402.68
2015	2,683.23	56,347.84
2016	2,431.37	51,058.71
2017	2,210.56	46,421.68
2018	2,016.25	42,341.33
2019	1,844.64	38,737.40
2020	1,692.49	35,542.27
2010 - 2020	27,006.74	567,141.31

E.5. Difference between E.4. and E.3. representing the emission reductions of the project:

Results of calculation of the project emission reduction from the Kremenchuk solid waste disposal site are given below. The value reflects only the expected operating months in 2010:

Year	$PE_{,grid,total}$	$PE_{y,generator,total}$	$BE_{CH4,SWDS,y}$	$BE_{CH4,SWDS,y} - PE_{y,grid,total}$	$BE_{CH4,SWDS,y} - PE_{y,generator,total}$
2010	12,645.40	12,554.57	22,764.70	10,119.30	10,210.13
2011	38,945.97	38,673.48	70,130.04	31,184.07	31,456.56
2012	39,994.30	39,721.81	72,036.09	32,041.71	32,314.28
2013	38,521.66	38,249.18	69,358.57	30,836.91	31,109.40
2014	34,695.92	34,423.43	62,402.68	27,706.76	27,979.24
2015	31,365.76	31,093.27	56,347.84	24,982.08	25,254.57
2016	28,456.74	28,184.25	51,058.71	22,601.97	22,874.46
2017	25,906.37	25,633.89	46,421.68	20,515.31	20,787.79
2018	23,662.18	23,389.69	42,341.33	18,679.15	18,951.64
2019	21,680.02	21,407.53	38,737.40	17,057.38	17,329.87
2020	19,922.70	19,650.21	35,542.27	15,619.57	15,892.06
2010 - 2020	315,797.01	312,981.32	567,141.31	251.344.29	254,159.98

E.6. Table providing values obtained when applying formulae above:

The following table shows the values for the case that electricity is used for the pumping system from the grid.

Year	Estimated project emissions tCO_2e	Estimated leakage tCO_2e	Estimated baseline emissions tCO_2e	Estimated emission reductions tCO_2e
2010	12,645.40	0.00	22,764.70	10,119.30
2011	38,945.97	0.00	70,130.04	31,184.07
2012	39,994.30	0.00	72,036.09	32,041.71
2013	38,521.66	0.00	69,358.57	30,836.91
2014	34,695.92	0.00	62,402.68	27,706.76
2015	31,365.76	0.00	56,347.84	24,982.08
2016	28,456.74	0.00	51,058.71	22,601.97
2017	25,906.37	0.00	46,421.68	20,515.31
2018	23,662.18	0.00	42,341.33	18,679.15
2019	21,680.02	0.00	38,737.40	17,057.38
2020	19,922.70	0.00	35,542.27	15,619.57
Total tCO_2e	315,797.01	0.00	567,141.31	251.344.29

The following table shows the values for the case that electricity is used for the pumping system from the mobile diesel generator.

Year	Estimated project emissions tCO_2e	Estimated leakage tCO_2e	Estimated baseline emissions tCO_2e	Estimated emission reductions tCO_2e
2010	12,554.57	0.00	22,764.70	10,210.13
2011	38,673.48	0.00	70,130.04	31,456.56
2012	39,721.81	0.00	72,036.09	32,314.28
2013	38,249.18	0.00	69,358.57	31,109.40
2014	34,423.43	0.00	62,402.68	27,979.24
2015	31,093.27	0.00	56,347.84	25,254.57
2016	28,184.25	0.00	51,058.71	22,874.46
2017	25,633.89	0.00	46,421.68	20,787.79
2018	23,389.69	0.00	42,341.33	18,951.64
2019	21,407.53	0.00	38,737.40	17,329.87
2020	19,650.21	0.00	35,542.27	15,892.06
Total tCO_2e	312,981.32	0.00	567,141.31	254,159.98

SECTION F. Environmental impacts

F.1. Documentation on the analysis of the environmental impacts of the project, including transboundary impacts, in accordance with procedures as determined by the host Party:

The following paragraphs describe the results of environmental impact analysis.

The project intends to collect combust and thereby destroy landfill gas generated from a landfill site. As a result, it will impart positive environmental improvement in terms of reducing emissions of pollutants into the atmosphere. Having said that, concern also exists over the following impacts, so the measures described have to be taken into consideration in order to mitigate their impact.

- **Human**
  High concentration of gases in the landfills brings about a risk of explosion. Controlled capture and combustion of LFG will reduce the risks of explosions or poisoning with high-toxic combustion products of inhabitants of enclosed settlements and on site workers.

- **Flora and fauna**
  Remediation of the landfill site will reduce presence of birds searching for prey and food, abating the pests and disease vectors. The project will abate methane migration destroying vegetation next to the landfill too.

- **Air**
  The LFG collection and flaring system might lead to some minor emissions of CO, VOCs and nitrous gases. However, due to the high-efficiency combustion and high-temperature an almost total destruction of gases is ensured. In that way, emissions of CO, VOCs and nitrous gases and other compounds present in the biogas such as ammonia will be minimal, and much lower to that which would have occurred in the absence of the project activity.

  The installed equipment does not produce any significant noise, since it will be placed in noise insulated container that will form a sound-absorbing casing.

- **Risk of fire from installation of flaring equipment**
  Installation of flaring equipment and the artificial collection of methane gas may increase the risk of fires occurring along pipe routes and around the flaring equipment. This can be resolved by measuring and monitoring oxygen concentration inside LFG collection pipes, stopping the system when the oxygen concentration becomes to high, and stabilizing flame by means of burner combustion control of the flare equipment.

CONCLUSIONS:

The landfill collection and flaring system has a significant positive impact on the environment. The system reduces emissions of greenhouse gases, odors and gases causing explosions as well as open fires and damage of wildlife. Additionally, the project will produce the following:
- positive effect on climate and local air quality;
- positive effect on flora and fauna in the surroundings;
- improved conditions for local inhabitants and site workers.

F.2. If environmental impacts are considered significant by the project participants or the host Party, please provide conclusions and all references to supporting documentation of an environmental impact assessment undertaken in accordance with the procedures as required by the host Party:

Environmental impact assessment in Ukraine is implemented according to the Ukrainian law 'On Protection of Ambient Air' (June 21, 2001). However, since the project intends to improve the environment, the host government has indicated that it should only be necessary to implement abbreviated environmental impact analysis.

SECTION G. Stakeholders' comments

G.1. Information on stakeholders' comments on the project, as appropriate:

In JI Projects in Ukraine there are no particular stipulations regarding who can become stakeholders. However, the inhabitants were always informed about the project and so the potentially stakeholders too. The local newspapers reported about the planned project in connection with the following occurrences:

- Signing the general agreement about the indented landfill site renovation between HAASE Energietechnik AG and city of Kremenchuk on the 1 of August in 2008
- Signing the contract about the granting of subsidies for the landfill site renovation between the KfW Entwicklungsbank from Germany and the city of Kremenchuk on the 16 of June in 2009
- Start-up of the test flare on the site in the presence of minister for municipal economy, the regional governor and the mayor of the city on the 23 of September in 2009

Press conferences took place to each of these occasions. Negative opinions to the project were not expressed. On the contrary the president of the Association for Ecological Conservation of the city of Kremenchuk, P.W. Kowalenko, wrote to the mayor on the 16 of January in 2010:
"…On behalf of our association we would like to give thanks for the implementation of the project. We are glad that the municipality recognized the environmental effects of the landfill site for the people of Kremenchuk. The population of the enclosed settlements suffers from the smell which originates on the site for many years. … For our part we are willing to support the implementation of the project with all necessary activities…."

The deputy of the mayor, N.N. Porizky, confirms the significance of the project concerning the containment of the fire risk on the site in an article of the newspaper "Kremenchukski Westnik" on the 18 of June in 2009.

During the period for public commenting questions on mainly technical and organizational issues have arisen and were properly explained. There are no open concerns remaining. All the activities resulted in positive comments from the stakeholders.

Annex 1

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Annex 2

BASELINE INFORMATION

LANDFILL CALCULATION PARAMETERS		
Parameter	Units	Data
Landfill data		
Year landfill started operation		1965
Waste in place at the beginning of project	T	2,450,000
Density of waste (non-compacted)	t/m²	225
Area of site	Ha	25,055
Average daily waste rate	t/day	320
Date gas collection project starts		September 2010
Project operational data		
Gas collection efficiency	%	50
Flare efficiency	%	➢ 90
Flare capacity (estimated)	m³/h	< 500
Diesel consumption by pumping and flaring system	l/h	4
Diesel CO_2 emission factor	kt CO_2/TJ	0.0741
Diesel calorific value	MJ/l	43
General data		
L_O	m³ LFG/t	88.24
K	1/yr	0.075
Methane content of landfill gas	%	50
GWP of CH_4	t CO_2/t CH_4	21
Density of methane	t/m³	0.0007168
Baseline data		
Proportion of methane flared in Baseline (AF)	%	0
Country		Ukraine
Crediting period (years and months) in the 1st commitment period (2008 - 2012)		2 years 4 months
Crediting period further beyond the 1st commitment period but no longer than project operational lifetime		7 years 6 months
Financial parameters		
Corporate profit tax		20%
Depreciation (quarterly)		5%
Price of carbon (€/tCO_2)		10

- **Efficiency of the gas collection system CE (-)**

CE expresses the performance of the landfill gas collection system to be introduced. Based on the specifications guaranteed by the manufacturer for the equipment and empirical values from past cases, this was set at 50 %.

- **Methane gas generation rate k (1/y)**

K, which exerts a major impact on the generated amount of LFG, is affected by the type of waste and climate (temperature, humidity, rainfall, etc.). it was decided to determine these values upon surveying the following literature:

1	McBean, Rovers & Farquhar 1995 „Solid Waste Landfill Engineering and Design, Englewood Cliffs, New Jersey: Prentice Hall PTR“
2	NEDO & Techno Consultants Co., Ltd.: Research into the waste power generation system utilizing landfill gas in Samarkand 2000, p4-9, p4-15

Upon considering the type of waste and climate in Kremenchuk, according to the above sources, the figure of k = 0.075 was deemed appropriate.

- **Rx: the quantity of landfill solid waste**

In this project, there is no accurate data record on the past quantity of waste carried in up to 1993 in addition, there is no accurate forecast on the quantity of waste carried in. But it is very important and essential to know the quantity of waste carried in, in order to estimate the amount of LFG by applying "First Order Decay Model".

The past quantity of waste determined through multiplying the data from 1993 by 10 % every year. Moreover, the amount of waste in the future was estimated through multiplying by 3 % per year.

Furthermore, we implemented a sensibility analysis to evaluate the uncertainty of baseline. In other words, we evaluated the change of lifestyle. Due to the changed lifestyle, the amount of waste shall increase obviously. This evaluation was implemented according to increase or decrease in the generation of LFG.

TABLE 2 RX FORECAST VALUE

year	disposed quantity	increase rate	Year	disposed quantity	increase rate
x	Rx	-	X	Rx	-
-	tons/year	%	-	tons/year	%
1981	48,067	10	2003	66,537	-
1982	52,874	10	2004	72,504	-
1983	58,162	10	2005	85,184	-
1984	63,978	10	2006	96,357	-
1985	70,375	10	2007	97,389	-
1986	44,840	10	2008	88,932	-
1987	77,413	10	2009	101,826	-
1988	85,155	10	2010	104,880	3.0
1989	93,670	10	2011	108,027	3.0
1990	103,037	10	2012	111,268	3.0
1991	113,340	10	2013 (6 months)	57,303	3.0
1992	124,675	10	2014	0	-
1993	137,142	-	2015	0	-
1994	136,015	-	2016	0	-
1995	136,840	-	2017	0	-
1996	124,712	-	2018	0	-
1997	96,855	-	2019	0	-
1998	86,322	-	2020	0	-
1999	84,398	-	2021	0	-
2000	74,910	-	2022	0	-
2001	60,060	-	2023	0	-
2002	65,738	-	2024	0	-

Note: Shaded parts indicate actual disposed quantities.

- Lo: Methane generation potential

The value of the methane generation potential is determined by the composition of solid waste and climate, etc. of the area where the landfill site is located. In the project, survey has been carried out on the composition of solid waste carried into Kremenchuk Landfill Site so far, and the results are as shown in

TABLE A2.2 COMPOSITION OF SOLID WASTE

waste category	mass portion %	component code
Food waste	30.00	C
Paper, cardboard	14.00	A
Wood	3.00	D
Ferrous and nonferrous metal	5.00	-
Textiles	5.00	A
Bones	no data	B
Glass	3.00	-
Leather, rubber	no data	B
Stones	no data	-
Plastic	15.00	-
Other	25.00	B
Total	100.00	

Note: the type of waste indicates the type of IPCC Guideline.

Concerning L_0 based on the composition shown in Table A2.2, this is estimated as follows using Expressions 1 and 3 from the Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories: Reference Manual CHAPTER 6 WASTE.

$$L_0 = MCF * DOC * DOC_F * F * 16 \div 12 \div D_{CH4}$$

•

MCF	methane correction factor
DOC	fraction of degradable organic carbon
DOC_F	fraction DOC dissimilated
F (= $W_{CH4,y}$)	ratio of methane gas in landfill gas (default value is 0,5)

According to the revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories: Reference Manual CHAPTER 6 WASTE, the default value for MCF is 1.0 in managed landfill sites (anaerobic).

Calculation of DOC according to the Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories: Reference Manual CHAPTER 6 WASTE is performed using expression 2.

DOC = 0.4* (A) + 0.17 * (B) + 0.15 * (C) + 0.30 * (D)

(A)	rate of paper and textiles in solid waste
(B)	rate of waste in garden, park, other perishable waste other than food in solid waste
(C)	rate of food in solid waste
(D)	rate of wood and straw in solid waste

Out of the components given in Table A2.2, upon dividing organic waste partially into (B), (C) and (D), each value works out as follows: (A) = 19.00, (B) = 25.00, (C) = 30.00 and (D) = 3.00 and DOC = 0.175.

The IPCC recommends that a value of 0.77 is used for DOC_F. However, in recent research, since it is claimed that 0.77 can only be used when the lignin in solid waste is removed from the calculation in advance, while it is appropriate to use a value of between 0.5 - 0.6 in cases where lignin cannot be removed, DOC_F = 0.55 was adopted as the setting.

Therefore:

$$L_0 = 1.0 * 0.175 * 0.55 * 0.5 * 16 : 12 : 0.7168 * 1{,}000 = 88.24 \text{ m}^3/\text{Mg}$$

In the IPCC Guideline, the general value of L_0 is from 100 m³/Mg to 200 m³/Mg. The calculation here falls not in this scope. Accordingly, in the project, it has been decided to adopt the value of 88.24 m³/Mg for general landfill sites based on the IPCC Guidelines.

Annex 3

MONITORING PLAN

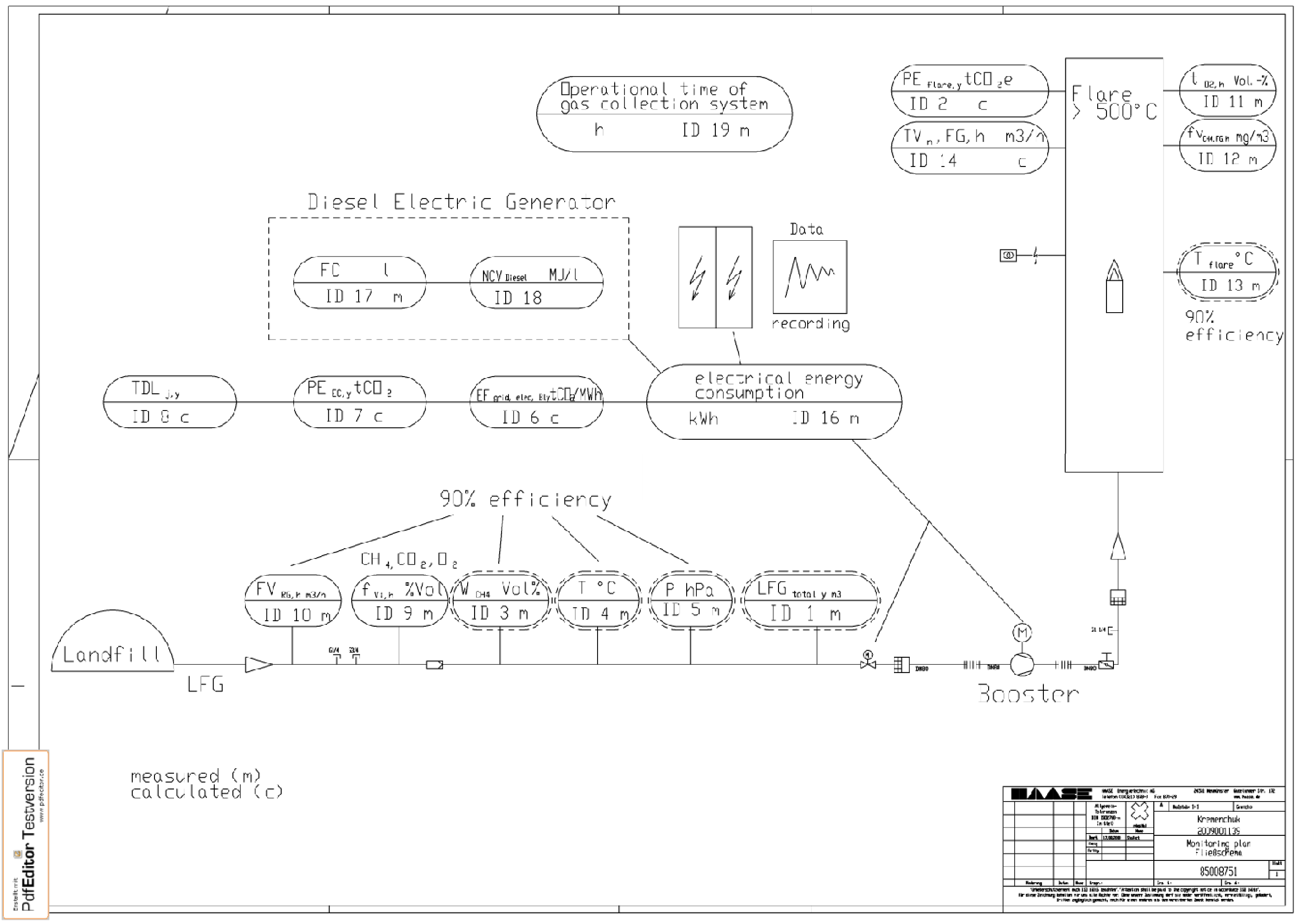

Figure 4 shows the monitoring plan in the project as a flow sheet.

The following table shows the equipment used to monitor emissions reductions from the project activity.

ID Number	Variables monitored	Equipment	Calibration procedures	Responsible	Procedure in case of failure	Default value to use in case of failure
ID1	$LFG_{total,y}$	On-line LFG flow meter	maintenance/ calibration min. 1 x half-year; testing/ calibration 1 x year	Site engineer/ equipment supplier	Repair of the component. If it is not possible, equipment will be re-placed by equivalent item within one month. Failure events will be recorded in the site events log book.	Daily average of the volume in the previous month minus 5% per day of flow meter failure.
ID3	W_{CH4}	Con-tinuous gas quality analyzer	maintenance/ calibration 1 x week; testing/ calibration 1 x year	Site engineer/ equipment supplier	Repair of the component. If it is not possible, equip-ment will be replaced by equivalent item within one month. Failure events will be recorded in the site events log book.	Average of the methane content in the previous month minus 5% per day of gas analyzer failure.

ID4	T	Thermo-couple	maintenance/ calibration min. 1 x year; testing/ calibration 1 x year	Site engineer/ equipment supplier	Equipment will be re-placed by equivalent item within one week. Failure events will be recorded in the site events log book.	Average of the temperature of the LFG in the previous month per day of thermocouple failure.
ID5	P	Pressure gauge	maintenance/ calibration min. 1 x half-year; testing/ calibration 1 x year	Site engineer/ equipment supplier	Repair of the component. If it is not possible, equipment will be replaced by equivalent item within one month. Failure events will be recorded in the site events log book.	Average of the temperature of the LFG in the previous month per day of pressure gauge failure.
ID9	$f_{Vi,h}$	Con-tinouos gas analyzer	maintenance/ calibration 1 x week; testing/ calibration 1 x year	Site engineer/ equipment supplier	Repair of the component. If it is not possible, equipment will be replaced by equivalent item within one month. Failure events will be recorded in the site events log book.	Average of the volumetric fraction of components CH_4, CO_2, O_2 in the hour h of the residual gas in the previous month per day of gas analyzer failure.
ID10	$FV_{RG,h}$	Different pressure type flow meter	maintenance/ calibration min. 1 x half-year; testing/ calibration 1 x year	Site engineer/ equipment supplier	Repair of the component. If it is not possible, equipment will be replaced by equivalent item within one month. Failure events will be recorded in the site events log book.	Average of the volumetric flow rate of the residual gas in dry basis at normal conditions in the hour h of the residual gas in the previous month per day of different pressure type flow meter failure.
ID11	$t_{O2,h}$	Con-tinouos gas analyzer	maintenance/ calibration 1 x week; testing/ calibration 1 x year	Site engineer/ equipment supplier	Repair of the component. If it is not possible, equipment will be replaced by equivalent item within one month. Failure events will be recorded in the site events log book.	Average of the volumetric fraction of O_2 in the exhaust gas of the flare in the hour h in the previous month per day of continuous gas analyzer failure.
ID12	$fv_{CH4,FG,h}$	Con-tinouos gas analyzer	maintenance/ calibration 1 x week; testing/ calibration 1 x year	Site engineer/ equipment supplier	Repair of the component. If it is not possible, equipment will be replaced by equivalent item within one month. Failure events will be recorded in the site events log book.	Average of the concentration of methane in the exhaust gas of the flare in dry basis at normal conditions in the hour *h* in the previous month per day of continuous gas analyzer failure.
ID13	T_{flare}	Thermo-couple	maintenance/ calibration min. 1 x half-year; testing/ calibration 1 x year	Site engineer/ equipment supplier	Repair of the component. If it is not possible, equip-ment will be replaced by equivalent item within one week. Failure events will be recorded in the site events log book.	Average of the temperature in the exhaust gas of the flare in the previous month per day of thermocouple failure.

ID16	*Electricity consumption*	Kilowatt meter	The kilowatt meter will be calibrated delivered from a local manufacturer in a sealed state and it will be exchanged according to manufacturer's data.	Site engineer/ equipment supplier	Equipment will be replaced by equivalent item as soon as possible. Failure events will be recorded in the site events log book.	Daily average of the electricity used by the project in the previous month plus 5 % per day of kilowatt meter failure.
ID 17	*FC* Quantity of fuel type *i* combusted in process *j* during the year	Diesel gauge	testing/ calibration 1 x year	Site engineer/ equipment supplier	Repair of the component. If it is not possible, equipment will be replaced by equivalent item within one week. Failure events will be recorded in the site events log book.	It is calculated on the hourly consumption given by the manufacturer of the generator + 5%.
ID 19	Operational time of the collecting system	data logger	testing/ calibration 1 x year	Site engineer/ equipment supplier	Equipment will be replaced by equivalent item as soon as possible. Failure events will be recorded in the site events log book.	Daily average of the collecting system worked by the project in the previous month minus 5 % per day of data logger failure.

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